SUMMARY

The Systemwide Initiative on Water Management has defined **Enhancing the Productivity of Water in Agriculture in an Environment of Growing Scarcity and Competition** as its central theme and objective. To achieve this objective, research will focus on the analysis of water use, both rainfall and irrigation, in water basins with growing water scarcity, to identify the practices and policies for managing water supply that will lead to real water savings, reduction in soil degradation, and higher water productivity.

This proposal requests a sum of $500,000 in 1996 in order to undertake the following *plan of action*: (i) establish a Steering Committee, (ii) complete research and initiate training on standard procedures for measuring water productivity, (iii) establish procedures for coordinating and integrating research activities in a water basin, and (iv) organize teams of scientists to prepare proposals and initiate research on priority themes.

Increased competition for water threatens food security in a number of river basins where poverty is present. The negative link between water availability and poverty is clear and direct. There is a pressing need to increase the productivity of water in irrigation, save water through better management, and reduce crop losses due to soil degradation.

Accounting for water savings and measuring gains in water productivity is best accomplished in a *water basin perspective*. Through the holistic perspective of the water basin, it is nec-

essary to look beyond the confines of the irrigation system, taking into account both the on-site and off-site (up-stream and down-stream) impacts of interventions, both positive and negative. It is equally important to understand how policy interventions will effect water allocations in the basin and impact on income, health, food security, and gender equity.

In order to achieve our objective, ***enhancing the productivity of water in agriculture***, an initial step will be to complete the research on and test procedures needed to properly ***measure water productivity***. Subsequently, research will be conducted in those areas where there appears to be high potential for ***enhancing water productivity***. These include: (i) water savings through selection of alternative plant varieties, cropping systems, and crop management practices, (ii) reducing losses in crop yields due to salinity and waterlogging, (iii) identifying the potential returns to supplemental irrigation in areas of high soil fertility and low rainfall, and (iv) benefits to be achieved from reliable delivery of surface irrigation water. This research agenda will be undertaken by interdisciplinary teams of scientists from the CG centers and NARS capable of addressing the relevant technical, institutional, and policy issues.

Competition for water will be studied at both the *sector* and the *local* level. The agricultural sector, and irrigated agriculture in particular, face increasing uncertainty about the quantity, quality, and timing of irrigation supplies. How the transfer of water can best be achieved, minimizing the impact on agricultural production is an important research issue. Options which must be examined include water markets, redefined water rights, basin management authorities, and unregulated

competition. Understanding in more detail the uses of water at the *local level* will provide a better perspective on basin level competition and demand for water. Research should focus on identifying uses and users, assessing water entitlement, asset structures, determining the formal and informal transaction costs associated with each use, and determining who in the household, community or water basin will bear the costs. IIMI, International Food Policy Research Institute (IFPRI), and the International Center for Research on Women (ICRW) will collaborate with NARS and NGOs in this research.

The initial sites for research may be located in the following suggested water basins: Indo-Gangetic-Brahmaputra, Nile, Niger, Mekong, and Mahaweli. Improved management of water resources is essential in these basins to sustain growth in agricultural production, maintain food security, and protect the environment.

Training and information dissemination complement research activities. The training component will be designed jointly by CG centers, NARS, and NGOs, with initial training activities focused on standard procedures for measuring water productivity. As the Systemwide Initiative on Water matures and research results become available, we will use various methods for disseminating research findings and recommendations.

Our strategy will be to collaborate with other intercenter programs and associated NARS and NGOs wherever appropriate. We are initially establishing linkages with the Rice-Wheat Consortium; Water in WANA; the Soil, Water, Plant Nutrient Initiative; and the Property Rights and Collective Action Initiative.

The Systemwide Initiative on Water will be governed by a Steering Committee consisting of representatives from participating CGIAR centers, NARS and NGOs. A Coordinator will act on behalf of the steering committee and work closely with research teams. These teams, consisting of scientists from different research institutes, will develop proposals and conduct research on priority research themes. The Steering Committee will allocate funds received from donors to the approved research projects. There will be a simple and direct flow of responsibility from Team Leader through the Coordinator to the Steering Committee.

