From: The Secretariat

October 5, 1992
ICW/92/15

International Centers' Week
October 26 - 30, 1992
Washington, D.C.

Agenda Item 19 - Other Business

A CGIAR Response to UNCED Agenda 21 Recommendations

1. At the Istanbul Mid-Term Meeting (May 19-22, 1992), the Group endorsed the continuing association of the CGIAR with the evolving UNCED process, and decided that when specific activities are proposed as a follow-up to the Earth Summit (Rio de Janeiro, Brazil, June 3-14), the CGIAR should determine the role that it could play in such programs.

2. To assist the Group in making that determination, the CGIAR Secretariat in collaboration with CGIAR centers has produced the attached paper which responds to Agenda 21, UNCED's action plan that covers over 100 program areas which integrate the environment with development.

3. The paper points out the high degree of congruence between the goals of the CGIAR and Agenda 21 recommendations relating to agricultural sustainability and improved conservation and management of natural resources. It contains concrete examples of how CGIAR centers have already contributed, within the framework of their own priorities, to the objectives of Agenda 21, and indicates how much more could be undertaken. The analysis and record of achievement point to a range of opportunities for additional investment in the CGIAR system as an instrument for implementing elements of Agenda 21.

4. The Group is asked to react to the substance of this paper, to comment on its ideas in the context of the discussion at Istanbul, and to recommend the appropriate next steps by which the experience and expertise of the CGIAR system should be directed towards Agenda 21.

Attachment

Distribution

CGIAR Members
Center Board Chairmen
Center Directors
TAC Chairman
TAC Members
TAC Secretariat
Observers
A CGIAR RESPONSE TO UNCED AGENDA 21 RECOMMENDATIONS

CGIAR Secretariat
Washington, DC
October 5, 1992
### Table of Contents

<table>
<thead>
<tr>
<th>Section III.</th>
<th>CGIAR Sustainability Related Research: Emerging Results</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Conservation of Genetic Resources</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>• Genetic Improvement and Disease Resistance</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>• Integrated Pest Management</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>• Reducing Dependence on Commercial Fertilizer by Increased Use of Legumes and Development of Nitrogen Efficient Cultivars</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>• The Role of Crop Residues and Green Manures in Containing Soil Erosion</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>• Improved Water Management and Integrated Agriculture/Aquaculture</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>• Improved Agroforestry Technologies</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>• Socio-Economic Policy Research on Fragile Ecosystems</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section II.</th>
<th>UNCED Agenda 21 Recommendations on Agricultural Sustainability, and Improved Conservation and Management of Natural Resources</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Integrated Approaches to the Planning and Management of Land Resources</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>• Integrated Approaches to Improved Management and Use of Water Resources</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>• Conservation of Biological Diversity and Environmentally Sound Management of Biotechnology</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>• Management of Fragile Ecosystems</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>• Marine Resources and Coastal Area Management</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>• Combating Deforestation</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>• Policy Research</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>• Strengthening the Capacity of National Institutions</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

| Section I. | Introduction: The CGIAR’s Revised Goals | 1 |

| Executive Summary |  | i |

---

*Note: The table is a summary of the main sections and topics covered in the document.*
Section IV.

Key Issues and Problem Areas

- Identifying Emerging Threats to Sustainability
- Sustainable Agriculture and External Inputs
- The Special Challenge of Marginal Lands
- Blending Traditional Knowledge and Modern Science
- Systems Research: Interaction with NARS
- Research Time Horizons

Section V.

Financial Implications

- Current Status of CGIAR Financing and Center Resource Allocations
- Donor Support to the UNCED Agenda 21 Recommendations and Likely Pay Off
- Conclusion
A CGIAR RESPONSE TO UNCED AGENDA 21 RECOMMENDATIONS

Executive Summary

(i) The main objective of this paper is to emphasize the potential of the CGIAR System to contribute to implementation of recent UNCED Agenda 21 recommendations and in particular those relating to agricultural sustainability and improved conservation and management of natural resources.

(ii) There is a high degree of coincidence between UNCED Agenda 21 objectives and CGIAR goals and the CGIAR welcomes that coincidence as confirming the validity of the research priorities it has been following in the past.

(iii) A review of the track record of the CGIAR in contributing to sustainability and the accumulated research experience in the System, also confirm that the CG System could make a decisive contribution to tackling many of the major areas of environmental concern identified in the UNCED Agenda 21 recommended Action Program.

(iv) Key elements in CGIAR strategy include its potential to contribute to the intensification of agricultural productivity in more favorable lands which is helping to reduce pressure on marginal ecosystems. Germplasm conservation, evaluation and enhancement research, is contributing to maintenance of biological diversity and to production of crop/livestock genetic material that can resist abiotic stresses and survive well in marginal environments. Increased emphasis on use of integrated pest management technologies and leguminous nitrogen fixing agricultural and tree crops, is helping to reduce dependence on chemical pesticides and fertilizers. CGIAR research on agriculture, forestry, and aquatic farming systems, has led to development and adoption of improved technologies and sustainable management practices. Support to socioeconomic policy research is leading to improved understanding of the underlying causes of environmental degradation and to identification of policy reforms that will help to foster sustainable land and aquatic resource use. The CGIAR’s major commitment to research training, is strengthening the capability of national research institutions to tackle natural resource management issues. Collectively, these CGIAR programs are making a significant contribution to alleviation of rural poverty, better nutrition and to conservation and improved management of natural resources.

(v) Section I of this paper briefly summarizes the evolution of the CG’s Goals, Priorities and Strategies over recent years to reflect greater concern for resource conservation and agricultural sustainability.

(vi) Section II summarizes UNCED Agenda 21 recommendations relating to resource conservation and management, highlighting those Agenda 21 proposals that coincide well with the revised Goals, Priorities and Strategies of the CG System as outlined in Section 1 above.
Section III discusses emerging results from past CG research. This section illustrates that the CG System is highly familiar with many of the priorities developed in Agenda 21 and that sustainability research has long been an integral part of the activities of many of the Centers. It gives specific examples of past CGIAR research that have already made a significant impact on natural resource conservation and sustainability.

Section IV highlights several key issues and problem areas that the CG System will face in addressing evolving issues of sustainability and resource conservation. These issues are more complex than increasing the productivity of individual crops. To address them, the CG System has been substantially restructured and expanded and its mandate has been broadened to embrace both forestry and fisheries. Natural resource conservation and sustainability related research will require even greater interaction with national agricultural research systems (NARS). It will require a longer term time horizon to achieve meaningful results. All of these factors have significant financial implications for the future of the CG System.

Section V briefly summarizes the financial situation of the CGIAR. Overall funding for the CGIAR System is stagnant and the CGIAR Centers are currently trying to address resource management and sustainability concerns by internal reallocation of existing resources.

Given clear recognition in both the CGIAR goals, priorities and strategies exercise and also within the UNCED Agenda 21 of the strong linkages between increased production and containment of environmental degradation, restraining resource allocations for germplasm collection, evaluation and enhancement, and cutting back on crop production and management related research, will constrain the CGIAR Centers potential to contribute to UNCED Agenda 21 objectives. If additional financial resources are not allocated, many of the initiatives that the CGIAR could now take to implement Agenda 21 recommendations will not be possible.

The eighteen CGIAR Centers are currently in the process of revising their Medium Term Plans working towards a common Group wide planning horizon of 1994-1998. During the coming year (1993), more specific recommendations will emerge indicating how the individual Centers intend to adapt their ongoing research programs to focus to an even greater extent on resource management and sustainability related research.

In the interim, it can be noted that current CGIAR research funding (about US$ 250 million), represents less than 3 percent of world wide agricultural research expenditures. Taking into account the positive impact the CG System has already made on world food production and agricultural sustainability, the potential of the CG System to contribute to UNCED’s goals and the prospects of increased funding becoming available for environmental protection programs, there are compelling reasons for the donor community to support a significant increase in resource allocations to the CG System.
A CGIAR RESPONSE TO UNCED AGENDA 21 RECOMMENDATIONS

I. INTRODUCTION: THE CGIAR'S REVISED GOALS

1. During recent years, the CGIAR's goals and objectives have been substantially modified to give greater emphasis to research that will contribute to agricultural sustainability and environmental protection. An earlier CGIAR Committee on "Sustainable Agricultural Production" ¹ examined the CGIAR's potential role in this area and defined some of the key issues. Later studies by the Technical Advisory Committee (TAC) recommended revised goals for the CGIAR (see Box 1). They reviewed priority areas of natural resource related research and recommended changes in the structure and organization of the CGIAR System to deal more effectively with these issues.

