An International Action Programme on

WATER

AND

SUSTAINABLE AGRICULTURAL DEVELOPMENT

A Strategy for the Implementation of the Mar del Plata Action Plan for the 1990s

First published 1990

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Foreword

This International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD) has been formulated by FAO with the full cooperation of other appropriate UN Organizations within the framework of the UN Administrative Committee on Coordination-Intersecretariat Group on Water Resources (ACC-ISGWR). The IAP-WASAD will form an integral component of the UN strategy for the implementation of the Mar del Plata Action Plan for the 1990s.

Since its adoption, in 1977, significant progress has been made in the implementation of the Mar del Plata Action Plan. In spite of this progress, however, much remains to be done. The progress in implementation has generally been hampered by a host of complex factors and circumstances, which are often interrelated. Deficiencies in planning and policy frameworks, weak implementation capacities and lack of monitoring and evaluation of performance have generally impeded progress of its implementation. These problems were further compounded by the continuous worsening of the national and international economic environments, the depressed production systems and the occurrence of severe climatic anomalies which have prevailed since the adoption of the Mar del Plata Action Plan.

Agriculture in most of the developing countries continues to be the primary source of economic growth and the main sector for employment and sustenance for the majority of the population. This primacy of agriculture can only be maintained or enhanced by the sustainability of its productivity and continuing increases in the total food and agricultural production. Moreover, according to various perspective studies, including FAO's Agriculture Toward 2000 study, the future expansion of food production will be increasingly dependent on sound irrigation and water management.

The Mar del Plata Action Plan, to a significant extent, recognized the linkages between water and sustainable agricultural development. For example, it sharpened the focus on efficient water use as a key issue in the process of water resources development and management to secure and ensure good agricultural production and thus the highest level of human welfare.

While significant expansion of the area under rainfed and irrigated agriculture has been achieved during the past decade, the productivity response and its sustainability have been constrained by many complex and interrelated factors. Deterioration of irrigation systems and problems of waterlogging and salinization have caused loss of agricultural production. Soil erosion in the upper watersheds, mismanagement and over-exploitation of the natural resources in the drought-prone areas and acute competition for water, have all accelerated the spread of poverty, hunger and famine in the developing nations, particularly on the African continent.

The IAP-WASAD recognizes the complexity and seriousness of the situation. The Action Programme is designed to update and expand the implementation of the Mar del Plata Action Plan for agricultural water use on the premise

that the farming community, given an enabling environment, can contribute significantly to sustainable agricultural development. This Action Programme stresses the importance of the traditional farming sector and its effective role in sustainable agricultural development, as well as the private and public sectors.

The IAP-WASAD has identified five priority areas of action and some common measures which require concerted actions to realize sustainable agricultural development with special reference to water use. The priority areas of action include: efficient water use at the farm level; waterlogging, salinity and drainage; water quality management; small-scale water programmes; and scarce water resources development. The common actions are: development of adequate data bases, adaptive research, institutional strengthening, human resources development, environmental protection and technology transfer and infrastructure.

The Action Programme specifically aims to rekindle the spirit of Mar del Plata by encouraging a new spirit and commitment for its implementation during the 1990s. I wish to express my personal appreciation to the UN System in general and FAO in particular for their gallant efforts to give a new boost to the implementation of the Mar del Plata Action Plan in the 1990s. I wish the Action Programme all success.

May 1990

Yahia Abdel Mageed
Secretary General
United Nations Water Conference

Introduction

The concept of sustainable development is not new. For example, considerable similarity exists between the concepts of eco-development, a term which was widely used during and immediately after the UN Conference on the Human Environment held in Stockholm in 1972, and sustainable development. However, the concept of sustainability came into prominence in 1980. It is now accepted by many that development which destroys the natural resources on which it is based is not development. The report of the World Commission on Environment and Development (WCED), Our Common Future, 1987, (the Brundtland Commission) emphasized the central necessity of agricultural sustainability.

Sustainability has been defined in many different ways *(see box on right)* and there is no single, universally accepted definition. On the other hand, long-term strategic and policy choices require a clearly defined concept. FAO has therefore formulated its own definition in the context of agriculture, forestry and fisheries:

> *'Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for the present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.'*

Scarcity of water is a major constraint for further agricultural development of arid and semi-arid countries. In many countries, all available water sources which can be economically used have already been developed or are in the process of development. As the demand for water continues to increase, it is imperative that this limited resource be used efficiently for agricultural and other uses. In developing countries, on average 80 percent of water used is for agriculture, and accordingly rational use of water by this sector is absolutely critical for any overall efficient water management strategy. Resolution of conflicts between various

Alternative definitions of sustainable development

'Development which meets the needs of the present without compromising the ability of future generations to meet their own needs ...' *(WCED 1987, p.43).*

'... sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations' *(WCED 1987, p. 46).*

'Sustainable development is economic change subject to the constancy of natural capital stock—the stock of environmental assets is held constant while the economy is allowed whatever social goals are deemed appropriate.' *(D. Pearce, Economics, Equity and Sustainable Development, Futures, Special Issue, 1988).*

'Sustainable development ... as a pattern of social and structural economic transformations (i.e. 'development') which optimizes the economic and other societal benefits available in the present without jeopardizing the likely potential for similar benefits in the future.' *(R. Goodland and G. Ledec, Neoclassical Economics and Principles of Sustainable Development, Ecological Modelling Vol. 38, Nos. 1/2 1987).*

'... development that maintains a particular level of income by conserving the sources of that income: the stock of produced and national capital.' *(P. Bartelmus, Accounting for Sustainable Development, UN/DIESA Working Paper No. 8, 1987).*

'... sustainability ... the ability to maintain productivity, whether of a field, farm or nation, in the face of stress or shock.' *(G. Conway and E. Barbier, After the Green Revolution, Futures, Special Issue, 1988).*

Source: FAO 1989a

water demands is currently a major problem in most arid and semi-arid countries, where water availability is limited.

Renewable water supplies are essential for sustainable agricultural development. Agriculture, in the context of the International Action Programme, includes both irrigated and rainfed agriculture. While inputs like pesticides, fertilizers and better quality seeds are important, reliable water availability and control are commonly critical prerequisites for the profitability of such input use and for the enhancement of agricultural production on a sustainable basis. Thus, the interrelationship between water and sustainable agricultural development is a direct and vital linkage: the latter is not possible without the former.

The linkage between water and sustainable agricultural development was implicit in the Mar del Plata Action Plan. For example, the preamble to the recommendation on agricultural water use states that 'particular attention should be given to land and water management both under irrigated and rainfed cultivation, with due regard to long-term as well as short-term productivity'. Similarly, the operative part of this recommendation states that 'high priority should be given to the adoption of urgent measures for soil and water conservation within the framework of integrated land and water management in order to increase agricultural production without destroying these resources'.

During the formulation of a comprehensive strategy for implementing the Mar del Plata Action Plan for the 1990s, sustainable agricultural development issues were explicitly stressed. Such a strategy requires that sustainability concepts be translated into actions in order to achieve desired results. This International Action Programme is the result of this conviction.

This document presents an International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD) for the 1990s. The objective of the IAP-WASAD is primarily to assist member countries of the United Nations System in planning, developing and managing water resources on an integrated basis in order to meet the present and future needs for agricultural production on a sustainable basis, bearing in mind competing demands for limited water resources.

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Background to the Action Programme

The United Nations Water Conference, convened in Mar del Plata, Argentina, in March 1977, was the first meeting of its kind on water at a very high policy-making level. All member states of the United Nations System approved the Action Plan at the Conference and recommended its implementation. The box below presents additional information on the Water Conference, with particular reference to its recommendations on agricultural water use.

Since 1977, various reports had been prepared on progress and issues encountered in implementing the Mar del Plata Action Plan which were considered by intergovernmental bodies of the United Nations System. At its 8th Session, in 1987, the Administrative Committee on Coordination-Intersecretariat Group on Water Resources (ACC-ISGWR) agreed that these reports had played a useful role in monitoring the progress and in recommending actions for solving various problems. However, the ACC-ISGWR felt that a comprehensive strategy for action should be developed at national, regional and global levels for the implementation of the Action Plan in the 1990s.

Following the 10th Session of the Committee on Natural Resources (CNR), the Economic and Social

The Mar del Plata Action Plan

The United Nations Water Conference was held in the city of Mar del Plata, Argentina, during 14-25 March 1977. The meeting was convened upon the realization that the accelerated development and orderly management of water resources are prerequisites in improving the economic and social conditions of humankind, especially in the developing countries. Specific and concerted actions are required to find solutions to various water problems and these need to be applied at national, regional and international levels in order to ensure better quality of life of all people on this planet.

Recognizing the important role played by the Republic of Argentina to host the UN Water Conference in Mar del Plata and its great contribution to the success of the Conference, participants declared the recommendations of the Conference to be known as the Mar del Plata Action Plan and urged strongly that the recommendations be effectively implemented by all States.

The Conference was attended by representatives from 116 States, 14 UN Organizations, and 7 UN Specialized Agencies. Observers from 18 intergovernmental organizations and 63 non-governmental organizations were also present.

The recommendations of the Conference covered 8 major areas: assessment of water resources; water use and efficiency; environment, health and pollution control; policy, planning and management; natural hazards; public information, education, training and research; regional cooperation; and international cooperation.

Based on the above set of recommendations, the Conference agreed on 10 resolutions on the following topics: assessment of water resources; community water supply; agricultural water use; research and development of industrial technologies; role of water in combatting desertification; technical cooperation among developing countries in the water sector; river commissions; institutional arrangements for international cooperation in the water sector; and water policies in the occupied territories.

The main recommendation on agricultural water use, which was included within water use and efficiency, was as follows:

> The increase of agricultural production and productivity should be aimed at achieving optimum yield in food production by a definite date, and at significant improvement in total agricultural production as early as possible. Measures to attain these objectives should receive the appropriate high priority. Particular attention should be given to land and water management both under irrigated and rainfed cultivation with due regard to long-term as well as short-term productivity. National legislation and policy should provide for the properly

Council (ECOSOC), through Resolution 1987/7, agreed with the ACC-ISGWR's view and requested the Secretary-General to undertake the following:

'In consultation with the Regional Commissions and Organizations of the United Nations System, to report to the Committee on Natural Resources on progress in formulating proposals for a comprehensive strategy to implement the Mar del Plata Action Plan during the decade 1991-2000, and to include an assessment of these proposals as they relate to the action of the United Nations System.'

Accordingly, it was decided, during the 9th Session of the ACC Intersecretariat Group on Water Resources in October 1988, that a meeting of a Panel of Experts be convened to advise on the formulation of a strategy for the implementation of the Mar del Plata Action Plan in the 1990s. This meeting was held in March 1989 at Challes les Eaux, France. The Panel recognized the important role of water in sustainable agricultural development, and recommended that an international programme on water and sustainable agricultural development be formulated as one of the areas requiring concerted action by the United Nations Organizations. The Panel of Experts also endorsed the proposal to carry out

integrated management of land and water resources. Countries should, when reviewing national policies, institutions and legislations, ensure the coordination of activities and services involved in irrigation and drainage development and management. It is necessary to expand the use of water for agriculture together with an improvement in efficiency of use. This should be achieved through funding, providing the necessary infrastructure and reducing losses in transit, in distribution and on the farm, and avoiding the use of wasteful irrigation practices, to the extent possible. Each country should apply known techniques for the prevention and control of land and water degradation resulting from improper management. Countries should give early attention to the improvement of existing irrigation and drainage projects.

The action programme on water for agriculture was included under Resolution III, Agricultural Water Use, a summary of which is given below:

Attention was drawn to the urgent need for action to initiate a worldwide programme for the intensification and improvement of water development in agriculture. It was stated that such a programme should in particular, though not exclusively, be directed at:

(a) improving existing irrigation with the objectives of raising productivity with minimum cost and delay, improving the efficiency of water use and preventing waste and degradation of water resources;
(b) developing efficient new irrigation for further expansion of production;
(c) improving and extending rainfed agriculture and livestock production, through both better soil moisture management and opening up of new land through the provision of water supplies to human settlements and livestock;
(d) protecting agricultural land against the harmful effects of flooding and waterlogging, and where necessary its reclamation; and
(e) introducing or expanding fish rearing in conjunction with overall rural development activities.

As an indication of the task ahead in the area of irrigation and drainage development, the magnitude of a 15-year global programme was estimated at some 45 million hectares of improved and 22 million hectares of new irrigation development.

The action programme also contained recommendations on phased action programmes: financing, training extension and research, promotion of national advisory services, and international programme support.

Chronology of events since the declaration of the Mar del Plata Action Plan

March 1977
Adoption of the Mar del Plata Action Plan by the United Nations Water Conference.

December 1979
General Assembly Resolution 34/191 requested the CNR to review during the 1980s the progress made by Governments in the implementation of the Mar del Plata Action Plan.

January 1981
Beginning of the International Drinking Water Supply and Sanitation Decade.

January 1987
Interregional seminar convened on 10th anniversary of the UN Water Conference, which included a detailed review of the progress made in implementing the Mar del Plata Action Plan.

May 1987
ECOSOC, in agreement with the ACC-ISGWR recommendation on the need for a comprehensive strategy for the implementation of the Mar del Plata Action Plan in the 1990s, requested the Secretary General to report to the 11th Session of the CNR on the strategy and measures necessary for implementation.

March 1989
ACC-ISGWR convened a meeting of a Panel of Experts to formulate a strategy. The Panel recommended six activities to constitute key elements of the strategy, namely, water resources assessment, sustainable agricultural development, mobilization of financial resources, human resources development, institutional strengthening and promotion of appropriate technology. A lead agency was designated for each of the key elements. FAO was designated the lead agency for sustainable agricultural development. The panel also recommended that regional assessments of progress achieved in the implementation of the Mar del Plata Action Plan be undertaken to determine the main issues on which to focus in the 1990s.

October 1989
ACC-ISGWR at its 10th Session endorsed the FAO proposal for an Interagency Action Programme on Water and Sustainable Agricultural Development as a key element of the Mar del Plata Action Plan strategy for the 1990s.

January 1990
Regional assessments of progress made in the implementation of the Mar del Plata Action Plan with regard to agricultural water use were carried out through a UNDP funded and UNDTCD executed project with technical backstopping by FAO.

February 1990
Interagency preparatory meeting convened to discuss the findings of the regional assessment missions and prepare the Interagency Action Programme on Water and Sustainable Agricultural Development.

May 1990
Technical Consultation on Water and Sustainable Agricultural Development convened by FAO to discuss the Draft Interagency Action Programme with all interested UN agencies, selected bilateral donor agencies and governments and developing countries.

October 1990
Adoption of the Programme as an International Action Programme by the ACC-ISGWR and as an integral component of the Strategy for the implementation of the Mar del Plata Action Plan for the 1990s.

Spring 1991
Submission of the Strategy to the CNR by the UN Secretary General.

Autumn 1991
ACC-ISGWR-UN Organization donor meeting to review and examine funding and implementation of action programmes.

in-depth regional assessments of progress and problems in the implementation of the Mar del Plata Plan.

The recommendations of the Panel of Experts were reported to the 11th Session of CNR and to ECOSOC. The ECOSOC through Resolution 1989/7 reiterated the need for a strategy for the 1990s, and requested that the strategy be submitted to CNR at its 12th Session in 1991.

Following these developments, regional assessments of the progress made in implementing the Mar del Plata Action Plan since 1977 were carried out. The assessments specifically took into account the principles of sustainable development as they affected the water and agricultural sectors. These regional assessments assisted in identifying the main elements of this Action Programme at the national, regional and global levels.