Research results will identify the potential areas for increasing water productivity in agriculture and for improved management and allocation of water among sectors. This should lead to a series of recommendations for changes in policies and water and crop management practices in the water basin.

BACKGROUND

Increased competition for water now threatens food security in a number of river basins where poverty is prevalent—the Niger, the Indo-Ganges-Brahmaputra, the Nile, the Mekong, and the Yangtze. At the same time opportunities for expansion of water supplies are limited. Food production in these areas is intrinsically linked to the availability of controlled waters. Declines in the availability and reliability of irrigation water will reduce food production unless offset be increased productivity of water and other inputs. Shortages and associated rises in food prices fall most heavily on those who spend a major part of their income on food—the poor. The negative link between food availability and poverty is clear and direct.

There is a pressing need to increase the productivity of water in agriculture through better management of supplies and control of soil degradation. At the same time, the growing competition for water requires greater attention to intersectoral allocations or demand management. However, there is no agreement as to the most effective strategy to pursue to achieve these goals. The demand for and value of water in alternative uses is not well documented. Furthermore, there is considerable debate as to how to measure water use productivity at the system or basin level, particularly when changes in water quality due to pollution and salinity are significant.

The Water Basin Perspective

Water savings and water demand are best analyzed in a water basin framework. Through a holistic perspective of the water

basin, it is possible to look beyond the confines of the irrigation system and take into account the positive and negative impact of interventions in the off-site (up-stream and down-stream) areas. The water basin provides the essential framework for measuring "real" water savings or the impact of interventions designed to enhance water productivity. To work "locally", one must think "globally".

A number of CG centers operate in the context of characteristics of the hydrological cycle that determine their agenda—humid lowlands, semi-arid tropics, tropical agriculture. Others concentrate on the agro-ecological systems which are important components of the hydrological cycle—forests, agro-forestry, rangelands. Commodity-oriented centers—rice, wheat, maize, potato, banana—depend directly on water availability as a primary determinant of productivity.

The water cycle provides the link among centers, and an important framework for defining the interfaces and interactions between the work of centers. However, the focus of most centers' work is 'on-site', in the sense that production is reported in terms of land (yield/hectare) rather than in terms of impact on the flow resource, water. This revised, or additional, focus is provided by the water basin.

If the argument that emerging shortages will be a dominant aspect of water resources management in future years is accepted, issues of 'productivity' and 'improved' management as alternatives or complements to physically enhanced supplies become important. Debate in this area is not always clear or well informed.

The most commonly proposed solution to problems of water scarcity is to increase the efficiency of agricultural use. The argument runs as follows: most of the available water is being used in agriculture; agriculture is wasteful; efficiencies in irrigation schemes are often well below 40% ; agriculture is a low-value water user; hence the relatively limited quantities needed to meet domestic and industrial demand can be diverted from agricultural uses with minimal disruption to society and the economy.

For example, in agriculturally developed portions of the Nile basin in Egypt and Sudan, observation of farms shows that excessive irrigation water is applied in relation to crop needs, that farmers are growing crops such as rice which require 1200 mm delivery to the field, and that water is flowing regularly to the drains. Farm efficiencies (the ratio of crop demand to supply) are probably in the area of 40% and one may easily conclude that if 10% of this waste were avoided, non-agricultural use could increase by 50% or more.

The view from the basin level—the appropriate frame of reference for the hydrological cycle—is dramatically different. The water flowing to the Mediterranean sea is of the order of 11–14 Km3, while total utilisable flows measured at Aswan average 74 km3—a basin efficiency of 85%. How can we observe 40% 'efficiency' at the farm level, and a basin efficiency of 85%? The answer lies in the high degree of re-use within the basin. The observed excessive applications at the field level are not consumed, but rather return to the system as recoverable groundwater, drainage return flows to the river, or are intercepted directly by downstream farmers. Thus improved local

efficiency, i.e. reducing the diversions to a field or farm while maintaining crop consumptive use and yield, do not automatically generate savings when seen in the basin context.

