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CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

NRM RESEARCH IN THE CGIAR:
A Framework for Programme Design and Evaluation

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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There is growing awareness - some would call it concern - about the need to pay more direct attention to issues related to environmental sustainability as the CGIAR and its partners move ahead in the quest to reduce poverty and increase food security. While for some time in the CGIAR, there has been an explicit recognition of the importance of the environment and the sustainability of the natural resource base on which all food production depends, it is only within the past 10 to 15 years that the CGIAR System has started to think seriously about an overall strategy for its involvement in "sustainability research" related to the integrated management of the environmental resources (or natural resources) that provide the basis for agricultural production (see Attachment: Evaluation of NRM Concepts and Activities in the CGIAR).

In tackling this increased concern about the environmental resource base for agriculture, the CGIAR Centre Directors (CDs) established an INRM Task Force and facilitated a rather large community of researchers within the System in their establishment of a CGIAR INRM "community of interest" or INRM group, that has met three times. Notably absent from the results of these meetings is a coherent Systemwide strategy for INRM priority setting and for operationalizing a more effective set of strategic INRM activities within the CGIAR. A key purpose of this background paper is to develop a concise statement of TAC's views on the way ahead.

The paper builds on what TAC has said previously and does not deviate from the general lines of approach laid out in the Committee's 2000 Vision and Strategy (V&S) document. However, some questions are raised in places for consideration in moving towards a more integrated strategy for including the most relevant NRM priorities that the System has accepted in the past, i.e., a strategy for how best to bring GPI, agronomic, water, LARM, agroforestry and forestry research together in the quest to reduce poverty and establish sustainable food security for the poorest of the poor.

The background paper takes into account the often forgotten fact that the CGIAR is focused not only on NRM to help reduce existing poverty and food insecurity, but also on *preventing future poverty and food insecurity by developing technologies that can help avoid future degradation of the natural resource base on which food, fibre, fuel and fodder production for the poor depends.* While getting people out of existing poverty may have the most dramatic political visibility, preventing people from going into poverty because of declining food production due to environmental degradation is just as important from a humanitarian point of view.

The paper is brief, recognizing that the background information on TAC's thinking is explored in detail in the attachment (SDR/TAC:IAR/01/18 - TAC Cali paper). Thus, this background paper covers basically the following ground:

- first the context is laid out, including the priorities set out in the 2000 Vision and Strategy paper;
- second, these elements are translated into a set of propositions on operational strategy;

- third, the propositions are linked to considerations of implications for the System related to the various component NRM elements involved and dealt with by the CGIAR.

1. Context

As evident from the discussion in the TAC Cali Paper, TAC's ideas on natural resources management research have been evolving in keeping with new knowledge, with the changes in CGIAR objectives and with new thinking on issues such as sustainability and poverty alleviation. They are still evolving. However, some points seem clear: While TAC fully acknowledges the multifaceted nature of the integrated management of natural resources, it also recognizes and emphasizes here that the CGIAR cannot deal with all issues, challenges and opportunities. *TAC's perspective of its role in INRM focuses on management of natural resources for the purpose of achieving the goals of the CGIAR related to poverty reduction and sustainable food security through improved sustainable food production.*

It is possible to argue that most aspects of INRM are inter-related and that, in a sense, all INRM issues and opportunities should be of concern to the CGIAR, since ultimately, in one way or another, they relate to the goals of the CGIAR. While this is true in theory and in concept, it also is true that resources within the CGIAR are limited and that many more institutions of diverse nature and often with greater resources than the CGIAR are tackling many of the issues, relationships, and research opportunities that exist in INRM. The CGIAR should focus on those INRM issues for which it has a comparative advantage, based on its many years of work in the agricultural systems of the developing world. At the same time, the *CGIAR Centres should be, and are open to, cooperation and collaboration with many other groups involved in researching INRM problems, which do not fall in the above category.*

More specifically, TAC recognized in its 2000 Vision and Strategy that there are limits to how much and what type of NRM research the CGIAR should support. TAC suggested that priorities for NRM research should be determined based on the following six principles:

1. *The CGIAR should concentrate on NRM research that contributes to productivity enhancement and sustainability of natural resources for production of crop, livestock, forest and fish outputs that have impacts on poverty reduction and food security, giving appropriate consideration to inter-generational equity of benefits.*
2. *The CGIAR Centres should use an integrated NRM focus in their planning to define problems in NRM that require research.*
3. *International integrated NRM research should be process oriented to ensure maximum contribution to production of international public goods.*
4. *The CGIAR should give greater attention to research to resolve water issues.*
5. *Focusing NRM research around common reference locations or benchmark sites is essential in incorporating the many dimensions of integrated NRM.*
6. *Priorities for specific NRM research themes should be determined by the CGIAR Centres in the context of the sustainability issues affecting productivity increases, regional priorities and comparative advantages of the CGIAR.*

These six principles seem as relevant today as they did in 2000. They are considered as the basic context for the discussion that follows.

2. A Possible Set of Priority Areas for INRM Research

Within the context of what TAC believes is appropriate boundaries for INRM activity within the CGIAR, candidates for priority natural resource areas for CGIAR research is as follows:

- management of land and terrain resources and related flora and fauna to enhance sustainable agricultural production, (e.g., prevention of soil nutrient depletion, declining physical properties of soils, etc., when used under intensive and extensive agriculture);
- integrated water and watershed management (i.e., management of land and water resources for the primary purpose of securing the best quantity and timing of water flows, and quality of water for the benefit of farmers and rural citizens, particularly the poor);
- management of water as habitat for living aquatic resources for rural, coastal and floodplain (including estuarine) livelihood enhancement;
- management of forest environments for rural livelihood enhancement, including social forestry as well as through sale and personal consumption of forest outputs, including, but not limited to wild game, fruits, nuts, oils and other forest products;
- INRM associated with intensive peri-urban agriculture, livestock and fuelwood production;
- incentive systems for securing improved NRM management, e.g., through downstream land and water user payments to upstream land users for conservation activities and through other means of bringing natural resources management into the market system.[1]

It is recognized that the issues and research opportunity areas could be cut in different ways. Thus, this is a major theme that should be debated at TAC81. Some classification of priorities is needed to go on to operational issues and to assess the potential complementarities that are so important in designing effective integrated NRM systems research.

The themes identified should be dealt with in an integrated fashion, within the four sets of linkages that TAC defined in its 1997 strategic review of soil and water research needs and priorities in the CGIAR:

- *links between productivity-enhancing and resource-conserving research (e.g., crop improvement and natural resources management);*
- *spatial or landscape level linkages (e.g., upstream-downstream linkages in a watershed management framework: or scaling up from plot to farm to watershed);*

[1] The CGIAR has a role to play in research related to securing poor farmers with payments for environmental services. This is evidently coming rapidly in the picture in many countries. Not only forestry, but also agroforestry, agriculture and livestock have roles to play. Payments which are a relatively modest source of income on a per hectare basis for developed country farmers may be significant contributions to income for poor farmers. There are important technological issues in which the CGIAR has been involved and could get more engaged, both to enhance the supply of services and to monitor delivery. An INRM focus would be useful since poor farmers need to design the delivery of environmental services as an integral element of their farming systems and livelihood strategies.

- *temporal linkages (e.g., links between present and future, short vs. long term; i.e., sustainability considerations);*
- *linkages between research and the diffusion/adoption of results from such research.*

These provide the context for linking research to application to implementation and eventual benefits in the context of the overall CGIAR goals. We emphasize that this is not a new perspective for TAC.

Scientific and technical developments, particularly in the information and communications technologies (ICT), are increasing our capabilities to carry out INRM research much more effectively, by extrapolating from point measurements to the higher scales in a realistic fashion. Furthermore, our understanding of the processes occurring at and beyond the field scale has increased substantially in recent years, thus providing new insights on the behaviour of ecosystems.

At the same time, interdisciplinary approaches based on agricultural, forestry and fisheries ecosystem sciences such as production ecology, landscape ecology, water resources management, and integrated pest and biodiversity management show promise for being able to help integrate different traditional disciplinary approaches and knowledge bases in more effective ways. To a large extent, the new technological developments in ICT are permitting this rapid progress. It is imperative that the CGIAR incorporates these new technologies and integrates them into its INRM research to the fullest extent possible. TAC also intends to devote a significant amount of time at its 81st meeting to a discussion of these themes and linkages.

There is no set model of INRM research. Regardless of which line of reasoning is followed, lessons from the past teach us that a key need is not to let the rhetoric of INRM get ahead of the science and not to focus too much on concepts without having common definitions and solid operational research approaches and procedures in mind.

In the past, research on natural resources has been too often conducted in a disjointed, fragmented fashion. We have now reached a situation where problems in managing natural resources are recognized to be multidimensional, with physical, economic social and cultural dimensions. It is now possible, with the modern tools of ICT and computers, to combine the various scientific and technological approaches to solving NRM problems with the social science approaches to achieve the goals of poverty alleviation and of sustainable food security. That should be a main focus of the CGIAR in the area of INRM.

3. Some Major Resource Management Components Relevant for CGIAR Research[2]

The CGIAR has for more than a decade been dealing not only with soils, livestock, irrigation systems and agronomic NRM related research, but also with trees in and around agricultural systems (agroforestry and forestry) and with living aquatic resources management. In addition, in recent years, the interest in water related irrigation management issues has broadened out to a concern with a host of additional micro and landscape level

[2] Some of the ideas below are adapted from those put forth in recent EPMRs, where such seemed relevant to the discussion.

water research related issues. What should TAC's positions be on (1) the priorities that should be given to these various resources in the overall research agenda; (2) the directions of research in each area; and (3) the ways in which the complementarities between research in each of the different resource areas?

First, the four resource domains are briefly described in a strategic context. Second, some possible directions are put forth for TAC discussion of their relative importance in the overall INRM research picture of relevance to the CGIAR and its partners.

4. A Strategic Perspective on CGIAR Role in Research Related to Soil Management

Effective soil management for sustainable productivity of crops, pasture and forests is a foundation for most land-based CGIAR programmes. The production potential and the returns on crop, tree or animal systems investment is dependent on soil quality as determined by nutrient suppliers capacity, physical characteristics and a favourable biological condition for plant disease and pest balance. Centre programmes have increasingly adopted a holistic approach to soil management, considering the entire production system over time. Soil science has increasingly moved away from a crop-by crop approach.

A first essential goal in long-term management is to minimize soil loss by wind and water erosion. Such loss removes the critical upper layers which are rich in nutrient and organic matters and which serve as habitat for all-important communities of beneficial flora and fauna. Erosion control must be built into patterns of field contouring, crop diversity over time and space, use of trees, wood shrubs and grasses, as well as appropriate and highly reduced tillage. The land use management schemes build these into their programmes.

A second intermediate goal in soil quality is to increase equilibrium levels of soil carbon (organic matter). Soil organic matter is crucial to favourable physical qualities, soil biological activity and nutrient recycling. Maintenance of a large active fraction of organic matter through crop biodiversity, legumes in the rotation and keeping crop residues and animal manure where available in the upper 10 to 15 cm of soil through limited or zero tillage is critical both to maintenance of total soil organic matters and efficient nutrient cycles. High soil carbon equilibriums are consistent with global warming mitigation, a clear win-win situation. Such soil ecosystem management should always be the starting point. Nutrients from outside sources, including fertilizers then can be used far more efficiently, having greater crop response then when added to poor quality, low organic matter, "dead" soil as a sole crop nutrition strategy.

Centres must therefore build soil management in as part of a system strategy. Such measures normally require a 3 to 10 year-time frame for full response and adequate return on management investment. Land tenure or access must be guaranteed. In summary, it is becoming clear from current research that effective soil management requires careful carbon husbandry, appropriate low to zero tillage regime which keep residues in the upper soil layers with a flourishing soil flora and fauna when properly done, fertilizers inputs are complementary and even provide synergies with biological management.

Indicators of soil chemical, biological and carbon status can be made available for GIS mapping and management extrapolation over large areas. These approaches are highly

consistent with benchmarks, watershed and other regional approaches. Finally, many of the molecular tools, including use of marker genes are increasingly being used to characterize soil flora and fauna. The Centres can make significant contributions through the characterization and tracking of soil processes in this production system over time and space.

5. A Strategic Perspective on CGIAR Role in Research Related to Water Management

For too long, research on water issues has been disjointed, based on traditional disciplinary sciences without crossing boundaries, focused on short-term issues, and lacking coordination and cooperation among potential partners. Surface waters were treated separately from ground waters; water quality, independently from water quantity and each sector of users (i.e., agriculture) was ignorant of all the others. This approach to research often led, not surprisingly, to inadequate policies that were not well suited to solve the problems addressed.

