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Workshop Record

The Soil Management CRSP Global Planning Session

January 25–28, 1993
NCSU Campus
Raleigh, NC,
USA

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Foreword

Born out of Title XII legislation, the Collaborative Research Support Programs (CRSPs) enable U.S. and host-country scientists to work together toward a common goal: the establishment of agricultural systems that are sustainable, productive, and equitable. Since 1981, the Soil Management CRSP, in partnership with the U.S. Agency for International Development (USAID), has successfully initiated research and development programs in the humid, savanna, and semiarid tropics.

At USAID's request, the Soil Management CRSP agreed to offer administrative leadership in a large-scale integration project that would place soil and water management programs from the U.S. Department of Agriculture (USDA) and the Nitrogen Fixation by Tropical Agricultural Legumes Center under the auspices of the CRSP. To help prepare an integrated research and development strategy, the expanded CRSP conducted a Global Planning Workshop from January 25–28, 1993, at North Carolina State University in Raleigh, NC. The purpose of the workshop was to identify the natural resource and environmental management issues that the CRSP should target in its next five-year work plan. To achieve this objective, the CRSP brought together, as partners, representatives from USAID, U.S. institutions, host countries, PVOs, NGOs, and International Agricultural Research Centers.

This Workshop Record is the product of our Global Planning Session. Included are summaries or direct transcripts of all the formal speeches delivered during the three-day event, as well as summaries of the future issues and programmatic needs identified during group discussions on research support, research, and outreach needs. Every effort has been made to record accurately the thoughts and intentions of the participants. This record will serve as a guide as we prepare the Soil Management CRSP's next global plan.

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Opening Ceremony
&
Keynote Speakers

Workshop Opening

Dr. Roger G. Hanson
Management Entity Director
Soil Management CRSP

Welcome to the first Soil Management Collaborative Research Support Program Global Planning Workshop. Each of you is here for a special role, and the organizing committee has worked hard to ensure that you might serve that role.

Before we begin, I would like to direct your attention to someone you should make a special effort to meet during this workshop: Dr. Charles B. McCants, the first Management Entity Director for the Soil Management CRSP. Dr. McCants still serves us in numerous ways, and we owe him many thanks. I am sure he would enjoy talking individually with you during this workshop.

In focusing on *Soils and Society: Responsible Management*, we face a challenge that is both simple and complex. As the ratio of land to people decreases from 0.3 ha to 0.15 ha/person by the year 2050, the simple challenge is to produce more on the same or less land. The complex challenge is to mobilize multinational collaborative activities in research, education, development, communications, outreach, and clientele services to generate and implement the technologies needed to meet this challenge. We must also convince political leaders, responsible donors, benefactors, and our clientele that we can focus on the aforementioned challenges, that we can dedicate our united professional efforts to ensuring that the finite natural-resource base can be managed for productivity, stability, equitability, and sustainability.

To outline the goals of this workshop, I introduce Dr. Robert R. Shaw, Deputy Chief for Technology, USDA, Soil Conservation Service. Dr. Shaw is the Chairman of the Soil Management CRSP's Board of Directors.

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Workshop Goals

Dr. Robert R. Shaw
Chairman, Board of Directors
Soil Management CRSP

I would like to say how pleased I am to be involved in this partnership. We have had a very productive journey, and we should recognize how far we have come. But at the same time we need to anticipate changes in the road ahead. We need to read the signs, read the signals. And that's the purpose of this workshop.

I'm sure we all sense, in some way, that there will be a change in direction. We certainly feel it in Washington as we make the transition to a new administration—one with an extraordinary mandate for environmental action and for changing the way government and public-supported institutions operate.

That leads me to our goals for this workshop.

- First of all, we need to look at who we are, as a partnership, and how we have changed.
- Second, we need to identify the most pressing global research and development issues and come to a clear understanding of what our future goals and objectives will be.
- Finally, we must discuss the best ways to deploy our resources over the next five years.

I want to emphasize that our purpose is to exchange ideas, not to preempt future planning. But at the same time, I want us all to feel the urgency to get some kind of framework in place and to be sure that we are truly responsive to the global community.

As to where we've been, I can immediately think of four very significant accomplishments:

- Spreading the word on managing soil resources for food and fiber production. The mix of programs we offer brought out this key to the sustainability of agricultural production systems.
- We've also spread the concept of soils as watershed units, a concept which ties soils to natural resource management.
- We have really brought along the science as to chemical and physical constraints of soils. We are far ahead of where we were 15 to 20 years ago. And Soil Taxonomy now has gained worldwide acceptance.
- Training is a product of CRSP that was not anticipated (particularly from AID's perspective). We've trained a lot of people who are moving to quite high positions throughout the world. These are people who have obtained a global outlook and are multilingual in the science of soils and their management. I really think we've proved that professionalsfrom different countries working together can build an understanding you can't build in any other way.

As to where we're going, I believe we'd better start reading those signs and signals that our customers—the global agricultural community—are getting. Agriculture worldwide is getting the signal to be environmentally benign, sustainable, holistic, customized (and customer-ized), technologically driven, and prepared for regulation.

Government agencies and every one of you in the research and technology-transfer community are getting the signal that we'll be closely scrutinized as to how we are using public investments. And that scrutiny means looking at the efficiency, effectiveness, pragmatism, and strategic value of our work.

A couple months ago, the World Resources Institute distributed some of its environmental recommendations to the Clinton Administration. And

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I might add that Gus Speth, then president of the Institute, is heading up the Administration's environmental "cluster" group, which will help set priorities for policy development.

The Institute's report recommends that the U.S. start forging programs aimed at "cooperating with the developing countries to achieve broad-based and environmentally sustainable growth. This program should respond to the gravity of the environmental, poverty, and population challenges these countries face. It should be viewed as a long-term investment that can yield large benefits for our country."

So I think the challenges ahead for us are these:

- We have to focus our policies and channel our thinking. Our programming has to be problem-oriented and customer-focused. Our goals have to be structured. They have to be interdisciplinary, interagency, holistic, and pragmatic. Global climate change, for example, is an area to focus on.
- We'll have to focus on process-oriented research and more global practical, on-farm research in collaboration with producers. We're seeing more of that in this country as we pursue crop residue management and involve producers in sharing on-farm results.
- We'll be under greater pressure to show how our research has been utilized and to quantify the impact of our research.
- We have to step beyond "business as usual." We have to do business differently in terms of programming and getting donor support. We have to understand that as America gets its fiscal house in order, so purse strings will obviously be tighter, and we may be in for substantial cuts later this year. That means continually expanding our partnerships.

As to the future, I see a lot of positives in our favor. For all our concerns about money, we have human resources, the expertise. We've laid a lot of groundwork, and we don't have to invent a new institution. We have played a strong role in training people and developing new science and management practices. And we've expanded the CRSP, moving to a higher level of visibility. In so doing, we are moving toward a more global management board.

But, again, we need to get the technical issues to the surface and establish our priorities and goals, making sure that we have global representation.

Let's take a minute and look at our role in terms of AID's objectives. Here's a critical sponsor whose purpose is to help reshape human activities to minimize environmental damage and to ensure sustainable development.

We'll be under greater pressure to show how our research has been utilized and to quantify the impact of our research.

Not one of the organizations represented here can make a dent in what AID needs to be done if we try to do it alone. But collectively we can make an impact. So we must leverage our resources towards achieving our objectives. We must seek the best minds and innovate to enrich our program. And we must work on the most critical research problems.

We've seen the enormous changes on our globe over the past two years—for example, the enormous opening up of opportunity for Eastern Europe. At the same time, we've seen catastrophic environmental and economic problems there and elsewhere in the world. We must be willing to change in the face of these new challenges.

To repeat: We must be ready for change. We must listen to our donors, our customers, their constraints, and their needs and to the taxpayers and the accountability issues. And let us remember that, as we stand on this beautiful blue and green spaceship of ours, poverty strikes a billion people (a fifth of the world's population), and malnutrition plagues some 500 million.

But let's also remember what Buckminster Fuller said about "Spaceship Earth" some years back. He said that the most important fact about this spaceship is that it "didn't come with an instruction book."

What's unique about our partnership is that we're helping to write that book.

Let's do it right.

New Challenges for the Soil Management CRSP

Mr. Alan R. Hurdus
Deputy Director, Office of Agriculture R&D Bureau
USAID

I am very happy to be here this morning and appreciate the opportunity to talk with you about the new challenges facing the Soil Management CRSP. In point of fact, I go back a long way with TropSoils. During my first five years with AID, I was the Agricultural Research Officer for the Mission in Indonesia and was rather intimately associated with the large group from Hawaii and North Carolina State in Sitiung, Sumatra. The Mission program was then very much into building capacity within the national agricultural research system, and I was concerned about integrating the CRSP's activity into that national program. We were also very concerned about impact and making a difference in the lives and livelihoods of the transmigrants trying to eke out a living on those acid infertile soils of West Sumatra.

We are today faced with the challenge of change and how to effectively deal with some new realities. The last few years at AID have been fraught with change—some good, some bad, but definitely at a pace unmatched in the 13 years that I have worked for the Agency. With change often comes apprehension and inaction. It is often easier to travel along a well-worn path than to go off in new directions. We are comfortable and confident going where we have been before. On the other hand, it makes little sense to resist change as it comes along, and, in fact, there are great opportunities for those with the foresight and courage to come forward to shape that change in their own image. The Soil Management CRSP now has that opportunity, and I believe that is why we are all gathered here today and for the next few days. We can position ourselves on the leading edge of the change ahead and be prepared to solidify our niche in the Agency's future.

In the next few minutes I would like to focus on the following three areas:

- Recent changes in the Agency, the Research and Development (R&D) Bureau, and the Office of Agriculture;
- Current realities and possible new configurations;
- The new Soil Management CRSP.

AID's World Changes . . .

First and foremost, the Cold War has ended, and with it much of the rationale and support for foreign assistance. We never had much of a constituency, but seemingly there is even less of one today.

At the same time, the number of countries we are working in has risen dramatically with the addition of Eastern Europe and the Newly Independent States (NIS) of the former Soviet Union, but funding levels, particularly for our operating expense (OE) budget, which supports our staff, have been reduced in real terms. In essence, we have been asked to do more (i.e., in more places) with less. Clearly something had to give.

Unfortunately, it appears that the Agency decided to cut the number of staff abroad, where most of us feel our strength and comparative advantage lies, to cope with the OE funding shortfall. In addition, our new programs in Eastern Europe and the NIS siphoned staff from other bureaus, including R&D. Because of all of this—as well as changes in the structure of our portfolio, with new emphases on democracy and private-sector development—the technical strength of our missions, our regional bureaus in Washington, and to some extent, even the R&D Bureau, declined. As a consequence of this and some very critical management audits of AID by the

Administration, Congress, and our own Inspector General about 18 months ago, the Agency reorganized rather dramatically, putting all of the regional and central operational bureaus together under a new Operations Directorate, and entreating and to some extent empowering the R&D Bureau to provide greater leadership and responsibility for field support.

CRSPs must find out what our missions are doing and let them know how and where the CRSP program can fit into their activities.

When I transferred from the Asia Bureau to the R&D Office of Agriculture a year ago, we were grappling with the question of field support and how to effectively organize and implement our new mandate. We decided to take a couple of days away from the office to come to grips with the field-support question. One of the outcomes of this retreat was a decision to break down some of the walls in our own office by forming inter-divisional theme teams to better harness our talent to support our missions.

At the same time, the missions were going through the focus and concentration exercise that most of you are probably intimately aware of, paring down their programs into two or three focus areas. The sailing was rough, but we survived that crossing.

. . . And Will Likely Change Again

Last week we lost all of our political leadership except for Ambassador Michels, former Assistant Administrator for the Latin American and Caribbean Bureau, now Acting Administrator. Alas, even Rich Bissell is gone, in my opinion a very strong and capable leader who understood agriculture and research. Before he left, he submitted to the Associate Administrator of the Operations Directorate, a plan to reduce the number of full-time equivalents (FTE) in the Research and Development Bureau from 247 to 199, a rather draconian reduction. Continuing budgetary pressures as well as the need to staff up the NIS group forced this reduction. The plan, which Rich Bissell stonewalled for many months, was submitted with the caveat that nothing would be done with it until the new Administration had a chance to review it, hopefully in the context of a new, soon-to-be-developed mandate and objectives for AID. (It is thought that a high-level group, perhaps at Senator Leahy's direction, will soon meet to hammer out a new consensus on U.S. foreign assistance. This would lead to a firm decision on whether AID remains a separate agency or becomes a part of the State Department).

Bissell's plan focuses on reorganizing R&D's work force and reducing its size, "while carrying out all of the traditional responsibilities of the R&D Bureau plus those which were acquired during the last Agency reorganization." He went on to say, "the stark fact is that reducing to any number approaching 199 positions could have Agency-wide impact in terms of the movement of personnel, and the Agency's technical capacity." Using a transparent methodology which apportions staff to a reduced number of offices based upon the office's *pro rata* share of appropriated dollar flows—which is the sum of the FY93 OYB plus actual demand from the field for services (buy-ins plus OYB transfers)—Mr. Bissell concluded that he would be derelict in his responsibilities to say that R&D could carry out its functions with less than 210 positions. At any rate, the elements of the plan are as follows:

- A new office will be formed which will combine the Center for University Cooperation, the Office of Research, and the Office of International Training. Sharp work-force reductions will take place, with many of the direct-hire functions in the Training Office contracted out.
- The remaining technical offices in the Bureau would be consolidated into four sectoral offices: Office of Population (no change), Office of Health (no change), Office of Human Resources (combining the current Offices of Education, Nutrition, Women in Development and part of the Office of Economic and Institutional Development), and the Office of Natural Resources (combining the current Offices of Agriculture, Energy, Environment and part of the Office of Economic and Institutional Development).
- The Offices of the Assistant Administrator, Program and Management would stay the same. If this plan is implemented, the proposed Natural Resources Office would lose 17 positions relative

to the current combined strength of the offices incorporated into it. The name "agriculture" would likely only appear in one or two of the Divisions of the Office.

Whither the Soil Management CRSP?

Under this scenario of change, the Soil Management CRSP is challenged to position itself to take advantage of the Agency's new directions, discussed above, and the even newer directions that are likely to come under the Clinton Administration. What might we expect?

First, it is a good bet that the Agency will get no fatter. As resources continue to dwindle, AID must improve the efficiency of its investments. How can we do this? At the Soil Management CRSP level, we must target our limited resources but world-class expertise on a few key constraints that are globally significant but at the same time relevant and important to our missions' bilateral programs. We can no longer afford to cover the waterfront, no matter how great the need. Once the two or three areas of focus are agreed upon, new activities should not be funded unless they clearly fit in with these objectives. Ongoing activities should be catalogued to see how they fit. If they do not, we must have the wisdom to continue some of those which promise great payoff. We should not be precipitous or indiscriminate in our decision making. But we cannot and should not defend all of our activities, and we must be prepared to end them. It is a truism that program change in research is difficult. But it is not impossible.

We then must manage ourselves efficiently to take advantage of our superb technical capabilities, now enhanced even further by the addition of NifTAL, SCS, ARS, and ERS. Management and organization must facilitate the work of our researchers, at the same time insuring that the total effort is tightly focused and producing results. Just as in our office, walls must come down and turf issues must be put aside. AID provides resources for the CRSP to organize and manage itself, and we would clearly prefer to keep that arrangement functional. We do not want to take this over for obvious reasons. We are stretched too thin as is. And certainly, you would not want us to manage the activity because you would be subject to too many bells and whistles and rules and regulations. It is in your hands.

At the next higher level, we must improve efficiency by integrating our program with other Agency programs in this area to take advantage of some clear synergies. The CRSP Council has certainly helped integrate the activities of the various CRSPs. More needs to be done to integrate TropSoils with the non-CRSP universe of activities including other projects of the Agency, other donors and their projects, and the International Agricultural Research Institutes.

After ten years in a country it is not enough to say that we now know how to better manage those soils if those soils are not, in fact, now being managed better.

Second, it is likely that R&D will continue to focus on field support. The Soil Management CRSP, and all CRSPs for that matter, must find out what our missions are doing and let them know how and where the CRSP program can fit into their activities. It is no longer enough just to communicate to them what we are doing. We must know what they are doing, and adjust our program to some extent to support their directions. In the past, I believe, the main clients of our CRSPs have been our local counterparts in the national agricultural research systems. I do not mean to say that this was bad or is bad today. However, we have often worked independent of our missions. We must change our approach and begin to view the missions as our primary clients. We must be ready to provide them with technical assistance when requested and able to convince them that what we are doing with our local counterparts is germane to development in their country. I believe that this will be one of the keys to our future success.

Another key to our future success will be the clear indication that technologies developed under the CRSP have been adopted here and there. Resources must be channeled into making this happen and documenting it. I cannot stress this point enough. I hearken back to Sumatra. After ten years in a country it is not enough to say that we now know how to

better manage those soils if those soils are not, in fact, now being managed better.

The new administration will have its own priorities, ideologies, biases, and bents, and AID will no doubt follow suit. If you ask me, we will likely see a greater emphasis on environment/natural resources and poverty alleviation. I do not know where the big A word—Agriculture—will fit into the new-think and new-speak. With Clifton Wharton as Deputy Secretary of State, and Matt McHugh from Cornell as the rumored-to-be new AID Administrator, there is a good chance that agriculture's role in development will again be better appreciated. Whatever the case, we must be poised for change.

In light of all this, our office has formally requested the Soil Management CRSP Board of Directors to consider restructuring its technical and operational activities. We sincerely believe that this will lay the foundation for a stronger and more fruitful CRSP for all concerned.

Wanted: The Wisdom to Address the Needs of Agriculture and the Environment

Dr. Richard Sawyer
President
International Fund for Agricultural Research

Planet earth is faced with many problems today. We are constantly reminded of them. We are deluged with requests for donations by the many organizations concerned about environmental degradation. Statistics on expected increases in population and their effect on food requirements are frequently in the press and an item of attention for almost every meeting on agriculture. The threat of famine is already touching some countries, and the pictures of starving children document adequately the need but leave us frustrated about how we can help in any permanent way. The help concentrated on African agriculture in recent years has not had the needed and desired effect, and some donors are shifting investments to programs which will give the kinds of early visible results they demand.

We talk about the rapid move towards the global village on earth at a time when ethnic disturbances are increasing in both developed and developing countries and clearly indicate the progress the village society has to make before there is any real appreciation of the great value of differences in culture, race, and religion to the changing needs on this rapidly changing planet. How do we develop the flexibility within society to accept and appreciate differences? What will this global village look like when our grandchildren have the responsibility which is ours today?

In some ways the prospects for addressing the many needs and problems associated with food and environment have never been better. The cold war is over and there is no major threat by a super power. Potential shifts from military spending to programs of agricultural improvement and environmental enhancement could markedly affect the economies in developing countries, which is an essential step to the elimination of poverty, population control, and acceptance of ethnic differences.

The portfolio available from science today to help solve the problems of food and environment is tremendous when compared to what was available for the green revolution. There are strong scientific bases in many developing countries today which were not there thirty years ago. There are a number of international research centers scattered across the planet concentrating on the problems of food, forestry, and environment. Plant genetic resources are being collected and made available for crop improvement today as well as being preserved for the needs of changing ecologies. The potential of biotechnology for crop improvement and environmental enhancement has clearly been identified and the need is apparent; however, a great gap exists between the laboratory and the field, between the potential and impact. Why is the portfolio of science available for agriculture today not making a greater difference to the urgent problems of society which concentrate around food and environment?

The five plenary speakers at the recent "First International Crop Science Congress" gave some indications of opportunities and directions programs might take. Following are some brief quotes with my own concerns about the recommendations from these experts.

Dr. Swaminathan stated that "Future improvement in productivity must come in an ecologically sustainable manner." That is fine Dr. Swaminathan, but the poor and hungry of this world must be

expected to choose survival at the expense of environment. Until there is economic improvement for the whole global village, attempts for environmental enhancement on this planet will be confined to those pockets where poverty and hunger have been eliminated. Dr. Ruttan said that "by the first decade of the next century, almost all of the increases in world food production must come from higher yields." That is fine Dr. Ruttan, but there are some major increases in food production which can be made by shifts in crops. For too long there has been a cereal mentality in the approach to world food needs. The green revolution with the cereals was wonderful and gave us a much needed break from the threat of famine, but we need to now start looking at calories and high quality protein production per unit area per unit of time per unit of energy and per unit of water as we move into the future. We need to look past the cereals at other alternatives which might fit into the cropping pattern and increase food production in a sustainable way.

The poor and hungry of this world must be expected to choose survival at the expense of environment.

Dr. Waggoner talked about "a portfolio of assets" that needs to be developed as we prepare for climate change. I would like to point out that there are scientists who believe that there are some great fallacies in the current global warming theory and that clear-cut evidence is needed which does not yet exist before we make major investments for the anticipated adjustments which will be required. Is this another case of scientists overplaying their hand in order to get funds for what would appear to be interesting projects? Dr. Waggoner indicates that genetic resources and water are a part of the portfolio which should be developed, and I believe that soils, which is what this workshop is about, should be basic to any such portfolio.

Dr. Day addressed the need for integrating molecular biology with plant breeding and states that "Molecular biology is a new tool whose power and usefulness we are still exploring," indicating the gap I have already mentioned between potential and impact. It seems to me we are spending too much time at the exploration stage, and we ought to be concentrating on a few priority crops in which we eliminate the obstacles now present in the move from laboratory to field application and thus provide examples for other programs to follow. Tapping the potential which has been identified must take priority over further exploration.

Dr. Evans explored the potential "for plant improvement by design rather than by empirical selection." He states that "for many of our most productive crops, there is little evidence that the limit to yield is close at hand." That may be true in the laboratory Dr. Evans, but in practical circumstances in many soils around the world, there is good evidence that yields of major crops are decreasing using the best of recommendations. This conclusion on lowering of yields was highlighted in the recently circulated summaries of round tables held during 1992 Centers Week in Washington, D.C. There is a great difference between laboratory potential and field capacity for yields with the resources available in many developing countries. Such comments coming from capable international experts need to be adjusted to the real world we live in today and the problems we are facing with agriculture and the environment. We need to take such comments into consideration as we discuss sensible management of soils.

Until there is economic improvement for the whole global village, attempts for environmental enhancement on this planet will be confined to those pockets where poverty and hunger have been eliminated.

In many ways those of us in agriculture are responsible for the decreasing attention being given to agriculture and the lack of funds presently available to address the needs for agricultural research nationally and internationally. Scientists have talked to each other about their achievements and have not maintained good communications with the general public as to the balance between achievements and present

global needs. In our search for funding, we have overplayed our hands about potentials and overemphasized achievements as awards are handed out. The awards do receive the attention of the press, and the general public could readily believe from the recognition being given that solutions for world hunger are already in hand. How can we adjust a needed recognition of accomplishments to an adequate recognition of continuing major problems which need attention?

Environmentalists have done a tremendous job in focusing the attention of the general public on ecological concerns. It remains to be seen whether they have overemphasized environment at the expense of other urgent problems. We are only starting to learn of planet earth's ability to heal itself if given half a chance. There has certainly not been the recognition that environmental enhancement and agriculture must be intimately linked. I sense that public opinion has influenced some donors to turn from agriculture to environment. It cannot be one or the other; it must be both together. Maybe the problem is ours in agriculture in not building support groups for agricultural programs as the environmentalists have for the environment. If so, we should learn from them and catch up fast. I can tell you from first-hand experience that The International Fund for Agricultural Research, a North American support organization, is having a hard time staying alive in spite of a very prestigious group of directors and advisory council members. This is a good indication of the interest and support to agriculture coming from both the public and private sectors today which needs to be turned around.

Almost forty years ago, when the threat of famine was facing the world, the wisdom and the vision were available, and investments were initiated by some far-sighted individuals in the Ford and Rockefeller Foundations which resulted in the green revolution. Credits for the miracle rice and wheat, however, should go to many scientists and many institutions which played a role in their development. The miracles did not take place overnight. They were not the result of donors and institutions requiring instant impact from their investments. They were not the result of donors who expected their investments to be mainly catalytic in nature to trigger the investments of others. These successes were the result of men with vision who could see potential and had the backing of donors willing to make a long-term funding commitment. Today there are still a few donors who have the willingness to make similar funding commitments in international agriculture.

These successes were the result of men with vision who could see potential and had the backing of donors willing to make a long-term funding commitment.

The one which stands out from my experience as an International Center Director General for twenty years is the Swiss Development Corporation. When they start a program, there is usually a commitment of funding for a number of years if there is good progress towards reaching the objectives of the project.

In my opinion there are several major problems in our national and international institutions which are affecting the emergence of vision to address the needs of food and environment today.

First, agriculture is no longer on the pedestal it earned during the green-revolution years. We need to determine a strategy to put it back on the pedestal. If we are astute in the development and use of biotechnology, it could be the tool which gets us up there again. We could then expect the bright young minds of today to turn to agriculture as they did thirty years ago during the green-revolution years.

Second, the shortage of funds for what we feel are high priorities has scientists creating false expectations about the results from their research and giving unrealistic time frames for impact to be achieved. Donors want to invest in projects which will give early results and have an early impact. For solutions to the major problems of food and environment today, it will probably take a minimum of two decades for any measurable impact from any valuable project which is started today. This means that the project has to last through various potential political changes. Programs need to be started today to solve African agricultural problems which might start to show results twenty to thirty years down the road, and we need to find donors who can accept

financially this waiting time. We need to change the mentality that requires instant success and that investments must be mainly catalytic.

Programs need to be started today to solve African agricultural problems which might start to show results twenty to thirty years down the road, and we need to find donors who can accept financially this waiting time.