No amount of local efficiency improvement can increase overall consumption by more than the amount now flowing to the Mediterranean sea, and indeed navigation needs, and the sustainability of the system, in terms of flushing wastes, salts and chemicals limit the degree to which the present outflow can safely be reduced. The Nile is an unusually clear example, but not unusual in its implications. More commonly in monsoon climates, wet-season run-off is uncontrolled and excessive, so that 'efficiency' gains would have no value and might even reduce aquifer storage. Dry season runoff is close to zero, implying that water is fully consumed with a basin efficiency of 100%.

The water basin framework therefore provides the basis for understanding the physical water savings possible from introduction of new technologies or reform of water allocation policy. In addition to physical water savings, the task of water management is also to generate economic benefits. Even where the potential for physical savings of water may be low, the potential for economic savings due to policies or investments may be substantial. Socioeconomic benefits can be produced by reducing water pollution through inappropriate or excessive use of water by reducing the cost of water diversion or extraction or by transferring water to higher valued uses. The extent of these potential savings and important research remains to be done on this issue. Definitive estimates of the potential for improving systems performance by increas-

ing effective water supply requires basin or sub-basin level analyses to evaluate the real potential for increasing the water supply.

The waterbasin framework has relevance beyond irrigation and the concept of irrigation efficiency. During the 1995 planning workshop for the Water Initiative, participants could not decide: if all the CGIAR technologies for 'improved' water use were implemented in the entire Nile basin, would water still reach Egypt, or would it be entirely consumed by 'improved' upstream forestry, water harvesting, rainfed agriculture, etc.?

The absence of response to the question indicates the need for attention to the water basin as the frame of reference for much of the water-related work of the CGIAR. Potential basin level impacts of the development of major storages result in legal disputes if not actual wars between nations and states. Land use changes and on-site technology changes have the potential for similar impacts on stream flows, and must be taken equally seriously.

PRIORITY RESEARCH THEMES

We have defined two priority problem areas: *productivity of water* and *competition for water*. The challenge is to make more productive use of existing water supplies and more effectively manage water demands for *sustainable development*. In an era of growing competition our goal is *sustainable water productivity*.

Research issues include crop specific questions of water productivity, site specific problems related to such areas as crop

and land management to macro policy issues. We have argued above that these issues are best understood from the perspective of the water basin. That is to say we must take into account the off site effects of interventions by adopting a water basin perspective. Viewed from this broader perspective, the research questions contain technical, institutional, and policy components. It is through interdisciplinary and collaborative research among the CG Centers, NARS, and others that these research issues are best addressed.

1. Productivity of water

Measuring water productivity: An important conclusion from the 1995 Systemwide Initiative on Water Management workshop was the need for a uniform approach to measuring and reporting water consumption and its value to different sectors and uses. During the workshop, participating centers described their approach to measuring water productivity. These approaches ranged from ICARDA, where irrigation water and rainfall are separately accounted for their contribution to production to other centers who do not measure water use at all. Most importantly, there is no consistent approach that will support a comparative analysis allowed for by a descriptor such as *yield per hectare.* Even in those CGIAR centers located in regions of extreme water shortage, *yield per hectare* is the dominant descriptor for crop productivity. Clearly, however, where water and not land is the most limiting factor and off-site effects are considered the more relevant descriptor is *yield per unit of water consumed.*

Research will be carried out by IIMI in collaboration with

(other centers) scientists and NARS to further refine, test and introduce a standard approach to measuring and reporting on water productivity. The differences in water regimes among crops and the relative importance of rainfall among some cropping systems will need careful examination if results are to be useful. Similarly, methodologies must be developed and extended to measure the impact on the water resource of land use changes (from forestry to terraced paddy, or introduction of water harvesting technologies in upper catchments).