Box 1

Revised CGIAR Goals for Natural Resource Conservation and Sustainable Agriculture

- Effective management and conservation of natural resources (i.e. land, water, forests and germplasm) for sustainable production.
- Improved productivity of important crops and their integration into sustainable production systems.
- Improved productivity of important livestock and their integration into sustainable production systems.
- Improved productivity of important trees and their integration into sustainable production systems.
- Improved productivity of important fish and their integration into sustainable production systems.
- Improved utilization of agricultural, forestry, and fish products in both rural and urban areas through improved post-harvest technology.
- Improved diets, family welfare and equity (including gender equity), through better understanding of the human linkages between production and consumption.
- Appropriate policies for increased productivity in agriculture, food, fisheries and forestry and for the sustainable use of natural resources.
- Strengthened institutions and human resources in national research systems to accelerate the identification, generation, adaptation and utilization of technological innovations.

Source - TAC (1991)

2. In its approach to defining a future research agenda the CGI System recognized that sustainability involves a complex interaction of biological physical and socioeconomic factors and that it requires a comprehensive approach to research in order to improve existing systems and to develop new ones that are more sustainable.

3. It concluded that these biological strategies will be important for future sustainability:

- Conservation of genetic resources must be continued and strengthened.
- Yields per unit of area and per unit of time must be substantially increased to meet the needs of rapidly increasing populations.
- Long-term pest control must be developed through integrated pest management and built-in resistance, because intensified production will tend to encourage a

build-up of pests and break down the effectiveness of pesticide and host-plant resistance.

- Improved methods for disease and parasite control will also be important to sustain animal production.

- Intensified biological research is needed to improve sustainable management and increased productivity of forestry and fishery resources.

4. These physical factors and constraints are deemed most important:

- Soil is the most important resource for ensuring sustainability; loss of topsoil through erosion and a reduction in soil fertility by not replacing nutrients turn a renewable resource into a nonrenewable one.

- Agriculture is the principal user of water globally; inefficiently using fossil water and overdrafting rechargeable aquifers can result in another renewable resource being eroded.

- Poor soil and water management in rainfed agriculture can cause severe land degradation.

- Misuse of agricultural and industrial chemicals can contribute to the accumulation of toxic substances in soil and water.

- Deforestation, particularly in upland watersheds, and loss of soil organic matter are contributory causes of accelerated soil erosion and disrupted streamflow.

- Nonsustainable exploitation of aquatic resources and pollution of coastal environments have precipitated a sharp decline in fish resources and marine biodiversity.

- Atmospheric changes brought about by human activities will adversely affect agricultural, forest and aquatic production.

5. These socioeconomic and institutional constraints affect long-term sustainable strategies:

- Weak infrastructure and institutional policies in many developing countries are a major constraint to delivering inputs and transporting farm products.

- Financial and administrative programs are often biased toward urban consumers.

- National taxation and fiscal policies frequently encourage accelerated and wasteful exploitation of forests, rangelands and fisheries resources.
Restricting access to natural resources together with centralized government management and failure to respect traditional common property rights and tenurial systems, have discouraged local people from conserving natural resources and investing in future productivity.

Sustainable land use, forest and fish management systems may not be attractive to poor people in the immediate term. Policies are needed that will compensate for foregone short-term production and encourage participation in sustainable systems.

6. The CGIAR's revised goal statement incorporates a continued focus on productivity, linked to a strong emphasis on poverty alleviation, while at the same time greatly strengthening the CGIAR's commitment to resource related research:-

"Through international research and related activities, and in partnership with national research systems 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."

7. In order more effectively to tackle this broader mandate, the size and structure of the CGIAR System have been significantly modified. Five new Centers have been recently added to the System, four of which will be concerned primarily with resource management. They are the International Irrigation Management Institute (IIMI), the International Center for Research in Agroforestry (ICRAF), the Center for International Forestry Research (CIFOR) and the International Center for Living Aquatic Resources Management (ICLARM). A fifth Center, the International Network for the Improvement of Banana and Plantain (INIBAP) will focus on these two crops.

8. Some of the existing Centers such as the Centro Internacional de Agricultura Tropical (CIAT), International Institute of Tropical Agriculture (IITA), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the International Center for Agricultural Research in the Dry Areas (ICARDA), will give greater emphasis to resource management. These latter Centers are in the process of taking on "ecoregional" responsibilities for tackling resource related research in an integrated multidisciplinary way in selected agroecological zones, whilst at the same time continuing to pursue crop oriented research on their mandated crops.

9. Specialized crop centers such as the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) and the International Rice Research Institute (IRRI) will also continue to give strong emphasis to resource conservation and management through their combined efforts to study for example rice/wheat cropping systems in S.E. Asia. Much of the older CGIAR centers earlier crop research was, and still is, directed toward sustainable management of the soil/water resource base.
II. **UNCED AGENDA 21 RECOMMENDATIONS ON AGRICULTURAL SUSTAINABILITY, AND IMPROVED CONSERVATION AND MANAGEMENT OF NATURAL RESOURCES**

10. There are three overriding recommendations of the UNCED Agenda 21 that indicate a high degree of coincidence with these revised CGIAR goals:

- The strong focus on poverty alleviation.
- Emphasis on the linkage between increased agricultural productivity and environmental protection.
- The role of scientific research.

11. Agenda 21 places strong emphasis on the linkages between poverty alleviation and sustainable resource management (see Box 2).

12. Second, Agenda 21 clearly recognizes the linkages between improved productivity and environmental protection and the need to promote sustainable agriculture and rural development as a step toward improved natural resource conservation.

13. It notes that by the year 2025, 83 percent of the expected global population of 8.5 billion will be living in developing countries. Yet the capacity of available resources and technologies to satisfy the demands of this growing population for food and other agricultural commodities remains uncertain.

"Agriculture has to meet this challenge, mainly by increasing production on land already in use and by avoiding further encroachment on land that is only marginally suitable for cultivation."

---

**Box 2**

**UNCED Agenda 21 Focus on Poverty Alleviation**

"While managing resources sustainably, an environmental policy that focuses mainly on the conservation and protection of resources must take due account of those who depend on the resources for their livelihoods. Otherwise it could have an adverse impact both on poverty and on chances for long-term success in resource and environmental conservation. Equally, a development policy that focuses mainly on increasing the production of goods without addressing the sustainability of the resources on which production is based will sooner or later run into declining productivity, which could also have an adverse impact on poverty. A special anti-poverty strategy is therefore one of the basic conditions for ensuring sustainable development."

Source - UNCED Agenda 21 (1992)
14. In its recommended Action Program for dealing with these issues, several of the objectives of Agenda 21 coincide quite closely with the CGIAR’s revised goals and strategies (see Box 3).

<table>
<thead>
<tr>
<th>Box 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UNCED 21 Objectives in Relation to Sustainable Agriculture and Rural Development</strong></td>
</tr>
<tr>
<td>• Agricultural policy review, planning and integrated programming in the light of the multifunctional aspect of agriculture, particularly with regard to food security and sustainable development.</td>
</tr>
<tr>
<td>• Ensuring people’s participation and promoting human resource development for sustainable agriculture.</td>
</tr>
<tr>
<td>• Improving farm production and farming systems through diversification of farm and non-farm employment and infrastructure employment.</td>
</tr>
<tr>
<td>• Land resource planning information and education for agriculture.</td>
</tr>
<tr>
<td>• Land conservation and rehabilitation.</td>
</tr>
<tr>
<td>• Water for sustainable food production and sustainable rural development.</td>
</tr>
<tr>
<td>• Conservation and sustainable utilization of plant genetic resources for food and sustainable agriculture.</td>
</tr>
<tr>
<td>• Conservation and sustainable utilization of animal genetic resources for sustainable agriculture.</td>
</tr>
<tr>
<td>• Integrated pest management and control in agriculture.</td>
</tr>
<tr>
<td>• Sustainable plant nutrition to increase food production.</td>
</tr>
<tr>
<td>• Rural energy transition to enhance productivity.</td>
</tr>
<tr>
<td>• Evaluation of the effects of ultraviolet radiation on plants and animals caused by the depletion of the stratospheric ozone layer.</td>
</tr>
</tbody>
</table>

15. Third the UNCED Agenda 21 gives strong emphasis to the significant role that scientific research will play in contributing to the implementation of its objectives.

16. The need to strengthen and expand the scope of sustainability related scientific research is a major theme recurring throughout the Agenda 21 document. In common with CGIAR goals, Agenda 21’s recommended research agendas in the areas of agriculture and natural resource management, emphasize the need to combine enhanced understanding of land and marine resource systems with an integrated approach to biological, physical and socioeconomic research.

17. Some of the more specific recommendations of relevance to the CGIAR’s work are summarized below. This is an illustrative rather than comprehensive listing - the primary purpose is to demonstrate the high degree of commonality between what Agenda 21 perceives as the way ahead and the newly emerging priorities of the various CGIAR Centers.

**Integrated Approaches to the Planning and Management of Land Resources**

18. In this area Agenda 21 gives priority to:

- Assessment of land potential capability in different ecosystems.

- Investigation of ecosystem interactions and interactions between land resources and socioeconomic and environmental systems.
• Development of indicators of sustainability for land resources, taking into account environmental, economic, social, demographic, cultural and political factors. It urges that:

"Governments at the appropriate level, with the support of the relevant international and regional organizations, should strengthen research on agricultural production systems in areas with different endowments and agroecological zones, including comparative analysis of the intensification, diversification and different levels of external and internal inputs."

