AGRICULTURAL WATER USE

Assessment of progress in the implementation of the Mar del Plata Action Plan

REPORT OF THE REGIONAL ASSESSMENT MISSIONS

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SUMMARY

As an input to the formulation of a strategy for world water activities in the 1990s, and to an International Programme on Water and Sustainable Agricultural Development, four regional missions were carried out in January-February 1990 to assess progress and problems in implementing the Mar del Plata Action Plan. The missions were funded by UNDP and executed by UN DTCD, with technical backstopping from FAO.

The reports of these missions to Africa, Asia/Pacific, Latin America/Caribbean, and Near East/North Africa form the basis of this document, with some supplementary material drawn mostly from the UN Regional Economic Commissions and FAO. A short section on Europe and North America has been added, using published material, to indicate trends in this region which are becoming progressively more relevant to developing countries.

Despite the brevity of the missions, which should be seen as a reconnaissance rather than an in-depth review, it was possible to record many successful initiatives and programmes, a number of impediments to progress and, most important, to identify problem areas which threaten present and future land and water development and the natural resource base, and to recommend appropriate actions. There are differences in types and magnitudes of such problems, due to the diversity of physical, social and economic conditions among and within the regions, but there are also many common factors, with regional and national variations being matters of degree and emphasis.

The primary issue is the interaction between the management of land and of water resources. While over-intensive use of agricultural land (whether rainfed or irrigated), due to population pressure, is a feature in parts of Asia, and over-exploitation of water resources is most prominent in the recent expansion of irrigation in the arid and semi-arid Near East, other regions face similar local problems - sometimes extensive. For instance, countries of Europe and North America are currently reviewing and revising their land and water policies, especially to protect against the progressive degradation of natural resources.

The decline in water quality is a threat to all countries that are heavily dependent on water for agriculture, with increasing effluent loads entering surface and groundwaters, and the contamination of overpumped aquifers from pollutants and seawater intrusion. The management of marginal quality water, is becoming a necessary feature of irrigated agriculture in many parts of the world. In arid and semi-arid areas, waterlogging salinization and drainage are now major and costly aspects of irrigation.

Most countries are being forced to aim at higher efficiences in agricultural water use, partly to contain problems such as salinization, arising from excessive water application, but also to meet the diverse, competing demands for a finite resource. Problems of real scarcity are imposing limitations, and fears of climatic variation are stimulating measures to adapt to reduced water availability. Irrigation efficiencies, which are generally low, tend to be depressed by poor scheme operation and maintenance, resulting from inadequate cost recovery from the farmers who, in turn, are constrained by low prices for their produce.

Many of the water-related problems have their roots in defective policies and institutional arrangements, with economic and social aspects prominent in this respect. All regions, whatever the extent and status of their water programmes, point to the need for emphasis on human resources development, with extension to farmers being a common theme.

Finally, the scope of future work to improve and advance the development of water resources for sustained agriculture, and to protect those resources from decline and deterioration, calls for greater, and more coordinated effort. Regional and interregional collaboration among countries and agencies active in this field should be more evident feature of future programmes, and the organizations of the United Nations system could contribute by strengthening regional offices to provide advice and assistance close to the areas of need.

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ACKNOWLEDGEMENTS

For the preparation of this assessment of progress in agricultural water use, the regional consultants visited 25 countries. In each of these, they called on various national and international organizations.

It is not possible to list all the individuals who contributed to the review, but the consultants wish to acknowledge the advice, assistance and information provided so willingly, in all these countries, by the officials and staff of national organizations with responsibilities for water and agriculture, and of intergovernmental river basin organizations.

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Finally, the support of FAO in backstopping the overall UNDP/DTCD project, especially through the efforts of Dr. A Kandiah, is gratefully acknowledged by the five consultants, and by the compiler of this consolidated report, T.H.Mather.

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
billion	1000 million
CDB	Caribbean Development Bank
cu.m.	cubic metre
cu.m/sec	cubic metre per second
ECA	Economic Commission for Africa (UN)
ECE	Economic Commission for Europe (UN)
ECLAC	Economic Commission for Latin America & Caribbean (UN)
ESCAP	Economic & Social Commission for Asia & Pacific (UN)
ESCWA	Economic & Social Commission for Western Asia (UN)
FAO	Food and Agriculture Organization (UN)
ha.	hectare
IBRD	International Bank for Reconstruction and Development
ICID	International Commission on Irrigation and Drainage
IDA	International Development Association
IDB	Inter-American Development Bank
IFAD	International Fund for Agricultural Development
IIMI	International Irrigation Management Institute
IRRI	International Rice Research Institute
km.	kilometre
m.	metre
M.	million
mm.	millimetre
PEEM	Panel of Experts for Environmental Management for Vector Control (WHO/FAO/UNEP)
RAPA	Regional Office for Asia and the Pacific (FAO)
UNDP	United Nations Development Programme
UNDTCD	United Nations Department of Technical Cooperation for Development
UNEP	United Nations Environment Programme
UNFPA	United Nations Fund for Population Activities
WFP	World Food Programme
WHO	World Health Organization

I. INTRODUCTION

The United Nations Water Conference, held in Mar del Plata, Argentina, in 1977, was attended by representatives from 116 Member States, 21 organizations of the UN system and many observers from intergovernmental and non-governmental organizations. The conference recommendations, forming the Mar del Plata Action Plan (MPAP), covered eight 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. In addition, resolutions were prepared on ten specific topics. Among these topics, that of Agricultural Water Use was developed in considerable detail, reflecting the widespread interest and concern of the Conference on this subject.

Reviews of progress of the Mar del Plata Action Plan in the 1980s showed that whereas there were some noteworthy achievements in many national programmes for various sectors and topics identified in the Action Plan, there were also many problems. Some of these were threatening to jeopardize prospects for development, and even the maintenance of existing levels of production, through the pressures that were being imposed on resources of water and land in efforts to meet demands of rising populations. This was particularly evident in agriculture - the major user of these resources.

In response to the recommendation of the UN ACC-ISGWR (Intersecretariat Group for Water Resources of the Administrative Committee on Coordination), on the need to formulate a comprehensive strategy for the MPAP in the 1990s and beyond, six key elements of the strategy were identified, among them - sustainable agricultural development. Regional assessments of progress and problems in implementing the Action Plan were called for, and four such assessments were carried out during January to March 1990, specifically for agricultural water use. The missions were funded by UNDP, executed by UNDTCD, and provided with technical backstopping by FAO as lead agency for the sector. Terms of Reference for the missions are attached as Annex I.

The timing of the missions coincided with the initiation, by FAO, of an interagency programme, later designated as an International Action Programme on Water and Sustainable Agricultural Development, (IAP-WASAD). The regional reports therefore formed an input into both the MPAP Strategy for the 1990s and the IAP-WASAD, identifying problem areas, and also successful initiatives in the management and development of water resources for agriculture, and indicating approaches to the formulation of future programmes. To gain maximum advantage of the national and regional experience reported by the missions, it was decided to present this information in a document which will serve as background to proposals for the MPAP Strategy and for the IAP-WASAD, and at the same time will provide a useful reference on the current status of agricultural water use and management.

This consolidated report consists mainly of summaries of the consultants' four regional reports, essentially at a reconnaissance level in view of time constraints, with the addition of complementary material from other recent documents provided by FAO and the UN Regional Economic Commissions. Although there was no mission to the region represented by the UN Economic Commission for Europe (ECE), a short section, developed mostly from ECE documents, has been included on Europe and North America as an indication of some recent experience and trends in agricultural water use, which are becoming increasingly relevant to developing countries in other regions.

Reproduced from "Africa South of the Sahara", with the agreement of Europa Productions Ltd, London

Figure 1 *Major regions of Africa*

II. AFRICA

1. REGIONAL OVERVIEW

Agriculture, land and population

The regional situation, analysed in detail in the 1986 FAO study "African agriculture: the next 25 years", is succinctly expressed in the following main conclusions:

i. "Africa is suffering from a crisis in food and agricultural production. A crisis most apparent in the widespread decline in per caput food production over the past 10-25 years. A crisis destined to get worse if the underlying causes are not removed rapidly, because Africa's population is likely to double, over the next 25 years. Inaction could lead to a situation in which half of Africa's people would be dependent on food imports and food aid from developed countries and - if food aid cannot reach those in need - to widespread famine, with destabilizing consequences both in and outside Africa.

ii. Africa has, in general, the land, water and technologies to produce much more. If this potential is realized, many African countries will become self-sufficient in food, and other countries more self-reliant and their economic situation more manageable.

iii. The most important single ingredient of recovery is the conservation of Africa's land and water resources, on which agriculture and many other sectors of the economy depend. Africa's soils are much more fragile than those of Asia and Latin America. Urgent measures are needed at the national and local levels to halt the degradation of these resources, and to enable them to contribute fully to economic recovery.

iv. Inadequate incentives, a lack of production inputs, inappropriate institutions and poor rural infrastructure are also holding back the development of agriculture. Radical reforms are required in each area, and practical measures exist to implement these reforms.

v. These measures must be implemented within a framework that allows sustainable growth. This framework requires that agriculture be given greater priority in national budgets, that Africa's external economic environment be markedly improved, and that donors re-examine the quantity and form of the aid they provide."

In almost all countries of the Africa region, agriculture will remain, for a long time to come, the primary sector for economic growth and the alleviation of poverty. In most countries, over 80% of the population live in the rural areas, and constitute the main force in agricultural production, particularly in rainfed crops and livestock. Increased productivity and total production, and their sustainability in both food and export crops during the 1990s are the major challenges. In all countries visited on this Africa mission, these challenges are well recognized.

Irrigated agriculture

The major regions of Africa are outlined in Figure 1, and the climatic zones, with their rainfall characteristics, are shown in Table 1.

Table 1 CLIMATIC ZONES IN THE MAJOR REGIONS OF AFRICA, (% OF THE TOTAL AREA OF EACH REGION

Region	Climatic zones					
	Desert 100	Arid 100-400	Semi-arid 400-600	Dry sub-humid 600-1200	Moist sub-humid 1200-1500	Humid 1500+
Mediterranean and arid North Africa	86	7	3	2	2	0
Sudano-Sahelian Africa	32	36	10	15	7	0
Humid and sub-humid W. Africa	0	0	3	15	47	35
Humid Central Africa	0	0	0	2	29	69
Sub-humid and mountain E. Africa	10	25	13	11	27	13
Sub-humid and semi-arid southern Africa	7	15	16	19	40	3
Total % by zone	29	17	8	11	21	14

In broad terms, some 46% of the land area is too dry for rainfed crop production, 8% suffers from very variable rainfall conditions and 14% is very humid. This leaves about 30% that is climatically well suited to rainfed production of millet, sorghum and maize, the main staple food grains of the continent. Overall, Africa has well over 600 million ha of land that could be developed for crop production, although some is suitable only for tree crops.

With this situation, it is estimated that both Africa as a whole, and the sub-Saharan region, have sufficient rainfed land resources to produce food for their estimated peak populations in the future, providing the level of input use, such as seeds and fertilizer, is increased. This estimate however includes the major, and unrealistic assumptions that all suitable land is cleared and cultivated to food crops, and that there is unrestricted movement of surplus food and labour.

There are major differences among the regions. For example, the land resources of North African countries are insufficient to produce directly that region's food needs, even at high levels of inputs and with rainfed and irrigated production. In West Africa, the situation with regard to the ability of the resource base to meet future food needs is somewhat different. Though there are difficulties now and in the future for individual nations, the region as a whole has substantial resources of both rainfed and irrigable

land. However, in view of differences in production potentials and difficult communications, further development of irrigation is likely to be required in some countries, particularly those with a high proportion of semi-arid areas.

In East and Central Africa, unless a significant part of the area is farmed at high input levels, difficulties in food production will arise in Burundi, Ethiopia, Kenya, Rwanda, Somalia and Uganda. The main sources of potential rainfed exportable surpluses are Zaire, Tanzania and Ethiopia, provided that parts of the areas of these nations are farmed at a high level of inputs. Irrigated agriculture may need to be developed further in the more marginal nations, but of these only Kenya and Ethiopia have sufficient water to produce significant additional food.

The southern African region has potential rainfed surpluses, but there are potential deficits at the intermediate level of inputs in the Comoros, Lesotho and Mauritius now, in Namibia after year 2000, and later in Botswana and Malawi. The other nations of this region seem able, in the very long term, to produce substantial rainfed surpluses, particularly Angola, Madagascar, Mozambique and Zambia, all of which have, in addition, important potential resources for irrigated agriculture. It may be necessary to consider additional irrigation in Botswana, Malawi and Namibia, and it clearly has local advantages in Angola, Madagascar, Mozambique and Zimbabwe.

These are general indications on the need for irrigated agriculture, when environmental resources for production are compared with the needs of future populations, and for more detailed information reference should be made to the report of the 1986 FAO Consultation on Irrigation in Africa.

Land and water degradation and conservation

Water pollution is not yet seen as an important area of general concern in most parts of Africa, either as a constraint on agriculture or as a result of agriculture. The exception is in some of the North African countries and Egypt, where the higher proportion of irrigated land brings water quality issues into greater prominence, both from the contamination of waters by urban and industrial effluents with the consequent need for increasing attention to the management of marginal quality waters, and the control of salinity on irrigated lands. There have, however, been problems of human health risk, especially in irrigation schemes, due to the entry of agrochemicals (fertilizers and pesticides), into water courses which serve as a source of domestic water. It would be fair to say that there is a growing awareness of water pollution in most countries of the region.

In contrast, land degradation is recognized as extremely serious, with erosion and resultant sedimentation creating severe and costly problems for agriculture. Water erosion is particularly widespread in the Mediterranean and North African countries; humid and sub-humid West Africa; sub-humid and mountain East Africa; and in the sub-humid and semi-arid southern Africa zones. This is linked to the over-exploitation of forests and vegetation cover, with special reference to rangelands, and the lack of effective control practices. Generally, the tropical soils of many parts of the region have fragile physical characteristics, and call for careful management to maintain levels of organic material and moisture.

The Ethiopian Highlands Reclamation Study of the 1980s gave comprehensive consideration of the complex issues involved in an area seriously affected by the pressure of growing rural populations. This, and other recent conservation projects in Kenya, Burkina Faso and Mali, show promise in remedial and preventive measures, but experience has shown that conservation can be achieved only if governments are committed to sustaining long-term programmes, supported by staff, legislation, finance and operational facilities. There are still fertile lands, suited to rainfed agriculture, which are underutilized because of the absence of infrastructure, and these could be opened up to relieve the areas at risk from over-exploitation and the depletion of soil fertility.

The arid and semi-arid zones, affected by persistent droughts and defective soil management techniques in water-scarce conditions, are now experiencing a serious breakdown of the natural resource base, and a collapse of socio-economic systems that had developed to suit the environmental fabric of these areas. A major contributory factor has been the absence of any comprehensive land and water use strategy to adapt to recent extreme conditions. The climatic fluctuations of the past few years are also constraints to production in the sub-humid areas, in parts of which soil and water data are still incomplete, and the inability to establish reliabilities of rainfall and water availability creates difficulties in crop and soil management for sustained rainfed agriculture.

Implementation of Action Plan recommendations

Any assessment of progress in the development and management of water for agriculture, in the Africa region, must take into account the impact of the economic and climatic crises that have characterized the past decade, and their far-reaching implications for regional and national efforts to implement the recommendations and concepts of the Action Plan.

The declining economic situation has resulted in a lack of funding to support not only proposed expansion programmes and improvements to existing developments, but even the essential day to day operation and maintenance of projects. In many areas, this has seen the deterioration of drainage and irrigation systems, and of associated infrastructure. Farming communities, and especially small farmers, have become demoralized because of depressed incomes due to falling crop prices, the rise in production costs and the cost of living in general.

Under the programmes for economic reform and recovery that have been introduced, most African countries have emphasized the rehabilitation of existing systems, rather than any expansion, as a safe route to recovery. In many instances, this has also had negative consequences through an increase in population pressures on the already developed areas, and the consequent emigration of rural populations to urban centres, in the search for alternative opportunities. This has reached such proportions that many areas are now facing a shortage of agricultural labour. The spread of poverty in a wide section of the population in many developing countries, and the expanding food gap resulting from the economic crisis in Africa, have had marked effects on the deterioration of the environment and of the natural resources base.

The repeated climatic crises of recent years, particularly the drought of 1983/84, and subsequent recurrences, have also impeded progress in implementing the Action Plan objectives for agriculture, and they have far-reaching implications for a whole range of water-related problems. However, the tragedies and hardships associated with the past decade have certainly intensified awareness of the vital role of water management in maintaining the stability of the environment, and in sustaining the natural resource base and production capacity. This was one of the most important aims of the Action Plan.

While various complex factors and constraints have emerged to hinder progress, there have still been achievements in the field of agricultural water use. Among these, efficiency in the use of water is now widely recognized by scientific and research institutions as a key to the increase of productivity, and is already reflected in policy statements, although it has yet to reach the farming communities in the countries visited on this mission.

The severity of climatic fluctuations, and the persistence of droughts, have also led to the development of techniques and approaches to appropriate agricultural practices for soil and water management, improved pasture production and water harvesting, with the management of soil moisture now appearing as a vital issue, determining the yield potential of Africa's tropical soils.

In Africa, there are 15 major shared river or lake basins. With agriculture as the main user of water, whether for rainfed or irrigated cultivation, the MPAP recommendation on the development of shared waters is clearly of importance in the region, and has in fact received considerable attention by many of the riparian states and by the UN system. The UN Interregional Meeting on River and Lake Basin Development - with Emphasis on the Africa Region, held in Addis Ababa in October 1988, gives evidence of this interest. In the formulation of new approaches to implementing a river and lake basin strategy for sustainable growth and socio-economic development in Africa, the meeting assessed the situation as follows:

> "In the world's most arid continent, the large river and lake basins of Africa are strategic starting points for comprehensive socio-economic development. This is especially the case in the Sudano-sahelian and other arid and semi-arid countries. Because river basin development programmes tend to involve the largest projects in national portfolios where there are sizable basins, and to have special support from the Heads of State, national and international river basin authorities have no substitute. While it is recognized that the performance of river basin organizations and the multi-donor approach have not come up to expectations, largely because of insufficient cooperation among member states, river basin organizations, donors and the financial institutions, there are realistic remedies which can be built into future modalities. While one remedy of special importance is to involve more actively the rural and urban populations of river basins in all stages of the development process, improvements are needed in planning, institutional structures and their collaboration, and financial structures".

In the same meeting, the point was made that cooperative development must emerge from each participating State's clear recognition that international development represents the best means of achieving national objectives. Such a recognition cannot be achieved unless the states have the capability to assess their own domestic alternatives against the international alternatives. National planning institutions must then be capable of carrying out that assessment, and thus international assistance should be directed at strengthening the national planning effort.

2. IRRIGATION

In general, Africa has less surface water and higher evaporation per unit area than other regions of the world. Most African rivers show considerable seasonal variation in flow, a notable exception being the Zaire River. To facilitate irrigation, some rivers would require major regulation works, as at present they are not able to meet the irrigation water demands in the dry season. Africa's surface water is very unevenly distributed. The Zaire basin, which occupies some 16% of the surface of sub-Saharan Africa, has 55% of its mean annual discharge. Only a few major rivers - most notably the Senegal, Niger and Nile - flow through the substantial drought-prone areas of the Sudano-Sahelian region, where there are severe climatic restrictions on rainfed agriculture.

Groundwater is estimated to comprise some 20% of the total water resources of Africa, and about 10% of the land is underlain by high yielding aquifers. The water-bearing formations underlying more than half the continent consist of fractured, altered granitic, metamorphic or volcanic rocks, containing small, discontinuous aquifers. They have a low recharge rate, sufficient only to meet the relatively minor requirements of domestic and livestock supply and irrigated gardens. Abundant shallow groundwater is most likely to be found along alluvial river beds, where runoff infiltration takes place. Many coastal deltas and plains of Africa include sedimentary basins with important and shallow permeable horizons. Where they are over-exploited, these groundwater reservoirs have been contaminated by intrusions of sea water.

Irrigation in Africa, perhaps especially in the sub-humid zones, has suffered from numerous constraints. One of the major impediments to success has been the failure to define its role in relation to that of rainfed agriculture which, for most countries is, and will continue to be, the dominant form of agricultural production. The over-emphasis of irrigation, and over-ambitious national programmes, especially in reaction to drought, have exceeded capabilities. Costs of development have been too high, operation and maintenance has been under-financed, administrative, managerial and institutional capacities have been weak, and at the farm level there is an absence of irrigation tradition and skills.