Enhancing productivity: Research will focus on areas where there appears to be a high potential for increasing water productivity. These include: (i) water savings through the selection of alternative plant varieties, cropping systems, and crop management practices, (ii) reducing losses in crop yields due to salinity and waterlogging, (iii) identifying the potential returns to supplemental irrigation in areas of high soil fertility and low rainfall, and (iv) benefits to be achieved through reliable delivery of surface irrigation water.

Research must also be undertaken on water use efficiency in order to be able to identify those interventions which will lead to "real" water savings. The issue of efficiency is currently under debate within the irrigation community, with greater attention now being paid to consumption of water rather than diversion or application of water. The "losses" in the traditional sense are often "sources" for other users through return flows to drains, and pumping from groundwater. Research on the measurement of "productivity" discussed above, would be of direct relevance to this area of study.

As noted in (ii) above, research under this theme includes *sustainability* of water basin productivity. Particular emphasis needs to be given to the problem of soil degradation and loss in productive capacity through salinity and sodicity. Control of soil erosion is a major focus of the research under the Soil, Water, and Nutrient Management Program.

2. Competition for water

Various forms of competition for water can be distinguished among sectors. At the *sector level* agriculture normally receives lowest priority compared to urban and industrial needs when shortages arise. In some developed countries, water to sustain the environment is receiving increasing priority. It is commonly believed that the agricultural sector, the greatest user of water, has the greatest potential for saving water. There is also competition for water *at the local* level between agricultural and a wide range of non-agricultural uses. Finally, there is competition within agriculture for the use of water. This competition is largely among crops, but also in horizontal (area) versus vertical (yield per area) expansion. *Intra-sector* competition is handled through alternative measures to increase water productivity discussed in the previous section. Managing *inter-sector* competition or the demand for water will require research on the implications of the allocations of irrigation water in terms of income, health, food security, and gender equity.

Sector level: Sector level analysis provides a macro or basin-wide view of competition for water. The agricultural sector, and irrigated agriculture in particular, faces increasing uncertainty

about the quantity, quality, and timing of water supplies. The transfer of water to non-agricultural uses will occur. How this transfer can best be achieved, minimizing the impact on agricultural production, is a critical research issue. Options include water markets, redefined water rights, basin management authorities, and unregulated competition. These options must be assessed at the basin level in relation to productivity, equity, sustainability, and environmental consequences.

The methodology for sector level analysis should include: (i) assessment and analyses of macro-level resource allocation processes, (ii) analysis of laws, contracts, and different forms of property rights and institutions, (iii) analysis of the impact of water allocation on intersectoral water use and conservation, choice of cropping pattern, input use, productivity, and resource degradation, and (iv) evaluation of the impact of various policy instruments on sector demands, investments in conservation and pollution control equipment, and agricultural output.

Local level: Understanding the uses of water at the local level will provide a detailed perspective on basin level competition and demand for water. Measures to increase productivity of water use for irrigation purposes often do not take into account non-irrigation uses in the rural areas, and the associated risk due to reduced water availability. These uses include domestic, livestock, aquaculture, household, gardens, and small enterprises. The management of irrigation water can impact the health of humans, livestock, marine life, and crops.

While actual quantities of water used in non-agricultural activities may be small, the impact on income and human health

may be significant. Irrigating the main crop may be the responsibility of both men and women, but many of the less recognized uses of water often fall under the responsibility of women. Gender equity can have a major impact on how water is allocated for specific purposes. The appropriate means of prioritizing such competition and the impact of alternative approaches on particular beneficiary groups (women, children) must be examined.

In summary, research should focus on identifying uses and users; assessing water entitlement and asset structures; determining the formal and informal transaction costs associated with each use; and on determining who in the household, community, or water basin bear these costs. For example, in physical terms the actions of one user may have downstream impacts on the quantity and quality of water available. These physical impacts raise issues that sometimes can only be addressed through social and legal mechanisms. Irrigation systems seldom perform properly if land and water rights are not clearly defined. Thus, the role of property rights and collective action are a central area of interest, and the Systemwide Water Initiative will be linked with the systemwide Property Rights and Collective Action Program. Estimates of benefits and full-income returns of different uses of water for individuals and households will provide the basis for properly assessing the social, health, and gender implications of different irrigation water allocation mechanisms, and thus assist in optimizing water use at the basin level.