In addition, the Committee on Development Planning (CDP), which met in May 1989, stressed the importance of water in sustainable development and requested concerted action by the United Nations Organizations. The problems of water scarcity resulting from uncoordinated and badly planned land and water developments, as well as water quality degradation due to agricultural, industrial and municipal water pollution, were highlighted. The CDP recommended that the Conference on Environment and Development, scheduled for 1992, should include in its agenda a separate item on sustainable development in utilization of water resources, and take into account the strategy for the implementation of the Mar del Plata Action Plan in the 1990s, to be formulated by CNR. The chronology of events since the Mar del Plata Conference in 1977 is summarized on page 10.

2

Water and Sustainable Agricultural Development—Challenges and Opportunities

Water is an essential component of sustainable agricultural development. Without appropriate and reliable water control and management, sustainable agricultural development is simply not possible.

Conservation and rational development of water, land and associated natural resources are essential ingredients for sustainable development. However, a root cause of deterioration and improper management of natural resources in most developing countries is the struggle for survival. Those who are poor and hungry will often destroy their immediate environment in order to survive; poverty itself could be major global scourge. As Mrs. Indira Ghandi, the late Prime Minister of India, pointed out graphically during the UN Conference on the Human Environment in Stockholm in 1972, poverty is the worst form of pollution. Poor farmers, fishermen and herdsmen are not necessarily less resourceful or less aware of the importance and need to conserve their natural resources and the environment than their counterparts in the wealthier countries. It is their desperate struggle for survival which compels them to adopt and undertake environmentally unsound practices. On the other hand, even today, there are some primitive people and forest dwellers living in Amazonia and other areas who are still able to meet their apparent needs using traditional, environmentally-sound practices.

Poverty, environmental degradation and population growth are related. The sustainability of agricultural development is intimately linked to population growth. The world's population reached 5 000 million in 1988, which was nearly twice what it was in 1950. By the year 2000, the world population is likely to increase to more than 6 000 million. Currently, over three-quarters of the world's population live in developing countries, and it is in these countries that 90 percent of the projected growth will occur.

One of the important concerns regarding population growth is how to ensure present and future needs of all people in terms of food, fibre, shelter, etc., without destroying the resource base and the environment. For example, it is axiomatic that food production must at least keep pace with population growth. To maintain even the present level of food consumption for the population in the year 2000, it is estimated that food production must increase by approximately 40 percent. Simultaneously, good agricultural land should not be unnecessarily lost due to urban and rural growth and infrastructure. Of equal importance, adequate quantities and quality of water must be available for agricultural and other uses. Ensuring that present and future generations will have adequate food and water, and concurrent maintenance of the resource base and the environment, are two of the most challenging tasks that have ever faced mankind.

The amount of land and water, available for all practical purposes, can be considered to be finite. Therefore, there are some natural constraints to development. Beyond these natural constraints, man dictates the pattern of development. If the strategies adopted are environmentally sound, it should be possible to increase agricultural production on a sustainable basis. Food and fibre crops are net products of an ecosystem, and as long as the ecosystem remains healthy, it will continue to produce sustainable levels of food and fibre. In contrast, unsound management of any ecosystem will undermine its production potential. The rate at which the production potential may decrease will depend on the intensity of such management practices.

However, the issues are not simply those of physical constraints. Economic constraints are equally important. A development path that is sustainable cannot be secured unless development policies consider economic aspects, such as costs and benefits to the society and individuals. This means that sustainable development and use of natural resources should be compatible with the principles of sustainable economic activity.

Economic aspects of water and sustainable agricultural development are vitally important, as is clear from analysis of why many past irrigation schemes have failed or were much less successful than expected at the planning stage. They—the economic aspects—range from

macro policies at the national and international level to micro policies and mechanisms for implementation at the project and farm levels.

Water is an indispensable resource for all life systems and is a critical component of sustainable agricultural development. In arid and semi-arid countries, irrigation is often the only option for achieving major increases in food and fibre production. In sub-humid and many humid areas, irrigation is essential for the multiple cropping necessary to compensate for high population densities or has a valuable role to play in counteracting rainfall variability.

During the past four decades, development of irrigated agriculture provided a major part of the increase in production necessary to meet population demands. By the mid-1980s, 36 percent of the total crop production came from less than 15 percent of the arable land which was irrigated. On a global basis, the average rate of expansion was about 1 percent per year in the early 1960s and reached a maximum of 2.3 percent per year from 1972 to 1975. The rate of expansion began to decrease in the mid 1970s *(see graphs below)* and is now less than 1 percent per year.

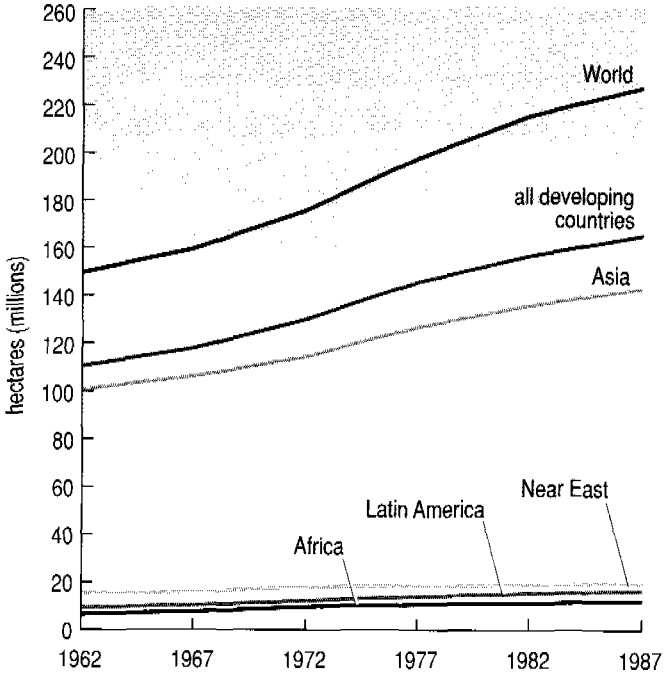
The reasons for the decrease in expansion in irrigated land are many and since the 1970s have been elaborated in various reports. One of the commonest causes was the high cost of irrigation development. Construction costs have risen steadily and the world price for major cereals has fallen sharply; for example, the price for rice fell by about 40 percent in real terms between 1965 and 1985. Further, as much of the suitable land for irrigation development and available water supplies are already developed, progressively more expensive and socio-economically less favourable areas are left for further expansion. Nevertheless, new lands need to be brought under irrigation. Their economic viability will have to be evaluated in the context of trade-offs between increased yields and environmental protection.

Of major concern is the continuing decrease in the rate of expansion of irrigated land in developing countries while population growth rates are about 2 percent per year. The FAO projections of expansion of irrigated land to the year 2000, based on previous trends modified by land, capital and inputs required to meet future needs, was 2.25 percent per year from 1982/4 to 2000 *(see illustration on next page)*. Recent data show that these projections are not likely to be met. Clearly, needed increases in production cannot be achieved from continuing increases in irrigated land. Rather, production increases must be achieved from both rainfed and irrigated agricultural lands. Investment costs in conservation measures to increase available water on rainfed lands

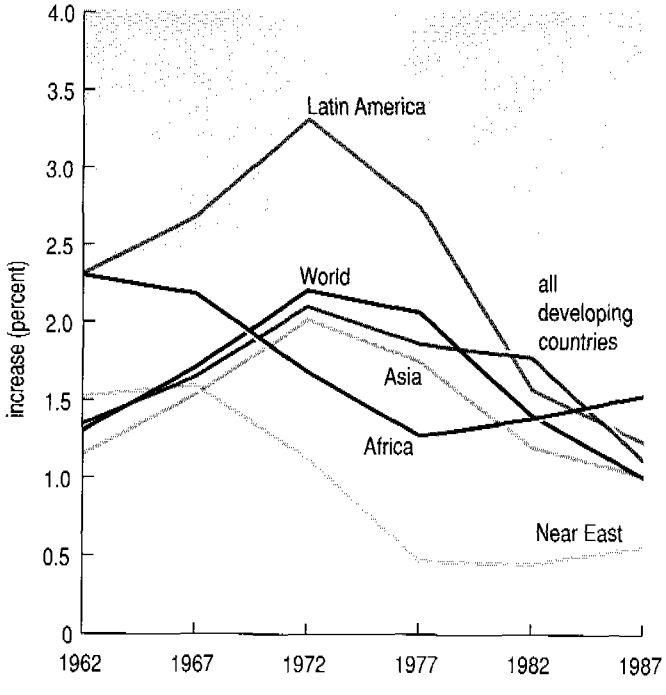
Trends in irrigation development

Source: FAO 1989b

area of irrigated land

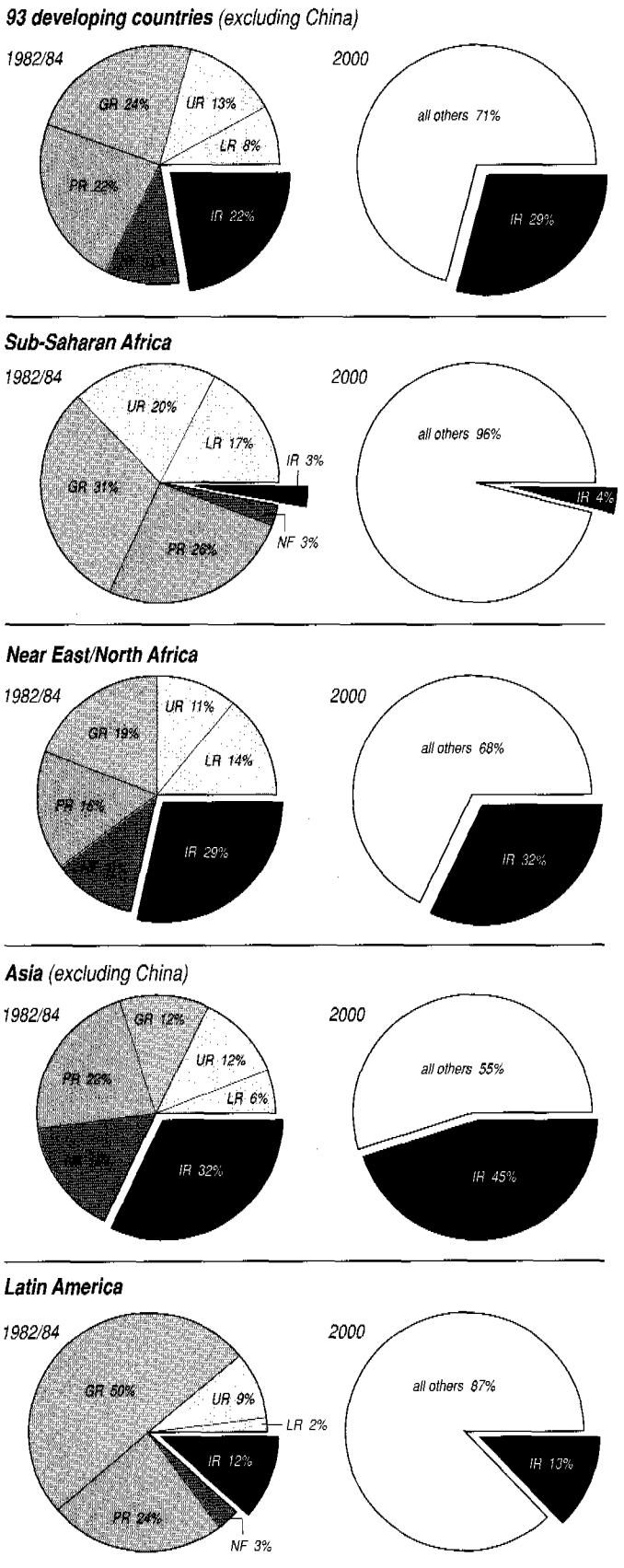


rate of increase in irrigated land



Land use by different water regimes (percent)

Source: FAO 1988



Key

LR **low rainfall rainfed land:**
rainfall provides 1-119 growing days;
soil quality marginal to very suitable

UR **uncertain rainfall rainfed land:**
rainfall provides 120-179 growing days;
soil quality marginal to very suitable

GR **good rainfall rainfed land:**
rainfall provides 180-269 growing days;
soil quality suitable to very suitable

PR **problem land—area with excessive rainfall or marginal soil:**
rainfall provides more than 269 growing days;
soil quality marginal to very suitable

naturally flooded land:
land under water for part of the year,
and lowland non-irrigated paddy fields (gleysols)

IR **irrigated land:**
fully or partially irrigated lands

must be evaluated relative to capital investments and operating costs of irrigated agriculture. In some regions such as sub-Saharan Africa, rainfed agriculture is the primary source of agricultural production and this production can be increased significantly by implementing effective soil and water conservation practices.

Currently, the overall performance of many irrigation projects is much less than was expected. Inadequate operation and maintenance and inefficient management of an increasingly scarce water resource contribute to many socio-economic and environmental problems. Of major concern is the rapid rise in groundwater leading to waterlogging, depressed crop yields and soil salinity. It is not unusual to find that 60 percent of the water diverted or pumped for irrigation is not made available for crop use. This excess input to project areas from canal and watercourse seepage and deep percolation on farm fields is the major cause of waterlogging.

In modern high input systems of irrigation, cereal yields of 1.5 kg/m^3 of water consumed can be expected. The cost of providing this water by irrigation is high and when more than half is not used by crops, the cost per unit production may be doubled.

The estimated gross area of irrigated land globally is 270 million hectares. The gross irrigated area includes the land commandable and equipped to be irrigated and cropped, fallow and land temporarily not irrigated due to rehabilitation of irrigation systems and reclamation from waterlogging and salinity. About 20/30 million hectares are severely affected by salinity and an additional 60-80 million hectares are affected to some extent. The principal techniques for controlling waterlogging and salinity are well-established, but they are not being applied for a variety of reasons. The total area currently irrigated is about 235 million hectares.

The quality of water available to agriculture is as important as the quantity, and the quantity and quality are interlinked. Depending on the sensitivity of the crop, when the nature and composition of dissolved salts and pollutants or ions in the water exceeds threshold levels, crop production decreases with increasing concentrations. In addition, there may be phytotoxic and consumer health implications. Agricultural practices can also affect surface and groundwater quality. Excess plant nutrients in surface runoff and deep percolation from both irrigated and rainfed areas can contribute to eutrophication of surface water bodies and to the growth of aquatic weeds in canals and watercourses. Effluents from agro-industries and aquaculture also contribute to serious water quality problems.

In many arid and semi-arid developing countries, availability of fresh water is limited for agricultural and domestic use and thus marginal quality water is being used. This includes treated wastewater as well as drainage water. China, Egypt, Jordan, Kuwait, United Kingdom, USA and many other countries are now using such marginal quality water for irrigation and groundwater recharge. Use of marginal quality water requires special attention in terms of salinity control, health considerations and other environmental protection measures.

Sustained production on both irrigated and rainfed lands requires optimal use of the physical environment in each soil-crop-climate ecosystem. In rainfed areas, of primary importance are water conservation measures such as fallow management including crop residue management, control of runoff and water harvesting. Integrated with these practices are selection or development of high-yielding, drought-tolerant varieties, efficient use of herbicides and fertilizers, crop rotation and optimal planting dates to maximize the probability of rainfall during critical periods of crop growth. The synergistic effects of such practices are complex when integrated through rainfed farming systems, yet are even more pronounced under irrigation. Under irrigated agriculture, additional effects may arise because of continuous monocropping. In rice production areas, for example, drainage may be required to remove toxic substances that accumulate in the soil after several consecutive crops of rice.

