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Sustainability Research in the CGIAR--Its Status and Future

Agenda Item 9

Attached is a preliminary report from the CGIAR Committee on sustainability of agricultural production systems for discussion under Item 9 of the agenda of the Canberra Meeting. This paper has been prepared by Jeffrey Leonard, Vice President of the World Wildlife Fund/Conservation Foundation. It is based on a meeting of experts from all of the CGIAR centers plus some others who conducted a detailed and systematic review of the programs of the centers, and of areas needing attention from the point of view of sustainability. The Committee, which is chaired by Leslie Swindale, Director General of ICRISAT, intends to continue its work and will present a final report, with supporting documentation, at a later stage.

Attachment

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CONSULTATIVE GROUP MEETING

May 29-June 12, 1989

Canberra, Australia

SUSTAINABLE AGRICULTURAL PRODUCTION:

REPORT OF THE CGIAR COMMITTEE

(Document No. MT/89/14)

Agenda Item 9

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1. INTRODUCTION

1.1 Scope of this Report

This report presents a summary of the work of the CGIAR's Sustainability Committee. The Committee has sought to build upon the findings of the TAC Report "Sustainable Agricultural Production: Implications for International Agricultural Research" (AGR/TAC: TAR/87/22 Rev. 2) presented at the Consultative Group Meeting in Berlin, Federal Republic of Germany, May 16-20, 1988.

Like the TAC Report, the Committee commenced its work with the assumption that much of the activity of the CGIAR Centers is already concerned with developing techniques that contribute to the introduction of sustainable agricultural systems. The underlying commitment of the CGIAR system to promote the reduction of poverty through increased food production, coupled with relentless increases in population and food demand, have necessitated that the CGIAR and the individual centers keep an eye fixed on the horizon. Will techniques developed today be sufficient to meet tomorrow's needs; will they endure the test of time? These have always been crucial questions helping to guide the centers in planning their research agendas.

The Committee in the initial phases of its work has focused attention on the strategic questions related to the subject of sustainability:

- Are the Centers doing enough?
- Is their research on sustainability addressing the most urgent and pressing problems?
- Is it an adjunct to existing research, or is a "sustainability perspective" infusing all research?
- Are there obvious gaps in the current work pertaining directly to the promotion of sustainable agriculture?
- Is there as much collaboration among IARCs as appears to be warranted by the cross-cutting nature of sustainability; for example, between commodity-, area-, natural resource-, and policy-based Centers where sustainability is a factor of the crop, the ecological setting, the level of resource management and the socioeconomic incentives that condition farmers' behaviors?

- Are there opportunity costs and other hidden trade-offs related to the fact that a growing portion of IARC research addresses long-term sustainability, as opposed to short-term production needs?

- Finally, what longer-term questions pertaining to overall CGIAR strategy and organization are raised by the sustainability issue?

1.2 Increased Focus on Sustainability

Rising concern about the sustainability of agricultural production systems in developed and developing countries provides both a measure of the past three decades of successful agricultural improvements and a profile of the most pressing agricultural challenges to be faced in the coming generation. As a result of considerable increases in yields and total production in critical food crops -- in general through the introduction of new varieties and input technologies on lands with high production potential -- there are many agricultural areas in developing countries where the critical task has become sustainability: maintaining and building on the gains already secured through agricultural modernization.

Greater attention to sustainability issues is also necessitated in many developing countries because population pressures have led to expanded efforts to cultivate more marginal soils under more difficult ecological conditions: drylands, steeplands, forestlands. The susceptibility of these lands to decreasing soil fertility, erosion or compaction is compounded by the fact that the poor people who exploit them generally do not have the technical knowledge, access to technology or finances to afford high levels of inputs that could help to compensate for natural soil limitations and environmental hazards.

Finally, growing concern about the environment in developing countries has also focused greater attention on agricultural sustainability. The strains on the natural resource base accompanying current efforts of poor populations to secure adequate food, fuel, fodder, and shelter, as well as growing environmental pollution from modern agricultural systems have been the subject of numerous recent studies and journalistic reports. Among the environmental problems linked to agriculture in developing countries are: soil erosion and degradation, deforestation, desertification, waterlogging, salinization, and pollution from agrochemicals. In addition, rising international concern about global climatic changes due to continued release of carbon and other greenhouse gases, and about the reduction in the earth's biological diversity, have highlighted awareness about the degree to which unsustainable agricultural practices in developing countries may have far-reaching, global ramifications.

1.3 The TAC Report on Sustainability

In its 1987 paper on CGIAR priorities and future strategies, TAC emphasized the need for an increased focus on sustainability. The CGIAR concurred with this recommendation and requested TAC to develop a comprehensive paper to a) characterize the specific problems of sustainability in agricultural production systems, and b) develop proposals for CGIAR strategies to address these problems.

The TAC Report on Sustainable Agricultural Production characterized the sustainability challenge in terms of removing impediments to forces threatening to reverse long-term increases in agricultural production. While emphasizing the need for input-lowering technologies and the need to stabilize existing agricultural production through improved land and water management, the TAC Report explicitly stressed that the CGIAR needed to promote sustainable agriculture within the context of continuing population growth and rapidly increasing food demand.

Although the TAC Paper was primarily addressed to the CGIAR and its role in international agricultural research, it stressed that many of the problems relating to sustainability could not be solved by the IARCs or through agricultural research alone. Hence, the TAC Paper concluded that the larger context for approaching the challenge of sustainability needs also to include: a) the national systems of research and development services that, ultimately, must bear the largest burden of delivering sustainable agricultural techniques to individual farmers in developing countries; b) the commitment by developed countries, as well as developing countries, to address forcefully the challenges of sustainable agriculture; and c) stronger support from bilateral and multilateral donors to assist developing country programs to attach higher priority to agricultural sustainability.