Third, over the past two decades, management tools and strategies have become an important part of scientific production. Most scientists moving into management responsibilities are exposed to concentrated management courses. I frankly believe that there is considerable over-management at the International Agricultural Research Centers today and at many universities, so much so that leadership which requires wisdom and vision does not have a chance to emerge. Having the management tools does not give vision or bring leadership. In fact, in times of financial stress such as today, following the five-year plan becomes more important than having the flexibility to take an interesting side road that may lead to a breakthrough and provide the institution with financial security for the next ten years. Today, across many of our institutions, we have become so concerned with doing things the right way as our management courses have taught us that we forget about the importance of doing the right things. The only five-year plans or long-term plans which are valid in my opinion are rolling plans which have to be adjusted every year in these rapidly changing times and provide the flexibility for adjustments and the following up of interesting leads which may emerge. How can an environment be established in our institutions which will permit vision and leadership to emerge today in agriculture as it did for the green revolution three decades ago?

Fourth, agriculture has positioned itself very poorly with the many audiences on whom it must depend for the financing of research which will lead to solutions to the needs of food and environment. Grower groups in developed countries such as the United States believe incorrectly that help to developing-country agriculture will make competition for their surplus. The major way to increase developing-country economies so that they will purchase and consume more goods from abroad is through agricultural improvement. The tremendous cost of agricultural subsidies is a concern to taxpayers in developed countries where only a small percentage of the population is involved in agriculture. These subsidies provide unfair competition to the production of valuable commodities in a number of developing countries. We are a long distance from the global village where production will be in those fields which can produce and send to the consumer quality products the least expensively. We are a long way from reaching the point where the best reason for being in production for a given product is because we have a comparative advantage. We in science should think the same way, and maybe this is a good time to turn for a few minutes to the theme of this workshop.

In my opinion the major reason that there is a TropSoils program with the specific universities involved is because those universities have a comparative advantage for doing research with tropical soils. So I ask the question, is this the case? Or is there political pressure within the university system which has got you to this enviable position? Can you this week in your discussions and planning, position yourselves so that you have the comparative advantages to address the problems of soils in the food and environmental revolution we are facing?

Before the centers of The Consultative Group for International Agricultural Research (CGIAR), there was a recognition of the importance of soils. As The International Institute for Tropical Agriculture (IITA) was created by the Ford and Rockefeller Foundations, soils were supposed to be a part of its program, but for some reason did not materialize. Today there is a feeling by some donors that soils, water, and nutrient research presents the biggest gap in the program of the CGIAR system of research centers. There is a feeling that what is being done is without coordination or integration. Where does TropSoils fit into this picture? How can TropSoils be perceived as being a joiner with a comparative advantage to serve some priority needs and merging its talents with others to respond to the expressed needs of developing countries? I want to emphasize *the expressed*

needs of developing countries. What is most important is not what we want to do but what they feel they need and will accept and use.

Concern for the ecology has been a major concern of the international agricultural research centers as they exploited the germ plasm of the major food crops in an attempt to identify plant resistance to control pests and diseases and cut down on the use of chemicals. They have searched for wider adaptation of the major food plants and cropping patterns which would provide more efficient systems of production. But apparently this recognition of environment was not enough, and they are now being pressured through recommendations of The Technical Advisory Committee (TAC) to visibly integrate regional ecological responsibilities within their present programs. This is being done at a time when their real budgets are being reduced and new responsibilities are being added to the system. Within any program, concentrating on the ecology, soils, water, and nutrient recycling must play a very important role. It would appear to me far more sensible for the centers to join forces with institutions where expertise already exists with these subjects than to have each center add its own units to address these ecological research needs. Many of the centers have been concentrating mainly on crop improvement through breeding up until now, and these new additions will require some major staff additions and changes if they are to be handled in-house.

Today, across many of our institutions, we have become so concerned with doing things the right way as our management courses have taught us that we forget about the importance of doing the right things.

Whatever is done with these subjects in agriculture so important to the ecology, it must be done with the active participation of national scientists and their administrators. Whatever is planned at this meeting this week must be perceived as responding to an expressed request for help by the developing countries to be served. And this requires their active involvement in the planning. International planning conferences with a strong involvement of developing-country scientists have played an important role in those research accomplishments of the centers which have received rapid acceptance up until now. However, in these times of budgetary restrictions, the planning conferences are being reduced in some institutions or restricted to participation of experts mainly from developed countries. Forgotten is the fact that a major reason for the planning conferences is to show that the programs of the centers are for developing countries, responding to their expressed needs, and that these are their centers. I hope we are not going to go through another period where institutions such as the centers or programs such as TropSoils develop a list of accomplishments and then determine their need and acceptability by the users.

Back to the title of this presentation, *Wanted: The Wisdom*—and I add the word *Vision—To Address the Needs of Agriculture and Environment.* In my opinion the institutions are in place, the potential for research breakthroughs have been identified, and I am sure the vision and leadership exists if we can only provide an environment to let it emerge. We must build comparative advantages and join forces. With modern-day communications capabilities we must make rapid strides towards the global village in science on this planet despite the limitations which may exist in political, cultural, and religious fields. We do not need to create new institutions; we need to build differing capabilities across institutions and join forces. What is missing most these days at meetings such as this is an adequate representation of the farmers, the producers, the users of our research and what they need and will accept from what is accomplished in our laboratories and at experiment stations. I seriously doubt if there are many in this room from developed or developing countries who capably represent farmers or have even been on a farm in recent months. How do we get this much needed input as we plan for the needs of agriculture and environment? It is essential in my opinion and indicates the tremendous gaps along the food chain, the tremendous gap between potential and impact. At meetings such as this, we must be concerned with the development of strategies which will close these gaps.

These times of financial stress can present opportunities for needed changes and adjustments of

priorities which will help our institutions address with strength the problems of food and environment. Let us show wisdom in our discussions at this workshop, let us join forces in the projects we plan, let us identify strategies which will let leadership emerge in our institutions to address the needs of agriculture and environment.

Our Partners: Experiences & Challenges

Host Country Experience: The Case of Niger

Dr. Mohamadou Gandah
Head, Soil Science Section
Institut National de Recherches Agronomiques du Niger

Background

Geography of the country: Located in West Africa, Niger is a typical Sahelian country. It is landlocked, located about 1,000 kilometers from the coast. The country is in its majority desertic, with the agricultural zone stretching from east to west in a band 300-kilometers wide. The river Niger is the only permanent water body in the west, Lake Tchad in the east. The total area is 1,267,000 square kilometers.

Climate: Being a landlocked and a sub-Saharan country, Niger has a climate characterized by two distinct seasons: the dry season (October to May) and the rainy season (June to September). The annual rainfall has decreased constantly over the last thirty years. There is a very high variability in the starting date of the rainy season, but also in the distribution of the rains during the four months of the monsoon season. The duration of the rainy season is highly correlated to the date of the first efficient rains. Wind is an important climatic factor in Niger. The Harmattan (the dry-season wind) blows from east to west and causes most of the wind erosion. During the wet season, the wind blows from southwest to northeast, moving the Inter-tropical Front (ITF) northward.

Agriculture: Rainfed agriculture is possible only in a band 300-km wide south of the 300-mm rainfall range. Crops are grown on eolian deposits of the plateaus and slopes, but also in valleys. The main crops are millet, sorghum, cowpeas, peanuts, and some minor crops such as maize, sesame, and vouandzou. When irrigation water is available, crops such as rice, cotton, wheat, vegetables, and fruits can be grown.

Present research programs in soil management: The research programs are guided towards restoration of soil fertility, conservation of soil resources, and cropping systems aimed at maintaining a sustainable agriculture. Soil-fertility research addresses the topics of maintaining fertility through organic-matter management, cropping systems (millet/cowpea intercrop), and rock phosphate. The cropping systems make use of the traditional systems of intercropping, using better varieties and agroforestry.

INRAN's Experience with TropSoils

Training activities

During its ten-year presence in Niger, TropSoils has organized or supervised many training activities with INRAN. At least eight students from Texas A&M have done their master's or Ph.D. research in Niger. TropSoils personnel in Niger have also served as advisors to many students from the University of Niamey. A three-month training in Geographical Information Systems has been granted to an IMAW scientist in conjunction with the project on the Integrated Management of Agricultural Watersheds (IMAW). Through the Laboratory Assistance Project and the Assistance to the Department of Ecological Research, financed by USAID Niger, TropSoils has posted a qualified scientist in soil analysis and laboratory management, a scientist who has helped INRAN improve the quality of its various soil and plant analyses. Technicians have been trained on the job and in neighboring countries to broaden their experience. Through its three senior scientists and three junior scientists, TropSoils has helped maintain a strong scientific community in soil science within INRAN over the last ten years.

It should be mentioned that TropSoils, through Texas A&M, has supported three USAID-sponsored students for their master's and Ph.D. degrees. TropSoils has also been co-organizer of an Interna-

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tional Workshop on Soil, Crop, and Water Management (1987), a soil science tour (1989), and a National Workshop on Soil Management and Conservation (1989). These are only a few of TropSoils' training activities.

Research Programs

Several research programs have been carried out on soil-water-plant relationships. The following are the most important:

- Regenerating bare spots on plateaus of the Continental Terminal,
- Protecting crops against sand blasting,
- Examining how windbreaks affect millet growth and yield,
- Analyzing how millet crops use water,
- Quantifying and preventing water erosion,
- Managing soil fertility,
- Quantifying how wind-blown dust contributes to soil fertility,
- Managing watersheds for sustainable agriculture.

Research Findings

1) Soil and Agroclimate Data Base: One unique characteristic of the Sahel is climate. Not only is rainfall unpredictable over time, but it also varies over space. TropSoils' semiarid tropics program (SAT) made it a priority to compile and analyze daily rainfall records and to identify and quantify the spatial and temporal variations in rainfall. This information was used to develop decade-long tables on probable rainfall totals for different regions. Such tables have helped in selecting appropriate varieties depending on the onset of rains.

Additional TropSoils contributions to the understanding of soil-water management have focussed on collecting data on infiltration rates, hydraulic conductivity, and water balance under optimum and minimal fertility conditions. The TropSoils program has demonstrated the potential for using water-harvesting techniques to increase grain yields even under minimal rainfall conditions in farmers' fields.

TropSoils SAT has collaborated effectively in the characterization, quantification, and evaluation of land resources in Niger. This information has served as baseline data for resource-management research and technology transfer. A soil survey of the ICRISAT Sahelian Center was carried out by a joint TropSoils/INRAN team. As part of a soil resource evaluation, chemical and physical characterizations of dust inputs have been carried out over a period of five years.

Natural resource management is the major field where joint efforts from both INRAN and the Soil Management CRSP can lead to highly significant results.

2) Soil Fertility Constraints: Microvariability, a phenomenon in which plant growth variations occur over short distances, is a constraint to agricultural research and also significantly affects crop yields. Through principal investigators and graduate students, TropSoils has carried out in-depth research on this problem. The areas of research have been as follows:

a) Identification of soil chemical and physical parameters responsible for crop growth variability. Assessments have been made of variations in parameters in the vertical (profile) and horizontal (landscape) directions.

b) Determination of the problem's areal extent using remote sensing techniques. This was combined with a ground truth survey to help calibrate the infrared spectra obtained with probable causal parameters.

c) Remediation methods.

TropSoils worked in a neem windbreak in the Majjia Valley and established an important relationship between windbreaks and dry-matter production, grain yields, and water-use efficiency of millet.

A landmark activity of the TropSoils project in Niger has been the use of an integrated approach in the management of small agricultural watersheds. The physical, chemical, climatic, and socioeconomic attributes of a watershed were assessed during the first phase of this project. Data obtained were put in layers and introduced into a Geographic Information System (GIS) to delineate and characterize land

management units (LMUs). With these LMUs as sub-units, research and demonstration activities were carried out with technologies that could enhance crop yields and at the same time maintain the natural resource base. This project is still going on.

Expectations for the Future

Research Priority Needs for Soil and Water Resources Management

New ways of defining research priorities have recently been implemented by INRAN. The various constraints to agricultural development are defined by a regional committee (CORRA) made up of extension and research agents, farmers, and regional officials. Based on CORRA meetings, the following research needs have been identified:

- Restoration of soil fertility through low-input technologies
- Wind and water erosion control
- Soil resources assessment
- Integrated land management

Research Needs for Sustainable Procedures on Food, Fiber, Fuel, and Construction Materials

In the Sahel, *sustainability* is the key word for all agricultural development strategies proposed to farmers. This concern is particularly critical in the Sahel, where any intervention on the natural environment may yield unexpectedly adverse effects. Fuel and construction materials commonly gathered from wood invariably lead to desertification. The traditional method of land rejuvenation is fallows, but fallow periods are short; new methods of food production must improve the environment. Another important factor in Sahelian agricultural sustainability is the role played by extensive cattle raising commonly practiced in the region. This practice should be evaluated for both its beneficial effects (manure) and its destructive effects (tree and ground-cover deforestation).

Major Environmental Problems for Soil Scientists

Soil scientists face many problems in the Sahel. Very low soil fertility is a primary constraint. Another problem is soil erosion, both by wind and by water. This constraint will often result in surface crusting when the topsoil is removed. Soil variability is a third challenge to soil scientists, both in carrying out research and in devising remedies to the problem. Finally, the sandy nature of the soils used for rainfed agriculture causes problems with low water-holding capacity and deep drainage of most of the soil moisture.

Niger's Expectations in Future Collaborations with the Soil Management CRSP

From our long-lasting collaboration with the Soil Management CRSP, several fields of collaboration can be foreseen for the next five-year plan. Natural resource management is the major field where joint efforts from both INRAN and the Soil Management CRSP can lead to highly significant results. This field would include soil and water management in rainfed agriculture, the study of economic factors, and many other topics.

INRAN can gain from the Soil Management CRSP's international experience. Since trained personnel are available, INRAN can identify an in-country coordinator for the Soil Management CRSP, thus helping to reduce some of the costs in a manner currently employed with the INTSORMIL CRSP. Research topics can then be jointly identified and implemented, with both parties involved in every stage of the process—from planning to the publication of results.

Collaborative Activities and Opportunities: IBTA/Chapare, Bolivia[1]

Dr. Armando Ferrufino
Director, La Jota Experiment Station
IBTA/Chapare, Bolivia

The collaboration between TropSoils/NCSU and the Bolivian Institute for Agricultural Technology (IBTA/Chapare) began in 1986 with the creation of RISTROP Network (Red de Investigacion de Suelos Tropicals) at the Latin American workshop on tropical soil management held in Yurimaguas, Peru. Initial collaboration consisted of technical backstopping for three IBTA/Chapare scientists, with the financial support of USAID/BOLIVIA, as they sought to transfer and adapt improved soil management technologies in legume-based pastures, low-input cropping, and agroforestry systems. Another seminar held in Yurimaguas on alley-cropping systems allowed researchers of IBTA/Chapare and NCSU TropSoils to develop research plans.

Research implementation was difficult due especially to financial restrictions and problems obtaining access to laboratory support services (soil and plant labs). However, all these limitations were overcome with the support of the Coordinator of NCSU TropSoils. Previous TropSoils activities in Bolivia relied primarily on analysis of soil and plant samples in U.S. labs and short-term consulting during the layout and evaluation of cropping experiments in the Chapare region. Preliminary results of these experiments were presented in 1990 at the Latin American II workshop on tropical soil management held in San Jose, Costa Rica.

The research IBTA/Chapare has done on tropical soil management has been supported by NCSU TropSoils in many ways: short-term consulting of several scientists, long-term collaborative research in Bolivia with junior scientists (primarily graduate research assistants), and the supply of scientific information and publications.

Activities in the next years involve supporting ongoing or concluded studies and initiating new field activities in the Chapare region. Activities focused on the following:

- Natural resource management.
- Soil-classification studies on the relationships between parent material, landscape, and climate.
- Soil management technologies for improved agroforestry systems that include pastures, and grazing research for small and large ruminants.
- Improved soil, water, and cultural practices with special interest on preventing soil physical degradation.
- Soil microbiology studies.
- Socioeconomic studies.

The Memorandum of Agreement with TropSoils is undergoing a final review.

Characteristics of IBTA/Chapare

IBTA/Chapare is the programmatic and technical institution in charge of the Agriculture and Forestry program in the tropical region of the Cochabamba Department. This institution is under the control of the Alternative Development of the Ministry of Agriculture and Farmer Affairs. The goal of IBTA/Chapare is to develop, adapt, and transfer improved crop, soil, and livestock management technologies. In

[1] *Translated from Spanish by Elio Durón, NCSU.*

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addition, IBTA will produce and increase both animal and vegetative materials to be distributed to farmers in the Chapare region.

IBTA/Chapare actions are focusing on sustainable agricultural production and enhanced natural resource management that will be agronomically, ecologically, and socially sound for the Chapare region and that will provide food, shelter, fuel, and building materials to the farmers. Most of the research and technology validation is conducted on-farm, with the active cooperation of the farmers. The transfer of technology is oriented toward farmers with the collaboration of extension agents and leadership farmers.

Characteristics of the Chapare Region

Climate and Soils

The Chapare region is located in the Cochabamba Department (16°35' S–64°55' W) and covers 2,500,000 ha. IBTA/Chapare covers 422,000 ha of this total area.

The main ecosystems that predominate are moist subtropical forest and humid tropical forest. The relief of the area is dominated by high and medium terraces (400–1,000 meters above sea level) and alluvial plains (200–300 meters above sea level).

The rainfall in the Chapare region ranges from 2700–5000 mm and decreases progressively toward the North-Northeast, from the Piedmont to the Amazon plain, due to the effect of the mountains.

Soils are formed in alluvial and residual deposits. Soils formed in Quaternary alluvium are classified as Tropepts, Aquepts, and Fluvents. The residual soils were formed in situ from calcareous and sandy rocks and sediments from schist of Tertiary age. These soils are classified as Tropepts and Udults and are located on the high and medium terraces. In general, the main cropping constraints are high aluminum saturation, low base saturation, and an aquic moisture regime.

Agriculture

The size of the farms in the areas of older colonization (in the 1950s) ranges from 5–20 ha, and in the more recently colonized areas from 20–50 ha. The majority of the farmers come from the highlands of Bolivia and are not traditional tropical farmers.

Land use in the area is mainly shifting cultivation, with fallow periods that vary between four to ten years or more. The most common cropping system consists of two or three years of annual crops (rice, corn and cassava) followed by coca in association with citrus.

Traditional crops, in addition to citrus (mainly orange), are as follows: bananas, plantains, and papaw (especially in the fertile alluvial soils). Pineapple and turmeric (Curcuma) are grown on a small scale in low fertile soils. Cattle production, though incipient, has expanded during the last four years, especially in the areas with less rainfall. The capital resources for investments are limited; therefore the use of inputs such as fertilizer and pesticides is minimal.

Since 1985 IBTA/Chapare has been introducing new crop species, especially perennials, with the objective of diversifying production. The first priority are crops with potential international and national markets. These crops include: bananas, pineapple, peach-palm meal, passion fruit, citrus, black pepper, turmeric, ginger, and *Bexis orellana*. Livestock includes pigs, cattle and small ruminants.

During the last two years, farmers have exported bananas to Chile and pineapples and bananas to Argentina. To support this exportation, the program has built infrastructure, such as refrigerated centers for collection and small packing.

Collaborative Activities

Through RISTROP, TropSoils NCSU has supported the following collaborative activities with IBTA/Chapare.

Training and Exchange

The first Latin American workshop on tropical soil management was held in Yurimaguas, Peru, from September 1–28, 1986. Two scientists from IBTA/Chapare and one from PDAR participated. They helped plan the experiments which began the collaborative research between IBTA/Chapare and RISTROP.

A workshop on alley cropping was held in Yurimaguas, Peru, from September 9–16, 1987. Two scientists from IBTA/Chapare assisted. Experiments were planned on this topic.

A second workshop on tropical soil management was held in San Jose, Costa Rica, from July 7–12,

1990. Participants included the technical manager of PDAR, a consultant, and three researchers from IBTA/Chapare. Results of the RISTROP experiments planned in the two past workshops were presented.

Research on Soil Management

Some of the experiments which will be mentioned here were planned in discussions with RISTROP collaborators, while other experiments were planned with advice from TropSoils personnel during their visits to the Chapare region.

Low-input systems focussed on nutrient cycling, clearing systems, manual slash and burn, annual crops, perennial crops, and cover crops. These experiments were planned in the first workshop, and the preliminary results presented in the second workshop.

Agroforestry systems focussed on the following areas:

- Alley-cropping experiments concentrated on leguminous trees/shrubs and annual crops. This experiment was planned in the alley-cropping workshop, and the results were presented in the second workshop.
- Improved fallow experiments concentrated on leguminous trees/annual legumes and natural secondary forests. This experiment was planned in the first workshop.
- Multistrata-systems experiments concentrated on timber trees, species which produce nuts and fruits, shrubs, and herbaceous species. This experiment was planned in the first workshop.
- Cover-crop experiments concentrated on herbaceous legumes in association with several perennial crops.
- Experiments were conducted to select acid-tolerant tree species with multiple uses. Several species from America, Asia, and Africa have been introduced.
- Silvo-pastoral-systems experiments focussed on tree species (legumes and others), forage grasses, cattle and sheep.
- Continuous crop-production experiments concentrated on fertilization trials in banana, pineapple, black pepper, and citrus.

Pasture-systems work focussed on the following areas:

- Selecting grasses and legumes with tolerance to acid soils.
- Reclaiming pastures using fertilization and grass-legume mixtures. Part of this research was planned in the first workshop, and the preliminary results were presented in the second workshop.
- Grazing management in systems of grass-legume mixtures.

Research of Junior Scientists

IBTA/Chapare has supported with equipment, lodging, and transport the following graduate research students, most of whom are from NCSU:

- 1990–1993. Pedro Luna (Ph.D. Candidate). Use of short-term legume cover crop fallow for recovery of farmers' abandoned fields.
- 1991. Linda Sturn (M.Sc. Candidate) Socioeconomic studies.
- 1991–1992. Steve Monteith (Ph.D. Candidate) Soil Classification studies based on parent material-landscape-climate relationships.
- 1993–ongoing. Ing. Angel Salazar (Ph.D. Candidate) Developing improved tree management practices to offset negative effects of tree-crop competition.
- 1993–ongoing. Karl Glassener (Ph.D. Candidate) Assessing the fertilizer N replacement value of legume mulches and green manures for alternative crops.

Visits of Senior Scientists for Short-term and Scientific Exchange

The objectives of these visits were to monitor progressive RISTROP experiments and other trials in order to exchange ideas and experiences, plan future activities, supervise the research of the graduate junior scientists, and negotiate the final stage of consultation for the Memorandum of Agreement between NCSU and the Minister of Agriculture and Farmer Affairs within the Bolivian government. The visits followed the following chronology:

1987	July	Dr. T. Jot Smyth
1988	September	Dr. T. Jot Smyth
1990	March	Dr. Pedro Sanchez
		Dr. Stanley Buol

1991	January	Dr. Frank Smith
	June	Dr. Frank Smith
	July	Dr. Stanley Buol
1991	December	Dr. Roger Hanson
		Dr. T. Jot Smyth
		Dr. Michael G. Wagger
1992	June	Dr. Art Wolium
		Dr. Michael G. Wagger
		Ing. Angel Salazar
		Ing. Karl Glassener
	December	Dr. Thurman Grove
		Dr. T. Jot Smyth

Institutional Resources of IBTA/Chapare

Tables 1 and 2 outline the IBTA/Chapare's principal human and material resources.

Table 1. Human resources

Research Area	Researchers
Low-input systems	1
Agroforestry	2
Pastures systems	3
Animal production	2
Continuous crop production	6
Socioeconomic studies	1
Extension agents: technicians working in multidisciplinary areas.	23

Financial Resources

Provided by USAID/Bolivia

Future Program Opportunities

Research and validation of technology

- Natural resource management
  - Reforestation
  - Forest enrichment
  - Watershed management
  - Protected areas management
- Low-input systems
  - Nutrient cycling
  - Mulches
  - Germplasm selection for tolerance to soil acidity
- High-input systems
  - Fertilization trials in banana, pineapple and black pepper
  - Elaboration of nutritional budgets for important economic cash crops
- Agroforestry systems
  - Introduction and selection of tree/shrub species and bamboo
  - Alley cropping (on farm)
  - Improved fallow (on farm)
  - Cover crops with perennial crops (on farm)
  - Multistrata systems (on farm)
  - Silvo-pastoral systems
- Pastures systems/animal production
  - Fertilization trials with cut forages
  - Reclamation of degraded pastures
  - Management of pastures
  - Interaction among pastures/trees/animals
- Socioeconomic studies
  - Validation and transfer of technology and adoption studies
- Others
  - Soil classification (FCC)
  - Drainage studies
  - Soil microbiology studies

Training

This includes on-the-job training, graduate-degree training, short-term, and non-degree training in the U.S. and elsewhere. Areas of training are as follows:

- Management of soil labs. Physical and chemical analyses of soils and tissue and their interpretation.
- Planning and interpretation of fertilizer trials.
- Planning and interpretation of agroforestry systems trials.
- Use of statistical software for analyses of experiments.
- Methodology for socioeconomic studies.
- Planning and design of drainage.
- Soil microbiology.
- Elaboration of crop nutritional budgets.