19. Most of the CGIAR’s Centers are in the process of strengthening their capability to research these issues.

**Integrated Approaches to Improved Management and Use of Water Resources**

20. Specific Agenda 21 recommendations include:

• Development of interactive databases, forecasting methods and economic planning models appropriate to the task of managing water resources in an efficient and sustainable manner.

• Application of new techniques such as geographical information systems to gather, assimilate, analyze and display multisectoral information and to optimize decision making.

• Development of new and alternative sources of water-supply and low-cost water technologies.

21. The above will require the development/transfer, adaptation and diffusion of new techniques and technology among developing countries, and development of endogenous capacity to integrate engineering, economic, environmental and social aspects of water resources management and predict the effects in terms of human impact.

22. The Strategic Plans and ongoing research agendas of IIMI and ICLARM in particular are deeply concerned with these same issues. Older centers such as IRRI, ICRISAT, CIAT, IITA and ICARDA have long been concerned with improved water management as an integral component of their farming system/crop productivity related research.

**Conservation of Biological Diversity and Environmentally Sound Management of Biotechnology**

23. Specific aspects that Agenda 21 recommends addressing include the need to develop:

• Efficient methodologies for baseline surveys and inventories, as well as for the systematic sampling and evaluation of biological resources.

• Methods and technologies for the conservation of biological diversity and the sustainable use of biological resources.
• Improved and diversified methods for both ex situ and in situ conservation with a view to the long-term conservation of genetic resources of importance for research and development.

24. Among measures aimed at biotechnology development is specifically mentioned:

"Increasing to the optimum possible extent the yield of major crops, livestock, and aquaculture species, by using the combined resources of modern biotechnology and conventional plant/animal/micro-organism improvement, including the more diverse use of genetic material resources, both hybrid and original. Forest product yields should similarly be increased, to ensure the sustainable use of forests."

25. Within the CGIAR System the International Board for Plant Genetic Resources (IBPGR) is playing a lead role in methodology and organization of gene banks and many Centers are already involved in plant germplasm collection, evaluation and improvement. The International Laboratory for Research on Animal Diseases (ILRAD) and International Livestock Center for Africa (ILCA) focus on animal genetic resources. ICRAF and CIFOR are giving special attention to conservation, breeding, improvement and distribution of germplasm of multipurpose trees. ICLARM is contributing to conservation of aquatic biological diversity by documentation of the status of a large number of species (via a computer database) and evaluation of selected species. Several Centers have made considerable progress in harnessing biotechnology to increase the productivity of CG mandated crops.

Management of Fragile Ecosystems

26. In reviewing strategies for combating desertification and degraded rangelands, Agenda 21 recommends that increased emphasis should be given to scientific research aimed at:

• ‘Promotion of improved land/water crop management systems that will make it possible to combat salinization in existing irrigated croplands, to stabilize rainfed croplands and to introduce improved soil/crop management systems into landuse practice.’

• Promotion of integrated research programs on the protection, restoration and conservation of water and land resources and landuse management based where feasible on traditional approaches.

27. Similar areas of concern feature strongly in the Strategic Plans of many CGIAR centers particularly CIAT, IITA, ICARDA, ICRISAT, IRRI, ILCA, IIMI, ICRAF and CIFOR.

28. In a chapter dealing with Sustainable Mountain Regional Developments, Agenda 21 urges that governments and international and regional organizations should support a strengthening of scientific research and technological development programs in the areas of hydrology, forestry, soil and plant sciences.²

² The role of the CGIAR centers in this area is specifically recognized on page 73 (para. 13.18(a)) of Agenda 21 document A/CONF.151/4 (Part II).
"Increased support should be given to generation of technologies for specific watershed and farm conditions through a participatory approach involving local men and women in promotion of technologies and vegetative conservation measures for prevention of soil erosion."

The Centro Internacional de la Papa (CIP) located in Peru is particularly concerned with natural resource management research in the upland Andean ecoregion and is collaborating with ICRAF which is working in the East, Southern and Central African highlands and with the International Centre for Integrated Mountain Development (ICIMOD), a non-CGIAR Centre working in the Himalayan region countries of South Asia.

**Marine Resources and Coastal Area Management**

29. Agenda 21 recommends new approaches to marine and coastal area management and development at the national, subregional, regional and global levels of approaches that are integrated in content and precautionary and anticipatory in ambit. It calls for:

"Protection of oceans, all kinds of seas, including enclosed and semi-enclosed seas, coastal areas and the protection, rational use and development of their living resources."

30. Suggested programmes in this area include:

- Integrated management and sustainable development of coastal areas, including exclusive economic zones.
- Marine environmental protection.
- Sustainable use and conservation of marine living resources of the high seas.
- Sustainable use and conservation of marine living resources under national jurisdiction.
- Addressing critical uncertainties for the management of marine environment and climate change.
- Strengthening international, including regional cooperation and coordination.
- Sustainable development of islands.

31. ICLARM brings considerable past experience of fisheries and coastal area management to these agenda items. Its new Strategic Plan specifically identifies coastal resources, coral reef systems and institutional strengthening as major areas for future research.

**Combating Deforestation**

32. Agenda 21 recognizes that forests worldwide have been threatened by uncontrolled degradation and conversion to other types of land uses, influenced by increasing human needs; agricultural expansion; and environmentally harmful mismanagement, including, for example, lack of adequate forest-fire control and antipoaching measures, unsustainable commercial logging, overgrazing and unregulated browsing, harmful effects of airborne pollutants, economic incentives and other measures taken by other sectors of the economy.
33. It states that the present situation calls for urgent and consistent action for conserving and sustaining forest resources. The greening of suitable areas, in all its component activities, is an effective way of increasing public awareness and participation in protecting and managing resources. It should include the consideration of land use and tenure patterns and local needs and should spell out and clarify the specific objectives of the different types of greening activities.

34. Other specific Agenda 21 recommendations include for example:

- Consolidating information on genetic resources and related biotechnology, including increased action related to genetic improvement and application of biotechnology for improving productivity and tolerance to environmental stress (tree breeding, seed technology, seed procurement networks, germplasm banks, in vitro techniques and in situ and ex situ conservation.)

- Promoting non-wood forest products, (for example medicinal plants dyes fibers, gums, resin, fodder, cultural products, rattan and bamboo) through participatory forestry programs and intensified research.

- Compiling and analyzing research data on the site interaction of species used in planted forest and assessing the potential impact of forest climate change as well as effects of forest on climate.

35. CIFOR's and ICRAF's Strategic Plans respond directly to these objectives. CIFOR will be particularly concerned with conservation, productivity and improved management of natural forests, open woodlands, plantations, woodlots and the role that trees can play in reclamation of degraded land. ICRAF is heavily involved in researching the interaction between trees, crops and livestock. ICRAF is spearheading a "Global Alternatives to Slash and Burn" initiative which directly addresses a principal cause of tropical deforestation.

Policy Research

36. The importance of socioeconomic policy research aimed at improved understanding of underlying causes of ecological degradation and remedial policies is highlighted throughout all of the sections of Agenda 21 dealing with sustainable land use management and resource conservation.

37. The report urges the adoption of country specific economic policy reforms to promote the efficient planning and utilization of resources for sustainable development. In a chapter dealing with promotion of sustainable development through trade, it is acknowledged that interactions between environmental policies and trade issues need to be more fully assessed. Increased support is needed to promote the policy framework and infrastructure required to improve the efficiency of export and import trade.

38. Concern is expressed that structural adjustment programs may have a negative impact on the environment and that policy research is needed better to understand the linkages. The report also recognizes that improved understanding of environmentally sound pricing policies and the use of appropriate economic instruments can influence consumer behavior (through
environmental charges and taxes; and concluded that further research is needed to underpin this recommendation.

39. TAC in its Priorities and Strategies studies has emphasized the need to integrate policy management with technical and human issues in sustainable resource management. For example in its Strategic Plan, IFPRI gives special attention to environment-related policy research. The Institute is strengthening its staff capability in this area, and implementing environment-related policy research in a number of fields. IFPRI is collaborating with ICRAF, CIFOR, and FAO in a series of forestry policy workshops, and with the German Foundation for International Development (DSE) and other agencies in a series of workshops on policy research for agricultural sustainability. Similar approaches are planned between IFPRI, ICLARM and FAO in fisheries and coastal management policy.

40. CIAT has organized a new Resource Management Research Division including a Land Use Program and research programs for three critical agroecosystems in tropical America: the Hillsides, the Savannas and the Forest Margins and is involving IFPRI in the socioeconomic policy research aspects of these programs.

**Strengthening the Capacity of National Institutions**

41. Agenda 21 clearly spells out the important role and responsibility of national institutions in managing and coordinating locally derived programs of resource conservation and management and recognizes the important contribution of technology transfer to economic development.