1.4 The IARC Response

Although the mandates of individual centers differ substantially, all the IARCs -- CGIAR and non-associated centers -- have focused on sustainability in their research. This is especially true in Centers with a mandate to address specific commodities (CIAT, CIMMYT, CIP, ILCA, ILRAD, IRRI, WARDA), geographical areas (ICARDA, ICRISAT, IITA), agricultural inputs (IFDC, ICIPE), natural resource systems (IBSRAM, ICLARM, ICRAF, IIMI), and overall food policy (IFPRI).

1.5 The CGIAR Sustainability Committee

The present CG Sustainability Committee was established by the Chairman of the Group, Dr. David Hopper in May, 1988 with Dr. Leslie D. Swindale, Director General of ICRISAT, as its Chairman. Its membership included representatives of all the CGIAR centers, TAC and the CGIAR secretariat. IIMI represented the non-associated centers.

The Committee's prime purpose is to: a) describe what the IARCs are already doing in relation to sustainability, and b) propose a program of new research initiatives for individual CG Centers and collectively among them, as well as with other IARCS, NARS, and universities.

2. MAJOR SUSTAINABILITY ISSUES DEFINED BY IARCs

A wide variety of challenges is encompassed under the concept of sustainability in agricultural systems. These include the need to find technical, institutional, and policy solutions to problems created by resource depletion, environmental degradation and contamination, natural and man-induced ecological changes, and the unequal distribution of resources and benefits. The IARCs are not set up to cover all aspects of sustainability. They are not directly concerned with research that impacts on the earth's ozone layer or on monitoring global warming. In the context of their collective mandate and of CGIAR policies and directives, they have focused on the following major threats to sustainable agricultures. A more comprehensive analysis of the processes which endanger or enhance sustainable agricultural production is found in Chapters 1 and 2 of the TAC Report.

2.1 Soil Degradation

Across all the commodities, regions, agroecological zones, and natural resource systems that comprise the research agendas of the major IARCs, the problem of soil erosion and degradation clearly emerges as the most significant threat to sustainable agriculture. Some combination of soil erosion, deterioration of structure, loss of nutrients, buildup of salts or other toxic elements, waterlogging and acidification is leading to the diminution or destruction of the productive potential of the soil in virtually every agricultural area of the developing world. IARCs have been forced to address this threat through breeding (e.g., for saline tolerance), additional inputs or shifts in cropping emphasis. However, the perception is growing, among commodity-based centers as well as those focusing on agroecological areas, that such "micro-adjustments" are not sufficient in many areas, and that sustainability will depend increasingly on improved soil and water management at the farming systems and national levels.

Soil degradation arising out of clearing of tropical rainforests is a serious problem affecting the integrity of the tropical ecosystem environment and the world's atmosphere. The efforts of CIAT in the Amazon, IITA in West Africa and IBSRAM, associated with these and other institutes in a global network, are worthy of note.

2.2 Genetic Diversity

The erosion or narrowing of the genetic base of agriculture is also universally seen by IARCs as one of the most significant threats to agricultural sustainability. The inherent increases in vulnerability that have accompanied the introduction of a few similar varieties of improved cultivars over large areas, and the potential loss of natural variability and primitive land races are viewed as increasing the risks of catastrophic collapses in the sustainability of agricultural systems under IARC jurisdiction. Most Centers with a focus on germplasm collection and research are seeking to reduce this risk by stepping up efforts to build well-preserved, pathogen-free germplasm banks with a full genetic range of improved and native species. One center, IBPGR, is dedicated entirely to activities related to plant genetic resources.

2.3 Variations in Climate

There has been some concern among climatologists and agricultural scientists about a change in rainfall patterns in an adverse direction in some parts of the world. An example is the Sahelian Zone of West Africa. Decreasing rainfall and devastating, recurring droughts in this region of Africa during the 70s and 80s induced many studies related to these changes in climate. Whether these are permanent trends and irreversible changes, short-term, irregular fluctuations or components of long-term cycles has not been fully established. While one study concluded that there appears to be no identifiable trend associated with these decreases of rainfall, another concluded that the wettest month in West Africa has recorded a persistent decrease in rainfall in the recent past. Decreases in rainfall and persistent droughts, leading to desertification have dire consequences for sustainability of agriculture in this region. Coping with decreasing trends in rainfall, frequent droughts and desertification are common concerns of those IARCs that work in these fragile agroecological environments.

Rainfall, everywhere, varies from place to place and year to year. Moving from high rainfall zones to lower ones in the world, the coefficient of variability of rainfall increases. As rainfall decreases, risks associated with cultivation of crops increase. Stabilizing production of agricultural commodities in these low rainfall environments is not only a question of sustainability of agriculture but also sustainability of human societies associated with them. A good example of agricultural production under a low rainfall regime is farming in Sub-Saharan Africa, particularly in the Sahelian Zone. Stabilizing production, by decreasing year to year fluctuations, in low rainfall zones of the world is the clearest way of achieving sustainability of agriculture. This could be achieved by a host of methods - breeding short-duration, drought resistant cultivars, using crops with high water use efficiencies, better residue management and other measures aimed at improved water management for escaping the risks associated with variable rainfall.