Attempts at the rapid introduction of irrigation, without prior history and experience, have lacked the necessary measures in support of water management and development, in the form of planning, monitoring and evaluation services. Similarly, extension services to farmers are still basically crop-oriented, without a water-related component, and suffer from poor mobility, staff shortages and a lack of incentives to rectify these problems.

Research is also lagging behind the needs of irrigation development and management, and is insufficiently financed. The essential linkage with extension, to develop and disseminate advice to farmers, is a serious handicap to the achievement of projected production targets.

Irrigation programmes in Tanzania provide evidence of a number of these problems and constraints. As early as 1953, irrigation was cited as an important measure to protect agricultural production in areas of marginal rainfall, and supporting this recommendation the World Bank, in 1960, set a development target of 10,000 ha/year by 1970. River basin studies were carried out to identify irrigation potential, and in 1975 irrigation units were established in all regions of the country, irrespective of their need for irrigated agriculture. The 1980-85 programme listed 12 projects of village and large-scale farms, totalling 18,400 ha of irrigation, with a budget of $US185 million. At the end of that period, one scheme of 2,000 ha had been completed and another was under construction. Investment totalled $37 million. By 1989, apart from 30% completion of two 500 ha schemes, there had been no further progress.

The failure of irrigation in Tanzania has been attributed to:

- The absence of a clear, consistent irrigation policy, which has resulted in the concentration of investment by parastatal organizations in expensive, sophisticated irrigation technology.

- A lack of personnel with experience in design, construction, operation and maintenance of large-scale irrigation.

- Poor planning of village-based smallholder irrigation schemes; the failure of regions to identify development priorities in terms of geographical areas or target groups, and their inability to provide extension services to small farmers; political pressures created by the village irrigation programmes, which resulted in demands for schemes throughout the country - well beyond the capability of finance and technical expertise.

Priority has been given to rice production, and yields in unimproved traditional irrigated areas are about 2 tons/ha - about the same as in the small areas of rainfed rice using an enhanced water supply from local runoff (essentially a simple form of water harvesting). Improved traditional irrigation raised this to as much as 4 tons, and fully developed small-holder schemes realized 4 to 6 tons/ha, with medium and high input packages respectively. State farms are achieving only 2.4 to 4.0 tons/ha, with the same input levels, or about 40% of their potential production. Sugar cane, the other major irrigated crop in Tanzania, is grown on 10,600 ha on four estates. All are working at about 60% of installed factory capacity, and all are operating at a loss.

An evaluation of irrigation in Tanzania, by FAO in 1987, concluded that the role assigned to irrigation was far too ambitious in relation to country resources and technical capacity, and recommended that it should in future be limited to:

- low cost production of commodities in short supply, particularly rice;

- stabilization of the production of perishables, especially fruits and vegetables;

- increasing productivity of land in climatically or ecologically marginal areas, or areas subject to severe population pressure.

It is now recognized that the attainment of these objectives requires the coordination of planning for irrigation development with planning for other sectors, notably rural infrastructure, and the protection of water rights of all users. In particular, the provision of operational support to farmers is an essential component of any future irrigation programme.

Ethiopia has also given high priority to the development of irrigation, to increase total agricultural production and to mitigate the effects of drought. The potential for irrigation is estimated at 3 million ha, and present development is about 54,000 ha in large-scale projects (over 3,000 ha), 11,000 ha in medium-scale schemes (200-3,000 ha), and an estimated 60,000 ha of small-scale schemes of less than 200 ha. The large and medium schemes are designed, constructed and operated under the supervision of the Water Resources Development Authority, while new small-scale projects are built and operated by peasant farmers, with technical and advisory inputs from the Ministry of Agriculture. The large-scale schemes produce mainly cotton, sugar cane and other cash crops. In the medium-scale projects operated by peasant farmers, food crops are grown, while those under state farms generally grow cash crops. The small schemes are primarily under food crops.

During recent years, Ethiopia has evolved and strengthened a comprehensive system of institutions to deal with the growing importance of water development. In doing so, it was realized that the shortage of trained personnel was impeding the growth of water-related activities, and in 1987 the Arba Minch Water Technology Institute was set up to train high and medium level professionals. A special water resources manpower development programme was also launched to train engineers in India and at Addis Ababa University. Additional short and long-term training has also been provided to water resources staff through fellowships, study tours and seminars.

One of the main areas of concern in Ethiopia is the degradation of the Highlands under severe population pressure and, as part of the FAO-supported Ethiopian Highlands Reclamation Study, a reconnaissance level investigation was carried out to assess the potential for irrigation in the region, which includes land over 1,500 m, totalling about 540,000 sq.km - approximately half the country's land area. For agricultural purposes, temperature and rainfall form the most appropriate base for zoning, and the region was divided into High Potential Cereal (HPC), Low Potential Cereal (LPC), and High Potential Perennial (HPP) crop zones.

The total area estimated as potentially attractive for irrigated development at large, medium and small scale, was 270,000 ha, or 0.5% of the highlands study area. The results indicated that the potential for medium and large scale development was in the order of 98,000 ha, mostly in the Blue Nile catchment. For small-scale irrigation, storage reservoirs were not found to be attractive, in view of the high costs, and risks of rapid sedimentation, and recommendations therefore concentrated on development of the 165,000 ha potential for run-of-river irrigation. This included 27,000 ha of perennial irrigation in the HPP and HPC zones, which were financially attractive, and 42,000 ha in the LPC zone, which could be justified for food security. Other areas of seasonal irrigation could be developed as a second priority.

This approach to the initial assessment of irrigation potential, especially for smaller projects, is useful in identifying the role and scale of irrigation within the context of mainly rainfed agriculture in areas of diverse geography, soils, water and climatic characteristics. There is a general tendency to over-optimism among planners looking for benefits from the introduction of small-scale irrigation, and a systematic, preliminary reconnaissance, such as in the Ethiopian Highlands, can give a clearer perspective to development policies.

Agriculture in Ghana accounts for 50% of the GDP, 70% of export value, and employs 66% of the labour force. Rainfed agriculture predominates, with emphasis still on a bush-fallow period to restore soil fertility, and with the integration of livestock in the system. Irrigation has only a minor role, with about 8,800 ha of government sponsored projects (numbering 18, and ranging from 100-2,000 ha), and an unspecified number of very small traditional irrigation schemes. The total irrigation potential is estimated at about 120,000 ha. Costs of irrigation development are extremely high, projects with reservoir storage being quoted at $US 40,000 to $50,000 per hectare. Topography, inappropriate sites and designs, contractual arrangements, foreign exchange and the lack of local experience contribute to such costs. The threshold for economic viability is considered to be about $6,000/ha.

Government schemes call for major rehabilitation and improvement of irrigation and drainage networks, and in those dependent on small dams, some 800 are not fully utilized, need repair, or suffer from sedimentation. Extension services are weak in water-related aspects, both for irrigated and rainfed cultivation and, although there are numerous well established research centres with programmes on water, only about 3% of total agricultural research time is devoted to water-related issues.

In the government's medium-term strategy, it is considered that irrigation provides a potential for augmenting the resource base. In view of high costs, best results could come from the completion and improvement of existing schemes, where justified, and the reduction of operating costs. Attention could also focus on small and micro-scale projects, with farmers basing development on existing small, unutilized dams, and on small flood-irrigation schemes in the river bottom lands, for rice cultivation.

The increase in production, and the conservation of the natural resource base depend mainly on improved soil and water management under rainfed agriculture, for better soil moisture retention, protection from erosion, the removal of limitations imposed by waterlogging in some areas, and the provision of drainage. The 1991-95 programme of work and expenditure for the agricultural sector allocates some 30% to irrigation and water resources. In the livestock sub-sector, which represents about 6% of the overall programme, 40% of the budget is devoted to water supply, which will contribute to the relief of pressure on the range areas surrounding existing water sources. Irrigation is perhaps over-funded, but the general trend reflects an encouraging awareness of the importance of water use and management in programmes of sustainable agricultural development.

In the West African countries of the Sudano-sahelian sub-region, modern irrigation was introduced generally in the 1960s. Uncertainties in policy orientation with regard to the desirable scale of projects; whether fully controlled water supply or a modification of natural flooding should be the favoured method; and the choice between

private, capital-intensive development and labour-intensive community schemes have obscured the search for an optimal solution to irrigation development. The problems have been further compounded by the multiplicity of institutions involved in agriculture and water development, and by repeated re-organizations, restructuring and shifts in responsibility.

In Mali, development by the Office of the Niger (ON), and the Rural Development Offices (ORD), gave emphasis to partially controlled irrigation, some of which aimed at the improvement of traditional flood-irrigation systems. Total area developed was about 120,000 ha, with 100,000 ha under the management of these offices. But the dry years 1983 and 1984 revealed faults in the large ODR schemes which could not be rectified, and priority shifted to full water control under village-operated irrigation projects (PIV), with the decentralization of national services.

Many PIV schemes are heavily dependent on a pumped supply, which calls for an efficient support system for equipment, fuel, operation, maintenance, repair, replacement and distribution, together with a high level of management and trained technical staff. Deficiencies in these areas, combined with weak extension services to farmers, and the inevitable shortfall in the collection of water service charges - only to be expected in view of the inadequate service - has placed many of the recent PIV schemes in a very vulnerable operational situation. The Irrigation Service (Service du Genie Rural), is now carrying out an analysis of small-scale schemes, aiming at the selection of technical concepts appropriate to the various site conditions and approaches to development. An early conclusion has been the need for technician training for such basic tasks as simple mapping and construction, in small-scale controlled flooding and bottom land projects.

Under the ODR, current annual rates of irrigation development are about 7,000 ha of controlled flooding and 900 ha of full water control (large and medium-scale and PIV). Indicative costs used for construction estimates are $US16,000 to 20,000 per ha for PIV- contractor built; $8,000/ha PIV with farmer participation; $12,000/ha full water control, large and medium-scale; and $2,000/ha for controlled flooding. The benefits of controlled flooding for rice production do not compare with full water control, but provide real gains over natural flood-irrigation. However, unpredictable climatic variations, and their possible impacts on river flows, raise doubts on the future of flood-irrigation in general.

In addition to the main rivers and their tributaries, there are other, fairly abundant water resources in Mali. Renewable groundwater is estimated at 55 billion cu.m., of which only about 100 million is now exploited, and groundwater reserves are about 2,700 billion cu.m. Under a National Master Scheme, assisted by UNDP and DTCD, a water development policy and medium-term programmes are being formulated to provide drinking water for 10 million people, and to supply 5.6 million livestock units by the year 2001, and to make water available for a general improvement of living conditions - which will include irrigated agriculture. The Master Scheme gives attention to the role of women in water supply, recognizing the improved efficiency that accompanies their participation in water management. It is also expected that the dispersal of water sources under the scheme will reduce concentration on land use, and thus help to protect the resource base, and the environment - a concept that has received little attention so far.

The irrigation potential of Niger is estimated at about 270,000 ha, of which 140,000 ha are in the Niger valley, 20,000 in the Ader, Doutchi, Maggia (ADM) valley, 50,000 bordering the Komadougou River and Lake Chad, and the remainder in various small valleys. In the Niger valley, only 30,000 ha are lowlands, with good soils, easily irrigable by low-lift pumping. The rest is on upland terraces with heterogeneous soils, and requiring costly high-lift pumping. To date, about 10,000 ha of modern irrigation is developed, or under construction - 6,500 in the Niger valley, and 3,500 in the ADM valley. There is also 15,000 ha of partially controlled irrigation and some 70,000 ha of flood recession cultivation.

Under the full water control of modern schemes, double-cropped rice is grown, or a combination of cotton, vegetables, maize and sorghum. Other forms of irrigation produce rice during the wet season in the bottom lands, and a mixture of cereals and vegetables elsewhere, and in the dry season. Water supply to modern schemes in the Niger valley is by low-lift diesel-powered pumps, and development costs are about $US10,000/ha. In the ADM valley, irrigation by gravity, from small catchments, makes up for rainfall deficits in the wet season. Sedimentation is reducing reservoir capacities, and poor maintenance of the hydraulic infrastructure threatens the abandonment of some areas.

The current Five Year Plan, (1987-91) foresees no construction of new projects, because of the high costs involved, and claims of neighbouring countries on water from the Niger river. Instead, the plan focuses on rehabilitation and improvement of existing irrigation perimeters. The World Bank is encouraging this policy, and supporting the implementation of small rural operations, of which one third is related to irrigation development, (shallow wells, drilling, development of small perimeters etc.). Almost a quarter of operations is devoted to the protection of natural resources, (reforestation, wind breaks, regeneration of pasture land, dune fixation etc.). The balance of about 40% is shared among integrated operations such as the improvement of rainfed cropping and family-level livestock production. Despite this, technical institutions are proposing 22,000 ha of new irrigation schemes for financing. The National Irrigation Service - ONAHA (Office National des Amenagements Hydro-agricoles), hopes to double the area under modern irrigation in the Niger valley from 6,700 ha to 13,300 ha within the next four years, and in March 1988 the EEC signed an agreement with Niger for the development of 2,000 ha of new, modern irrigation.

The role of ONAHA, as now defined, is:

- to develop new irrigation schemes and to rehabilitate existing schemes,
- to act as manager, until perimeters are taken over by cooperatives,
- to provide services (maintenance, extension, inputs etc.) at full cost, at the request of cooperatives,
- to help cooperatives to establish and to ensure self-management.

Irrigation suffers from constraints at both scheme and farmer levels. A major problem is that of scheme maintenance, which is dependent on state, or external subsidy. Service charges, already set below the real needs, are often unrecovered from the irrigators. This suggests that expenditure for the expansion of the full water control schemes should be deferred in favour of ensuring the proper maintenance and, where necessary, the rehabilitation of existing projects, in order to raise standards and reliability

to the point where operating costs can justifiably be recovered. It appears, though, that donors prefer to finance new projects.

From the farmer's viewpoint, as in so many African countries, irrigation is often only a part of his activities, which may also include rainfed cultivation, livestock, market-gardening and work in a non-agricultural sector. It may not therefore receive the high priority in his programme that is assumed by irrigation planners. In the Niger schemes, full recovery of irrigation operating and maintenance costs, plus farm production costs, are estimated at about 40% of the gross value of products, generally considered as the top limit. Any reduction below assumed yields will exceed this limit. Cropping patterns offering more attractive returns than the usual rice and cotton have not found the necessary marketing opportunities for farmer committment to such changes.

Burkina Faso has less than 14,000 ha of irrigation of all forms, out of a potential of about 160,000 ha, and the definition of a large scheme is one which exceeds 300 ha and requires a major component of hydraulic infrastructure. Medium schemes are from 100-300 ha. The 1986-90 programme for hydro-agricultural development, in addition to an expansion of 8,500 ha of irrigation under full water control from dams, (mostly small), and partial control in valley bottoms, includes an item of 63,000 ha of anti-erosion sites, as a soil and water conservation measure. Under this item, there is provision for small-scale irrigation, the establishment of water points, and other forms of physical and social support to rural communities.

The scale of irrigation development in Burkina Faso does not give impetus to the formation of technical, economic, training and legislative support needed to create an efficient sub-sector of agriculture, neither is it easy to justify the economic feasibility of irrigation for foodcrops, but this is still an important element in the national food production strategy.

3. WATERLOGGING; SALINIZATION AND DRAINAGE; WASTEWATER RE-USE

The problems of waterlogging and salinization are not so intense or extensive in Africa as in other regions, although there are affected areas in some countries or parts of countries. In the Horn of Africa, salinity occurs in Sudan and in Ethiopia. In Sudan, salinity is associated with the use of groundwater with a high salt content, in the northern region, and is a local problem. On the other hand, waterlogging and salinity is significant in the Awash valley in Ethiopia, where irrigation development has been intensive. It is reported that of an estimated 30,000 ha of waterlogged, saline lands in Ethiopia, 20,000 ha are in the Awash valley region. Secondary salinization has also occurred in Senegal and in the north of Nigeria.

4. LEGAL AND INSTITUTIONAL ASPECTS

One of the basic, and most typical constraints to successful irrigation development in Africa is that of uncertainties about land tenure,land usage, and water rights. About 45% of African irrigation has developed under customary law, and since land titles are not legally recognized as security for loans, farmers have been unable to obtain credit from formal sources. Another constraint is conflict between central government and

local views on ownership, since this reduces the security which is a precondition for farmer investment. A further problem has been the failure to recognize the water rights of those who develop their own farm or group scheme, and some farmers have lost the fruits of their investments as a result of government projects upstream.

In Mali, a new law concerning water exploitation is being introduced, and a new rural code is in preparation in Niger, which is intended to remove ambiguities of land tenure. Under traditional systems of usage in Burkina Faso, a parcel of land may be farmed with rainfed practices in the wet season, by a customary owner, land then under off-season irrigation by a non-owner farmer. The inability to coordinate the two systems often leads to the abandonment of irrigation.

The frequent changes in organizational structure and in policies for irrigation have been among the more obvious constraints to the success of this form of development, which is so evident at national level, in agricultural and water programmes, and at international level in relation to shared river and lake basins. A number of countries now seem to be adopting more clearly defined systems and objectives, and with suitable collaboration and coordination of activities and financing, it is to be hoped that these will improve performance in the region.

5. CONCLUSIONS AND RECOMMENDATIONS

Following the missions to a small selection of countries in Africa, compressed into a very short time frame, it was recognized that the situations in those countries reinforced the findings of the FAO Consultation on Irrigation in Africa, held in Lome in 1986. This meeting brought together representatives responsible for irrigation on 41 countries of the region, and technical sessions were conducted by the consultant for the anglophone countries of this 1989 assignment. It is therefore appropriate to draw on the expertise and experience expressed in the report of the Consultation, in formulating conclusions and recommendations which are entirely in accordance with the findings of the consultants.

1. The development of irrigation, or the raising of input levels in rainfed agriculture both tend to meet similar constraints. They are largely of an economic, social and institutional nature, and include inadequacies in market systems, storage facilities, management of prices of agricultural produce, credit services, rural infrastructure, etc. These constraints must be reduced or eliminated to permit increases in agricultural production, whether through irrigation or rainfed cultivation.

2. Governments should adopt policies which provide appropriate incentives to motivate the irrigation beneficiaries to increase production. Examples in several countries showed that, in the absence of such policies, irrigated lands were not given the attention needed to produce economically, especially in a mixed rainfed and irrigated system.

3. Irrigation projects should not be appraised on the basis of a narrow economic analysis only. Social parameters should be established and included to arrive at a realistic assessment of the viability of the scheme within the context of the specific community and environment.

4. A "within-country" regional planning approach is preferable to a project by project approach. This requires the preparation of region-wide or national master plans for irrigation development. These, in turn, should be based on firm government policies regarding the long-term role that is to be played by irrigation.

5. The establishment of irrigation development policies, as well as the planning and implementation of irrigation development, require a sound data base. In many contries, the available information on water and land resources, land use and crop production, and on social and economic conditions of the farmers is incomplete. Additional surveys and studies are needed.

6. While support to small-scale irrigation schemes should be considerably increased, the development of large-scale projects should not be excluded. A desirable mix of large and small-scale development should be established in relation to prevalent physiographic features, national capacities to handle schemes, and social and economic conditions.

7. Rehabilitation of schemes, considered by many to have advantages over the development of new projects, is expected to be successful if it is extended beyond the physical system to include the management structure. Such institutional rehabilitation should be based on clear perception of the roles of government, farmers and private enterprises in scheme management.

8. The national capacity for irrigation development and management, limited in most countries, needs to be increased through:

   a. training of staff at all levels, and of farmers,

   b. building, or reinforcing appropriate institutions for planning and management,

   c. reinforcing research programmes on problems encountered in development, and extension services.

All are recommended for action by governments committed to the expansion or improved efficiency and sustainability of irrigated agriculture.

III. ASIA AND THE PACIFIC

1. REGIONAL OVERVIEW

Agriculture, land and population

The Asia-Pacific region, encompassing 30 countries, covers 22.9% of the world's land area. In 1987, the region accounted for 30.4% of the world's arable and permanently cropped land. In the same year, the region was home for 56.1% of total world population. In other words, over half the world population and almost three quarters of the world agricultural population exist on less than one third of the world's arable and permanently cropped area.