Other necessities

- Laboratory equipment
- Soil and tissue analyses
- Scientific publications

Table 2. Material resources

Infrastructure	Facilities
Experimental Stations	
La Jota	• Experimental fields (annual and perennial crops, agroforestry, germplasm banks). • Plant tissue and plant protection labs (future implementation). Greenhouse, computer center, nursery houses, office building, vehicles and agricultural machinery.
Chipiriri	• Experimental fields (pastures and cattle, annual and perennial crops, agroforestry), nursery houses, office building, vehicles and agricultural machinery.
Extension Agencies	
Villa Tunari	• Computer center, nursery houses. office building, vehicles.
Ivirgarsama	• Houses, office building, vehicles.
Isinuta	• Houses, office building, vehicles.

Knowledge to Manage Soils for Present and Future Generations: Perspectives on Rice-based Systems of Asia

Dr. Kenneth G. Cassman
Agronomist and Head, Division of Agronomy, Plant Physiology, and Agroecology
International Rice Research Institute

With increasing human pressure on a resource-limited planet, the need for agricultural systems with greater productive capacity is obvious. Optimistic projections suggest that population will double in 40 to 50 years and stabilize at 10–12 billion. Most of this increase will occur in developing countries. Food production must double to meet the increase in demand, but without the luxury of a large expansion of arable land and with little scope for increasing irrigated area. To achieve a two-fold increase in food supply will require increases in yield per unit area, higher cropping intensity, and larger quantities of applied inputs to support greater exploitation of soil and water resources. The challenge facing the international agricultural research community is whether these achievements are possible without destroying the natural resource base on which sustained production depends.

The discussion that follows considers the role of the International Agricultural Research Centers (IARCs) as participants in the global effort to meet this challenge, and elaborates on some of the key issues concerning responsible soil management in rice-based systems of Asia, issues that are addressed in the workplan of the International Rice Research Institute (IRRI).

The International Agricultural Research Centers

IRRI is one of 18 research institutes which comprise the International Agricultural Research Center (IARC) system. The IARC network is governed by the Consultative Group on International Agricultural Research (CGIAR). CGIAR membership includes donor nations and institutions which pool resources to support the IARC system towards a common goal, which reads: "Through international research and related activities, and in partnership with national agricultural research systems (NARS), the CGIAR aims to contribute to sustainable improvements in the productivity of agriculture, forestry, and fisheries in developing countries in ways that enhance nutrition and well being, especially among low-income people."

Although each center has a specific research mandate with respect to commodities, regions, and subject matter, all centers serve to facilitate the exchange of knowledge and technologies between research institutions in developed countries and the NARS of developing countries. To serve in this capacity, the IARCs focus on strategic research concerning soil and plant processes and new technologies to improve the performance of food and fiber production systems, selecting those issues for which they have a comparative advantage. Leadership for application and adaptation of knowledge and technologies at the farm level rests with the NARS. This role does not ignore the capacity for strategic research in the NARS, but recognizes the need for coordination, complementation, and partnership among members of the international research community.

With increasing emphasis on research to develop sustainable production systems, however, it has been

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difficult to find the appropriate niche for IARC participation. Much of the research on identifying appropriate land-use systems for a given environment tends to be site-specific, with little potential for spillover benefits to other production environments. To extend the extrapolation domain of information generated from such research requires quantification of system performance in relation to specific properties of the biophysical resource base (e.g. soil chemical, physical, and biological properties) and the socioeconomic environment that have the greatest influence on system performance. With regard to responsible soil management, linking system performance with quantitative characteristics of the resource base and how these properties change over time allows identification of the critical processes that govern long-term sustainability. The theme of crop intensification and a framework for identifying the seminal processes that sustain productivity are explored in the following sections with regard to irrigated rice systems.

We know little about the longer-term effects of intensified production on our soil and water resource base.

Intensification of Rice Systems: Structural Changes

The changes in the structure of crop production systems within the past 30 years are called a "green revolution." This description is fitting because technological innovations from numerous scientific disciplines (genetics, soil and crop sciences, engineering, etc.) were rapidly adopted by farmers in a relatively short period, and these innovations changed the face of agriculture. It can be argued that the magnitude of recent change in the means of production in food-crop systems is comparable in scope to the changes in manufacturing that resulted from the "industrial revolution" of the 18th and 19th centuries. Like the industrial revolution, it is clear that there are costs associated with greater exploitation of natural resources to sustain the marked rise in food output, yet we know little about the longer-term effects of intensified production on our soil and water resource base. Trends in rice production systems are a case in point.

Total rice production doubled from 250 million tons in the early 1960s to about 500 million tons in the early 1990s. By the year 2020, rice demand is expected to increase by another 250 million tons. Asia accounts for 90% of global rice production and consumption, and more than 70% of all rice is produced on irrigated land. In most of the major rice-producing countries of Asia, harvested rice area has remained constant or decreased in the past 10 years, and a net increase of irrigated area is not expected. Increases in rice production must therefore come from further intensification of rice cropping systems on existing farm land.

Looking back, we can distinguish three dimensions of the intensification process that characterized the green revolution for rice in the tropics and subtropics. First, cropping systems were intensified in time with more crop cycles per year—made possible by short-duration high-yielding cultivars, expansion of irrigated area, and development of small threshers and hand tractors that reduced the turnaround time between crops. Second, there was an intensification in the quantities of applied inputs including fertilizer-nutrients, pesticides, and water from irrigation. A third dimension was that specialization in which cropping systems became less diverse: continuous rice cropping with two and sometimes three rice crops per year now dominate on much of the irrigated land in Asia. Together, these components of the crop intensification process confer massive structural changes on the cropping system. To a large degree, these same trends occurred in the other major food-crop systems, which emphasizes the need to understand how structural alterations due to the intensification process affect the long-term viability of food production systems.

Linking Structure to Function of Cropping Systems

System function, or performance, can be quantified in many ways. Economists are concerned with costs, returns, and present values which can be modified for short- or longer-term benefits or discounts. Ecologists look at stability and resilience in terms of material and energy balances, interactions among trophic levels, regulating feedback mechanisms, and

biodiversity. Agronomists seek to harness solar, soil, and water resources to optimize crop yields in relation to input requirements. Farmers, however, are the agents of change, and they are concerned with maximizing their return to labor, land, or capital depending on the socioeconomic and policy environments in which they operate. Despite these different perspectives, there are common performance parameters relevant to each that provide a framework to quantify short- and long-term effects of cropping system structure on the quality of the natural resource base.

Two measures of system performance that link the perspectives of farmers and scientists are the efficiency with which inputs are utilized to produce the desired output and the total output. A broad economic index of output/input efficiency is total factor productivity (TFP), which is the ratio of total output value (i.e. grain and harvested biomass or forage) to the total cost of all inputs used to produce the crop, including labor, animal work, fossil fuels, organic and inorganic nutrient applications, pesticides, irrigation water, and seed. Lynam and Herdt (1989) propose that "the appropriate measure of output by which to determine sustainability at the crop, cropping system, or farming system level is total factor productivity; a sustainable system has a non-negative trend in TFP over the period of concern."

To measure TFP, one must quantify the amount of all inputs applied to the system and all economic yield that is removed. But output/input analysis alone does not account for changes in the natural resource base that may influence future output/input efficiency. Thus, it is the job of biological and physical scientists to quantify these "residual effects," and to understand the processes that govern such changes. Partial factor productivities based on the key biophysical constraints to crop production in a given environment can be monitored to indicate the trendline for biological efficiency. Relevant indices include output/input ratios for nutrients, grain yield per unit water as rainfall and irrigation, or an energy ratio based on the caloric value of all outputs and inputs. When a partial factor productivity index changes over time, such a change results from a change in the constitution of the natural resource base.

Soil is the foundation of the natural resource base of agricultural systems, yet soil scientists continue to struggle with the concept of soil quality. Although soil quality indexes are used by the SCS to assess land suitability for various purposes, these indices were designed for categorization at a large scale. In a farmer's field, these indices are not sensitive enough to measure changes in soil properties that can have a significant impact on future production efficiency. The same is true of site quality indices used by foresters.

If we assume that farmers would not expend labor or capital to maintain soil quality unless there was a benefit that justified the investment, then soil quality must be defined and measurable within the limits of relevance to the farmer. Thus soil quality indices must be linked to system performance if the goal is to develop crop management systems that are adopted by farmers. Partial or total factor productivities and total output provide this linkage. Furthermore, the need to double food production on existing farm land in the tropics and subtropics makes it imperative to define soil quality in relation to system performance.

At IRRI, we have chosen to define soil quality as the suite of physical, chemical, and biological properties that have the largest impact on productivity of a given cropping system. The set of soil properties that govern productivity may differ in different environments. Changes in soil quality can then be identified by a shift in the response to applied inputs as illustrated in Figure 1. The underpinning hypothesis is that partial factor productivity increases when a cropping system results in improved soil quality, and vice versa.

The Soil Quality Hypothesis and Intensive Irrigated Rice Systems

At odds with the need to greatly increase rice yields in the next 30 years are disturbing trends in rice production and production efficiency based on aggregate data by country, farm monitoring studies, and long-term experiments conducted at research stations. In Indonesia from 1976 to 1986, for example, total rice production increased by 70% mostly due to greater average yields (IRRI, 1991). By contrast, the quantity of nitrogen (N) fertilizers applied to rice increased by 440% (Figure 2), which means that the partial factor productivity for N fertilizer decreased by two-thirds from 75 to 28 kg

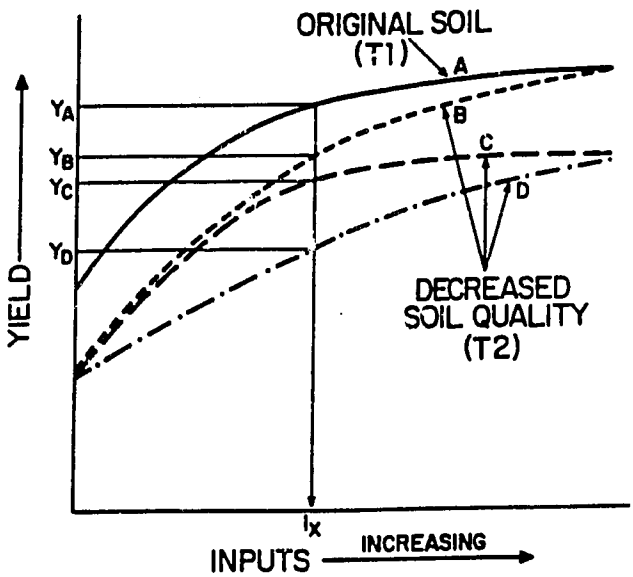

Figure 1. Conceptual model linking factor productivity with changes in the soil resource base of a cropping system. The model assumes an initial (T1) soil quality and a response to inputs such as fertilizers, irrigation or rainfall described by curve (A). When soil quality decreases after a period of cropping (T2), the manifestation of this decline may result in a shifted response curve to applied inputs: (B) a lower Y-intercept without inputs, but a similar slope and yield potential, (C) a lower Y-intercept and a similar slope, but a decrease in the yield potential, or (D) a decrease in the Y-intercept, slope and yield potential of the system. In all cases this conceptual model illustrates a decrease in total factor productivity (Y/I), regardless of input level, due to a decline in soil quality. The magnitude of the decrease in total factor productivity reflects the effects of reduced soil quality on: (i) yield without exogenous inputs, quantified by the Y-intercept, (ii) the output/input efficiency, quantified by the slope of the response function, and (iii) the yield potential of the system when inputs are not limiting. Soil quality is considered to be quantified by the physical, chemical, and biological properties that govern the supply and acquisition of nutrients and water by the crops grown.

total grain output per kg N applied in 1976 and 1986, respectively. Much of this decrease can be attributed to the diminishing return of the yield response to increasing rates of N input, and possibly to fertilizer subsidies that encouraged inefficient use of N fertilizer by farmers. But the magnitude of the decrease in output/input efficiency raises the issue of whether some of this decrease results from a change in the biophysical environment.

Data from long-term farm monitoring studies summarized by Rosegrant and Pingali (1991) suggest declining input use efficiency in farmers' fields of several Asian countries. These authors conclude that early adopters of modern rice-production technologies were already using relatively high rates of fertilizer inputs in the early 1980s, and continue to increase fertilizer input rates to maintain yields. Greater fertilizer inputs without a proportional increase in yield translates into declining factor productivity. But farmers continually modify other components of crop management, such as pest control measures, planting dates, varieties, tillage, and so forth, which makes it difficult to identify the reasons for such a large decrease in N fertilizer efficiency.

Long-term experiments at research stations, however, hold fertilizer-input rates constant over time. Results from most long-term experiments on continuous irrigated rice systems conducted in the Philippines indicate decreasing yield trends (Flinn et al., 1982; Flinn and De Datta, 1984). These experiments were conducted from 1968–1988 and included 20–28 elite lines grown in five N-rate treatments in both the wet and dry season, with N-rate treatments reapplied to the same plots. Pest management followed recommended practices, and nutrients other than N were applied as required. Yield trends of the highest yielding entry each year were evaluated by eliminating year-to-year variation in disease incidence and solar radiation. Negative linear yield trends of 120 to 160 kg grain/ha/yr were highly significant at three of four sites regardless of N input rate. Similar yield declines in continuous irrigated rice systems were also reported in long-term experiments conducted in India (Nambiar and Gosh, 1984).

Based on the soil quality hypothesis, significant yield declines in these long-term experiments indicate a fundamental change in the biophysical resource base when nutrient inputs and other management practices are held constant. We are now focusing attention on the processes responsible for this trend. Continuing long-term experiments show yield declines that are comparable to the earlier experiments,

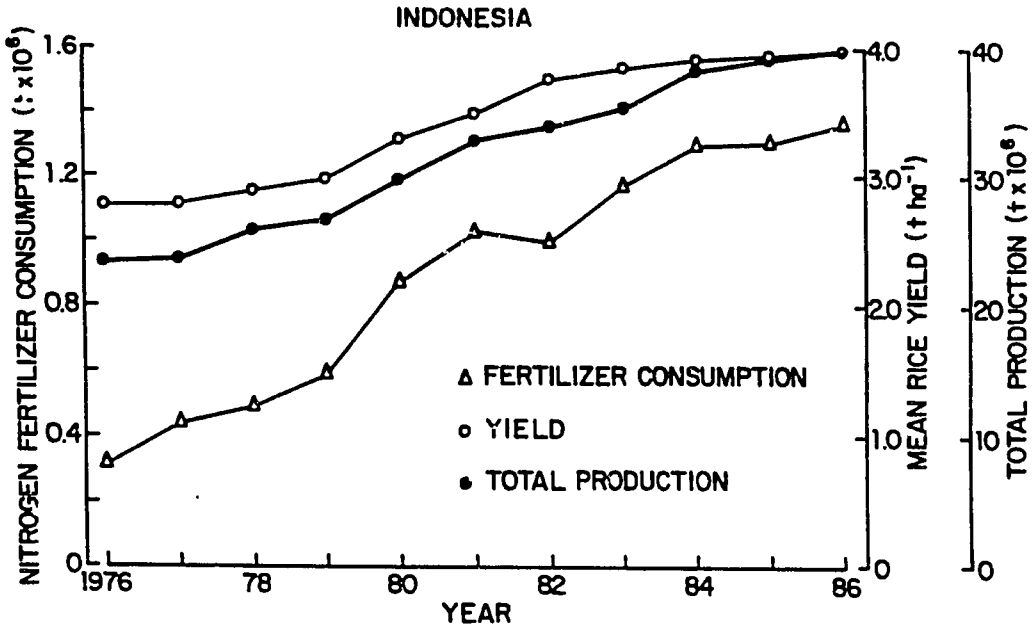

Figure 2. Trends in nitrogen fertilizer use, average rice yield, and total rice production in Indonesia from 1976 to 1986 (IRRI, 1991).

and the yield decline occurs in soil with or without inputs of fertilizer-N (Figure 3). Recent evidence based on monitoring of the N input/output balance in four consecutive crops since 1991 and total soil N content since 1982 reveal that the rice crop has become N limited even in treatments with the highest N rate, and this limitation cannot be attributed to known diseases or pest problems. Moreover, although total soil N content is thought to be a good index of soil N-supplying capacity for rice (Ponnamperuma, 1980; 1984; Sahrawat, 1982), there is no decrease in soil N content in any of the long-term continuous irrigated rice experiments.

Quantifying N output/input efficiency and changes in soil properties in these long-term experiments leads to the hypotheses that (1) soil N-supplying capacity decreases over time as rice systems intensify and soil remains submerged to produce two or three rice crops per year, and (2) the decrease does not result from a decline in soil organic matter or total N. Dei and Yamasaki (1979) described a similar phenomenon in paddy fields of Japan and speculated that the chemical nature of organic matter which accumulates under flooded soil conditions is more recalcitrant to microbial decomposition than humus formed in aerated soil. In Japan, however, cropping intensity is low with only one rice crop per year, and

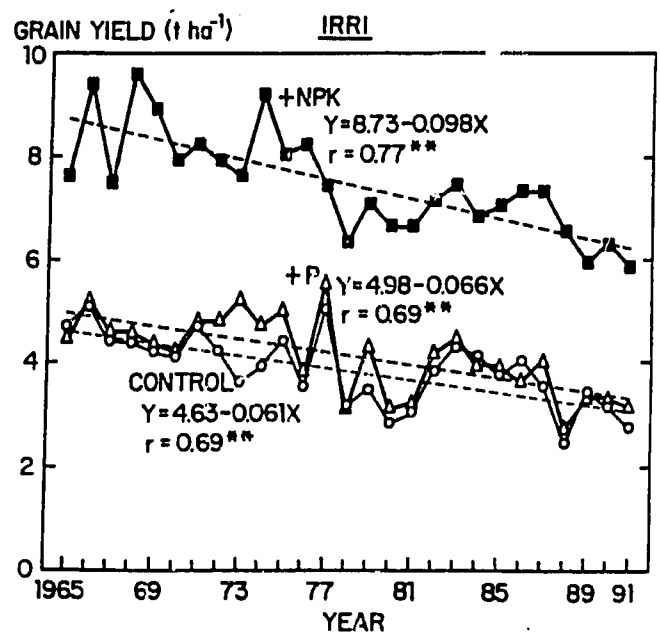

Figure 3. Yield trends in the dry-season crop in the long-term fertility experiment conducted at IRRI for the full NPK treatment, and the +P alone and control treatment without fertilizer-nutrient inputs. Zinc was applied as needed to all treatments, and there has been no yield response to nutrients other than N in this experiment.

the magnitude of decline in "effective" soil N supply was relatively small. In the tropics with continuous double- and triple-crop rice systems, the magnitude of the decrease appears to be much larger.

We now speculate that the humification process differs in paddy soils due to the reduced soil conditions, repeated puddling operations that destroy soil aggregation, and the reduced role of fungi in anaerobic decomposition of incorporated crop residues. Research is in progress to test these hypotheses. Clearly, the ability to increase rice supplies will be difficult to sustain if output/input efficiency declines when cropping intensity increases. Likewise, properties that control the N-supplying capacity of paddy soils appear to be major determinants of soil quality for irrigated rice systems in the tropical lowlands. Identifying the soil factors that control soil N-supplying capacity is a first step towards defining paddy soil quality, and it will be crucial for developing improved management options to support sustained increases in productivity.

The Challenges Ahead

From a global perspective, the combination of finite land and water resources and population growth makes it clear that food production systems must further intensify to meet anticipated growth in food demand. We are finding, however, that the current degree of intensification causes changes in the biophysical resource base involving complex chemical, physical, and biological interactions. Some of these changes have had a negative impact on productivity, not only in continuous irrigated rice systems of the tropics, but also in the annual rice-wheat systems that cover 13 million ha in South Asia, and in the tropical uplands where increasing population pressure leads to decreasing periods of bush-fallow regeneration on fragile acid soils. There is a need to quantify the rates of change in key soil properties that govern the long-term productive capacity of these agroecosytems, to understand the processes responsible for these changes, and to identify management options that will meet the needs of present and future farm families and rapidly growing urban populations. Together, the soil quality hypothesis and monitoring of factor productivity provide a research framework for developing testable hypotheses about the mechanisms that control long-term performance of food production systems. Such research will require collaboration and sharing of responsibilities among the IARCs, NARS, and research institutions in the developed countries.

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Soil/Water Resource Management: Research and Development Issues[1]

A summary of the presentation by Dr. S. M. Virmani
Principal scientist, Agroclimatology and Resource Management Program
International Crop Research Institute for the Semi-arid Tropics

Soil and water are key natural resource bases. Soils, a crucial agricultural resource, are not renewable on a human time-scale. Although water resources are renewable, water use needs to be optimized because of the greater demand from multiple users.

The rational and wise use of soil and water resources requires a careful husbandry. Management strategies should be flexible and responsive to site specific needs and contingencies. Emphasis should be placed on strategies which are sustainable and environmentally friendly.

Research should work to devise innovative farming systems that are:

- Economically productive,
- Buffered against risks,
- Stable over time,
- Synchronized with climate,
- Harmonized with the environment,
- Sensitive to soil degradation,
- Responsive to change,
- Easily adoptable by resource-poor farmers,
- Capable of being maintained without large-scale purchased external inputs.

In soil management research, we can have short-term goals, but our perspective must be long-term (Figure 1).

Over the last 30 years, most of the increases in agricultural production have been the result of increased cropping intensity, the rise of the irrigated fraction, and increases in nutrient consumption. In low-input areas without irrigation, the green revolution has not taken place.

In India's well-endowed environments the period from the 1960s through the 1980s saw dramatic increases in wheat production. In the stressed environments, yield increases have not occurred: sorghum yields averaged about .8 t/ha in 1960, and they have improved very little over the intervening years. Part of the problem has been that these areas often have low political interest.

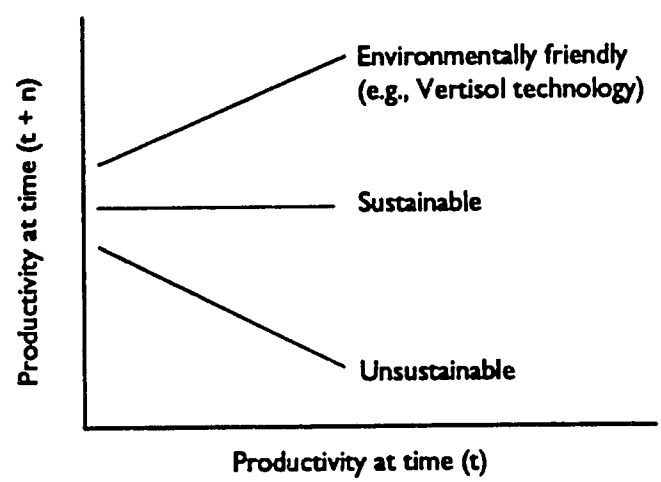

Figure 1. Sustainability relationships (Source: Ryan, 1992)

[1] *Dr. Virmani's comments were accompanied by a series of overheads. What follows is a summary of those overheads and Dr. Virmani's presentation.*

Well-endowed environments, what we think of as green-revolution areas, exhibit the following characteristics:

- Effective irrigation,
- Few soil-related constraints,
- Developed infrastructure,
- Good education/research support,
- Excellent extension support,
- Fairly uniform production increases over the last three decades.

Stressed environments, on the other hand, exhibit these characteristics:

- Dryland areas,
- Several soil-related constraints,
- Poor infrastructure,
- Weak R/D support,
- Less developed extension support,
- Sporadic production increases over the last three decades.

Research and Development Issues

The following are important research and development issues for well-endowed environments:

- High investment costs,
- Long development periods,
- Cereal-based systems,
- Capital intensive,
- Low biodiversity,
- Increasing soil constraints,
- Serious ecological problems,
- Environmental hazards,
- Sustainability,
- Equity,
- Social problems,
- Low resilience,
- High political interest.

The following are important research and development issues for stressed environments:

- Dispersed hydrological units,
- High technical investments,
- Diverse farming systems,
- Unique land uses,
- Location specificity,
- Labor-intensive strategies,
- Fewer environmental hazards,
- Serious ecological problems,
- Sustainability,
- Equity,
- Social problems,
- Low political interest,
- Overall low productivity.

Conclusions

The following conclusions should be borne in mind as the Soil Management CRSP prepares its 1994–99 Global Plan.

Researchers need to establish soil quality standards, paying special attention to:

- Soil climate: moisture, temperature;
- Soil variability: nutrients, physical characteristics, erodibility;
- Soil degradation: reduced crop yields, loss of soil, accumulation of toxic elements.

Soil resource inventories and systematic soil surveys need to be developed to help:

- Make wise decisions for alternate land uses,
- Establish a framework for resource conservation programs,
- Clarify the geographic organization of research,
- Establish natural resource data aggregates,
- Transfer technical know-how.

International cooperation needs to be developed in:

- Operating Geographical Information Systems,
- Furthering the use of Global Positioning Systems and Digital Evaluation models,
- Developing robust simulation models and expert systems,
- Training technicians in database management and exchange.

In addition, benchmark experiments need to evaluate and monitor the sustainability of selected land-use systems in some well-defined agroclimates. And finally, increased support should be given to soil and water management research that has a sustainability perspective.

Soil Management and Environmental Relationships: Central and Eastern Europe[1]

Summary of presentation by Dr. Gyorgy Varallyay
Director of RISSAC
Budapest, Hungary

Agricultural Development in Central and Eastern Europe

Before World War II, small-scale farming was the dominant mode of production in Central and Eastern Europe. Typical farm sizes ranged from one to five hectares. Farmers used few inputs and produced low yields. No special attention was given to soil conservation.

From the end of the war until fairly recently, collectivization and large-scale farming were the rule. Though more productive than small-scale farming, this system became over-centralized and inefficient. The current trend is toward privatization and market-oriented production. Greater emphasis is being placed on environmental issues and long-range sustainability.