2.4 Maintaining Growth in Productive Agricultural Systems

All physical and biological systems are subject to a common law of nature - output in some manner depends upon input. Agricultural production systems being both physical and biological adhere to this principle. Inputs in the case of agriculture are cultivars, fertilizers, agrochemicals, light, water and management. The output is yield. The proportionality constant between input and output for any production system may vary widely. It is the challenge that agricultural scientists face to create as large a proportionality constant as possible so that a specific quantity of input is multiplied many times over as output. This is indeed the objective of much of IARC research.

The production systems for irrigated rice and wheat that have long been regarded as the CGIAR's most visible successes are also its main examples of high-input production systems. Maintaining their productivity is important for the world's supply of food. Increasing the genetic potentials for yield of the mandate crops, improving fertilizer and water use efficiencies, making crops and animals resistant to diseases and pests and improving the designs of irrigation systems are the IARCs contributions to this goal. The basic strategy is to maintain growth in productivity while reducing the harmful side effects of high-input systems wherever necessary in the developing world.

2.5 Pests and Nutrient Management

Pests and diseases reduce crop yields. Their control in much of the developed world has been through the use of agrochemicals. But agrochemical use is costly to the small farmers and has its hazards. Where they are used unwisely pests can become resistant to them. Excessive use -- due to ignorance in many instances -- is hazardous to the environment. The IARC answer to pest and disease control, where use of chemicals can be heavy, has been to try to develop crop cultivars which are pest and disease resistant. This has been part of the plant breeding philosophy for all commodity-based IARCs. Not all pests and diseases, however, can be controlled by this approach, and gene-based resistance usually loses its efficacy over time. In response to these concerns, centers have been moving towards greater emphasis on integrated pest management which combines genetic, biological, agronomic and chemical approaches in a strategy that is sustainable over time and least damaging to the environment.

A somewhat similar strategy of integrated nutrient management is receiving increased attention in several IARCs. It is aimed at reducing the dependence on chemical fertilizers and -- at the same time -- increasing the effectiveness of organically supplied nutrients.

2.6 Promoting Change in Less-Productive Systems

In the many marginal areas of the developing world, in the humid forests, the drylands, the extensive rangelands, most uplands and the hills, low-input agriculture has been practiced for centuries. Most centers devote significant attention to improvements in such low-input systems. They are concerned with accurate appraisals of the resources available, water use efficiency, nutrient cycling and residue management, low tillage systems, vegetative measures for soil conservation and improving the efficiency and yield potential of traditional cropping and grazing systems. Farming systems approaches are much in evidence. Agroforestry will play an important role.

There is clear recognition that there is often no alternative to low-input systems. But, such systems can increase income and ecological sustainability if farmers are able to utilize improved farming methods or advanced genetic varieties and are assisted to substitute management expertise for purchased inputs.

3. SCOPE OF IARC PROGRAMS ADDRESSING SUSTAINABLE AGRICULTURE

3.1 IARC Workshop on Sustainable Agriculture

The CGIAR Sustainability Committee organized an IARC Workshop on Sustainable Agriculture from February 20 to 23, 1989 at the headquarters of Winrock International. The names of participants are listed in the Appendix. In preparation for the IARC Workshop, IARCs were invited to prepare reports presenting their current projects and activities as well as future plans relating to sustainability. The participants at the Workshop used, and slightly revised, the TAC classifications of the determinants of sustainbility in analyzing their current activities and future intentions. These determinants are:

A. Physical Determinants
   - Soil
   - Water
   - Energy
   - Atmosphere
   - Hazardous Chemicals

B. Biological Determinants
   - Animal Health and Nutrition
   - Genetic Resources
   - Pests and Diseases
   - Natural Vegetation

C. Socioeconomic Determinants
   - Technology Policy
   - Prices
   - Institutions
   - Population
   - Infrastructure
   - Cost-benefit Relationship

Each IARC classified its existing and planned work in these subject areas, characterizing this work according to eight levels of complexity:

- Cell
- Organism
- Community of Organisms
- Production Level - Low and High
- National
- Regional
- Ecosystem

3.2 Sustainability Perspectives in Center Programs

A sustainability perspective is clearly discernible in much of what the Centers do. This is to be expected because the CGIAR from its inception has indicated to its Centers a strong inclination towards low-input agriculture, biological methods for controlling pests and diseases and methods for dealing with edaphic and climatic stresses. The Centers' mandate to serve the poor farmers of developing countries has often necessitated a focus on low-cost sustainable technologies.

3.3 Shift Toward Major Sustainability Issues

In recent years the Centers have taken substantial steps to respond to growing internal, donor community, and general public concern about sustainability. Several important general points can characterize these responses:

- All the IARCs surveyed are carrying out significant research relating to the sustainability of agriculture in relation to their crop, livestock, regional, and resource mandates. Most have firm plans to increase the scope and level of intensity of such work.

- Of the three broad sets of factors identified by the IARCs as determinants of sustainability, nearly 50 percent of all research activities relate to physical determinants. Another 32 percent relates to biological determinants and 19 percent relates to socioeconomic determinants of sustainability.

- Sustainability related research is dominated by four subjects: soil, genetic resources, pests and diseases, and technology policy. Taken together, these four subjects account for 52 percent of all the IARC research activities related to sustainability.

- The level of intervention varies widely among centers and across the various factors. Broadly, research relating to the physical determinants of sustainability clusters at the production level, while that relating to the biological determinants centers more on the cellular, organism, and community of organisms levels, and that relating to the socioeconomic determinants tends to emphasize production at national, regional, and ecosystem levels.