A consequence of the research approach described above is that progress in some disciplines has been lagging behind relative to others, and in some cases, they have been largely ignored in much of the research on water issues. It is now evident that research in the social sciences has not contributed sufficiently to the development of new knowledge in the water area, and that the progress made in the biophysical and engineering sciences, have not been matched by that made in social sciences research. Yet, it has been evident for some time that science and technology are just two components of the solution to most water problems, and that the economic, social, institutional, and cultural aspects of water are essential determinants of its use and management.

Improving the efficiency of water use in all sectors is a major challenge now and in the future. This is particularly important in agriculture where the focus should be in conducting research on the improvement of water productivity, the ratio of yield to the water consumptively used. It is very difficult to increase WP in the short term by changes in the genetic make up of crops. However, biotechnology offers new possibilities that, combined with the expertise that several CGIAR Centres have in crop adaptation and performance in adverse environments, should open an important avenue for research in the medium term.

One critical problem worldwide is the lack of reliable hydrologic data, either because of lack of monitoring programmes or because many of the programmes designed in the past for field data collection have deteriorated. One result of the inadequate data collection programmes is the unreliability and uncertainty of water supplies caused by the lack of precision in hydrologic forecasting. The problem is particularly critical in the developing countries where the absence of data even prevents hydrologic forecasting and rational water resources planning.

The last decades have seen a decline in the quality of water due to anthropogenic activities. Surface water quality deteriorated first but now, evidence of the lowering of groundwater quality is becoming apparent in many world areas. We need a better understanding of the physical, chemical and biological processes that determine the long-term changes in water quality, particularly in groundwater, which is expected to be an increasingly important source of supply in the future. Much progress has been made in recent years in the development of simulation models of contaminant transport in soils and water but more

efforts are needed in producing means for preventing pollution, in assessing the capacity of environments for processing contaminants, and in predicting impacts of water quality changes at the ecosystem level.

Many more research challenges could be listed but regardless of the problem tackled, what is most important is to approach it with the correct framework and focus. It is time to consider simultaneously water quantity and quality; to analyse jointly surface and groundwater; to bring into the analysis at the start, all the social, environmental, and health components that are relevant to the problem under consideration. To summarize, it would be hard to find an area of research where multidisciplinary approaches would be more effective that they can be in the area of water.

6. A Strategic Perspective on CGIAR Role in Research Related to Living Aquatic Resource Management (LARM) Research

Major portions of the world's population of poor (as many as one billion people) depend on aquatic products for the main part of their animal protein. Yet projected requirements are considerably beyond projected supplies of aquatic products for human consumption. Many millions of people depend on fish and fishing as their source of income; and the numbers are growing. Aquaculture production of the world alone now contributes around US$ 47 billion per year (including aquatic plants). These numbers will increase further as other sources of protein stabilize or become more scarce. Other statistics also indicate the immensity of the dependence on aquatic resources by poor people. The basic point is clear: This is a major and important sector in meeting humankind's need for food and other products; and it is a major, important area in which the CGIAR should be involved.

It also is clear that research related to LARM is at a very early stage in terms of application of the tools of modern science; and there is every evidence that expanded research in this area could have significant payoffs in terms of the goals of the CGIAR. Past research shows the promise that lies ahead if LARM research gets the necessary boost to bring it up to its potential. Thus, while capture fisheries have reached a plateau of production (around 90 to 100 million tons) and are mainly in need of sound management to avoid future declines, the technical potentials for aquaculture expansion have hardly been tapped.

The aquaculture sector is the fastest growing major food production sector, increasing at an estimated annual rate of about 9%. And most important from the CGIAR's perspective, aquaculture production is particularly important in the low-income food deficit countries (LIFDCs). The species base potential for aquaculture is enormous. Relatively few species are being used for culture. Increased aquatic food production can benefit from further research on candidate species representing different trophic levels. The potentials for gain are widespread.

Approaches to fisheries management, which are based on massive state appropriations of natural resources, centralized administration, policing, and heavy demands on financial resources, have proven to be generally ineffective and increasingly obsolete. Current management initiatives, such as co-management and user-based fisheries management, which are development-oriented, people-centered and based on traditional approaches, promise to be more effective for sustainably managing fisheries. These approaches depend on a broad approach to NRM, i.e., an INRM approach that considers coastal management in a more

systems oriented framework that integrates fisheries, tree and forest management (e.g., mangrove management), with associated crop and livestock management.

7. A Strategic Perspective on CGIAR Role in Research Related to "Forests for People" (Social Forestry) Research

Whatever the revolutionary changes that will be taking place in technology related to travel, communication, trade, agriculture, medicine and industry - and the corresponding positive changes that will take place in many people's lives, the fact is that 10-20 years from now there will still be hundreds of millions of poor rural inhabitants; as in the past, they will depend centrally on forests and trees for essential ingredients for living and for gaining access to better lives. The CGIAR has to continue to be concerned with this component of the overall rural poverty challenge to find the ways to make the evolving technological opportunities work for the rural poor and forest-dependent people.

The Alternatives to Slash and Burn Systemwide Programme is a good example of where forests and agriculture – the main business of the CGIAR – come together. Some of the most critical environmental/INRM challenges are at the forest margins – those vast areas on all tropical continents where living for the poor depends both on agricultural technologies for oftentimes nutrient depleted fields and on technologies for gaining maximum sustainable food, fodder, fuel and timber for survival and for bringing people out of poverty. Research on forests and forest communities provides a unique opportunity to complement the more traditional CGIAR research related to farming systems and agricultural and livestock crops. The CGIAR has shown in many ways the strong, beneficial complementarities that exist; and in the process, it has provided strong continuing justification for continued involved in forestry research.

In addition, there is an expanding role for forests in production of global environmental services. Several CGIAR Centres have shown how systems of realistic payments to poor farmers for environmental services can help both in production of such services and in bringing poor people out of poverty. The same types of complementarities exist in the case of research related to watershed management, a theme that cuts across several resource systems.

Throughout the world, forestry is changing in concept and in practice. Countries are changing their policies and objectives; stakeholders are changing their management methods; and new values, such as the global environmental ones associated with forests (e.g., biodiversity, carbon sequestration, water and soil quality) are coming to the forefront. Devolution towards participatory management and sharing of benefits, the privatization of forestry, and the global awareness of the values of the local environmental and social benefits of trees and forests require research of new types, with new approaches and methods, and the collaboration of scientists from both biophysical and social disciplines, many from outside forestry research institutions. The CGIAR, working with its partners, is in an advantageous position to contribute to this research.

8. A Strategic Perspective on CGIAR Role in Research Related to Agroforestry

Farmers have been blending trees with annual food crop production and livestock management for thousands of years ago, probably because they could obtain closer to home a better, more appealing diet from fruits and nuts and enjoy the shade of trees, as well as other direct, visible benefits from trees on their farms. In many areas, agroforestry started with people introducing annual crops in among trees, rather than introducing trees into agricultural fields. In the early days of agroforestry, population pressure was not a problem in most areas, and shifting cultivation was the norm, rather than the exception in the tropics. Fallows could be as long as needed, because the pressures on land were slight. Fuelwood and building poles were available nearby. In sum, agroforestry in the early days likely was a response to quite obvious direct needs and wants that trees can satisfy. Only later did agroforestry become popular as a means of taking maximum advantage of the biophysical conditions of the soil and the climate.

The CGIAR, led by ICRAF, has evolved in its agroforestry research towards activities related to the introduction of new institutional and policy approaches, watershed and landscape level systems studies and, more fundamentally, improved understanding of all the components along the research to development continuum. These areas of research are needed to complement the more field oriented technical agroforestry research that is being undertaken by individual countries and smaller research groups.

While there always is the need for more and better technology research, the CGIAR recognizes that much of the technology already on the shelves of research institutions is far ahead of practice and the ability, resources and motivation of local agencies and farmers to adopt it in the fields. There is a need to discover why this is so and do research on how to overcome the barriers to adoption of new and improved systems. Oftentimes, the barriers prove to be quite amenable to research, and the constraints small and easy to solve through research and development support.

There is need to continue:

- Developing more dynamic planning processes that will permit analysis and prediction farther into the future of NRM needs and potentials related to agroforestry. Many different types of input are needed in addition to the traditional farm-level biophysical research inputs. Large scale simulation modelling, trend analysis tools, GIS input and social science research to analyse trends and predict developments, are all needed. ICRAF and other CGIAR Centres already have in place many of the skills that will be called upon; and they have linkages with ARIs interested in these issues.
- Increasing landscape and watershed level research to understand NR interactions in agroforestry systems. Such research requires significant resources, interdisciplinary approaches, long term presence at sites, and concern for understanding externalities – all conditions that the CGIAR can meet but most others cannot or will not meet. The Systemwide programme, Alternatives to Slash and Burn, is a good example of this type of longer term, international collaborative programme.
- Expanding policy research to help countries set the context for agroforestry development. The incentive for countries is that agroforestry can contribute both to increasing rural welfare and to the broader national objective of environmental enhancement and

protection, particularly related to soil conservation and prevention of downstream damages from poor land use.

- Increasing CGIAR understanding of the enabling components and conditions along a successful research to development continuum. Research and technology development are only the tip of the iceberg, so to speak, if the ultimate goals are poverty alleviation, food security and environmental enhancement. From technology development through research to adoption and successful implementation is a long way, as evidenced by past experience. The CGIAR needs to continue expanding its understanding of the appropriateness of varied dissemination and adoption pathways under different social, cultural and environmental conditions.

The INRM perspective on sustainable development is essential in agroforestry research and will become more so as the linkages between resource utilization, management, and conservation practices become stronger and more direct. The integrated framework involves inter- or multidisciplinary research. The Panel's view of this approach is one where the partners from different disciplines come together to understand the issue(s) being addressed and the roles of each discipline in a common framework as contributed to by all the disciplines involved. Each discipline then goes off to do the components agreed upon. In a simplified sense, the partners then come together again to reach consensus within the common interdisciplinary framework on the issue(s) addressed. In reality, this is an iterative process of successive approximations as the team moves towards acceptable solutions and advancements in terms of the common INRM context.

9. Disciplinary Perspectives in INRM: Further TAC Consideration Needed

The five NRM components listed above exist in the CGIAR at present to a greater or lesser extent than needed. In order to focus on *strategic issues*, it is necessary to cut across these with discussion of the role of different disciplines in social, economic, ecological, biological, and physical sciences. In putting forth suggestions for operationalizing INRM more effectively and efficiently within the overall CGIAR research framework, TAC also needs to come back to the four sets of linkages that it defined in its previous work on NRM, and to bring those together in a perspective on the appropriate way ahead along the research-to-development continuum. This means considering explicitly the impact pathways from INRM problem/opportunity identification, to priority and agenda setting, to project formulation, implementation and dissemination, to support in application and implementation, and finally on to impact monitoring and assessment. Moving ahead in this area will not be a neat sequential process, but rather an interactive one of successive approximations as the projects, centres and System as a whole searches for the *operational* INRM paradigms most relevant for the CGIAR in moving towards its goals.

As INRM problem sets, priorities and potential impact areas are identified, an appropriate research and development (impact) processes must be developed through stakeholder interaction and consensus. Examples of focal areas and NRM components for INRM focus are given above. TAC has laid out below the elements and processes for developing an operational framework for any given problem or opportunity set addressed. The properties of concern will certainly include an operational plan to deal with scale. The process framework should begin with a minimum set of interacting parameters for scope, and then make provision to add or delete parameters as the problem set changes, progress is

made, project resources change, or scientific breakthroughs occur. Stakeholder interaction, NRM coverage, (implying which disciplines are needed) and a host of other factors will vary with problem/opportunity type, geographic scale and with time as the project progresses. The points and intensity of integration also change.

TAC's role in all of this is to monitor the process, assess adequacy of the emerging applied frameworks, assure that the appropriate science is being accessed, that science quality is acceptable, that the objectives are appropriately matched to project resources, and that potential impact justifies the cost.

The CGIAR is focused on resource-poor farmers in poor countries with uncertain and often unstable social, institutional and physical infrastructure, farmers who deal with production systems which depend on resiliency as much as productivity. In this case, the location of expertise for INRM integration within the scientific community, reside with the centres, and with researchers who have many years of experience in dealing with such complexity. The role of a Science Council in that process must be carefully thought through. Wisdom is as much knowing what you don't know and should not do, as much as knowing what you do know and should do.