In Central and Eastern Europe, a large percentage of the population continues to work in agriculture. In Yugoslavia, for example, 23.6% of the population is so employed. In other nations the percentages are as follows: Poland, 22.2%; Romania, 22.1%; Bulgaria, 13.2%; Hungary, 11.8% (Table 1).

The Case of Hungary

Hungary covers 35,902 square miles and has a population of about 10.6 million. About 50.6% of the land is arable, the remainder being divided as follows: 17.8% forest, 13.3% grassland, 6.2% orchards and vineyards, 0.7% reeds and fishponds, and 11.4% other uses.

The cropping pattern, by percentage of arable land, is as follows: 30.4% wheat and rye, 24.2% maize, 8.4% sunflower, 5.5% barley, 2.2% sugarbeet, 0.9% potato, and 2.2% other vegetables. Private farms account for 12% of all agricultural holdings. State farms account for 26%, while cooperatives account for 62%.

Precipitation levels average 500–550 mm/yr, with evapotranspiration rates of 800–900 mm/yr. Rainfall exhibits a very high spatial and time variability. Because 85–90% of the surface water flows into Hungary from other countries, both the quality and the quantity of this resource must be safeguarded. And because of the increased demand for water resources from nonagricultural uses (industry, urban development, recreation, etc.), Hungary must increase its water-use efficiency.

About 53% of the nation's total area suffers from soil fertility limitations. The principal limiting factors are as follows: extremely coarse texture, 8.0%; soil acidity, 12.1%; salinity/alkalinity, 8.1%; salinity/alkalinity in the deeper layers, 2.6%; extremely heavy texture, 6.8%; peat formation (water logging) 1.7%; soil erosion, 11.9%; and shallow depth, 2.3%.

Significant soil-degradation processes include the following: water and wind erosion, soil acidification, salinization/alkalinization, physical degradation (compaction, structure destruction, surface sealing), extreme moisture regimes, biological degradation and decreasing organic matter, unfavorable changes in the nutrient regime (leaching, biotic and abiotic immobilization), decrease of the buffering capacity (soil

[1] *Dr. Varallyay's comments were accompanied by a series of overheads. What follows is a summary of those overheads and Dr. Varallyay's presentation.*

pollution and toxicity).

All actions to maintain and increase soil fertility are related to the regulation of the soil's substance regime; most are also related to soil moisture control.

Future Tasks

Throughout Eastern Europe, it is becoming important to introduce up-to-date soil conservation practices. The following issues are especially crucial:

- The criteria of sustainable agricultural development and crop production have to be defined and quantified.
- The necessary economical regulations have to be elaborated to ensure the fulfillment of these criteria.
- The criteria and regulations (above) have to be formulated in appropriate legal documents.
- Efficient methods of sustainable crop production have to be elaborated, published, demonstrated, and adopted. This process will require appropriate mechanisms for research, training and education, extension, and advisory services.
- The necessary mechanisms for continuous control have to be established.

New Opportunities

The new trends in Eastern Europe provide greater opportunity for a rational and sustainable system of agricultural development. The most significant of these trends are as follows:

- Territorial coordination of agroecological conditions and requirements of crops;
- Homogenization of agricultural fields (reduction of size, differential agrotechnics, etc.);
- Precise crop production technologies, including (a) adequate cropping patterns and crop rotations; (b) minimization of production wastes (maximum recycling); (c) improved water-use efficiency; (d) rational use of fertilizers; (e) and rational integrated pest management strategies.

Future Trends in Land Use and Agricultural Production

One of the most significant trends is a movement toward market-oriented production based on cost-benefit analyses. Crucial to success in the international market are issues of quality (e.g., beauty, taste, content, absence of pest residues and toxic elements). Energy efficiency is also an important consideration.

Though not conducted on the basis of a cost-benefit analysis, environmental protection is an imperative task. Three workshops between U.S. and Eastern European nations have addressed this issue over the past few years. Erosion, integrated pest management, and groundwater pollution have all been addressed.

Another important issue is the mixed ownership of farm units (state, cooperative, private) and a trend toward decreasing the size of unmanageably large farm units. Combined with a movement toward mixed production systems, such changes should help the farm system to be more flexible and adaptable.

One area that will need to be rationalized concerns the use of fertilzers (Figure 1). In years past, the following polarization has developed. The better soils, occupied by the richest farms, had the highest rates of fertilization—despite the better nutrient

Table 1. Statistical data on the importance of agriculture in the national economies of Eastern European countries.

	BG[1]	CS	H	PL	RO	YU
% of population working in agriculture	13.2	10.0	11.8	22.2	22.1	23.6
	hectares					
Agricultural land/100 inhabitants	69	44	61	50	66	60
	kg/ha of agricultural land					
Fertilizer consumption	121	230	211	174	92	73

[1] Bulgaria, Czechoslovakia, Hungary, Poland, Romania, and Yugoslavia

status of the soils and the reduced need for amendments. The result was a problem with excessive fertilization and the attendant environmental side effects. On the poorer soils, occupied by the poorest farmers, fertilization rates were very low—in spite of the greater need for amendments. To avoid low fertilizer efficiency, high losses, and environmental side effects, producers will need to tailor fertilization strategies to specific soil conditions.

Problems in Agricultural Development

The large-is-better concept has produced unfavorable changes in land-use and cropping strategies throughout Eastern Europe. The most significant of these problems are as follows:

- Limited flexibility of farm units,
- Too large agricultural plots: heterogeneity,
- Overconcentrated livestock production,
- Overtillage from heavy machinery—resulting in soil structure deterioration (compaction, sealing, cracking),
- Serious problems in fertilizer application,
- Saturated home food market,
- Limited export possibilities for agricultural products,
- Sharply increasing quality requirements,
- Radical increases in the importance of efficiency (input rationalization/reduction),
- Increasing hazard of environmental side effects,
- Changes in the political situation,
- Inefficient water-use efficiency.

The changing circumstances in Eastern Europe call for new approaches to these problems.

Recommendations

1. Soil Management CRSP activities should be expanded to include countries with moderate

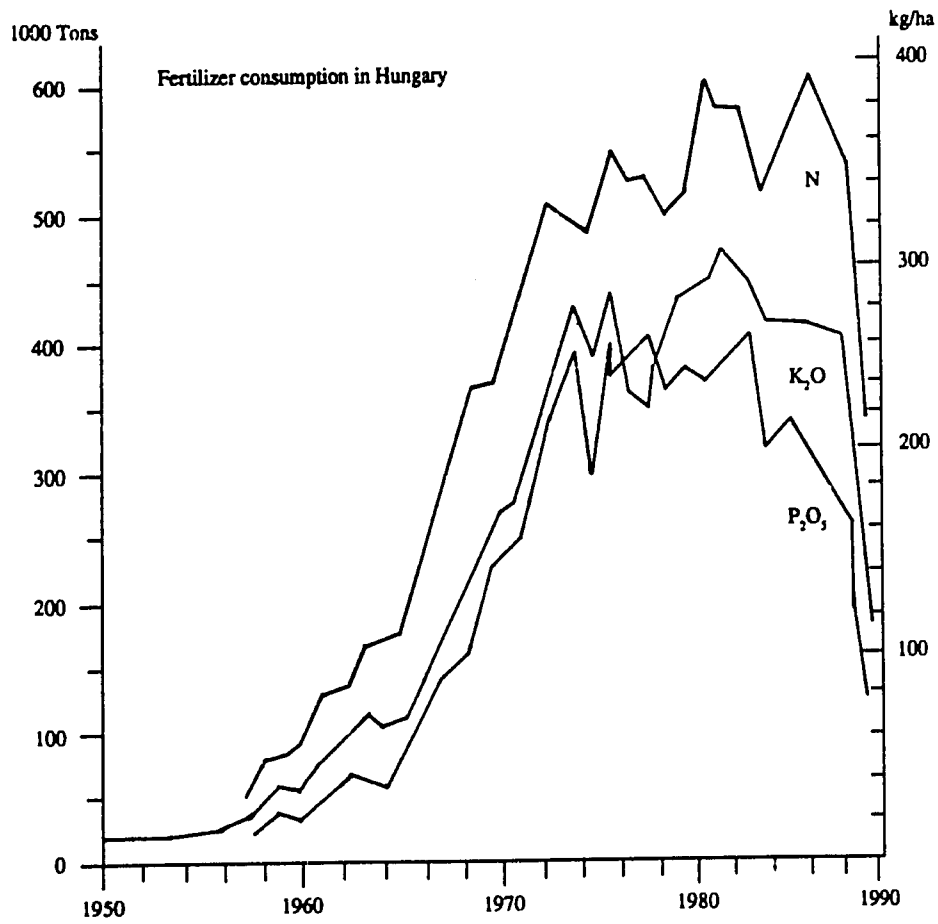

Figure 1. Fertilizer consumption in Hungary 1950–1990.

climates, including the post-socialist countries of central and Eastern Europe.

2. The CRSP activities should be extended to countries having soil management/environmental impact problems—regardless of their level of development.
3. Activities should be extended to the environmental aspects of soil management:
   - Soil degradation processes.
   - Pollution/contamination of soil and water resources (including both surface and subsurface waters).
   - Resilience and sustainability of various ecosystems and land-management practices.
   - Prevention of unfavorable environmental side-effects.
   - Remediation (reclamation, amelioration, recultivation, improvement) of polluted/degraded sites.

For number three (above), priority should be given to the following scientific topics:

- Sources (emission, immision) of pollutants have to be identified.
- Transport, abiotic, and biotic transformation processes of pollutants have to be described and quantified.
- The vulnerability of soils and various ecosystems has to be defined, characterized, and quantified.
- The scientific knowledge and available data on the above-mentioned phenomena have to be organized into an integral GIS data base on global, regional, national, and local levels.
- These data bases have to be further developed into computerized expert systems, which would then be available and applicable to clients (researchers, international and national research organizations, decision makers, extensionists, education professionals, etc.).
- The changes in soil quality (productivity, buffering capacity, filter function, etc.) have to be registered by uniformly organized integrated monitoring systems.

4. Researchers need to analyze, evaluate, and model soil processes for their efficient control, with particular attention to the prevention of environmental deteriorations and unfavorable side-effects.
5. Researchers need to develop exact criteria for soil quality, various soil functions (media for biomass production, buffer media, filter function), and soil resilience. Researchers must also be able to assess the environmental impacts of various land-use/soil-management activities.

Preparing the Research and Development Agenda

Soil Resources and Challenges of Global Agricultural and Environmental Concerns

Dr. Hari Eswaran
National Leader, World Soil Resources
Soil Conservation Service

About a month ago, three of us were in India for a training course on "Soil Taxonomy and Sustainable Land Management." We had to leave in a hurry due to religious upheavals. In fact, if we look around ourselves, we find that there are few places in the developing parts of the world where peace and tranquility prevail and where the average person can go to bed in the evening without worrying about how he or she will feed the family tomorrow. I have been in this business of international technical assistance for more than two decades, and I can say that our impact has been minimal. We use brave words and fancy language in our reports and analysis, but when it comes to implementation, many projects are designed for institutional or personal glorification. The primary objective of helping people in developing countries to enhance their production or improve their quality of life is frequently forgotten in the maze of administrative and bureaucratic obstacles we, the front-line people, are confronted with. Mr. Chairman, we need change. We need to rededicate ourselves to the noble objectives toward which we have committed our lives.

Mr. Chairman, when we were in India, the Minister of Agriculture of Kerala gave us a publication called, *Agricultural Development Policy*. He was very proud to point out that Kerala is the first state to develop an agricultural strategy. The report commences with an analysis of the basic issues and problems of Kerala agriculture; 15 issues are listed. I will quote the first two:

1. *Failure to formulate a policy and strategy for Kerala agriculture and to design and develop appropriate technology and infrastructure to meet the special requirements of small farmers.*
2. *Absence of scientific and systematic farming systems consistent with land capability and ecological sustainability.*

I believe that these problems sound familiar to most of you and that they could serve as the objectives of this CRSP. These problems are repeated in practically every developing country of the world and can be summarized as follows:

- We need to know our resources.
- We need to manage them well.
- We need appropriate policies and strategies to ensure sustainable use of the resource base.

Mr. Chairman, earlier I sounded frustrated. I still am, but I believe that events in the last five years have created the necessary political awareness and support for our work in developing sustainable systems. The two driving forces in global concerns are sustainable agriculture and global climate change, and both are major propellants of research and development—due to the political awareness and support they have received. No other efforts in recent history have received the kinds or magnitude of support from the global community. This is the silver lining on our cloud of uncertainty.

The concept of sustainable agriculture becomes pertinent and takes on a new dimension when viewed

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in the context of limits to resource availability and use. If such limits do not exist or are perceived not to exist, exploitation with disregard to consequences is the result—as has happened in the past. Sustainability hinges on the premise that arable agricultural land is finite. It also assumes that much of the land that is suitable for agriculture is already in use except for land in a few African and South American countries. Of the 13.4 billion hectares of ice-free land on the world's surface, only about 25% is potentially arable. Of this potentially arable land, about 40% is suitable for productive agriculture. The remaining land, largely in the inter-tropical regions, requires high inputs and good management for sustained productivity.

Perhaps for the first time in the history of mankind, there will be insufficient land for agricultural expansion.

The emerging crises are primarily related to a growing population competing for the limited land resource. Perhaps for the first time in the history of mankind, there will be insufficient land for agricultural expansion. For the first time, mankind is faced with the challenge of not only increasing productivity but also preserving the resource base to achieve intergenerational equity.

The Issues

The Food and Agriculture Organization (FAO) has reported that, in the tropics, cultivated land per person fell from 0.28 hectares in 1971 to 0.22 hectares in 1986. This is evidence of the great pressure on available land. In Southeast Asia and the Near East, the amount of land cultivated is already close to the amount of potential land suited for cultivation. With geometric increases in population, availability of land for agriculture becomes a critical resource issue in most of these countries.

The major issues toward which we can directly or indirectly provide assistance are as follows:

- *Limits of land resources.* Many countries have reached or will be reaching the limits of their arable land resource base by the end of this century. Increased food and fiber production must result from increased productivity of land rather than increased land for production.
- *Rural poverty and unequal equity distribution.* Continued migration from rural to urban areas results partly from inadequate opportunities and poor support of agro-based industries in rural areas.
- *Degradation of arable land.* Degradation and, in some instances, urbanization of arable land reduces land available for agriculture at accelerating rates. This increases the use of marginal lands and fragile ecosystems, which are more difficult to maintain under sustainable production.
- *Weak institutional framework in NARS.* There is a continuing lack of infrastructure and suitably qualified personnel in developing countries to coordinate and conduct research, thereby reducing the ability of National Agricultural Research Systems (NARS) to address problems and respond to changing needs.
- *Research emphasis on past concerns rather than future problems.* With the increasing pressure on land there is a need for a greater emphasis on resource-focused—as opposed to commodity-focused—research, and the need to provide an ecosystem emphasis in agronomic research and transfer. Additionally, a holistic, systems approach to agronomic research is required to address globally relevant problems through regional agro-ecological networks.
- *Global climate change.* Future uncertainties about anticipated climate change—specifically as these changes affect sustainability of production—risks associated to production, and the impact of climate change on the quality of the resource base, must be adequately presented if they are to influence decisions and actions.
- *Policy options for decision makers.* Because there are insufficient policies based on meaningful research results, the role of scientists has clearly diminished. In addition, there is frequently little effort by responsible and knowledgeable scientists to link national policies to global environmental concerns, which are crucial to sustainable land management.

In many countries, misuse of land has or is resulting in stressed lands that are degraded and whose production potential is considerably reduced. Stressed ecosystems are those that are degraded or have reached a stage of degradation at which they cannot support their original biotic communities or cannot support agriculture in the absence of relatively high inputs. The stresses may be biotic and specifically anthropically induced, or abiotic.

For agricultural purposes, some ecosystems are naturally stressed. In the context of sustainable agriculture and technology to mitigate the effects of anticipated global climate change, there is an urgent need to better understand such ecosystems, develop methods to assess and monitor them, and evaluate technological options for their management. The subject must be addressed in a multi-disciplinary manner and must involve environmentalists, ecologists, agriculturists, soil scientists, and others.

Challenges and Opportunities

1. Identifying and monitoring parameters (including indicators) that control the enhancement of land-resource quality, and quantification of their impact in different agroenvironments.
2. Development of methodologies to evaluate the resilience of stressed ecosystems and implementation of preventive measures to retard degradation.
3. Identification of prime lands and application of modern technology to enhance and sustain their production and ensure their preservation for such uses.
4. Development of a conceptual, integrated framework for sustainable land management and its validation for different land-use scenarios.
5. Development and utilization of systems-based analysis and strategy tools for assessing the impact of agricultural practices on the land resource and for developing environmentally sound land-use options.
6. Development of methods and approaches to evaluate the impact of land-use changes on global climate and the converse, which is the impact of global climate change on soil resources.
7. New approaches to soil resource inventory and monitoring, utilizing recent computer technology, to make farm-level resource information readily available to clients, particularly in developing countries.
8. Translating soil resource information and soil research findings into implementable policy options.

Mr. Chairman, these are what the Soil Management Support Services (SMSS) sees as our challenges. These are what we have been working towards and what we will continue to work towards if given the opportunity and facilities.

Mr. Chairman, as the century draws to a close, we can help catalyze the new global environmental paradigm. Feeding and clothing an expanding population and striving for zero-degree degradation of land resources is still the most viable and exciting option for the 21st century. The knowledge and experience we have accumulated over the last two decades are extremely relevant to the changing conditions of our world; but they will be insignificant if we fail to satisfy the critical needs of our governments and the people they represent. We can draw on the strength of our ancestors, revisit our capabilities as professionals, implement the call of our new President for change, and basically see beyond the obvious.

Let our vision be "Productive nations in harmony with a quality environment."

The Soil Management CRSP Global Plan: Perspectives from Resource Economics

Dr. John C. Day
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Technology for Soil Moisture Management

Abstract: The new Soil Management CRSP Global Plan must include an appropriate social science research agenda. Issues pertaining to the design of such a program are identified. Many of these issues must also be addressed as other components of the CRSP program are put together. The point is emphasized that true integration across disciplines requires recognition that decisions made in one program area will affect what is done in another. The need to articulate a central theme oriented around people and *people problems* leading to strategic research focused on resolution of those problems is mentioned. The question of how to overlay such common themes across our list of five program thrusts, three program areas, and ten subprograms is raised.

Introduction

Our primary objective in the context of agricultural development is sustainable increases in food supplies, income, and standards of living on the part of rural inhabitants. Included in the desiderata is equitable distribution of the benefits of increased productivity across gender, class and ethnic groups, age, social groups, regions, and time.

From the point of view of the Soil Management CRSP, we see improved use and management of soil, water, and land resources as fundamental components of sustainable agricultural systems. We look to research to eliminate or narrow information gaps, and/or under-utilization of information, which serve as basic constraints to adoption and diffusion of improved resource management strategies.

The purpose of this workshop is to collectively specify the dimensions and content of a collaborative research support program addressing these constraints. Workshop presentations and discussions are to provide the grist for internal review and analysis of issues leading to a formal CRSP Global Plan for the future.

In choosing the CRSP social science research agenda a number of issues arise, the resolution of which determine the scope of the program and the design of specific project activities. An issue also is the need for some central theme, or a strategic research framework, to guide the program/project design process.

Research Planning Considerations

Research Areas

The social science research agenda could include work in the following five areas:

- farm production and farm management analyses,
- marketing studies,
- institutional analyses,
- distributional impact assessments,
- policy implications.

In the *farm production and management* area the general focus would be on the economics of soil and water technologies, and land management strategies. The scale of analysis could be individual crop production activities, or the whole farming system. Concepts and methodologies could be extended to landscapes, watersheds, and regions. Indigenous

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knowledge about natural resources and farming practices is extremely important in this research area.

Marketing studies would deal with the factors that influence agricultural input and output prices. Key research issues for the CSRP are the price effects of output enhancing resource management technologies and strategies.

Work on institutions would address such questions as the role of credit, land tenure, and local rules, regulations, and customs in resource use and technology transfer.

Work on *institutions* would address such questions as the role of credit, land tenure, and local rules, regulations, and customs in resource use and technology transfer.

CRSP research in the realm of *distribution* would include evaluation of gender, class, and ethnic differences as they affect soil and water conservation practices. It would also include the potential impacts of technological change across those same population parameters, as well as broader impacts across farm families, regions and the nation.

Policy studies would seek to shed light on the way in which public policies create incentives or disincentives for technology transfer. An aspect of work here would be to identify policy measures to encourage diffusion of improved soil/water management practices.

Farm production, or farm management, studies are particularly important for the CRSP in that economic analyses of farm production and resource conservation practices are usually carried out using this analytical framework. The farm production area provides the opportunity for direct input from scientists in the physical and biological areas who must produce the production functions and the soil-loss and environmental degradation damage functions that are needed. The value of this type of information for economic analysis cannot be overemphasized. Without response data, accurate economic feasibility studies and social impact appraisals of resource management options are not possible.

These areas cover most of the basic social science questions pertaining to the development and transfer of soil technologies and related land and water resource management strategies.

Obviously, the problem CRSP planners face is, *Which of these areas need to be addressed, and with what level of effort?*

Research-Program Design Issues

Some of the issues associated with putting together a socioeconomic research component in the CRSP program involve making certain choices with respect to what the various activities might try to accomplish and how the work is to be organized and carried out. Principal issues of this sort are as shown in Table 1.

These issues are also relevant considerations for all other components of the CRSP program as well. Decisions made in one area may well have significant

Table 1. Program Design Issues

Choice of	Possible Choices
Audience	Farm, watershed, village, regional/national planners, donor agencies, other researchers.
Problem	Low income, food security, protection of entitlements, asset preservation.
Methodologies	Farm surveys, informal interviews, formal modeling, crop budgets, farming systems analyses, descriptive appraisals.
Perspective	Ex anti, ex post, ex interim feasibility studies, impact analysis.
Participation	Target audience, others, participation paradigm: • contractual • consultative • collaborative • collegial
Collaboration	Other disciplines or specialties.

implications for what is done, and how, in another area of work. Therefore, how do we bring everything into sync?

If soil scientists focus on watershed-level soil erosion and land use, economists should too, but what happens to work in the policy area?

In other words, one of the problems with "integration" is that it tends to force the social science component to try to cover the whole range of research areas because they are all important in developing "transfer-sensitive" technologies.

But how do we do that with limited budgets? Will we not need some basis for comparing projects across disciplines to determine which constraints will be addressed at what level of effort? Is there not a need to articulate a central theme, or *strategic research* framework, that drives the program-design process?

If so, should not such a theme focus on people, their problems, and the need to match technologies to the social setting as well as to the agroecological setting?

And finally, how do we raise and resolve the issue of central themes across our list of five program thrusts, three program areas, and ten subprograms?

Environmental Protection

Dr. Ray Meyer
Project Officer
USAID

The title of this workshop, *Soils and Society: Responsible Management*, reflects that historically the rise and fall of societies have been intimately linked to the management of the soil resources upon which they depend. That environmental protection is a component for consideration at this workshop further indicates a realization that soil resources have functions other than as a nutrient and water medium for biomass production (food, fiber, fodder, renewable energy) or engineering purposes (infrastructure of roads or building material). Soil resources also are important for protecting the environment—filtering and keeping groundwater clean; buffering and transforming adverse compounds; immobilizing essential compounds to prevent loss in water movement or volatilization; synthesizing nitrogen; providing a source for genes, for medicinal drugs, for pest management; providing bioremediation, waste disposal; and keeping the food chain free from contaminants.

That we have not been successful in fully realizing the potential of soil resources to contribute to societal development is indicated by a few statistics.

1. Food staple self-sufficiency has declined between the late 1960s and late 1980s—
   - 99–94% in Asia (excluding China and India),
   - 98–93% in subSaharan Africa,
   - 92–76% in Middle East & N Africa,
   - 112–93% in Latin America and Caribbean.
2. Environmental resources are, and continue to be, degraded.
   - About half the surface-irrigated land of India is degraded by salinity and waterlogging.
   - 40% of Guatemala's land has been lost to erosion.
   - 1.3 million hectares of closed broadleafed forest have been cleared annually in Africa.
   - Agriculture is the greatest nonpoint source of pollution in the U.S.
   - Over 45% of the rural wells tested in Iowa were dangerously contaminated with coliform bacteria (75% of the rural wells in one part of the state). It is difficult to feel that an agricultural system is sustainable if the farmer has to purchase bottled water for household use.
3. Economic losses are hidden: nitrogen and phosphorus losses from the arable land were about three times the level of total fertilizer applied in Zimbabwe in the 1984–85 season. If fertilizers were applied to compensate for these losses, the cost would have been $1500 million in 1985. The implications are that erosion is a massive *hidden* cost on the economy of Zimbabwe.

Economic Growth and Resource Conservation

How do we make sure that our assistance to other countries does not result in a repetition of our mistakes but instead improves livelihoods? Governmental policy is the process of societal change and requires the expenditure of social and political capital. Development of agricultural systems is by legislation and resulting policy. Research agendas are also affected, often indirectly, as occurred in the U.S. with a production-oriented focus and an overemphasis on maximizing yields without sufficient cognizance of environmental effects. One analysis would indicate that only 5% of natural-resources research in agriculture is focused directly on obtaining sustainable

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agricultural systems. For example, the system developed and directed by research has substituted capital in the form of applied inputs for land and people in farming, without sufficient consideration of a greater risk for water quality.

The tension between economic growth and resource conservation; the immediate economic, social, and political pressures; and the lack of solid information and/or ability to manage the necessary information to help make difficult decisions—these problems are always present, but they are particularly acute in developing countries.