"Skills, knowledge and technical know-how at the individual and institutional levels are necessary for institution-building, policy analysis and development management, including the assessment of alternative courses of action with a view to enhancing access to and transfer of technology and promoting economic development. Technical cooperation, including that related to technology transfer and know-how, encompasses the whole range of activities to develop or strengthen individual and group capacities and capabilities. It should serve the purpose of long-term capacity-building and needs to be managed and coordinated by the countries themselves."

42. A major goal of all the CGIAR Centers (and particularly the International Service for National Agricultural Research (ISNAR)) is to strengthen research capability of national institutions. Something in the order of 20 to 25 percent of CGIAR System resource allocations are specifically directed toward training and capacity building.

43. To summarize, the preceding discussion confirms that there is a high degree of coincidence between what UNCED has identified as priority research and development programs that can contribute to sustainable agriculture and environmental protection and the revised goals and objectives of the CGIAR System.
44. The past track record of the CGIAR Centers also illustrates the Group's capability to deliver research results that will help to ensure that the expectations raised by UNCED are realized in practice. Specific examples are given below.

III. CGIAR SUSTAINABILITY RELATED RESEARCH: EMERGING RESULTS

45. Although the recent revision of CGIAR goals gives greater emphasis to resource management than in the past, it is important to reiterate that much of the earlier research work of the CGIAR Centers already incorporated sustainability concerns. As an indication of the potential of the CG System to contribute to UNCED objectives, this section provides some illustrative examples of what has already been achieved. The focus is on past research efforts that have given special attention to:

- The key role that germplasm collection, evaluation and enhancement will play in contributing to agricultural sustainability and conservation of biological diversity.
- The contribution of genetic improvement to disease and pest resistance.
- The effectiveness of integrated pest management research in reducing dependence on chemical pesticides.
- The impact of CGIAR research aimed at increased use of nitrogen fixing plants and reduced dependence on artificial fertilizers.
- The potential of crop mulches to contain soil erosion.
- Improved water use efficiency.
- Integrated agricultural/aquatic resource management.
- The application of improved agroforestry technologies.
- The impact of socioeconomic policy research on improved understanding of underlying causes of environmental degradation and policy options for fostering sustainable land use.
Conservation of Genetic Resources

46. Conservation of plant genetic resources is inextricably linked with containment of environmental degradation. In its goal statement and via the ongoing research work of almost all the International Agricultural Research Centers (IARCs) the CGIAR gives very high priority to germplasm conservation, enhancement and plant breeding. (see Box 4)

47. Plant breeders develop new cultivars by selection from the most suitable germplasm available to them. To produce the cultivars that have contributed to past increases in production, a wide variety of plant genetic resources was required. Much of the germplasm used in CGIAR breeding programmes was readily available in existing landraces and primitive cultivars. A wide range of crop germplasm will be required in future to adapt crops to new and changing conditions and to sustain high yields under low input regimes. The wild relatives of crop species will often be the best sources of the natural adaptations and resistances required.

48. IBPGR plays a special role in this area. IBPGR has developed a strategy to assist countries to assess and meet their needs for plant genetic resources conservation by strengthening links to users; strengthening and contributing to international collaboration; developing and promoting improved strategies and technologies for conservation, and providing an international information service on plant genetic resources. In its first 10 years, IBPGR undertook more than 300 collecting missions in 88 countries; these missions involved more than 550 collectors. The resulting materials, covering 138 crop species, were stored in genebanks by more than 450 organizations in 91 countries, well over half of them in developing countries.

49. In the early 1980s, emphasis moved from broad collecting of cultivated material to collecting of specific cultivars under threat from genetic erosion, or material needed to fill gaps in existing collections. More attention was paid to careful pre-mission preparation, equal participation by National Programme researchers, and deposition of half of the samples collected in a genebank within the country of origin. Collaborative programs with other IARCs working on germplasm collection were strengthened. (For example CIP working jointly with IBPGR organized several major collections of wild potato and sweet potato relatives). In its recently revised Strategic Plan, IBPGR is also giving special emphasis to its potential future contribution to conservation of global biological diversity both via ex situ and in situ conservation.

Box 4

*Plant genetic resources are crucial to the survival of agriculture in a changing climate. They provide new sources of natural variation already adapted to cope with deficient rainfall, temperature and diseases.*

Genetic resources have an important role in rehabilitating degraded lands. Damage to ecosystems can be reversed by selective replanting of species adapted to growing in the area and by use of trees to bind eroding soils. Desertification can be arrested by stabilizing dunes with plants. However, rehabilitation is only possible if the genetic resources are identified and can be made available from conserved stocks. A wiser use of genetic resources for restoring eroded lands, as well as for improving crops, including forage and agroforestry species, and increasing agricultural production in environmentally sustainable ways, is essential to ensure a healthy environment while alleviating poverty.*
50. In an extensive training programme over 15 years, IBPGR has identified and trained a total of more than 1400 people including more than 300 at post-graduate level in germplasm conservation methodology and techniques.

**Genetic Improvement and Disease Resistance**

51. Nearly unknown outside of Africa, maize streak virus is among the most serious disease problems of the crop on that continent. Its destructive potential was fully manifested during 1983 and 1984, when outbreaks seriously affected maize production in several countries of West Africa, and again in 1988 in a severe epidemic in Kenya.

52. Practices such as timely planting and treatment of seed with systemic insecticides can help control yield losses, but a more effective and practical solution for subsistence farmers of streak-threatened regions is high yielding, disease resistant maize.

53. In the late 1970s and early 1980s IITA scientists vigorously pursued a research program for developing resistance through "conversion" of superior materials by backcrossing and recurrent selection in tropical populations. They generated a sizeable collection of improved, streak resistant germplasm of lowland adaptation for use by national programs throughout Sub-Saharan Africa. IITA in collaboration with CIMMYT plant breeders produced about 100 streak-resistant, high-yielding elite germplasms for all the major agroecosystems of Africa, including open-pollinated, hybrid, early-, medium- and late-maturing, and now widely used yellow and white grained, lowland and mid altitude materials. In 1986 IITA’s role was recognized with the CGIAR’s highest accolade, the King Baudouin Award.

54. Similarly ICRISAT has contributed to the development and release of improved pearl millet cultivars in India that currently cover one-third of the sown area of that crop. Besides their high yielding ability, they all have stable resistance to downy mildew disease, which devastated Indian hybrids released in the 1970’s. CIP is about to receive a prestigious international award for its scientific research work on resistance breeding for potato pests with special reference to use of wild potato species that have insecticidal pubescence. CIP has also been a world leader in work on potato blight.

55. Wild relatives of legumes have been used intensively at ICRISAT as a new source of resistance to disease. Among many thousands of entries a derivative from a cross between wild and cultivated groundnut was the only line to show resistance to a major crop disease, Groundnut Rosette Virus. Another derivative has multiple pest and disease resistance and is in regional trials.

56. In the field of livestock related research ILRAD’s work on alleviating animal diseases has positively influenced livestock productivity. It has evaluated the environmental benefits of tsetse and trypanosomiasis control and given special emphasis to livestock genetic disease resistance.

**Integrated Pest Management**

57. The CGIAR Centers are putting much effort into research on methods to control major pests and, at the same time, cut excessive use of pesticides. The most successful and
well publicized research in this area has been control of the cassava mealybug which was introduced into Africa in the 1970s and quickly developed into a serious problem. That bug and the cassava green spider mite now occur in 31 of 35 countries in Africa’s "cassava belt." They can cause up to 80 percent yield losses.

58. These two insects have been singled out as targets for an innovative program of biological control. At a special center for biological control in Cotonou, Benin, since 1980, scientists have introduced 14 species to Africa that are considered natural enemies for the two pests. Four of these have become permanently established as enemies of cassava mealybug in Africa. The most dramatic success has been the identification, multiplication, and release of a species of wasp, *Epidinocarsis lopenezi*, that is parasitic on cassava mealybugs. This biological control agent has shown remarkable potential for reducing mealybug infestations.

59. Biological control of the cassava mealybug has been recognized as one of the best cases in world literature. It is an excellent example of the introduction of a low cost, environmentally safe, sustainable technology. The same can be said for the spread of cassava varieties resistant to cassava mosaic and bacterial blight. As a result of such research, cassava production practiced by small farmers in Nigeria, has doubled in about five years time, without any additional external inputs.

60. Similar work on potato pests has been carried out in Costa Rica through close cooperation between the International Potato Center (CIP) and the Costa Rica national program. The target in an experimental program in Costa Rica was the potato tuber moth, which ranks as the most destructive and ubiquitous potato pest in developing countries, particularly of the Andes Region and North Africa. Potato farmers in Costa Rica had resorted to spraying against the tuber moth. The moths’ natural predators were killed off so that when moth populations exploded there was nothing to control them. Research led to the onset of spraying being delayed by several weeks and farmers have reduced their rounds of spraying from about 20 to four or five. That meant a major drop in chemical pollution and in cost. The same formula is now being tried in an area of Mexico near Leon where the tuber moth is rampant and potato farmers are spraying 24 to 35 times each season.