The proportion of arable and permanently cropped land to the total land area of the region in 1987 was 15%, while the estimated proportion of land free from soil-related constraints to agricultural production was only 14.2%. Although a number of countries in the region have, at least in theory, some constraint-free land left, the region as a whole appears to have reached or passed the safe limits for the horizontal expansion of agricultural production.

This hypothesis is supported by the low average annual growth rates of both arable and permanently cropped land and total agricultural land area (including permanent pasture) recorded in the region in the past 25 years, which were 0.41% and 0.06% respectively. The little growth in arable and permanently cropped area during this period appears to have been mainly at the expense of land previously under permanent pasture. At the same time, although the ratio of agricultural population to total population has declined from 72.8% in 1961 to 60% in 1987, the agricultural population has increased in absolute numbers. As a result, the ratio of arable and permanently cropped land to agricultural population has declined from 0.34 ha/capita to 0.27 ha/capita in 1987.

Irrigated agriculture

The region is extremely diverse, both topographically and in climate, ranging from desert to humid tropics. Except in the western part of the Indian sub-continent, northern China and Mongolia, precipation is significant but with marked seasonality in its distribution. Rainfall in the southeastern part of the region may average over 2000 mm per year. High precipitation over the Himalayan massif feeds some of the worlds major rivers, including the Indus, Ganges, Mekong, Irrawady, Yangtze and Huang-Ho, on the flood plains of which irrigation has been practised since antiquity. Numerous smaller rivers and streams also support traditional irrigation, sometimes through storage in shallow reservoirs or "tanks". During the past century, and especially in the last four decades, there has been massive expansion of irrigation through major regulating dams, reservoirs and diversion works.

The proportion of arable land irrigated in 1987 had risen to 77% in Pakistan, 25% in India and 46% in China. This accounts for 103 million hectares, some 78% of the total for the region's developing countries, and 76% of all countries of the region.

Table 2 IRRIGATED LAND AS A PROPORTION OF AGRICULTURAL LAND

Country	Agricultural Land (A)		Irrigated Land (B)		Percentage of B to A	
	1977	1987	1977	1987	1977	1987
DEVELOPING COUNTRIES						
1. Bangladesh	9118	9164	1218	2199	13.4 %	24.0 %
2. Bhutan	88	103	-	-	-	-
3. Burma	9994	10060	939	1079	9.4 %	10.7 %
4. China	100523	96976	44484	44833	44.3 %	46.2 %
5. Cook Islands	6	6	-	-	-	-
6. Dem. Kampuchea	3046	3056	89	90	2.9 %	2.9 %
7. DPR. Korea	2210	2392	1000	1180	45.2 %	49.3 %
8. Fiji	233	240	1	1	0.4 %	0.4 %
9. India	168260	168990	35147	42100	20.9 %	24.9 %
10. Indonesia	19418	21220	5304	7400	27.3 %	34.9 %
11. Iran	15400	14830	5617	5740	36.5 %	38.7 %
12. Laos	853	901	66	120	7.7 %	13.3 %
13. Malaysia	4280	4380	316	338	7.4 %	7.7 %
14. Maldives	3	3	-	-	-	-
15. Mongolia	1100	1335	27	46	2.4 %	3.4 %
16. Nepal	2326	2339	350	660	15.0 %	28.2 %
17. Pakistan	20110	20760	14260	16080	70.9 %	77.5 %
18. Papua New Guinea	356	386	-	-	-	-
19. Philippines	7530	7930	1110	1480	14.7 %	18.7 %
20. Rep. of Korea	2231	2143	1104	1260	49.5 %	58.8 %
21. Samoa, W.	119	122	-	-	-	-
22. Solomon Islands	51	57	-	-	-	-
23. Sri Lanka	1896	1887	486	530	25.6 %	28.1 %
24. Thailand	17385	20050	2576	3996	14.8 %	19.9 %
25. Tonga	46	48	-	-	-	-
26. Vanuatu	112	145	-	-	-	-
27. Vietnam	6530	6470	1272	1800	19.5 %	27.8 %
SUB-TOTAL	393224	395993	115366	130932	29.3 %	33.1 %
DEVELOPED COUNTRIES						
28. Australia	41254	47105	1480	1836	3.6 %	3.9 %
29. Japan	4985	4708	3133	2890	62.8 %	61.4 %
30. New Zealand	446	522	165	268	37.0 %	51.3 %
SUB-TOTAL	46685	52335	4778	4994	10.2 %	9.5 %
ASIA-PACIFIC TOTAL	439909	448328	120144	135926	27.3 %	30.3 %
REST OF WORLD	998190	1025371	77565	91182	7.8 %	8.9 %
WORLD	1438099	1473699	197709	227108	13.7 %	15.4 %

Source: FAO-RAPA.

NB:

Agricultural land refers to arable and permanently cropped land, excluding permanent meadows and pastures, fallow land from shifting cultivation and land under trees grown for wood or timber. Double-cropped areas are counted only once.

Irrigated land area is net.

Principal crops are rice, wheat and cotton, and all three of the above countries are facing major problems of waterlogging and salinity, with consequent loss of production.

Many other developing countries of the region have very large areas under irrigation, totalling 28 million hectares, with nine in excess of one million hectares, (see Table 2). With rice as the principal crop, even in the humid southeastern countries protracted dry spells call for irrigation in both dry and wet seasons, to give stability to crop production. Schemes range in size from a few hectares to many thousands of hectares, some with seasonal carry-over storage, some dependent on run-of-river flows. Dry season cultivation and cropping intensities are therefore highly variable among schemes.

The spur to the rapid expansion of irrigation has been the need to feed the increasing regional population, which had a mean annual growth rate of about 2.3% from 1965 to 1980, and is predicted to average 1.7% from 1986 to 2000. There has in fact been a significant increase in food production, with daily per capita food availability rising from 2168 Kilocalories in 1974-76 to 2434 Kilocalories in 1984-86, compared to an estimated requirement of 2285 Kilocalories.

A study by the FAO Regional Office for Asia and the Pacific (RAPA) indicated that productivity growth during the period 1961-85 contributed almost 93% to the overall increase in cereal production. In the light of problems of land scarcity and population pressure, this reflects a greatly intensified level of cultivation on a more or less fixed land resource base. The question now to be asked is whether the growth in agricultural production, and even the land base itself, can be maintained. Furthermore, many countries of the region are facing increasing constraints in the availability, quality and cost of water resources for both on-going and projected agricultural developments.

The issue of sustainability of irrigated agriculture in the region is now a major concern, and calls for urgent re-thinking of the management of natural resources and of inputs. This is particularly the case for water, which also faces increasing, competing demands from domestic and industrial users. In view of the heavy use of water in agriculture, (sometimes to the detriment of both production and land), even a marginal improvement in efficiency could release considerable volumes for further productive purposes.

Drainage and flood protection

Agriculture in general, as well as irrigated agriculture, is faced with problems of drainage and flood protection, especially in the Asia-Pacific region, where so much is located in major river valleys. The developing countries of the world have a total of 55.4 million ha of land protected by drainage and flood control. The Asia-Pacific region has 38.6 million hectares of that total, (Table 3).

These figures do not differentiate between the areas provided with land drainage as a necessary measure for cultivation and those protected from inundation. Experience of land degradation due to waterlogging and salinization from inadequate water management, and of increased incidence of flooding resulting from catchment degradation and disrupted river regimes, shows that these causes will demand further

action, and the extension of such developments.

Table 3 PRINCIPAL AREAS PROTECTED BY DRAINAGE AND FLOOD CONTROL ASIA-PACIFIC (1000 ha)

Country	Area
Bangladesh	1 700
China	17 330
India	13 000
Indonesia	450
Korea, Republic of	110
Malaysia	460
Myanmar	930
Nepal	105
Pakistan	3 550
Philippines	710
Sri Lanka	60
Thailand	10
Vietnam	225

Source: ICID et al.

Land degradation and conservation

Some parts of the region inevitably suffer from considerable loss of soil and land as a normal geological process. Examples are the steep river bank lands of highland catchments, as in Nepal, and the loess soils of China. Remedial or protective measures are limited, and in most cases not viable when compared with benefits. More serious is the "accelerated erosion" resulting from activities of man, due to the loss of vegetation and consequent exposure of soil to the action of water and wind.

Within the region, three main causes can be identified, all resulting from increased pressure of populations coupled with deficiencies in control and management techniques and resources. Deforestation for fuelwood and for the clearing of land for cultivation is a major contributory factor. Overgrazing of pasture and rangeland is another cause, and the loss of soil nutrients, due to inadequate fertilizer inputs to cultivated land, with subsequent loss of plant cover, forms the third cause. The extent and the damage are further exacerbated when they occur on steep slopes, often due to increasing populations opening up new land beyond the margins of traditionally cultivated areas in valley bottoms. The resulting soil loss, in addition to depleting the land resource base, has severe repercussions for downstream areas, and for water management and use. Sediment raises river bed levels in flood plains; productive land is inundated or waterlogged with rising river levels, and perhaps covered by infertile water-borne deposits; and reservoirs, canals and drains are filled with the sediment, affecting other agricultural and water-related activities.

Following from the impeded drainage and waterlogging, there may also be loss of land from salinization, due to water and dissolved salts moving up in the soil through capillary action. This, however, occurs most frequently on irrigated lands, where it has marked adverse effects on soil productivity and crop yields and, in extreme cases, causes irreversible damage. The scale of the problems of degraded lands resulting from erosion and lost fertility is indicated in Table 4, and areas affected by salt, including naturally occurring saline soils, are shown in Table 5. Precise data are not available, and the figures are intended only as an indication of the order of magnitude.

The 1989 World Food Day Symposium on Environment and Agriculture, held by the FAO Regional Office for Asia and the Pacific, was largely devoted to the discussion of land resources degradation and to proposals for remedial action, and the paper by Dent on **Land Degradation in Asia and the Pacific** stressed:

"Orthodox or conventional conservation techniques alone cannot hope to combat situations caused by overwhelming socio-economic pressures. There is therefore an urgent need to develop solutions which are attractive to farmers, by designing programmes which provide short-term, obvious and tangible benefits to the farmer - in other words, programmes which would put money into farmers' pockets. Problems of maintenance would then be avoided, and costs to government agencies reduced. Such programmes would be attractive to administrators and economists, while from the politicians' point of view, support of the programmes might well win votes".

Table 4 ESTIMATED EXTENTS OF DEGRADED LAND FOR SELECTED COUNTRIES IN THE ASIA-PACIFIC REGION (1981)
(million ha)

Country	Total Land Area	Arable and Permanent Crops		Estimated Degraded Land Area	
Bangladesh	13 391	9 164	(68)	989	(7)
China	932 641	96 976	(10)	280 000	(30)
India	297 319	168 990	(57)	148 100	(50)
Indonesia	181 157	21 220	(12)	43 000	(24)
Lao	23 080	901	(4)	8 100	(35)
Myanmar	65 754	10 060	(15)	210	(3)
Pakistan	77 088	20 706	(27)	15 500	(17)
Philippines	29 817	7 930	(27)	5 000	(17)
Sri Lanka	6 474	1 887	(29)	700	(11)
Thailand	51 089	20 050	(39)	17 200	(34)
Tonga	72	48	(67)	3	(5)
Vietnam	32 536	6 470	(20)	15 900	(49)
Western Samoa	283	122	(43)	32	(11)

Note: Percentage of categories of land to the total land area is shown in parentheses.

Source: FAO/RAPA.

Pollution and water quality

Problems of pollution affecting, or induced by agriculture vary in type and magnitude from country to country and among locations within countries. The major, and most generally occurring problem is that of sedimentation, with its severe impact on all water users, including agriculture, where it imposes serious and costly constraints. This is especially evident in the operation of direct-diversion irrigation schemes, which suffer from the blockage of intakes, reduced canal capacity and the deposition of sediment on crop land. This last point is not always detrimental, though, and the system of "warping", widely practised in China, aims at utilising the fertility of some of the sediments to improve crop yields.

Engineering solutions, aimed at excluding sediment, and flow management techniques to prevent the intake of water at times of heavy sediment loads, are only partially effective, and applicable only where the loss of the potential supply is

acceptable. Many countries in the region are therefore giving high priority to programmes for the improved management of watersheds which have been degraded through deforestation or improper agricultural practices. The scale of the problem can be illustrated by the situation in Thailand, where some 83% of the country's forests have been removed. Similarly, in the Philippines, with a total land area of 30 million hectares, the past two decades have seen a reduction of forest land from 16.1 million to 6.5 million hectares.

Table 5 EXTENT OF SALT-AFFECTED SOILS IN SOME COUNTRIES OF THE ASIA-PACIFIC REGION (million ha)

Country	Area
Australia	357.3
Bangladesh	3.0
Dem. Kampuchea	1.3
India	23.8
Indonesia	13.2
Iran	27.1
Malaysia	3.0
Myanmar	0.6
Pakistan	10.5
Thailand	1.5
Vietnam	1.0

Source: FAO/RAPA.

At present, other forms of water pollution are not generally seen as a major area of concern, either as a threat to agricultural water supplies or as a result of agriculture. However, the national press in various countries has frequent coverage of instances of pollution from specific industrial sources, affecting rural water supplies, crops and livestock. Awareness of the pollution of water resources is certainly increasing, and a national conference in India, on pollution control, in February 1990, was informed that special environment courts are to be set up. Some 70% of pollution was considered to come from waste water of industries and from agricultural runoff, and state governments were asked to pressurize civic authorities to treat the waste water before releasing it into rivers.

Similar concern is shown in the Water Law of the People's Republic of China, 1988. Article 6 states: "All units shall strengthen the prevention and control of water pollution to protect and improve water quality. People's governments at various levels shall, in accordance with the provisions of the Law of the Prevention and Control of Water Pollution, strengthen supervision and management of prevention and control of water pollution".

However, while recognizing the development of pollution control legislation, the establishment of national coordinating bodies for environmental protection, and the provision of specific powers of pollution control, through environmental and effluent standards, the functioning of these is not yet a reality, mainly because so many bodies are involved, particularly at the local level.

Water quality management is becoming a feature of irrigation in parts of China, India, Pakistan and other countries of the region where there are problems of salt content in the water supply and the soils. Conjunctive use, or alternating use of surface and groundwater is becoming more common. There are various examples of the use of urban waste water for agriculture, notably in exchange for fresh water supplies for domestic and industrial use. Background material on this subject indicates a growing need for intensive technical, legislative and managerial study to ensure that waste-water re-use systems are designed and operated to be "fail-safe" for each particular site, to avoid the potential risks to crops, soil, water resources and human health. Clearly, this

form of development is applicable only where major sewerage systems are installed which, for the most part, locates it at present in the vicinity of some of the region's larger cities.

Agricultural water use and health

Linkages between agricultural water developments and human health are recognized in general terms, but there is little evidence that concrete measures are incorporated in designs and operational procedures. The almost universal dichotomy between development/production agencies and health ministries is only too apparent. Even in the Philippines, where there was a functioning system dealing with the vector-borne diseases of malaria and schistosomiasis, this seems to have declined. The current tendency in much of the region towards a devolution of scheme management to farmer groups must give rise to concern regarding the sustainability of even the present rudimentary services for incorporating human health considerations into agricultural water development.

As noted in the 1989 publication on "Policies and Programmes for Environmental Management for Vector Control", by the WHO/FAO/UNEP panel (PEEM), the main prospect for improved attention to health within agricultural development appears to be in its close association with environmental issues, which are becoming more prominent. It is perhaps worth noting here, that NGOs, which in many parts of the world have been effective in obtaining government response to such matters, seem to be less influential in the larger countries of this region.

Inland fisheries and aquaculture

Because of its close association with rural communities and food production, in the Asia-Pacific region, coverage was also given to the MPAP recommendation on fisheries:

> "Plans for the use of water resources and for territorial development should take into account the use of water for fisheries, in order to increase the supply of proteins to the world population".

Although the Asia-Pacific region represents less than a quarter of the world's land area, its share in inland fisheries production was 67% in 1987, and is increasing at a more rapid rate than in the rest of the world. However, this growth rate appears to have reached a peak. At the same time, the share of inland fisheries as a proportion of total regional fisheries production has risen from 14% in 1977 to 20% in 1987, while it has remained at about 8% for the rest of the world. The region's developing countries produced more than 7.9 million tons in 1987, out of a world total of 12.2 million tons for inland fisheries. For comparison, corresponding figures for marine fisheries are 19.6 million and 80.5 million tons respectively, (FAO/RAPA).

Reliable data are not available for assessing the ratio of capture fisheries and aquaculture within total inland fisheries. Most aqua-farming practices are done in water bodies categorized as inland waters. There is, however, an evident and rapid decline in

inland capture fisheries in the Asia-Pacific region, and in the rest of the world, due largely to over-exploitation and to the effects of water resources develoment and pollution.

There is a complex relationship in the widely practised joint production of rice and fish. In China, in recent years, 60,000 ha of ricefields were converted entirely to fishponds. In order to prevent this loss of riceland, controls were implemented in 1987, and fisheries are now being shifted to swampland areas. At the same time, there is active interest in the rice-azolla-fish system, which is reported to extend to 180,000 ha.

Implementation of Action Plan Recommendations

The Terms of Reference for the regional missions were essentially linked to the MPAP recommendations on Agricultural Water Use. In addition, it was necessary to take into account other issues incorporated in the Action Plan under the headings of Environment, Health and pollution control; Policy, planning and management; Natural hazards; Public information, training and research; Regional cooperation; and International cooperation. All are factors influencing achievements and capabilities at national level.

National plans and programmes for countries in the Asia-Pacific region are not formulated within the context of the MPAP, but in response to perceived national needs. At the same time, it is fair to say that the recommendations formulated at Mar del Plata correctly identified the requirements, objectives and areas of concentration for agricultural water development.

During the course of the regional mission, a picture emerged of noteworthy achievements in the development of land and water resources since the 1977 UN Water Conference, of problems encountered, and of attempts and approaches to design and implement policies, programmes and technical measures to overcome them.

It is only recently, though, that the complex inter-relationships among physical, social, political and economic factors have become acutely apparent as impediments to the implementation of Action Plan objectives and, in particular, to the concept of sustainability implicit in its call for attention to "long-term, as well as short-term productivity".

Failure to overcome the problem of sustainability in this region, with more than half the world's total population, and almost three-quarters of its agricultural population, could have consequences as grave as any that have been faced in human history.

2. IRRIGATION

In most countries of the region, irrigation has a major production role within agriculture, especially for food crops. There are, in general, small reserves of new land suited to cultivation, and any sizeable expansion of irrigation would involve the use of areas which are only marginally suitable, and also relatively costly to develop. Indicative costs are about $2000 - $5000 per hectare, although in some parts of the region this is

greatly exceeded. There has consequently been a reduction of investment in such development, and a large number of schemes are now being critically reviewed with respect to their physical, organizational and productive status.

In 1986-88, FAO/RAPA attempted to analyze problems confronting large and medium irrigation projects in the region. This was done through a questionnaire, with the usual limitations of such an approach, but a number of common problems were identified. These can be summarized as:

- Inadequate planning and design (10 responses)
- Deficiencies in on-farm irrigation and drainage facilities (27 responses)
- Poor operation and maintenance (35 responses)
- Other defects (15 responses).

There is now a common regional trend towards scheme rehabilitation, upgrading and the improvement of infrastructure, which promises to yield better returns than new developments. The Appplied Study of the Northeast Small Scale Irrigation Project in Thailand is an example of this, and one which is being considered by the European Development Fund as a possible model for replication within the region.

Recent recurrent droughts and declining water availability have demonstrated the need for greater attention to overall land and water management practices, especially in the more arid parts of the region. This has involved studies into more efficient water use in both irrigated and rainfed farming. The concept of "drought proofing", reflecting concern over possible climatic changes, is becoming an integral part of planning in India and in China, which are encouraging conservation measures such as minor water storages, groundwater recharge, water harvesting, improved soil moisture practices and associated small-scale irrigation in upper catchments. With regard to the status of small-scale irrigation, this is already well established throughout most of the region, where about 50% of irrigation is so classified , under groups of farmers and individuals. The study by R.B. Singh of FAO/RAPA on The Impact of Conservation Cropping on Rainfed Agriculture shows the high benefit/cost relationship attainable from such an approach.