It is stressed again that the outputs of INRM research will need to be relevant for the small-scale farmer or land user, since every day such land users deal with INRM issues, by taking advantage of the synergies between all the components in the farm environment, and in the context of the broader institutional environments they face in their communities. The truly successful farmers are the practitioners of INRM.

Finally, it needs to be stressed again that the CGIAR should not lay claim to dominance in INRM research. It needs to focus on the international public goods dimensions of the subject, leaving the more site specific, complementary activities to be led by its partners. *Effective partnership is the order of the day*, which implies a productive marriage of ideas, activities, actions, *and* resources and responsibilities. The result is communication and understanding of mutual benefits, but not necessarily resulting in equal roles and responsibilities for all. The CGIAR brings a number of special skills and advantages to the table; but these should always be considered in the broader context of complementarities or synergies that can be developed with other groups – NARS, private and public organizations in developed countries, NGOs, and farmers groups.

10. Complementarities: Bringing the Pieces Together in a Strategic, Operational Framework[3] for Action

The elements and processes essential to effective INRM programmes and projects have been spelled out in many of the documents reviewed by TAC (Evolution of NRM Concepts and Activities in the CGIAR, 2001) and in notes, reports and papers from the Bilderberg, Penang and Cali meetings convened by the CDC task force.

[3] Framework here is defined as a process with common elements of design, procedure and verification that applies to the fullest range of INRM project sizes and problem focal areas.

Most of the elements are common to high quality research programmes in any setting, but understanding the integrative nature of target ecosystem processes, and the regional nature of stakeholder problem identification and priority setting within them is a particular strength of Centre experience and programmes that is reflected in outcomes from these recent meetings. TAC suggests the following framework (Figure 1) guide to programme planning and structure as well as monitoring and evaluation. The details of most elements and processes will change with each programme and geographical area of application.

Framework Summary

The framework for INRM/sustainable production projects or programmes has five elements, linked and integrated through a series of researcher/developer interactive processes:

1. Partnerships:

   These are created beginning at a local/regional level, consisting of stakeholder and partners in the research/development process. There is a growing CGIAR literature on roles and effectiveness of CGIAR partnerships, particularly with a regional focus. Partnerships should begin at benchmark sites with farmer collaborators.

2. Scientific structure of the programme:

   There are four components to structure:

   - Location and scale, which covers temporal dimensions, particularly for the natural resources components, and scale for both production systems and their natural resource base. Geographical scale must be built in at the design phase. It has scalar elements as shown in Figure 2, with function and partnerships changing at each level. The activities of CGIAR Centres is maximum with respect to those of other partners at the benchmark sites, where most of the field research is done as shown by the shaded areas at each level. Other partners have a much greater share of the work at other levels. The nature of the work changes at each level as well. Benchmark sites are chosen to provide key data prints along gradients of ecosystem or socioeconomic process and interaction. A site may be made up of multiple communities, watersheds or cluster of smaller units.

   - Social and policy domains

     All land and aquatic resource use systems operate within and are highly governed by social and policy environments. They should be outlined for each system, with critical elements which influence the production ecosystem targeted for attention.

     Social interaction and public policy nearly always interact with and influence the biographical relationships between production system and natural resource status.

     The process of programme integration through stakeholder and partner interaction to identify problem focal areas and their boundaries is critical to a programme's scientific structure. Priority setting is a dynamic process, changing with success, new opportunity and new problem occurrence. The farm family is both the manager and primary beneficiary of the production ecosystems.

- Production system and their associated NRM domains are subsets of broader agroecosystems. Much of present INRM discussion centers around the characteristics, processes and components of these agroecosystems. Elements of biodiversity, resiliency and sustainability are fundamental at this agroecosystems level. Conceptual models derived in Penang, 2000 pertain in particular to crop-dominated agroecosystems. Those with major forestry, fisheries or livestock components may show differences. It is felt by agroecosystems scientists that most systems have from 3 to 5 "drivers" of process which are continuous across gradients of environmental change, and which are key to their improvement and productivity.

- Production system focal areas are chosen within the framework of integrated production systems. The focal areas must be elements of limiting technologies, and where CGIAR Centres have component technology expertise and advantage. They should be identifiable problem areas where there is reasonable scope for improvement.

- INRM domains

  These are natural resource constraint areas for water, soils, biodiversity, soils or other resource – limitations and problem focal areas. They occur within broad land/resource management systems (production systems). Any given resource will have interaction patterns with human management practices and production system type. A Programme can start with either an NRM or a production system problem set.

3. Governance of the programme must reflect a local and regional priority-setting and blending with stakeholder priorities up to the global level. Governance must be cost-effective and have clear responsibilities and lines of accountability. It must be dynamic, driven by both resources and scientific progress.

4. Financing must be of reasonable duration and at a level consistent with programme objectives.

5. A process of programme tracking should follow the systems of logframe benchmarks and outputs. Impact expectations must be clear. Any programme must impact people's food security and their well being, in addition to having (usually) longer-term positive impact on the resource base.

This framework contains elements essential to improving any sustainable production system or natural resource domain. TAC suggests it as an operational framework within which programmes evolve. The specifics of any production system and natural resource domain must be articulated at a regional level to be of any practical usefulness. The process of regional priority setting is as important as the eventual priorities chosen.

This suggested is an outline for programme structure. Nested within this are operational frameworks for the production ecosystem itself and for each domain within it. These will change with each ecosystem type (i.e., aquatic, forest, watershed, etc.). The domain framework can occur at the component level, the operational level or at the level of

underlying flows and processes. The programme structure framework suggested here is a general model which exists as a top-level, with structure, operational and process frameworks arrayed in descending order beneath it. The programme planner or evaluator must clearly understand that hierarchy and where each conceptual framework fits within it. Many of these models are spelled out in various reports coming from the INRM meetings at Penang and Cali. The project component diagram only is presented here for clarity and simplicity.

11. The Role of the Science Council

The success and eventual impact on the lives of rural people and on the resource base will very much hinge on appropriate and effective scientific structure and focus of the programme. It is a given that management processes must be appropriate and in place. The complexities of problem identification and scientific or technical solutions across gradients of change to achieve large-scale impact is not simple. The conceptual models must be relevant, limiting factors clearly understood, and priorities for change evolved through stakeholder involvement at relevant scales.

The Science Council should assume a research and science oversight role, at least in the early years, during programme planning, early implementation and programme evolution for the CGIAR challenge programmes in particular. While the framework remains constant, regional and specific agroecosystem requirements will demand significant flexibility. Advanced laboratories may be excellent sources of component science, but they are of little help in the integrative science and processes effected for the new programmes.

Experience in the CGIAR with integrated systems research has repeatedly demonstrated that the weakest link in the process is nearly always a lack of focus on a clear problem set and on areas for potential impact over wide areas. The Science Council should focus squarely on both the quality and relevance of science in stakeholder-identified focal areas.

If water and climate change are to be early programme candidates, the Science Council should mobilize or play a key role in task forces to evolve regional priorities and foci within appropriate agroecosystem types and assure that an appropriate scientific structure and focus is embedded within effective programmes.

Figure 1: Framework for Programmes Sustainable Production Systems and INRM

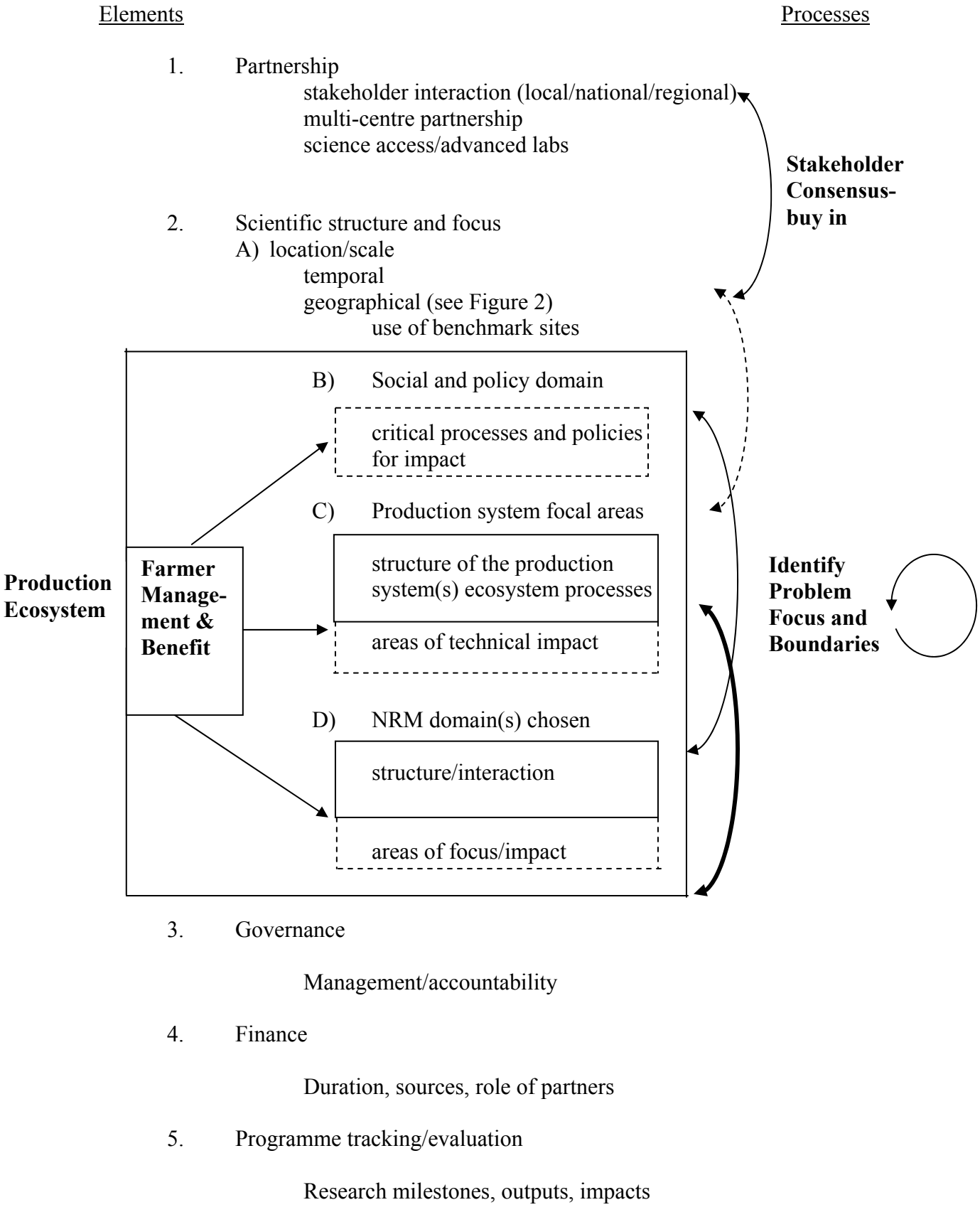
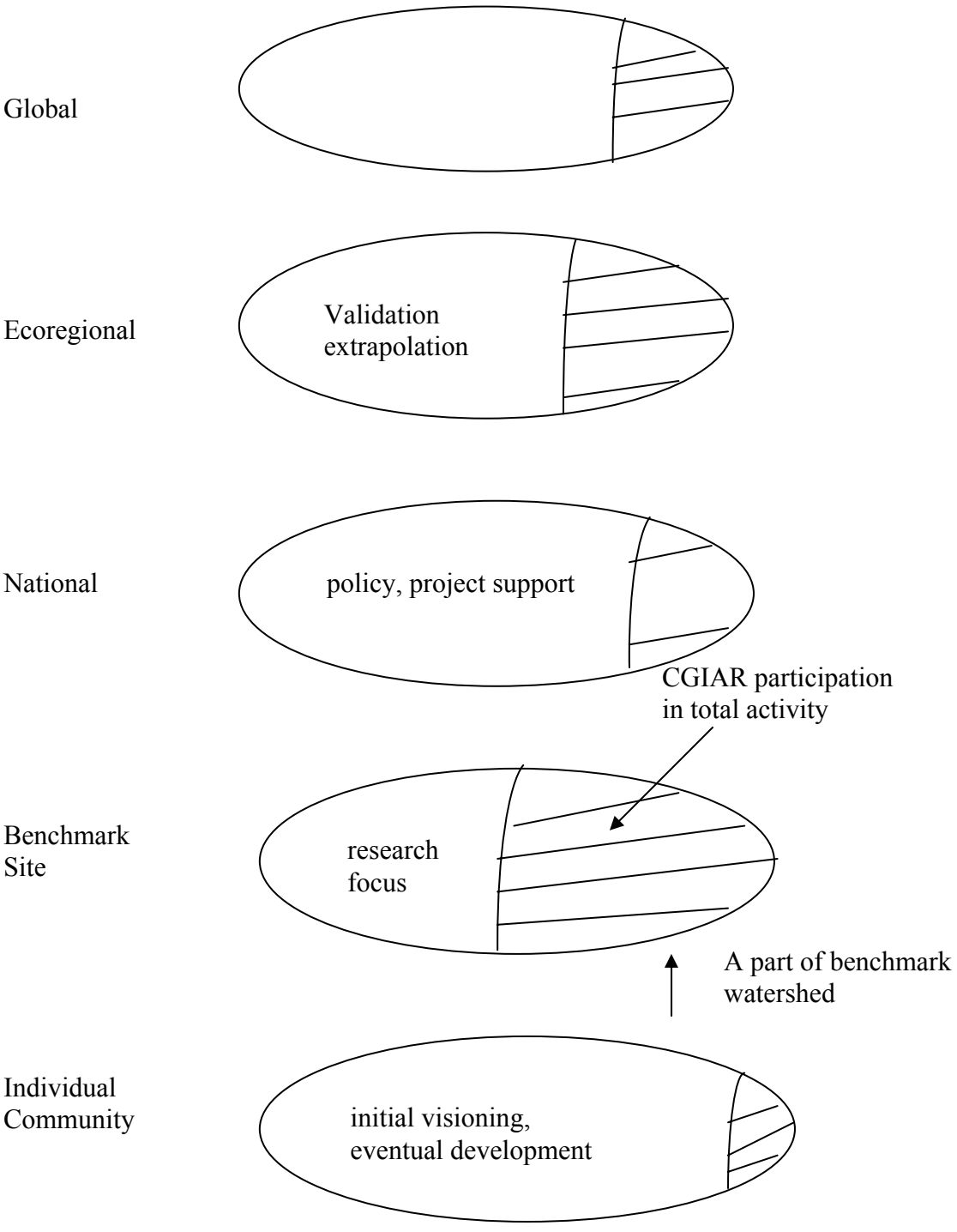