61. CIP research in this area is of particular importance to sustainable development because potato is the largest user of agricultural chemicals of all food crops. CIP’s work is widely spread and in addition to potato moth has included successful containment of sweet potato and potato weevils in Cuba and the Dominican Republic.

**Reducing Dependence on Commercial Fertilizers by Increased use of Legumes, and Development of Nitrogen Efficient Cultivars**

62. Legumes are viewed as a major alternative to expensive and largely unavailable nitrogen fertilizers in conditions of low soil fertility where increased cropping pressures are reducing fallow periods and depleting soil resources. Their importance to smallholders is their nitrogen-fixing and often erosion-halting capacities, at low cost and risk. A major concern to subsistence farmers and other smallholders is the potential of legumes as food crops. In mixed livestock/cropping systems, and in rangeland livestock production, legumes are a very important source of animal feed and improved protein content is a premium asset.
The capacity of legumes to improve soil fertility and physical properties is particularly important in the fragile environments of sub-Saharan Africa.

63. Data from long-term crop rotation experiments on black soils at ICRISAT confirm the good residual effects of grain legumes. Grain yields of rainy season sorghum with no added fertilizer increased from 1,400 kilograms per hectare to 3,400 kilograms per hectare where an intercrop of pigeonpea and cowpea was grown the previous year. In the Sudanian zone of Africa, planting a relay crop of cowpea in millet before harvesting the cereal enables effective use of the end of season rain and harvesting of a substantial amount of hay (300-400 kg/hectare). In the following year, the cereal benefits from the residual effect of the legume.

64. In Latin America, major production zones for cassava include poorer, more acid soils, and irrigation is not normally available. About 40 percent of total cassava production occurs in mixed cropping systems with maize, beans, and cowpeas. Technology is generally labor-intensive with little use of fertilizer, herbicides, and pesticides. Use of CIAT's low-input technology has increased yields of local varieties in Colombia from a national average of 8 tons to 20 tons per hectare. On-farm validation trials have shown that small farmers can readily increase yields 70 percent.

65. CIAT has also assembled a large collection of tropical forage legumes, grasses, and browse species and screened them for adaptation and productivity in acid, low fertility soils. Several legume-grass pastures that effectively recycle nutrients have been developed and are increasingly being adopted by farmers. Legumes in symbiosis with indigenous rhizobia contribute directly to the improved diets of animals in terms of protein (particularly during the dry season) and improve the yield, quality, and persistence of grasses through enhanced nitrogen availability. The new pastures increase animal weight gains by more than 100 percent and increase land productivity 10 to 20 times. Farmers are growing the improved pastures with semidwarf upland rice varieties that CIAT bred to tolerate the acid soils of the savannas. The pastures benefit from residual fertilizer applied to the rice that, in turn, benefits from the enhanced fertility due to nutrient cycling of well-managed pastures. These productive ley-farming systems in the savannas that surround the Amazon basin will help relieve market and social pressures leading to forest encroachment and deforestation.

66. Waterlogging-tolerant legumes which have the capacity to fix atmospheric nitrogen on stem nodules, are a major way in which riceland can be utilized for green manure production during slack periods. IRRI has developed agronomic systems for two legume species both new to agriculture (Sesbania rostrata and Aeschynomene afraspera) that have remarkable nitrogen fixation capacity and adaption to wetland conditions and it is working with national research systems throughout Asia to exploit this potential in suitable environments.

67. Legumes are also emphasized in ICARDA's research on pastures and forages in rotation with cereals to improve native pastures and animal nutrition, hence, productivity and the effective use of crop by-products. Analysis of a 4-year series of trials to test the feasibility of replacing fallow with forage legumes, such as vetch and leethyrus, indicates that forage substantially increases barley's water-use efficiency.

68. CIMMYT's maize program has increased its attempts to identify maize that can be grown with limited nitrogen. At IRRI, significant differences in the ability of 37 lowland rices to support biological nitrogen-fixation suggest that it should be possible to breed rices
for high nitrogen-fixing ability. Results show that atmospheric nitrogen was higher in the
grain of IR42 than in other varieties. CIP scientists are also seeking nitrogen-efficient
cultivars in a research program that is testing 64 potato varieties.

The Role of Crop Residues and Green Manures in Containing Soil Erosion

69. Crop residues and green manures are being used to maintain soil fertility in the semi-
arid regions of West Africa, where farmers are being forced, due to population pressure, to
change from traditional shifting cultivation and fallow systems to continuous cultivation and
reduced fallow. IITA has over a decade of research experience in the application of
minimum tillage and cover crops. In a two-year experiment in Burkina Faso involving IITA
and the Semi-Arid Food Grain Research and Development Institute (SAFGRAD), six crop
residue and four tillage treatments were tested in cowpea production. Because of beneficial
effects on physical and chemical properties of the soil, cowpea seed yields were positively
associated with the amount of crop residues left in the field, either as in situ mulch on no-
tillage plots or incorporated into the soil in tilled plots. No-tillage with in situ mulch was as
effective as conventional tillage.

70. Similarly, at the ICRISAT Sahelian Center, research conducted for 6 years has shown
that leaving millet stalk on the fields is the best way to fight wind erosion and replenish
chemical and physical properties of the region’s fragile sandy soils.

Improved Water Management and Integrated Agriculture/Aquaculture

71. The policy implications of IRRI and the West Africa Rice Development Association
(WARDA) major research efforts on the role of water management in rice farming and of
IIMI’s policy related research on sustainable water use have become increasingly apparent.
For example, research on irrigation systems having no active farmers organizations, and on
others where such organizations are active or are being promoted through donor-funded
projects, has clearly brought out the potential advantages of organizing users for local
management of irrigation.

72. IIMI research in Pakistan indicates that toward the outer limit of irrigation systems,
where high-quality surface water is not delivered reliably or often never arrives, farmers
compensate by using a higher percentage of pumped groundwater, whose quality is low.
This is having a significant impact on agricultural yields, and has serious implications for the
future sustainability of irrigated agriculture in that country. IIMI has brought these findings
to the notice of policymakers, because it is at this level that solutions must be promoted and
supported. Numerous similar examples from other countries can be cited, where the lack of
a research basis for policy formulation has led, or is leading to, serious mistakes in policies,
with potentially negative impacts on the natural resource base.

73. ICLARM’s research activities have shown that integration of aquaculture within
agricultural activities greatly improves farmers’ management of water. In both rain-fed and
irrigated rice environments farmers’ have a greater incentive to improve dykes around rice
paddies, while daily inspection of the fish results in greater attention to water management
(repairs to dykes, greater control of inflow and outlet, and so on). Research by Asian
national programs coordinated by ICLARM indicates a 10 percent increase in rice yields.
Moreover, fertilizer efficiency for both nitrogen and phosphorus and better management of
pests improve when fish are present. Policies have been identified that will encourage rapid adoption of these approaches to sustainable water resource management.

74. In Indonesia rice and fish farming has been expanded in West Java and North Sumatra by over 40,000 hectares resulting in increased farm income and decreased use of phosphorus fertilizer. Efforts are now underway in the Philippines and Bangladesh to use the integration of rice and fish to promote integrated pest management. An ecological approach to managing irrigated ricefields by integrated pest management and aquaculture provides a route to the regeneration of these lands.

### Improved Agroforestry Technologies

75. ICRAF's research on agroforestry technologies focuses on traditional and innovative practices that have the potential to alleviate rural poverty while arresting the global threats of deforestation and land depletion. Work addresses alternatives to slash-and-burn agriculture in the humid tropics, problems of land depletion in the subhumid and semi-arid tropics, and reclamation of abandoned lands. Technologies under study include improved fallows, hedgerow intercropping, scattered trees in cropland, fodder production in erosion-control systems, fodder banks, and systems combining upperstorey trees for wood production with other trees and crops.

76. In their search for land, farmers everywhere in Africa are forced to cultivate steeper and steeper slopes, leading to soil erosion and siltation of waterways. Ironically, erosion caused by rainfall is often most severe in dry areas. Here, a large part of the total rain for the year may fall in two or three violent tropical storms. Vegetation cover tends to be sparse and heavy rainfall can lead to dramatic soil losses, making what was already a difficult farming situation even worse.

77. ICRAF has been testing agroforestry farming system soil conservation technologies since 1984 at the Machakos Research Station in Kenya's semiarid zone. Low hedgerows of Cassia siamea, a leguminous shrub from Asia, planted on the contours have led to the natural formation of micro-terraces on land sloping at 14 percent. The hedges take up much less space than conventional conservation structures, leaving more land available for crop production.

78. In April 1990 some 52 millimeters (2 inches) of rain fell in just 30 minutes on slopes that were already saturated. Fields with only crops lost more than 34 tons of soil per hectare, while fields with tree hedgerows lost at most 6 tons per hectare and many lost less. The effect of the storm on subsequent crop production was also striking. Where maize and cowpeas were grown between hedgerows, they produced two to three times the harvests from fields with crops alone.