The increased visibility and importance given to environment is the result of social and political capital being invested by various advocate and lobby groups. Public perception drives policy and may be the result of actual, projected, or perceived risk/benefit indications. Involuntary risks are treated differently than self-imposed risks. Public opinion trend information indicates that public support for environmental protection not only remains strong, but has continued to increase. Public perception of the 1990s reflects concern about environmental protection and wise management of the entire ecosystem. Agriculture is just one part of that ecosystem.

Public Concern & Environmental Policies

In the future, consideration of public concerns and environmental policies will be crucial. Institutions and budgets concerned with agricultural development are changing. The World Bank has recently placed their agriculture and environment departments under a new vice-presidency for "Environmentally Sustainable Development." In AID budgets for agriculture have been decreasing while those for environment have been increasing—there is a $460 million earmark for environment. Domestically the budget increase for EPA has been greater than for USDA. Budget increases of SCS have been due primarily to environmental concerns. At least part of this shift in budgets to EPA is due to USDA making a major error 20 years ago in evaluating public concern about environmental issues and losing much of the environmental initiative.

There is now a greater incentive and societal demand to integrate agricultural and environmental policy with more appropriate emphasis on both production and environmental protection. The process of policy development is centrally concerned with defining incentives and/or rules that will change how people act. Economic analysis, particularly the effect of financial incentives or disincentives, continues to be a vital part of considerations of risks and benefits. Issues of who pays and who benefits may be greatly influenced by institutional policies and practices established many years ago. Determinations of economic efficiency, the balancing of costs and benefits, including social and environmental costs, are complicated by existing laws, court interpretations, and governmental/institutional responsibility. Changes in the rights and obligations of users, or in the economic and social cost of resource-use options may be needed to increase environmental protection.

Examples of successful environmental policy reform include the elimination of pesticide subsidies in Indonesia, land titling in Thailand, water pricing in China, communal resource management in Papua New Guinea, urban congestion fees in Singapore, and the elimination of ranching subsidies in Brazil.

Examples of market failures include the following:

- Unmarketed, unpriced, or undervalued resources, including both products (e.g., nonwood products of forests) and services (water, C-sinks);
- Pervasive externalities, such as the inability to assess costs imposed on society (e.g., pollutants);
- Inapplicability of public goods to private sector (e.g., inability to exclude free-riders or to do so at a reasonable social cost);
- Risks which affect individuals more than society, risks which can cause irreversible losses before a value is set or understood (e.g., extinction of species).

There should be little question of the need to work toward a new agricultural ethic that will achieve both agricultural- and environmental-quality goals of a safe and affordable food supply, a prosperous farm sector, and a stable, productive ecosystem.

Incorporating Environmental Issues

How are environmental issues effectively incorporated and integrated into agricultural programs and into the policy-development process? Serageldin indicates the difficulty for neoclassical economic analysis to address sustainability. The "blackboxes"

of externalities and exogenous variables must be opened. He suggests the concept of capital, and that the need to sustain the capital base of humanity must be broadened and emphasized. The concept must not only include man-made capital, both physical and nonmaterial (such as information), but also natural capital, with proper valuation of the environmental services that natural resources provide (not just as inputs into productive processes); and it also includes social capital, not only in the conventional terms of investing in people, but also in terms of the institutional and cultural framework that makes civilized transactions possible (links with concerns of poverty reduction and equity). Conventional economic analysis has always maintained the distinction between capital and income. Capital was to be kept at a level to produce income in the next reporting period. We must extend this consideration, of being able to produce in the next period, to natural and social capital. Economic accounting must adequately reflect environmental and social concerns if policies and investments are to effectively promote sustainable development.

Agriculture embodies the idea of interactions among people, land, water, and air (climate). Environmentalism is concerned with guaranteeing people the right to pure water, to clean air, and to productive soil. We must search for opportunities for better coordination of strategies for agricultural production, for conservation and development of soil and water resources available to support rural livelihoods, and for improved access of the rural poor to clean water, roads and other infrastructure necessary for a productive and healthy life. We must improve the productivity of all kinds of "capital" to provide incomes and services for future populations.

The concept of technology should differentiate between two types of technologies:

- The mostly material inputs such as those of the green revolution—chemicals, machinery, imported energy, other purchased inputs; and
- Information-intensive, nonmaterial inputs that have significant potential to enhance productivity and reduce the intensity of use of other factors—IPM, crop rotation and diversity, complex farming systems (grain, legume, fodder, livestock), reuse of organic materials. Many of these are not likely to be promoted by the private sector alone since they cannot be appropriated and marketed.

Future challenges

- How can we best integrate the concerns of agriculture and environmentally sustainable development into policy?
- How can we develop responsible approaches to soil and water resources management that will improve agricultural production and environmental protection?
- How can we improve economic measurement and analysis to take into account ecological and social concerns?
- How can we ensure that what is already known in terms of technology is effectively disseminated and used among the poor farmers of the world?
- Do we have the right skills and knowledge and experience within the CRSP? Where is soil science as an environmental science? How many CRSP participants publish in the *Journal of Environmental Quality* vis-a-vis the *Agronomy Journal?*

Increasing Environmental Knowledge

More knowledge is necessary when considering environmental factors in agriculture rather than just commodities. We must improve scientific understanding of environmental issues and improve data on the natural resource base and on the nature of environmental problems affecting the host countries. However, this question then still remains: how do we manage this increase in information for economic decision making?

Do we (can we? should we?) determine global economic, social, and natural capital stock losses and recurring costs of the following:

- Soil degradation and desertification,
- Soil erosion and declining fertility,
- Loss of vegetative cover,
- Loss of water resource in runoff,
- Loss of water quality,
- Loss of irrigated soil resource productivity,
- Lack of intensification on better soil resources without environmental debits,

- Lack of use-efficiency and losses in inputs in intensive systems,
- Loss of soil biodiversity,
- Loss of valuable nontraditional products or services (tourism, recreation, ecosystem services),
- Not understanding the value of diverse systems such as risk-management rotations, trees, alley-farming, noncommercial products.

Making Knowledge Useful

Knowledge, along with the science behind it, is important primarily for its impact on how people use resources. It is useful only if it is sufficiently understood and used by people—business and household owners, community leaders, and government bureaucrats. Do we understand how to obtain the participatory input of rural people and their leaders to make the substantial impact required to reverse the decline and realize the full potential of the natural resource base with respect to the following questions:

- What is an adequate economic return to farmers?
- What is the importance of maintaining the soil and water resources base and productivity indefinitely?
- What can be done to minimize adverse environmental impacts?
- How can we optimize production with minimal external inputs?
- What is important for the social needs of farm families?

New ways of thinking and new policies and practices are necessary to achieve the extraordinarily rich potential for new technologies to resolve environmental and economic problems in agricultural systems. How do we make decisions on selecting research problems? Do we consider the potential number of graduate students (foreign, domestic), postdoctorals, research publications? Do we—can we—research high-risk but potentially high-payoff/impact problems?

The World Bank has a long effort in the use of Vetiver grass as vegetative barriers to improve water management, decrease erosion and land degradation, and increase production. The new BOSTID/NRC book on Vetiver indicates that in spite of the information and case studies available, conventional and comprehensive research is lacking. Why?

Work is being conducted that would indicate that the earth's magnetic field and the auroral electrojet affect cyclic fluctuations in the biosphere and may affect soil and surface-water acidity, availability of soil minerals for plant uptake, herbivore health and productivity (summer slump). Understanding these fluctuations in natural electromagnetic phenomena could provide better strategic timing, placement and method of fertilizer application, and with cover crops, such an understanding could reduce environmental contamination. These fluctuations also correlate with the cyclic release from soils of oxides of N and sulfur, and of methane and ethylene release, which coincides with the maximum annual atmospheric concentration of ozone-depleting gases. Why is this potentially important work not receiving greater attention?

It is difficult to feel that an agricultural system is sustainable if the farmer has to purchase bottled water for household use.

Certain volatile organic compounds produced by vegetation and soil organic material provide nucleation at higher temperatures in the atmosphere. Lack of these compounds caused by vegetation and soil organic-matter loss is postulated to be the cause of a change in rainfall patterns and intensity in Africa and to be a causative factor in the current droughts and desertification of Africa. Why is this hypothesis not being more fully explored?

Global Climate Change

Cropland emits more C than it absorbs. Changed but still economical husbandry could cause a net absorption of C equal to one-third of all emissions from farming. More efficient fertilizer use could cut emission of nitrous oxide, and the return of manure and wastes and improved fertility could cut C emission. The greatest need is for research capacity to provide the knowledge and technology for adapting to climate change and to manage uncertainty and unpredictability. We also need information systems to

monitor change and adaptation. A better understanding of the biological processes in soils under different systems could help modify/manage the agricultural contribution of greenhouse gases.

Conclusions

We must maintain and increase the potential of the soil resource for food, fiber, and wood production; for ecosystem services of clean air, clean water, and biological diversity; for environmental cleansing of waste products; for aesthetic and recreational uses of nature; and for mitigation of global climate change. If we are unable to do so, reasonable quality livelihoods for an increasing global population will be impossible. Economic and social costs of delaying the necessary research and development to adequately address the problem of declining soil resource productivity will increase.

Interdisciplinary research can, when coupled with the appropriate policy and institutional environment, contribute to the design and development of management systems resulting in more environmentally sustainable and productive utilization of the soil resource. An integrated and whole-system approach to analysis, planning, and implementation is essential. Participatory approaches are essential for implementing the capability to address the multiple dimensions of environmental sustainability.

The knowledge base necessary for decision makers, planning agencies (rural, urban, and regional), transfer agents, farmers, and ranchers to develop and implement policies and strategies for improved consideration of environmental factors must be available in various formats for the end-user. Social, economic, and political criteria for competitive uses for soil resources, whether for production, environmental aspects, or intangibles must be established. Formal and informal expert systems must be coupled to indigenous knowledge, existing research knowledge off-site, and research knowledge on-site.

There is a tremendous amount of information available; but it must be organized, synthesized, and communicated. Collaboration and cooperation are essential as organizations, governmental institutions, and governments move toward strategies and policies for the future. In the end, environmentally sustainable management of soil resources may be more a guiding philosophy and perception for the way we do business than specific prescriptions which have universal application. Implementation will vary with changing ecological, socioeconomic, and sociopolitical conditions. It is essential that the scientific bases for alternatives be explicit, well-defined, and communicated in the appropriate format.

I close with a quote from the *Our Common Future*, published in 1987 by the World Commission on Environment and Development: "To achieve global food security, the resource base for food production must be sustained, enhanced, and—where it has been diminished or destroyed—restored."

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Information Technology

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This is a concept paper designed to formulate questions about the role of information technology in TropSoils' future programs. The questions which emerge should serve to facilitate discussion on this topic later this week.

This concept paper is premised on the assumption that TropSoils' existence depends on its ability to make a difference in the intelligent management of land resources. It also assumes that to make a difference, TropSoils must produce results that can be applied by land-use practitioners and policy makers to extract higher performance from our natural resource base, and to do so on a sustainable basis. To improve land performance, two types of information are required by decision makers:

1. Site-specific data on the characteristics of land where a particular practice or policy is to be evaluated or implemented.
2. Global knowledge about biophysical processes which our clients can use anywhere in the world to diagnose problems and prescribe solutions for them.

The information needs of our client, therefore, consist of (1) site-specific data and (2) global knowledge of processes.

Site-specific Data

How much information does one need to assess problems and conditions about a parcel of land? If this question were asked of a group of scientists, it is likely that each would offer a list of parameters from her/his discipline. The climatologist, for example, would list rainfall, maximum and minimum air temperature, solar radiation, relative humidity, and wind speed and direction. The soil and crop scientist would similarly produce lists of soil and plant parameters, and scientists from the social sciences would list demographic, economic, political and infrastructure data.

Everyone agrees that problems cannot be diagnosed and corrected unless site-specific information is available. Three questions can be raised about the specification, collection, and storage of site-specific information needed by decision makers to improve land-use practices and policies:

- What is the minimum data set needed to improve practices, policies and performance?
- Who should be responsible for specifying the minimum data set?
- Who should be responsible for collecting and storing the minimum environmental data set for easy retrieval by clients?

Global Knowledge of Processes

While it is obvious to most that two adjacent parcels of land can differ greatly in characteristics, it may not be so obvious that their behavior and performance are governed by similar processes. Thus to predict land behavior and performance, we need to know processes that govern them and the site characteristics that drive processes and determine outcomes.

A great deal of TropSoils' past effort has gone into understanding processes. But the amount of knowledge which a group such as TropSoils can produce is minuscule compared to the quantity already preserved in libraries, personal files and people's minds. One of the great tragedies of modern science is that this huge store of knowledge is inaccessible to people who need it most.

The key question related to global knowledge is this: should TropSoils concentrate its efforts on generating new knowledge or on learning to make existing knowledge accessible and useful to clients?

Human Experts Versus Machines

The quality of a human expert's assessment of a problem is only as good as the quality of site data and knowledge available to the expert. The most competent and knowledgeable expert can reach outrageous conclusions if supplied with incorrect site information. Garbage-in, garbage-out applies as much to humans as to machines.

The problem with human experts is that there are so few of them. They are also expensive so that only the rich can afford their services. But in an interdependent world, everyone must have equal access to knowledge or else the have-nots will impoverish the earth and render it uninhabitable for all. Equal access to knowledge is therefore not a humanitarian goal, but a utilitarian and pragmatic one.

The key questions for this section are these:

- If human experts are rare and expensive, what alternatives do we have to meet the information needs of the future?
- Can machines do some of the critical tasks human experts now perform?

The hope of the information age was that it would foster democracy by empowering people through knowledge. Knowledge, it was believed, would empower people by enabling them to make better decisions for themselves and society. Proper management of the natural resource base requires knowledge—knowledge possessed not by a few, but by virtually every individual who works the land.

Now we are told that in 40 years the world will have to produce twice as much food on less land than is now cultivated. Not only are we required to double food production, we must also do so without compromising the productivity and sustainability of our natural resource base. To make matters even more difficult, the future is now blurred by the uncertainty of climate change. TropSoils must help prepare the world to deal with changes that appear suddenly and take unexpected directions.

The key questions for TropSoils are these:

- How can TropSoils produce results that allow farmers and government officials to choose better practices and policies?
- How can TropSoils' research help societies prepare and plan for a future filled with risks and uncertainties?
- How can TropSoils' performance in meeting client needs be measured?

Setting Priorities

Setting priorities is not easy. Part of the difficulty stems from the infinite nature of the problem domain of agriculture.

Just to illustrate the magnitude of the problem domain, let me name a few examples. There are, for example, 17 essential plant nutrients, any one of which can constrain productivity or sustainability. There are drought stresses, heat and cold stresses, oxygen stresses, and stresses imposed by countless insects, diseases, and other pests. Irrigation to reduce drought stress often results in salinization and waterlogging. Machinery causes soil compaction, fertilization causes soil acidification, and pest control leaves toxic residue. Erosion, desertification, and soil impoverishment are all part of the problem domain. But what makes the problem domain infinite is the incalculable number of higher order problems that emerge from interactions among basic problems.

The final question then is this:

How does TropSoils set priorities in the face of an infinite problem domain?

Sustainable Ecosystem Management

Summary of slide presentation by Dr. Tony Juo
Soil Management CRSP Program Coordinator
Texas A&M University

Soils play a vital role in sustaining the productivity and stability of natural and agricultural ecosystems. It is no coincidence that productive and durable farm systems are often located on productive and durable soils. Think, for example, of the sustainable systems established on the Mollisols of southern Minnesota, the fertile alluvial soils in the river valleys of southern China, or the young volcanic soils of Central America. Properly managed, these soils can support large populations.

In many parts of the world, however, population growth has exceeded land carrying capacity under the present level of inputs. As a result, more and more marginal and easily degraded land is being cultivated. This problem is particularly acute in parts of West Africa, East Africa, Southern Asia, Java and the Philippines, the Andes and Central America, and Madagascar.

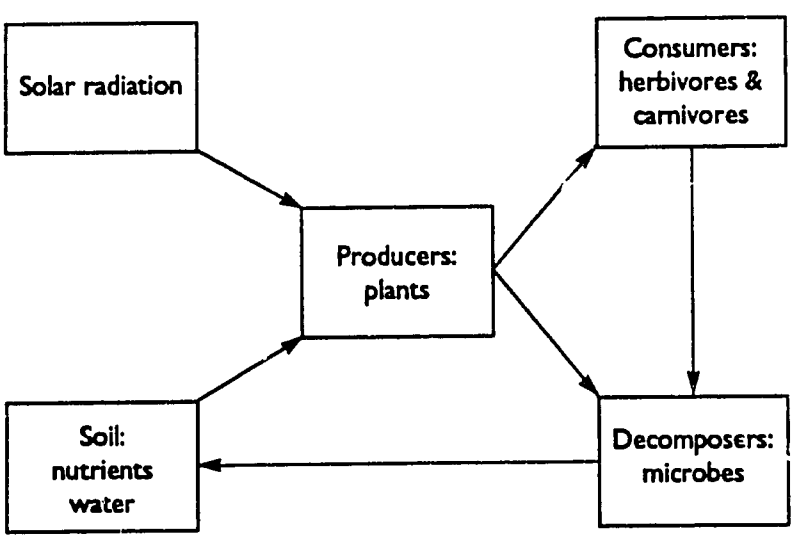

Figure 1. Energy and material flow in natural ecosystems.

Natural and Agricultural Ecosystems

Understanding energy and material flow is essential to the establishment of sustainable systems. In natural ecosystems, this flow is cyclic and sustainable. Soil plays a major role in processing, supplying, and storing nutrients and water (Figure 1).

In agricultural ecosystems, energy and material flow is non-cyclic, dependent on external inputs, and characterized by losses through harvest, leaching, runoff, and erosion (Figure 2). Agricultural ecosystems are also characterized by losses of biodiversity (e.g., plant species and beneficial insects).

Table 1 contrasts energy inputs and outputs in major agroecosystems. The farming systems range from shifting cultivation in New Guinea, to post-green revolution semi-industrialized agriculture in Southern India, to fully industrialized agriculture in Southern England. Further increases in farm labor efficiency at the expense of higher energy input from fossil fuel have occurred in North America from 1970-1990, due to the rise of agribusiness.

In order to evaluate and transfer soil-management systems, one needs to consider a broad range of economic, ecological, and landscape variables. The improved input/output efficiency of modern agriculture, for example, is dependent upon fossil fuels. Modern agriculture is not efficient on an energy basis, but highly efficient on a land or labor basis. It thus makes a poor candidate for transfer to regions with low energy reserves and large labor reserves.

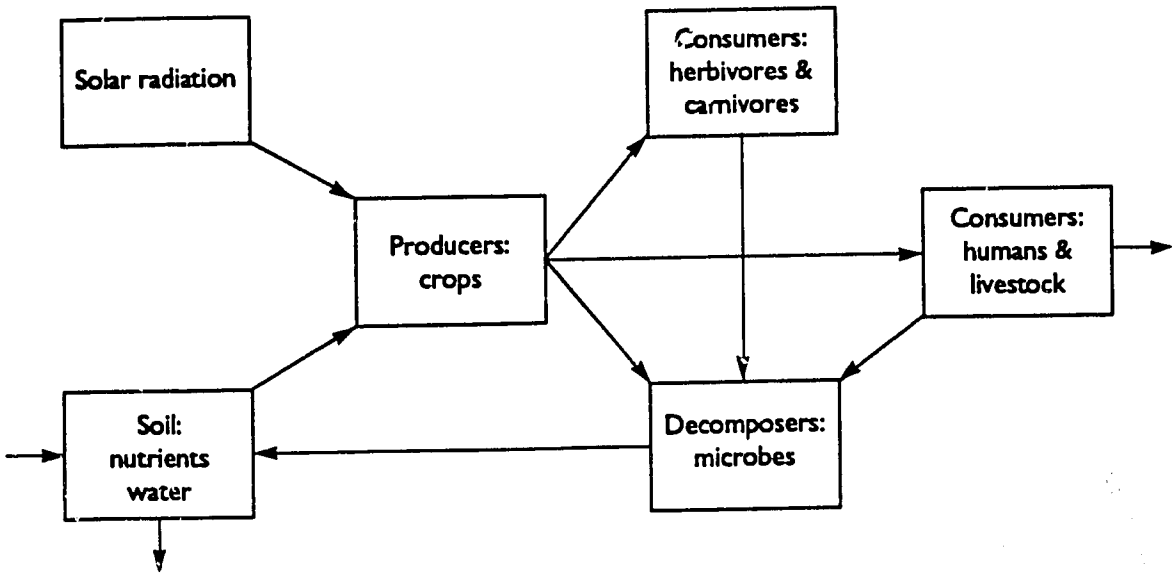

Figure 2. Energy and material flow in agroecosystems.

One of the challenges that faces the Soil Management CRSP is determining the scale at which we address the issue of sustainable ecosystem management. Do we operate at the world level, the national level, the ecological-region level, the watershed level, the farm level, or the field level?

What We Need To Know

In order to develop sustainable systems, we will need to evaluate the experience of industrial nations and determine what can be applied to other economic, environmental, and social contexts.

From our developing-country collaborators, we need both an overall sense of their research and development problems and a more sharply focussed understanding of the critical and interactive issues concerning agricultural production and environmental protection. The development of sustainable systems will also require that we learn more about indigenous knowledge and local resources. Finally, we will need to understand the soil and land-use policy options which affect developing-country producers.

In designing future projects, we will need to develop a better understanding of the following properties and processes at both field and watershed levels:

- organic matter dynamics,
- nutrient dynamics (immobilization, transformation, gains and losses),
- water movement and retention,
- soil atmospheric processes.

To address the research gaps in these areas, future soil science training should devote greater emphasis to the basic sciences: biology, physics, chemistry, geology, and geography.

Concerning landscape processes, we will need to develop a better understanding of the following:

- soil erosion (deposition, sedimentation),
- watershed hydrology (surface flow, interflow),
- nutrient cycling.

Adjusting Our Research Goals and Approaches

The primary purposes of this workshop are to gather information about the most pressing global research and development issues and to discuss the best ways for the Soil Management CRSP to deploy its collaborative resources over the next five years.

With your input, we will construct a program with the following general attributes:

- It will employ an ecosystem approach to food production.
- It will employ a landscape approach to soil management.
- It will employ a multidisciplinary approach to research and development.

Table 1. Energy input and output in agroecosystems (Source: T. P. Bayliss-Smith, 1981).

Farming systems	Input	Output	Input/output ratio	% for subsistence
	——MJ/ha——			
1. New Guinea	103	1,460	14	100
2. S. England, 1830	183	7,390	40	2
3. S. India, 1955	3,255	42,280	13	12
4. S. India, 1975	6,878	66,460	10	1
5. S. England, 1971	21,870	44,890	2	0

Conclusion

Sustainable management of soil and water resources has become a global concern. In the developed world, industrialized agriculture has produced large food and fiber surpluses for export markets. But it has also increased threats to genetic diversity and degraded and polluted our soil and water resources. On the other hand, food security remains the most pressing problem in many developing nations where population has exceeded land carrying capacity at the current level of technological inputs.

Concern about environmental stability is growing, particularly concerning the impact of deforestation, desertification, and intensive cultivation on steep slopes and other types of marginal lands. New research and development programs are needed to integrate and harmonize agricultural and economic development with environmental protection, especially in regions where land productivity and plant diversity are at risk.

Identifying Research Issues

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Group I: Soil and Land Assessment and Monitoring

L. P. Wilding and H. Eswaran, rapporteurs

Introduction

The Total Quality Management (TQM) or "facilitator approach" was used to conduct discussion during the work-group breakout session. While the process was effective in fostering participant interchange, it was a bit too structured to allow for effective dialogue on many critical issues germane to the work-group interests. The process tended to stifle or temper in-depth discussions on CRSP programmatic details, which were clearly group expectations. However, the process functioned reasonably well as a survey to ascertain majority perceptions of group consensus and opinion. It also allowed for minority inputs and responses.

The diversity of the discussion reflected the broad array of occupational, professional, geographical and ethnic backgrounds represented by participants (Appendix I). Participants from ten different countries included administrators, teachers, researchers and graduate students. Participants represented the following disciplines: soil science, range science, biology, agronomy, ecology, and agriculture engineering.

Definitions

To promote clarity among the work group the term "Soil and Land Assessment and Monitoring" was defined in two parts as follows:

- *Soil and Land Assessment*—the quality, extent, and distribution of soil and associated natural resources relative to their physical, chemical, and biological attributes; and
- *Monitoring*—the change in the quality of a resource with time.

No attempt was made to identify the soil and land parameters or criteria that identify quality, though the group recognized that these would likely be temporal attributes (e.g., soil structure, porosity, hydraulic function, biological components, etc.).

A further attempt was made initially to develop a consensus on what the definition of CRSP clients, collaborators, and partners were before such entities were identified and prioritized. While closure on this matter was not complete, it was generally agreed that the following definitions could serve as a guide:

- Clients—consumers of CRSP products
- Collaborators—partners of CRSP activities

The goal for the work group—which was judged adequate enough to promote discussion of the topic was:

To determine how the Soil Management CRSP can best serve the needs of its clientele who have interests in the products of Soil and Land Assessment and Monitoring.

Significance of Soil Resources

Page four of the report *Soils and Society: Responsible Management* (see page 107) nicely captions the importance of Soil and Land Assessment and Monitoring activities as a fundamental research support program for the Soil Management CRSP. Soil resources are the long-term "capital" on which any nation builds and grows. They are the wellsprings that undergird other renewable natural resources; they are the integrator and dissipator of solar energy for biomass production; and the living filters that purify our waste products and water supplies—the

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base component of ecosystems and ecosystem management.