- Research related to socioeconomic determinants is heavily concentrated on technology issues, with nearly half of all IARC activity in this area addressing either technology evaluation or technology policy concerns. There is a notable dearth of research on institutional or economic policy issues relating to sustainability.

- Among the CGIAR Centers, sustainability is particularly important for Centers with area-related mandates -- CIAT, ICARDA, ICRISAT, IITA, and ILCA -- that include environments in the humid tropics, dry areas, or steeplands, with limited agricultural potential. In such areas, virtually all agricultural research projects face the test of sustainability at the outset because climatic and soil conditions leave little margin for extractive or high-risk techniques. The non-associated Centers with a natural resource mandate (IBSRAM, ICRAF, ICIPE, and IIMI) all have research programs that focus heavily on sustainability issues.

All of these general results tend to indicate that the CGIAR system's overall response to sustainability issues is surprisingly coherent. The specific problems receiving the most attention are clearly at the top of the list of developing country priorities and of concern to a wide variety of external constituencies.

3.4 Contributions of IARC Work to Sustainable Agriculture

The IARC Workshop on Sustainable Agriculture, and the materials prepared by IARCs in advance of the meeting, provide the basis for a broad overview of how the Centers are addressing the determinants of agricultural sustainability.

3.4.1 Physical Determinants

A sound, viable, and sustainable agricultural production system relies heavily on a stable natural resource base. In their current research programs, efforts to reduce or eliminate soil degradation are being pursued at varying degrees of vigor by almost all the international institutions. IRRI, ICRISAT, ICARDA, IITA, and IBSRAM are working on the problems associated with soil erosion, maintenance of soil fertility, and improved productive capacity of soil resources on a sustained basis. Other institutes (ILCA, CIAT, ICARDA, CIMMYT) are adopting conservation farming principles in their commodity programs for maintaining increases of crop production. CIAT, for example, is working on rice-pasture rotational systems for savanna

environments. IRRI is identifying common principles on conservation of soil resources, and in association with ISNAR, will be suggesting how these might be applied in agricultural development projects to increase the chances of their rapid adoption in country programs.

Maintenance of the quality of water resources and atmosphere is another area of concern. Several of the IARCs are devoting attention to issues related to the water component. IRRI, CIP, ICRISAT and ICARDA have research programs, currently underway, to monitor the quality of surface and groundwater on the production of their mandate crop/livestock systems. IRRI has made considerable progress in studying the effect of fertilizer and pest control chemicals application and the quality of water in paddy rice. ICRISAT has studied the nutrient and silt content of the run-off water in drylands in tropical environments. IIMI, of course, is much involved in promoting improved water management at the irrigation system level. IFPRI has also initiated several studies of irrigation policies, which have implications for environmental degradation.

All the centers have recognized that the potential sources of human-induced alterations of the "agricultural environment" have increased. There is a wide agreement in the IARCs that the application of fertilizers and agrochemicals to increase yields and to control crop and livestock pests pests must be done judiciously so that no unfavorable changes in the quality of water, soil, or atmospheric environment occur. ICRISAT, IITA, ICARDA, and IRRI, in their resource management programs, are attempting to evolve land use systems which increase crop production while conserving soil and water resources through inter-disciplinary research. ILRAD and ILCA are working out efficient systems of animal disease control and animal management systems for the small African herders which lead to environmentally sound sustained increases in productivity. ICIPE is conducting research and field trials on low-cost alternatives to chemical means of pest control.

In the coming years, several Centers indicate plans to initiate research on changes in the physical environment related to atmosphere, energy, and water. The impact of precipitation variability in the Sahel on sustainable farming systems is to be studied by ICRISAT, ILCA, and IITA. In the Indian sub-continent the variability of seasonal rainfall has shown a remarkable increase in recent years.

3.4.2 Biological Determinants

The prospects for the widening deficit between food supply and demand in many developing countries underscore the need for continued research efforts to expand food output. The IARCs are currently placing major emphasis upon research to achieve sustainable crop and animal production. The centers are making a distinction between sustainability and productivity. While greater productivity will be required to achieve sustainable goals, the productivity must be achieved in such a manner as not to jeopardize the ability of agriculture to meet future needs.

Biological determinants of sustainable agriculture are being addressed through the collection, conservation, and improvement of genetic resources of cultivated crops and related species; research on pests and disease and animal health and nutrition. Animal-based farming systems have been the mainstay of sustainable agricultural systems in ecologically fragile agroenvironments. ILRAD and ILCA located in Africa are two of the IARCs conducting studies on various aspects of animal production systems. ILRAD has by far the most extensive program of research on animal disease control and chemotherapy. ILCA pursues research on animal traction, reproductive wastage, and nutrition and geographical information systems. ICARDA is working on more productive crop-livestock systems, focusing on small ruminant nutrition through increased crop yields, fallow replacement with forage legumes, and natural pasture improvement on marginal lands. CIAT is studying animal-based rice/pasture systems. These research activities related to animal production systems in the IARCs would help introduce sustainable land use systems in African agriculture.

Given that a dynamic concept of sustainability implies increasing productivity to meet the needs of an expanding population, without degrading the environment, germplasm-related research at the IARCs has major implications for sustainability. Many of the IARCs have a substantial program of germplasm collection, maintenance, and improvement through crop/animal breeding. IBPGR has a broad mandate to stimulate work on plant genetic resources. Genetic improvement research at IRRI, ICRISAT, CIAT, ICARDA, CIP, and IITA is designed to increase crop productivity while introducing and maintaining resistance to environmental stresses such as pests, drought, salinity, and soil-related constraints. IFPRI is exploring the social and economic consequences of the adoption of high-yielding crop varieties and related agrotechnologies on income generation and labor requirements.