Crop diversification in irrigated agriculture, shifting away from crops with high water demand, is another topical issue in the region. In general, and except where immediate benefits can be perceived, farmer response is slow, because cultivation practices and risk levels associated with traditional crops (particularly rice and wheat) are well understood, and infrastructure and services are adapted to those crops.

Recent work among agronomists and soil and water specialists in IRRI and elsewhere in the region, suggests that there is a need to review, and perhaps to revise concepts of HYV rice as such a high water-demanding crop, and to view it rather as a water-tolerant plant which will give better results from a reduced, and carefully regulated supply, together with more scientific fertilizer application. This could have profound effects on irrigation water requirements, and thus on overall plans for water development and use.

The efficiency of water use, associated with the need for more sophisticated water management, is a subject of considerable interest in the main irrigation countries of the

region, (China, India and Pakistan). It is seen from the multiple standpoints of increased crop production, higher yields per unit of land and water, maintenance of soil quality and overall economy of water use in order to meet the rising demands of all sectors.

On-farm water management is certainly a main theme in this respect, and considerable work has been carried out into the appropriate density of farm water distribution networks and on the more finely controlled application of water, together with drainage, the manipulation of water tables and salt balances. The need for a supply system which provides the level of reliability necessary to this degree of sophistication is now being recognized, and is capturing attention in some recent proposals for high-technology application to the design and operation of water supply systems.

This approach, popular with many design engineers with perhaps stronger academic than agricultural background, is evident in China and India, and poses the risk of still further imbalance between the engineer's ability to despatch water to the land and the farmer's ability to manage that water with an inadequate field system. Both abilities should be upgraded concurrently, if the targets of productivity and efficiency of water use are to be attained.

These associated themes of irrigation water reliability and farmer capability are expanded in the World Bank report on India, Poverty and Social Services, which deals with the problems of small irrigation farmers. Complementing this, the concern of the Government of India is illustrated in the Ministry of Agriculture's Revised Guidelines for the Implementation of the Centrally Sponsored Scheme of Assistance to Small and Marginal Farmers for Increasing Agricultural Production, and in the section on Minor Irrigation in the 1988-89 Annual Report of the Ministry of Water Resources.

There is an increasing tendency to encourage and enable the involvement of farmers in decision-making and management roles in irrigation, and examples of such initiatives were presented at the FAO/RAPA Regional Expert Consultation on Water Users Associations, July, 1989.

An outstanding development in irrigation has been the rapid and continuing expansion of groundwater uses, especially in the larger irrigation countries - Bangladesh, China, India and Pakistan. India has an annual target for installing 600,000 pumpsets. In China, the 1987 report of the Ministry of Water Resources illustrates progress and problems during recent years:

Well Irrigation in North China

"Tubewell development started in the late 1950s. There were 110,000 in 1961, and over one million in 1971. Tubewells have now spread to the 17 provinces, municipalities and autonomous regions in the northern part of China.

By 1985, there were 2.37 million tubewell installations for agriculture in the whole country, with 2.69 million machine sets and 23.17 million kW of power, equally divided between diesel power and electricity. Annual pumped groundwater was 41.2 billion cubic metres. Well irrigation served 11.13 million ha, accounting for 23% of the country's irrigated area. The

area irrigated by groundwater alone was 8.8 million ha, the other 2.33 million being served conjunctively by water from both surface and groundwater sources. Tubewell irrigation is mainly concentrated in the Huang-Huai-Hai plains, east of the Taihang mountains and the Funiu mountains. In Hebai, Shandong and Hehan provinces, the area irrigated from wells accounts for 78%, 49% and 56% of the irrigated area of each province respectively.

Because abstraction has now exceeded recharge rates in the suburbs of some large and medium cities in the north, and in some irrigation districts, the level of groundwater has declined. This is a serious problem, and the following measures have been applied:

- controls on the number of wells to be drilled
- conservation and economies in water use
- enhanced recharge of groundwater with surface water".

In India too, problems of over-exploitation are being encountered in the alluvial plains, where shallow tubewells (40-50 metres depth) have been so successful where water quality is suitable. But escalating costs of this form of water development are now exceeding the ability of small farmers, even with the generous government subsidy, because of very limited farm sizes.

3. WATERLOGGING; SALINIZATION AND DRAINAGE; WASTEWATER RE-USE

The UN Economic and Social Commission for Asia and the Pacific, in its Water Resources Series Paper No. 62, Water Resources Development in Asia and the Pacific - some issues and concerns, gave detailed coverage to environmental issues of water development. This section of the report has drawn on that document.

Many irrigation schemes in the region have resulted in degradation of cropland and water quality, and in the spread of water-related diseases. Since the impact of irrigation on the environment tends to be cumulative, the results can best be seen in those regions where irrigation has been practised intensively for a relatively long time. But it should be recognized that the same practices may have an even more rapid and severe effect when introduced into the fragile and delicately balanced ecosystems of some of the developing countries of the region.

In India, Iran, Pakistan and some of the other countries, irrigated agriculture accounts for more than 90% of total fresh water use. It is estimated that only about 40% of this water, taken into major distribution networks reaches the fields, and even there losses from faulty irrigation practices are high, further reducing the efficiency of water use, and leading to the degradation of valuable cropland. Irrigation water is typically delivered to crops through unlined canals and ditches that allow vast quantities of water to percolate. Flood irrigation methods, widely practised in the region, also contribute to the infiltration of excess water.

Where drainage is inadequate, the groundwater level gradually rises, eventually reaching the crop's root zone, and waterlogging the soil. In arid and semi-arid areas,

waterlogging may be accompanied by salinization as water near the soil surface evaporates, leaving behind a damaging residue of salt. But even before often-saline groundwater reaches the surface, it starts to affect crop yields. Thus, in Shaanxi Province in China (where the impact of waterlogging on wheat and cotton production has been carefully recorded), it was found that normal yields could still be obtained when the water table level was from 2 to 3 metres below the soil surface, but fell drastically when it rose higher, see Table 6.

Table 6 IMPACT OF WATERLOGGING ON CROP YIELDS, SHAANXI PROVINCE, CHINA

Water table depth	Harvest as a proportion of normal yield	
	Wheat	Cotton
metres	percentage	
2-3	100	100
1-2	50	65
0.5 and higher	0	10-20

In support of the above findings, IRRI estimates that the average yield of drained paddy lands is about 2.5 tons per hectare, compared with 1.7 tons for undrained paddies in the ricelands of Asia, and that in many cases the difference is much greater.

The problem of salinization is particularly urgent, as the processes are continuing at a rapid pace in China, India, Iran and Pakistan. In the Indus Valley in Pakistan, there is one of the largest irrigation systems in the world. With the expansion of irrigation, started about 40 years ago, groundwater levels have risen from an average depth of 25 metres up to near the surface. In the country as a whole, more than 10 million ha are now estimated to suffer from salinity and waterlogging. Of that land, 2 million ha are classified as severely affected by salinity, 4 million as suffering patchy salinity, and 4 million as being poorly drained. Overall, 23% of the country's land is affected in varying degrees by salinization or waterlogging. According to some estimates, 40,500 ha of irrigated land are degraded annually by these causes. In India, the area of land affected by waterlogging and salinization is estimated at 10.5 million ha, constituting about a quarter of the area under irrigation. Large areas of irrigated land have been abandoned in the region for the same reason, thus contributing to the spread of desertification, which is estimated to be expanding at one million ha annually in Asia.

Waterlogging and salinization are not inevitable consequences of irrigation development, and can be alleviated by sound design of irrigation and drainage systems and efficient water management, especially by the reduction of seepage losses from irrigation networks and by better on-farm water use. To achieve this objective, delivery of correct amounts of water must be based on research into local conditions of soils, crop needs and climatic factors. It also calls for accurate flow measurement, farmer collaboration and effective scheme supervision. Adequate drainage must be incorporated in irrigation schemes, to control groundwater levels.

The quality of irrigation water must also be monitored. Some of the brackish water sources, and other low quality waters may be used, on the condition that adequate dilution is achieved by mixing with fresh water. The research proposals for irrigation and drainage, prepared by the World Bank, UNDP, and ICID, (1990), make the following statement:

"Waterlogging is now widespread in all regions of the world. Salinity is essentially an arid or semi-arid zone problem. Both of these problems have severe adverse effects on the ecosystem, and cause enormous losses in production. The agricultural research community and the FAO have identified these problems as being crucial to the sustainable use of land and water resources. Research would also address technology-related problems of re-use of wastewater. There is increasing awareness of the need to augment water supply and to improve water quality through the use of treated sewage and drainage water in agriculture. Experiments have been launched in a few countries, but policies and programmes for technology-related research have not yet been formulated in most parts of the developing world".

4. THE INTERACTION OF IMPACTS OF LAND AND WATER DEVELOPMENTS

Reference was made earlier to the complexity of inter-related factors as an impediment to the implementation of the Mar del Plata Action Plan. These intricate relationships are most evident in the aquatic environment, notably in the context of rivers and lakes, where the effects of the many factors are integrated, and often mutually reinforcing, in the creation of problems and constraints to the development, management and sustainability of land and water resources.

An interesting example of the interactions among developments is the case of Laguna de Bay, in the Philippines. The hydrology of the lake is complex, and has been markedly altered since the early 1980s through the operation of a flood control structure at its outlet, which prevents the ingress of sea water. Further changes will be caused by the construction of a channel to divert flood flows from an adjacent river. It will therefore be some time before the impact of waste input on water quality can be understood and modelled, which is the intention of the Laguna Lake Authority, assisted by the University of the Philippines at Los Banos.

The water body receives industrial and domestic wastes from a large number of tributary streams of variable quality. Pesticides and fertilizers are used for agriculture in part of the catchment, with instances of drastic reduction of fish, although usage has now been curtailed.

The National Irrigation Authority has planned for further irrigation development in the vicinity, and a large pumping station is being installed for this purpose. In the meantime, the loss of land to urbanization has changed the pattern of development, reducing the land area available for agriculture and increasing demands for domestic and industrial water. A considerable part of the pumping capacity will therefore be transferred to the Metropolitan Waterworks and Sewerage System, for supply to Metro Manila, which has now to consider the treatment and associated costs of the water for uses other than those originally planned.

Concerns over the unplanned effects of land and water development are regularly expressed in the national and international media within the Asia-Pacific region. A common theme of such articles is the failure to foresee negative impacts of projects, coupled with the failure to achieve the predicted benefits - the net result being

unacceptably low returns for the high economic, social and environmental costs of development.

While some caution is needed in assessing the validity of press reports, especially in so political a context, the adverse side of so many recent development ventures is only too evident, as is the poor level of returns. The situation must also be viewed against the background of a continuing rise in populations and the fear, in some parts of the region, that water availability is declining. In North China, for example, average annual precipitation in the decade 1980-89 is reportedly only 80% of the 30-year normal for 1950-79. There is clearly good reason to call for more effective planning, development and management of natural resources.

The reconciliation of land and water developments with their long-term impacts is basic to the whole concept of sustainability, but it is also necessary to understand that "long-term" can not be equated with "stable" or "static". It is this fact that caused the Interim Committee for Coordination of Investigations of the Lower Mekong Basin to decide that a major up-dating of its 1970-2000 plan was already called for in 1987, in the light of changing technological, economic, social and political circumstances.

In presenting the Revised Indicative Plan (1987), the Committee noted its intention to revise and up-date the plan at regular intervals, whenever new circumstances arise, or information becomes available which would make an adjustment desirable. In addition to the projects, project-related studies and investigations, and basin-wide studies, the indicative budget for 1988-2000 also includes provision for institutional strengthening and for environment programmes and projects; the collection and validation of hydrological data; flood and low flow forecasting and other research activities. These last items form the monitoring component which is essential to any such plan, in order to identify changes in resources and in circumstances; to assess the effects of interactions among development activities, and thus to provide up-to-date information for action by the planners and policy-makers.

5. PROSPECTS

The challenges facing most countries of the region may, in general terms, be typified by the frank appraisal of the Chinese Ministry of Water Resources in its report on Irrigation and Drainage in China, (1987):

> "Although a series of achievements of water conservancy developments has been made in the past thirty-odd years, the country is still facing the same trouble concerned with water. Still, half the farmland lacks irrigation facilities. The extraordinary floods of the main rivers have yet to be conquered. Waterlogging and salinity continue to affect the agricultural production of many regions. Soil erosion remains very serious. As industry, agriculture and population in China grow, the deficit of water supply, and the contamination of water quality have become key problems to the development of the local economy. Existing irrigation and drainage projects and facilities are threatened with reduced efficiency due to natural aging and improper management. The tasks for their renovation and rehabilitation are very great, but China is determined to redouble its total

industrial and agricultural output value by the end of this century, and to move its rural economy towards modernization and commodity production".

Throughout the region, the problems have been recognized and technical solutions are being applied, or at least sought. National abilities in planning, design, construction, management and research are being strengthened and supported by many international agencies, some of the more evident being the Asian Development Bank, World Bank, IRRI, IIMI, ICID, ESCAP, IFAD and WFP. Sometimes, these agencies engage in collaborative efforts, and sometimes act in conjunction with bilateral assistance.

With all this support, there is, however, one problem which overshadows the efforts of almost all the region's developing countries - that of meeting a rising population-linked demand from a fixed, and even declining resource base, and this equation cannot indefinitely be balanced by technological advances in land and water development and management.

6. CONCLUSIONS AND RECOMMENDATIONS

The tasks involved in fulfilling the recommendations of the Mar del Plata Action Plan are enormous. For many of the countries of the region, and for the majority of its population, the limited availability of land means that sustainable agriculture, and in particular food production, is mainly dependent on a managed water supply, with even direct rainfed cultivation calling for careful manipulation of soil moisture conditions.

Governments are well aware of this. In general, organizational structures exist for the implementation of land and water development programmes, together with national institutions for education, training and research. External assistance is available, and functioning through multilateral agencies and various bilateral arrangements. But the scale of the work required is beyond the present capacity of national and international systems, both in terms of human resources and of finance.

There is also ample evidence that past efforts and funding have failed to produce the predicted benefits, and have often created unanticipated adverse social and environmental conditions which, in themselves, are an additional cost to national economies or national resource bases. The causes of failure are usually multiple, and varied. Therefore, successful ventures in land and water development must be founded on a broader base of scientific knowledge, technical skills and greater abilities in the management of natural resources and of the populations dependent on them. National awareness of this need is already apparent, and is beginning to show in the strengthening of institutions with responsibilties in these areas. This trend deserves greater external support. It would gain impetus from the establishment of regional centres, offering an exchange of information and the transfer of knowledge, in order to derive maximum benefit from the considerable capacity and talent available in the region.

The complexity of social and economic systems, and the inertia, self-protection and competition among bureaucracies is a common impediment to progress, especially where the size of a nation requires a federal or multi-tier political structure. This is a point for solution by national governments themselves, but it forms the background

against which any development processes must be viewed and, in particular, those concerning society so closely as do land and water development. It also provides the context within which the effectiveness of any external support to national efforts will be judged.

For the most part, assistance in such development has tended to be directed at project support - at technical, economic or financial aspects; at management techniques; and at research issues. There are exceptions to this, notably in some recent work by ADB (also currently up-dating its irrigation sector review), and IIMI, and in the on-going Government of India/World Bank study on the assessment of water resources and irrigation potential. It is hoped that this indicates a trend towards a policy-oriented approach to the investigation of problems in real-life, full-scale situations within entire communities, rather than under isolated project conditions. The need for study and research into many aspects remains, as for example into drainage, salinity and reclamation; re-use of effluents in irrigation; water quality management; crop-soil-water relationships; crop diversification in water-short and drought contexts (and in marketing terms), but this work too should be formulated and implemented with a view to its early applicability to overall national circumstances.

An interesting outcome of experience in India has been the knowledge gained in irrigated farming in various parts of the country, which has led to valuable insights into practical measures for improved cultivation and production. But dissemination of the findings has been limited by the constraints of the local languages in which the information is recorded, with no version in one of the major national languages. On a regional scale, the FAO/RAPA questionnaire-based investigation into medium and large-scale irrigation was severely hampered by difficulties in comprehension of the English-only documents. There is a real need for expanded facilities for screening and evaluating reports and studies based on practical experience, and for translating those which can, with benefit, be disseminated more widely. IRRI has long been producing its own documents in many languages, and may serve as a guide to any broader initiative.

The major technical areas requiring study were correctly identified in the Terms of Reference for the regional mission, and were covered in the original mission report and its annexes. On the basis of a very brief visit - essentially a small sample of countries, and a narrow selection of contacts within those countries - it would be presumptuous to attempt to define in any detail the activities to be undertaken by national and international communities in so massive a task. It is, however, only fair to suggest possible guidelines for the future involvement of the UN system, which was sufficiently concerned to mount the mission to study the problems of agricultural water use in the region:

1. The region, in spite of its heavy dependence on the skilled management of land and water resources for its food and agricultural production, and for the sustainability of those resources to support its people, lacks any regional UN system presence offering experienced, easily accessible advice and assistance in agricultural water use. In this context, the recent establishment of ASOCON, the Asia Soil Conservation Network, supported initially by FAO and UNDP, may be a useful model, although primarily focused on small-farmer land use

2. The experience of many countries of the region demonstrates the need for

support to UN member states on policy, institutional and programme issues related to land and water development and use. This is a priority area for action, with specific project activities being incidental.

3. There is urgent need for a stimulus to the implementation of long-term monitoring of trends in hydrological regimes; water quality; changes in land use and management; and their mutual impacts. This must include efforts at mobilizing the long-term finance which is never forthcoming under project-associated funding, but which may possibly be encouraged in the context of planned UN conferences on the environment and sustained agriculture.

4. Finally - perhaps a major partner in any UN system initiative to assist in land and water development and management in the region should be the UNFPA, the United Nations Fund for Population Activities.

IV. LATIN AMERICA AND THE CARIBBEAN

1. REGIONAL OVERVIEW

Agriculture, land and population

The Latin America and Caribbean (LAC) region, which forms 15% of the total world area, is well supplied with natural resources when compared with the rest of the world. It has 24% of the forest or woodland, 20% of the agricultural land and 11% of the inland water. In the majority of countries, and in the region as a whole, land is not a severe restriction for agricultural development, and the estimated land reserves are a higher proportion than in any other developing region. Institutional, technical and economic constraints tend to be more binding than those of natural resources.

Notwithstanding this favourable picture at the aggregate level, there are large differences within the region. In some countries, land in use and in reserve is scarce, in comparison with the present and projected population. Among the Caribbean islands, only Cuba is estimated to have the capacity to feed its entire year 2000 population at a low level of inputs. In the continental part of the region, Guatemala and El Salvador suffer from a shortage of agricultural land. Situations within countries also vary considerably. Population pressure on land is high in some areas and low in others. Land resource availability must therefore be assessed both at national and local levels.

In the region, in general, land use is extensive. Average cropping intensity was estimated at 63% in 1982-83. Between 1961-63 and 1984-86, yield increases and the intensification of cropping contributed only 44% to the growth of regional crop output, most of which came from the expansion of arable land. This indicates a large potential to intensify production and to increase crop yields.

During the period 1960-1988, the region almost doubled its population, from 207 million to 415 million. Although the overall growth rate slowed somewhat in the 1980s, the impact of the total population increase is significant in terms of demands for food. Brazil estimates that grain deficits alone will rise from 10.5 to 18.6 million metric tons between 1995 and 2005, calling for 11 million rainfed ha, or 5 million ha under irrigation, to meet the deficit. Mexico, already importing about 9.5 million tons of basic grain, is subsidizing food imports, and Peru, with an annual inflation rate reaching more than 2700% in 1989, and over 8 million inhabitants in a state of poverty, is also subsidizing imports, which is discouraging agricultural production.

Another significant regional factor is the rapid rise of urban population, caused primarily by rural migration to the cities, particularly in Brazil, Mexico, Peru and Central America. Brazilian statistics show a rural population of 32 million in 1986, with a projected decrease to about 25 million by the end of 1990. This has resulted in massive problems of housing, water supply and sanitation in the cities, with high crime rates, unemployment and the proliferation of slums. The rural areas have been affected by the abandonment of agricultural lands, reduced productivity and increased poverty. Besides the effects of the economic crises of the 1980s, rural emigration has received further impetus from periodic droughts, as in Northeastern Brazil and the southern high plateaux of Peru, and from terrorism and guerilla warfare.