Aquaculture is becoming an increasingly important consideration in use of land and water resources. Fish can be considered to be a crop with specific requirements for water quality and quantity. It thus competes with other agricultural uses for land and water but provides farmers the option of diversifying their production. Harmonious interactions have been developed between fish and other crops in many parts of the world, like the rice-fish culture in south and south-east Asia. There is also increasing use of small on-farm water storage reservoirs for agriculture and aquaculture. Alternatives need to be explored by which all these activities can be considered within an integrated programme of water and sustainable agricultural development.

During recent decades, large irrigation projects have been given high priority while small-scale water programmes for agriculture have received inadequate attention. Small-scale irrigation, including supplementary water for rainfed agriculture, and a variety of water harvesting and water spreading techniques, have considerable potential to meet agricultural and domestic water needs and to enhance land and water conservation. It has been estimated that in the semi-arid and dry subhumid regions of Africa, water harvesting can increase agricultural production on 10 million ha in the short term and 50 million ha in the long term.

The climatic anomalies of the seventies and eighties, especially in Africa, and the associated problem of how to ensure sustainable agricultural development under such uncertain water regimes, have highlighted the importance of rational water management in water-scarce and drought-prone areas. Increased rates of land and water degradation, induced by low and uncertain rainfall, are often the principal long-term effects of drought. Accelerated erosion by water and/or wind is a main hazard. In drought-prone areas, a few very short duration and high intensity rains may occur each year. The accelerated runoff from these rains causes soil erosion and permanent soil damage.

Land degradation such as soil erosion is accelerated by increasing human and livestock populations, resulting in overgrazing, bushfires, exploitation of croplands and deforestation due to demands for firewood. Such degradation in semi-arid and arid areas is called desertification. It was estimated in 1983 that desertification affected nearly 75 percent of all productive rainfed lands (3 500 million ha out of a total of 4 500 million ha) and 60 percent of the rural population (280 million people) living in

Destruction of topsoil on pasture could be caused by improper land development and inappropriate water management. When such problems are not corrected at a very early stage, uncontrolled erosion can lead to the formation of gulleys.

these areas. Thus, water and land management under water scarce conditions needs special attention.

In recent years, there have been a number of notable cases of adverse changes in patterns of water-borne diseases resulting from development of water-related projects. One reason is because many irrigation projects provide an ideal environment for the multiplication of water-borne disease organisms and their increased contact with people. Of notable importance is the increased population of mosquitoes that cause malaria and aquatic snails that infect people with schistosomiasis. The water-borne vector related diseases seriously threaten the health and productive life of rural families and hence the sustainability of irrigation development itself. Thus it is imperative that sustainable water development should take into consideration these health hazards and should build into the process of irrigation project planning, design and operation means to overcome these hazards. Many interventions are now available to minimize the health hazards, such as chemotherapy, improved water supply and sanitation for farm families, and control of multiplication of disease vectors. In the case of the latter, environmental management measures that would lead to reduction of vector multiplication sites are found to be cost effective. Measures such as drainage, filling depressions, land levelling, vegetation clearance, improved irrigation systems and water management, broadly classified as environmental management measures, can lead to significant reduction in the occurrence of water-borne diseases in water development projects.

All the foregoing subject areas are important in the development of water for sustainable agriculture, but five are identified in this International Programme as priority areas for action. These are:

- efficient water use;
- waterlogging, salinity and drainage;
- water quality management;
- small-scale water programmes; and
- scarce water resources management.

The main reasons for the selection include the importance to national development; magnitudes of problems, and their geographical distribution; solutions are generally known and thus the problems can be controlled if appropriate measures can be implemented.

However, all the five subject areas selected require a set of common supporting actions, namely, development of adequate data bases, adaptive research, institutional strengthening, human resources development, improvements in socio-economic analysis, environmental protection, technology transfer and infrastructure development.

Availability of reliable hydro-climatic data is an essential prerequisite for rational planning, design and management of water resources. Thus, development of functional data bases and data management systems should receive priority attention.

Adaptive research on agricultural water use and management requires strengthening in developing countries. The research approaches should be inter-disciplinary, and the research foci should cover technical as well as socio-economic and environmental issues.

Institutional strengthening is another important task. Without an efficient institutional framework at the national level, it will not be possible to promote and ensure sustainable agricultural development.

Shortage of properly trained and experienced staff at all levels is an important constraint to efficient water development and management. Systematic assessment of manpower requirements for the agricultural water use sector has not been undertaken in all countries. It is not only essential to assess manpower requirements at various levels, but also it is critical that appropriate steps are

taken to train national staff within the shortest time possible. Without a complete trained human resource base, it will not be possible to ensure efficient management of water for agriculture.

In many societies, women play a major role in food production, distribution and nutrition. Women contribute labour for cash crop production, they grow food for daily consumption or to earn money to purchase off-farm commodities. In Africa, women not only contribute labour to the production of crops and care of small animals, they are often the decision makers. This is increasingly the case due to male out-migration to find work, or because of separation or divorce. Unfortunately, women are often not recognized as farmers in their own right. They do not have access to resources, inputs and services such as training needed to strengthen their skills and to increase their efficiency. When women lack technology, larger families may be wanted to help with home responsibilities as well as in the field. Thus, improvement in quality of rural life by research and development of technology appropriate to women as well as men could help reduce population growth. Extension services for credit and marketing as well as home economics can enhance production of subsistence food crops to improve food security and nutrition. Women should be intimately involved in development assistance programmes as food producers. Assistance programmes targeted at women should be a major component of human resources development.

There must be an increased focus on the farmers and their capabilities in managing water resources and improving production. Thus, data collection, adaptive research and training of officials must all involve greater interaction with cultivators and livestock herders. The role of local communities in implementing and managing water developments should also be enhanced.

Economists and financial analysts always argue for a strict application of economic criteria in evaluating the feasibility of new agricultural development. A common criterion used is the Economic Internal Rate of Return (EIRR). As a rule of thumb, a project is recognized to be in the danger zone if the EIRR is less than 10 to 12 percent.

The strict application of the EIRR to evaluate feasibility of projects is now seriously questioned. The EIRR is only one indicator of the project's merits as it is only concerned with those effects of the project which can be measured in monetary terms. There are inevitably other effects to be taken into account in making a responsible judgement on whether a project is feasible or not. The effect of development, both favourable and adverse, on natural resources, human welfare, and the ecosystem as a whole, should be evaluated. Perhaps, the application of 'cost-effectiveness' as an economic principle to evaluate new investments may offer a new realistic approach.

Multilateral development banks and funding agencies will have to consider effective financial mechanisms that will promote sustainable development. These approaches should pay specific attention to the conservation of ecosystems in developing countries.

The environmental implications of water management are an important consideration at present. Objective environmental impact assessment in the upper catchments, especially evaluating the effects of deforestation, is an important aspect of feasibility studies for most water development projects. The main impacts of deforestation, as they affect water projects, are accelerated soil erosion and changing river flow regimes, which can change intensity and frequency of floods. FAO estimates that 160 million ha of watershed areas have been degraded in tropical developing countries alone. In arid areas, where water is the major limiting resource, all new uses of water will require trade-offs. The initial and continuing environmental impacts must be considered in all water development projects. Knowledge and technology transfer among scientists, technicians and farmers continues to be a major constraint to improved land and water management. Equally, experience and technology transfer among developing countries needs to be enhanced.

The actions proposed under the IAP-WASAD constitute a 10-year programme which will contribute to sustainable agricultural development through optimum use of water and associated natural resources. The proposed programme will also increase the capacity of the organizations of the UN System to act as catalysts in formulating national and regional policies and programmes and to assist, in a concerted manner, national agencies in the formulation of policies and programmes, and in the implementation of field projects.

3

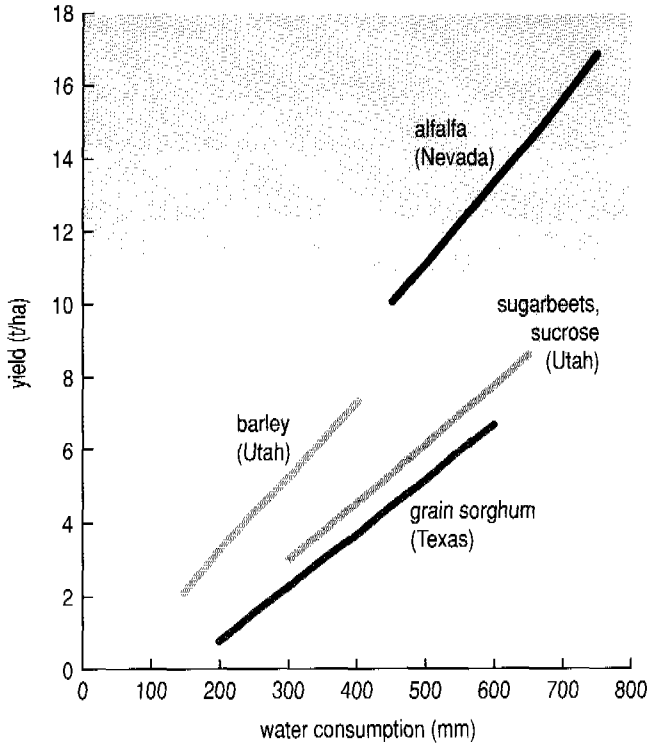
Priority Action Programmes

Efficient Water Use at the Farm Level

Issues

Large amounts of water are consumed (evaporated) in producing food, feed and fibre crops. Plant leaves have openings that enable plants to absorb carbon dioxide from the air in producing photosynthates. These same openings result in evaporation from internal wet cells and diffusion of the water vapour to the atmosphere. Examples of water consumption (evaporation and transpiration) from planting to harvest required to produce a unit of marketable product are about 1.4 kg of grain sorghum or sucrose and 2.0 kg of maize grain per m^3 of water. Example yields per unit of water consumed for these and other crops are illustrated in the figure below.

Yield versus water consumption



When crop yields are reduced by other factors such as plant nutrients, plant diseases or pests, the amount of water consumed remains about the same. As a result, production per unit of water consumed will be reduced in proportion to the reduction in yield. With limited irrigation, the addition of water at critical stages of growth may produce about 2.0 to 2.4 kg of grain sorghum for each m^3 of irrigation water added.

The production of grain per unit of water consumed under rainfed agriculture is less than that under irrigated agriculture because a larger part of the water consumed evaporates from the soil surface. Significant increases in production from rainfed agriculture can be achieved by reducing evaporation and minimizing runoff. Land shaping helps reduce runoff. Maintaining crop residues on the surface reduces both runoff and evaporation. Studies have shown that the amount of rainfall stored in the soil during a fallow period can be increased by up to two-fold by maintaining 11-12 tonnes per ha of wheat straw compared with bare soil. Where runoff occurs, water harvesting, e.g. diversion of runoff water to basins, can significantly increase water storage and consequently increase crop production.

The current and potential roles of rainfed and irrigated agriculture need to be quantified taking into account the probabilities of rainfall, the available irrigation water supplies and their cost. With this information, resources can be invested proportionally to the probable benefits to be derived from both rainfed and irrigated agriculture.

Actions

Increases in developing country production in the 1990s must come primarily from increases on existing irrigated lands and secondly from increases on rainfed lands; positive actions are required to transfer existing technology and to support its implementation. Urgent action is required to educate and train extension staff, strengthen water and soil management research under irrigated and rainfed conditions, monitor

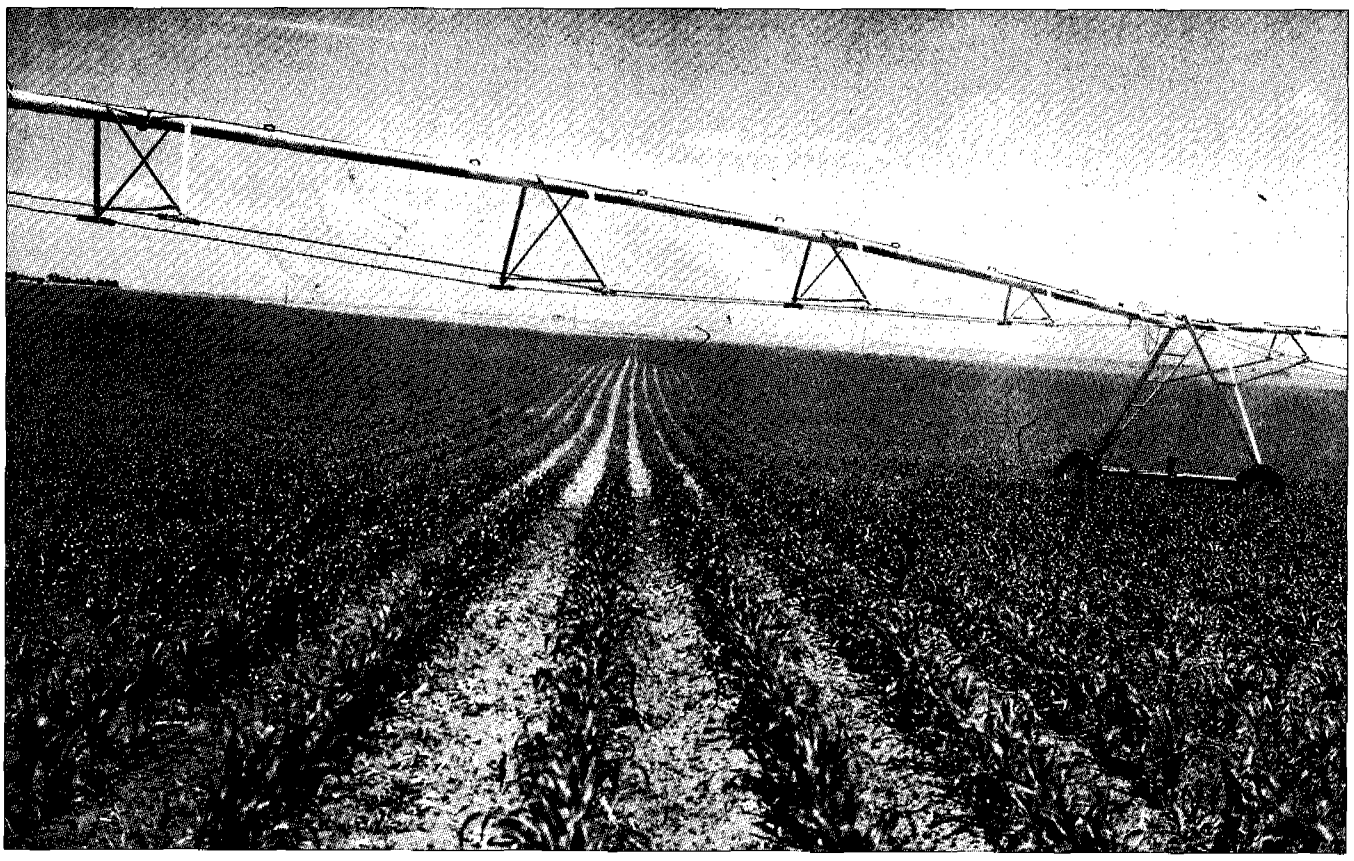
and evaluate irrigation project performance and establish effective demand management procedures and water pricing policies.