Philosophically, the group felt strongly that because *Soil Science* and *Soil* are such integral components of earth science systems, the term "soil" should not be removed from the title of this CRSP. Likewise it should remain as a part of the name of this work group. The text *Opportunities in Basic Soil Science Research* edited by Sposito and Reginato (1992) further elaborates the role, function, and uniqueness of soil science in addressing contemporaneous global natural-resource challenges. It is clear that the group consensus reaffirmed this identity and posture and wanted to communicate this fact to the Board.

Expectations of the Work Group

Expectations from work-group breakouts were perhaps a little too ambitious for a four-hour breakout period. However, they were enthusiastic and germane to the purpose of the workshop. Twenty-four expectations were expressed—sufficient in work load and scope to occupy several generations of soil scientists. An underlying theme among the group was the need to do well a few projects that were within the capabilities, compatibilities, and expertise of the CRSP. A common thread included the following, but the total is given in Appendix II:

- Obtain inputs from developing-country scientists.
- Serve as a forum for exchange of ideas.
- Develop long-term research strategies.
- Elucidate identification, standardization, and scaling of methodologies.
- Identify and focus on key gaps in current information sets.
- Utilize GIS as a working tool.
- Identify how biologists can use land evaluation and monitoring products.
- Establish how biological criteria can be incorporated into land evaluation and monitoring methodologies.

Who Are Our Clients?

Next, the breakout group addressed the establishment of a priority listing of clientele groups. In short who are the clients that the soil and land resource information serves. A total of 17 clientele groups were identified (Appendix III); the higher priority groups are as follows:

- National Agricultural Research Systems (NARS)
- USAID Missions
- International Agricultural Research Centers (IARCs)
- Policy makers/Politicians, Other Donor Agencies
- Teachers, Trainers, In-Country Scientists, etc.

What Are Our Clientele Needs?

A total of 19 clientele needs were identified (Appendix IV), but most were general ideals rather than specific targets. The needs identified are a little like "motherhood and apple pie" and do not focus sharply (or narrowly) on the critical needs for the clientele identified. Hence, it was not possible to correlate needs identified with clientele groups as might be most desirable. It is clear that within the funding constraints of this CRSP, the available human resources, and the clientele groups' broad need of soil assessments and land inventories, most of the needs identified cannot be delivered. A more targeted focus is warranted. In spite of these constraints the group had a good interaction for general framework thrusts. Those which were judged of highest priority are as follows:

- Establish a standardized methodology for soil and land assessments.
- Enhance training of scientists.
- Employ new technology (remote sensing, GIS, GPS, GPR, etc.).
- Inventory and assess "gray" literature.
- Assess and monitor soil resiliency—temporal attributes.
- Establish minimum data sets.

Constraints Limiting Achievement of Needs

With the limited time remaining in the work-group breakout period, the group identified a total of 19 constraints. These were not prioritized but do clearly illustrate the magnitude of challenges and opportunities. The total list developed is presented in Appendix V; those judged by the rapporteurs to be most germane are listed below:

- Lack of financial, human, and facility resources.
- Non-uniform methodology and quality control.
- Communication—lack of coordination and cooperation among partners and clientele.
- Lack of vision, creativity, and direction.
- Host country political instability and changing government policies.
- Changing strategies of USAID, Soil Management CRSP Board, and collaborators.
- Low-priority, identity and recognition of soil scientists and their expertise.

Summary

No attempt was made by Work Group I to develop recommendations to the Soil Management CRSP Board. Time simply was not available. The rapporteurs did encourage work-group participants to transmit specific proposals or position statements to the rapporteurs so these suggestions could be incorporated into the minutes of the work-group report. No responses were received prior to the preparation of this document. The strong emphasis of soil and land resources as the fundamental essence of this Soil Management CRSP was clearly evident from the group dialogue. Further, the diversity of the group resulted in some leveraging of discussions towards geographical regions that would engender CRSP activity in given regions of participant preference. Those who were represented wanted to be part of the Soil Management CRSP action. It is just as clear to those of us with considerable experience in the CRSP that broader representation is desirable but not realistic.

Hard decisions will have to be made on focusing this multifaceted CRSP so it continues to serve the soil and land-resource needs of the targeted clientele.

Appraisal of Group Accomplishments

We do not believe that the working group achieved the major objectives or identified the major thrust of the new CRSP. This is partly because most of the participants focused their comments on what needs to be done in developing countries in general rather than how can the CRSP contribute to targeted needs. The "facilitator approach" was not so useful to achieve the narrower objectives of the workshop, because the facilitator: (1) was unable to clearly focus the discussions on the narrower objectives of the working group; (2) followed a fixed format which is ideal for TQM training but less suitable for a program-planning meeting; and (3) spent too much time on items of lesser importance (identification, expectations, etc.) and insufficient time on the real question of "Where is this CRSP going in the future?" Thus, we believe that there is an urgent need for CRSP PI's to meet soon to develop the issues, strategies, and subject-matter areas germane to CRSP program thrusts and areas of research activity.

References

Sposito, G. and Robert J. Reginado. 1992. Opportunities in basic soil science research. Soil Science Society of America.

Appendix I: Participants*

James H. Ware—Facilitator
Hari Eswaran—Rapporteur
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Gordon Tsuji
Gyorgy Varallyay
Charles W. Wendt

* A list of addresses appears at the back of this report.

Appendix II: Expectations

1. Enhance communication with developing-country participants, and get expectations and inputs.
2. Interact with soil management scientists from the Sahel region.

3. Establish long-term and short-term research and development strategies.
4. Develop methodology of land assessment and evaluation.
5. Discuss how to incorporate biological aspects into land evaluation and monitoring and how to practically apply land evaluation for biological purposes.
6. Explore how soil-fauna can be incorporated as an index of soil quality evaluations.
7. Define who our clients are and criteria to better identify them (research, rural development, extension, etc.).
8. Define land assessment and reliable monitoring of resilience.
9. Identify key information gaps.
10. Focus on priority issues compatible with CRSP capabilities.
11. Focus on conducting detailed assessments of land resources rather than generalized protocols.
12. Indicate how the Soil Management CRSP may help complete fragmented soil inventories and laboratory data sets (also facilities) in developing countries.
13. Incorporate geographic and spatial data sets into a GIS and establish soil quality criteria—physical, chemical and biological.
14. Standardize methodology for soil-resource assessments and land evaluation, and determine minimum data sets for some.
15. Explore how to scale assessment activities—global, regional, national, local, etc.
16. Determine time scale for achieving completion of activities—short, medium, and large range.
17. Establish focus of such activities geographically.
18. Develop key strategies and priorities for soil and land resource assessments.
19. Establish environmental productivity indices—buffering and filter systems for soils that mitigate environmental pollution.
20. Match soil assessment criteria with needs of clients.
21. Encourage changes in strategies to get practical solutions to rural development challenges.
22. Establish integrated projects—soil, environmental, economic, and social/political issues, as well as agronomic and technical ones.
23. Establish mechanisms by which partners through their own strengths mutually contribute to the soil monitoring and evaluation goal—serve clientele needs in a more holistic manner.
24. Create public awareness, identity, and positive proactive posture to enhance funding from donors.

Appendix III: Prioritized Listing of Clientele Groups To Be Served

1. NARS (National Agricultural Research Systems), 41*
2. USAID Missions, 14
3. International Agricultural Research Centers, 9
4. Land Planners and Users, 8
5. Policy makers/Politicians, 6
6. Other Donor Agencies/Countries, 4
7. Teachers/Trainers, 4
8. In-country Scientists, 3
9. Extension/Non-government Organizations, 3
10. Farmers, 3
11. United Nations Bodies, 3
12. Land Managers, 2
13. Farm Associations, 1
14. Individual Countries, 0
15. Advisory Service, 0
16. Private Sector, 0
17. Other CRSP Entities, 0

* Number of votes cast for each entry.

Appendix IV: Prioritized Listing of Critical Needs

1. Establish methodology for soil and land assessment, 20.*
2. Training of scientists, 19.
3. Use of new technology—remote sensing and GIS, 8.
4. • Criteria for assessment and monitoring, 6.
   • Concentrate on methodology—spatial and temporal, 6.
   • Inventory and assessment of "gray literature" (i.e., existing literature that is not easily available), 6.
5. Establishment of criteria for transferability of data and soil-survey information from one area to the next, 5.
6. • Establish good resource inventory of country-wide basis, 4.
   • Assessment and monitoring of soil resiliency, 4.
7. • Develop minimum data sets, 3.
   • Establish soil quality criteria, 3.
   • Provide technical assistance and complementary facilities, 3.
   • Develop integrated information systems, 3.
8. • Support institutions in land resource inventory, 2.
   • Make data available to users, 2.
   • Establish quality criteria for "other" soil functions (e.g., environmental indices of soil buffering and filtering), 2.
   • Follow-up and reevaluation of data obtained from soil and land resource assessments, 2.
9. Develop global data bases, 1.
10. Develop information exchanges among data bases available, 1.

* Number of votes cast for each entry.

Appendix IV: Identification of Constraints

1. Lack of funding—financial and human resources.
2. Physical facilities and technical capabilities "in-country."
3. Common standards for data collection and analysis.
4. Non-uniform methodology and quality control.
5. Lack of trained personnel (manpower).
6. Lack of graduate students.
7. Lack of cooperation—more coordination.
8. Lack of software/hardware computers.
9. Lack of "in-country" coordination.
10. Lack of common vision, creativity and sense of direction.
11. Political instability.
12. Stable government policies.
13. Too heavy work load.
14. Administrative and bureaucratic obstacles with CRSP.
15. Legal aspects of availability of data base.
16. Lack of creativity.
17. Arbitrary decisions and paternalistic attitudes from sources of power.
18. Low priority and identity of soil and land assessment products.
19. Changing strategies of AID and CRSP Board.

Group2: Knowledge Synthesis and Decision Support Systems

Goro Uehara, rapporteur

Introduction

Soil management information increases daily, but resource-poor farmers often cannot avail themselves of it. To overcome that problem, the National Research Council states that research organizations "should be encouraged and funded to synthesize available information into formats . . . useful to policy makers and activists working at the production level (e.g., extension agents, representatives of private voluntary organizations, and producer associations and cooperatives)."

Expert systems and geographic information systems provide just this kind of synthesis: by allowing users to evaluate a complex range of physical, chemical, biological, and economic variables, they turn raw information into useful knowledge. As a result, scientific expertise need no longer be confined to the research site or circumscribed by the movement of a specialist. By enabling us to organize what we know into problem-solving products, these systems also expose research gaps and guide research priorities in ways that encourage the efficient use of limited funds. They help us avoid doing what has already been done and rediscovering what we already know.

Format

The group leader did not follow the IRRI-logframe format outlined in the various memoranda that preceded the workshop. That format was designed to analyze relevant interest groups, establish a core problem and objective, and identify constraints, concerns, goals, assumptions, and potential research outputs.

The IRRI model was replaced with an alternate format, designed to produce four products:

- A survey of group expectations
- A prioritized list of clients
- A list of research and development needs
- A list of research concerns

Expectations

Perhaps more time than was helpful was devoted to discussing what group members expected to derive from the four-hour session. Nonetheless, participants raised a number of important issues that will need to be addressed as the CRSP prepares its 1994–99 Global Plan. Among the recurrent themes that emerged were the following (a complete list of group expectations is given in Appendix I):

- Given its limited resources, the CRSP needs to prioritize projects so that its research will have maximum impact.
- The CRSP needs to carefully target the end-users of its decison support systems (DSS): we need to determine who the users are, what we have to offer them, and how we can best convey information.
- Translating scientific knowledge into sound agricultural practices and environmental policies is one of the most important challenges the CRSP faces. DSS systems are among the most efficient ways to meet that challenge.

Who Are Our Clients?

The group identified 18 potential customers. After eliminating some redundancy, group members voted for the categories they felt the CRSP should target. The result was the following prioritized list of

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principal customers. The number of votes a category received is listed after the entry. A complete list appears in Appendix II.

- Researchers, 59
- Extension agents, training personnel, USAID field staff, 31
- Policy makers, 19
- Non-government organizations (includes environmental groups), 18
- Farmers, women, minorities, 15
- Agribusiness consultants, 3

Research and Development Needs

After developing a list of 31 research needs (Appendix III), the group established the following framework for program development:

- Gather existing knowledge.
- Identify minimum data requirements.
- Develop an integrated data base.
- Decision Support Systems.
- Develop analytic and predictive tools.

Research Concerns

The group indicated that the following concerns must be taken into account when developing the 1994-1999 Global Plan:

- Customers must be carefully identified.
- The development of DSS must be customer-driven.
- Researchers should serve as conduits to end-users.
- DSS should be a key to identifying research needs and transferring knowledge.

Appendix I: Expectations

1. Obtain information on the sorts of publications that might complement decision support.
2. Discuss the future direction of the CRSP, particularly concerning its relationship to the International Centers.
3. Improve two-way communications between host countries and the CRSP.
4. Develop new projects and directions for the CRSP.
5. Learn what can be done in science to build a foundation for synthesis systems.
6. Determine who the end-users are, determine whether we have anything to tell them, and determine the best way to do it.
7. Clarify resources and prioritize programs.
8. Discuss population and food production.
9. Clarify ways to incorporate microbiology, biodiversity, and bioactivity into DSS.
10. Focus on technology transfer.
11. Focus on resource conservation and exploitation without degradation.
12. Develop the foundation for coordinating research efforts and avoiding redundancy.
13. Evaluate successes and failures.
14. Answer the question: Who is the user? (farmer, scientist, extension workers, etc.).
15. Discuss ways to increase farmer participation in the CRSP activities.
16. Discuss how we can multiply CRSP resources by working with other organizations.
17. Clarify the CRSP's interest in agricultural policy.
18. Clarify what kinds of products the CRSP should produce and determine who should be responsible for disseminating them at each level.
19. Clarifying the types of publications that might assist extension personnel.
20. Establish personal contacts with CRSP members and collaborators.
21. Discuss the process of validating and transferring technologies to small farmers.

Appendix II: Clients

1. Extension agents
2. Collaborators in host countries
3. National policy makers (U.S. and developing countries)
4. Professional agricultural workers and consultants
5. Teachers and trainers
6. USAID field staff
7. National and international agricultural communities who use BNF (NARs)
8. Farmers (through extension service)

9. International community of researchers and collaborators
10. People in agribusiness
11. Credit agencies
12. National research institutions
13. Women and minorities
14. Non-government organizations (including religious groups)
15. Conservation groups
16. Environmentalists
17. Farmers
18. Sustainable agriculture groups

Appendix III: Research and Development Needs and Gaps

1. Experience in using local resources for intercropping in sustainable systems.
2. Site-specific biophysical and socioeconomic information.
3. An integrated data base on existing knowledge.
4. Customized decision tools (computer and otherwise) for use in developing-country institutions. These tools should be capable of assessing both land-use and policy alternatives.
5. Characterizations of the socioeconomic conditions of farmers.
6. A means of identifying, quantifying, and designing sustainable management systems.
7. A better understanding of how soil properties respond to management practices.
8. A means of involving customers in the design, conduct, and delivery of DSS.
9. A more efficient use of BNF tree legumes for low-input sustainable agriculture.
10. A method for identifying constraints within a given ecosystem so that such information can be built into the DSS.
11. A systematic means of identifying research gaps and generating new knowledge.
12. Methods for transferring DSS to national research institutes.
13. Tools to predict sustainability.
14. User interfaces suitable for nonexperts.
15. A concerted effort to identify customer needs and knowledge gaps so that site-specific problems can be overcome.
16. A better understanding of how genotype influences various processes.
17. Management practices that evaluate site-specific soil properties—particularly in tropical areas.
18. Farm systems research with an emphasis on a cost/benefit analysis of management practices.
19. Clear evidence that various models can be used to improve crop management and natural resource management.
20. Assessments of both short- and long-term impacts of management on hydrology.
21. New proposals based on biological and socioeconomic characteristics of production systems.
22. DSS and research priorities organized around the link between national programs and graduate education.
23. Better integration of the work between researchers with expertise in socioeconomics, soil science, and DSS.
24. The integration of microbiological information into the minimum data set (identify useful parameters).
25. New ways to conduct research and transfer research results to small farmers.
26. A prioritized list of projects.
27. A system of risk assessment.
28. An understanding of how to build soil fertility, perhaps as a theme for research focus. Goals might be (1) to develop sustainable agricultural systems that are matched to specific environmental needs (i.e., how does one quantify sustainability?) and (2) to develop and validate a decision support system and to demonstrate that it is being used to improve resource and farm management.
29. Integration of animals into farm systems.
30. A better understanding of soil microbiology and soil nutrient dynamics.

Appendix IV: Participants*

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Group3: Anthropology, Economics, and Public Policy

John Day and Frank J. Smith, rapporteurs

Introduction

The group discussed expectations about the future development of the Soil Management CRSP. Group members identified the potential clients and partners of a revitalized CRSP addressing the priority issue of the 1990s and beyond. Each member of the group suggested objectives for the CRSP and identified real or potential obstacles that must be overcome in order to achieve the objectives of the CRSP. Finally, the group proposed and discussed a series of recommendations for strengthening the CRSP.

There was apparent consensus that the Soil Management CRSP would benefit from integrated and balanced contributions of biological and social sciences.

Expectations

- Understand direction of the Soil Management CRSP.
- Generate stronger socioeconomic component and develop mechanisms to integrate social-science information with development of technologies.
- Find mutual benefits between individual goals and program goals.
- Integrate social science and biological sciences at the program and project-planning phase.
- Improve effectiveness at the field level as determined by long-term client satisfaction.
- Develop recommendations for addressing policies necessary to insure adoption and sustainability of technology.
- Determine how the CRSP can work more closely with international and regional development banks and vice versa.
- Integrate biological and social sciences throughout the project.
- Learn how the CRSP can help.
- Create a world-class CRSP.
- Define who our clients are.
- Develop practical recommendations for use by developing countries.
- Develop recommendations that the Soil Management CRSP Board can use to plan future direction.
- Develop a better strategic perspective for the CRSP (i.e., more client-oriented and more accountable).
- Involve host countries in the planning stage.
- Specify the level of detail and type of information needed from physical, biological, and social sciences.

Who Are Our Clients?

- Farmers
- Donors
- Policy makers/administrators
- Researchers
- U.S. and international students
- AID/Washington/Missions/projects
- Community leaders
- NGOs
- Private sector (U.S. and developing countries)
- National research institutions (U.S. and international)
- Developing countries

- Extension personnel
- School systems
- U.S. Congress
- Communication media
- International donors/banks
- CRSP Board
- Gender, class, and ethnic groups
- CRSP member institutions (universities, USDA, etc.)
- International agricultural research centers
- Information agencies (e.g., CAB)
- International research agencies (e.g., IRAT, CIRAD, etc.)

Objectives

1. To develop clear and defined recommendations upon which the client can act.
2. To collaborate with clients to validate their needs.
3. To develop sustainable technologies that can be applied to the ground.
4. To accelerate knowledge gains and technology transfer.
5. To establish more aggressive Soil Management CRSP policies.
6. To improve recipient benefits from sustainable farm systems.
7. To improve income, food security, protection, entitlements, and asset preservation for farmers and their families.
8. To accelerate information flow for long-term research and to balance short- and long-term research activities.

Barriers

1. Lack of long-term commitment from donors.
2. Lack of resources and commitment from governments.
3. Failure of policies and strategies.
4. Failure of communications with clients/user groups.
5. Lack of compatibility of goals and objectives between the CRSP and recipients.
6. Conflict of multiple goals by AID Missions, host countries, and the Soil Management CRSP.

Recommendations

1. Develop a better understanding of the focus and project portfolio of USAID Missions.
2. Reevaluate the allocation of CRSP resources to individual clients—create a balance between research, policy, and meeting user needs.
3. Achieve a better balance between basic research and user/policy research.
4. Broaden CRSP goals, operating procedures, and lines of communication because of the new members' functions, capabilities, and expertise.
5. Develop a formal process for integrating physical, biological, and social sciences from project planning through project life.
6. Assess socioeconomic constraints/barriers to adoption of sustainable and environmentally appropriate technology.
7. Identify key actors and potential collaborators.
8. Monitor impacts of CRSP-generated technologies.
9. Gather available information from all sources.
10. Create integrated/automated data base.
11. Become proactive in policy recommendations.

Appendix I

Gary Jann—Facilitator
John Day—Rapporteur
Frank J. Smith—Rapporteur
Deandra Beck
Fred Boadu
Nantakorn Boonkerd
Walter Butcher
Thomas Carr
Jean Fruci
Mohamadou Gandah
Richard Grimshaw
Mitiku Habte
Dana Hoag
Anthony S. Juo
Eugenio Marcano-Martinez
Titus Ngoumou-Nga
Arthur Onken
Jorge Quinonez
Charles Sloger
Benjamin Smallwood
Daniel Taylor
Thomas Thurow
Diane Ursone

Group 4: Dryland Ecosystems Management

L. R. Hossner and James F. Parr, rapporteurs

Charge

The charge of the dryland ecosystem management working group was to determine how the Soil Management CRSP can best meet the needs of our collaborators, clients, and customers in dryland ecosystem management. Dryland ecosystem management programs must be sustainable, consider natural resource management, and involve host-country collaboration.

Mission

Soil and water are the foundation for sustainable development. Whether one talks about crops or livestock, family health or economic vigor, genetic diversity or global warming, the underlying issue is the same: how are we using our soil and water resources? Dryland ecosystems are fragile, marginal soils that are easily and rapidly degraded and subject to excessive population pressures. Our challenge has been and will continue to be the development and transfer of sustainable soil- and water-management practices that are socially and environmentally acceptable.

Fragile dryland areas like the Sahel are extremely vulnerable to degradation. In many regions, population pressures, the loss of vegetative cover, and shortened fallows have severely reduced the productive capacity of the resource base. Wind and water erosion, moisture management, nutrient dynamics, spatial variability, and soil crusting all pose large-scale problems for farmers on dryland ecosystems. System-specific solutions to these problems are a prerequisite to land rejuvenation and sustainable management.

In light of our new resources—and in view of the problems identified above—our tentative mission is (a) to develop sustainable soil- and water-management practices for a broad range of landscapes and ecosystems, (b) to foster host-country capabilities which lead to the continued development and adoption of sustainable practices and policies, and (c) to increase awareness about the relationship between sustainable land management and environmental stability.

Collaborators/Customers/Clients

The following prioritized listing was considered by the work group to be the top five collaborators, customers and/or clients for the technology produced by the Soil Management CRSP. A complete listing of the proposed Soil Management CRSP clientele as identified by the group can be found in Appendix I.

1. National agricultural institutions (research, education and extension)
2. Host-country scientists
3. International Agricultural Research Centers
4. USAID Missions and Bureaus
5. Farmers—the ultimate recipient and beneficiary

Expectations

The expectations of the work group were rather diverse; fourteen items are identified in Appendix II. The top five are listed below:

1. Develop more productive and sustainable dryland/rainfed farming systems (low-input, low-cost, and profitable).
2. Determine how U.S. institutions can develop more effective research and training programs for host countries.
3. Develop more effective criteria for evaluating land degradation and ecosystem impacts of traditional and improved management practices.

4. Provide Board of Directors with information and strategies to enhance the effectiveness of the CRSP (e.g., convey the importance of integrating agricultural, environmental and socioeconomic components into holistic programs).
5. Implement the new five-year Soil Management CRSP and coordinate with other ongoing projects to insure continuity and maximum impact.

Needs

The primary needs in dryland ecosystem management involve technology development and transfer, training, and project funding. The top five needs were prioritized by the work group and are presented here; a complete list appears in Appendix III.

1. Systematic exchange of innovative technology—networking.
2. Host-country scientist training.
3. Affordable and acceptable technologies to improve dryland ecosystems; technologies should include: crop residues, water, organic wastes, and legumes. Long-term implications of these technologies should be studied under dryland ecosystem management conditions.
4. Project funds for improving the capability of national agricultural institutions are needed.
5. Information-gathering activities for regional resource analysis are needed for both integration and policy matters.

Constraints and Barriers

The main constraint to effective programs in the dryland areas appears to be largely associated with the lack of financial, personnel and physical resources. Communication, coordination of programs and policy decisions, or lack of them, are also deterrents to effective programs. Priority constraints considered by the working group are summarized below and detailed in Appendix IV.

1. Lack of adequate resources (i.e., funding, technically trained personnel, facilities).
2. Lack of communication and coordination of project/programs at both technical and administrative levels.
3. Inconsistent priorities of USAID Missions and Bureaus, donors and NARS.
4. Critical knowledge gaps in data sets.
5. Lack of suitable and/or adaptive technologies.
6. Dominance of top-down management systems and lack of feedback response.
7. Lack of well-defined national (NARS) policies, priorities, goals, and objectives for agricultural and economic development, and natural-resource conservation.

Concerns and Other Issues

A number of associated issues were identified by the work group for inclusion in the report. They are listed in no particular order and are provided for consideration to the Board of Directors, the Management Entity and the Technical Committee.

1. The Soil Management CRSP must identify its strengths and consider its resources—focus our efforts on a few "problem-oriented programs."
2. The Soil Management CRSP should be encouraged to promote policies to enhance inter-CRSP cooperative projects.
3. The Soil Management CRSP needs to provide encouragement and incentives to secure the participation of "key" U.S. scientists in the Soil Management CRSP.
4. Soil Management CRSP participants should ensure that the new CRSP title reflects our expertise, e.g., soil and water conservation and natural resource management (i.e., a strong linkage of agriculture and environment).