Irrigated agriculture

The region is well endowed with water resources. There are, however, substantial subregional and country differences in water availability. High population density, together with only modest runoff in the Caribbean, gives a low per capita water availability. In Brazil, with ample water per hectare, and low density of population, the per capita availability is high.

The irrigated agriculture area has grown proportionally more than the rainfed area, at about 300,000 ha per year in the period 1961-63 to 1984-86. In most of the LAC countries, water availability is not in itself a constraint to the expansion of irrigated agriculture, but some countries, such as Barbados, Haiti, Jamaica, Mexico and Peru, are approaching the water potential that can be developed at an affordable cost, and the marginal cost of irrigation is rapidly increasing in nearly all countries. In the region as a whole, irrigation has played a relatively minor role in agriculture, rising from about 6% of arable and permanently cropped land in 1961 to 8% in 1980. In Mexico, however, the share rose to 20%.

Total loans for irrigation in the region, from the major international development banks and funds, (IBRD, IDA, IDB, CDB), show a fluctuating and declining trend in the 1980s, from a maximum of $US600 million in 1981 to almost zero in 1983, 85, and 87, in constant 1985 dollars. Lack of capital for the maintenance of existing infrastructure, and the absence of economic incentives, are the main causes for the neglect and abandonment of millions of hectares of land equipped for irrigated agriculture. This was observed primarily in Mexico, with more than 500,000 ha abandoned, and in Argentina, where 10% of the irrigated area in the province of Mendoza alone has been taken out of production because of decreased demand for agricultural food products by local markets, due to reduced disposable income. The decline in investments in irrigation accompanies a generalized sharp decline in agricultural investments, a long-term declining trend in the prices of many traditional irrigated crops, increased production costs and higher energy prices.

Land and water degradation and conservation

Data on soil erosion are incomplete, but this is an evident problem in many countries, including Guatemala, El Salvador, parts of Brazil and Peru. The last-named country reports a total of 500,000 ha affected, of which 100,000 are in the coastal region, and 350,000 in the upper and lower jungle. The main causes of deterioration have been the uncontrolled expansion of agricultural frontiers, resulting from demographic pressures, coupled with the abandonment of traditional soil conservation practices, with consequent deforestation and soil degradation. However, also in Peru, inadequate irrigation systems and poor water management in the Sierra region have provoked on-farm soil erosion in irrigated areas. Defective irrigation systems and practices are also to blame for the degradation of many hundreds of thousands of hectares of land throughout the region, but mainly in arid and semi-arid areas, due to salinization.

Despite efforts to control water pollution, the region is experiencing a continuous decline in the quality of water for agriculture and other uses. The UN Economic Commission for Latin America and the Caribbean (ECLAC), reports that the main

point-sources of water pollution are from domestic sewage and industrial effluent, whereas non-point sources include runoff from agriculture, storm-water runoff, the percolation of polluted water into groundwater, and precipitation of polluted water. The urban population in Mexico produces a total of 110 cu.m/sec of urban-industrial residual waters. The metropolitan cities of Mexico, Guadalajara and Monterrey contribute 53 cu.m/sec. of waste-water. Residual waters from industry are often discharged into water bodies without any prior treatment. Heavy metals carried by these waters have harmful effects on crops and the soil and, together with pathogens, can enter the food chain along with other pollutants. These problems have been experienced in Chile, Mexico, Cuba, Peru and Central America.

In Mexico, the agricultural sector contributes to the problem with return flows from irrigation, containing agro-chemical residues causing pollution with toxic substances, and over-fertilization, giving rise to eutrophication. The irrigation return flow discharging to groundwater and surface water bodies, including the sea, is estimated at 265 cu.m/sec.

The national strategy for controlling water pollution has proved to be a failure. The required standards could not be met, because of inadequate financial and technical capabilities of municipalities and commercial companies. At present, in Mexico, there are some 400 industrial and municipal effluent treatment plants, of which less than 30% are operating.

The concentration of metals, including heavy metals, as a result of mining, far exceeds those specified by existing laws in the Mantaro River in Peru. Iron is over 200 times in excess, and manganese 55 times. The Rimac River is one of the most polluted in the continent, and contains harmful elements such as arsenic, cyanide, lead, chromium and selenium. While water pollution from mining is not a serious problem in Central America, industrial pollution from coffee processing and sugar production is a major concern.

Groundwater pollution is a serious issue in the region, because many cities, including several large metropolitan centres such as Mexico City and Havana, and thousands of rural communities, rely on springs and wells for drinking water and irrigation. The percolation of water from septic tanks, sewerage systems and waste dumps is a significant source of groundwater contamination. Pollution by fertilizers and toxic agro-chemicals, although cases are reported, for example in Mexico, is not so acute or widespread as in more developed regions. This is due to the substantially lower utilization of these materials in the region's agriculture and to the predominant climatic and soil characteristics.

As a result of the growing use of groundwater for irrigation and other purposes, there is an increase in salt water intrusion into aquifers. This is seen in many coastal areas of the region, particularly in islands of the West Indies, where intensive irrigated agriculture is based on groundwater. Other examples are to be found in Argentina, El Salvador and in Mexico, where numerous aquifers are being salinized, due to over-pumping, and abstraction has now reached 28,000 million cu.m. annually, of which 19,000 million are used to irrigate about 2 million ha. Although there is a positive recharge at national level, the situation is becoming critical in the vast arid parts of the country, where abstraction exceeds replenishment rates.

Implementation of the Action Plan

The impact of the MPAP on agricultural water use in the region was discussed with senior political, technical and managerial personnel of national and international agencies in the seven countries visited, (Argentina, Brazil, Chile, Costa Rica, Cuba, Mexico and Peru). It was agreed that the recommendations of the Action Plan represent a global consensus of the need for efficient use of water for agriculture and other purposes, and the rapid approach of a global water crisis caused by improper use of the resource was acknowledged. There has, however, been insufficient dissemination of the Water Conference recommendations to raise the conscience of the leadership of the countries and the general public for the more effective use of water.

The Economic Commission for Latin America and the Caribbean has been following the specific recommendations that were directed at ECLAC, and has produced several publications on the subjects identified, based on information from the countries of the region. Considering the limited number of technical personnel, and the fact that no additional funds were provided to follow up the Action Plan, this work of the ECLAC Division of Natural Resources and Energy represents an important contribution. Apart from this example, there was little awareness of the MPAP or of the follow-up symposium in 1987, and the reports of the Conference and the symposium were not available in libraries visited.

The MPAP was not seen as a true action plan, as it lacked any formalized objectives, strategies or anticipated results, and gave no time frame for implementation. Most countries are aware of the problems they are facing, and have been trying to solve them for many years, too often with disappointing results. Their urgent need is for strategies to avoid and to solve those problems. Agricultural water use activities in the region have little to do with the Water Conference, and arise from national awareness of needs and a desire for progress.

2. IRRIGATION

Irrigation has a long tradition in Latin America and the Caribbean. Increasing pressure to step up the production of food and industrial raw materials, for internal consumption and for export, has been reflected in recent decades in a considerable expansion of the area under irrigation, and many countries have adopted ambitious plans for future increases. The regional area under irrigation grew at an average rate of 2.8% per year between 1961 and 1980. Since then, the annual rate of increase has fallen, averaging less than 1.3% between 1980 and 1987, (see Table 7).The reduction in this expansion rate can be explained by the considerable cut-back in the general availability of funding for large infrastructure projects, and by the largely disappointing performance of many irrigation schemes in the region.

There is considerable variation among estimates, from different sources, of the areas of irrigated land. For example, the Irrigation Sub-sector Review for Brazil gives a total of 2.3 million ha compared with the ECLAC figure of 2.5 million, and estimates for Mexico range as high as 6 million ha. Differences in definition, such as net or gross irrigated land; equipped area; harvested area; and the degree of completeness and accuracy of cadastral surveys, probably all contribute to this uncertainty.

Table 7 LATIN AMERICA AND THE CARIBBEAN: LAND UNDER IRRIGATION, 1980-87
(1000 hectares)

Country	1980	1987	Increase 1980/87	Average annual growth rate (%)
Caribbean				
- Belize	1	2	1	10.4
- Cuba	762	890	128	2.2
- Dominican Republic	165	206	41	3.2
- Guyana	125	128	3	0.3
- Haiti	70	70	0	-
- Jamaica	33	34	1	0.4
- Saint Lucia	1	1	0	-
- Saint Vincent and the Grenadines	1	1	0	-
- Suriname	42	60	18	5.2
- Trinidad and Tobago	21	22	1	0.7
Sub-total	1 221	1 414	193	2.1
Central America and Mexico				
- Costa Rica	61	118	57	9.9
- El Salvador	110	117	7	0.9
- Guatemala	68	79	11	2.2
- Honduras	82	88	6	1.0
- Mexico	4 980	4 900	-80	-0.2
- Nicaragua	80	84	4	0.7
- Panama	28	30	2	1.0
Sub-total	5 409	5 416	7	-
South America				
- Argentina	1 580	1 700	120	1.1
- Bolivia	140	165	25	2.4
- Brazil	1 800	2 500	700	4.8
- Chile	1 255	1 300	45	0.5
- Colombia	400	496	96	3.1
- Ecuador	520	546	26	0.7
- Paraguay	60	66	6	1.4
- Peru	1 160	1 200	40	0.5
- Uruguay	79	100	21	3.4
- Venezuela	315	328	13	0.6
Sub-total	7 309	8 401	1 092	2.0
Total	13 939	15 231	1 292	1.3

Source: United Nations, Economic Commission for Latin America and the Caribbean, Statistical yearbook for Latin American and the Caribbean 1989 edition, LC/G.1606-P, 1990 February, pp. 608-609.

In recent years, there have been important changes in both the structure and direction of irrigation investments, particularly in the countries with the longest histories of irrigated agriculture, Argentina, Chile, Mexico and Peru. In these countries, changing investment priorities have resulted in a more balanced territorial allocation of resources than in the past. There is now a more equitable distribution of irrigation investments among regions, and more resources are allocated to the operation and maintenance of existing systems and to the conservation of water and soil resources. A new emphasis is being placed on smaller, farmer-managed irrigation, rather than large, bureaucratically-run projects.

In Mexico, with the largest irrigated area in the region, irrigation accounts for 30% of the total agricultural area and 50% of total agricultural production value. Public irrigation schemes, organized in irrigation districts, comprise 60% of irrigation, with the remainder developed by the private sector in medium and small schemes. Of these

latter, almost half the area - more than a million hectares - is irrigated by groundwater. Irrigated agriculture began to decline from 1976. Since then, there has been a drop in productivity and a deterioration in the management, operation and maintenance of projects. Large areas equipped with irrigation infrastructure are now underutilized, including 300,000 ha of surface water projects. Small and medium developments slowed down or stopped. Out of 77 irrigation districts, 41 - equivalent to about 850,000 ha require rehabilitation, primarily due to salinization and to deferred maintenance. This decline has led to the loss of expertise which had accumulated over many years, to the point where there is now a shortage of personnel to carry out future irrigation development plans.

The irrigated area of Argentina is variously estimated at between 1,080,000 ha and 1,540,000 ha, but expandable to some 1.9 million ha without additional major structures. With reduced demand for national agricultural output, particularly wine, and rising production costs, farmers have taken thousands of hectares out of production. In the Province of Mendoza, from about 360,000 ha, only 295,000 remain under irrigation. There is also extensive waterlogging and salinization, and in the irrigation districts of arid and semi-arid areas the main problems are identified as:

- insufficient technical assistance to farmers,
- inefficient irrigation infrastructure,
- inappropriate land preparation,
- farmers are unfamiliar with irrigation techniques and crop- water requirements,
- low efficiency of water distribution systems,
- lack of farm-level irrigation schedules.

Chile has 5.1 million ha of arable land, 3.3 rainfed and 1.8 irrigated, of which 0.7 million ha with infrastructure are only sporadically irrigated because of irregular water supply. Irrigation can be expanded, by providing the necessary infrastructure to 700,000 ha at present under rainfed agriculture. Water is obtained through numerous water control structures on permanent rivers which are fed by snow- and ice-melt from the Andes.

By the 1960s, the Government was practically the exclusive developer of irrigation works. Over 70 schemes were constructed to irrigate 780,000 ha. About 285,000 ha are now under private ownership, with the remaining 495,000 ha, in 36 schemes, being in state ownership. Of these, 30 are in the process of privatization. The construction of large irrigation works ended in 1970.

In 1985, the Government enacted a law for the Promotion of Private Investment in Irrigation and Drainage Works. Under this law, up to 75% of the cost of a project is paid by the Government. The law benefits owners or renters of agricultural lands, or associations of water users, for investment on land under their jurisdiction, and covers the following developments:

- all irrigation works except those for field preparation, such as land clearing and levelling,
- drainage works for the removal of excess surface and subsurface water,
- installation of equipment for mechanized irrigation, including deep wells, pumps, sprinkler and localized irrigation equipment.

Projects must conform to established technical, administrative and legal requirements, and must be prepared by competent professionals. Between April 1986 and December 1989, 500 projects were approved, totalling 250,000 ha of new and rehabilition areas, and an investment of about $US37 million.

There are various deterrents to the development of new irrigation, which include:

- the high cost of hydraulic works,
- slow private-sector implementation of on-farm works,
- low irrigation efficiency, which is caused by delays in converting from traditional to modern irrigation systems, and the low cost of water. Surface irrigation is used on 70% of the area, with efficiencies of between 15% and 30%.

In Peru, inefficient water use for irrigation is causing severe problems of deteriorating land and water quality in the coastal zone, especially in the lower parts of the valleys. Costa Rica has targetted its plans on the more efficient use of existing irrigation infrastructure, with minimum investment in the development of new irrigated areas. One of the approaches to this is the National Irrigation Programme for Small Farmers, which appears to offer a potential for 50,000 to 70,000 ha of irrigation, and which is attracting major funding from Germany and support from UNDP and FAO, in addition to finance from the Government and USAID sources.

Under the Cuban Central Government Administration, the National Institute of Water Resources is responsible for directing, executing and controlling government policies on water resources. There are 181 dams in the country, with a total storage capacity of nearly 8,000 million cu.m. By the year 2000, it is expected that this capacity will double, with another 112 reservoirs. There are 900 small dams for irrigation, totalling 600 million cu.m, and this is expected to rise to 2,000 million cu.m. with an additional 800 dams. The water distribution network consists of 551 km of main canals and 25,000 km of irrigation canals.

The remoteness of many structures and the lack of personnel means that maintenance of irrigation works and canal networks is difficult. Large irrigation works have priority for maintenance, with consequent rapid deterioration of many small dams and irrigation canals. There are further complications due to the massive accumulation of sediment and aquatic plants in reservoirs and canals, and the growth of algae is another problem, affecting the operation of pressurized irrigation systems. To help in long term solutions, the National Institute of Water Resources is studying the automation of water delivery and control systems, for which it is preparing two projects:

- Optimization of the use of water in the hydraulic systems, for agricultural production,
- Maintenance of hydraulic works for irrigation.

The first of these will introduce simulation models for daily operation, organizing a data base, modernization of hydrological stations, and studies for establishing water measuring stations for the control of five hydraulic systems to irrigate some 300,000 ha. The second project involves the selection and testing of techniques (biological, chemical or mechanical, as best suited to local conditions), for the maintenance of the hydraulic structures.

The Irrigation and Drainage Research Institute is engaged in supporting studies into the reclamation of areas with drainage problems (2.4 million ha); reclamation of salinity-affected areas (1.2 million ha); introduction of sprinkler irrigation machines, and of localized irrigation; testing and introducing modern irrigation and drainage practices for local suitability. Impediments to this programme include problems of importing equipment, lack of trained personnel, and inadequate incentives at the farm level.

Brazil has an estimated potential of 29 million ha with ample water resources in six out of eight of the country's watersheds. Irrigation development is hampered by water shortage in the Nordeste and in the areas fed by the eastern tributaries of the Sao Francisco river. At present, there are between 2.3 and 2.7 million ha under irrigation, of which 94% were developed by the private sector and the remainder, mostly in the Nordeste, under public schemes. Expansion of the irrigated area has been selected as the best solution to meet increased food demand in the country, and Brazil has accounted for more than half of the total regional increase in the decade to 1987.

Irrigation achievements can be summarized by their contribution to crop production. The 2.3 million ha under irrigation, equivalent to about 4% of the total 52 million ha of cultivated land, have provided 16% of total crop production - mostly grains - representing 25% of the farm-gate value of national production.

The Brazilian government's irrigation priorities are set out in its Irrigation Sub-sector Review of 1988. The main issues are the following:

- Irrigation should be a self-sustaining economic activity in future, and should not depend on subsidies, i.e. farmers and agro-businesses would repay, at positive real interest rates, any investment loans provided by the government.

- Settlement in so-called "public irrigation" projects should be recognized as a social activity, and would be supported by specifically earmarked federal and state funds, separate from normal irrigation development budgets.

- The government plans to support development of 350,000 ha of irrigation annually, to meet the demand for irrigated crops, which is projected to grow in future.

- Except for settlement projects, which are "top-down" developments, all other future irrigation construction would be "demand driven". Farmers should finance the facilities from their own resources, or request government assistance for supporting infrastructure, or organize themselves in irrigation associations and try to raise the required funding from commercial banks or the government.

Among the constraints to irrigation, credit is a major limiting factor, primarily due to high inflation rates. High interest rates, in the order of 40% or more, are difficult for agribusiness to withstand, and even more so for the small farmer. Consequently, available credit for irrigation development has not found the expected demand. Additional negative credit-related factors are: it is usually not available just when the farmer needs it; the rise in input costs between the request for credit and its disbursement; lack of collateral, on the part of the small farmer, to qualify for a bank loan; and small farmers are sometimes not even aware that credit is available to them.

3. WATERLOGGING; SALINIZATION AND DRAINAGE; WASTEWATER RE-USE

Drainage problems affect large areas of land in Latin America and the Caribbean, and in many cases these problems are compounded by salinization. Thus, in Argentina 555,000 ha are in need of drainage. In Peru, 60,000 ha in the coastal region and 34% of the cultivated lands in the upper jungle, equivalent to 150,000 ha, are affected by drainage problems alone. Rehabilitation through drainage exceeds 60,000 ha in Costa Rica, and Mexico has started an ambitious programme (Programma de Desarollo Integral del Tropico Humido, PRODERITH), for land reclamation through drainage. Already, 54,000 ha has been incorporated into agricultural production in a first phase, towards the reclamation of a total of 360,000 ha.

Most countries of the region have problems of soil salinization due to the inefficient use of water for agriculture. Argentina and Chile have about 35% of their irrigated lands affected by salinity, whereas 30%, or 250,000 ha of the coastal region of Peru under irrigation suffers the same problem. In Brazil, 40% of the irrigated land in the Nordeste is affected by salinity as a result of improper irrigation. Natural and man-induced salinity in Cuba covers some 1.2 million ha, the provinces of Guantanamo and Granma being the worst affected. To help control the problem, Cuba is planning to dam the salt-contaminated waters with the Rio Cauto Dam, in order to introduce controlled mixing with fresh water for irrigation.

Chile suffers from a variety of soil/water problems in its irrigation schemes. Almost 50% of the irrigated area has some form of drainage-related constraint, and apart from salinization there are also areas affected by excessive drainage causing a loss of fertility through the leaching of nutrients, a problem that extends to more than 200,000 ha. In the valley of Copiapo, about 6,000 ha are affected by salinization, a large part of which is caused by intensive trickle irrigation without leaching. This is being studied together with FAO, experimenting with the effectiveness of sprinklers to leach the salts.

The deliberate use of effluent from urban sources is increasing in the region, and offers an additional resource where water is scarce, together with nutrients that are regarded as cheap fertilizers, capable of raising crop yields. From the beginning of the century, the Mezquital Valley has used waste water from Mexico City to irrigate an area which has now extended to 85,000 ha, partly supplied by an average flow of 31 cu.m/sec. from the metropolitan area. Unplanned re-use is frequent throughout the region, as there is widespread discharge of untreated effluent into rivers which supply irrigation schemes. This has given rise to concern about long-term health risks, as contaminants have been reported in vegetables and other crops in Argentina, Chile, Cuba and Mexico.