Rainfed Agriculture

a. Take necessary measures to translate existing soil and water management knowledge into action to increase agricultural water use efficiency:
   - ❑ educate and train extension staff in water and soil management principles and practices;
   - ❑ establish or strengthen infrastructure including transport facilities for extension staff to provide effective extension services in soil and water management; and
   - ❑ train extension staff and lead farmers in effective and economical water conservation practices.

b. Strengthen rainfed water and soil management research:
   - ❑ conduct and assess long-term research training needs;
   - ❑ educate and train research staff and technicians in adaptive water and soil management research techniques and in establishing field test plots, collecting field data, and in laboratory techniques;
   - ❑ establish or strengthen soil and water research infrastructure, establish procedures for setting priorities based on needs, and allocating resources to high priority adaptive research including strengthening research on traditional farming practices and on crop residue management;
   - ❑ provide adequate and stable funding for adaptive research programmes as most rainfed research

Modern irrigation methods can greatly enhance water use efficiency and increase yields. A low-pressure, centre-pivot spray irrigation system such as this applies water uniformly and does not cause erosion or ponding of water on the surface.



requires multiple years of testing to verify adapted and new technologies; and
- ❑ facilitate interdisciplinary research projects including socio-economic aspects.

c. Document and disseminate, through international support, examples of successful and effective rainfed practices.

Irrigated Agriculture

a. Establish monitoring, evaluation and feedback systems for all existing and future irrigation projects to improve performance of water deliveries and maintenance of distributary systems and watercourses, and to control groundwater levels to increase crop yields and social and economic benefits:
   - ❑ train project managers in use of monitoring, evaluation and application of feedback techniques to improve irrigation performance and to reduce operating costs;
   - ❑ identify meaningful irrigation component performance parameters, establish required measurements including their accuracy and sampling frequency and establish a management information system to assist real-time project management decision-making and scheduling of major maintenance operations; and
   - ❑ link project performance with operation and maintenance costs and agricultural production.

b. Develop and strengthen irrigation extension services and provide appropriate irrigation management training at all levels including water users:
   - ❑ educate and train extension staff in irrigation water management principles and practices and associated agronomic and cultural practices;
   - ❑ establish or strengthen irrigation technical support infrastructure, train extension staff in establishing demonstration plots on farmers' fields, and provide adequate transport facilities to enable extension staff to interact with farmers and project officers; and
   - ❑ train lead farmers in effective and economic irrigation management practices.

c. Promote exchange of information among farmers, extension workers, design engineers and researchers so that research and new design approaches meet the changing needs of farmers and the farmers fully understand the relevance of new and improved technology. In this regard it is recommended that action be taken to:
   - ❑ create opportunities for increased interaction among farmers, extension workers and researchers through organized visits of farmers and extension workers to research stations and the researchers to farmers' fields; and
   - ❑ hold regular 'field events' for the participation of design engineers, extension workers and farmers to enable exchange of knowledge and information among the participants.

d. Enhance design, operation and maintenance of irrigation projects by training of relevant professionals and members of water users' organizations:
   - ❑ initiate training for operation and maintenance personnel during the construction phase of new projects and during rehabilitation of existing projects to prepare them for project operations;
   - ❑ train system designers and operators in effective and economic approaches to modernizing irrigation and drainage systems and in effective and economic maintenance technology including principles of preventative maintenance; and
   - ❑ develop operation and maintenance criteria, taking into account the cost, manpower availability and requirements and social and environmental protection needs. Ensure that the criteria are taken fully into account in the design of irrigation systems.

e. Review, develop and implement water pricing policies, establish effective demand/supply management procedures and cost recovery mechanisms for operation and maintenance of irrigation projects:
   - ❑ establish manageable water demand and pricing systems which will minimize excess water application and reduce drainage requirements and costs; and
   - ❑ ensure that new or rehabilitated irrigation projects will have adequate resources for sustained operation and maintenance.

f. Document and disseminate, through international support, examples of successful irrigated projects.

Waterlogging, Salinity and Drainage

Issues

The greatest technical causes of decreasing production on many irrigated projects, or failure of large areas, are waterlogging and salinization of soils especially in arid and semi-arid areas. Waterlogging is not an inevitable

Increase in water table due to irrigation

irrigation project	water table	
	original depth (metres)	rise (m/year)
Nubariya, Egypt	15-20	2.0-3.0
Beni Amir, Morocco	15-30	1.5-3.0
Murray-Darling, Australia	30-40	0.5-1.5
Amibara, Ethiopia	10-15	1.0
State Farm 29, Xinjang, China	5-10	0.3-0.5
Salt Valley, USA	15-30	0.3-0.5
SCARP I, Pakistan	40-50	0.4
Bhatinda, India	15	0.6
SCARP VI, Pakistan	10-15	0.2-0.4
Khaipur, Pakistan	4-10	0.1-0.3

Adapted from Smedema, 1990

Irrigation often results in a rise of the groundwater level. The table above shows the increase in groundwater levels resulting from the introduction of irrigation without adequate drainage in a number of projects. Waterlogging and salinity can be prevented by better water control and by ensuring that all irrigation projects have provision for proper drainage.

result of irrigation. It is due to excessive input of water into systems that have finite natural drainage capacities (*see table above*). The excess water input causes the groundwater level to rise until a new equilibrium is reached. The sources of excess water input include seepage from unlined canals and on-farm distribution systems, deep percolation on irrigated fields, and rainfall. After waterlogging has occurred, soil salinity increases as plants extract pure water and evaporation from the soil surface leaves dissolved solids in the soil that were present in the irrigation water. Waterlogging also may contribute to human health problems, particularly malaria, because of ponded water.

Monitoring the change in water table levels from the beginning of a new project is essential to implementing corrective actions before soil damage has occurred. Monitoring and evaluation will also enable prediction of whether small-scale drainage will be adequate to prevent localized waterlogging problems, or whether a large-scale system will be needed.

For new irrigation projects, an integrated design of the irrigation and drainage systems along with operating practices will minimize irrigation development and management costs. Farmers also must be involved in the development, operation and maintenance of effective waterlogging and salinity control measures.

Waterlogging can be corrected by reducing excess water input and increasing natural drainage capacities by vertical (well) and horizontal drainage (pipe drains). Once soil salinity has increased to levels that affect plant growth, salts must be leached from the soil and the leachate disposed of in an acceptable manner. Typically, pipe drainage costs are high for projects that have low efficiency irrigation systems and unlined canals. As a result, installation of drains is often postponed until no alternative remains for increasing or maintaining soil productivity. Optimal systems consider the trade-off in reducing excess water input by lining irrigation canals, lining or using on-farm pipe distribution systems, using more efficient on-farm irrigation systems, and improving irrigation scheduling to minimize excess input. These actions increase irrigation system capital costs, but reduce drainage requirements.

On large irrigation projects with small topographic gradients, disposal of drainage effluent has become a major problem. Because of increasing competition for good quality water, saline drainage waters are being diverted into evaporation ponds and, where feasible, separate drainage channels to coastal waters or salt sinks have been constructed.

Waterlogging and salinity also occur in rainfed areas such as the semi-arid plains of northern India. In that region, standing surface water containing sodium bicarbonate has caused the formation of sodic soils in lower layers. Reclamation of these soils requires a combination of surface drainage and soil amendments for eliminating sodicity, in some cases irrigation water for leaching, and subsurface drainage.

Waterlogging and salinity can also be observed in rainfed areas which may be referred to as saline seep areas. They are caused by changes in vegetation over decades which have changed the hydrological balance and increased localized groundwater flow. Such problems have occurred in semi-arid areas of southern and western Australia, central Canada, and parts of the Great Plains of the United States.

In humid tropical areas, waterlogging occurs due to excess rainfall and may not be associated with salinity. Soil salinity occurs in coastal areas mainly due to primary saline deposits of marine origin in contrast to salinity

When, as a result of improper irrigation, soil salinity levels exceed crop threshold levels, crop damage will be severe. Typical results of such damage are poor stand establishment, stunted plant growth and extensive leaf burn.

caused by man-made activities. Waterlogging in these areas typically can be corrected by surface drainage. A special problem in some coastal areas is the reclamation of acid-sulphate soils.

Lack of drainage facilities in many projects exists because at the start of an irrigation project the water tables may lie at great depths below the surface. Typically, the estimated canal and on-farm irrigation efficiencies are over-estimated during project design and the amount of excess water input is greater than planned. In most cases water table monitoring can give adequate forewarning of the impending waterlogging crisis that is imminent. Unfortunately, a rising water level is often not taken seriously by decision-makers because the adverse effects may not become significant for several years *(see table on previous page)*.

Technology is well established for designing, constructing and managing drainage systems. Some adaptive research may be needed where local materials are used and where unique local soil problems exist.

With current irrigation systems in developing countries, increased drainage will almost invariably be required to maintain soil productivity. The main question is a matter of when such drainage systems should be constructed. Monitoring should be part of the operation of all irrigation projects to predict more accurately when the drainage system must be completed to avoid development of waterlogging and salinity problems.

Actions

In rainfed agriculture, surface drainage is required to prevent any temporary waterlogging and flooding of low lands. In irrigated agriculture, artificial drainage is essential under most conditions. It is essential to minimize drainage requirements and costs by reducing the sources of excess water through improved system design and on-farm water management practices. Design of appropriate drainage systems, securing funds for their construction and maintenance, farmers' involvement in the management of drainage systems and safe disposal of drainage effluents are important. Groundwater monitoring, water balance studies and conjunctive use of surface and groundwater should be encouraged. Pilot projects in waterlogged and salinized areas need to be established in order to verify available technologies and provide training for personnel.

Rainfed Agriculture

Improve drainage to prevent temporary waterlogging to increase and sustain productivity:

- ❑ provide surface drainage where needed; and
- ❑ prevent unnecessary flooding of low lands.

Irrigated Agriculture

a. Ensure that all new or rehabilitated irrigation projects have adequate drainage:
   - ❑ use realistic distribution and on-farm irrigation efficiencies when estimating drainage volume and drainage system requirements;
   - ❑ consider alternative capital investments in irrigation facilities for increasing the efficiencies of distribution and on-farm irrigation systems, which can greatly delay the need for drainage and reduce the eventual capacity and costs of drainage;
   - ❑ carry out thorough drainage investigations, evaluate alternative drainage designs and operation and maintenance practices and introduce cost recovery mechanisms;
   - ❑ where a drainage system will be needed, develop the organization and estimate costs of financing the project and its operation and maintenance including manpower and equipment needs;
   - ❑ develop organizational arrangements and facilities to enable farmer participation in drainage activities at the local level; and
   - ❑ investigate environmentally acceptable alternative approaches for disposal of saline drainage effluents.

b. Implement groundwater monitoring and water balance studies to predict drainage requirements and implement conjunctive ground and surface water use, where feasible, to prevent or reduce waterlogging:
   - ❑ implement groundwater monitoring to record water table level and water quality changes from the beginning, in all irrigation projects;
   - ❑ encourage, when applicable, conjunctive use of ground and surface water for irrigation, thereby reducing drainage requirements and cost;
   - ❑ initiate water balance studies in order to predict water table build-up and drainage requirements, taking into consideration contribution to groundwater from canal seepage, farmers' fields and other sources; and
   - ❑ assist farmers with development and adoption of more efficient on-farm irrigation methods to reduce excess water input to problem areas.

c. Establish pilot drainage projects in waterlogged and salinized areas to verify design and effectiveness of materials, demonstrate the effect of drainage on productivity, and train personnel in operation and maintenance of drainage systems with emphasis on:
   - ❑ adaptation and testing of drainage technology developed in other areas using local materials and construction techniques where feasible; and
   - ❑ use of pilot areas to train personnel to operate and maintain of drainage systems concurrent with the installation of large-scale drainage systems.

d. Implement soil salinity monitoring in problem areas and adopt appropriate water, soil and crop management practices to overcome the problem:
   - ❑ initiate appropriate soil salinity surveys, analyse data, and adopt techniques to measure changes in soil salinity;
   - ❑ equip laboratories with suitable instrumentation and train professional staff and technicians in salinity investigation and related techniques; and
   - ❑ adapt established and effective water, soil and crop management practices to local conditions and train farmers in adopting such practices.

Water Quality Management

Issues

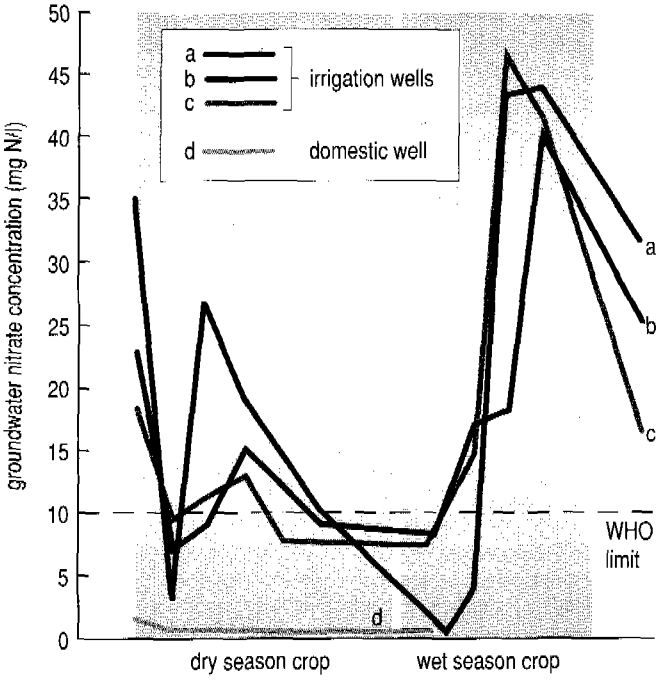
From the viewpoint of sustainable agricultural development, water quality management has two major implications:

1. The quality of water used in irrigated agriculture

Seasonal nitrate variations in shallow sand aquifers

(Sri Lanka, areas under intensive fertilized irrigation)

Source: Lawrence and Kuruppuarachchi, 1986



Intensive use of fertilizers and manures, especially in irrigated areas, has resulted in high nitrate concentration of water in many parts of the world. Field investigations have shown that less than half the nitrogen applied to the soil may be removed by crops. This means that more than half the nitrogen applied is either retained in the soil or leached, contributing to water pollution.

In some irrigated areas of developing countries, higher rates of fertilizer application have already contributed to high concentration of nitrates in groundwater, which is often used for drinking. The figure on the left shows seasonal variations of nitrate concentration in groundwater in four wells in Sri Lanka.

should not cause crop damage and adversely affect agricultural yields. The presence of certain constituents like soluble salts, and ions like sodium, chloride or boron, in water at above threshold level concentrations not only reduces total agricultural production, but also could significantly reduce the sustainability of the agricultural projects. Hence, quality of water being used for agriculture is an important consideration.

As a general rule, the quality of water required for use in agro-industry and aquaculture has to be of a much higher order than that for agriculture per se.