The key areas of agrobiological research for sustained agricultural growth for the future are: a better integration of genetic improvement research with resource management research; and the introduction of woody perennials (trees) and herbaceous perennials (pastures) to sustain crop and animal productivity; and development of relatively high performance production systems that do not necessarily require considerable large amounts of commercial inputs.

3.4.3 Socioeconomic Determinants

Sustainable socio-economic systems -- at household, community, and governmental levels -- provide the institutional environment within which sustainable agriculture is carried out. Socio-economic research conducted by the Centers has helped guide the development of new agricultural technologies to address farmer's needs, and to monitor the adoption phases of technology introduction. At the same time, the methodologies of on-farm socio-economic research with close farmer-scientist interaction has served as an important model to NARS scientists and government agencies. The importance of farmer participation in developing and selecting new technologies is critical to sustainable adoption, and necessary adaptation, of those technologies.

Nearly all the Centers are addressing some aspect of the links between socio-economic conditions, adoption of agricultural technologies, and environmental degradation. The issue of ex-ante analysis of new technologies has received attention at IFPRI, ICRISAT, IRRI and ILRAD. A collaborative study by IFPRI and CIAT is focusing on the socio-economic circumstances, and economic policies, affecting technology design for the Peruvian Amazon.

An increasing interest in technology and resource management, and the macro-economic policies influencing agricultural practices, has brought several Centers face-to-face with sustainability issues. The capacity of small farmers to obtain fertilizer (CIAT and IFDC), storage and marketing of potatoes (CIP), producer cooperatives for cassava (CIAT), and efficient use of natural resources (IIMI and IBSRAM) are examples of program areas where this has happened. IFPRI's work in policy analysis has drawn attention to the importance of national-level agricultural policies in rationalizing resource use. Cooperative activities with IRRI, IIMI, ICRISAT, CIAT, ILRAD, CIMMYT, ICARDA, IITA, and other Centers have explored particular aspects of policy which have direct as well as indirect implications for sustainable agriculture.

The IARCs acknowledge that the factors that influence adoption of sustainable and improved agricultural technologies by resource-poor, small farmers are often largely socioeconomic in nature. Therefore, a growing awareness was expressed that future research by IARCs on issues related to sustainable agriculture must consider the interaction between physical and agrobiological (technical) factors on the one hand and socio-economic factors on the other. Hitherto, more emphasis has been placed on the technical factors. In future, increased attention needs to be accorded to socio-economic factors as well. Since poverty is not the only factor which determines the adoption of sustainable agricultural technologies, socio-economic research should emphasize national policy intervention, financing, and population growth as important interacting factors that must be researched in-depth for introducing technologies that reduce environmental degradation.

3.5 Opportunities for Cooperation Among IARCs

The common interests of most centers in such major issues as soil degradation, genetic resources, maintaining high-input systems and improving low-input systems provide opportunities for cooperation among centers. ICRAF, ICRISAT, IFDC, IITA, and ILCA, for example, are cooperating in the development of sustainable, low-input millet-based cropping systems in the Sahel. ILCA, ILRAD and ITC are cooperating the development of animal production in tsetse-infested areas. IBSRAM, CIAT and IITA are working on improving the productivity of acid soils in humid areas.

Achieving sustainable agricultural production in broad agroecological zones inevitably requires that several IARCs work together. And donors and NARS, increasingly, require focus on a total package of the crops, technologies and inputs necessary to maximize incomes. They want to know not only what IRRI or WARDA can provide to help make upland rice more productive and sustainable, but what the other commodity alternatives are in the same highland areas.

While most of the IARCs have made considerable progress in identifying the major sustainability concerns to be addressed in accordance with their particular mandates, the activities do not yet constitute a concerted strategy oriented around a set of global and regional priorities. In short, the micro issues of sustainability are being well addressed by the IARCs, while broader strategic questions that cut across the work of many Centers - and should provide guidance for the work of individual Centers - are now largely dealt with through ad hoc cooperation.

A major activity for the Sustainability Committee in the next 12 months will be to examine these areas for intercenter cooperation on sustainability issues on a zonal, regional and global basis.

3.6 Helping National Organizations Address Sustainability Issues

3.6.1 Cooperation with NARS

The TAC Report strongly recommended that all Centers should give high priority to strengthening the capacity of National Agricultural Research Centers (NARS) to incorporate a sustainability perspective in their work. Recognizing that many problems of sustainability are location specific, the TAC Report concluded that "the success of research related to sustainability will ultimately depend on the commitment and effectiveness of the national systems."

Participants at the IARC Workshop emphasized strongly that the spread of agriculture into marginal and low-fertility soils, or areas with extreme topographic or climatic conditions, coupled with the growing need to develop input-lowering technologies to meet the needs of poor farmers, greatly add to the urgency of strengthening the capability of National Agricultural Research Systems (NARS). Technological innovations that hold promise for contributing to sustainability need to be adapted to a widening variety of localized ecological and socioeconomic conditions.

One concern raised by several participants at the IARC Workshop was the sense that sustainability will not be perceived to be a major issue by NARS which are currently preoccupied by the need to secure short-term production increases to meet rising food demand. IARCs agreed that the issues of long-term sustainability must be weighed against immediate demands for results that are often placed on NARS. In some instances, the acceptability and reversibility of gradual decline (e.g., in soil fertility) might need to be stated explicitly as a planned phase of a strategy to accommodate first the short-term necessity of growth and address later the sustainability questions.