4. LEGAL AND INSTITUTIONAL ASPECTS

Legislation and the administration of water use for agriculture is a concern of all countries of the region, especially with respect to the contamination and pollution of water, and its pricing for irrigation. In many countries, such as Mexico and Peru, water is considered a public commodity, and little or no charge is made for its use in irrigation.

In Chile, water can be owned by users and by non-users, and the purchase of a farm does not guarantee the right to use the water that flows through the property. This

creates problems, and conflicting water rights issues will continue to grow. Mendoza, in Argentina, offers an example of good water administration. Water Users' Associations administer the supply to areas of between 10,000 and 15,000 ha, and are in charge of distributing water among the users of a particular canal system for agriculture, domestic, industrial and public use. All users pay a tax, in four quotas each year, to defray the costs of administration by the Department of Irrigation and of the Association; of operation and management of irrigation infrastructure in the province; and of the construction of irrigation networks.

The Mexican Constitution specifies that the nation is the proprietor of water, and irrigation water is free of charge. This situation is in the process of change, by the decentralizing of the water administration and the progressive shift of managerial and development responsibilities to the private sector. In Cuba, water for irrigation is free, up to an amount prescribed for the user by the National Institute of Water Resources and the Irrigation and Drainage Research Institute, according to location and the crops irrigated. Water use above this amount is charged on an escalating tariff. The country has powerful legislation on water pollution, and the sugar industry (a common source of pollution in a number of the region's countries) has been heavily fined.

There is apparent contradiction between the widespread occurrence of water pollution and the existence of sophisticated control legislation in many countries of the region. This seems to arise from the weak implementation of such legislation. In some cases, regulations may not have been promulgated, while in others, even when appropriate norms exist, their application is hampered by the dispersion of legislative authority; the failure to set out the provisions of the regulations in sufficient detail; or both. Positive steps have been taken, however, particularly in the more industrialized countries, toward the serious control of polluting industries and the enforcement of requirements that effluent be treated. The same trend can be seen in regard to other sources of water pollution, especially the treatment of municipal wastes, and there are examples in Argentina, Colombia, Cuba, Brazil, Uruguay, and elsewhere in the region.

5. HUMAN RESOURCES, TRAINING AND RESEARCH

All the region's countries need to upgrade their human resources in knowledge and skills, and to improve the relevant institutions so as to provide an efficient working environment. In most countries, there is good awareness of irrigation problems. Technical knowledge is there, or is fairly easy to obtain, but there is difficulty and lack of ability in managing the application of technology at a large scale, to solve or avoid problems, or to establish appropriate practices and programmes. In most technical communities, it is known what constitutes good irrigation; how to be water-efficient; to determine consumptive use; to schedule irrigation supplies; and to avoid salinization and erosion. The failure lies in the design and implementation of effective procedures which will establish the already available knowledge within the water-user communities, and will ensure the acceptance and continued application of proven practices needed for sustainable agriculture.

Farmers and cultivators using rainwater, groundwater and surface waters in the region, range from those with entrepreneurial and managerial skills, practicing advanced and modern agriculture, to rural dwellers, barely surviving with meagre harvests from

small patches of poor land. Sustainable agriculture requires good farming and water management, and cannot be accomplished by the poorer "farmers" who, in many parts of the region form the majority. The region lacks specific programmes for improving the knowledge and skills from that of subsistence farming to at least the minimum level necessary for sustainable agriculture.

In too many countries, notably Argentina, Mexico and Peru, expertise in agricultural water use has decreased, mainly because of insufficient incentives and the stagnation of irrigated agriculture. However, in some of the countries studied, (Brazil, Chile, Costa Rica, Cuba), there is a marked gain in expertise. Chile's encouragement of modern private irrigation has promoted the introduction of modern equipment and the automation of water application; the organization of competent private firms providing technical services to farmers; and has raised interest in upgrading the technical competence of practising professionals and in the pursuit of careers in agriculture. Brazil has recently been the most active country in the region in irrigation development. Although the creation of expertise lags behind that needed to handle the magnitude of project development and the manifestation of new problems, there has been a considerable improvement in standards of human resources, due to the demand for technical enterprises for design and project implementation, and for technical personnel to carry out the government plans.

The practice of sustainable agriculture, with environmentally sound and efficient water usage, requires a level of practical and theoretical knowledge that is not found in the majority of the region's farmers. To make up for this, educational campaigns and training programmes must be launched. The educational campaigns should reach, and be tailored to all types of farmers. They should define sustainable agriculture and demonstrate ways for its achievement. Ad hoc training programmes must be designed to upgrade the technical, managerial and entrepreneurial skills to the minimum level necessary to practice sustainable, profitable agriculture. Farmers above this level, including advanced farmers, do not always practice sustainable agriculture, and also need training to improve their practices.

In most countries, an improvement in professional expertise is required, emphasizing efficient water use and environmentally sound, sustainable agriculture. Each country should have a coordinating unit with responsibility for a programme to provide information, analysis, training, education and technical assistance to farmers, for the implementation of appropriate production systems, with technical guides on:

- protection of farm soils against degradation,
- controlled use of agricultural chemicals to avoid harm to humans and the environment,
- protection of water supplies from depletion, pollution and contamination,
- minimum use of non-renewable natural resources, including energy.

In support of these programmes, research should be aimed at producing technological packages tailored to the capabilities and means of the users. These should be practical and include procedures for easy and successful implementation, which necessitates an understanding of farmers' problems, culture, aspirations and technical knowledge. The packages must be developed through "adaptive research" and "action research", the first being the utilization of existing knowledge in structuring viable

packages for sustainable agriculture and efficient water use, the second involving testing the suitability of the packages under farmer and field conditions.

6. CONCLUSIONS

Some major areas needing remedial action can be identified. Action programmes on these should be prioritized by each country according to its own needs and economic means. Whenever possible, there should be regional cooperation and coordination in solving problems and sharing information and experience. The action areas include:

1. Training at various levels.

2. Water legislation.

3. Control of pollution of irrigation waters and management of water re-use.

4. Efficient use and rehabilitation of irrigation infrastructure.

5. Modernization of irrigation schemes, through monitoring, automation, optimization of energy use, etc.

6. Regional technical cooperation and water use data bank, covering:

   - cooperation through technical centres,
   - exchange of specialists to solve problems,
   - training, etc.
   - monitoring climatic changes and forecasting effects on agriculture.

7. Organization of water users, water pricing policies and service charges.

8. Technical assistance to farmers.

9. Rainwater management techniques.

10. Adaptive and action research.

Each country must make the political and economic commitments to ensure successful implementation of the programmes. It is only through such commitments, and with the active participation of all parties, that environmentally sound and efficient water use for sustainable agriculture will become possible.

7. RECOMMENDATIONS

1. The importance, magnitude and complexity of the subject dictate an in-depth, systematic study on the state of the art of water use for agriculture in the region. This will serve as a guide and framework for regional and national design and implementation of water use programmes. To expedite the necessary programme development and implementation, the study must be initiated as soon as possible,

in both English and Spanish, and include the following:

a. Accurate country and regional socio-economic analysis of the sector.

b. Legal and institutional aspects.

c. Details and methods of present water use.

d. Study of current programmes assisting water use in agriculture, such as research, technical assistance, training, credit and commercialization.

e. In-depth analysis of problems resulting from inefficient water use.

f. Human resources, availability and needs.

g. Detailed profiles of each water-user group, including social, economic and technical aspects.

h. Strategy framework for detailed programme development and implementation of environmentally sound water use and sustainable production systems.

i. The study should be carried out under the leadership of the Economic Commission for Latin America and the Caribbean, (ECLAC), which has already compiled substantial data on the subject.

2. To promote the efficient use of water, and awareness of its importance, the United Nations should institute a region-wide dissemination programme, emphasizing the benefits of proper water use and the consequences of improper use. This programme should make use of radio, television, newspapers, posters etc. Special educational programmes should be designed for all school levels and universities.

3. Programmes for environmentally sound water use in sustainable agriculture should be tailored to each of the following classes of water user in the region:

a. Farmers at present lacking the knowledge and means to practice sustainable agriculture, including poor subsistence farmers.

b. Farmers with the current potential to practise effective sustainable agriculture.

c. Entrepreneurial, advanced farmers, utilizing sophisticated techniques to attain high quality products, mainly for export.

4. These programmes call for the following basic elements:

a. A strong organizational framework at regional and national levels, with well defined administration, operational linkages and cooperation among participating entities;

b. Clearly defined roles of the participating organizations;

c. Understanding and agreement on how the entities and activities will combine to achieve programme goals;

d. Sufficient numbers of skilled, capable personnel to implement the programmes.

5. Both regional and country programmes must be established to assist water users and farmers to adopt systems for sustainable agricultural production and the efficient use of water. Regional collaboration and participation should utilize existing centres and institutes, and receive support from the UN system.

6. Executing agencies of the United Nations should design an operational programme identifying their roles, their individual activities and the mechanism for coordination.

V. THE NEAR EAST AND NORTH AFRICA

1. REGIONAL OVERVIEW

Agriculture, land and population

A common feature among the countries of the region is that of arid, or at least semi-arid conditions over much of their land area, with Turkey being perhaps the only country where rainfall of 200 mm or more can be expected in all areas, with a maximum of over 2,000 mm on its Black Sea coast. In the other countries visited on the mission, rainfed agriculture is possible only on a relatively small proportion of the land. For example, Egypt's population of 55 million, on 3% of its land area, depends almost entirely on the 3.1 million ha of irrigation (95% from the Nile), for its agriculture, apart from a mere 45,000 ha of rainfed land; Saudi Arabia's 200 million ha has virtually no rainfed agriculture, but has developed 1.16 M.ha of irrigation; Tunisia is more favoured, with 5 M.ha of rainfed cultivation out of 16 M.ha, but in North Yemen, with 10 million people, only 1.1 M.ha of its 20 M.ha are cultivated without irrigation, and a further 250,000 ha are irrigated. In Syria, with its population of 11.6 million, only about 3.3 M.ha of land are cropped annually under rainfed conditions, and 0.7 M.ha under irrigation, but as in other countries of the region, government policy is to achieve a level of self-sufficiency in basic crops, and a balance of trade in agricultural commodities.

A number of social factors serve as constraints to the development of agriculture in general, especially where farming has not acquired a high status in the community, and pricing policies and marketing conditions have not been conducive to improved agricultural practices. As an example, in Turkey, with an average per capita income of $US1,200 in 1989, that in the agricultural sector was only $348, but this conceals a wide ratio of 4 to 1 among the regions of the country, with maxima in the west, and south, and a minimum in the east. By contrast, in Saudi Arabia, with government subsidies, and in Yemen where the import of many agricultural products was banned in 1984, national agricultural income is rewarding. Another retarding influence on agricultural development is the fragmentation of land holdings, which is most evident in Turkey and in Egypt.

Irrigated agriculture

The countries visited have made impressive achievements in the development and use of their water resources. Despite competing priorities over financial allocations, and at times over-riding defence expenditures, countries like Iraq, Syria, Jordan, Tunisia and Yemen have managed to build dams and new irrigation networks, to increase agricultural production and, in varying degrees, to reduce deficits in the trade balance of agricultural commodities. Other countries have developed even beyond the sustainable potential of their water resources. Saudi Arabia and its five partners in the Gulf Cooperation Council (United Arab Emirates, Bahrain, Oman, Qatar and Kuwait) have developed irrigated agriculture on previously desert territories with the use of non-renewable groundwater resources.

These developments have not been entirely government efforts and investments. Even in centrally planned economies like Syria, 52% of the total expansion of 170,000 ha since 1977 is credited to the private sector. Private investments have been encouraged in Iraq, and are taking over the operation and maintenance of vast irrigated areas that were once state farms. Development by private farmers in Turkey accounts for 20% of the total 3.6 M.ha of irrigated land. Virtually all the development of irrigation in Saudi Arabia, with the exception of two basins, is credited to the private sector, encouraged by substantial government support and subsidies and, under an accelerated agricultural development plan, irrigation has increased from 0.56 M.ha in 1977 to 1.16 M.ha. While agricultural commodities accounted for a third of all imports in 1977, they dropped to 13% in 1988.

In North Yemen, the private sector share of irrigation expansion since 1977 has been about 17% (12,000 out of 72,000 ha); in Jordan, 35% of the total of 40,000 ha of expanded irrigation; in Egypt, 50,000 ha of an increase of 220,000 ha; and of Tunisia's 243,000 ha of irrigated land, 60% of the development is credited to the private sector. This has been achieved in general accordance with national plans, although the level of project definition and detail varied from country to country. In several countries, new trends in water use have recently emerged. These are the use of marginal quality waters and the desalination of sea water.

Land and water degradation and conservation

The main problem of land degradation in the region is related to the build-up of salinity in the irrigated areas on which so many of the countries depend for a large part of their agricultural production and for the employment and income of their expanding populations, with the limited opportunities to extend rainfed agriculture. There is, however, scope for soil and water conservation measures in the hilly lands of a number of countries, under both rainfed and irrigated agriculture, and Yemen provides the finest example of sound land and water conservation, in one of the world's oldest bench-terraced irrigated agriculture systems.

The deepest concern, in all countries of the Western Asia region, is for the progressive depletion of surface and groundwater resources and the deterioration of their quality. There are three major causes of these problems - all linked to the pressures of rising populations. The first of these is the construction of large surface water schemes, diverting water from main rivers for irrigation and returning saline agricultural drainage water into a depleted flow, the second is the overdraft of groundwater resources, and resulting intrusion of saline water from the sea, or from recharge by return flows, and the third is the increasing discharge of domestic and industrial effluents, usually untreated, into water bodies serving as sources of supply for other users.

The Euphrates river, one of the major surface water resources of the region, and a watercourse shared by three riparians, (Turkey, Syria and Iraq), is deteriorating in water quality as it enters Iraq, the downstream riparian state. A rise in salinity to 900 ppm was recorded in 1989, which is believed to have been caused by the reduced summer flow in the river, aggravated by irrigation return flows from upstream states. Water quality is expected to deteriorate still further in future, because of the expansion of irrigated area in the basin in Syria (up to 700,000 ha) and in Turkey, planned to reach

about 1.2 million ha by the year 2025, and also due to the reduction of base flow throughout the year as a result of storage in the dams in Turkey and in Syria.

In North Yemen, there is a threatened crisis in the supply of water to agricultural and municipal users. Groundwater abstraction is generally unregulated, and water rights are inseparable from land ownership. The main regulation on the drilling of wells and the use of groundwater is that spacing between wells be about 500 metres. There is also a restriction of well drilling in the Sanaa basin to 5% of the area, but this is not enforced. The result has been the drilling of 20,000 to 25,000 wells, and the overpumping of the aquifers, with a decline in water levels of 1 to 7 metres annually. At the same time, the return flow of irrigation waters, percolating to the aquifers, is degrading water quality. Monitoring of these effects, and the introduction of measures to protect the aquifers are now matters of urgency. Similarly, in Saudi Arabia, there is little control on the abstraction of groundwater, and quality is deteriorating in many areas because of overpumping. Water tables are falling, and sea water is intruding into coastal aquifers.

The disposal of untreated wastewater in water courses is reaching alarming levels in some of the region's countries. In Turkey, traditional agriculture on the banks of the Ankara river can no longer be sustained because of municipal and industrial pollution from the capital, upstream, and the waters of the Hancagiz dam are degraded by untreated wastewaters from the city of Nizip to a point where environmental problems and health hazards are occurring, and restrictions may have to be applied to crops grown on the 7,000 ha irrigated area. The Zarqa river, the drain of the populated Amman-Zarqa urban area in Jordan, receives treated municipal and industrial water from these cities, with some problems detected, but these are closely monitored. Untreated industrial waste is a menace to irrigated agriculture near Helwan, a southern neighbourhood of Cairo, but collection and treatment facilities are under construction. It is expected that the sewerage networks and treatment plants being installed in the Nile delta region will resolve the problems caused by the disposal of untreated wastewater in irrigation canals and drains.

At first sight, the control of groundwater abstraction may appear straightforward, but there are many complex factors. The diversion of freshwater supplies to urban and industrial users in Syria and Tunisia has caused farmers to drill for alternative sources and to overpump these in spite of legislation to the contrary. Tradition, and social structures, combined with a lack of legislation are causes in Yemen, and the unrestrained expansion of irrigated agriculture has been the reason in Saudi Arabia.

In all the countries visited, officials expressed concern for the depletion and degradation of water supplies, and were aware of the need for environmental protection. Syria has set up a specialized department for the protection of irrigation water against pollution, and in other countries the organizational requirements for the environment are met to varying degrees, but effective action for environmental protection is lagging behind in several, if not all these countries.

Implementation of Action Plan recommendations

In all the countries visited on the regional mission, there has been real progress

in the development of water for agriculture since the UN Water Conference prepared the Mar del Plata Action Plan in 1977. However, there have also been common constraints which have limited that progress. Many countries of the region have experienced balance of payments deficits during this period, and a shortage of foreign exchange, which has restricted the availability of agricultural inputs and particularly the import of spares for the maintenance of irrigation mechanical works, farming equipment and machinery. These problems of national economy threaten to slow the pace of development, to increase unemployment, and to place at risk the prospects for sustainable irrigated agriculture.

Social factors, relating to the status of farming, and conditions of land tenure, are impeding progress in some countries, while poor coordination between authorities dealing with water and those responsible for agriculture is a general feature, even among departments within a common ministry. In most countries visited, there is need for more active agricultural research work, including the training of researchers, and for the funding of such research, and agricultural extension services also require more attention to training in irrigation, especially where new technology is being introduced. Systematic efforts are called for in marketing, where high value export crops are grown, and there must be more readily available agricultural credit for working capital. All these factors have strong influence on productivity and income, and therefore the sustainability of agriculture and associated water developments.

The MPAP recommendation on the development of shared water resources is particularly relevant in this region. There are five international rivers, and several transboundary aquifers in the countries visited, with no agreements concluded for the sharing of the international waters. In the case of the Tigris and the Euphrates, riparian countries have plans for the use of their waters that affect one another in terms of the quantity and quality of water that could be made available. Both these factors have serious implications for the sustainability of irrigated agriculture in the basins of these rivers. Bilateral agreements exist on some of the rivers where there are more than two riparians, e.g. Jordan and Syria on the Yarmouk, and Egypt and Sudan on the Nile at Aswan. The need to accelerate efforts to conclude riparian agreements is more urgent than ever before, because of the on-going expansion of major works for irrigation in virtually all the international river basins of the region.

2. IRRIGATION

Among the countries visited, some are heavily dependent on irrigation, and each has its own characteristics of water use practices, intensity of production, and management techniques. Egypt, with almost complete reliance on the Nile for agricultural production, throughout its history, now has a total of 3.15 million ha under irrigation, and with a perennial water supply regulated by the Aswan High Dam has achieved an average cropping intensity of 190%, with two or even three crops yearly on some areas. This is high, compared with most countries of the region. Since 1980, about 170,000 ha of new irrigated land, (previously mostly desert), has been developed by the government, and a further 50,000 ha by the private sector. An additional 63,000 ha per year is planned for the next five years. This programme was originally intended as an integrated rural development, with all social infrastructure, but is now limited to the land reclamation, irrigation and drainage components.

No irrigation water charges are levied in Egypt, although irrigated lands are taxed. There is therefore little, if any incentive to economize on the use of water when it is available for irrigation. High efficiencies are cited (70% overall, and 80% on-farm), but considering the status of gravity systems, land tenure and the farmers' tradition of flood irrigation from before the time of the Aswan High Dam, it may be difficult to attain these efficiencies in the Nile Valley and the Delta.

There are many reasons for suggesting lower overall irrigation efficiencies, including:

- daytime irrigation and the absence of night storage,
- the lag between the release of water from the high dam and its receipt on the irrigated land,
- long, tortuous channels delivering water to small holdings, and inequity in distribution,
- differing water requirements of a variety of crops irrigated by the same lateral,
- free irrigation water,
- lack of land levelling,
- limited farmer response to improved irrigation practices.

In the newly reclaimed land, the law requires that advanced irrigation practices be used on the farms, unless it is proved that conditions dictate the use of surface methods. Conveyance systems are open, but lined, canals (principally concrete). Actual irrigation efficiencies are not known.