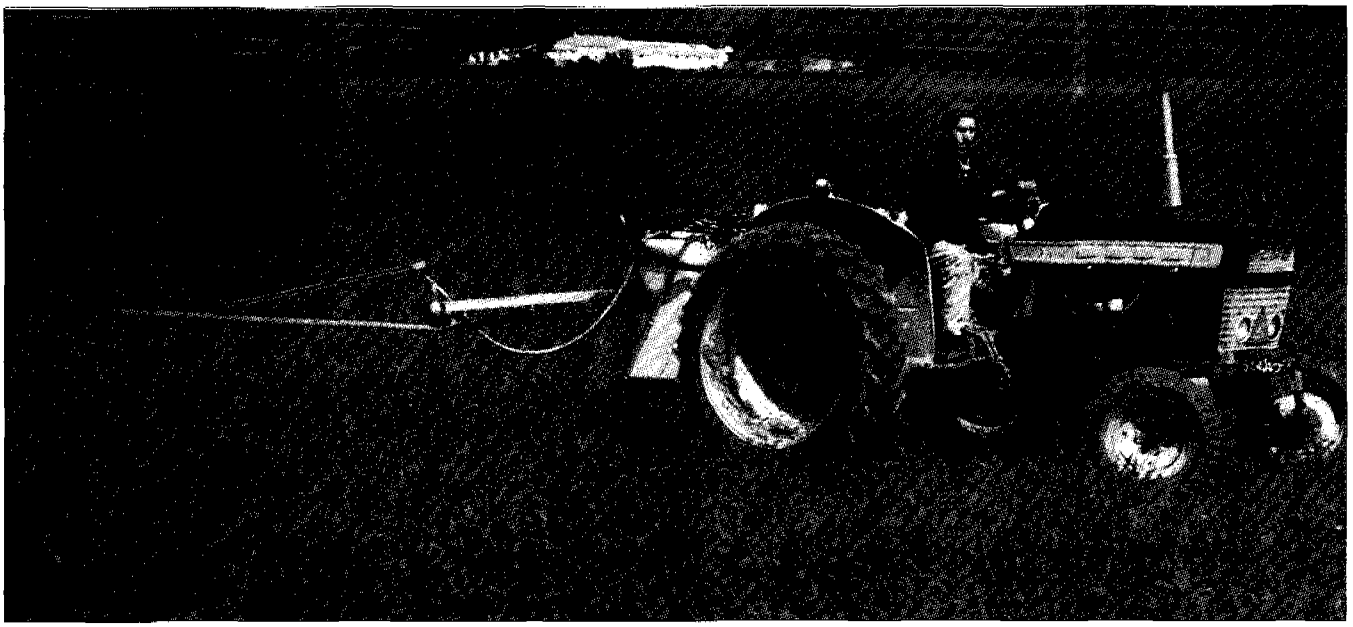
2. Agricultural activities should not adversely affect the quality of surface and groundwater such that their subsequent use for other purposes has to be curtailed. Water quality considerations for agricultural uses have received considerable attention, but concomitant attention has not been given to the potential impacts of agricultural activities on water quality. Viewed from the standpoint of agricultural chemicals alone, this could perhaps be explained by the low rates of application of fertilizers and pesticides in developing countries. However, as their application rates are increasing, especially for irrigated agriculture, nitrate and pesticide contaminations are increasingly becoming areas of concern *(see graph above)*. High levels of salinity and sediment concentrations have always been considered to be serious water quality issues for agriculture.

In addition to mineral fertilizers, manure and other organic residues are an important source of nitrogen reaching surface and groundwater in many countries. Farmers require education to promote proper and efficient use of fertilizers to avoid over-application. Management of fertilizers use has an important role to play since current methods of large-scale removal of nitrates from water are seldom economic.

The main objective of water quality management as related to sustainable agricultural development is twofold, namely:

1. to ensure that human activities do not degrade water quality so that its potential uses are impaired for agricultural purposes; and
2. to ensure that agricultural activities do not contribute to unacceptable levels of water quality deterioration so that other uses of water are precluded.

In arid and semi-arid developing countries, where possibilities for further economic development of tradi-



Proper application of agrochemicals can greatly reduce their potential to contaminate both groundwater and surface water. Low-volume sprays reduce contamination and increase the efficacy of application.

tional sources of water are limited, alternative measures should be undertaken in order to make effective use of marginal quality water, e.g. wastewater and drainage water. With the construction of extensive sewer systems and treatment plants in many urban centres of developing countries, treated wastewater is increasingly becoming a new and important source of water for irrigation. Ways and means must be found for optimal use of this nutrient-rich water, consistent with necessary environmental and health safeguards. Thus, water quality monitoring for agricultural use of treated wastewater is an important consideration.

Water quality monitoring networks and associated required facilities are significantly less well developed in developing countries, for a variety of reasons. Among the main reasons are: technical complexities of establishing functional and realistic water quality monitoring networks; high investment costs required to organize and operate water quality monitoring systems; lack of adequately trained human resources; absence of properly equipped laboratories; difficulties associated with operation and maintenance of sophisticated equipment; and non ready availability of spare parts. Because of the complexities and high costs, functional national water quality monitoring systems have generally not been fully established in many developing countries.

Actions

Concerted and planned actions are necessary to establish and operate functional and cost-effective monitoring systems, and to ensure that water available for agricultural uses is of an acceptable quality. Simultaneously, appropriate steps must be taken to ensure that agricultural activities do not adversely affect water quality so that subsequent uses of water for different purposes are impaired.

a. Develop cost-effective and functional surface and groundwater quality monitoring programmes for assessing agricultural water quality, and evaluate the impact of agricultural activities on water quality:
   - upgrade existing water quality monitoring networks by taking a long-term view of future needs and by following as far as possible the recommendations of international specialized organizations on standardization of instruments, techniques and analytical and sampling procedures;

- ❑ standardize, coordinate and organize the processing and timely publication of water quality data;
- ❑ establish and/or strengthen training programmes on water quality monitoring and assessment;
- ❑ consider specific national characteristics and socio-economic conditions in establishing implementable water quality regulations and standards;
- ❑ cooperate in the coordination, collection and exchange of necessary data in cases of shared water resources; and
- ❑ international organizations and bilateral donors should, on request and as appropriate, offer technical assistance and provide funds to implement the above actions.

b. Develop and implement strategies to minimize the magnitude and extent of water pollution by agricultural activities, including agro-industries:
   - ❑ develop appropriate criteria, standards and legislation for regulating the use of agricultural chemicals, such as fertilizers and pesticides, and manures, taking into consideration relevant national factors, including crop yields, soil and water management practices, disposal of farm runoff and effluents, and socio-economic conditions;
   - ❑ encourage more efficient use of fertilizers and pesticides;
   - ❑ ensure that technology and appropriate financial incentives are available to agro-industries to reduce the impact of products and processes on water quality; and
   - ❑ introduce effective legislation and regulatory mechanisms to minimize pollution of surface and groundwater bodies.

c. Prepare national strategies and plans for rational use of treated wastewater and drainage water for agriculture:
   - ❑ develop appropriate procedures for reuse of water of marginal quality for specific uses, including necessary health and environmental monitoring on a regular basis;
   - ❑ improve inter-institutional cooperation among water, health, agriculture and other appropriate ministries in order to ensure continued safe reuse of wastewater and drainage water;
   - ❑ identify institutional and socio-cultural constraints to the reuse of wastewater for agriculture, and devise programmes to overcome such constraints;
   - ❑ develop pilot projects as needed to evaluate and demonstrate effective practices for safe reuse of marginal quality water; and
   - ❑ international organizations and bilateral donors should, as appropriate, assist countries in the review of experiences and the exchange and dissemination of information on the use of wastewater and drainage water for agriculture and provide required technical assistance in developing national pilot projects.

d. Review the extent of current and potential salt water intrusion due to over-extraction for agricultural activities:
   - ❑ establish pilot salt water intrusion control projects in areas where salt water intrusion has already occurred, and/or implement action to reduce the existing magnitude and extent of such encroachment; and
   - ❑ identify areas where salt water intrusion could occur in the future due to agricultural development and take necessary preventive measures.

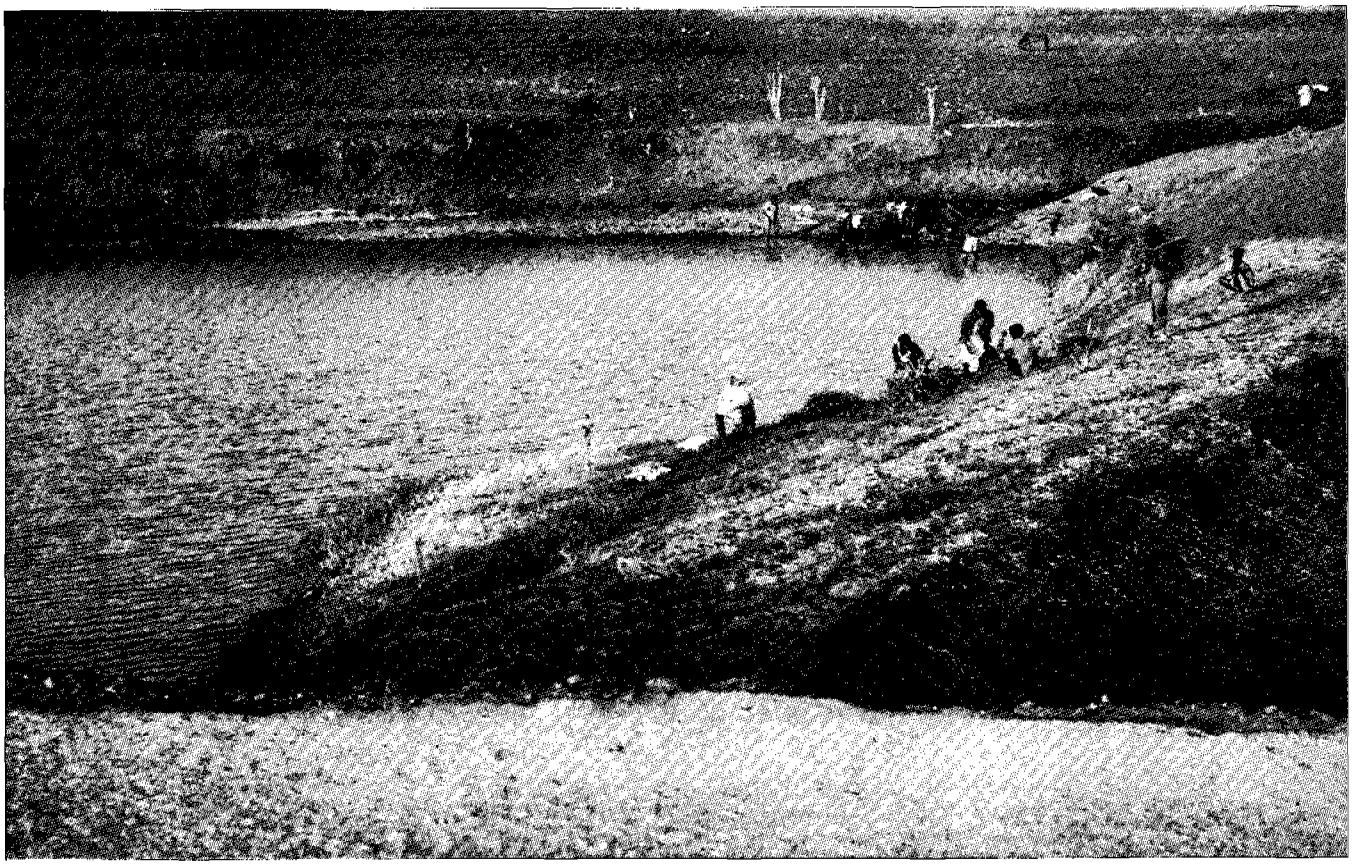
Small-scale Water Programmes

Issues

Small-scale water programmes can fulfil many local water needs and have considerable global potential for the achievement of sustainable agricultural development. The purpose of such programmes includes development of small-scale irrigation, water supply for humans and livestock, improved infiltration to groundwater, soil conservation, flood spreading and flood control. These initiatives can often integrate development and conservation, and enhance local involvement in environmental management. The programmes, when properly implemented, can generate employment, promote equity, improve health standards and help to slow or prevent migration to urban areas.

Definitions of 'small-scale' based on size or cost are culturally or site specific, and could vary from one country to another. However, the concept of small-scale applies where communities or individuals develop and operate most activities of the projects themselves, although technical assistance is often necessary during survey, design, construction and maintenance. Small-scale programmes include a diversity of technologies such as water harvesting, well development, river off-takes and use of wetlands.

Small-scale irrigation development is a major activity of small-scale water programmes, and affects sustainable agricultural development in several ways. Firstly, well-designed projects lessen the vulnerability of agricultural activities, and the risk of soil and water degradation. Secondly, small-scale irrigation enables the use of renew-



On-farm water storage has multiple benefits. In addition to meeting the supplementary irrigation needs of the farm, farm reservoirs can be used for fish culture and domestic water use.

able energy sources where suitable. Finally, the rates of expansion of small-scale irrigation can be controlled consistent with locally available water resources.

Small-scale irrigation schemes can complement the development of larger projects. Small-scale programmes can be efficient and amenable to cost recovery and thus can operate reliably with private as well as public operation and maintenance services. Such schemes provide inexpensive and cost-effective extensions to irrigated production by small-scale producers, whose aggregated output is a key factor in the economic development of many developing countries.

Various approaches have been adopted to expand small-scale water programmes. In some countries, many types of state organizations have been involved, as have programmes of public works. Elsewhere, non-governmental organizations (NGOs) and private sector organizations have also provided technical advice and support. There have been many successes where a participatory approach that involved local people was combined with sound technical design and siting. However, many programmes have failed as they have not been properly integrated with local farming activities and patterns of water use. Other programmes have been planned but never implemented, as many countries fell victim to the 'blueprint' approach of targets that were never fulfilled due to financial and staffing problems, or because they depended too heavily for implementation on inappropriate central institutions. Other initiatives have failed because of conflicts or poor integration between development agencies and resource management bodies. Future programmes need to be based on better design,

and far better institutional coordination, with a key focus on participation at the local level in all stages of design, implementation and management.

Actions

Small-scale water programmes can assist sustainable agricultural development but further expansion must be founded on adequate technical advice and support, improved institutional collaboration and greater involvement of local communities.

a. Formulate national policies and develop programmes for implementing small-scale water projects for rural development:
   - ❑ develop fora to plan and promote coordinated activities in small-scale water programmes involving donors and national organizations, and central, regional and local organizations;
   - ❑ develop the role of local institutions and agencies in planning, advising and implementing small-scale water projects;
   - ❑ increase the role of small-scale water projects in special public works programmes, where these are consistent with local priorities and promoted with full participation from the local community;
   - ❑ enhance data collection and monitoring capacity to ensure the efficient expansion of small-scale water programmes; and
   - ❑ focus promotion of small-scale water programmes in areas where local expertise exists in agricultural water management and cooperative management, and use pilot projects to investigate the adaptation of small-scale water programmes in areas without these traditions.

b. Develop more effective institutional coordination to integrate the development of agricultural and rural water supplies and soil and water conservation:
   - ❑ promote greater investigation, adaptation and dissemination of successes and failures to integrate water control and water supply; and
   - ❑ increase local capability for integrated water planning and documentation, with special emphasis on linking technical executive agencies with agencies for resource management, public administration and rural development administration.

c. Enhance the capability of farmers in the implementation, operation and maintenance of small-scale water programmes:
   - ❑ enlarge local capabilities in design, construction and maintenance through more flexible design approaches, training and appropriate funding;
   - ❑ improve technical advisory services for water management and crop production, particularly in areas where water quantity and quality may fluctuate over time;
   - ❑ formulate rules and responsibilities for operation, management and use of small-scale water projects, which are consistent with existing traditions and with local financial and labour capabilities;
   - ❑ increase opportunities for dialogue between water users and technical services;
   - ❑ develop the role of small-scale community water projects, such as water harvesting, spring protection or well developments, in local council budget and expenditure programmes; and
   - ❑ ensure collection of data which show the diversity of water use, and disseminate these in forms which can be used by local people.

d. Provide stronger representation and support to small-scale producers including development of a more effective production and marketing environment:
   - ❑ ensure effective programmes for credit and other agricultural inputs required for small-scale water programmes; and
   - ❑ assure reliable and economical sources of energy for small water pumps and other mechanical devices.

e. Adapt and disseminate appropriate technologies for small-scale water projects:
   - ❑ promote exchange of information and experience on technologies that are suited to small-scale water projects;
   - ❑ ensure that adaptation and dissemination of technologies fully address gender divisions of labour in rural communities; and
   - ❑ disseminate irrigation technologies appropriate to small-scale water sources and suitable for small plots of land, and including assistance in the use of poor quality water where necessary; adapt low-cost irrigation technologies for small and marginal farmers.

f. Enhance the role of NGOs and the private sector in promoting small-scale water programmes:
   - ❑ encourage NGOs to improve coordination and increase their support to small-scale water projects;

- ❑ assist NGOs to enhance managerial and technical skills of field officers through appropriate training programmes;
- ❑ expand opportunities and improve the performance of the private sector in small-scale water projects; and
- ❑ improve collaboration between public and private sector agencies to ensure standardized programmes in credit and technical assistance, and increase information on private sector activities.

g. Monitor performance, evaluate successes and failures and identify constraints in order to provide feedback and disseminate lessons learned:
- ❑ develop monitoring and evaluation procedures for projects by local representatives;
- ❑ promote education and media activities to raise and/or develop the profile of rural achievements in small-scale water programmes, and highlight the involvements of resource-poor groups, such as the landless or women;
- ❑ promote the transfer of existing knowledge on community participation into practical expectations and approaches for small-scale water programmes;
- ❑ promote the transfer of techniques for mobilizing community participation among different rural development activities for example, between community health work and community water projects, or between rural water supply and small-scale irrigation;
- ❑ ensure that participatory approaches in small-scale water programmes involve all members of the community, including marginal farmers, landless labourers, pastoral groups and women; and
- ❑ encourage development of participatory approaches by government departments and the private sector involved with small-scale water programmes.