79. Starting in 1989, ICRAF's collaborative programme at Makoka, Malawi, has been testing a relay planting arrangement designed to maintain the full recommended population of maize plants under continuous cropping while utilizing the soil-improving capability of leguminous trees. Maize grain yields on plots interplanted with tree seedlings have been higher than yields from control plots, and woody biomass production from the same plots has ranged up to 5.6 tons/hectare dry weight. These results suggest that at a minimum, farmers with severe land limitations may be able to obtain household fuelwood requirements while
sustaining crop yields, thus alleviating the need to collect fuelwood from natural forests and reducing their requirements for fertilizer.

80. Similar research has been undertaken by International Livestock Center for Africa (ILCA) working on the potential of nitrogen-fixing leguminous trees that, in addition to contributing to soil fertility, produce large quantities of fodder and fuelwood. In Ganawuri, Nigeria, for example, *Gliciridia* trees planted in 1986 attained an average height of 1.02 meters after 14 months. Four years after establishment, these trees had attained an average height of 2.49 meters and produced an average dry-matter yield of 30 tons/hectare. Maize grown in the alleys of these browse species yielded an average of 2.5 tons/hectare of grain, compared to 1.5 tons/hectare in pure stands. Trials at ICRAF's Machakos Research Station in Kenya have identified 2 out of 15 provenances of *Gliciridia sepium* that are outstanding in terms of total biomass production and coppice regrowth after cutting.

81. Research on hedgerow intercropping by IRRI (in collaboration with ICRAF) has indicated that soil loss is commonly reduced by 60-90% accompanied by the development of natural front-facing terraces on sloping land. The organic matter added by pruning the biomass of leguminous trees increased the grain yields of upland rice and maize by 35-200 percent compared with open field cultivation, even when the lost cropped area is accounted for. Because the availability of labor to manage tree legume hedgerows is often a limitation, studies on the incorporation of cash perennials into hedgerow intercropping were conducted, and showed that major economic benefits may thus be derived from these soil conservation strips. Farmers experience with hedgerow intercropping also stimulated greater livestock integration into upland farming systems, another major element in promoting their long-term sustainability.

**Socioeconomic Policy Research on Fragile Ecosystems**

82. Many questions have been raised about the environmental and social effects on long-term viability of human settlement in the Amazon Basin region. A socioeconomic policy study carried out as a collaborative effort between IFPRI and Brazilian government agencies aimed to gain better understanding of the factors that determine the direction and speed of agricultural development in a region highly vulnerable to environmental degradation.

83. The study reinforced a decision by the Inter-American Development Bank (IDB) to revise its criteria for lending for agricultural development in the area. The IDB until recently refused to make loans to support rural development projects that had livestock components. The clearing of land on a massive scale for cattle ranching, particularly in the Amazonian rain forest, had caused severe environmental damage. Livestock loans were seen as an encouragement to accelerated deforestation and the IDB stopped making them. On close examination, the researchers concluded that livestock in more modest numbers make an important contribution to viability and sustainable land use of mixed farming systems that are environmentally suitable to the area. The IDB saw things that way too and let livestock back into its portfolio, indicating how policy research of this sort can have a direct effect on development agency lending policies and practices.

84. In several countries of West Asia and North Africa ICARDA is promoting small multi-disciplinary case studies that are providing critical assessments of existing systems of agricultural production and resource management in dry areas; their impact on the natural
resource base, and land users' perception of their problems and acceptable solutions. Socioeconomic policy research is a major component of that work.

85. To summarize, the above illustrative listing of past CGIAR Center research results suggests that further expansion of CGIAR resource management related research will yield a high pay off. Many of the existing CGIAR Centers have had more than a decade of past experience of dealing with sustainability related research problems. CGIAR developed technologies which provide a sound basis for sustainable land and water management, are already being widely adopted. CGIAR research on germplasm conservation, improved disease resistance, on integrated pest management, and on ways of reducing dependence on artificial fertilizers is already well advanced. Together with research on improving the productivity of agricultural, forestry and aquatic farming systems and the Group's support to sustainability related training programs, the CGIAR has already made a major contribution to improved food security, alleviation of rural poverty, better nutrition conservation of natural resources and containment of environmental degradation. In short, The CG System is well placed to make an early and decisive contribution to implementation of the recommendations of UNCED's Agenda 21.

IV. KEY ISSUES AND PROBLEM AREAS

86. As the CGIAR Centers further extend their research agendas to incorporate greater emphasis on resource conservation and management, they will face difficult issues and more complex problems than has been the case in the past.

Identifying Emerging Threats to Sustainability

87. In its Interim Report, the CGIAR's Sustainability Committee (1990) noted the need for IARCs to develop improved capabilities to anticipate the impact of rapidly changing demographic and economic circumstances that could undermine the sustainability of existing farming systems. The Committee believed that this challenge is likely to take on greater urgency in the coming decade as a result of population pressures, changing international agricultural trade regimes, and changing levels of agricultural intensity. Several Centers are currently reviewing ways of modifying their ongoing research agendas to give a stronger focus to identifying trends in land use change and underlying causes of ecological degradation. One obvious such area of concern is IRRI's current pre-occupation with a long-term decline in rice yields in intensive farming systems.

88. The CGIAR 1990 Sustainability Committee also noted that the possibility of global or regional changes in climate in response to increased atmospheric levels of greenhouse gases, could disrupt or alter current natural conditions in many farming systems. Interest in studying this latter issue, which was a low priority within CG Centers at the time of the Committees deliberations, is now gaining ground. Some research in this area has already been initiated (for example by IRRI on methane emission from rice fields and by ICRAF on the potential for reducing carbon emissions from forest burning by development of alternatives to slash and burn farming). Other Centers are also reviewing their potential contribution. A key issue will be identifying where the CGIAR's comparative advantage lies in this area taking into account the complexity of the issues and large number of research organizations already engaged in this field.
Sustainable Agriculture and External Inputs

89. Concerns about sustainability have induced the IARCs to increase their efforts to develop a more complete and scientifically based understanding of how poor farmers can maximize the use of on-farm resources to sustain and increase agricultural, including livestock, production. This has been a major emergent theme in IARC research programs during the past decade, with increased focus on biological and ecological interactions, nutrient cycling techniques and integrated crop/livestock management systems that poor farmers can use (and often traditionally have used) to generate inputs they otherwise could not afford. Precisely because such input lowering systems can actually reduce sustainability if not scientifically based, the Sustainability Committee believed that even greater concentration by IARCs on the potential for on-farm production of inputs could yield substantial gains in coming years.

90. In developing countries the CGIAR considers that the concept of “sustainable” agriculture cannot be equated with alternative agricultural practices such as organic farming or low-input agriculture. Introduction of such techniques may be the primary means of increasing sustainability under certain ecological circumstances (excessive build up of chemicals in soil and groundwater) or economic conditions (rapidly increased costs of external inputs) in settings where use of synthetic inputs is already high. But, in many developing countries and particularly in fragile or marginal environments, sustainability is itself threatened by the lack of external inputs (such as phosphate fertilizers) to supplement on-farm practices for maintaining soil fertility and structure, or for protecting agricultural systems from pests and diseases. In both situations, studies on nutrient cycling in agricultural fields, and in agroforestry and fishery systems provide a basis for designing systems that can simultaneously conserve productivity and protect natural resources.

91. Scientifically based sequences for planting, cropping, intercropping, pest and disease thresholds, mulching, conservation tilling, fertilizer applications and other farming practices—especially when accompanied with seed varieties adapted to these conditions—have been shown to enable farmers in many different agroecological settings to reduce the levels of external synthetic inputs and imported moisture without necessarily decreasing and indeed in some cases increasing crop and livestock yields. But sustaining and increasing yields through the application of these techniques invariably leads to dramatic increases in the amounts and technical-skill levels of labor required in the fields thus emphasizing the importance of sustaining a strong CGIAR effort in training and the need for complementary programs for strengthening of agriculture extension services.

The Special Challenge of Marginal Lands

92. As an overall strategy, it makes sense to concentrate food production on the optimal lands. But a host of factors, ranging from inequitable land ownership to population pressure, often force farmers to settle on marginal lands. Areas with erratic or excessive rainfall, poor soils, steep slopes, or inadequate drainage pose daunting challenges for agriculture.

93. Research strategies for sustainable agriculture in marginal areas are required distinguishing between lands that are - (a) marginal with respect to production, due to various stress factors — which research might seek to alleviate through adapted cultivars and new management techniques; and (b) fragile in respect of the natural resource, soil, water and
natural vegetation. Here the responsibility of research is to avoid policies and technologies that will hasten degradation but rather to work with the land-user to conserve natural resources while optimizing sustainable production.

94. There are vast land resources in the tropics that have uniquely optimal productive uses, but not for conventional food cropping. The challenge is to move these fragile lands toward optimal uses, through an evaluation of land use systems that support traditional management, and accelerate adoption of more diverse and less risk prone farming systems.