Figure 2: Functional activities and responsibilities at each level of scale



Source: Workshop on Integrated Management for Sustainable Agriculture, Forestry and Fisheries. Cali, Columbia, August 2001. Working group report on Frameworks.

ATTACHMENT:

Evolution of NRM Concepts and Activities in the CGIAR

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CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

Evolution of NRM Concepts and Activities in the CGIAR

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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Evolution of NRM Concepts and Activities in the CGIAR[4]

For some years, TAC has been evaluating and planning for natural resources management research within the context of the CGIAR's main goal of sustainable poverty alleviation and food security through agricultural and related research. The present paper provides a synthesis of such assessment and planning activities since the Canberra meeting in 1989 when the formal decision was made by the members to consider expanding the System to include a number of natural resource and environmentally focused centres, including specifically centres dealing with forestry, agroforestry, water management and fisheries.

This paper traces in broad terms the evolution of the concepts and activities of the CGIAR related to sustainability, natural resources and integrated natural resources management. We start with a brief review of the early years and the post Canberra meeting years. This is followed by a discussion of the 1996 TAC study on priorities for soil and water research in the CGIAR. It was in this document that the term "integrated natural resources management," or INRM formally entered the System's vocabulary, although the concept, in various forms had been around for decades.

1. Pre 1996 CGIAR Activity in NRM

Up through 1996, there was a significant evolution of CGIAR thinking on NRM and a substantial broadening of its activities in this area. 1990 was the key year when the Group agreed to proceed with consideration of expansion of the System to include a number of natural resources related centres and activities.

1.1 The Early Years

Through the 1960s, the CGIAR focused almost exclusively on agricultural productivity and efficiency for its mandate crops. This included efficient use of fertilizer and other nutrient sources, as well as effective pesticide use. Emphasis was on genetic improvement which not only focused on yield increase but also on: pest and disease resistance, nutrient response and efficiency, adaptability to growing environments and stress tolerance. Reduction of environmental impact was a stated objective of much of this work. Water-related research addressed primarily issues on water distribution

[4] Prepared by Richard Harwood, Hans Gregersen, Elias Fereres and Amir Kassam, with input from Tim Kelley, for the Workshop on Integrated Management for Sustainable Agriculture, Forestry and Fisheries, 28-31 August 2001, CIAT, Cali, Colombia. Helpful review comments were provided by Emil Javier and Alain de Janvry. A revised version of this paper incorporating the output of the Cali Workshop will be discussed at TAC 81, 24-28 September 2001.

networks and on crop adaptation to water stress. This general approach was a sole focus, but continued as a central theme as new components were added in the eighties.

Through the 70s and 80s, a cropping/farming systems approach was added to the research agenda, including research on optimum rotations and cover crops. In addition, work was started in the area of integrated pest management. Some programs researched entire farming systems, including animal feed and other components. Others focused on the mandate crops "in a farming systems context". These efforts broadened the crops grown and the agronomic management of these crops. Varietal selection was often done, but genetic improvement by breeding was not included for those "companion" crops. Farmer-participant methods became central to that work, as most was conducted on-farm, by farmers. In all cases the "systems" researched were based on mandate crops, i.e., upland rice, irrigated lowland rice, cassava, maize, etc. Economic production research increasingly extended beyond individual crops to include systems impact on farm family incomes, labour use and food security. Water research emphasized water management and operations at the district level. Research on genetic improvement and on related agronomic practices continued for the mandate crops.

The concept of "sustainability" (related to the NRM base on which all agricultural production depends) officially entered TAC and the CGIAR language in 1987, when TAC identified sustainability and natural resource management concerns as deserving high priority attention and the inclusion of the word "sustainable" in the CGIAR goal statement in 1987 (TAC 1987 CGIAR Priorities and Future Strategies). In 1988, TAC produced its first seminal work on sustainability and conservation and management of natural resources entitled "Sustainable agricultural production: implications for international agricultural research" (TAC 1988), which presented sustainability as a dynamic concept under the following definition: "sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources."

1.2 The 1989 Canberra Meeting and the Early 1990s

The Canberra meeting in 1989 represented a watershed in the CGIAR in terms of opening the doors to a broadened, more environmentally and NRM focused mandate and set of activities. It was at this meeting that the proposal was put forth and accepted to move ahead with preparations to add centres dealing with forestry, agroforestry, water management, livestock and fisheries, broadening the focus beyond the agricultural systems that were being covered.

In 1990, TAC reviewed the role of the non-CGIAR, NRM focused Centres (IBSRAM, IFDC, IIMI, ICRAF), and considered how best to add forestry to the system. At the same time, TAC reviewed the weaknesses in CGIAR NRM research and the need to broaden the CGIAR NRM mandate. The ecoregional approach emerged as one way to focus more on integrated crop and natural resources questions within a broad ecoregion.

At ICW90, the CGIAR endorsed the concept of an ecoregional approach. This broadened the mandate beyond geographical areas delineated by commodity systems (upland rice, lowland rainfed rice, etc.) to areas delineated by other (non-commodity) factors. Boundary conditions were left unclear; and there was need for further clarification. In 1991, TAC laid out the concepts underlying an ecoregional approach.

In the 1992 Review of CGIAR Priorities and Strategies, and in the 1993 CGIAR Medium-Term Resource Allocation, TAC provided guidelines and targets for investments in NRM related research through ecoregional programmes and subject matter global programmes on genetic resources, water, fisheries, forestry/agroforestry and livestock.

In the mid nineties, a number of activities took place that helped to define the current perspectives held in the CGIAR on INRM. For example, two CGIAR-initiated Task Forces were established on: Sustainability (Rudy Rabbinge, Chair) and on Ecoregional Approach (Cyrus N'Diritu, Chair). Both task forces reported to MTM95 in Nairobi, and their deliberations helped shape future programs and perspectives. They also helped to widen the network of linkages between the CGIAR and other groups and key individuals working in the broadly defined area of INRM.

In 1996, there was a key TAC-led study on "Priorities and Strategies for Soil and Water Aspects of National Resources Management Research in the CGIAR". This report put forth the first call for an "integrated" approach to NRM (INRM), based first and foremost on soil and water resource management. It was a seminal report, having broad implication. Thus, its recommendations are summarized in the following Section, while post 1996 evolution of INRM at the System level is sketched out in Section 3.

2. INRM in the 1996 TAC Study on Priorities and Strategies for Soil and Water Research in the CGIAR.

As mentioned, the 1996 S&W study incorporated most of TAC's ideas that had evolved over the past decade or so.[5] Notably absent, was a strategic discussion of forestry and fisheries; and of biodiversity – generally now accepted in the System as a separate, but equally important part of NRM. It was reasoned that these specific themes had been covered in other recent TAC discussions and studies or that they would be covered in the future. We consider that the 1996 document introduced many key ideas and concepts that form the basis for our current thinking as discussed below.

[5] It should be noted that while this TAC-led study of NRM research was in progress, the CGIAR established two Task Forces, one on sustainable agriculture and the other on ecoregional approaches to research. TAC attended the meetings of both Task Forces. The conclusions and recommendations/ commentaries of the two reports were taken fully into account in preparing this paper, including in the recommended modes of implementation.

TAC wanted to focus on the "integrated" aspect of NRM as the concept was evolving in the System. Prior to the S&W study, the term was not widely and officially used in the System. While TAC used the INRM term somewhat differently from the more recent way in which the current CGIAR INRM group (the Bilderberg, Penang and now Cali meetings) uses it, the two uses are fully compatible and complementary.[6] The S&W paper went on to emphasize that:

…the CGIAR System could benefit from introduction of a more consistent, systematic, and environmentally sensitive integrated natural resources management (INRM) framework for research. This framework would serve two main purposes. One is to provide a logical framework for linking the various natural resources management activities in the System. The other is to provide a better means of showing the rest of the world how the System is addressing the interrelated set of environmental and natural resources issues that are of concern when moving towards sustainable agricultural, forestry and fisheries production. Such a framework would involve four sets of interrelated linkages:

- *Links between productivity-enhancing and resource conserving research (e.g., crop improvement and natural resources management);*
- *Spatial or landscape level linkages (e.g., upstream-downstream linkages in a watershed management framework);*
- *Temporal linkages (e.g., links between present and future, or sustainability considerations);*
- *Linkages between research and the diffusion/adoption of results from such research.*

Research within this INRM framework incorporates a broad spectrum of disciplines and activities outside the soil and water focus of this study, including those related to forestry, fisheries and genetic resources. These other areas of activity are fully as important and critical to the successful use of an INRM framework as an integrating tool. Thus, they will need to be incorporated into a more operational INRM framework and approach. One example of an INRM framework focusing on the spatial (watershed) linkages is provided by an integrated watershed management framework (a detailed model was presented in Annex I of the S&W study). *(Elsewhere in the S&W Study, TAC uses the IPM model as an example of INRM).*

[6] **TAC suggest that**: "INRM can be defined as the responsible and broad-based management of the land, water, forest and biological resources base--including genes--needed to sustain agricultural productivity and avert degradation of potential productivity." **The Penang proceedings, on the other hand, defined it as follows:** "Integrated natural resources management is a conscious process of incorporating multiple aspects of natural resource use into a system of sustainable management to meet explicit production goals of farmers and other uses (e.g., profitability, risk reduction) as well as goals of the wider community (sustainability)."

The main conclusions and recommendations of the TAC S&W study were as follows:

Conclusion 1: There is a need to improve the state of information on land and water degradation and its impacts on agricultural, forestry and fisheries production

There is a serious, widespread lack of adequate information on land and water degradation and the state of the environment, and knowledge of the impacts of environmental change (both degradation and enhancement) on crop production, particularly over time. Arguments regarding the seriousness of the problems abound among reputable groups. The arguments arise almost entirely because of deficiencies in basic data and because of differences in interpretations of the scarce data available.

Given the need for transnational information and research on the condition of natural resources and the environment, and particularly on the extent and impact of degradation and enhancement of the environment by humans, TAC believes that there is a critical role for the CGIAR System to play in developing a better understanding of some of the linkages between agriculture, forestry and fisheries and the condition of the environment and the natural resources base on which all agriculture depends. (In fact, the recently completed SPIA Nelson Panel report on environmental impacts of the CGIAR was to a great extent a response to this recognized need).

Recommendation 1: The CGIAR System should develop improved mechanism(s) by which centres, collectively, can be involved with other partners in generating and interpreting improved scientific evidence on the extent and magnitude of the impacts of agriculture, forestry and fisheries on the degradation or enhancement of natural resources and the impacts of such degradation or enhancement on agriculture, forestry and fisheries production and food security.