Scarce Water Resources Management

Issues

Many countries of the world face constraints to their economic and social development as available water resources are insufficient to meet demand, and conditions of water scarcity arise.

Water scarcity is a general condition of countries with arid or semi-arid climates, which necessitates the development of production strategies appropriate to the variable, unpredictable and limited water supplies that characterize such climates *(see graph over page)*. Dry climates in the tropics are characterized by an average annual rainfall of less than 700 mm, which is usually markedly seasonal in character.

Such areas support traditional land use practices, but these often become less sustainable as a result of social, economic and environmental changes. Land use strategies require careful use of water in the soil, or the use of a very diverse range of water sources. Livestock keeping is an important activity as well as crop production. The development of improved production strategies depends not only on sound knowledge of water resources, but also on strategies that maximize biomass production in relation to water, and the conversion of biomass by livestock. Traditional practices are often involved in just this kind of production strategy, in relation to prevailing labour, soil and economic conditions. Strengthening traditional strategies may prove to be as important as modernizing or replacing them, although the latter is an approach which should also be considered.

Dry climatic zones also need development programmes which stabilize and improve water regimes and support agricultural activities that create more prosperous and less vulnerable communities. Poverty and famine have their roots in unstable and inequitable socio-economic conditions; agricultural production and rural communities are frequently disrupted and depressed by droughts and/or floods, and some of the worst examples of hunger and deprivation occur in these dry lands. Thus actions must include both long-term programmes—which reduce the general vulnerability of drought-prone areas—and short-term programmes, such as the development of effective warning systems for crop failures and food shortages, and the provision of emergency assistance at times of natural catastrophe.

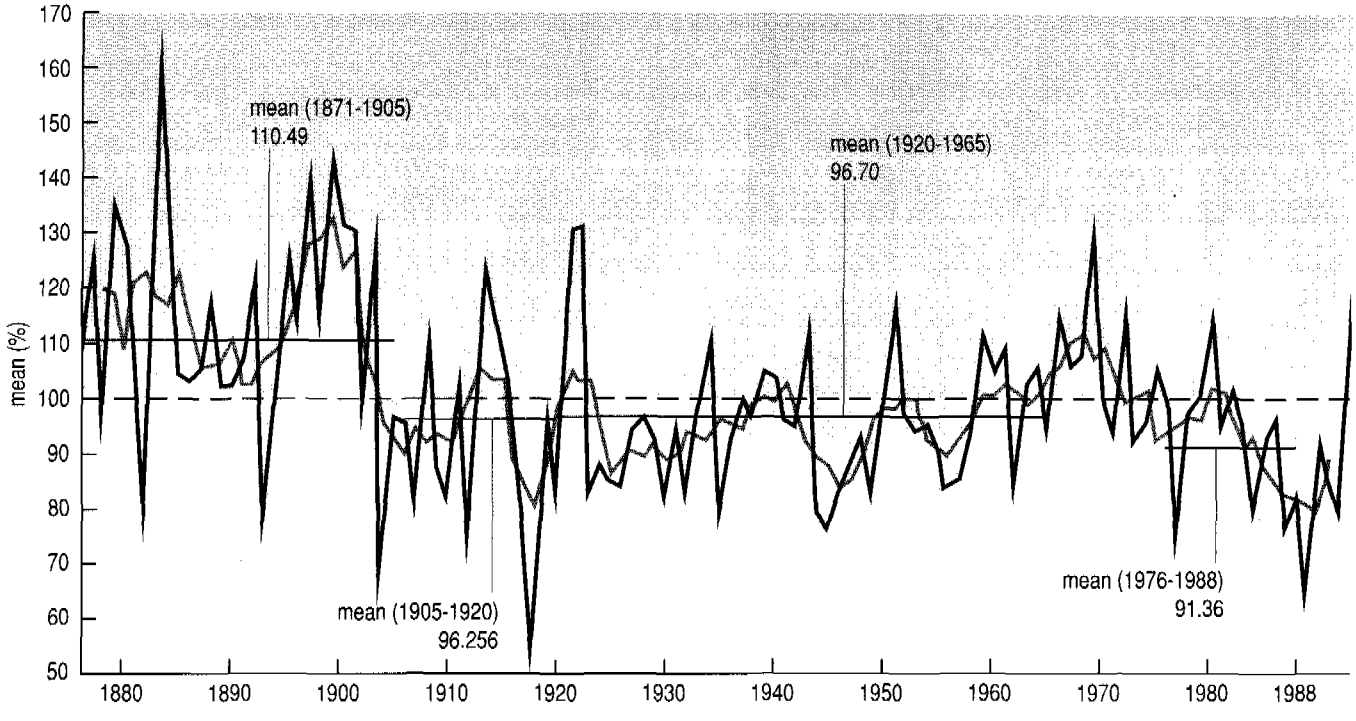
In arid and semi-arid areas, easy and economic availability of water is generally an important constraint to economic development. Because of water scarcity, rational and equitable decisions on water allocations must be made among various water users and uses. Such decisions can only be properly made and implemented within the functional and institutional frameworks.

At present, in many arid and semi-arid countries, the most important additional accessible sources of water are international and interprovincial rivers, lakes and aquifers. Because of the inherent complexities associated with development of international water bodies, many of these have not yet been tapped. There is no question that the development and management of international water bodies will become even more important issues in the 1990s and beyond than they ever were in the past.

The urgent need to develop appropriate land and

Annual Nile flow at Aswan, Egypt

Source: Abu Zeid and Biswas, 1990 (personal communication)



In arid and semi-arid countries, severe annual fluctuation of rainfall and river flow is a serious constraint to agricultural production. Production from rainfed agriculture under such conditions could vary significantly from one year to another. The figure shows annual flows in the Nile at Aswan during 1871-1989. For irrigated agriculture, a succession of drought years, as observed during 1976-88, can create a difficult problem if water storage capacities are inadequate to provide carryover supplies.

Another serious problem with such severe fluctuations is the necessity of having data over a long period in order to design and operate water resources projects cost-effectively. Note that if a water project had to be designed at Aswan on the basis of data over the 1871-1905, 1905-65, 1965-76 or 1976-88 periods, the characteristics of the designs and the costs would have differed considerably.

water uses and effective allocation procedures raises administrative dilemmas for many countries. There have been many initiatives in data collection, land use zoning and control of over-exploited water resources, yet many plans remain unimplemented or controls unenforced due to lack of continuity and expertise. Some plans or controls may be inappropriate or unenforceable under the current socio-economic conditions.

Actions

Water scarcity conditions require long-term strategies and practical implementation programmes for the development of agricultural water use in ways consistent with limited water resources and competing demands for water.

a. Formulate an integrated and comprehensive strategy for the management of land and water for sustainable agricultural development under water scarcity conditions:
   - ❑ develop national planning capacities to formulate policies and strategies for management of scarce water resources and technical and institutional capacities, so that long-term goals can be achieved through refinements in short-term policies and their implementation; and
   - ❑ promote exchange of information on techniques which assist decision-making under conditions of water scarcity and political and administrative approaches to managing land and water use programmes.

b. Develop land and water use policies and plans for areas of scarce and highly variable water supplies, ensuring that they remain compatible with prevailing socio-economic conditions and the environment:
   - ❑ develop better analytical techniques for understanding the behaviour of the diverse water sources used in water-scarce areas;
   - ❑ encourage studies on climatic fluctuations and cycles in order to ensure more reliable water availability for agricultural production;
   - ❑ consider use of supplementary irrigation to optimize agricultural production;
   - ❑ promote agricultural development strategies which maximize biomass potential and conversion in relation to water, and which give the best food security under extreme scarcity conditions rather than average conditions;
   - ❑ consider the possibility of water demand management in addition to supply management; and
   - ❑ strengthen adaptive research and dissemination of irrigation and water supply technology which minimizes water losses.

c. Design legal frameworks for the regulation of land and water developments and management and procedures for their implementation which take into account customary laws and traditions:
   - ❑ document customary laws and traditions in land and water management, review their implications on new land and water developments and enact new laws if required.

d. Develop policies and coordinated activities for managing groundwater withdrawals for irrigation within the safe yield limits of aquifers:
   - ❑ assess groundwater resources, and design and approve new groundwater projects and plans in such a manner that they do not withdraw groundwater beyond safe yield limits;
   - ❑ strengthen monitoring procedures for all groundwater development projects by state, private and NGO activities;
   - ❑ based on these policies, develop licensing and zoning procedures for the development of groundwater, and ensure their enforcement; and
   - ❑ develop direct and indirect methods to control groundwater abstractions, such as control through electricity tariffs, better water pricing and collection of charges on public tubewell projects, and taxation and/or pricing strategies.

e. Formulate and implement effective drought preparedness measures with special emphasis on environmental protection and improving community resilience:
   - ❑ develop government capability to deal with the effects of drought in the short-term, including:
     i. procedures for assessment of the impact of drought on livelihoods;
     ii. design and implementation of assistance programmes to re-establish agricultural activities during and after a drought; and
     iii. coordination of emergency food and water needs, where possible linking these to execution of locally-supported community development projects, and ensuring that all sectors of the community, especially women and other vulnerable groups, benefit from assistance.
   - ❑ assist and improve initiatives to stabilize and augment water resources in the longer term, and develop production strategies which are less vulnerable to drought:
     i. fund small-scale water programmes designed to improve catchment recharge and provide temporary storage for water use;
     ii. promote water harvesting techniques as a means of coping with water shortage situations for drinking, domestic and agricultural uses;
     iii. develop water for drinking and irrigation based on the concept of sustainability;
     iv. assist local developments in food storage;
     v. assist local communities to develop suitable plans for water allocation and water rationing to minimize conflict during periods of water scarcity; and
     vi. analyse past projects and/or activities which have not produced the desired results, and identify the steps that should be taken to rectify the shortcomings.

f. Intensify efforts to formulate agreements for the allocation and protection of interstate and international waters as an important requirement for sustainable agriculture.

Supporting Actions

The five priority areas of action identified and elaborated upon earlier constitute the means to optimize water use for crop production and achieve agricultural development on a sustainable basis. In order to implement effectively the actions proposed in these five priority areas, certain common and complementary actions need to be taken. These common actions include:

- ❑ development of adequate data bases;
- ❑ adaptive research;
- ❑ institutional strengthening;
- ❑ training (human resources development);
- ❑ better socio-economic analysis;
- ❑ environmental protection and conservation; and
- ❑ technology transfer and infrastructure.

Development of Data Bases

The absence of adequate and reliable hydro-climatic and other associated natural resources data in developing countries is a major factor which currently hinders rational water and sustainable agricultural development. As long as adequate and reliable data are not available, planning, design and management of water programmes will continue to remain guesswork, use of natural resources haphazard and wasteful, and the development process unsustainable. Water programmes for sustainable agricultural development can only be soundly formulated on the basis of adequate data on suitable soil and its production capacity, potentially available surface and groundwater resources, performance of existing water projects (including small-scale traditional systems) and other related factors that contribute to success under the farmers' economic conditions and aspirations.

In consequence, there is an urgent need to: assess available water and other related natural resources data as they relate to irrigated and rainfed agriculture; identify gaps, and establish suitable methodologies for data collection and analysis; monitor water resources, water and land use and crop production; compile inventories of type and extent of agricultural water development and their present and future contributions to sustainable agricultural development; and improve the availability and dissemination of data to planners technicians and farmers. Mobilization of financial resources is essential to ensure the continuity of these activities on a long-term basis.

The actions required are as follows:

a. Review and evaluate adequacy of existing data on water and associated natural resources:
   - ❑ review existing data on land and water resources for rainfed and irrigated agriculture, human resources and population-supporting capacities at national, river-basin and regional levels;
   - ❑ evaluate the adequacy of the data available, identify gaps and where appropriate develop and disseminate better methodologies for data collection and analyses, and establish readily accessible data banks;
   - ❑ where appropriate, develop tools to integrate data, such as the Geographic Information System; and
   - ❑ review the capacity of the relevant institution in charge of developing and managing proper data bases, and rectify any shortcomings.

b. Initiate actions to secure funding to ensure continuity of the data bases, and quality, availability and accessibility of data:
   - ❑ develop pilot projects to establish national and multinational (especially for international rivers, lakes and aquifers) systems for data collection, monitoring and analysis as well as their storage and retrieval; and
   - ❑ obtain national and, if required, international funds to support such projects.

Adaptive Research

Research and development go hand-in-hand. Since new problems develop with time, and economic and environmental conditions change, it is necessary to update and modify existing technologies and develop new ones. Applied and adaptive research play very important roles in attaining these goals. Research programmes in most developing countries in the area of agricultural water use have mainly been somewhat limited in scope, and often discontinuous and fragmented. Furthermore, research should not be limited to technical issues only but should also include social, institutional, environmental and economic aspects of water management in agriculture. Current research efforts in developing countries mostly tend to follow disciplinary lines within narrowly-defined topics. Adaptive research needs to be reoriented by recognizing the complex role of water in agricultural development, and by following a broad-based holistic approach.

As a result of these situations, adaptive research programmes must be initiated and supported to investigate the real problems associated with the planning, design, implementation and management of water in agricultural development projects. It is important that the resulting technology be technically feasible, environmentally and economically viable and socially acceptable.