Appendix I: Collaborators/Clients/Customers

- National agricultural institutes/extension personnel, 18
- IARCs (International Ag. Res. Centers), 15
- Host-country scientists, 13
- USAID, 9
- Farmers (host country), 7
- Students, 4
- Educators and researchers—universities, 2
- Donor organizations, 1
- NGOs, 1

- U.S. farmers, 1
- Policy makers & politicians, 1
- Community-level decision-makers, 1
- Other CRSPs, 1
- Gender, class, and ethnic groups, 1
- USDA institutions, 0
- Private-sector entities (credit, bankers, etc.), 0
- Nomads/minority groups, 0

Appendix II: Expectations

1. Focus attention on how to achieve sustainable dryland farming systems.
2. Determine how U.S. institutions can assist host-country collaborators through research and training.
3. Look at appropriate input for given locations (drylands) to develop partnerships in R&D.
4. Furnish Board of Directors with information that will be useful in meeting CRSP goals.
5. Hearing about issues in stressed ecosystems, desertification, and research ideas in other parts of world.
6. Statement for Board on how to achieve integration of physical, biological, and social research. Involve host-country scientists.
7. Criteria to evaluate land degradation and ecosystem impacts—physical, biological and chemical.
8. Identification of constraints to accepting new technology in dryland ecosystems.
9. Focus on host-country involvements.
10. Gather experiences on intercropping systems.
11. Determine how to develop low-cost technology for LDCs.
12. Determine how to set up suitable agriculture with low input.
13. Determine how to fit five-year program into ongoing programs in countries.
14. Determine how to improve productivity within context of country's environment.

Appendix II: Needs

The following is a prioritized list of needs. The number of votes each entry received appears in parenthesis.

1. Technology and know-how exchange. (12)
2. Host-country scientist training. (11)
3. Affordable technology to improve dryland ecosystems. (7)
4. Project funds for national agricultural institutions. (6)
5. Support soil information-gathering activities in dryland ecosystems for regional resource analysis. (4)
6. Regional networking for scientific exchange and technology transfer. (3)
7. Determine feasibility of recycling organic wastes as soil conditioners and bio-fertilizers. (2)
8. Efficient and affordable water collection systems (1)
9. Innovative ideas to improve dryland agriculture. (1)
10. Soil and plant analytical laboratory support systems. (1)
11. Farming systems analysis to identify affordable technology. (0)
12. Research and identify those dryland ecosystems susceptible to desertification. (0)
13. Develop better mechanisms for communication and interchange between clients and CRSP. (0)
14. Policy analysis. (0)

Appendix IV: Constraints and Barriers

1. Resources—money, scientists, facilities.
2. Communications.
3. Coordination of activities within country.
4. Uniform approach.
5. Lack of consistency in USAID and donor agencies.
6. Gaps in critical data sets (critical knowledge gaps).
7. Availability of suitable or adaptable technologies.

8. Bureaucratic mazes (jungles).
9. Applications of appropriate technology (projects in cultural context).
10. Inadequate technical training.
11. Politics.
12. Lack of national policies.
13. Lack of infrastructure.
14. Management.
15. Territorial imperatives.

Appendix V: Participants*

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* A list of addresses appears at the back of this report.

Group 5: Steepland Ecosystems Management

Keith Cassel and Anthony S. Juo, rapporteurs

Introduction

Steeplands are difficult to define exactly. For this discussion, we assumed that they are *steep* lands that occur in the humid tropics as well as in other climatological settings. The hydrologic processes are altered, as compared to the hydrologic processes on non-steeplands, in such a manner that surface and subsurface waters have the potential to transport soil material from the land and deposit sediment in areas downstream. In many regions of the world, soil is lost from these farmed steeplands at rates exceeding hundreds of tons per hectare per year. Large acreages of steepland occur in such countries as Peru, Honduras, Costa Rica, the Philippines, Nepal, Rwanda, Madagascar, Malaysia, and Southeast Asia.

In some cases, steepland soils have been farmed for hundreds of years and productivity has been sustained. In other areas, population pressure recently has forced farmers to cultivate fragile steeplands. Continued deforestation of these steeplands has resulted in severe soil erosion and water runoff. Severe siltation of rivers and coastal waters has resulted in degradation of water quality and aquatic systems.

Expectations

1. To help define sustainable agricultural and forestry systems on steeplands.
2. To stabilize steeplands using biological N fixation as one of the inputs.
3. To develop an integrated and coordinated approach to steeplands research.
4. To develop research projects in which farmers participate, thus ensuring that research is based on farmers' needs.
5. To incorporate the socioeconomic potential in the steepland approach.
6. To transfer and fit the technology which exists to the farmers.
7. To prioritize research so that it addresses key information gaps which currently limit management effectiveness.
8. To develop new linkages with institutions and individuals.
9. To determine the CRSP's comparative advantage in working in steeplands.
10. To create public and community awareness of long-term benefits of soil and water conservation.
11. To measure impacts of existing technology.
12. To define policy related to using steeplands.
13. To develop better land-use policy and land tenure.

Customers

- Farmer/rural communities
- In-country agencies
- Researchers

Objectives

1. To develop or maintain long-term sustainability of steeplands (on-site user):
    - productivity (yield, income),
    - stability (consistency of production),
    - resiliency (capacity of system to recover from perturbations),
    - equitability (equal sharing of benefits).

2. To understand off-site physical and socioeconomic effects—measure, monitor, establish critical limits, and recommend land-management alternatives (off-site or non-farm user).

Customer Needs

1. To develop or refine cost-effective technologies for long-term sustainability of steeplands (farmer, agency).
2. To identify knowledge assets, including indigenous knowledge and gaps (researcher).
3. To develop a computer-based data support system to evaluate sustainability (agencies, researchers).
4. To develop in-country technical and professional expertise (agencies, farmers).
5. To preserve hillslope physical stability and a medium on which to farm (farmers, agencies).
6. To obtain feedback from farmers to reorient research and ensure that it remains iterative, dynamic, and self-correcting (researchers).
7. To tap existing organizations dealing with steeplands (agencies, researchers).
8. To evaluate possibilities of land improvement, rehabilitation, and reclamation (farmers, agencies).

Recommendations

Need to structure research based upon unique environmental and socioeconomic characteristics.

Appendix I: Participants*

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Carlos Cervantes
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George Wilson

* A list of addresses appears at the back of this report.

Group 6: Rainforests and Man-influenced Humid Ecosystems[1]

T. Jot Smyth and Charles Davey, rapporteurs

Charge

The Soil Management CRSP should provide agrotechnology that will improve production stability and thus limit further incursion into existing rainforests. It should not pursue rainforest management *per se*.

Clients

All of the collaborators listed below are seen as conduits to the desired and ultimate target: the farmers.

- Ecologists
- AID Missions and their projects
- Extension agents, NGOs and PVOs
- Policy makers and politicians
- Agribusiness, private sector
- General public—beneficiary of actions taken at the farm level that provide no clear advantage to farmer
- National research institutes

Priority Client Needs/Objectives

Improved farmer standards of living through development of sound land-use alternatives through the following methods:

- Soil erosion control
- Improving soil fertility
- Proper water management

[1] The group agreed to adopt this name rather than the originally listed *Rainforest and Humid Ecosystems Management.*

Priority Barriers

The voted to establish the top three barriers (below). The final two barriers were considered of lower priority.

1. Expansion of inappropriate land-use systems by resource-poor farmers
2. Lack of incentives for farmers to use degraded lands
3. Inappropriate government policies
4. Tradition
5. Diversity of interest groups

Recommendations

- Promote the transferral of improved soil management knowledge and technology to collaborating host-country scientists.
- Increase accuracy and promote the use of diagnostic methodologies for formulation of sustainable agricultural systems.
- Seek greater precision in nutrient management from the standpoints of productivity, economics, and environmental protection.
- Identify and develop alternative land-use systems consistent with local socioeconomic conditions.
- Identify minimum socioeconomic and biophysical data sets required to formulate appropriate policies for sustainable land-use options.
- Focus on a few key issues that will maximize integration of CRSP expertise and CRSP activities.

Group 7: Remediation of Polluted Lands

Paul Singleton and Janice Thies, rapporteurs

Opening Concerns

Group members raised the following concerns early in the meeting. The bulk of these concerns were not resolved.

- Some participants questioned whether the CRSP has a strategic advantage in this area when DOE, NSF, and other organizations have large pollution/remediation programs already in place. Participants also pointed out that incorporating this new and very different program might be beyond the CRSP's current resource capability.
- Other participants felt that this is a field of the future, something completely different for the CRSP; the subject addresses many urgent imperatives raised by USAID Mission environmental programs. A CRSP program would thus be an obvious way to link with domestic and foreign industry, as well as with private-enterprise development. It would also demonstrate the CRSP's flexibility in accomodating Mission needs.
- Participants noted that prevention may be more important than remediation, prevention being more of an industrial policy issue.
- Group members recognized the need to redefine the scope of the problem to include agricultural pollution.
- Group members recognized the need to specify focus (i.e., which types of pollution should be addressed?).
- There was a general consensus that the CRSP could explore the world's interest with little cost or risk in a potentially highly visible and self-sustaining problem area.

Customers and Clients

The top six clients and the list of votes they received are listed below. A complete list is given in Appendix I.

1. Government, policy makers, and national institutes, 42
2. Scientific community, 25
3. Private sector, advisory services, remediation companies, land-use planners, 14
4. AID Missions, international donors, banks, 10
5. Affected citizens, 7
6. Polluters, 2

Research and Development Needs

The nine principal research and development needs are listed below, along with the votes they received. A complete list is given in Appendix II.

- Research on soil characteristics controlling biotic and abiotic transport and transformation of pollutants. (13)
- Assessments of the vulnerability of ecosystems to pollutants in terms of critical (tolerance) and target (objective) loads. Development of scientific criteria for assessing soil quality in terms of physical, chemical, and biological characteristics. (13)
- Provide public-awareness information on the impact of pollutants (health, safety, and toxicity). (11)
- Develop cost-effective, adaptable methods for amelioration of polluted lands, with a focus on bioremediation and technology transfer, including waste management. (10)

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- Determine a policy focus: what alternatives should be undertaken? Evaluate socioeconomic feasibility of introducing policy and technology to support pollution prevention. (10)
- Develop and coordinate a network for information exchange and cooperation. (7)
- Quantify the effects of current practices on soil quality. Characterize changes in activity and function of rhizosphere microorganisms in response to pollutants. (6)
- Develop a data base and decision support for evaluating the severity of existing pollutants and managing downstream problems from catastrophic events. (4)
- Develop capability to identify contaminants and diagnose toxicity, persistence, movement, and transformation in soil. (2)

The CRSP has:

- Extensive expertise in soil biology and plant-soil relations which allows a whole systems approach to be taken.
- A history of rapid response to technical requests.
- Established linkages and international relationships.
- Soil data bases/decision support systems available.
- Experience in local capacity strengthening.

The CRSP can:

- Facilitate links to domestic and foreign policy.
- Provide linkage to environmental groups.

Potential Constraints

- Availability of resources.
- Mission/donor/client interest has not been determined.
- Potentially sensitive issue for host governments.
- Intellectual property rights, especially in relation to industry collaboration.
- Large departure from historical view of CRSP.
- Lack of perception that pollution is a priority within developing countries.
- Five-year time frame of CRSP is too short to consider a new area.
- Image of CRSP as a land-management entity.
- Can CRSP deliver an implementable program?
- AID may be reluctant to buy in—the program may be too research-oriented.

Appendix I: Clients

- Farmers/land owners
- Polluters
- Government agencies
- Scientific community
- Land-use planners
- Citizens living in polluted areas
- Private sector
- Advisory services
- USAID Missions
- Policy makers
- International donors and banks
- National institutes
- Remediation companies

Appendix II: Research and Development Needs

1. To develop a working objective akin to the following: to increase soil productivity by remediating polluted soils (i.e., to develop methods to ameliorate arable soils compromised by erosion).
2. To develop cost-effective, adaptable ways for small industries/farmers to remediate polluted land.
3. To identify and quantify heavy metals and other contaminants, including organic pollutants.
4. To develop a network of international scientists and cooperating agencies.
5. To develop a policy focus for program development.
6. To focus on bioremediation methods (plants, animals, and microbes).
7. To determine the socioeconomic feasibility of introducing policies and technologies to support pollution abatement and remediation.

8. To develop scientific criteria for soil quality in terms of chemical, physical, and biological properties.
9. To develop a method to transfer technologies and disseminate information.
10. To conduct research on the soil properties and processes controlling the behavior of pollutants.
11. To model surface and subsurface movement of pollutants.
12. To work with other agencies and institutes on projects in this area to identify data and information needs.
13. To provide information to the public on the impact of pollutants.
14. To study the activity and function of microorganisms in the rhizosphere of crops growing in polluted areas, with the intention of developing bioindicators of pollution.
15. To identify and quantify transport and transformation processes of pollutants, including biotic transformations.
16. To assess the vulnerability and resilience of various ecosystems (e.g., agricultural, national) to various pollutants, using a farming systems approach, as a basis for determining critical (tolerated) and target (objective) loads for pollutants.
17. To quantify the effects of current practices on soil quality.
18. To prioritize the severity of pollutants in terms of their toxicity, persistence, and leachability.
19. To apply GIS technology (e.g., demographics) for managing problems and as a tool in disaster reduction.
20. To define what we mean by a "polluted" land, since this is a relative term based on prospective land use.
21. To develop methodology/transfer technology on waste management.

Expressed as a percentage of the vote:

- Soil processes controlling pollutant behavior. (17)
- Assessing vulnerability/resilience of ecosystems. (17)
- Public awareness. (15)
- Remediation methodolgy. (13)
- Policy focus. (13)
- Identify need, develop infrastructure, network activities. (9)
- Define current management effects on soil quality. (8)
- Modeling/data base/GIS activities. (5)
- Identify/quantify. (2)
- Soil biological responses to pollutants (bioindicators). (1)

Top priorities for research and development:

1. Soil vulnerability/resilience/quality analyses.
2. Soil properties and processes controlling pollutant behavior.
3. Public awareness activities.
4. Socioeconomic/policy/feasibility.
5. Methods for bioremediation.
6. Networking activities.

Appendix III: Participants*

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Richard Arnold
Philippe Baveye
Crisanto R. Escano
Hari Eswaran
Alan R. Hurdus
W. Fred Johnson
Eugene Kamprath
Marian Krol
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* A list of addresses appears at the back of this report.

Group 8: Technical Support of USAID Missions and Programs, and International, National, and Private-Sector Organizations

Thomas Carr and John Kimble, rapporteurs

Extract from Discussion Document

Directly or indirectly, many development initiatives advocated by USAID and other organizations require land-management expertise: private enterprise programs must match land uses to land-use characteristics; health programs must safeguard soil and water quality; nutrition programs must evaluate the productive capacity of the environment; natural resources programs must predict and monitor the environmental impact of various human interventions. In addition, IARCs, NARS, and other CRSPs often lack the soil expertise necessary to maximize the effectiveness of their efforts. If these organizations are to serve their clients, they must have access to an integrated soil/water program. The Soil Management CRSP can provide both long- and short-term support to a wide range of such organizations.

Clients/Customers

- USAID Missions and Programs
- National Organizations
- International Organizations
- Private Sector

Constraints/Barriers To Providing Technical Assistance

International Organizations

1. Recognition of CGIAR's new goals and objectives in planning for potential collaboration.
2. Lack of formal mechanism for coordinating between CGIAR centers and the CRSP.
3. Lack of clear definition of the CRSP's area of operation and emphasis. What are the boundaries?
4. Lack of synthesis in information on soil management with regard to policy.
5. Transfer of technology:
   - understanding of the CRSP mission
   - look at alternative ways of transferring knowledge
   - lack of financial resources
   - lack of marketing information
   - policy constraints

National Organizations

1. Geographical focus and operational scope of CRSP is not well-defined.
2. Unclear scope/focus on the degree of development by the CRSP.
3. Limited number of countries coordinating with the CRSP.
4. Lack of access to resources in-country to participate with the CRSP.
5. Lack of vertical and horizontal coordination.
6. Insufficient number of scientists and level of training to utilize CRSP output; need output

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balance in distribution of training programs and disciplines.

USAID Missions and Programs

1. Difficulty in establishing and maintaining a working relationship with mission due to lack of continuity of personnel and policy.

2. Conflict between centrally funded and mission funded programs.

3. Lack of understanding of TropSoils' programs and services by missions.

4. Conflict of finance allocation and planning cycles and between missions and the CRSP.

Private-Sector Organizations

Bypassed

(Rapporteur note: Perhaps it can be stated here that the fact that this topic was bypassed indicates a barrier on behalf of the participants to recognize the importance of this sector in the technological transfer process of soil science.)

Recommendations

1. The CRSP should be developing a strategy for wider distribution to NARS and beyond.

2. The CRSP should exploit other sources of relevant technology; analyze, synthesize, and disseminate it.

3. The CRSP should provide and solicit information critical for developing policies relevant to soil management.

4. Greater exploitation of collaborative efforts with international research institutions.

5. The CRSP needs a program for temperate countries.

6. More coordination is needed in the development efforts among donor agencies.

7. Increase collaboration between the CRSP and the private sector in terms of joint research, product development, production and marketing, and adoption and implementation of new technology.

Appendix: Group 8 Participants*

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W. Frederick Johnson	BIFADEC/AID/State
John Day	USDA/ERSI
Ronald Jones	USDA/OICD
Bob Caldwell	University of Hawaii
Tony Juo	Texas A&M
Richard Grimshaw	World Bank
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* A list of addresses appears at the back of this report.

Group 9: Human Resources Development

Philippe Baveye, rapporteur

Introduction

As outlined in the *Workshop Discussion Document*, the mandate of this breakout group was to assess the needs that exist in developing countries in terms of human development. According to that document, "Developing countries often lack well-trained researchers, educators, policy makers, and extension agents. Such expertise is the foundation upon which sustainable land-management practices are built, refined, and adopted. Degree programs, workshops, scientific networks, and short-term seminars can all help to overcome this deficiency."

At the onset of our discussions, Jeri Berc, the USDA facilitator, proposed the following sequence of topics for the discussion:

1. Ground rules
2. Introduction/expectations
3. Customers
4. Development/training/transfer
5. Needs/gaps
6. Constraints
7. Institution roles

The breakout working group managed to go through steps 1–5 but did not have time to get into steps 6 and 7.

Who Are Our Customers?

In this part of the discussions, the group repeated pretty much in *extenso* the discussions that had been held the day before in breakout working groups 1–7. After writing down the various possible customers of the CRSP's Human Resource Development Outreach activities, and after prioritizing them, the group came up with the following list (total votes appear in parenthesis):

- Researchers (24)
- NGO, PVO, and extension agents (13)
- Professors in U.S. and developing countries (7)
- National research institutions (6)
- Working professionals (6)
- Farmers (5)
- Graduate students (4)
- Non-degree trainees (4)
- Policy makers (4)
- USAID (Missions and R&D office) (4)
- International & National Agricultural Research Centers (3)
- Other international development agencies (FAO, IFDC, etc.) (3)

Even without doing any kind of aggregation of these various customers, one clearly sees that the group considered that researchers should be the targeted customers of the CRSP's outreach activities in the area of human resources development. Extension agents and NGO and PVO workers are second in importance. Comparatively, the farmers received very few votes. The members of the breakout group all agreed that farmers should be the *ultimate* users of anything that the CRSP develops. However, most attendees agreed that, for a number of cultural, language, and socioeconomic reasons, it would be very inefficient for the CRSP researchers to try to work directly with farmers. Local scientists and extension agents are much more qualified to do so than U.S. researchers. In addition, working efficiently at the farmer's level requires resources that the CRSP does not have.

To remove some of the overlap that exists in the list above, one can aggregate some of the categories.

In particular, it makes sense to combine researchers, professors in the U.S. and developing countries, national research institutions, and graduate students under the single global heading of *researchers*. This customer type then receives a total of 41 votes. The modified list is the one that was presented during the last afternoon of the planning workshop.

List of Needs/Gaps

Once the customers or clients had been identified, the group then focussed its attention on identifying the needs that exist with respect to Human Resources Development. Since there was no one in the group from Eastern Europe, the discussion concentrated entirely on the needs arising in developing countries in the tropical and subtropical regions.

A list of 34 needs was compiled and consolidated. It was further divided into three categories: educational needs, communication-related needs, and recommendations. The list of educational needs was then prioritized (whenever appropriate, the number of votes is indicated in parenthesis).

Educational Needs

1. Systematic continuing education. (7)
2. Funds for sabbatical leaves, attendance at conferences. (7)
3. Training in soil conservation and management.
4. Training in areas other than soil fertility (e.g., soil physics). (6)
5. Training courses designed to bring proven technologies to educators of farmers. These training programs should focus on building capability to train others. (8)
6. Graduate students who pursue research topics in tropical/non-temperate areas and bring advisors to these areas. (3)
7. Professors from non-temperate regions on dissertation committees.
8. • To increase the quantity and quality of trained people in research and extension on tropical land management.
   • To reduce the educational gap between researchers and extension agents.
   • To provide advanced-degree training for extension agents.
   • To establish communications specialist positions.
9. To invest in equipment, libraries, and program development in host countries (including training of Ph.D.'s) and to develop host-country advanced-degree training capabilities (22).
10. To track training programs. To monitor what participants are doing and where. To evaluate if the programs have a multiplying effect (this may be a role for social scientists).
11. Training with a broad spectrum and program development in extension (5).
12. Links to technical resources in research institutions and to beneficiaries (NGO agents, . . ., farmers).
13. Coordination with other training organizations for non-degree training.
14. To provide advanced-degree training for extension agents, in addition to researchers (12).
15. To find ways to improve communication between "urban" agricultural researchers and rural farmers, perhaps through improvement of the education system for rural populations (1).

Communication-related Needs

1. Distribution of library materials/papers.
2. Multilingual publications.
3. Distribution of conference proceedings.
4. Creation of national journals with regional scope.
5. Creation of site-specific, applied publications.

Recommendations

The following recommendations were defined as needs not necessarily requiring money inputs.

1. Administrators should not be the ones participating in technical training programs: participation of technical staff/researchers should be encouraged.
2. Emphasize on-the-job training, problem-solving.
3. Retain well-trained degree scientists in the tropics.
4. Weigh scholarships evenly among national and international institutions.
5. Balance technical and social-science training for effective technology transfer; plan research to capture indigenous knowledge.

6. The training should be multifaceted, multidimensional.
7. Trainees need more hands-on experience with resources, applied thrust to research.
8. Training in mechanical skills.
9. More training in research leadership/organization, management of broad programs (observation, workshops, bringing in other disciplines for these training programs).
10. Include farmers in setting the research framework.
11. Graduate training should be only a part of larger, longer-term programs.
12. Legitimize opportunities for involvement in broad-based research programs; avoid narrow specialization.

This last recommendation (#12) spurred a very intense discussion on the training of graduate students from developing countries. Several participants argued that the standards should be exactly the same for U.S. students as for students from the Third World. In both cases, there should be a mix of fundamental and applied research. In addition, narrow specialization is an integral part of Ph.D. programs in the U.S. and Europe, and it should be maintained at all cost. The discussion did not lead to a consensus. However, those in favor of a *double-standard* system—with graduate students from developing countries trained less rigorously and more in the applied aspects of their fields of emphasis—were a very small minority.

From the above lists of needs and recommendations, it appears clear that the development of technical and human research capabilities should be the CRSP's top priority. Also, the CRSP should be actively involved in developing the ability of host-countries to train their own scientists (at M.S. and Ph.D. levels) and their extension agents. These priorities are consistent with the earlier conclusion that researchers are the CRSP's direct clients or customers.

Appendix I: Participants *

Jeri Berc—Facilitator
Philippe Baveye—Rapporteur
Alfredo Alvarado
Manuel Arca
Katherine Daniel
Diego De Lozada
Armando Ferrufino
Jean Fruci
Mohamadou Gandah
Mikitu Habte
Lloyd Hossner
A. S. Karama
Harold H. Keyser
Zoumana Kouyate
William Larson
Paul Singleton
Diane Ursone
Larry Wilding

* A list of addresses appears at the back of this report.

Group 10: Communications

Sidney Westley and Tim McBride, rapporteurs

Introduction

Diverse populations and agroecosystems require equally diverse resource-management technologies. Although a large base of soil-management information exists, only a fraction of that information is being applied by developing-country farmers. This breakout group was charged with identifying the crucial communication issues the Soil Management CRSP will need to consider if it is to reduce that gap over the next five years.

To fulfill its charge, the group established the following agenda:

- Develop a problem statement
- Establish a program goal
- Identify clients and their needs
- Identify barriers that block the fulfillment of client needs
- Prepare a list of recommendations for the Board and the Technical Committee.

Problem and Goal

The group began by establishing a detailed list of communications problems (Appendix I). A number of recurrent issues emerged during this discussion:

- We must do a better job of identifying our clients and their needs.
- We must develop information that responds to those needs.
- We must determine more effective ways to disseminate soil-management information.

After some debate, the group established the following problem statement as a guide for the next five-year plan:

CRSP output needs to reach diverse users more effectively.

Recognizing that the CRSP cannot respond directly to developing-country farmers, the group stressed the importance of packaging results for in-country transfer agents, who can serve as intermediaries between researchers and producers (Figure 1).

After reviewing the list of problems, the group established the following goal for the communications program:

CRSP output reaches diverse users more effectively, with adequate feedback.