C. SELECTION OF WATER BASINS

Final selection of water basins for research will depend upon a number of factors—location of CG center and other CG initiatives, the interests of centers and donors, willingness of local authorities to cooperate and availability of data. Criteria for selection should ensure that water basin management is an accepted issue, and that a range of agro-climatic situations are covered.

Four basins are suggested for activities: Indo-Gangetic-Brahmaputra, Nile, Niger, Mekong, and Mahaweli. Poverty and scarcity of water are prevalent in all of these locations, requiring improved management to sustain growth in agricultural production and protect the environment. IIMI has offices in three locations, and well established Consultative Committees are in place, with representation of NARS.

D. TRAINING AND INFORMATION DISSEMINATION

Training and information dissemination are essential complements to research. Through various formal and non-formal activities, common agreement on principles and approaches can be reached among the participants. Formal training courses and various avenues of information dissemination provide access to improved and new research methods developed as a result of the research phase.

The training component will be designed to complement to the research activities; and demand for training will flow from the research agenda. Researchers working on problems of water management need to be exposed to and share ideas

about research methodologies and problems. Some may also need training on special skills such as geographic information systems.

An initial focus of the training activities will be on procedures for measuring water productivity. Following the completion of our research and testing methods for measuring water productivity, we will hold training courses for participants in the Systemwide Water Initiative to ensure that all scientists are conversant with the accepted procedures, know what data to collect and how to make the necessary measurements and calculations, and are prepared to use these procedures in their research.

The Systemwide Water Initiative will facilitate information dissemination among researchers. Following the 1995 workshop, an electronic mail list server for sharing information on water management research was established. Membership to date has been limited primarily to those who have been involved with the Water Initiative, but we are receiving requests from a number of others to be included in the network.

As the Systemwide Water Initiative matures and research results become available, various vehicles for disseminating research findings and recommendations will be used. These will include workshops and seminars, a Newsletter and other publications to disseminate research findings.

The mix of training and information dissemination activities will serve to strengthen research capacity and extend research methodologies, and provide an important vehicle to promote

testing and implementation of recommendations that result from research findings.

E. THE NEED FOR A SYSTEMWIDE INITIATIVE

The challenge for the future is to explore new agricultural and water management strategies to satisfy food demand. While further yield increases to meet future food demand could be achieved through extraordinary scientific and technological advances, it is clear that agriculture must conserve the resource base if it is to remain sustainable. Better soil and water management techniques are required to complement the input-intensive methods used previously to increase agricultural production.

Achieving greater agricultural productivity with less water will require technical, organizational and policy changes. The research required to support these changes can be successfully accomplished through collaborative work among the centers and between the centers and their national and international partners. The Systemwide Water Initiative provides the CGIAR with a comprehensive agenda for water management research.

F. COLLABORATIVE LINKAGES

Our strategy will be to work with other Systemwide Programs and their NARS/NGO partners whenever possible. For example, a strong linkage with the Rice-Wheat Consortium for the Indo-Gangetic Plains could involve water management research studies on (I) linkages between water-saving activities at the farms level and at the distributary canal and (ii) con-

junctive water use of surface and groundwater to improve productivity, reduce waterlogging and salinity on declining water tables. Linkages are envisioned with WANA and the Soil, Water and Nutrient Management initiatives. Another critical linkage for Systemwide Initiative on Water Management will be with the Property Rights and Collective Action Initiative.

G. FUNCTIONS AND RESPONSIBILITIES

The working arrangements for the Water Initiative are simple and direct. The basic principle of our management system is that the research policies and programs will be set at the institutional level, the Steering Committee, while the actual research will be conducted by individual scientists working together in research teams. We believe that this approach will provide an effective and efficient means of producing important international public goods under the Water Initiative.