The priority requirements are as follows:

a. Identify priority areas for water-related adaptive research:
   - ❑ review and evaluate adaptive research programmes that deal with water development and management, crop, soil management and husbandry practices and social, environmental, institutional and economic aspects which are relevant to sustainable agricultural development; and
   - ❑ identify appropriate research 'packages' composed of a number of these components that are applicable under a wide range of geographical, farming and socio-economic conditions.

b. Strengthen the adaptive research capacities of institutions in developing countries:
   - ❑ evaluate specific technical assistance, training and material needs of research institutions in order to strengthen their capacities;
   - ❑ mobilize national and international funds to strengthen research institutions; and
   - ❑ enhance opportunities for exchange of research ideas and findings among developing countries and between developing and developed countries.

c. Enhance translation of water-related and farming systems research results into practical and accessible technologies and provide the support needed for their quick adoption at the field level:
   - ❑ conduct verification research at the farm level with full involvement of the farmers; and
   - ❑ produce easily understandable and simplified 'how-to-do' manuals in local languages in order to introduce the new and proven technologies, and ensure their wide distribution among potential users.

Institutional Strengthening

The importance of a functional and coherent institutional framework at the national level to promote water and sustainable agricultural development has been generally fully recognized at present. The solution may not always require the creation of new and enlarged institutions and establishment of larger government services. Since it is the farmers who grow crops and not the civil servants, an important criterion in reorganizing and/or establishing new institutions should be the ability of such institutions to address successfully the multi-dimensional problems that are generally faced by the farmers at local and national levels. Such institutions should be capable of undertaking, regulating, stimulating and facilitating roles. The importance of inter-ministerial and interdepartmental linkages cannot be over-emphasized to perform these functions. Institutional strengthening should thus be based on these types of functional requirements and linkages. The roles of local communities and NGOs, particularly with regard to small-scale water programmes, should not be under-estimated. Strengthening these organizations in many cases may prove to be the most cost-effective and thus attractive alternative.

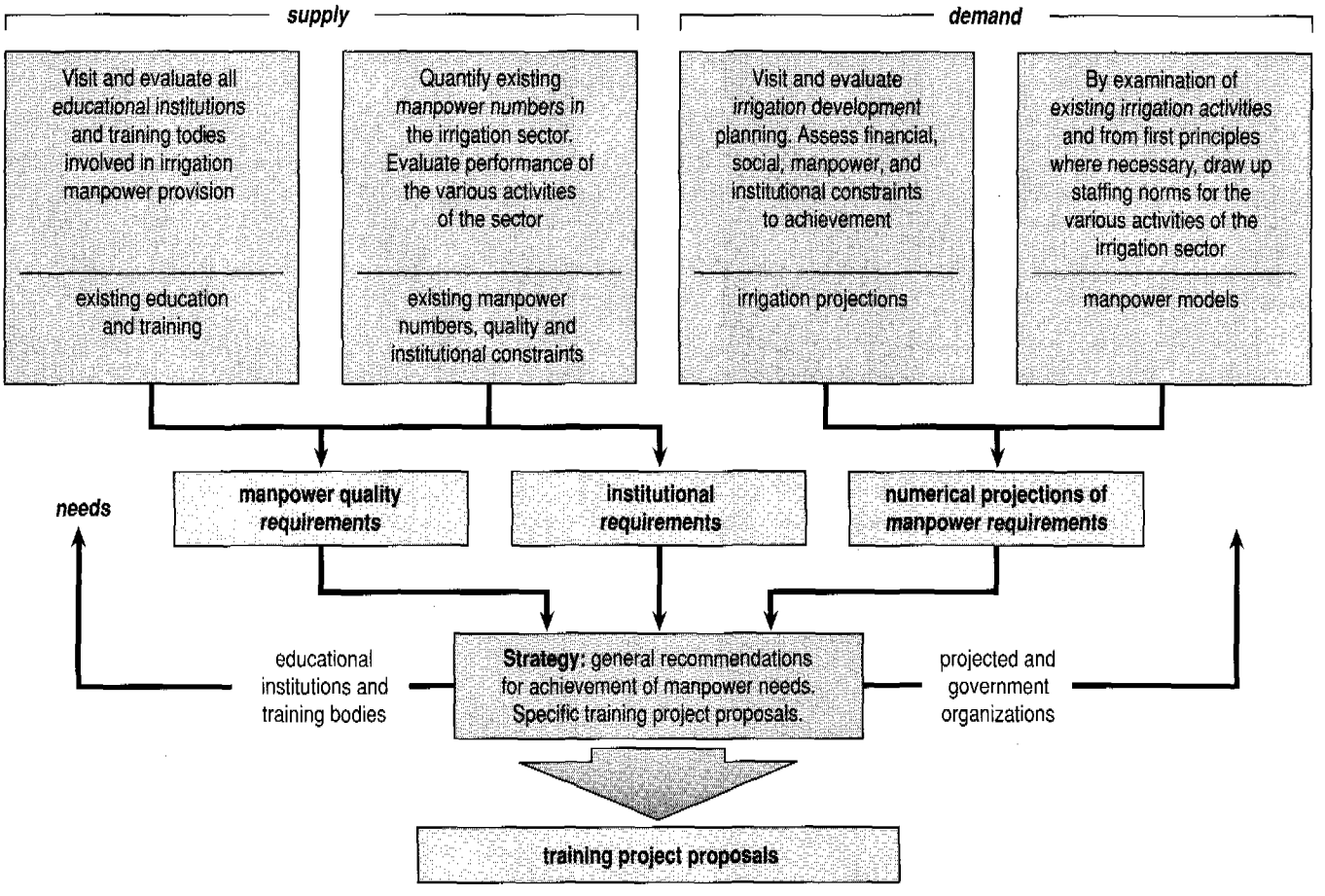
In addition, an adequate legal framework of rules and regulations should be in place to facilitate actions on agricultural water use, drainage, water quality management, small-scale water programmes and the functioning of water users' associations. Legislation specific to the needs of the agricultural water sector should be consistent with, and stem from, general legislation for the management of water resources.

In particular, institutions that deal with agriculture and water development need to be strengthened or restructured to meet efficiently the requirements of the farmers and to promote sustainable agricultural development. Principal institutions should have effective linkages with all other related institutions so as to optimize the use of physical, financial and human resources.

The necessary actions are as follows:

a. Review, strengthen and restructure, if required, existing institutions in order to enhance their capacities in water-related activities:
   - ❑ organizational structure, functional relationships and linkages among ministries and departments within a ministry should be reviewed and, if needed, revised and strengthened. In this regard, research, extension and planning, implementation, operation, monitoring and evaluation functions deserve special attention; and
   - ❑ specific measures that require support for institutional strengthening include long-term programme budgeting, staff training, incentives, mobility, equipment and coordination mechanisms.

Manpower planning methodology Source: FAO 1986



The principles of human resources planning are conceptually straightforward. An analysis of both the present and future demand for trained human resources is carried out together with an evaluation of the existing supply. Demand and supply are then reconciled and a detailed human resources strategy is produced. The aims of the strategy are to produce sufficient numbers of personnel of the appropriate quality.

b. Review, assess and revise, if required, existing legislation on the management of water for sustainable agricultural production within the broader framework of legislation for the development, use and conservation of water resources.

Human Resources Development

Shortage of educated, trained and experienced staff at all levels is a major constraint to rainfed and irrigation development in most developing countries. So far only very few developing countries have undertaken systematic human resources studies in the agricultural water use sector. Education and training programmes are essential to ensure that adequate numbers of properly trained staff are available to deal with relevant managerial and technical issues involved in agricultural water use. The training programmes should be compatible with an overall national policy of human resource development for the agricultural water use sector. Establishing this national policy is an essential precondition to developing an effective education and training programme. Human resources planning should include identification of areas for which education and training are needed and the subsequent manpower needs *(see chart above)*.

Opportunities should be provided for career develop-

ment for professionals and technicians in service along with a rewards system that is based on performance.

The importance of education and training of farmers, especially for irrigated agriculture, should not be underestimated. Farmers must understand the technology that is being introduced to them. There is thus a strong case for increasing farmers' training utilizing demonstration plots and other innovative means when new technologies are introduced which are expected to be adopted by farmers.

Particularly, training and human resources development should be actively pursued through: assessment of current and long-term human resources requirements and training needs; establishment of a national policy for human resources development; and initiation and implementation of training programmes for staff at all levels as well as for farmers.

The necessary actions are as follows:

a. Assess training needs for agricultural water management.
b. Increase formal and informal training activities.
c. Develop practical training courses for improving the ability of extension services to disseminate technologies and strengthen farmers' capabilities with special reference to small-scale producers.
d. Increase the opportunities for career development to enhance the capabilities of administrators and officers at all levels involved in land and water management programmes.

Better Socio-economic Analysis

Sustainable development, as defined earlier, should meet two basic considerations, namely economic viability and social acceptability. A great many water development projects in the past have failed due to inadequate attention given to social and economic aspects in their planning and implementation. The application of strict economic principles in certain cases has resulted in the so-called economic non-feasibility of potentially beneficial and sustainable projects. This was mainly due to the inability to quantify the social and economic benefits in monetary terms. At the same time, many social benefits and environmental goods are at present either underpriced or unpriced. This has led to over-exploitation and inefficient use of natural resources. Application of appropriate socio-economic analysis in all phases of project planning and evaluation is urgently required in water resources development projects.

Efforts should be made to incorporate economic and social analyses in national water development planning and evaluation methodologies. Multinational and bilateral donors should use appropriate socio-economic analytical tools in project evaluation and appraisal for funding.

In this regard, it is recommended that:

a. efforts should be made to develop appropriate socio-economic analytical tools in project planning, appraisal and evaluation;
b. multilateral and bilateral donor agencies should adopt appropriate socio-economic methodologies in their overall economic and financial appraisal of projects;
c. governments and relevant international agencies should ensure that socio-economic analyses are adequately applied in formulation and the selection of projects for implementation.

Environmental Protection

The importance of environmental protection and conservation measures has been increasingly recognized during the past three decades. It is now generally accepted that environmental protection will not take place without development, and development cannot be sustainable without environmental protection. Thus, environment and development are two sides of the same coin.

Much agricultural land is deteriorating due to inappropriate soil and water management. Soil erosion, nutrient depletion, salinization and waterlogging all reduce productivity and jeopardize long-term sustainability. Agricultural expansion programmes have often encompassed marginal land in many parts of the world. Wise management of the environment requires an ability to forecast, monitor, measure and analyse environmental trends and assess the capabilities of land and water at different levels, ranging from a small irrigated plot to a watershed. Adopting environmental impact assessments will enable countries to plan water and land use without irreversible environmental damage and allow sustainable resource use. Environmental impact assessments should be followed by monitoring and implementing necessary actions. Appropriate action is needed in upper catchment areas, not only to conserve them, but also to ensure available water downstream, groundwater recharge, water quality protection and overall sustainability of water development projects. A number of environmental protection measures need to be implemented throughout watersheds in order to preserve their environmental quality, maximize positive impacts of development and minimize potential environmental hazards.

In particular, environmental protection and conservation of natural resources must be made an integral part of development. Objective environmental impact assessments must be considered as prerequisites for approval of development plans and projects. All environmental factors should be considered from the beginning of any project cycle. Integrated environmental monitoring, evaluation and feedback are essential to ensure sustainable development. Emphasis needs to be placed on the management of upper watersheds and implementation of environmental protection measures across the watershed.

The necessary actions are as follows:

a. For water-related projects and programmes, countries should:
   - ❑ carry out objective environmental impact assessments in order to ensure their sustainability and environmental acceptability;
   - ❑ take appropriate measures and actions to maximize positive environmental impacts and minimize adverse environmental impacts;
   - ❑ ensure amelioration measures, recommended to reduce environmental problems, are implemented; and
   - ❑ institute environmental monitoring, evaluation and feedback systems on a long-term basis.

b. Develop and implement appropriate land use and environmental programmes in upper catchments to ensure continued availability and suitability of water for agriculture.

c. Identify and implement environmental protection measures across entire watersheds.

d. Expand, improve and coordinate international assistance to improve the capabilities of developing countries to assess, manage and protect their environment and natural resources.

e. Provide necessary investments to ensure control of water-borne human disease vectors in irrigated and rainfed agriculture.

Technology Transfer and Infrastructure

Transfer of experience and technology and enhancement of feedback among scientists, technicians and farmers (horizontal) and between them (vertical) continues to remain a major constraint in most developing countries. On the basis of past experiences, it is evident that the success of a project on water development for agriculture during all its phases—planning, design, construction and operation—is strongly influenced by the availability of technology and whether or not the appropriate choices have been made to suit the local conditions. A scheme for information transfer which includes storing, disseminating, receiving feedback and updating information is urgently needed to support water activities for sustainable agricultural development. An important function of the transfer system is to enhance the capacity of human resources of nations through dissemination and feedback of information. Transfer of experiences among developing countries through an already established UN mechanism, namely, Technical Cooperation among Developing Countries (TCDC), could be made an important element of information transfer.

As in all economic activities, agricultural development, particularly involving the water sector, has infrastructural requirements to ensure its success. Farmers must have enough funds; good quality supplies must be delivered in time and in adequate quantities; and proper marketing facilities and pricing structures should be assured. In addition to physical infrastructure, services such as education and health are also necessary.

Specifically, transfer of technology, both horizontal and vertical, needs to be strengthened. In planning, design, implementation, operation, maintenance and adoption of improved technologies and practices, there is a need to examine a range of technology options and select and adapt the optimum package for a given set of local conditions. Strengthening of physical, economic and social infrastructures should proceed simultaneously with other related developmental activities. Mechanisms to provide credit, input supplies, markets, appropriate pricing and transportation must be developed. Provision of health facilities and basic education as part of the social infrastructure is important.

The necessary actions are as follows:

a. Establish effective methods to facilitate the transfer of new and proven techniques and practices, including greater use of demonstration plots, training at all levels and dissemination of relevant information in local languages.

b. Encourage and provide required facilities for transfer of knowledge and experiences among developing countries in the area of water and sustainable agricultural development.

c. Expand integrated rural water supply infrastructure for multiple uses and assist in developing the rural economy including facilities for water-related education and training and support services for agriculture (farmers' involvement/commitment).
d. Provide stronger representation and support to small-scale producers, including development of a more effective production environment.

4

Implementing the Action Programme

The main objective of the International Action Programme on Water and Sustainable Agricultural Development (IAP-WASAD) is to assist developing countries in planning, developing and managing water resources at national and international levels on an integrated basis to meet the present and future needs for agricultural production. In meeting this objective, the IAP-WASAD will assist national governments and regional institutions in setting priorities concerning the use of water and land resources for agricultural development, in updating their current policies and strategies, and developing and implementing programmes to translate their policies and plans into action.

The UN system will play a catalytic role in the implementation of the Action Programme by creating greater awareness of the importance of integrated water and land development, responding to specific requests of member governments for technical cooperation and assisting in mobilizing bilateral and multilateral donor support for technical assistance and investment for development.

The success of the IAP-WASAD will depend on:

- commitment of the national governments and their continued support to the objectives and goals of the Action Programme;
- coordination of activities in relation to water use and agricultural development among countries within a region and between these countries and regional and international institutions;
- adoption of a holistic approach in utilizing water for agricultural development taking into consideration technical aspects as well as economic, social, political and cultural factors;
- full involvement of farmers during all stages of water planning, development and management;
- effective involvement of local NGOs and the private sector; and
- support of the multilateral and bilateral organizations, particularly in terms of technical cooperation, funding and improved coordination of external assistance.

In its present form, IAP-WASAD is designed to be implemented within the framework of 'Arrangements for Inter-organizational Cooperation of the UN System at the Global, Regional and Sectoral Levels', as well as within the mandate and policy, programme and operational guidelines of FAO—the lead agency of the programme. Full participation of bilateral and multilateral development agencies is foreseen in every phase of the Action Programme. The requirement for flexibility of approach compatible with the policies and needs of national governments, regional institutions, United Nations System organizations and bilateral and multilateral development agencies is fully recognized.