Clients and Their Needs

The group divided the communication program's clients into two categories, *end users* and *direct clients*. End users include farmers, planners, policy makers, and the research community. Direct clients include National Agricultural Research Services, USAID, and change agents (extensionists,

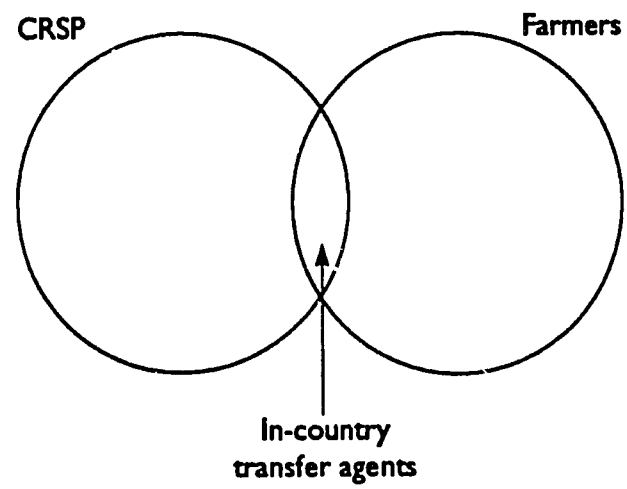

Figure 1. Participants stressed the importance of focusing communications efforts on in-country transfer agents.

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non-governmental organizations, and private voluntary organizations).

The following were considered the most important client needs:

- Information to make better decisions
- Explanations concerning how particular research packages can benefit users
- Information presented in a usable form
- Information presented in appropriate languages
- State-of-the-art technologies.

Barriers

The following were considered the most significant barriers to the fulfillment of client needs:

- Lack of feedback mechanisms
- Inadequate financial and human resources (e.g., communications expertise, funds for translation, etc.)
- Disciplinary rather than systems approach to research
- Institutional constraints
- Unrealistic USAID evaluation criteria (Is the goal state-of-the-art research or farmer impact?)
- Inappropriate reward system for researchers.

Recommendations

The group developed nine recommendations for the Board and the Technical Committee as they prepare the next five-year plan. The number of votes each recommendation received is listed in parenthesis.

1. The CRSP should establish a committee from each member institution to support communication, make policy, and establish peer review. (20)
2. The CRSP should develop a more effective mechanism for disseminating information to users. (15)
3. The CRSP should increase the development and distribution on non-technical materials—slides, print material, posters, audio-visual materials, radio. The CRSP should also work to provide equipment to National Agricultural Research Services and extensionists. (15)
4. The CRSP needs to develop better feedback mechanisms so that it can assess the effectiveness of its communications effort. (12)
5. Communications should receive high priority in designing and funding of CRSP activities. (12)
6. The Soil Management CRSP should cooperate with other CRSPs in communications activities. (11)
7. Research should be reoriented towards a systems approach/problem solving. (10)
8. Current and potential communications activities should be scrutinized in light of client needs and cost-effectiveness. (9)
9. Research projects should be selected according to clients' needs. (4)

Appendix I: Communications Problems

- Patronizing attitudes toward clients.
- Narrowness of the approach.
- Failure to listen.
- Failure to focus on relevant issues.
- Failure to establish a dialogue rather than a monologue.
- Unfamiliarity with audience.
- Lack of honesty.
- Inadequate understanding of cultural diversity.
- Language barriers.
- Financial/material constraints.
- Use of unfamiliar terminology.
- Attempts to reach a large and diverse audience with one form of communication that fails to meet any of the users' needs.
- Lack of two-way communication between farmers and researchers.
- Lack of follow-up to evaluate successes and failures.

Appendix II: Publications Survey

The rapporteurs conducted a publications survey among all the conference participants in an effort to identify target audiences and the types of publications that might improve soil management in developing countries. Forty people responded to the survey, 16 from developing countries.

Target Audiences

When asked to rank the five most important target audiences in order of priority from one to five, participants responded as follows; total votes are listed after the target group:

• Researchers in developing countries	120
• Extension personnel	98
• Administrators, developing country	82
• Farmers in developing countries	60
• USAID field staff	54
• NGO/PVO staff	45
• Teachers, trainers	34
• University lecturers	26
• Researchers in developed countries	26
• Administrators in developed countries	26
• General public in developing countries	7
• General public in developed countries	2

Although the private sector was inadvertently left off the list of choices, it nonetheless received four votes.

Types of Publications

When asked to rank the five most important types of publications, participants responded as follows:

• Technical reports	118
• Training manuals	107
• Extension booklets	95
• Journal articles	88
• Annual/biannual reports	48
• Newsletters	45
• Conference summaries	32
• Full conference proceedings	19
• Newspaper/magazine articles	9

Who Should Produce?

When asked to indicate who should be responsible for producing the various publications listed above, the general consensus was as follows:

- Technical reports: Individual CRSP members (IC)
- Training manuals: IC
- Extension booklets: IC
- Journal articles: IC
- Annual/biannual reports: Management Entity (ME)
- Newsletters: ME
- Conference summaries: ME
- Full conference proceedings: ME
- Newspaper/magazine articles: IC

Translations

To the question, "Is publication in English sufficient?" 30 respondents said *no*, and 10 said *yes*. Of those who said *no*, 9 felt that the Soil Management CRSP should be responsible for translations, 16 felt that developing-country organizations should assume that responsibility, and 5 indicated that a joint venture would be best.

Appendix III: Participants*

Gary Jann—Facilitator
Sidney Westley—Rapporteur
Tim McBride—Rapporteur
Russell Almaraz
Walter Butcher
Fred Cox
Hari Eswaran
C. Allan Jones
Charles McCants
Arthur Onken
Jorge Quinonez
Freddy Sancho
Benjamin Smallwood
Numbem Simeon Tchatchoua
Janice Theis
Thomas Thurow
Samba Traore
Gordon Tsuji
Goro Uehara
Charles Wendt
Russell Yost

* A list of addresses appears at the back of this report.

Appendix 1: Poster Session and Software Display

I. Sustainable Agriculture Posters

Number	*Title*	*Authors*	*Institution*
1.	Cumulative soybean response to phosphate in an Ultisol: N and P balances and impact on soil P availability	K. Cassman, P. Singleton, B. Linquist	NifTAL
2.	The fate of introduced rhizobia in tropical soils	P. Woomer, P. Singleton, B. Bohlool	NifTAL
3.	Responses of tree legumes to rhizobial inoculation in relation to density of indigenous rhizobial populations	D. Turk, H. Keyser, P. Singleton	NifTAL
4.	Soil phosphorus dynamics during continuous cropping in a Brazilian Amazon Oxisol	J. Nurwakera, J. Smyth	NCSU
5.	Ammonia volatilization from tropical legume mulches	K. Glasener, C. Palm	NCSU
6.	Long-term performance of alley cropping on an acid soil of the Amazon Basin	C. Palm, A. Salazar, L. Szott, E. Fernandes	NCSU
7.	Interaction effects of sorghum—genotypes, water level, and nutrient level	A. Onken	TAMU
8.	Soil related crop spatial variability in the Sahel	A. Manu	TAMU
9.	Decomposition of milled residue and cowpea green manure during the rainy season in Niger	K. Grahammer	TAMU
10.	Interactions of water, nutrients, and mulch on sorghum growth in a Sahelian soil-plant-atmosphere continuum	C. Zaongo	TAMU
11.	The economics of soil-water management technologies: a case study from Mali	J. Day	ERS
12.	Mycorrhizal dependency of the neem	M. Habte	UH
13.	An economic analysis of field trials in Mali	D. Taylor	ERS

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II. Outreach Posters

Number	Title	Authors	Institution
14.	NifTAL: BNF resources for agricultural development		NifTAL
15.	NifTAL's training program		NifTAL
16.	RISTROP: Four years of networking in Latin America on tropical soil management research	A. Cordero, F. Bertsch, J. Smyth	NCSU
17.	Evaluation of the initial responses to the alternative crops program by Bolivian farmers in the Chapare Region	L. Sturm, F. Smith	NCSU
18.	Soil Management CRSP alumni: a survey of their roles and responsibilities	D. Ursone, F. Smith	NCSU
19.	The training program of the Soil Management Support Services		SMSS
20.	TropSoils at Texas A&M University: past, present, future	A. Juo	TAMU
21.	The Technology for Soil Moisture Management	J. Day	ERS
22.	Contract growing to finance extension in Bolivia	D. Hoag, R. Castedo	ERS

III. Natural Resource Management Posters

Number	Title	Authors	Institution
23.	Application of GIS to assess constraints to sustainable land management in the Cimanuk Watershed (Java)		SMSS
24.	Major soil regions of the world		SMSS
25.	Microvariability in Vertisols		SMSS
26.	Integrated management of agricultural watersheds I	A. Manu	TAMU
27.	Integrated management of agricultural watersheds II	A. Manu	TAMU
28.	Soil properties influencing hydraulic sealing of the surface on Alfisols in the Sahel	J. Heil	TAMU
29.	Economic analysis of soil and moisture management and conservation	W. Butcher	ERS
30.	Soil moisture conditions in Africa		SMSS

IV. Software Display

Number	*Title*	*Authors*	*Institution*
31.	Models to predict legume yield responses to rhizobial inoculation	J. Thies, P. Singleton, B. Bohlool	NifTAL
32.	Fertility capability classification system	S. Buol	NCSU
33.	CROPSYST	C. Stockle	ERS
34.	CropSys: computer-based assessment of sustainability	B. Caldwell	UH
35.	Financial analysis for inoculant manufacturing enterprises	J. Rourke, M. Bartolins, P. Singleton	NifTAL
36.	U.S. Soil Taxonomy	S. Buol, R. Rebertus	NCSU
37.	A global database for soil moisture, temperature, and climate stress indices		SMSS
38.	Decision support systems for soil acidity and phosphorus	R. Yost	UH
39.	Soil data base for decision support systems	G. Tsuji	UH

Appendix II: Workshop Discussion Document

About This Document

This preliminary document was prepared by the Soil Management CRSP's Technical Committee and is based on the experience of CRSP project leaders and collaborators. It is intended to provide background information and to serve as a starting point—and only a starting point—for workshop discussion and focus.

To make the workshop as efficient as possible, we have briefly outlined the program's rationale and history. To stimulate discussion, we have also identified what we see as some important global research and development issues, and we have proposed a tentative mission statement, a tentative list of guiding principles, and a tentative framework of program activities.

We want you to react to this document—to raise questions and to provide information. Indeed, we are counting on you to do so. Only from such input can we hope to fashion a program responsive to the challenges we will face—together—over the next five years.

Workshop Purpose

The Global Planning Workshop has three primary objectives: (1) to provide information about who we are and how we have changed, (2) to identify the most pressing global research and development issues, and (3) to discuss the best way to deploy our collaborative resources over the next five years. After introducing you to our expanded capabilities, we will solicit your contributions on

- Establishing research and development constraints and priorities
- Specifying those areas where Soil Management CRSP input is most vital
- Identifying opportunities for collaboration,
- Identifying clients and strategies for implementation
- Establishing a framework for our 1994–1999 Global Plan

Program Rationale

Soil and water are the foundation for sustainable development. Whether one talks about crops or livestock, family health or economic vigor, genetic diversity or global warming, the underlying issue is the same: how are we using our soil and water resources?

The Soil Management CRSP begins here. We recognize that sustainable growth and rural economic development depend on the responsible use of these finite resources. Degrade the soil, mismanage water supplies, and the results are all too predictable: crops fail, economies founder, malnutrition increases, and the quality of life declines. As growing populations occupy ever more fragile lands, such problems threaten to proliferate.

To avoid such calamities, nations across the globe must increase the production of food, fuel, fiber, and construction materials without degrading the environmental resources on which their future well-being will depend. The Soil Management CRSP helps them meet this challenge. We collaborate with a broad range of national and international organizations to achieve a common goal: the development of culturally appropriate land-management technologies that are economically desirable and environmentally sound.

Program History

Core Universities

Founded in 1981 under Title XII of the United States Foreign Assistance Act, the Soil Management CRSP originally consisted of four institutions: *Cornell University, North Carolina State University, Texas A&M University,* and the *University of Hawaii.* This

partnership was designed to tap the large repository of scientific expertise housed in the U.S. land grant universities. Acting in concert with USAID and developing nations, researchers targeted a formidable problem: how can we become more efficient stewards of the world's soil and water resources?

Over the last 10 years, the Soil Management CRSP and its collaborators have begun to develop some answers, particularly with regard to the following subjects:

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

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

1992 Expansion

In 1992, the Soil Management CRSP expanded to include four additional organizations: the Nitrogen Fixation by Tropical Agricultural Legumes Project (NifTAL), the USDA/Soil Conservation Service (SCS), the USDA/Economic Resource Service (ERS), and the USDA/Agricultural Research Service (ARS). This merger broadens the CRSP's capabilities in new and exciting ways.

NifTAL

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

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

SMSS

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

USDA/ERS & USDA/ARS

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

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

Expanded capabilities

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

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

Research and Development Problems for 1994–1999

Before we can construct a program strategy that makes efficient use of our expanded capabilities, we will need to identify the most pressing constraints to sustainable soil and water management. In particular, we need to identify (a) knowledge gaps and (b) those areas where existing knowledge has not been organized in forms useful to policy-makers and land users. To help stimulate discussion, we propose that this process begin with the following tentative list of research and development issues:

- Soil resource assessment and monitoring (biological, physical, chemical)
- Managing soil biology
- Nutrient dynamics in low-input systems
- Soil organic-matter dynamics
- Solute transport processes
- Wind erosion
- Water erosion and sedimentation
- Soil crusting and amelioration
- Soil spatial variability
- Surface charge characteristics
- Soil water management—drought and waterlogging
- Genotype *x* environment *x* management interactions
- Socioeconomic variables
- Private-sector linkages
- Human and institutional resource development

Tentative Mission Statement

In light of our new resources—and in view of the problems identified above—our tentative mission is (a) to develop sustainable soil- and water-management practices for a broad range of landscapes and ecosystems, (b) to foster host-country capabilities which lead to the continued development and adoption of sustainable practices and policies, and (c) to increase awareness about the relationship between sustainable land management and environmental stability.

In carrying out this mission, the Soil Management CRSP will work

- To conduct demand-driven research aimed at increasing the productive capacity of the natural-resource base.

- To integrate social, cultural, and economic information into our analysis of the physical, chemical, and biological constraints to sustainable land management; particular attention will be placed on matching land uses to land characteristics and carrying capacity.

- To collaborate with host-country peers, members of regional and international centers, other CRSPs, PVOs, and private entrepreneurs—thus ensuring that

we use information wisely, adapt technologies to the user and the setting, and link programs to active networks. Such collaborations will also allow us to promote all the components of agroecosystem sustainability: productivity, stability, resiliency, and equitability.

• To provide technical assistance, as requested, on those soil- and water-related projects where our research and development programs afford us a comparative advantage.

• To deploy our activities in agroecological regions with representative physical, climatic, and economic constraints, thus increasing the global impact of our program.

• To generate economic and environmental indicators that enable natural-resource planners to simulate and assess the long-term impacts of various technologies.

• To encourage the broadest possible exchange and use of our technologies by holding technical conferences, developing expert systems, publishing research information, and establishing private-sector linkages.

Workshop Discussions

To help link program thrusts to specific constraints, the workshop is organized around three tentative program areas: Research Support Programs, Research Programs, and Outreach Programs. Discussion groups will concentrate of the topics listed below. Within each group, participants will be asked to

- Identify critical research and development problems
- Underscore those areas where Soil Management CRSP input is most vital
- Identify clients and strategies for implementation
- Identify partners and collaborators

I. Research Support Programs

1. Soil and land assessment and monitoring

Environmentally sound agricultural policies demand an accurate assessment of the natural-resource base and a reliable monitoring of its resiliency. Organisms and husbandry cannot be matched to the in-site characteristics of the land unless those characteristics are properly identified. In many developing countries, resource inventories are outdated, inadequate, or nonexistent. As a result, development plans often fail to consider the kinds of uses the land will support.

2. Knowledge synthesis and decision support systems

Soil management information increases daily, but users are often unable to avail themselves of it. If we are to overcome that problem, scientific data must be organized in forms that extension agents and policy-makers can use. Expert systems and geographic information systems can do just that: they turn raw information into useful knowledge. As a result, scientific expertise need no longer be confined to the research site or limited to the movement of a specialist. By forcing us to organize what we know into problem-solving products, these systems also expose research gaps and guide research priorities in ways that encourage the efficient use of funds. They help us avoid doing what has already been done and rediscovering what is already known.

3. Anthropology, economics, and public policy

Soil researchers recognize that socioeconomic realities influence the development and adoption of improved resource-management practices. New systems must offer lasting benefits and be compatible with indigenous perspectives. To identify such systems, we must integrate agroeconomic information and cultural feasibility considerations into each phase of the land-management research effort—from conception, to implementation, to recommendation.

Researchers also recognize that inadequate or inappropriate institutional policies can cripple development as effectively as acid soils or drought. Sustainable systems will not be developed unless we clarify the environmental impact of national policies on issues such as land use, private enterprise, agricultural prices, and credit.

II. Research Programs

1. Dryland ecosystems management

Fragile dryland areas like the Sahel are extremely vulnerable to degradation. In many regions, population pressures, the loss of vegetative cover, and shortened fallows have severely reduced the productive capacity of the resource base. Wind and water erosion, moisture management, nutrient dynamics,

spatial variability, and soil crusting all pose large-scale problems for farmers on dryland ecosystems. System-specific solutions to these problems are a prerequisite to land rejuvenation and sustainable management.

2. Steepland ecosystems management

Throughout the developing world, inappropriate steepland management threatens economic security and the environment. Preventative action is particularly important on these systems since mistakes can be irreversible: once the soil is stripped from a hillside, corrective measures often prove futile. Off-site problems can be equally dire: the risk of flooding increases, and siltation and runoff threaten water quality, public health, and aquatic biodiversity. Avoiding these problems will require an understanding of soil moisture and nutrient regimes, solute transport processes, and the complex interactions between genotype, the environment, and various management strategies.

3. Rainforest and humid ecosystems management

Every year, 14 million hectares of tropical rainforest disappear. These losses are often irrecoverable: genetic diversity is not a renewable resource, and the specter of global climate change threatens to alter permanently the balance of our world. If the expanding needs of growing populations are to be satisfied over the long-term, natural resources must be responsibly managed. Shifting cultivation—whether by slash-and-burn or bulldozer—must give ground to sustainable practices.

For that to happen, producers must maximize the productivity of lands that have already been cleared and minimize future clearing by carefully matching land characteristics to land use. Such outcomes are contingent upon a system-specific understanding of humid ecosystems. Soil acidity, nutrient deficiencies and losses, soil compaction, and an inadequate understanding of how various soil-crop-tree interactions affect the environment are among the chief constraints to the sustainability of these systems.

4. Remediation of polluted lands

In Eastern Europe and other heavily industrialized regions, severe soil and water pollution threaten human health, food security, and the productive capacity of the resource base. Rejuvenating these lands will require a detailed analysis of system-specific pollutants and an assessment of the remedial influence of various genotype/management interactions.

III. Outreach Programs

1. Technical support of USAID Missions and programs, as well as international, national, and private-sector organizations

Directly or indirectly, many development initiatives advocated by USAID and other organizations require land-management expertise: private-enterprise programs must match land uses to land-use characteristics; health programs must safeguard soil and water quality; nutrition programs must evaluate the productive capacity of the environment; natural-resource programs must predict and monitor the environmental impact of various human interventions. In addition, IARCs, NARs, and other CRSPs often lack the soils expertise necessary to maximize the effectiveness of their efforts. If these organizations are to serve their clients, they must have access to an integrated soil/water program. The Soil Management CRSP can provide both long- and short-term support to a wide range of such organizations.

2. Human resource development

Developing countries often lack well-trained researchers, educators, policy-makers, and extension agents. Such expertise is the foundation upon which sustainable land-management practices are built, refined, and adopted. Degree programs, workshops, scientific networks, and short-term seminars can all help to overcome this deficiency.

3. Communications

Diverse populations and agroecosystems require equally diverse resource-management technologies. Simply publishing and disseminating experimental results will not meet that need. In addition to synthesizing knowledge and organizing decision support systems, researchers must develop soil-management publications that serve the needs of technology-adoption personnel. If institutional strengths are to be effectively integrated, research goals, gaps, and results must also be communicated to an audience of prospective collaborators, as well as to policy-makers and private entrepreneurs.

Soils and Society: Responsible Management

Soil Management CRSP Global Planning Workshop
January 25–28, 1993
NCSU Campus
Raleigh, NC
USA

Monday, January 25

1:30–5:00 p.m.

Arrival and Registration: Brownestone Hotel

5:30–7:00 p.m.

Reception: Brownestone Hotel

Tuesday, January 26

7:30 a.m.

Transportation from Brownestone Hotel to McKimmon Center

8:00 a.m.

Late Registration: McKimmon Center

Opening Ceremony: Dr. Roger G. Hanson presiding
- Dr. J. C. Wynne: Welcome to NCSU
- Dr. Robert R. Shaw: Workshop Goals

Keynote Speakers: Dr. Robert R. Shaw presiding
- Dr. Alan R. Hurdus: New Challenges for the Soil Management CRSP
- Dr. Richard Sawyer: Wanted: The Wisdom to Address the Needs of Agriculture & the Environment

10:00 a.m.—Coffee

10:30 a.m.

Plenary Session: Experiences and Future Challenges: Dr. Richard Arnold presiding

- Host-Country Experiences
  Dr. Mamadou Ouattara
  Dr. Armando Ferrufino
- International Agriculture Research Centers
  Dr. Kenneth Cassman
- Soil/Water Resource Management Research and Development Issues—Present and Future.
  Dr. S. M. Virmani
- Soil Management/Environmental Relationships—Central and Eastern Europe
  Dr. Gyorgy Varallyay

Noon—Lunch

1:00 p.m.

Panel Session: Preparing the Research and Development Agenda—Research Support Programs, Research Programs, and Outreach Programs

- Moderator: Dr. Roger G. Hanson
- Panel Members:
  Dr. Hari Eswaran: *Soil & Water Resources Assessment*
  Dr. John Day: *Resource Economics and Policy Assessments*
  Dr. Ray Meyer: *Environmental Protection*
  Dr. Tony Juo: *Sustainable Ecosystem Management*
  Dr. Goro Uehara: *Information Technology Management*
- Rapporteur: Dr. Paul Singleton

2:45 p.m.—Coffee

3:15 p.m.

Session for Open Interactions: Dr. Jot Smyth and Dr. Paul Singleton presiding

- Poster sessions
- In-house achievements
- Computer scene

5.30 p.m.

Transportation to hotel

Wednesday, January 27

7:30 a.m.

Transportation from Brownestone Hotel to McKimmon Center

8:00 a.m.

Breakout Working Groups—Session I: Research Support Programs

Group 1: Soil & Land Assessment and Monitoring
- Facilitator: Dr. James H. Ware
- Rapporteurs: Dr. Hari Eswaran, Dr. Larry Wilding

Group 2: Knowledge Synthesis and Decision Support Systems
- Facilitator: Dr. Jeri Berc
- Rapporteurs: Dr. Goro Uehara, Dr. Susan Riha

Group 3: Anthropology, Economics, and Public Policy
- Facilitator: Dr. Gary Jann
- Rapporteurs: Dr. John Day, Dr. Frank Smith

Noon—Lunch

1:00 p.m.

Breakout Working Groups—Session II: Research Programs

Group 4: Dryland Ecosystems Management
- Facilitator: Dr. James H. Ware
- Rapporteurs: Dr. Lloyd Hossner, Dr. James Parr

Group 5: Steepland Ecosystems Management:
- Facilitator: Dr. Jerry Hammond
- Rapporteurs: Dr. Keith Cassel, Dr. Tony Juo

Group 6: Rainforest and Humid Ecosystems Management
- Facilitator: Dr. Gary Jann
- Rapporteurs: Dr. Charles B. Davey, Dr. T. Jot Smyth

Group 7: Remediation of Polluted Lands
- Facilitator: Dr. Jeri Berc
- Rapporteurs: Dr. Paul Singleton, Dr. Janice Thies

5:30 p.m.

Transportation to hotel

7:00 p.m.

Workshop Dinner: Brownestone Hotel, Dr. Eugene Kamprath, MC; Guest speaker: Dr. Tejpal Gill, USAID.

Thursday, January 28

7:30 a.m.

Transportation from Brownestone Hotel to McKimmon Center

8:00 a.m.

Breakout Working Groups—Session III: Outreach Programs

Group 8: Technical Support of USAID Missions and Programs, and International, National, and Private-sector Organizations
- Facilitator: Dr. Jerry Hammond
- Rapporteurs: Dr. Thomas H. Carr, Dr. John Kimble

Group 9: Human Resources Development
- Facilitator: Dr. Jeri Berc
- Rapporteurs: Dr. Philippe Baveye, Dr. Victor Phillips

Group 10: Communications
- Facilitator: Dr. Gary Jann
- Rapporteurs: Sidney Westley, Tim McBride

Noon—Lunch

1:00 p.m.

Workshop Conclusion: Dr. Richard Arnold presiding

- Reports from the Breakout Working Groups
  - *Group 1:* Hari Eswaran and Larry Wilding
  - *Group 2:* Goro Uehara and Susan Riha
  - *Group 3:* Frank Smith and John Day
  - *Group 4:* Lloyd Hossner and James Parr
  - *Group 5:* Keith Cassel and Tony Juo
  - *Group 6:* Charles Davey and Jot Smyth
  - *Group 7:* Paul Singleton and Janice Thies
  - *Group 8:* Thomas Carr and John Kimble
  - *Group 9:* Victor Phillips and Philippe Baveye
  - *Group 10:* Sidney Westley and Tim McBride
- The Task Before Us: Global 1994–99
  Dr. Roger Hanson and Dr. Tony Juo
- Workshop Highlights and Closing Remarks
  Dr. Robert R. Shaw

5:00 p.m.

Transportation to hotel

Appendix III: Addresses of Participants

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