The growing complexity of public sector - private sector (including NGOs) interfaces for agricultural research poses major requirements for institutional innovation to link farmers with technology designers. Such links will be essential for technology generation for sustainable small farm systems, and this implies massive adaptive research capacity for addressing location-specific interactions. Farmer participation in research will become an increasingly important strategy of NARS, with farmers playing key roles in planning and executing adaptive research.

3.6.2 Cooperation with Universities

Many sustainability issues in agriculture are also environmental issues of national and international concern. They must be studied and remedial action taken through enlightened national and, in some cases, inter-governmental policies. Universities with their intellectual freedom, and academic insights could be partners in investigating the broader issues of sustainability in relation to the environment. Cooperation among NARS, IARCs and developing country Universities with their intelectual freedom, and academic insights could be partners in investigating the broader issues of sustainability in relation to the environment. Three-way cooperation among NARS, IARCs and developing country universities could evolve into a powerful system that not only generates technological solutions to sustainability issues but helps bring about public awareness and necessary policy changes.

4. GAPS IN CURRENT CENTER ACTIVITIES

4.1 Measurement and Long-Term Studies of Sustainability

The difficulty that has accompanied even the process of trying to develop an agreed-upon definition of sustainable agriculture points to a major task remaining: to develop practical and quantifiable indicators by which the concept can be measured. There is universal agreement on the need for longer term studies pertaining to the factors that contribute to sustainable agriculture, as well as the need to develop shorter term measures of sustainability. Without measurement we cannot make comparisons or assign priorities among competing alternatives. The real issues that are unaddressed include who should undertake such studies, how they should be conducted, and who will finance them. Sustainability must become an operational concept which can help guide IARC priorities.

4.2 Sustainability of Emerging Farming Systems

Farming systems evolve with changing population densities, demographic profiles and economic circumstances. In Africa, for example, it is not sufficient to work to ensure the sustainability of existing low-intensity, labor-short farming systems when these will almost certainly evolve into more intensive, labor-abundant farming system within one or two generations. Efficient management of land, labor, and agro-inputs becomes increasingly critical to environmental sustainability, as well as economic productivity, under conditions of greater agricultural intensity. There is little evidence that the Centers are undertaking significant research addressing these dynamics.

The urgency of developing measurable definitions of sustainability in agriculture is redoubled by the need to address the issue of emerging farming systems. If input-lowering techniques result in reduced yield, or decreased soil productivity over time, they are not likely to prove sustainable. In short, IARC efforts to meet one priority (lowering inputs) may conflict with the priority to promote sustainability for the future. A critical need, therefore, is to provide the NARS, and hence, farmers with accurate, readily usable information about how adaptation of low-input methods will likely affect sustainability -- long-term soil productivity, farm profit margins, level of environmental externalities generated, labor requirements, etc. This research is likely to prove methodologically complex because the net result of specific changes in farming methods for agricultural sustainability cannot be anticipated without extensive information about the variables throughout the whole farming system. To ensure the accuracy and usability of such research results, the design and implementation phases must emphasize a multidisciplinary and multiorganizational approach --incorporating the participation of farmers, public agencies, and private organizations.

4.3 Farmer Responses to Changing Environments

Many recent studies have documented the elaborate adaptations which small farmers undertake to increase production in response to changing environmental or ecological circumstances. At the same time, much of the failure to maintain sustainable agricultural systems in certain environments (e.g., tropical moist forest and semi-arid zones) can be attributed to the fact that traditional low-level systems of utilization have broken down in the face of population growth, political change or socioeconomic trends and there have not been appropriate higher production systems to take their place.

IARC efforts to develop and introduce improved germplasm materials and appropriate packages of inputs within a sustainable farming system will need to be based more and more upon an understanding of the process by which farmers adjust to changes in external environmental circumstances. Farming systems research merits re-emphasis.

4.4 Livestock Gene Bank

The scope of Center activities aimed at preserving livestock genetic resources lags far behind the work on plant resources. ILCA is the primary Center with a program to characterize and evaluate indigenous livestock breeds, as a supplement to national efforts. Thus far, this work has not included preservation of germplasm. An FAO program to establish regional animal gene banks is still at the desk study stage. There exists a critical gap in research to develop storage technologies (e.g., deep freezing of DNA) and utilizing known technologies (germ plasm storage) to preserve rare breeds.

4.5 Potential Role of Biotechnology

A number of Centers, as well as the 1988 TAC Report, raised the potential for forthcoming advances in biotechnology to be channeled more toward the promotion of agricultural sustainability. Nevertheless, aside from the general assumption that biotechnology innovations will per force contribute to sustainability by raising productivity and lowering inputs, little effort appears as yet to be going into assessing the utility of future biotechnology research in offsetting such major threats to agricultural sustainability as soil degradation and the erosion of genetic resources.

A more explicit effort to integrate the sustainability dimension into CGIAR Center biotechnology agendas may be of critical importance because private sector advance in biotechnology may be driven by market forces and corporate strategic planning factors that militate against a focus on sustainability criteria.

The current World Bank/ISNAR/Australian Government study, "Agricultural Biotechnology: Opportunities for International Development," which is the subject of the May 25-26 meeting prior to the CGIAR meeting in Canberra, may provide an appropriate forum for discussions about integrating long-term biotechnology research and sustainability concerns.