95. Increased emphasis is needed on developing crop varieties that withstand moisture stress, are adapted to poor soils, resist disease, and pest attack, and in highland areas, tolerate cold. Marginal environments call for deployment of a range of practices that serve as insurance against late rains, lower than normal rainfall, or pest and diseases epidemics. This involves dependence on a wider range of different crops as well as several varieties of each crop, each with different nutrient requirements and tolerances to environmental stresses. Farmers on marginal lands generally have fewer resources to combat such challenges, such as access to irrigation and pesticides.

**Blending Traditional Knowledge and Modern Science**

96. Answers to sustainability in tropical agriculture will be found among traditional farmers, field workers and from such disciplines as anthropology, ethnobotany and geography, as well as from agricultural scientists. The appropriate mix of traditional knowledge and modern science will vary widely, depending on ecological constraints and market opportunities. In some highly intensive agricultural systems on optimal farm lands, technologies to raise and sustain yields may come from laboratory/research station experimentation. In other situations, such as marginal environments, traditional resource management systems may have more to offer.

97. Taking these concerns into account, more emphasis is now being given in the CGIAR System to a participatory approach to research that aims to tap into traditional knowledge and local farmers' understanding of sustainable farming practices and to blend this with scientifically developed improved technology. Among other issues is growing recognition of the major role that women play in decision making at the farm level and in contributing to sociological research and research program design. There is commitment within the CGIAR to deal more effectively with gender issues than in the past.

**Systems Research: Interaction with NARS**

98. Many issues relating to sustainability of productive potential are specific to ecosystem and location. This raises the imperative of strengthening cooperation: (a) among IARCs working in similar agroecological settings around the world, and (b) between IARCs and NARS to ensure that research at the international level is relevant and adaptable to national and local settings.

99. In addition, problems in sustaining agriculture in many settings often arise because of the interaction between technologies, the natural resource base, economic factors and government policies. Thus, many IARCs found it more and more difficult to focus narrowly on the scientific challenges associated with designing improved agricultural technologies and
techniques without a clear picture of context. This has necessitated a system oriented approach in research and much greater attention to such tasks as: characterization of agroecological areas; understanding socioeconomic settings; assessing institutional capabilities; and promoting efficient and sound economic policies. All of these factors have brought complexity to the research programs of the CGIAR Centers. This makes it more imperative than ever for IARCs to identify clearly their comparative advantages, to outline priorities for future scientific research and to build ties and networks with other institutions capable of contributing to and complementing CGIAR work on sustainability.

100. The CGIAR Centers are uniquely situated and structured to foster innovative approaches to resource management issues. To give a recent illustration of this evolving approach, building on its geographic information system capabilities and the research output and experience of its commodity programs, CIAT’s new Resources Management Research Programs aim at understanding the socioeconomic and agroecological context, as well as integrating research efforts with NARS, NGOs, and other IARCs and regional organizations for the development of sustainable production systems in three important and interlinked agroecosystems in tropical America: the hillsides, the forest margins, and the savannas.

101. Similarly, CIP’s potato research work in the Andes has developed strong collaborative programs with local farmers, NGOs and NARS and with several other IARCs whose research will contribute to improved soil water and tree conservation and management in that region.

**Research Time Horizons**

102. In some areas of sustainability research (such as for example ICLARM’s ongoing work on integrated fish production systems in Bangladesh and on community based coral reef fisheries management) an early research impact can be anticipated. However in general terms, compared with crop commodity plant breeding related research, a longer time horizon will be required to produce meaningful research results applicable to conservation of soil, water, forest and fishery resources and to achieve significant advances in strengthening national research capacity for dealing with resource management issues. It will take time to work through some of the more urgent natural resource conservation and management problems which currently face developing countries and for the CG System to make a significant contribution in this area. At a later stage it would be feasible to contract the size of the CG System and to focus more on maintenance research that will help to sustain increased crop yields and disease resistance.

103. A combination of the above factors and in particular the complexity and multidisciplinary nature of natural resource related research and length of time required to produce meaningful results, have significant financial implications for the future effectiveness of the CGIAR System.

**V. FINANCIAL IMPLICATIONS**

104. This section highlights the importance of increased financial resources for tackling the broad sustainability related research agenda implied in the CGIAR’s evolving Priorities and Strategies Paper and in UNCED’s Agenda 21.
105. TAC’s recent recommendations on Priorities and Strategies and suggested approach to revised resource allocations for the Centers were a major item of discussion at the CGIAR’s Mid-term meeting held in Istanbul in 1992.\textsuperscript{3} An exercise carried out jointly by TAC and CG Secretariat staff reviewed the changing mandate and structure of the CG System and projected likely future CGIAR financial availability and possible resource allocations to the year 1998.

**Current Status of CGIAR Financing and Center Resource Allocations**

106. In its approach to this topic, TAC took into account the reluctance of donors at that time to consider any major increases in funding for the CGIAR.\textsuperscript{4} TAC was therefore obliged to use the current budget of the CG System (US$250 million a year in 1992 current dollars) as a point of departure.

107. It was suggested that TAC use a 5 year budget forecast period (1994-98) as a basis for its assessment of future likely funding availability and possible CGIAR Center resource allocations. This initial approach assumed a "no-real-growth", approach in long standing activities of existing Centers combined with selective real growth for forestry and fisheries.

108. In summary, CG core funding availability was estimated at US$270 million by 1998 in 1992 values ($342 million in 1998 values assuming a 4 percent annual rate of inflation).

109. Given the currently stagnant financial resources situation hard choices had to be made between various research programmes. Inevitably this required cutting back on some ongoing areas of research. Within this restricted budgeting framework, TAC’s suggested resource allocation priorities by major CGIAR areas of activity were based on the following assumptions:-

- Taking into account the new emphasis on resource conservation and management, **Natural Resource Conservation and Management** was projected to increase significantly in both absolute and relative terms by rising from 13 percent of the total 1991 core allocation to 18 percent by 2010.

- **CG support to Germplasm enhancement and breeding** was projected to increase marginally in absolute terms and in relative terms from 21 percent in 1991 to 22 percent of total in 2010.

- **Socioeconomic public policy and public management research** were projected to increase from 9 percent in 1991 up to a total 11 percent in 2010.

- The above increases in resource allocations would be achieved at the expense of (a) **production systems development management** (which would decrease in absolute terms and in relative terms with a share of total declining from 33 percent to ...
to 29 percent in 2010) and (h) a reduction in institution building (a decrease from 24 percent to 20 percent in 2010).

110. Box 5 summarizes the proposed 1998 core allocation by category of activity.

111. TAC clearly recognized that these resource allocation guidelines may be considered too conservative and stressed that this approach was not to be interpreted as an indication by TAC that it regarded the current level of resources as adequate fully to meet the challenges and task faced by the Group.

112. The CGIAR Centers have therefore been requested to review their research programs initially on the basis of the restricted budgeting situation outlined above to see what can be achieved by internal reallocation but also taking into account in their revised Medium Term Plans what the impact could be on their programs of increased levels of core funding.

113. Currently, the CGIAR Centers are in the process of responding to this request with the objective of coordinating all Centers' estimates to use a common Medium Term Planning horizon from 1994 to 1998. It is therefore premature to prejudge the likely outcome of this exercise.

114. However, in the context of the follow-up debate on UNCED’s Agenda 21 it is relevant at this stage to highlight some concerns that have already been expressed by several Center Directors and also by some donors.

115. First particularly for those Centers with an ecoregional mandate, the levels of funding needed to provide an expanded and multidisciplinary scientific input to natural resource management related research, are likely considerably to exceed what can be generated by internal reallocation of research priorities without adversely affecting their research output. If no-real-growth assumptions prevail, a shift in emphasis to resource management will require significantly reduced research expenditures on crop/livestock production.

---

**Box 5**

<table>
<thead>
<tr>
<th>Categories of Activity</th>
<th>US$ Millions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conservation and Management of Natural Resources</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ecosystem conserv./mgt.</em></td>
<td>27.0</td>
<td>29</td>
</tr>
<tr>
<td><em>Germplasm coll./conserv./char./eval.</em></td>
<td>21.6</td>
<td>22</td>
</tr>
<tr>
<td><strong>Germplasm Enhancement and Breeding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Crops</em></td>
<td>53.2</td>
<td>53</td>
</tr>
<tr>
<td>*Livestock .3</td>
<td>4.7</td>
<td>5</td>
</tr>
<tr>
<td><em>Fish</em></td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Production Systems Development and Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cropping Systems</em></td>
<td>38.5</td>
<td>38</td>
</tr>
<tr>
<td><em>Livestock systems</em></td>
<td>30.5</td>
<td>31</td>
</tr>
<tr>
<td><em>Tree Systems</em></td>
<td>8.3</td>
<td>8.3</td>
</tr>
<tr>
<td><em>Aquatic systems</em></td>
<td>1.8</td>
<td>2</td>
</tr>
<tr>
<td><strong>Socio-Economic, Public Policy and Public Management Research</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>29.6</td>
<td>29</td>
</tr>
<tr>
<td><strong>Institution Building</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Training/Conferences</em></td>
<td>19.5</td>
<td>20</td>
</tr>
<tr>
<td><em>Doc./Pub/ Dis. Info.</em></td>
<td>16.9</td>
<td>17</td>
</tr>
<tr>
<td><em>Org./Mgt. Counselling</em></td>
<td>6.2</td>
<td>6.2</td>
</tr>
<tr>
<td><em>Networks</em></td>
<td>6.2</td>
<td>6.2</td>
</tr>
<tr>
<td><strong>System Total</strong></td>
<td>270.0</td>
<td>100</td>
</tr>
</tbody>
</table>

*In constant 1992 $ Source: TAC 1992*

---

See Table 14.4 on page 303 of Chapter 14. of CGIAR Priorities and Strategies Part II.
116. Given clear recognition in both the CGIAR goals, priorities and strategies exercise and also within the UNCED Agenda 21 of the strong linkages between increased production and containment of environmental degradation, restraining resource allocations for germplasm, collection evaluation and enhancement, and cutting back on crop production and management related research will constrain the CGIAR Centers potential to contribute to UNCED Agenda 21 objectives. If additional financial resources are not allocated, many of the initiatives that the CGIAR could now take to implement Agenda 21 recommendations will not be possible.