Conclusion 2: The CGIAR System has need for an Integrated Natural Resources Management (INRM) framework for research

(TAC's thinking on this conclusion was summarized above).

Conclusion3: Within the INRM framework there is need for additional focus on specific subject matter

TAC concluded that most of the areas of research within the INRM framework that are relevant for the CGIAR System already are being dealt with to some extent in the System. However, TAC also emphasized that the linkages covered within the INRM framework need to be introduced into the CGIAR System not only through centre activities, but also to a great extent through work in the Systemwide Programmes, essentially those that implement the ecoregional approach. The INRM framework is mainly an integrating mechanism that helps to develop full coverage of natural resources management issues while being fully sensitive to environmental externalities and linkages.

TAC recognized back in 1996 that water is one area of focus that particularly needed much greater emphasis within an INRM framework. It identified a number of issues and challenges in the water area faced by agriculture, forestry and fisheries that were considered critical for food security now and even more pressingly in the future. Thus, TAC concluded that water-related research is a priority area in which the System's scope and intensity of work should be significantly expanded to embrace the problem of water scarcity and competition among the different users. Emphasis was placed on sustainable resource use and conservation by addressing water quality issues and broad watershed management activities to complement, the existing work on soil-plant-water relationships, allocation and distribution of irrigation water, and the role of water users associations and management schemes.

A number of other research priorities were identified within the context of the four INRM linkages discussed above. They are mentioned below, although not all of them should be or will be undertaken by CGIAR Centres.

In terms of linkages between **productivity-enhancing and resources-conserving research** the following topics seem particularly relevant:

- managing water and nutrient supplies for greater efficiency and sustainability; research on the efficiency of water and nutrient use by crops, especially to prevent degradation of irrigated land; both economic and biophysical efficiency should be considered;

- research on the processes underlying the long-term, less obvious forms of soil and water degradation. (This will complement existing production-oriented CGIAR soils research);

- managing soil fertility (organic matter, mineral nutrients, acidity).

In the case of **spatial or landscape linkages**, the key areas include research on:

- the pros and cons of devolution of NRM responsibilities to local government bodies and user groups;

- the physical, economic and social impacts of agriculture, forestry and aquaculture production practices on the quality and quantity of downstream water supplies and on assemblages of aquatic organisms in downstream and upstream water bodies;

- development of acceptable methods for combating soil erosion (mainly associated with its off-site impact on environment);

TAC also advocated a greater use of the interdisciplinary and systems approaches (including simulation models) in developing research within the INRM framework, and it suggested the need for development of a limited number of carefully selected watershed

or catchment studies that can serve as baseline studies or benchmark sites within the ecoregional approaches developed by centres and their partners.

In the case of **temporal linkages**, the key area for research is:

- measurement of the rates of change in key dimensions of natural resources (the dynamics of resources management, use, enhancement and degradation); and research on the impacts of such changes on food and water security; and on health.

This work is particularly critical, given the conclusion above concerning the state of knowledge and understanding of the impacts of agriculture on natural resources and the environment and the impacts of land and water degradation on overall agricultural production. (See Recommendation 1 above.)

In the case of **linkages between research and diffusion/adoption**, the key area for research is:

- the long delays between information development and generalized adoption including the reasons why existing information has not been used more effectively to improve natural resources management practices. For instance the move from shifting to permanent cultivation; also, research on how to get more effective implementation of existing knowledge for improved INRM, i.e., research on cultural diffusion and adoption of research results already on the shelf, in the context of fostering a participatory approach to improving natural resources management.

TAC was concerned with the fact that there is a great deal of research-generated NRM information that is readily available, but unused in practice at present (e.g., knowledge regarding soil conservation technologies and watershed management practices). Further, based on the assessments of the S&W Study, consultants and others, it was concluded that many of the past improvements in NRM can be related back to research that was carried out for other purposes. Thus, the links between research and changes in management practices are weak in such cases.

There is need for increased research on why there is a lack of widespread progress in natural resources management using much of the available research-generated information and technologies. This is a promising, potential area of significant gains. TAC believes that there is opportunity for the CGIAR to expand its activity in this area, particularly looking at the NRM technologies and ideas generated in its own centres, but also at related knowledge developed by its partners. The kinds of research questions which appear to have promise include: Was the research undertaken in isolation of the needs and incentives of potential beneficiaries? Were the costs of diffusion, adaptation and adoption ignored or underestimated? To what extent were issues of diffusion and adoption ignored? Have the research results been adequately translated into practical language that is understood by the potential users? Why is it in areas of success, that it

appears that strong local organizations are one key factor in effective transfer and utilization? How can existing knowledge and technologies be used more effectively and efficiently to generate gains in terms of natural resources management and conservation?

Recommendation 2: Intensified and expanded collaborative mechanisms and activities should be developed among centres, and between centres and their non-CGIAR partners, to help focus increased research and institution strengthening on issues related to adoption, adaptation, and utilization of existing NRM technologies and knowledge that so far have remained unused.

This recommendation should be implemented through a coordinated effort of the Centres, based on their own ongoing, individual programmes in this area. Such an activity should become part of every research programme and centre activities, where it is not already so. TAC does not envision it as a formal Systemwide Initiative but as a reallocation of resources into areas of higher priority.

Conclusion 3: There is a need for uniform and consistent criteria for judging the priorities for NRM activities/research in the CGIAR Centres and programmes

TAC considered various criteria for assessing the relative importance of the proposals to strengthen or expand INRM research in the System. TAC recognized that the criteria or factors involved also could be used to look at the desirability for continuing current programmes.

TAC concluded that at least four factors, described in detail in the report, should be considered by those preparing proposals and in judging the relative importance of new research themes. More specifically, priority activities should:

1. make an identifiable contribution to poverty alleviation and environmental protection or enhancement;
2. be results-oriented and utilization focused (demand-driven with high probability of use);
3. make optimum use of existing information and fill knowledge gaps;
4. build on the CGIAR's international advantages.

TAC also considered various criteria for judging the usefulness of alternative modes of operation for implementing INRM research (see section 4.2). It concluded that seven such factors should be considered in choosing among options:

1. degree and effectiveness of collaboration with others;
2. cost-effectiveness/value added of the option;
3. extent to which stakeholders' interests are considered in defining problems and planning research;
4. clarify for communicating the importance of the research to CGIAR members and others;
5. continuity of funding/support;

6. ease with which acceptable lines of accountability can be established;
7. standards of planning, monitoring and evaluation proposed.

The above criteria for judging importance and for choosing among operational modes are fully consistent with those that have been adopted for use in the broader TAC Priorities and Strategies exercise related to Systemwide Initiatives and Programmes. In fact, they have evolved from TAC's experience in assessing future funding of the NRM components of Systemwide Initiatives and Programmes, including those based on the ecoregional approach.

The above conclusions and recommendations are probably as relevant today as they were in 1996 when the study was released. In fact, the CGIAR has made strides in alleviating some of the problems identified and taking advantage of some of the opportunities pointed out in the TAC study. Some areas of NRM information have improved markedly, but most remain in an unsatisfactory state. That is particularly so in the more complex areas that link the biophysical processes to the human/social processes that drive land degradation and natural resources use and misuse.

3. Recent Thinking and Activities Related to INRM

In 1998-99, TAC introduced and the System accepted the logframe as a basic organizing and accountability tool for the System and its centres. Within the context of the logframe reporting procedure, INRM was to be a part of production systems research for crops, trees, livestock and fish. This outlined the framework for conducting INRM research within the context of production systems, rather than as a separate entity within Centres or in a completely separate Centre or programme. It called for an output-based approach, with a need for impact assessment procedures to be put in place.

By the late 1990s, IIMI had changed its name to IWMI, with a shift in focus and a broadening of mandate beyond the management of irrigation systems to include issues on watershed and river basin management up to the global scale This represented a conceptual change which was increasingly demanded by changing global needs. More recently, the activities of IBSRAM were merged with IWMI to form a broader alliance directed at conducting water research in a land and water conservation context.

At IWC99, a TAC-sponsored external panel reported on a study of CGIAR activities and priorities for “marginal lands.”. This study reviewed past efforts and assessed potentials and methods for research on marginal lands. Definitions, land classification difficulties and social impact dimensions were reviewed. This study contributed to a better understanding of the linkages between poverty and land types, or natural resource systems broadly defined.

Also in 1999, a TAC led study, “The systemwide review of programmes using an ecoregional approach,” concluded that the approach could be effective, subject to effective management, clear articulation of, and focus on, researchable problems, and appropriate partnerships.

Another key 1999 CGIAR activity, led by a coalition of centres, was the Bilderberg meeting on natural resources management research. Its outcome confirmed many of the concepts that had been evolving, and strengthened emphasis on some points, namely that:

- an integrated approach to NRM was needed;
- the social component was equally as important as the biophysical one, and that it should be strengthened;
- increasing emphasis should be placed on identifying and including stakeholder groups; and
- the problem focus must be clear and specific in INRM activities;

In 2000, the CGIAR INRM group had a second, followup meeting to Bilderberg. This meeting was held in Penang, Malaysia, to further refine CGIAR ideas related to INRM. The meeting resulted in a strengthening and broadening of the CGIAR "community of interest" group and a re-emphasis of the Bilderberg points of focus. Considerable attention was given to agroecology and ecosystem processes as ongoing concepts.

TAC's most recent involvement in the INRM area was a TAC commentary on the 15 March, 1999 Centre Directors' Committee (CDC) "note on integrated natural resources management," prepared in response to the recent System Review's recommendation no. 5, which included a number of proposals for strengthening INRM research in the System. It is instructive at this point to briefly look at what the System Review said about INRM, review the CDC response, and then look at TAC's commentary on it, since this relates directly to the INRM activity that has evolved in the System since the System Review was presented to the CGIAR members.

3.1 The System Review and INRM

In 1999, the System Review team presented its final report to the Group. It had a number of things to say about natural resources and NRM as a cornerstone of CGIAR work. It pointed to the emerging natural resource management methods as illustrating the paradigm shift in agricultural sciences: from classical agronomy to ecological sciences; from analytical research to systems dynamics; from top-down to participatory approaches; and from factor-oriented management to integrated natural resource management.

The report highlighted that new agricultural techniques will have to be rigorously assessed before being introduced in order to avoid potential negative impact on ecosystems. Technical changes as well as social, economic, and institutional changes, will have to be seen as modifications of the whole system in which they are included, not simply as independent introductions. Innovation in production systems will thus have to be considered as sets of changes related to strategies addressing the entire System. Integrated approached to the study of system change will be needed. Agroecological systems management will therefore become a major research area. Ecosystems

management in a wide sense – cropping systems, livestock systems, fisheries, forestry, agroforestry, and the interactions with the surrounding ecosystems – is based largely on NR and policy management. The purpose of these management approaches is to guarantee ecological and economic viability and sustainability, as well as the social acceptability of technical, economic and institutional changes.

An integrated NRM approach will involve three basic steps. The first is to identify the extent of the resource degradation and rural poverty problems to be addressed, place these problems in their relevant spatial and temporal scales and identify their driving forces, and then predict their future trends and patterns. The second step is to undertake research activities to enhance the food production services of existing land use systems in a sustainable manner. The third step is to do on-farm research to assess the trade-offs among options arrived at thus far.

The implementation of the NR approach necessitates the establishment of partnerships with concerned stakeholders – including policy makers at different levels, from the village to the international sphere – as well as new collaborative modes among the CGIAR Centres, NGOs, NARS and ARIs. The emphasis is no longer on large-scale adoption of a single solution, such as an improved crop variety, by one category of stakeholders (farmers). On the contrary, it is on ensuring that a given problem occurring in a variety of environments is solved in a sustainable manner through the adoption of ranges of options by farmers, regional bodies (including NGOs), and policy makers at the national and international levels.

The System Review team recommended the following:

"That the CGIAR enhance its research methodology by adopting an integrated natural resource management approach. Further, the organization of an International Network for Integrated Natural Resource Management will link productivity research with environmentally sound management of natural resources. The Network should be based on, among other things:

- centres that are retooled with sciences needed to manage the viability and sustainability of ecosystems;
- a definition of the corresponding methods at different spatial scales, particularly at local levels;
- adoption of precision farming techniques in relation to tillage, irrigation, nutrient supply and pest and post-harvest management;
- development of indicators for measuring sustainability;
- development of sustainable systems of management for aquatic resources;
- joint preparation of national agricultural research strategies by respective NARS and a consortium of IARCs; and
- development of more bottom-up, demand-driven projects.