The Systemwide Water Initiative will be governed by a Steering Committee. IIMI has appointed Randolph Barker to serve as Coordinator. The Committee will consist of representatives from participating CGIAR centers and other organizations. The following groups will be invited to participate:

- CGIAR NGO Committee
- Committee on Agricultural Sustainability in Developing Countries
- International Center for Research on Women (ICRW)
- International Commission on Irrigation and Drainage (ICID)

(ICID is the professional organization of NARS, with over a hundred country members, each having its own national committee. ICID is an important organization for fostering Systemwide Initiative on Water Management collaboration with NARS.

The committee will choose its own chair and will be responsible for: (1) establishing priority research topics; (2) establishing guidelines for proposals; (3) reviewing and approving proposals for funding; (4) establishing procedures for reporting and dissemination of research findings; (5) monitoring research and training progress. One requirement of all proposals will be to demonstrate a clear link with NARS and NGOs and/or existing systemwide projects. Donors will be requested to contribute funds to the Systemwide Water Initiative through the Steering Committee to support research activities.

Individual researchers or research teams will develop the proposals. For example, a researcher at ILRI along with colleagues from other centers, may submit a proposal examining the conflict between crop farmers and livestock owners over water use in Sub-Saharan Africa. Once the proposal is approved by the Steering Committee, the Team Leader will be responsible for supervising the research. Teams may also take an active role in raising funds for the Initiative to support their research.

H. WORKPLAN

This section presents a preliminary Plan of Action for the Systemwide Water Initiative. The Table on page 15 illustrates the workplan.

Steering Committee

Following approval of the Initiative, the Steering Committee meeting has been scheduled for July 1996. All Centers who wish to participate are being asked to send a representative. Results of the meeting will include election of a chairman and detailed operating procedures for identification of priorities, proposal preparation and selection of team leaders. A detailed plan of action for research and training over a five year period will be accompanied by target funding requirements.

Methodologies

We will move as quickly as possible to finalize procedures and methodologies that are not site specific. These activities need not wait the formation of the Steering Committee. The agreement on and use of a common language and research methods will greatly advance our objective of producing international public goods.

Research will be conducted for approximately six months by IIMI in collaboration with CGIAR and NARS partners to refine and test standard water accounting procedures. This research on methodology is considered essential in order to develop a common accounting procedure to be followed in essentially all Systemwide projects.

A workshop will be held to identify the methodologies to be used in assessing water competition and utilization at the local level .

Research

An agenda will be developed for integrating research efforts in the water basin.

A workshop of participating centers, NARS, and other experts will be organized to develop an integrated plan of action across research themes.

We anticipate that research projects will be approved and research underway in at least one water basin in early 1997.

Training

Training activities will complement the research effort.