In Turkey, of the 8.5 million ha of estimated potentially irrigable land, 3.6 M.ha were equipped with irrigation infrastructure by 1989, the average annual expansion rate being about 26,000 ha/year from 1976-81, rising to 100,000 ha/year since then. This has not been matched by an equivalent performance with respect to on-farm development works, (land levelling, surface and sub-surface drains, farm roads, land consolidation and land reclamation), where there is a considerable backlog. From the annual reports of DSI (the State Hydraulic Works agency, operating 1.16 M.ha of irrigation) it appears that irrigation facilities are underutilized, with about 35% of the scheme areas not being irrigated, and irrigation efficiencies are lower than assumed in project planning and design. Actual cropping patterns also differ from those planned, with a higher proportion of low-value traditional crops.

No measuring devices are installed on the tertiary canals, and service charges are made on the basis of cropped area. Farm holdings averaging one or two hectares are often scattered, and delivery of water from the tertiary canal is the responsibility of the farmer, which poses difficulties and hardship, especially in flat terrain. There is a growing tendency to use buried concrete pipes or elevated flumes for tertiary canals, which makes it technically possible to deliver water to the farm boundaries

The target of DSI is a cropping intensity, or irrigation ratio, of 90% within 5 years of project completion. Intensities are dictated by climate, and there are areas where two crops can be grown each year. DSI records show that the target is far from being attained in many of their schemes, and the 1987 DSI evaluation reports that only 65% of total irrigable area received water for the first crop, with 1.3% of a second crop irrigated. Considering the climatic conditions in the country, and the possibility of

growing two crops a year in many of its regions, a practical intensity of 130% should be achievable.

The many factors restricting the irrigation ratio include the following:

- inadequate irrigation facilities, particularly the absence of an on-farm distribution system, which is the farmer's responsibility,
- inadequate drainage facilities,
- insufficient, reasonable agricultural credit, thus farmers are not encouraged to make substantial on-farm investments and prefer to retain their traditional (rainfed) crops that require minimum expenditure,
- inadequate extension services for agriculture and irrigation,
- unattractive pricing policies for farm produce.

The assumed overall irrigation efficiency for most projects is 57%, and this value is used to compute seasonal water requirements as well as the required system capacity. A range of from 7% to 91% has been calculated among projects, and for DSI schemes the average overall value is 39%. In effect, throughout a growing season, about 45% more water is given than was assumed in the design. Reasons for this include:

- deficient on-farm networks, causing excessive field losses,
- unsuitable water distribution methods, with delivery over 24 hours, and demand over a shorter period,
- irrigation charges based on area, rather than on water quantity,
- poor maintenance of tertiary canal networks.

Iraq has 1.95 million ha of irrigation, with two more major projects underway, totalling 575,000 ha. These will draw water from the Tigris and its tributary Diyala river. Both projects will use sprinkler irrigation. Design assumptions of irrigation efficiency are 60% in winter and 55% in the summer irrigation season, but a higher level of 66% is planned. Actual efficiency is believed to be about 40%. The design value of cropping intensity is 120%, which should be attainable.

The cropped area in the Kingdom of Saudi Arabia increased from 560,000 ha in 1977 to 1.16 million ha in 1988, entirely due to irrigation. If self-sufficiency in food is to be attained by the year 2000, it is estimated that 2.93 million ha will be needed. While land is not a limiting factor, the rational use of water is a definite constraint. Some 200 dams have been completed during this period, mostly for groundwater recharge and flood protection, with total storage of 425 M.cu.m. Wadi Jizan dam has an irrigation network serving 3,000 ha, with planned expansion to 6,000 ha. A further 50 dams are to be built in the next five years. Earlier irrigation (in general before the 1970s) used spring sources and flood application or spate irrigation. These lands continue with the same traditional methods. Since then, modern irrigation methods are obligatory, and centre pivot sprinkler systems are almost universal on cereal crops, with trickle and bubbler application on vegetables and on fruit trees. Although measurements of water use are lacking, an overall efficiency of about 70% can be assumed.

Most water used in agriculture is now abstracted from non-renewable sources in the form of fossil water aquifers. Total reserves have been estimated at 500 billion cu.m. and probably 340 billion are abstractable at a bearable cost. Maximum replenishment

of all aquifers is about 2.2 billion cu.m. per year, of which about 1 billion recharges the useable aquifers. At the 1988 rate of abstraction, estimated at 12 billion cu.m., and with 1 billion cu.m. returning to the underlying aquifers from irrigation water, the annual depletion of reserves will be at the rate of 10 billion cu.m./year. The useable reserves will thus last about 34 years.

With time, the quality of the abstracted water will deteriorate, because of the flow from incoming low quality water towards the core of depression at the point of use. It will then be necessary to limit production to selected crops of salt-resistant varieties. Continuing drawdown, and deepening cones of depression will require deeper and larger boreholes, and increased pumping heads, with consequent higher production costs.

The government is well aware that irrigation at this scale is "terminal" and cannot be sustained. Any improvement must come from a package of measures, including:

- redistribution of wells in the same aquifer, in an attempt to create a more uniform drawdown,
- adjusting abstraction rates to use the water reserve more sparingly,
- continuous monitoring of aquifer response to abstractions,
- limiting and metering the quantities abstracted by each farm, in accordance with a mandatory efficiency,
- taking measures to rehabilitate coastal aquifers damaged by sea water intrusion, including artificial recharge with treated wastewater.

Irrigation accounts for about 90% of total water consumption in North Yemen. Some 250,000 ha are irrigated, of which about 105,000 ha is controllable irrigation from groundwater pumping, with 25,000 ha from seeps and springs, and a very minor part from surface water reservoirs. In the mid-1970s, total controlled irrigation was reported to be 118,000 ha. Of this, 45,000 ha was irrigated from wells and 73,000 ha from springs, indicating the reduction of spring flows as a result of increased groundwater abstraction. The net expansion in irrigated area, since 1977, is about 72,000 ha, with some 60,000 ha of government rehabilitated spate irrigation and 12,000 ha developed by the private sector. Prior to 1977, there were 60,000 ha of primarily spate irrigated areas, which the farmers still utilize through efforts to rebuild the diversion dykes, washed out during floods.

In spite of a shortage of water, irrigation efficiency is low, and traditional surface application methods are widely employed. Where spate irigation is practised, on the Tihama plains and western mountain slopes, the objective is to divert the maximum possible flood flow to the farms, and it is not uncommon to apply 2,000 mm of spate flood water to a sorghum crop. The excess water is claimed to recharge groundwater, which is then utilized in conjunction with spate water to support more valuable crops.

In areas using groundwater and surface application, on-farm efficiency is unlikely to exceed 35%, and with conveyance and distribution by earth canals, giving about 80% efficiency, an overall irrigation efficiency is in the order of 28%. The use of pipes for conveyance and distribution of water is finding increased interest, and advanced irrigation methods are being introduced by an FAO/UNDP project. There is local capability for the manufacture of polyethelene pipes up to 32 mm diameter, for drip irrigation. More such projects are needed to enhance overall irrigation efficiencies throughout the country.

There are no direct water charges, even in government projects, but a Zakat, or tax, is levied at a rate of 2% of the value of the produce of the land. This value is self-declared by the farmer, without any audit. Experience has shown that the recovery of irrigation charges is far below the officially estimated levels, and insufficient funds are being generated for the operation and maintenance of the schemes, which is posing a serious problem of sustainability.

While water harvesting in the uplands improves the overall efficiency of water use in North Yemen, there is some dispute regarding the role of dam construction for the recharge of groundwater, and thus for controlled irrigation. It is being questionned whether these works result in net gains of useable water or merely in a geographical redistribution of resources, which would not justify the expenditure. This calls for detailed investigation, as does the estimate of groundwater reserves and recharge rates, and the accurate measurement of abstractions.

The Jordan Valley provides an example of a successful integrated river basin development. Initiated in 1973, the backbone for the scheme has been irrigated agriculture and its supporting services. Irrigated areas expanded from 10,400 ha to about 35,000 ha, and cropping intensities rose from an average of 80% to 116%. The value of agricultural produce increased from the equivalent of $US20 million in 1973 to $180 million in 1987. Job opportunities increased beyond the capacity of the national labour force, requiring an import of labour, primarily from Egypt. The sustainability of the valley's agriculture is therefore contingent on their continued contribution.

Population of the Jordan Valley region increased from 68,000 to 170,000, and social and economic gains are considerable. Under the integrated development plan, dams, irrigation networks and drainage systems were built, roads settlements, domestic water supplies schools, etc. have been constructed. The overall economic internal rate of return approached 24%. One cloud hanging over this achievement, since 1984, is the marketing of the agricultural produce, for which government efforts have been intensified through export markets, agricultural research and extension services.

3. WATERLOGGING; SALINIZATION AND DRAINAGE; WASTEWATER RE-USE

Waterlogging and salinity have emerged as threats to the sustainability of irrigation at different stages in the various countries visited. The primary reason for its occurrence, and for its escalation with time, has been the failure to give adequate attention to the assessment of drainage requirements during project conception, study and design. The usual concern was for the rapid implementation of irrigation for crop production, with drainage facilities deferred until the need occurred. Unfortunately, when problems did arise, there were often reasons for further delay, with the result that yields declined or fell, sometimes to a point where land was abandoned.

The risk of waterlogging was inherent in the location of many of the affected schemes, as irrigated lands were often reclaimed from poorly drained areas that became swamps in the rainy season. The Ghab project in the Orontes Valley in Syria is such a case. Similar conditions accompanied the introduction of perennial irrigation on lands that had previously been under spate irrigation in the flood season. The Nile Valley and parts of the Delta after completion of the Aswan High Dam are examples of this, as also

are several projects in southwest and eastern Turkey. In Turkey, with its relatively high rainfall for the region, waterlogging has in part been due to inundation from river flooding, and many cases have been solved by regulating river discharges through the construction of storage reservoirs and embankments. Flooding problems are reported to have been prevented in 39 out of 60 projects in this way. Waterlogging has also been induced in new, perennial irrigation in the proximity of existing low-lying irrigated land, such as the peripheral areas of the Nile Valley.

Inadequate study of soil characteristics and soil profiles, prior to embarking on development, has led to problems of waterlogging in many areas, and is demonstrated in the Euphrates projects in Syria and projects in Saudi Arabia. One of the commonest causes has been that of low irrigation efficiencies, combined with higher cropping intensities and the lack of field drains, and this has affected schemes in the Lower Euphrates and Tigris basins in Iraq, the Nile Valley and most of Turkey's irrigated areas.

There has been substantial damage to irrigated agriculture, both directly from waterlogging and from resulting salinization. In the DSI operated areas of Turkey, 772,000 out of 1.15 million ha, (67 of the 168 projects) have been reported to have problems of salinity and to require drainage. Some of the south coast low-lying areas with poor natural drainage, have called for a dense network of sub-surface drains, feeding into collectors with pump-lift discharge to the sea. In Iraq, 50% of the irrigated lands in the centre and south of the country were degraded by 1977, due to waterlogging and salinity. Syria has suffered to the extent of 72,000 ha of waterlogging in the Orontes Valley and 60,000 ha in the lower Euphrates project developed salinity problems when new lands were put under irrigation.

There have been considerable efforts to deal with these problems. Since the early 1980s, Iraq has completed drainage facilities for 700,000 ha, together with rehabilitation and improvements to the irrigation canal network, and is going on to complete a huge collector drain parallel to the Euphrates, to discharge drainage water to the Gulf. Egypt has completed field drains for 1.43 million ha, towards a target of 2.3 million by the year 2000, and Turkey has a target of 376,000 ha by 1994, of which 93,000 ha of surface and sub-surface drains have already been laid.

Some 15,000 ha has recently been reclaimed in the Ashkal Lake plains of Tunisia, and networks of sub-surface and surface drains have been installed to reclaim waterlogged areas in the Qala't Al-Andalus plains. The drainage network, in this case, was completed ahead of the commissioning of the irrigation project.

Prompted by the need for additional useable water to reconcile competing and increasing claims for the finite freshwater resources in the proximity of urban centres, and by concern for public health and the environment, several countries have embarked on a policy of municipal wastewater treatment and its re-use in agriculture. Jordan has already introduced this policy, and by the year 2005 about 30% of all irrigation water for the Jordan Valley will be from this source, and used for unrestricted agriculture after blending with flood water impounded by dams. Saudi Arabia, Kuwait and other Gulf States are using treated wastewater as the sole source for irrigation of restricted crops. Tunisia will shortly be irrigating 6,000 ha from wastewater, and will expand this to 20,000 ha by the year 2000.

The disposal of wastewater into watercourses used as sources of irrigation supply has caused problems to human health and to agriculture. Egypt is now implementing plans for sewerage networks and treatment plants, and will add the treated effluent to the inventory of useable water resources. The re-use of agricultural drainage water is at an advanced stage in Egypt, where 3.4 billion cu.m are now being used, and this is planned to rise to 11 billion under the on-going land reclamation programme relying on blending with Nile water to produce a supply with 850 ppm total dissolved solids. The recharge of aquifers with seepage from irrigation provides an indirect source of irrigation supply in Yemen and in Tunisia.

There has been rapid expansion of seawater desalination for municipal and industrial use in Saudi Arabia and the Gulf States. The annual capacity of the 29 plants in Saudi Arabia is 686 million cu.m, and together with 21 plants in the other states the regional output is 1190 M.cu.m annually, about 90% of world production. The desalinated water is blended with brackish groundwater from aquifers at the terminus of its conveyance, to produce a blend conforming to potable water specifications, before pumping it into the distribution system. Sea water desalinization therefore helps reduce the rate of degradation of the aquifers, but with continued groundwater abstraction to meet extravagant municipal consumption and the increasing demands of irrigation, the problems of deteriorating quality and declining supplies will persist.

4. CONCLUSIONS AND RECOMMENDATIONS

The major features of agricultural water use in the region are determined by the limited resources of arable land and water, but especially water, and the deterioration of both under present pressures for production, and with present standards of resource management. In many countries, this implies that agricultural development as projected, or even at current levels in some countries, will not be sustainable. This situation, which ultimately requires the balancing of resource potential against the degree of exploitation, calls for the highest possible efficiency in the use of natural resources, to sustain both production and resource availability and quality at optimum levels. The thrust of future water programmes in the region must therefore be directed at the preservation of land and water resources while practising economy in their use, and the maximization of crop production consistent with physical and economic constraints.

Experience in the expansion of water use for agriculture, since the UN Water Conference, has shown that there are vast opportunities for the improvement of standards of resource management throughout the region, particularly in relation to irrigation, but also for all other uses of water - which are mutually interacting through consumption and quality impacts on the resource. This can be seen in the effects of domestic and industrial wastewater disposal in the vicinity of major cities, which has led to severe environmental damage and risks to human health, whereas appropriate treatment can convert the effluent into an additional water resource for the benefit of agriculture, using suitable technologies for soil and crop management.

With these circumstances in mind, and subject to the differing needs and priorities of individual countries, the following general lines of action are recommended for the region:

1. Activities already in hand to preserve and sustain soil and water resources must be continued and intensified, with the main effort being placed on the protection of agricultural soils from waterlogging and salinization, and the protection of surface and groundwaters from over-exploitation and pollution.

2. The improvement of efficiencies in irrigation should be accomplished through the application of practicable technology that can be easily adopted under existing environmental and social conditions. For example, where surface on-farm irrigation is traditional, efficiencies can be enhanced through the application of land levelling, if necessary introducing new legislation, while not precluding future, more advanced options. In new areas, advanced methods should be utilized. Countries in the region should be encouraged to measure and report on irrigation efficiencies, within a specified programme period, in order to identify areas for improvement, and for the better management of land and water resources.

3. There is a general need for improvement in the maintenance and operation of irrigation systems, to ensure an acceptable reliability and efficiency of water supply. The training of maintenance crews, and the introduction of maintenance management systems is most important. In order to ensure the standards necessary to sustain schemes and the agriculture dependent on them, all countries must make radical approaches to develop realistic measures for cost recovery for maintenance and operation through irrigation service charges.

4. The need for the development of human resources in irrigated agriculture is apparent throughout the region, although at different levels among the countries, with training being directed at farmers, extension workers and research personnel, in order to achieve the requisite standards in the use and conservation of finite water resources.

5. In the approach to improved economy in water use, and adjusting to progressive scarcity and the declining quality of water, the adaptation and testing of crop varieties tolerant to these conditions must be considered, together with genetic modifications to develop suitable material.

6. For the overall optimum use of national water resources, there must be more attention to rainfed agriculture, with better practices for the conservation of soil moisture, the expansion of water harvesting techniques and, where appropriate, the use of supplementary irrigation.

7. There should be increased impetus in promoting the use and re-use of marginal quality waters, (treated waste-water, agricultural drainage water and brackish groundwater), directly and, where feasible, through the recharge of aquifers, to supplement limited or declining resources.

8. The regulation of groundwater use is now of vital importance in many countries of the region, and calls for the urgent formulation of legislation and administration,(including fiscal provisions), for the control of this resource. This must be accompanied by technical and scientific measures for monitoring the performance of aquifers, and for the metering of abstraction rates.

VI. EUROPE AND NORTH AMERICA

1. REGIONAL OVERVIEW

National and international situations and attitudes relating to water, in the countries of Europe and North America, are set out in the documents of the UN Economic Commission for Europe, particularly those of the Senior Advisers to ECE Governments on Environmental and Water Problems, (and previously the ECE Committee on Water Problems). One of the main features of the last few years has been the broadening scope of water management, which has evolved from the primary objective of satisfying demands for quantity of water, to a concept of integrated water management incorporating quality and the protection of ecosystems.

An important feature of current water management is the emphasis, in most countries of the region, on coordination for development between land-use planning and water use, and the agricultural sector is prominent in this, as further expansion of irrigation is expected in modern cultivation methods. This trend to a holistic approach to the management of land and water resources has become evident in a range of measures. For example, flood protection and control, a subject of great importance in a number of countries, has shifted emphasis to non-structural measures, such as the planned allocation and zoning of land, which reduce both costs and the negative impacts on the ecosystem associated with previous choices of structural modifications in the form of retention dams, diversions and flood banks.

But without doubt, the most noteworthy issue of recent years has been the regional concern over deteriorating water quality. Most achievements in arresting this deterioration, or improving quality, have resulted from measures to eliminate pollution from obvious point sources such as municipal sewage works and industrial plants. However, new and much more treacherous problems face all ECE member countries in the form of the effects of diffuse pollution that is related to factors difficult to control, e.g. agricultural technology that relies on heavy applications of fertilizers and pesticides; discharges from intensive livestock breeding; and run-off from sealed urban and industrial surfaces. Awareness of diffuse pollution is growing. It constitutes a threat not only to surface water, but also to groundwater which in many places of the region remains the only source suitable for drinking water. Several Governments report that their long-term supplies are in jeopardy, unless effective means are soon found to arrest non-point pollution. Groundwater contamination is often a chronic, cumulative process, thus it is far more serious than surface water pollution. Rehabilitation requires extensive time periods, and is sometimes not even possible. Countries recently expressing concern over groundwater pollution from agricultural sources include Bulgaria, Canada, Finland, France, Germany, the Netherlands, Hungary, and the United Kingdom.

There is a general move towards the establishment of more comprehensive monitoring of water quality and the collection of data to enable researchers to develop the measures and regulatory instruments necessary for the application of water management systems, and for the formulation of appropriate national water policies, which is taking place in various countries. As an example, in 1987 the Canadian Government adopted its first broad policy on water, calling for a radically new attitude. The policy encourages the use of fresh water in an efficient and equitable manner

consistent with the social, economic and environmental needs of present and future generations. It proposes five basic courses of action:

- Fair and realistic water pricing based on consumption;
- Federal leadership in water science;
- An integrated approach to water resources planning, involving all sectors of society;
- A broad view of water legislation; and
- A public awareness programme on water issues.

Water pricing policies affect all sectors, and agriculture is perhaps most likely to see changes because of freedom from charges in the past, in many countries. One efficient instrument for integrating the cost of water into the national economic accounting system has been the generalized application of charges and levies for abstraction and use of water and for discharges into waters. Many Governments have reported on the positive effects of applying differentiated charge rates in accordance with the polluter-pays principle or beneficiary/user-pays principle, aimed at promoting clean technology and water savings. Regulatory measures and economic incentives have a prominent place among policy instruments. Permits for abstraction of water, as well as for discharge of return flows are generally applied. Water is no longer considered a free good, neither for use as an unlimited supply nor for use as a medium in which to dispose of wastes. Charges and levies for abstractions and discharges generally prevail, usually at a level intended to promote both rational use of water and pollution control.