3.2 CDC "Note on INRM" – A Response to The System Review

The Centre Directors Committee presented a response to the System Review's Recommendation 5 at the CGIAR Consultative Council meeting in Brussels in January 1999. It can be summarized as follows:

- The CDC does not endorse the establishment of an additional network for INRM, but strongly supports the proposed conceptual framework and the need for increased support of ongoing INRM activities in the CGIAR.

- INRM should be seen as an approach that permeates the entire CGIAR, as a pillar of equal importance to integrated gene management (IGM). INRM is not amenable to being addressed through a single "international network". In fact this reductionist proposal runs counter to the more desirable objective of organizing research around natural resource management problems in a demand-driven way.

- The CGIAR has already invested heavily in establishing INRM-type ecoregional consortia and systemwide programmes, such as Livestock, Soil/ Water, and Alternatives to Slash and Bum. These programmes focus on the relationships between the resilience of the natural resource base on one hand, and poverty reduction and food security on the other. The next logical step for the CGIAR should be to reap full advantage of the time and financial investments made in these established programmes by providing sustained support.

- Emphasis should be made on scaling-up the research from the plot or farm scale to the watershed/village, national, regional and global scales. National, regional and global concerns such as carbon sequestration, greenhouse gas emissions, agrobiodiversity, deforestation, desertification and depletion of coral reefs should become a more explicit part of the CGIAR agreed agenda.

- The CDC strongly supports the Review's emphasis that technological research should go hand-in-hand with policy research at the same geographical scale. INRM is by definition interdisciplinary and highly participatory.

- NRM consortia based on ecoregions or problem areas should be operated through the leadership of the Centres already responsible. The CDC Committee on Sustainability and the Environment (CSE) will take explicit leadership for a system-wide sharing of experiences, approaches, results and ways to control the high transaction costs of INMR partnerships. The CSE will take the initiative to ensure increased cohesiveness and synergies of INMR between centres and with partners.

- Considerable confusion is associated with the use of the term "INRM" in the CGIAR. The CSE will also work on clarifying concepts and terminology.

The CDC went on to propose an "Action Plan" as follows:

1. The CDC believes that the CGIAR can best contribute to INRM and broader environmental objectives by strengthening ecoregional research capabilities and particularly by reinforcing intercentre cooperation at key ecoregional benchmark locations.

2. The CDC proposes to strengthen its Committee on Sustainability and the Environment (CSE) by including centre scientists who are leaders in INRM research. CSE will continue to be chaired by a DG, with additional DG's as members. It will take responsibility to assure the implementation of a strengthened INRM pillar in the CGIAR by the centres.

3. The CDC recognizes that there are major gaps in the research coverage of current ecoregional programmes, for example measurement of carbon sequestration and greenhouse gas emission in many ecoregions. A gap analysis in the form of a matrix of systemwide and ecoregional environmental issues will be undertaken by CSE.

4. The CDC also recognizes that locally, nationally and internationally resources tend to be spent on addressing symptoms of environmental degradation rather than understanding the underlying causes. We believe that a strong case can be made for donors to shift resources away from palliative "environmental protection" and towards investments in research to understand the underlying cause of natural resource degradation.

5. Centres believe they should further exploit their ability to address NRM issues beyond the confines of individual countries. There are potential opportunities to look at cross border environmental issues (large watersheds, for example).

6. The CDC proposes a number of immediate steps to strengthen INRM research in the CGIAR:

    - Further studies of relationships between natural resource depletion and poverty.

    - Case studies of the economic, social and environmental returns from INRM research.

    - Better understanding of the relationships between natural resource depletion and both sectoral and extra-sectoral policies. For example the impacts of agricultural policies on forests and fisheries; of land degradation policies which focus on soil erosion and ignore soil nutrient depletion and soil fertility policies which focus exclusively on fertilizers.

    - The need to bring INRM issues fully into the NARS agenda and to build NARS capacity in INRM research.

    - The special need to strengthen INRM research in sub-Saharan Africa, where poverty and resource degradation are most acute.

- Incorporation of appropriate climate change and biodiversity research issues in the research agendas of the CGIAR centres.

3.3 TAC Commentary on the CDC paper

TAC in turn reviewed the CDC response and associated Action Plan, presented at the March 1999 TAC meeting in Rome. TAC was in general agreement with the CDC positions and proposed Action Plan. Specifically, the TAC commentary stated that:

- TAC agrees with the SR Recommendation 5 that there is need for strengthening and for increased clarity and focus of INRM work in the CGIAR, and that INRM activities should be under regular assessment and update. This should be based on ecosystem science, the understanding of ecosystems as suggested in Recommendation 5 (attached). There is need for establishment of a conceptual framework for INRM.

- TAC agrees with the CDC and-the CBC that there should not be an additional Systemwide network established for INRM, but that it should remain a part of a sustainable production systems effort. The two are inextricably linked.

- TAC endorses the CDC recommendation that the CDC Committee on Sustainability and the Environment (CSE) will take leadership for Systemwide sharing of experiences, approaches, results, and ways to control the high transaction costs of INRM partnerships. TAC will work with the CSE in that endeavour.

- TAC will work with the CSE to incorporate appropriate areas of global climate change work in the INRM portfolio.

- TAC will work with the CDC to rapidly implement lessons learned from its ongoing review of ecoregional programmes, due for completion in late 1999, to increase the effectiveness of ecoregional methodologies as an INRM tool. It is agreed that these ongoing programmes can serve as platform for much of the System's INRM work.

- TAC will work with centres to increase their use of production ecology as a tool in INRM work within the framework of sustainable production systems.

With the recommendations of the System Review and a number of other studies in mind, TAC prepared the most recent Vision and Strategies document. It dealt in several key places with NRM issues and opportunities, as indicated below.

3.4 NRM in the "CGIAR Vision and Strategy (2000)"

TAC recognizes that poverty alleviation and sustainable food security for the rural and urban poor depend directly on the health of the environment and the sustainability of

the natural resource base on which food, feed and fibre production depend and therefore conservation and enhancement of natural resources and protection of the environment are central to the CGIAR core research agenda. However, there are limits to how much and what type of NRM research the CGIAR should support. Priorities should be determined based on the following six principles:

(1) The CGIAR should concentrate on NRM research that contributes to productivity enhancement and sustainability of natural resources for production of crop, livestock, forest and fish outputs that have impacts on poverty reduction and food security, giving appropriate consideration to inter-generational equity of benefits.

Effective management of the natural environment is an activity pursued by many organizations for many different and legitimate purposes, including global climate change, wildlife management, ecosystem health and recreational purposes. Given the competence and large numbers of alternative suppliers, the CGIAR should pursue activities that are targeting sustainable productivity improvements. Yet every effort should be made to create win-win situations and to minimize trade-offs between crop, livestock, forestry and fisheries production and environmental and natural resource protection.

(2) *The CGIAR Centres should use an integrated NRM focus in their planning to define problems in NRM that require research.*

The INRM framework proposed in the 1996 TAC paper should continue to evolve to provide a better defined and more operational focus for CGIAR-supported activities in NRM. Improvements will arise from a shift from NRM research on-station to production ecology research in integrated production systems at benchmark sites. The INRM framework incorporates a broad spectrum of disciplines and activities, including those related to forestry, fisheries and genetic resources and describes a number of critical linkages. In the case of linkages between research and the diffusion and adoption of technology, it is essential to enhance our understanding of why existing information and knowledge has not been used more effectively to improve NRM practices. This is a promising area of research and the CGIAR Centres are well positioned to undertake this assessment.

(3) *International integrated NRM research should be process oriented to ensure maximum contribution to production of international public goods.*

This principle applies to both biophysical and socioeconomic components, relationships and changes across environments, and the sociopolitical processes by which positive changes can be made or negative ones avoided. Such process research involves consideration of changes over time, comparability of results across ecoregional production systems, and mechanisms for translating results through adaptive research done by NARS. This implies a shift towards process-level relationships understanding and modelling across environmental gradients, and away from site-specific component trials. A number of examples were given (e.g., for water, forests, fisheries, livestock,

soils, etc.). In addition to the development and application of biophysical and economic models, CGIAR research in integrated NRM should target a range of other international public goods including the development of improved tools for research on land and water management, e.g., sustainability assessment, identification of resource management domains (typologies), and methods for impact assessment.

(4) *The CGIAR should give greater attention to research to resolve water issues*.

Irrigation currently uses two thirds of the developed water supplies worldwide and agriculture faces competing demands for water from all other sectors. Unless properly managed, lack of access to fresh water may well emerge as the key constraint to global food production. There are inter-sectoral water management issues (competition among agriculture, municipal, industrial, and environmental uses) as well as issues within and between countries. The resolution of these competing demands for water may be assisted by well-focused research to improve the management of water in ecosystems, in particular on improving the efficiency of water use in agriculture.

(5) *Focusing NRM research around common reference locations or benchmark sites is essential in incorporating the many dimensions of integrated NRM*.

This approach will provide a common environmental and problem set for multidisciplinary integration and interface with national programmers. The focal site (benchmark) work should be done within a GIS framework to facilitate extrapolation to the relevant recommendation or application domains.

(6) *Priorities for specific NRM research themes should be determined by the CGIAR Centres in the context of the sustainability issues affecting productivity increases, regional priorities and comparative advantages of the CGIAR.*

The CGIAR is well positioned to become the global focal point and provide visibility for international research to address NRM issues related to productivity enhancement. As a nucleus for global knowledge on sustainable land and water management, the CGIAR could lead and coordinate global efforts to improve the state of knowledge on land and water degradation and its impacts on agricultural, forestry and fisheries production. In addition, the CGIAR System can play a major role in surveying, analysing, integrating and disseminating information from a variety of sources dealing with scientific and indigenous knowledge on land and water management in relation to agricultural, forestry and fisheries production.

4. TAC's Currently Evolving Perspective on INRM in the CGIAR[7]

As evident from the discussion above, TAC's ideas on natural resources management research have been evolving in keeping with new knowledge, with the changes in CGIAR objectives and with new thinking on issues such as sustainability and poverty alleviation. They are still evolving. However, some points seem clear: While TAC fully acknowledge the multifaceted nature of the integrated management of natural resources, it also recognizes and emphasizes here that the CGIAR cannot deal with all issues, challenges and opportunities. TAC's perspective of INRM focuses on management of natural resources for the purpose of achieving the goals of the CGIAR related to poverty reduction and sustainable food security.

It is possible to argue that most aspects of INRM are inter-related and that, in a sense, all INRM issues and opportunities should be of concern to the CGIAR, since ultimately, in one way or another, they relate to the goals of the CGIAR. While this is true in theory and in concept, it also is true that resources within the CGIAR are limited and that many more institutions of diverse nature and often with greater resources than the CGIAR are tackling many of the issues, relationships, and research opportunities that exist in INRM. The CGIAR should focus on those INRM issues for which it has a comparative advantage, based on its many years of work in the agricultural systems of the developing world. At the same time, the CGIAR centres should be, and are open to, cooperation and collaboration with many other groups involved in researching INRM problems which do not fall in the above category.

Within the context of what TAC believes is appropriate boundaries for INRM activity within the CGIAR, the focus should be on the following broad natural resource areas:

- integrated water and watershed management (i.e., management of land and water resources for the primary purpose of securing the best quantity and timing of water flows, and quality of water for the benefit of farmers and rural citizens, particularly the poor);
- management of water as habitat for living aquatic resources for rural, coastal and floodplain (including estuarine) livelihood enhancement;
- management of land and terrain resources and related flora and fauna to enhance sustainable agricultural production, (e.g., prevention of soil nutrient depletion, declining physical properties of soils, etc., when used under intensive and extensive agriculture);

[7] It should be noted that this section presents the authors' thinking on TAC's current perspective on INRM and how it should evolve in the near future. The matter will be fully debated at TAC81 this September, and the ideas and conclusions emerging from the Cali workshop/consultation will be fully taken on board in that TAC debate.

- management of forest environments for rural livelihood enhancement, including social forestry as well as through sale and personal consumption of forest outputs, including, but not limited to wild game, fruits, nuts, oils and other forest products;
- INRM associated with intensive peri-urban agriculture, livestock and fuelwood production;
- incentive systems for securing improved NRM management, e.g., through downstream land and water user payments to upstream land users for conservation activities and through other means of bringing natural resources management into the market system.[8]

These issues or opportunity areas should be dealt with in an integrated fashion, within the four sets of linkages that TAC defined in its S&W study:

- *links between productivity-enhancing and resource-conserving research (e.g., crop improvement and natural resources management);*
- *spatial or landscape level linkages (e.g., upstream-downstream linkages in a watershed management framework: or scaling up from plot to farm to watershed);*
- *temporal linkages (e.g., links between present and future, short vs. long term; i.e., sustainability considerations);*
- *linkages between research and the diffusion/adoption of results from such research.*

We emphasize that this is not a new perspective for TAC.