4.6 Rehabilitation of Degraded Lands

At its May 1986 meeting, the CGIAR took note of the growing need to address the challenges of rehabilitating lands that have lost their agricultural potential. One of the few examples of IARC involvement in this issues has been CIAT's work in the Amazon to introduce perennial pastures to degraded lands. Obviously, such rehabilitation is often dependent upon: a) developing national political will to remove the source of excessive exploitation to allow natural regeneration, or b) major structural repairs or construction of large infrastructure --

such as dams and irrigation systems. The IARCs are unlikely to play a major role such cases. However, germplasm improvement and field trial research undertaken by IARCs could lead to considerable advances in the availability of technology and knowledge for promoting biological processes that can enhance efforts to regenerate the productive capacity of the lands themselves.

This is likely to be a subject which is of greatly increased concern to NARS in key countries where large amounts of arable land are currently being removed from production as a result of land degradation. In fact, IARC programs to screen plants for nitrogen-fixing, soil stabilization, moisture retention, and other regenerative qualities that would be valuable, might start by reviewing the experiences of NARS and other national organizations in countries such as India where major efforts are already being made to rehabilitate degraded lands.

4.7 Trees in Farming Systems

To maintain and improve soil productivity in fragile soils in rainfed areas with limited availability of inputs, several IARCs have promoted the introduction of small trees and shrubs (usually woody legumes with nitrogen-fixing ability) into traditional cropping systems. Long-term evaluation of these techniques have indicated that in many cases, other determinants being equal, they can enhance sustainability by helping to maintain soil productivity over time. The introduction of woody species also further enhances sustainability at the farm systems level by providing fuelwood, browse for livestock, and building materials.

Forestry techniques can be especially important in enabling resource-poor farmers to intensify land use in circumstances where size of land-holdings is decreasing and to reduce the demands for farm labor and management as labor becomes more costly. In addition, since poor farmers also are more likely to turn to agroforestry at a point where farm sizes are falling below the size needed to support basic household food needs, this is often also the point at which income generation from on-farm and off-farm activities becomes crucial to smallholder sustainability. This points to the need already well-stated in the recent Bellagio II meeting on tropical forestry for much greater attention or awareness by CGIAR Centers engaged in agroforestry-related work to the forestry side of the equation: the utilization and marketing of forestry products; and the analysis of the direct income-generating potential of various woody species, in addition to their potential for adding to soil fertility and stability. IITA and ICRAF have recently initiated a cooperative project to conduct a multipurpose tree screening operation in connection with alley cropping systems. One objective is to identify useful species for the generation of browse, fuelwood and wood products.

5. LONG-TERM ISSUES RELATING TO CGIAR AND AGRICULTURAL SUSTAINABILITY

5.1 New Resource Needs

An obvious dichotomy emerges between the sustainability concerns that IARCs are addressing, given in Sections 2 and 3 of this report, and the gaps in sustainability work identified in Section 4. In the case of the former, the IARCs have incorporated the sustainability dimensions directly into their ongoing work as the issue has gained salience and its omission in the past has been seen to have incurred costs or added risks. In most of the areas identified in Section 4 as requiring greater attention within the CG system, the low-level of incorporation into ongoing IARC work is attributable to two factors. The first is that many of these concerns are cross-cutting or system-wide by nature and no clear and obvious lead-center emerges. This, of course, is not an insurmountable problem, as a number of formal and informal coordinating mechanisms could be devised to assure that no one center bears the burden of the entire CGIAR system's responsibilities.

The second barrier to promoting greater attention to the sustainability concerns raised in Section 4 is probably more difficult to address -- the limited availability of resources for new programs. While generally agreeing that many of these concerns are of high priority and require additional attention, Centers are reluctant to reallocate existing resources so rapidly as to endanger the successful completion of ongoing research. It would therefore seem imperative that additional resources be made available in the interim period to allow a smooth transition of their research focus. Several of the commodity-based centers voiced concern about being pushed away from what they see as their distinct comparative advantage -- cellular and organism level research to improve the overall genetic quality and enhance desirable characteristics of plant germplasm. If the CGIAR as a whole is committed to establishing major new lines of research that focus directly on sustainability issues, new funds must be found or a sense of what level of priority these lines should take over existing activities will have to be clearly conveyed to centers.

5.2 Opportunity Costs of Sustainability Focus

The fundamental objective of the CGIAR is to raise farmer productivity through the generation and dissemination of improved technology. Like equity and poverty alleviation concerns, long-term sustainability issues are important criteria for guiding strategic choices about priority problems to address and solutions to pursue. But, as several participants at the IARC Workshop on Sustainable Agriculture noted, the CGIAR is judged,

year-in, year-out, on the basis of its ability to keep up yields of major food crops. Failure to do so, even where there is a sacrifice to long-term sustainability, could mean the difference between food security and deprivation for millions of poor people.

The point is not that sustainability should always take a backseat to short-term production goals -- all the participants in the IARC Workshop see the need for an emphasis on achieving levels of production that can be realistically expected to endure. At the same time, pursuance of sustainable agriculture as a single-minded goal in all instances would greatly reduce the flexibility of NARS and IARCs to meet urgent priorities or to pursue a transitional strategy through prudent introduction of a phased series of agricultural activities.