Resources Mobilization

The importance of human and financial resources in the implementation of the Action Programme needs no emphasis. This has direct implications for:

- national governments,
- NGOs and the private sector,
- UN organizations and
- bilateral and multilateral organizations.

The most important condition for success is a strong commitment and sustained support to the International Action Programme at all the foregoing levels.

National Government Level

The importance of implementing the activities of the Action Programme must be realized by national policy makers and planners. This means that the acceptance of the Action Programme at the country level should involve not only the Ministries of Agriculture and Water, but also the Ministries of Planning, Environment and other relevant ministries. To achieve a high level of commitment, a preliminary dialogue with all concerned national authorities is highly desirable.

It is also important that when governments make their commitment to the Action Programme, they should commit appropriate financial support and manpower

required for the implementation of the programme. Availability of local manpower to implement the programme is imperative. While it is recognized that many developing countries are faced with extremely difficult economic situations, it is urged that national governments take into consideration the possibility of reallocating committed funds or allocating extra-budgetary sources of funds to support the programme, if and when required. It should be borne in mind that the Action Programme deals with a most important sector of national economy, namely agricultural development on a sustainable basis, and hence the need to give priority to the proposed action should be well recognized by national governments.

NGOs and the Private Sector

Local and national NGOs have an important role to play in ensuring the participation of farmers and the local community in the implementation of agricultural water management programmes. Inputs from international NGOs will further strengthen the participation of local communities. The important role of the private sector in promoting appropriate technologies, facilitating marketing and input supplies and direct participation in the development itself is self-evident. The support and direct involvement of NGOs and the private sector need to be consolidated through an appropriate institutional framework.

UN Organizations

Basically the IAP-WASAD is a programme to promote and strengthen activities by developing countries to achieve sustainable agricultural development through more effective management of their water resources. The role of UN organizations in this regard is to provide technical cooperation and to mobilize international support for investment and development of the agricultural water sector. Often several UN organizations are involved in a given area of activity, and some overlapping is present in the UN System's responses to the needs of governments. During the implementation of the Action Programme, this overlapping will be minimized in order to optimize the use of financial and human resources of the UN System, governments and multilateral and bilateral donors. Such optimization can be achieved since the programme will be implemented under the umbrella of the UN Administrative Committee on Coordination-Intersecretariat Group on Water Resources *(see box, above right)*.

The participating UN Agencies are expected to provide an appropriate level of support to the programme through commitments in their regular programme and participation in joint formulation missions and through the exchange of information and technology by means of journals, special publications, seminars and workshops.

Active participation in and support to the ACC-ISGWR Working Group on Water and Sustainable Agricultural Development and support to the Secretariat is also anticipated from the participating UN Agencies.

Administrative Committee on Coordination and the Intersecretariat Group on Water Resources

Following the United Nations Water Conference, the Economic and Social Council requested the Administrative Committee on Coordination (ACC), the organizations undertaking water related activities and, where appropriate, the regional commissions, to make the necessary arrangements for intensifying interorganizational cooperation and to elaborate appropriate procedures so as to provide support for the periodic intergovernmental review of the Mar del Plata Action Plan.

Pursuant to this request, the ACC, at its third session in 1979, established an Intersecretariat Group on Water Resources (ISGWR) involving all the organizations of the United Nations System active in the water field.

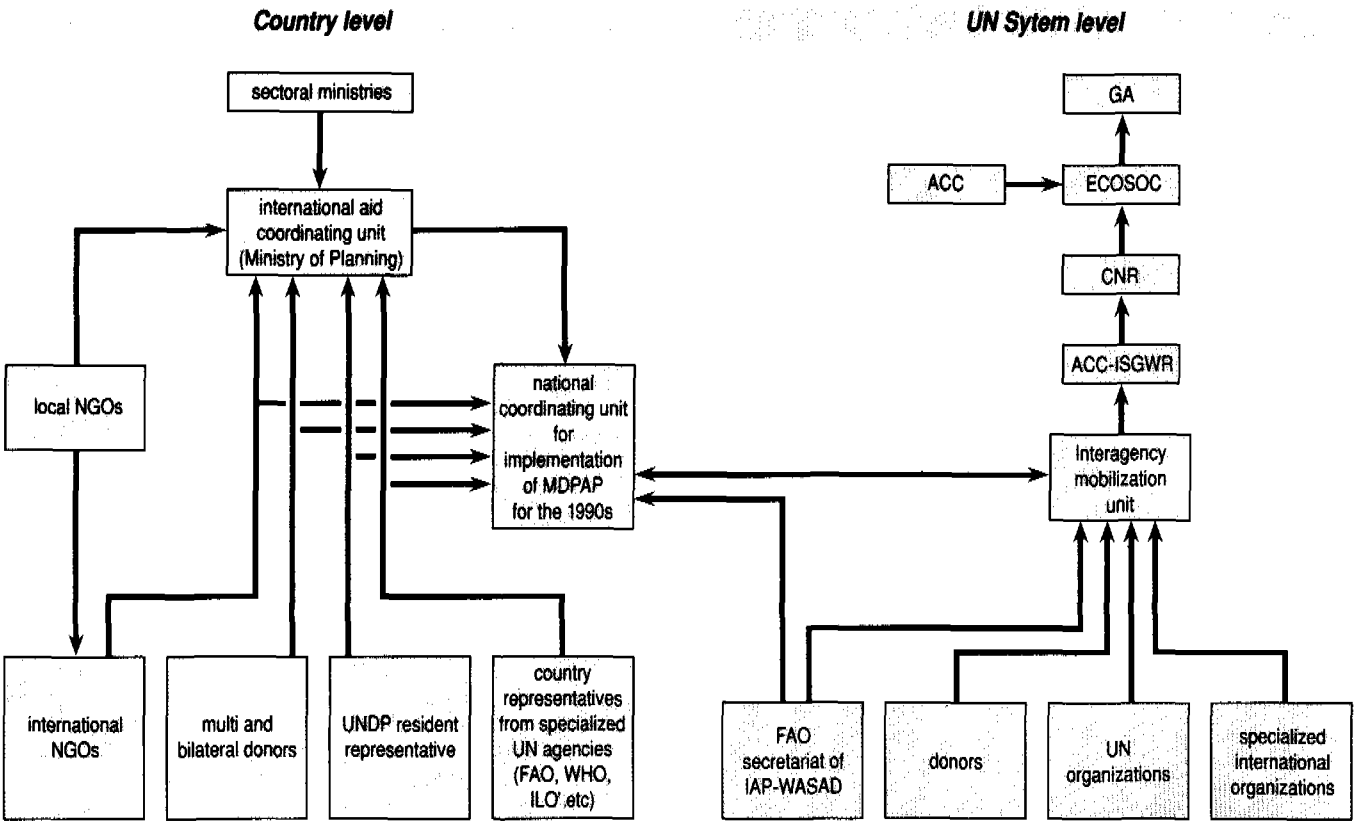
Following are the terms of reference of the ACC-ISGWR:

1. cooperation in the monitoring of progress being made in the implementation by governments of the Action Plan adopted by the United Nations Water Conference;
2. promotion of cooperation and joint planning of the water related programmes of the United Nations System and review of their implementation;
3. assistance in coordinating the water related activities of the United Nations System at country and regional levels.

The Group receives continuous secretariat support services from a nucleus of staff within the Office for Programme Planning and Coordination of the Department of International Economic and Social Affairs. Additional staff support is provided, as needed, from the other organizations. The Group holds regular meetings at yearly intervals supplemented by informal meetings organized as and when required.

Source: UN, 1980

Mechanism of coordination for implementing the Action Programme



Bilateral and Multilateral Donor Communities

The bilateral and multilateral donor communities have played and will continue to play a very significant and important role in water and agricultural development. Their share in water development activities, particularly in financial terms, is prominent especially when compared with other inputs in the agricultural sector. Despite the fact that different donor communities have differing criteria in selecting programmes and projects for support, all have the same goals in the agricultural sector, namely to promote accelerated agricultural development of the host country, and conservation and optimum use of natural resources, thus enhancing employment, equity and improved standards of living. Recently, most donors have promoted the concept of 'sustainable development' as another basic criterion in providing assistance to developing nations.

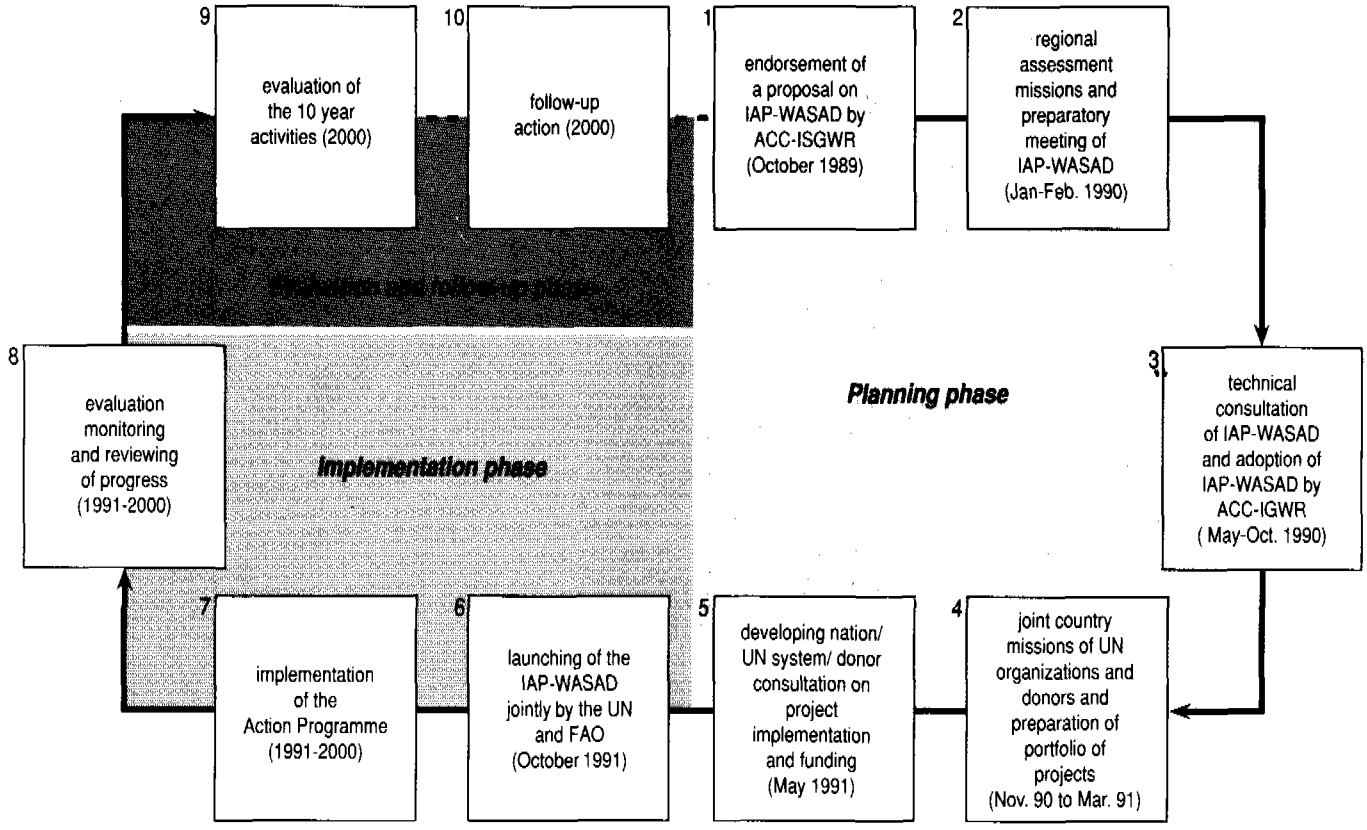
The commitment of bilateral and multilateral donors to support the programme is necessary if the international programme is to make a tangible and lasting contribution to the developing nations.

Commitment to the programme may be of various forms. In many cases, there are ongoing programmes of the bilateral and multilateral organizations in water and agricultural development which should be intensified or modified as needed. The UN Agencies' role will be to facilitate the activities of the donor communities, to ensure minimum overlap among donors and optimal use of financial and human resources.

Operational Arrangements

In implementing the IAP-WASAD, the important roles of the main participating groups—the national governments, the UN System and the bilateral and multilateral donors—will need to be defined and effectively integrated. Flexibility will be required to allow changes as the programme develops over the envisaged 10 year period. A proposed mechanism of coordination among the three groups is presented in the diagram above. Revisions to this coordinating mechanism may have to be made as the programme develops.

The programme cycle of IAP-WASAD



A national coordinating unit (NCU) for implementing the Action Programme under the umbrella of the Strategy for the Implementation of the Mar del Plata Action Plan for the 1990s is recommended. The major role of this unit is to serve as a national focal point to coordinate the Action Programme activities with relevant national and international organizations at the country level.

At the UN System level, the establishment of an inter-agency mobilization unit (IMU) is recommended. The major role of this unit is to assist UN agencies, national governments and donors in the implementation of multi-disciplinary water sector programming missions, identification of projects, developing project documents, seeking donor support, implementation of projects and their monitoring. This Unit will work directly with the ACC-ISGWR and will serve as the international counterpart to the national coordinating unit.

A national government's request for assistance in implementing these actions and activities through the NCU will be a first step in the implementation of the Action Programme.

It is proposed that when the Action Programme is adopted by the ACC-ISGWR, it will be distributed to all member governments through the 'UN System channel' namely, through FAO Representatives, UNDP Resident Representatives and other UN System focal points. Thus, the programme will be available to relevant government institutions for use in initiating requests for action and for periodic updating by the UN System.

It is also foreseen that UN organizations, and multilateral and bilateral donors can initiate action by identifying the need for assistance to appropriate member countries based on their past and ongoing activities in the field of water and agricultural development. Such actions, which are within the framework of the Action Programme, should be fully discussed with relevant institutions of the national governments, before they are initiated to develop projects for implementation.

The UN System naturally has a critical role to play, since the programme is being promoted as an UN interagency initiative. Basically the following three major functions should be fulfilled through the IMU:

- respond to requests of countries channelled through the NCU for technical and investment assistance, within the framework of the Action Programme;
- coordinate the responses within the UN System, in order to provide the most appropriate and effective assistance and service;
- consult with multilateral and bilateral donor communities on provision of the necessary support to meet the governments' requests.

Development Stages of the Programme

The proposed ten-year IAP-WASAD must be implemented with flexibility, yet the development must be directed. In order to achieve its goals, a sequence of important stages of development of the programme or 'programme cycle' is suggested (*see diagram on previous page).* The programme cycle is divided into three phases, namely, planning, implementation and follow-up phases.

As can be seen in the Programme Cycle, a major activity in the planning phase is 'the joint country missions' of the UN organizations and donors. It is foreseen that these missions which will be undertaken as 'water-sector' programming missions involving various UN organizations, will identify projects in the context of multipurpose water development and use and in relation to national water use master plans. The missions are expected to result in a portfolio of projects in the water sector, of which this Action Programme will act upon those which fall within the five identified priority actions.

Following the preparation of a portfolio of projects, it is intended to convene a donor meeting to seek funding support from multinational and bilateral agencies. This meeting will be convened under the auspices of the ACC-ISGWR at which projects that would fall under the various action programmes of the Mar del Plata Action Plan Strategy will be reviewed jointly by the national governments, donors and UN organizations. A successful conclusion of this meeting will lead to the launching of the action programmes of the Mar del Plata Action Plan for the 1990s.

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