TAC also recognizes, as done in the past that "cross disciplinary," "inter disciplinary" or "multi disciplinary" (whichever term is preferred) research is needed to deal with these six major NRM areas that are of concern to the CGIAR. It also recommends using both the biophysical and social science components required for a balanced approach to problem solving research. In this regard, TAC's view of an integrated or multi disciplinary research process is that (1) all relevant disciplines are brought together since the inception of the project and a research plan is developed under coordination; (2) researchers in each discipline define the components of the overall issue which are relevant and addressable by them; (3) researchers carry out the research in their own disciplines; (4) researchers come together periodically to see how the pieces are fitting together and where gaps exist; (5) finally researchers and practitioners come together to present results and develop an INRM framework to respond to the issue or opportunity in question. Obviously, using an INRM approach is not a guarantee for

[8] The CGIAR has a role to play in research related to securing poor farmers with payments for environmental services. This is evidently coming rapidly in the picture in many countries. Not only forestry, but also agroforestry, agriculture and livestock have roles to play. Payments which are a relatively modest source of income on a per hectare basis for developed country farmers may be significant contributions to income for poor farmers. There are important technological issues in which the CGIAR has been involved and could get more engaged, both to enhance the supply of services and to monitor delivery. An INRM focus would be useful since poor farmers need to design the delivery of environmental services as an integral element of their farming systems and livelihood strategies.

success and we have observed that, in some cases, more is promised from the integrated research model than actually can be delivered. Ultimately, good solid multidisciplinary research requires strong disciplinary input and effective coordination.

Additionally, scientific and technical developments, particularly in the information and communications technologies (ICT), are increasing our capabilities to carry out INRM research much more effectively, by extrapolating from point measurements to the higher scales in a realistic fashion. Furthermore, our understanding of the processes occurring at and beyond the field scale has increased substantially in recent years, thus providing new insights on the behaviour of ecosystems.

At the same time, interdisciplinary approaches based on agricultural, forestry and fisheries ecosystem sciences such as production ecology, landscape ecology, water resources management, and integrated pest and biodiversity management show promise for being able to help integrate different traditional disciplinary approaches and knowledge bases in more effective ways. To a large extent, the new technological developments in ICT are permitting this rapid progress. It is imperative that the CGIAR incorporates these new technologies and integrates them into its INRM research to the fullest extent possible. TAC also intends to devote a significant amount of time at its 81st meeting to a discussion of these themes and linkages.

There is no set model of INRM research. Regardless of which line of reasoning is followed, lessons from the past teach us that a key need is not to let the rhetoric of INRM get ahead of the science and not to focus too much on concepts without having common definitions and solid operational research approaches and procedures in mind.

In the past, research on natural resources has been too often conducted in a disjointed, fragmented fashion. We have now reached a situation where problems in managing natural resources are recognized to be multidimensional, with physical, economic social and cultural dimensions. It is now possible, with the modern tools of ICT and computers, to combine the various scientific and technological approaches to solving NRM problems with the social science approaches to achieve the goals of poverty alleviation and of sustainable food security. That should be a main focus of the CGIAR in the area of INRM.

Appendix 1: Review of Other TAC Papers of Interest

The S&W study provides TAC's main thinking on INRM up through 1996, when the study was written. Many other studies led up to the thinking that went into the S&W study. They are listed chronologically in Table 1. Below a few of them are reviewed.

TAC (1987) CGIAR Priorities and Future Strategies (AGR/TAC:IAR/85). TAC Secretariat, FAO, Rome

In this paper, TAC identified sustainability and natural resources conservation and management as areas of high priority, and the word "sustainable" was included in the CGIAR goal statement in 1987. TAC recommended that the proportion of total CGIAR expenditure to research and related activities devoted to NRCM be increased from 7% to 13%.

TAC (1988) Sustainable Agricultural Production: Implications for International Agricultural Research. TAC Secretariat, FAO, Rome (AGR/TAC:IAR/88/?)

This paper is a direct consequence of TAC (1987) recommendation on sustainability and conservation and management of natural resources. The paper reviews the circumstances threatening sustainability, analyses ways in which international research could be more effective, and makes recommendations for the future work of the Centres. Sustainability is treated as a dynamic concept and conceived the following definition - "sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources".

Key factors determining sustainability are: the level of external input used by farmers; population pressure on land resources; deforestation which, in upper watersheds, is causing soil erosion; salinization; soil fertility depletion; desertification caused by overgrazing; and the problem of climatic changes which may occur due to changes in the composition of the atmosphere.

TAC does not view research related to sustainability as a separate or discrete activity. Rather, concern for sustainability should be reflected in the way in which the research is approached. TAC therefore recommends that research at the Centres designed to generate agricultural innovations should be planned and conducted with a sustainability perspective. TAC further suggests that in formulating or revising their strategic plans, Centres should include proposals for maintaining a sustainability perspective throughout their programmes. TAC called for: increased attention to resource management including the need for measuring and monitoring sustainability, to ensure a balance in research between plant breeding and resource management, to cater for both short-term and long-term needs; greater emphasis to research designed to optimize productivity from the use of low levels of inputs to benefit resource-poor farmers especially those in the less favoured environments, and to investigate aspects of more intensive production systems that could evolve from sound traditional systems (including agroforestry); and a significant increase in policy research on sustainability.

TAC (1990) Role of the CGIAR in Natural Resources Conservation and Management: a desk study of the non-associated centres IBSRAM, IFDC, IIMI, ICRAF. TAC Secretariat, FAO, Rome (AGR/TAC:IAR/90/6 Rev.2).

TAC (1990) highlights the fact that natural resources conservation and management (NRCM) is central to the CGIAR mission and gaol as set down in the revised 1990 mission and goal statement. The statement specifically refers to "sustainable increases in the productivity of agriculture and forestry in developing countries" then defines agricultural sustainability as being "characterized by the successful management of resources for agriculture to satisfy human needs without degrading the environment or the natural resource base on which agriculture depends".

The paper concludes that major problems with natural resources are detrimentally affecting agricultural productivity in the developing world; that research on a number of key issues is needed to help overcome these problems but that the research needed is much more difficult because of the unique characteristics of research on NRCM which bear on strategic planning. These are: the long-term nature of research required to address NRCM and harder to measure benefits and impacts compared to varietal improvement research; inadequate data for priority setting on impact of resource problems on production, ecology, loss of biodiversity, number poor people affected; favoured versus less favoured areas, with increased attention to be given to less favoured areas because they are particularly subject to resource degradation processes but research strategies have to strike a balance between the favoured and less favoured areas; the location specificity of the resource base but widespread nature of the processes of resource degradation; the need for multidisciplinary systems approach. These characteristics may explain the relative neglect of research on natural resources within the CGIAR Centres which have generally and successfully capitalized on a multidisciplinary commodity approach which is more clear cut in terms of prioritization, research organization and impact assessment.

The paper raises the question as to whether or not research organized on a commodity basis can adequately deal with the multicommodity, and generally more complex problem of NRCM. Further, since NRCM research is usually location specific, national agricultural research systems must take primary responsibility for work on resource degradation problems. Nevertheless, international research centres can contribute by: (1) clearly defining the magnitude and potential for future consequences of the process; (2) by contributing methodology for characterizing and evaluating interventions in major ecological zones; (3) collecting, evaluating and disseminating available information from the global research community that is relevant to national policy choices; (4) doing actual research on a selective basis to both develop methodology and basic information and to provide examples of how to do it; (5) providing training; and (6) exploring appropriate institutional and management approaches.

TAC (1990) A Possible Expansion of the CGIAR (AGR/TAC:IAR/90/24). TAC Secretariat, FAO, Rome.

Sustainability of agricultural production: The report highlights the concern about the widespread depletion of the natural resource base for agricultural production that has grown over the past decades. Problems such as loss of genetic diversity, depletion of water resources, soil erosion, salinization, waterlogging, desertification, deforestation and environmental pollution threatened sustainability of agriculture in large areas of the developing world. Agricultural activities can have negative environmental consequences on other sectors such as fisheries. Efforts to increase agricultural production substantially in coming decades to meet population growth will accelerate these problems unless new strategies are formulated and adopted. An added dimension to be considered is the uncertainty introduced by prospects of global climate change which could further compound the problems.

The report points out that, within certain limits, sustainability and increased production are compatible gaols. Increased production on existing agricultural land reduces the pressure to clear and develop new lands. In the past, much of the incremental agricultural production has come from irrigated areas. Furthermore, intensive production systems can be managed to enhance land quality and reduce soil erosion. Therefore, as in the past, high priority should be given to research designed to increase yields. However, the past neglect of research on the conservation and management of natural resources must be addressed and higher priority given to both technical and socioeconomic aspects of sustainability.

*Need for international research in resource conservation and management***:** The combined impact of increasing population pressure and resource degradation points to the need for a broadening of the emphasis in internationally supported research to give greater weight to issues of resource conservation and management. Research needs in this area include for example: investigation of global environmental concerns; development of methods of ecological charaterization; conservation and evaluation of germplasm of plant and animal species of regional and global importance; improved understanding of natural forest ecology and management; natural fisheries ecology and management, including management models for sustainable development; soil conservation and management with special emphasis on better understanding of the long-term nutrient economy of tropical soils under increasing cropping intensity, with due consideration for trace element deficiencies in human and animal nutrition; better understanding of farmer decision-making under conditions of increasing land scarcity; development of principles and methods for management of water resources for irrigation and rainfed systems; and land use management and development of production systems. Emerging as a common theme from all the regional overviews is the message that continued emphasis on research topics aimed at increasing commodity productivity (including fuel wood) could make a significant contribution to the sustainability of resource management and land use.

The scope of CGIAR research on natural resources: As the System contemplates a broader mandate by incorporating research on the management of natural resources, it

will need to develop clearly defined criteria for evaluating the likely impact of such research on sustainable development. It is possible to identify some guiding principles of the CGIAR research related to natural resources. First, it will be important for the System to become involved in the measurement of rates of resource degradation and improved understanding of the underlying causes. Second, it needs to be acknowledged that there are areas of emerging global environmental concern that will inevitably have to be tackled by scientific agencies other than the CGIAR. Third, it would be preferable that CGIAR supported research in the area of sustainable resource management be set within the framework of clearly identified, quantifiable and realistically achievable short-term and longer-term development objectives.

Critical long-term activities for possible CGIAR support: Despite the fact that natural resource management and its components -- agronomy, natural forest management, soils, water, plant nutrition, and agroecological characterization – are often categorised as being "location specific", there are and will remain strategic research issues and environmental problems which will transcend specific production systems and geographical and ecoregional regions. These include for example basic understanding of soil-water-plant relationships, energy balances, sustainable input/output models, transnational issues of water basins, migratory pests, and soil erosion. Perhaps these could be characterized as issues in the broad research area of the ecological foundations of sustainable production systems. Again, strategic research addressed to these issues is international, has economies of scale and should have substantial spillover into national programmes and regional mechanisms.

Research supported by the CGIAR would fall into two clusters: global commodity activities and ecoregional activities. Global activities would be focussed on commodities and selected subject matter areas, such as policy management, conservation of germplasm and the maintenance of biodiversity. Ecoregional activities would focus on applied and strategic research on the ecological foundations of sustainable production systems, commodity improvement in collaboration with global commodity activities and interaction with national partners.

TAC (1991) An Ecoregional Approach to Research in the CGIAR. (AGR/TAC:IAR/91/8). TAC Secretariat, FAO, Rome

At ICW'90, the CGIAR endorsed the concept of ecoregional activities as a means of integrating natural resources management with productivity concerns. TAC developed a process utilizing agroecologically characterized regions (including associated national land use and socioeconomic characteristics) as a basis for a revision of the CGIAR priorities and strategies. It coined the term "ecoregional" to denote regionally defined agroecological activities. A major advantage of this ecoregional approach is that it allows geographically referenced ecological considerations to be readily combined with land use and socio-economic considerations. It also permits an assessment of potential research spillovers to be taken into account. Ecoregional approach addresses two concerns: the strengthening of research on natural resources management and conservation; and the strengthening of NARS. The successful management of resources (soil, water, crops,

livestock and trees) is a central tenet of the concept of sustainable agriculture. The techniques used in production and the soil and water management practices are a component tools for wider resource management. The components are shaped by criteria important to the productivity of the whole for a system whose sustainability depends on improving system productivity. Recognizing this, and noting the overriding importance of the human interaction with land base, TAC considers that formulation of the definition of a new integrated approach to resource management research is urgently needed.