5.3 Underlying CGIAR Goals and Objectives

Concern about the need to promote increases in agricultural production that are sustainable of necessity raises fundamental questions that go to the heart of the defined mission of the CGIAR system as a whole. While the system was born with the mission of increasing total food production potential in developing countries, it is ever clearer that this objective is tempered by sustainability considerations, by the need to lower external inputs, and by the need to support poor people who live in less-favored areas that will never contribute substantially to aggregate food production.

Maximizing total production of key staple foods must still be the objective in favored agricultural areas, as these areas must provide abundant, cheap food for growing urban populations. But three trends -- growing landlessness, decreasing plot size and increased exploitation of marginal lands -- make the maximization of household food production unsustainable from both economic and ecological perspectives for many poor farmers. Although increased food production must remain at the heart of CGIAR ideology if the system is going to truly meet the needs of poor farmers (with smaller and smaller plots of land in more and more marginal areas), it must in the long run orient itself to a greater extent to maximizing productivity of the whole farming system. More focus of Center research on perennials and non-food crops, income-producing agroforestry activities, poultry and other non-ruminant animals for market, on- and off-farm processing activities, part-time farming, and fruit and vegetable raising is likely in the future. The important point is the obvious one that, especially in marginal environments, neither food security nor sustainable agriculture are always built solely on food production.

5.4. Relations with Non-Associated Centers

The increased focus on sustainability, and the questions this raises about organization and coordination of work among the CGIAR Centers are interdependent with larger questions about the long-term relationship between the CGIAR and the non-CGIAR international research centers. The fact that these non-CGIAR centers have special mandates to address specific resources -- soil, water, forests - or management of strategic inputs - fertilizers, crop protection - gives them a strong interest in many of the critical issues underlying sustainability in agriculture. A special meeting held in March 1988 addressed the opportunities for greater CGIAR program cooperation with such Centers. The paper from that meeting, "Natural Resources and Sustainability in the Developing Countries: Meeting the Challenge with International Research," was discussed at the CGIAR meeting in Berlin in May 1988. It provided input for the discussions on cooperation at the IARC Workshop on Sustainable Agriculture.

5.5 Communicating the Appropriate Role of IARCs

Increasing focus on the issue of agricultural sustainability has prompted a broader array of external actors to become interested in influencing the research agenda of the CGIAR, either directly or indirectly through donors. In particular, a number of environmental and private voluntary organizations from the United States have devoted more attention to examining CG Center research programs and strategic plans. Although it is doubtful that these organizations will develop a broadsided critique such as their attempt to publicize environmental problems associated with infrastructural projects supported by multilateral development banks (MDBs), the potential for miscommunication about specific IARC-sponsored research is clearly increased.

One very crucial point for clarification is the distinct role that the IARCs play in the whole chain of actions necessary to develop, test, and disseminate agricultural technology. Probably the most prevalent criticism of the CG Centers voiced by the politically influential NGO community is the perceived lack of wide adaptation of Center-developed technologies in the fields of small farmers throughout mandate areas. In part, this stems from a continuing misperception that the IARCs are supposed to work directly with farmers in their fields and a misunderstanding of the role and mandate of the NARS. In addition, despite the priority focus of most CG Centers on input-lowering technologies for resource poor farmers, and the overwhelming commitment of the entire system to food crop production, it is remarkable the extent to which external observers associate the CGIAR with high input, large-scale, commodity production agriculture.

There is also growing potential for current international debates about plant genetic resources to inadvertently have an adverse impact on the CGIAR's ability to promote sustainable agriculture in many developing countries via plant introduction.

The challenge raised by growing external scrutiny of CG-Center activities is more one of communications than it is one of radically changing what Centers are doing. A 1988 letter by a consortium of U.S. environmental and development NGOs, the Committee on Sustainable Agriculture in Developing Countries, pointed out to the CGIAR Secretariat "the importance - indeed the urgency - of the Centers doing more effective work to get the story of their accomplishments out to political and opinion leaders in donor countries, particularly the United States."

6. CONCLUSION

In an age when agricultural research is becoming increasingly politicized by use of polarizing classifications such as low-input and high-input, or chemical and organic farming, the Sustainability Committee believes that all Centers should view the concept of sustainability as a guide to the introduction and development of agricultural techniques and technologies. IARC research and other activities should seek to optimize biological output and economic return to farmers through efficiency in the use of inputs, while minimizing or reversing, soil degradation and environmental contamination. The challenges will vary greatly according to environmental, economic, and social conditions, but the essential tasks for all the Centers must be to determine the appropriate balance based upon scientific research, field experimentation, and measurements of farming systems and their associated components. Production of good quality genetic materials through basic scientific work on the physical, chemical, and biological processes involved in plant and animal growth remains the critical contribution that the CGIAR Centers can make to the objective that must underlie sustainable agriculture: through efficient use of inputs, optimizing production within the agro-ecology of the resource base at less total energy and environmental cost.

APPENDIX

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ACRONYMS AND ABBREVIATIONS

CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIP	Centro Internacional de la Papa
IARC	International Agricultural Research Centre
IBPGR	International Board for Plant Genetic Resources
IBSRAM	International Board for Soil Research and Management
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIPE	International Centre for Insect Physiology and Ecology
ICRAF	International Council for Research in Agroforestry
ICRISAT	International Center for Insect Physiology and Ecology
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IIMI	International Irrigation Management Institute
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Center for Africa
ILRAD	International Laboratory for Research on Animal Diseases
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
ITC	International Trypanotolerance Center
NARS	National Agricultural Research System
MDB	Multilateral Development Bank

NGO	Nongovernmental organization
TAC	Technical Advisory Committee to the CGIAR
WARDA	West Africa Rice Development Association