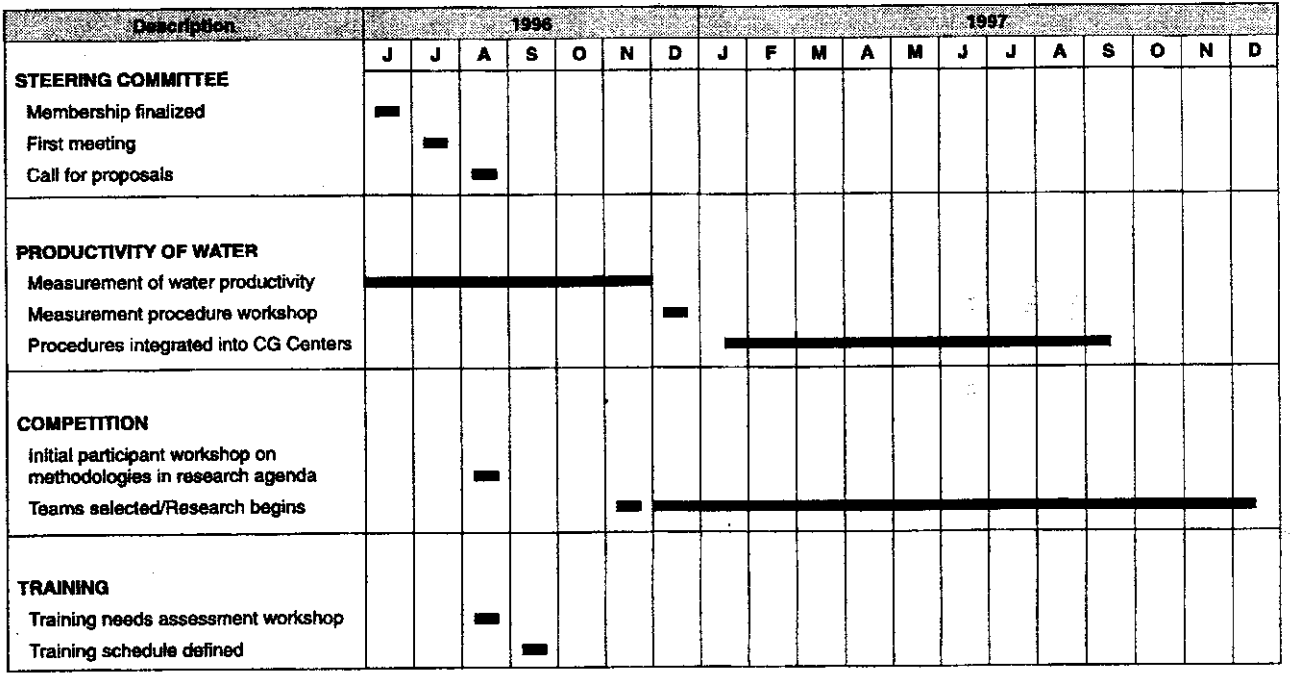
The first training workshop will be held following the completion of the research on accounting to instruct researchers in standard water accounting procedures.

I. PROPOSED BUDGET FOR 1996 AND 1997 (US $)

	1996	1997
Secretariat (including public awareness and electronic networking)	100,000	100,000
Steering Committee meetings and related activities	50,000	50,000
Seed funds for initial projects	250,000	250,000
Workshops/training	75,000	75,000
Contingency	25,000	25,000
Total	500,000	500,000

Systemwide Initiative on Water Management — Workplan

(Assume June 1, 1996 start date)



Procedures for Proposal Revision

At the end of September 1995, a group of scientists from ten CGIAR centers and other stakeholders from a wide range of organizations dealing with research in water management met in Colombo to launch the Systemwide Initiative in Water Management. The workshop was organized in two distinct parts. The first part involving some 60 participants - CGIAR scientists, donors, IIMI senior associates, and staff members - consisted of two days of presentations and discussions. The second part of the workshop lasted three days, and involved a smaller group of CGIAR scientists and partners. A research proposal was prepared by this latter group and submitted to TAC for consideration at their December 1995 meeting in Nairobi (TAC 68).

The comments received by TAC following the December 1995 meeting and suggestions for revision were then circulated to all involved in the original proposal preparation. Suggestions were received. The proposal was redrafted and circulated for comments in early February. After receipt of comments and considerable debate on some issues, agreement was reached among the partners. The final revision was circulated to TAC members on 1 March 1996. Following is the list of those involved in the initial proposal preparation and revision:

Randolph Barker (IIMI)

Adel El-Beltagy (ICARDA)

Sadiqul Bhuiyan (IRRI)

Randy Brummett (ICLARM)

David Flower (ICRISAT)

Andrew Keller (Keller-Bliesner Engineer)

Gil Levine (Cornell University)

Ruth Meinzen-Dick (IFPRI)

Chin Ong (ICRAF)

Theib Oweis (ICARDA)

Chris Perry (IIMI)

Prabhu Pingali (IRRI)

Carlos Garces-Restrepo (CIAT)

Mark Rosegrant (IFPRI)

L.K. Smedema (IPTRID)

To Phuc Tuong (IRRI)

Marco Wopereis (WARDA)

Margreet Zwarteveen (IIMI)