TAC's concept of an integrated approach to resource management research emphasizes the System level but also recognizes the importance of research on components such as soil and water management. Comprehensive problem identification, conceptualization of researchable issues and priority setting must occur at the System level. Execution of the search to develop new technologies must be done with a greater focus, i.e. at the component level. Attention at both levels is critically important. The reason why TAC has opposed factor research on a disciplinary basis is the lack, historically, of a holistic perspective vital in the integration of components into appropriate technological solutions. Some past efforts to develop new resource management technologies have failed because the research was on a disciplinary basis and did not take account of the socioeconomic environment of the target farmers.

In this regard, another important dimension to TAC's proposed integrated approach to resource management research is the need to tie the research into policy environment and so help push the pace of technology diffusion. In summary, three major considerations have shaped the TAC approach to resource management research: (1) Recognition of the need to marry the human and technical dimensions and address the in an integrated way. (2) Recognition of the need to adopt a system level approach and to plan and evaluate component research from this viewpoint. (3) Linkage of policy formulation as a key aspect of strategy. Three key principles for the organization of ecoregional research were recognized: systems approach; building multidisciplinary teams; and cooperation with NARS and global commodity and subject matter centres.

TAC (1996) CGIAR Priorities and Strategies for Resource Allocation, 1998-2000 (SDR/TAC:IAR/96/6.2). TAC Secretariat, FAO, Rome

In this report, TAC proposed that the CGIAR System would benefit from the introduction of a more consistent, systematic and environmentally sensitive integrated natural resources management framework for research. This would serve two main purposes: one would be to provide a logical structure for linking the various NRM activities in the System; the other would be to work out, in collaboration with partners, effective ways to address the inter-related environmental, natural resources and human wellbeing issues that are of concern when considering sustainable agricultural, forestry and fisheries production.

TAC’s preliminary view is that a future paradigm for NRM research in the System would have two main elements:

Firstly, it would have a biophysical element that would combine three factors: (a) a basic understanding of the processes that cause NRM and environmental degradation and of how they are influenced by climatic conditions; (b) resource data sets and GIS techniques that allow that basic understanding to be extrapolated on a large enough scale to be meaningful in terms of the CGIAR global goals, thereby overcoming the location specificity that has constrained the System's NR research in the past; and (c) the local scientific and technical skills and facilities needed to apply this international knowledge to the solution of particular NRM and environmental problems ("delivery systems").

Secondly, it would have a strong social science component to deal with the organizational and management challenges inherent in achieving the biophysical objectives. The number of institutions and different organizational cultures involved in this very broad field is likely to be very large and it will be absolutely essential to have effective planning and evaluation processes, while working in a participatory mode and controlling transaction costs.

TAC (1999) CGIAR Research Priorities for Marginal Lands (SDR/TAC:IAR/96/18.1). TAC Secretariat, FAO, Rome

The motivation of the study was driven by the following arguments. The technological innovations which the CGIAR System generates to achieve its goals tend to be specific to particular biophysical contexts. For rural poverty reduction, contextual specificity then raises the possibility of targeting the rural poor by focusing research on the geographical areas with biophysical features where the poor are most heavily concentrated. Thus, if, as conventional wisdom has it, that most of the rural poor are located in areas characterized by marginal (less endowed) lands, that marginal lands are more susceptible to resource degradation, that the poor themselves are a source of environmental degradations, then technological innovations for marginal lands can help achieve win-win outcomes, with synergy between the goals of poverty reduction and sustainable NRM. If there had been an initial under investment by the CGIAR in research in marginal areas (as implied by the ministerial level meeting in Lucerne in February 1995), then a high uncaptured potential return to research on marginal lands may exist. TAC took initiatives to address the issue through a systematic analysis of existing evidence.

The study found no conclusive evidence to support the view that marginal lands support a high proportion of the rural poor, and that the poor are the prime cause of resource degradation on marginal agricultural lands. In addition, it does not appear correct to say that the CGIAR under invested research funds for these lands. In seeking an alternative concept to help target CGIAR research using a geographical criterion, the Panel proposed the idea of "marginal area" defined as a geographical unit characterized by a high incidence of "marginal people" and relatively homogeneous determinants of poverty. Hence, starting from marginality, the question is whether one can identify relatively homogeneous regions in terms of causation of poverty, whether the region is characterized by marginal lands or not. Since data are generally not available, the validity of the Panel's proposed alternative criterion remains to be tested.

Based on these findings, the study made four recommendations which were endorsed by TAC. The first recommendation is that "the CGIAR needs to sharpen its strategic focus on poverty alleviation, particularly in setting priorities for research related to marginal rural areas. A prerequisite is development of a geo-referenced database linking land conditions with poverty and the processes that produce it (i.e. the dynamics of poverty)". The second recommendation is that "Centres should establish new forms of partnership in order to effectively address their role in a broader poverty alleviation strategy related to those who live in marginal areas". Recommendation 3 is that the CGIAR System should "develop improved mechanisms by which Centres can be involved with other partners in generating and interpreting improved scientific evidence on (1) the extent and magnitude of the impacts of agriculture, forestry, and fisheries on the degradation or enhancement of natural resources and the consequences for production, and food security; and (2) the linkage between poverty and observed resource degradation". Recommendation 4 is that "expanded collaborative mechanisms and activities should be developed among Centres and between Centres and their non-CGIAR partners, to help focus research and institution strengthening on issues related to adoption, adaptation, and utilization of research results that so far have remained unused" (particularly in the field of NRM).

The study concluded that there is no simplistic characterization of the link between poverty and natural resource degradation. What is needed is a set of conditional statements on this link that establish when the relation may hold or not and why. This defines an important research area which the CGIAR is well placed to address. The study showed that more research is needed before marginal areas can be targeted to achieve CGIAR objectives and before research resource allocation schemes are developed that take land types into account.

TAC highlighted several immediate implications for Centre and System research planning:

- At the global level, the lack of correlation between land resource endowments and poverty, based on available data, has led TAC to propose a logframe classification that does not separate outputs by land type at the System level. However, Centres are encouraged to consider specific targeting at the regional level where evidence supports the belief that the correlation between the ecoregion and poverty may hold.
- Given the lack of proof of causal effects between poverty and land degradation, it is logical to proceed on the assumption that threatening land use practices and technologies cause resource degradation irrespective of who employs them. The targeting of degraded land does not selectively target poverty in most instances.
- The analysis indicates that there are areas of marginal land that may, in fact, have a significant potential for research-driven productivity increases, and that the returns on investment in these areas may equal or surpass short-term potential on more favoured areas. Targeting of resources on these lands should consequently help the allocation of resources in terms of productivity gains.
- To optimize the allocation of research funds between marginal and favoured agricultural lands for the purpose of poverty reduction, the key criterion is the marginal effect of research expenditures on poverty in each type of land. To date,

there is little evidence of the measurement of these marginal effects and this issue deserves urgent attention.

- Lessons should be drawn from CGIAR success stories in marginal areas, specifically, in identifying those factors (e.g. technical assistance, access to credit) which complement centre research to enable poor farmers to adopt technological innovations in marginal areas.
- Investments in GIS applications would have significant payoff in assisting the targeting of marginal resource ecoregions with potential for productivity increase, and in identifying areas of poverty and marginal lands.

TAC raised four key issues which will guide future research and resource allocation decision for reducing poverty. These are: the potential of biotechnology and agroforestry for the marginal lands; the need for a cautious analysis of the determinants of rural poverty in marginal areas, with a full accounting of the role of different factors; the essential need to have access to reliable and well-documented data on number and location of the poor in identifying viable strategies to alleviate poverty; and the need for attention to research issues related to marginal lands defined in relation to water, cost of trade supporting infrastructure, and distance to markets.

TAC (1999) Review of Systemwide Programmes with an Ecoregional Approach (SDR/TAC:IAR/99/8). TAC Secretariat, FAO, Rome

The purpose of the review was to assess the experiences that have been gained by the CGIAR Centres and their partners since 1994 in implementing the Systemwide programmes with an ecoregional approach. The ecoregional approach is aimed at sustainable improvement of agricultural productivity. It is conceptually holistic, combining human and technical dimensions and linking productivity and natural resource management. The most important conclusion is that the principles underlying the ecoregional approach are valid and of continuing high priority for pursuing sustainable improvement in agricultural productivity. Important new research has been done by programmes to characterize their regions and research sites, and practical benefits have been gained from enhanced technology transfer and adaptation. One programme has gone further than the others in relating its research sites to the whole area over which the problem occurs, and in scaling up to the global level its findings on trade-offs between environmental concerns and agricultural productivity. But the full power of the holistic ecoregional approach to research, especially its human and policy dimension, has not been fully explored. There was good evidence of effective NRM and productivity linkages in the research of several of the reviewed programmes, particularly at the applied level. In general, there is scope for greater investment in innovative strategic research on NRM.

The programmes have made excellent progress in developing partnerships with national research systems. The most successful ecoregional programmes have been the ones with a clear focus on a major problem, strong leadership at the top capable of articulating a vision of how a problem should be addressed, plus effective facilitation of collaboration at the research level. Many of the deficiencies seem to have stemmed from the lack of a

clear general understanding of the meaning of the ecoregional approach. Despite this uncertainty, the principles of the ecoregional approach have taken a firm hold in the CGIAR community and are extremely positive for the future.

The advice for the future is directed largely to NRM issues. A continued implementation of the ecoregional principles is strongly advocated. It is proposed that the CGIAR and its members adopt a revised framework for NRM research comprising three elements: (a) research should be organized around major problems or opportunities of sustainable NRM that are of international relevance, (b) it should use holistic systems approaches that combine human and technical elements to address the problems on multiple scales, and (c) it should provide for its progress to be measured against specific performance indicators. The principles underlying the revised framework be applied by all CGIAR Centres involved in NRM research for the sustainable improvement in productivity.

Other recommendations include: strengthening collaboration with strong partners in strategic research on biophysical and social science and policy aspects of NRM to redress the frequently observed imbalance between biophysical and social science research; and addressing methodological issues of scaling within benchmark sites and of extrapolation from them. In the future, the greater part of the natural resources research in the System can be managed and supported at the Centre level. Only in few exceptional cases, where the research problem or opportunity is of major importance on a global or regional scale, should the CGIAR support a combined System effort.

Table 1: TAC Papers Related to Natural Resources Management Research

TAC (1987) CGIAR Priorities and Future Strategies (AGR/TAC:IAR/85). TAC Secretariat, FAO, Rome .

TAC (1988) Sustainable Agricultural Production: Implications for International Agricultural Research. TAC Secretariat, FAO, Rome.

TAC (1990a) Role of the CGIAR in Natural Resources Conservation and Management: A desk study of the non-associated centres IBSRAM, IFDC, IIMI, ICRAF (AGR/TAC:IAR/90/6 Rev.2). TAC Secretariat, FAO, Rome.

TAC (1990b) A Possible Expansion of the CGIAR (AGR/TAC:IAR/90/24). TAC Secretariat, FAO, Rome.

TAC (1991) The Ecoregional Approach to Research in the CGIAR (AGR/TAC:IAR/91/8). TAC Secretariat, FAO, Rome.

TAC (1992) Review of CGIAR Priorities and Strategies (AGR/TAC:IAR/92/18.1). TAC Secretariat, FAO, Rome.

TAC (1997) Priorities and Strategies for Soil and Water Aspects of Natural Resources Management Research in the CGIAR (AGR/TAC:IAR/96/2.1). TAC Secretariat, FAO, Rome.

TAC (1997) Review of CGIAR Priorities and Strategies (AGR/TAC:IAR/96/6.1and 6.2). TAC Secretariat, FAO, Rome.

TAC (1999) CGIAR Research Priorities for Marginal Lands (SDR/TAC:IAR/96/18.1). TAC Secretariat, FAO, Rome.

TAC (1999) Review of Systemwide Programmes with an Ecoregional Approach (SDR/TAC:IAR/99/8). TAC Secretariat, FAO, Rome.

TAC (2000) A Food Secure World for All: Towards a New Vision and Strategy for the CGIAR (SDR/TAC:IAR/00/14.1/Rev.2). TAC Secretariat, FAO, Rome

TAC (2001) Environmental Impacts of the CGIAR: An Initial Assessment (SDR/TAC:IAR/01/11). TAC Secretariat, FAO, Rome