117. Natural resource sustainability related research will require a more decentralized approach and increased collaboration with the NARS. In some countries and regions (particularly Africa) many of the NARS lack the multidisciplinary capability required -- especially in relation to the capacity building goals of Agenda 21 -- to ensure that they will be able to play an effective partnership role in this endeavor. It seems likely that the CGIAR Centers will need to provide a strong catalytic input and sustained scientific support to key NARS. Given the weaknesses of multidisciplinary research in many NARS it will take a sustained institution building effort over many years to achieve the desirable strengthening of national capacity.

118. This does not imply that the CGIAR Centers should become the major vehicle for strengthening institutional capability of the NARS. There are many other agencies that will contribute to that objective. However it does highlight the desirability of sustaining and expanding the CGIAR’s contribution to institution building without cutting back on financial allocations to other high priority research programs, which are important for improved natural resources conservation and management.

**Donor Support to the UNCED 21 Agenda Recommendations and Likely Pay Off**

119. Financial support for following up on Agenda 21 recommendations is now under active debate by the donors. In his recent report to the Development Committee, Lewis Preston, President of the World Bank observed:

"The great task in the follow-up to UNCED is now to work toward putting the requisite funding in place and to move forward with increasingly effective integration of development activities and efforts to protect the environment. The Bank is fully committed to do so. The incremental funding required will be substantial indeed, and much of this will clearly have to be supplied on concessional terms."

120. Although it is still early days in terms of assessing how the incremental UNCED resources are likely to be allocated between different areas of activity, it seems reasonably certain that some additional resources will be channelled towards the combined issues of poverty alleviation, increased agricultural productivity, conservation and protection of natural resources, and to capacity and capability building of national institutions concerned with natural resource management.
That there will be a high pay off from such investment is suggested in the World Bank’s recently published 1992 World Development Report that included an assessment of the likely benefits to be anticipated from incremental investment of some $75 billion a year in environmental and resource conservation programs. Of particular significance to the CGIAR were the study conclusions that there would be substantial benefit from a suggested annual incremental investment of US$ 5 billion a year in agricultural and forestry research. (see Box 6)

**Box 6**

ESTIMATED COSTS AND LONG-TERM BENEFITS OF SELECTED ENVIRONMENTAL PROGRAMS IN DEVELOPING COUNTRIES

<table>
<thead>
<tr>
<th>Program</th>
<th>Additional investment in 2000</th>
<th>Billions of dollars a year</th>
<th>As a percentage of GDP in 2000</th>
<th>As a percentage of GDP growth, 1990-2000</th>
<th>Long-term benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased investment in water and sanitation</td>
<td>10.0</td>
<td>0.2</td>
<td>0.5</td>
<td>Over 2 billion more people provided with services. Major labor savings and health and productivity benefits. Child mortality reduced by more than 3 million a year.</td>
<td></td>
</tr>
<tr>
<td>Controlling particulate matter from coal-fired power stations</td>
<td>2.0</td>
<td>0.04</td>
<td>0.1</td>
<td>PM emissions virtually eliminated. Large reductions in respiratory illnesses and acid deposition, and improvements in health and amenity.</td>
<td></td>
</tr>
<tr>
<td>Reducing acid deposition from new coal-fired stations</td>
<td>5.0</td>
<td>0.1</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing to unleaded fuels; controls on the main pollutants from vehicles.</td>
<td>10.0</td>
<td>0.2</td>
<td>0.5</td>
<td>Elimination of pollution from lead; more than 90 percent reductions in other pollutants.</td>
<td></td>
</tr>
<tr>
<td>Reducing emissions, effluents, wastes from industry</td>
<td>10.0-15.0</td>
<td>0.3-0.5</td>
<td>0.5-0.7</td>
<td>Approvable reductions in levels of effluents, and ambient pollution. Low-waste processes often a source of cost savings for industry.</td>
<td></td>
</tr>
</tbody>
</table>

| Program | Additional resources for agriculture, forestry, research and resource surveys. | 5.0 | 0.1 | 0.2 | Lower pressures on natural forests. All areas eventually brought under sustainable forms of cultivation and pasture. |

| Program | Family planning (incremental costs of an expanded program) | 7.0 | 0.1 | 0.3 | Long-term world population stabilizes at 10 billion instead of 12.5 billion. |

| Program | Increasing primary and secondary education for girls | 2.5 | 0.05 | 0.1 | Primary education for girls extended to 25 million more girls, and secondary education to 21 million more. Discrimination in education substantially reduced. |

Source: World Bank 1992
122. Relative to worldwide real agricultural research expenditures which in the period 1980-85 were in the order of US$ 7.2 billion the proportion allocated to CGIAR supported research (less than 3 percent) is quite modest in relation to the past impact of CGIAR research on world food production and its future potential to contribute to agricultural sustainability. (see Box 7)

Box 7

REAL AGRICULTURAL RESEARCH EXPENDITURES
(In Millions of 1980 US$)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing Countries</td>
<td>649</td>
<td>1013</td>
<td>1618</td>
<td>2179</td>
<td>2546</td>
</tr>
<tr>
<td>sub-Saharan Africa</td>
<td>121</td>
<td>203</td>
<td>267</td>
<td>348</td>
<td>382</td>
</tr>
<tr>
<td>Asia/Pacific</td>
<td>238</td>
<td>395</td>
<td>599</td>
<td>811</td>
<td>1106</td>
</tr>
<tr>
<td>WANA</td>
<td>111</td>
<td>163</td>
<td>305</td>
<td>363</td>
<td>344</td>
</tr>
<tr>
<td>Latin America/Caribbean</td>
<td>179</td>
<td>252</td>
<td>447</td>
<td>657</td>
<td>714</td>
</tr>
<tr>
<td>Developed Countries</td>
<td>2022</td>
<td>2955</td>
<td>3657</td>
<td>4090</td>
<td>4717</td>
</tr>
<tr>
<td>Totals</td>
<td>2671</td>
<td>3968</td>
<td>5275</td>
<td>6269</td>
<td>7263</td>
</tr>
</tbody>
</table>

Source - Pardey and Roseboom (1989)

Conclusion

123. To summarize, the main purpose of this paper has been to bring to the attention of the CGIAR’s donors that the System is well placed to make a significant contribution to UNCED’s Agenda 21 objectives and to urge that serious consideration be given to ensuring that incremental financial contributions will be forthcoming that are commensurate with the challenge ahead. Historically, the contributions that the CGIAR System has been able to make to improved food security, to improved nutrition and to productive agriculture are well established. As noted earlier some of its ongoing resource related research activities are already making a powerful impact on soil and water conservation and contributing to sustainable agriculture.

124. Key elements in CGIAR strategy include its potential to contribute to the intensification of agricultural productivity in more favorable lands which is helping to reduce pressure on marginal ecosystems. Germplasm conservation, evaluation and enhancement research is contributing to
maintenance of biological diversity and to production of crop/livestock genetic material that can resist abiotic stresses and survive well in marginal environments. Increased emphasis on use of integrated pest management technologies and leguminous nitrogen fixing agricultural and tree crops is helping to reduce dependence on chemical pesticides and fertilizers. CGIAR research on agriculture, forestry, and aquatic farming systems has led to development and adoption of improved technologies and sustainable management practices. Support to socioeconomic policy research is leading to improved understanding of the underlying causes of environmental degradation and to identification of policy reforms that will help to foster sustainable land and aquatic resource use. The CGIAR's major commitment to research training is strengthening the capability of national research institutions to tackle natural resource management issues. Collectively, these CGIAR programs are making a significant contribution to alleviation of rural poverty, better nutrition and to conservation and improved management of natural resources.

125. Continued and expanded support by the donor community to the CGIAR System will be one of the more effective investments it could make in contributing to the overall UNCED objectives of achieving improved human welfare and planetary sustainability.