Within the ECE region, it has also been accepted that responsibilities for water management call for international collaboration. This is embodied in the ECE Principles regarding Cooperation in the field of Transboundary Waters (1987), which declare that "Transboundary waters do not lend themselves to purely national approaches because natural phenomena and human activities, including effects beyond the transboundary area itself, may make themselves felt across borders, and require cooperation among riparian countries".

2. IRRIGATION

The largest user of water for agriculture among the ECE member states is the USA, which in 1980 reported the use of 230 billion cubic metres for this purpose. The USA National Academy of Sciences, in 1976, predicted large decreases in irrigated land in the country, but so far this has not occurred, and more recent studies indicate that, although this will be the case in the southern High Plains, there will be an overall increase in irrigated land. This will involve mainly sprinkler, and some trickle irrigation systems. The quality of water available for irrigation is declining in some river basins, such as the Colorado River, as consumptive use continues to increase, which calls for widespread application of appropriate measures for water quality management. Canada has 650,000 ha of irrigated land, mostly in the Province of Alberta. Sprinkler irrigation is common, and there were 900 centre pivot machines in 1984. A new water resources

programme was established in 1980, which included the development or rehabilitation and expansion of diversion works, main canals and storage projects. However, there has been opposition to the conversion of rainfed farming to irrigated farming on the grounds that it is ecologically damaging, is unnecessary or excessively costly, and that it discriminates among farmers.

Within the region, recent progress in irrigation techniques has related largely to the efficient use of water by crops, with the use of sprinklers increasing and the greater application of trickle or drip systems, which can attain 95% efficiency. In 1984, 37% of irrigated land in the USA was under sprinkler, and of this about 55% was irrigated by centre pivot equipment. Some 2% was using drip systems with the remainder under gravity flow or surface application. The transfer and adoption of new technology calls for some motivating purpose. In the region, this has come from factors such as the reduction in labour needs and in energy costs for pumping. In addition, changes in types of crops and their market values, coupled with quality requirements of more sophisticated markets, have dictated the most suitable practices and equipment. Changes in laws with impacts on natural resources use, employment, etc. also play a part in the adoption of new systems.

The 1989 ECE Symposium on Improved Irrigation Practices to Preserve and Protect Water Resources and Increase Crop Yields, aimed to promote the latest irrigation techniques to raise the productivity of the water supplied, and emphasized that the most appropriate methods could also reduce water losses due to infiltration into aquifers and runoff into surface watercourses. Consequently, this could help to diminish, or to prevent the pollution of water resources caused by the entrainment of fertilizers, pesticides, or saline return flows. Noting that there are already many countries in the region with substantial experience of advanced methods of irrigation, and that further technical and research programmes are in progress, the Symposium drafted a series of general conclusions, (presented in part below), which also draw attention to further work needed in order to derive greater benefit from the water resources available to agriculture:

- Since water is in most cases a finite resource, its use for irrigation is increasingly coming into competition with other uses. At the same time, those in charge of irrigation at all levels are more and more aware of the harmful consequences that irrigation and other farming practices can have for the environment. Well managed irrigation, on the other hand, can be beneficial for the environment.

- In all the ECE countries practising irrigation, it makes possible diversified and intensified farming, higher and more stable yields, better quality produce, and harvesting at a suitable time. Despite their costs, which must be reduced in the future, modern irrigation practices improve and stabilize farm incomes. In some areas, they play an essential role in the development and maintenance of efficient agriculture, and in the maintenance of an adequate rural population.

- In many ECE countries, water for irrigation is supplied either free of charge, or at a subsidized price. That may lead to over-consumption, with detrimental effects on surface waters and in some cases a salinization of the soil. In view of this, Governments should encourage more rational use of water for irrigation by better fixing of prices.

- One basic prerequisite for better use of water, is more thorough and precise knowledge of soil resources and crop physiology and needs. For example, there is a need to take greater account of soil conditions, soil moisture reserves and soil-water-plant relationships, factors often neglected that are modified by irrigation itself. There is also need for better evaluation of the water requirements of different crops, depending on their growth phase, and of irrigation needs in relation to soil and climatic conditions.

- As far as the environment is concerned, new irrigation practices are aimed primarily at conserving water resources through water-savings, more precise and better timed applications, and control of losses to the subsoil. Secondly, they are aimed at lessening adverse impacts on soil fertility (saturation, compaction, salinization). Specifically, irrigation management strategies make it possible to reduce to a minimum the problems arising after irrigation. It would be worthwhile to develop farming techniques in which irrigation is practised in concert with better use of fertilizer and pesticides.

- Efficiency in irrigation still leaves much to be desired. Good water management on the farm requires irrigators to have a high level of technical knowledge, and creates technical training needs. However, the advisory assistance provided by technicians is not always appropriate in view of the constraints facing farmers, and much remains to be done in the area of training and extension work.

- A great expansion is in progress in research and experimentation on irrigation. Many new techniques are emerging, such as the use of electronics, automatic control, mechanization and automation of surface irrigation, mobile micro-irrigation, underground irrigation and recirculation systems. To make these efforts more effective, there must be coordinated management of research work, and its adaptation to local conditions must be developed by taking into account the experience gained on the farms.

- Irrigation methods using wastewater should be improved in view of the increasing problems of pollution and effects on underground water.

- In order to meet water requirements more effectively, a sufficient number of agrometeorological stations should be installed and encouraged to transmit information to farmers.

3. CONCLUSIONS

While the sectoral interests of domestic supply and sanitation, industry, agriculture, etc. continue to be major elements in water resources planning and development, the need to pay increased attention to the ecological dimension of water management has gained gradual acceptance in the ECE region. Several Governments report research work, investigations and enquiries carried out with a view to reformulating their water policies. Their conclusions and recommendations generally tend to emphasize measures that will ensure sustainable use of water bodies. They pay particular attention to biological and ecological functions. Such considerations have been taken into account in the drafting of new water codes and provisions aimed at updating

and consolidating water legislation that had become inoperative under present-day conditions. With support in legislation, and re-arrangement of administrative structures to facilitate coordination among relevant institutions and services, the ground is being prepared for the implementation of truly integrated water management policies.

VII. CONCLUSIONS

The diversity of conditions among and within the regions makes it unrealistic to draw generalized conclusions. The consultant missions visited a sample of countries and a small selection of national organizations and individuals, and the results can fairly be described as a series of impressions of the current status of water-related activities, and of achievements, problems and prospects. Even so, many features are common to a remarkably high proportion of countries in widely differing locations, and a review of these features may help to point the way to a future, more effective use of water resources in productive and sustainable agriculture.

In all regions, whether per capita arable land is measured in fractions of a hectare, as in the Asia/Pacific region, or whether there are opportunities for continuing expansion of agriculture, such as exist in Latin America, there is a clear need to see water resources and their development in the context of land management. The type and standard of land use and management have direct implications for water availability and quality, just as the management of water on the land has its impact on the quality and productivity of that land. This is most evident in the Asia/Pacific region, where population pressures and economic growth have, in many places, stressed the land and soils beyond their sustainable limits through deforestation and unsuitable or over-intensive cultivation practices, with the classic results of soil loss, sedimentation, impeded river flows, waterlogging and the disruption of hydrological regimes. But it is not limited to Asia and the Pacific, and areas in Africa and Latin America face the same problems, though not so acute, as the overall per capita land base is not so constrained. The starting point in water management is therefore its occurrence as rainfall.

Despite the important, and often predominant role of rainfed agriculture in a majority of countries, there are many neglected opportunities for the improved management of water as soil moisture, through appropriate cultivation practices, and also through the adoption of policies for the involvement of rural populations in the management of sensitive upland catchments. This has been implemented in parts of Asia and Africa, where local population pressures and land degradation have demanded remedial action. There is vast scope for benefits from similar approaches to the management of water and land resources.

Competing demands for water by all sectors of national economies, and for domestic and social purposes, have reached the point where efficiency in the use of the resource has become an important feature of water policies. Whether this is measured in terms of volume or value of production, in savings of alternative resources (e.g. hydropower versus fuels), or in terms of residual value of water for multi-purpose use (degraded quality, loss of potential head), the issue of overall economy of use now has to be faced in an increasing number of countries. Where there is a large element of irrigated agriculture, this provides an obvious focus for savings, as even a marginal percentage reduction in irrigation water use may be equivalent to a high proportion of the needs of all other sectors.

Efficiency of water use in irrigation is therefore a primary concern in the main irrigation countries of the Asia/Pacific region, in the water-short areas of the Near East and North Africa, and in parts of the Latin America/Caribbean region. This is

particularly the case where the overdraft of groundwater is threatening supplies to agriculture and other users, especially domestic, for which there may be no easily accessible alternative source. However, the overall advantages to the community from more efficient water use in agriculture have had only limited response from that sector, as the improvement of irrigation efficiency inevitably involves a cost to the farmer, which must be offset by significant benefits. The greatest incentive is, of course, an increased net farm income from a rise in production and a possible reduction in costs. Other factors that have been effective in promoting more efficient irrigation in a number of developing countries as well as Europe and North America, are a shift from labour intensive operations to mechanized systems, or savings in energy. But the greatest challenge is that of improving the vast areas of surface irrigation where low efficiencies are wasting resources, depressing crop yields, and causing a deterioration of the sustainable productivity of the land. Improved efficiency should therefore be seen as an essential measure to offset the loss in value of productivity of the natural resources base, or the alternative costs of reclamation to restore and to sustain that base.

An almost universal factor contributing to low efficiency in irrigation is the deterioration of scheme infrastructure through poor maintenance - commonly associated with a short-fall in scheme income due to inadequate cost recovery from the farmers. This becomes a vicious circle, for a farmer whose production is depressed by an unreliable service is unwilling, and may even be unable to meet the costs of operating and maintaining that service. There is good reason for the current trend towards the decentralization of scheme management and the introduction of financial autonomy in place of centralized control and various forms of subsidy. At the same time, the efficiency and sustainability of any scheme depend ultimately on the farmers' incentive and ability to apply suitable standards of on-farm management of land and water. The key to this lies in an assured sufficient income from the sale of his produce.

The natural flooding and waterlogging of potentially productive land is a phenomenon affecting many of the humid and sub-humid regions. Its rectification depends on the pressures for developing that land and the economic viability. But this does not necessarily take place against a static hydrological background. The influence of poor land management in upper catchments, with its effect on flows and sediment loads, has severely reduced the predicted life of many high-cost flood control schemes relying on retention storage and bund protection, in Asia particularly, with some 60% of the total world area with drainage and flood control. The remedy must include corrective measures upstream, where this is physically, economically and socially feasible.

A problem now assuming alarming proportions in virtually all semi-arid and arid areas where irrigation is practised, is that of salinization induced by waterlogging from excessive water supply or inappropriate irrigation methods. The former is more usually the case, with the irrational use of low-cost or no-cost water; poor structural design or control; improper flow management; inequity in water distribution; faulty land shaping and levelling; and the absence or inadequacy of complementary drainage. Surface water schemes with low water efficiency are most at risk, with crop yields depressed even to the point of land being abandoned. Millions of hectares are affected, and the costs of drainage and reclamation in the Asia/Pacific, Latin America/Caribbean and Near East/North Africa regions will amount to billions of dollars in the present decade, in order to sustain agriculture on these lands. Moreover, the most susceptible areas are in those countries or locations where constraints on land resources have imposed the need

for intensive irrigated agriculture, leaving little alternative to costly remedial measures, but demanding a far higher level of future scheme and on-farm management.

Closely associated with salinity problems is the subject of water quality management, which is assuming greater prominence as sources of good quality water for agriculture become more restricted because of increased consumption by all sectors, or because of pollution from a range of sources - domestic and municipal effluent, industrial wastes and return flows from agriculture. Irrigation with marginal quality water introduces a further complication into an already complex scientific and technical activity, with the potential for damage to crops and soils unless proper management practices are applied. Unplanned irrigation with reduced quality waters is already a feature in many countries where municipal waste is discharged from major cities, untreated, into irrigation supplies, and in some, such as Egypt and Mexico, extensive systems for the treatment and use of effluent are already in use or under development. But the impact of marginal water use on crop selection may have far-reaching effects on production opportunities, markets and incomes.

This is only one facet of the general trend towards declining water quality, as the intensifying use of water, whether from surface or underground sources, is imposing a stress which those sources cannot sustain. Major rivers, especially in the Near East, supplying expanding demands for irrigation, with reduced base flows and increased return flows from a variety of users, demonstrate the decline in water quality. Aquifers are being over-pumped, and the fall in groundwater level is accompanied by intrusion of sea water in coastal areas and by contaminated inflows from urban areas, all with strong implications for agriculture, which must concede priority of water quality to domestic and industrial users.

Small scale developments have become a focus of interest in recent years, due to the disappointing performance and rising costs of major irrigation projects, specifically in Africa, where the development of large schemes, with all associated infrastructure, is considered economically non-viable. However, the concept of "small-scale" is subjective, and open to a range of interpretations when viewed against typical scheme sizes of hundreds of thousands of hectares in Asia compared with a few hundred hectares in sub-Saharan Africa. There are many initiatives to support small-farmer enterprises within the boundaries of large schemes in India, for example, and in other countries of the Asia/Pacific region responsibility for management is devolving to smaller groups of farmers. In Africa, there are numerous examples of small-scale development by individuals and local communities, with varying levels of success, and in Latin America there is the problem of giving subsistence farmers the basic skills to handle a sustainable form of agriculture, whether irrigated or rainfed.

Success seems most likely where the target is the management of land and water resources within a general, customary agricultural context, with the introduction of better soil-moisture and cultivation techniques, perhaps in association with soil conservation, water harvesting and simple supplementary irrigation. Problems arise when the planners lose sight of the fact that the introduction of more classic forms of irrigation demand certain basic standards of design, construction, technical and farming skills and management, whether or not they are small, and these may not be a feature of traditional local society or of their farming. Moreover, small schemes are vulnerable to physical, economic and social influences which they may have no ability to control, to

modify, or to rectify. The development of human resources, with the appropriate skills and of institutional support structures, is therefore essential to the introduction of small-scale projects.

In some countries of the Near East and North Africa, water scarcity has now reached a point where irrigated agriculture, even at present levels, is sustainable for only a limited period. Estimates of useable reserves and recharge of groundwater in Saudi Arabia give a life of about 34 years at current rates of abstraction. Other areas are at the limits of sustainability imposed by aquifer characteristics, especially in coastal or island locations, where saltwater intrusion and recharge rates set strict limits on seasonal abstractions. The decline in water quality in some aquifers, due to progressive replacement of freshwater with contaminated recharge, must ultimately set limits of scarcity on the amounts of useable water.

Recurrent droughts, and declining water availability have raised fears of water scarcity in various areas, including sub-Saharan Africa, India and north China. In the last of these, average precipitation in the decade 1980-89 was only 80% of the 30-year normal for 1950-79, which provided the design base for many major developments. This has given rise to the promotion of conservation measures such as minor water storages, groundwater recharge, water harvesting, improved soil-moisture practices and associated small-scale irrigation in upper catchments. It has also encouraged far broader measures, including research into crops with drought resistant or low water-demand characteristics; flexibility in conjunctive surface and groundwater use and the supply of energy for pumping; transport and market adjustments.

Where scarcity has been demand-induced, countries such as Egypt have reacted by planning the addition of treated effluent to the water budget, simultaneously solving severe pollution problems, and the development of crop varieties with reduced water requirements - most notably rice - is certain to become a prominent feature of measures to adapt to scarce water situations.

Since the UN Water Conference, one of the commonest constraints to the attainment of national objectives in agricultural water use and development has been the weakness of institutional support. For many countries, this reflects an enforced deterioration of economic circumstances, which has curtailed all development processes in the past decade. It has certainly meant that the mobilization of natural resources, human resources and finance has failed to achieve the levels of production, quality of life and environment that are necessary to the well-being of the community.

The rapid expansion of modern farming concepts to meet the demands of rising populations has inevitably outstripped abilities to respond to the need for new technologies; research and scientific advances; the establishment of markets to absorb and distribute production and, in turn, to reward the farmer; credit facilities to improve his ability to participate; legislation to enable the development of natural resources and to protect them against misuse, and to guarantee securityy of tenure and livelihood; and above all, the development of human resources to meet the demands of all these productive, enabling and regulatory components so necessary in the vast and complex task that now faces many developing countries.

In this regard, while the form, purpose and mandates of institutional systems is a matter for national decisions, there are many areas, such as science, technology, legislation, resource management techniques, and training, which have common regional characteristics. In some of these areas, and in certain regions, the UN has already contributed to the development and strengthening of institutions, both in agricultural water use and in the broader field of water resources management. This role could be expanded in response to national and regional demands.

Whereas a number of difficulties experienced in national programmes for agricultural water development can be traced, at least in part, to institutional shortcomings, the root problem has often been in the failure to formulate and apply national policies for the development, expansion and intensification of water use for agriculture. This too can be partly attributed to the rapidity of change, whether physical, social or economic, that has affected so many developing countries, and recent experience has shown that member states of the ECE region are also revising current policies to take account of new pressures that are threatening the sustainability of economic activities and social structures.

The problems are not dissimilar among all regions, the main differences being of emphasis. Basically, there is a growing stress on the resources of land and water for the support of populations and their standards of life. Decisions on the allocation and conservation of those resources, investment in their development, and their management by the community for productive use must form the basis of all future policy aimed at the sustainability of agriculture.

VIII. RECOMMENDATIONS

The consultants' reports identify issues and problem areas specific to each region, and recommend where efforts can best be directed for the improvement of agricultural water use, drawing attention to possible regional initiatives to assist in cooperation and exchange of knowledge among countries, and noting potential roles for the UN system. Some of the main themes of the recommendations are presented below.

1. POLICIES

One of the most basic findings of all the regional missions is the need for clear national policy lines for sectoral priorities and allocations of resources of land and water, and for their use, management and conservation in support of future programmes of sustainable agriculture within overall programmes for socio-economic development. Where these lines have been followed, performance has benefitted, but in the absence of such directives, development, production and resource quality have suffered.

Two factors in particular stand out in this respect. The first is the need for a policy on the integrated management of water as a resource, for the optimal benefit of national social and economic purposes, and in conjunction with overall land management policies. The second, closely allied, is to determine the most suitable balance of rainfed cultivation and irrigated farming, to give greatest benefits of production, income and resource protection and conservation.

Other issues under this heading are the preparation of master plans; the choice of scale of development; adapting to water-scarce conditions; and, in a number of cases, progressing towards agreement and collaboration in respect of shared basin resources.

2. INSTITUTIONAL SUPPORT

The pace of development has already outstripped the capacity of institutions in many countries, and has brought with it a wide range of problems calling for the review, modification and strengthening of all administrative, operational, financial, technical and scientific services. In many cases, attempts to do this have resulted in a continuum of revisions and changes of responsibility and authority which have themselves been destabilizing. Usually, this arises from a lack of clear policy objectives, or from a diversity of such objectives at various hierarchical levels.

Institutional reform and reinforcement relating to the major areas of land and resources issues and rural populations, should be formulated and implemented at a high level in national administrations, with clear, agreed arrangements and processes for devolution and decentralization, where appropriate. A necessary stage in the identification of institutional needs is the preparation of a master plan showing the broad lines of resource development and comparing management and human resources requirements with their availabilities.

Issues of particular concern, identified by the regional missions, include:

- the establishment of national data bases on water and land resources, including the monitoring of changes in status of surface and groundwater;

- the provision of facilities for credit, for marketing and for the security and stability of farm produce prices;

- legislation to enable the development of land and water resources, to regulate their use and to protect their quality, and to allocate and secure their use for the benefit of communities, organizations and individuals;

- scheme management and administrative structures for operation, maintenance and rehabilitation, and for the recovery of costs through water or service charges;

3. RESEARCH

Continued research is needed into scientific, technical, economic and social aspects and problems in the development and management of schemes, programmes and policies associated with the expansion and intensification of agricultural water use. This should include such subjects as crop/soil/water management; the use of marginal quality waters from various sources; the prevention reduction and rectification of salinization; economy of water use through technical and biological methods; scarce water management at farm, scheme and national levels; cost recovery methods for scheme operation and maintenance. There is considerable scope for the exchange of experience and information, within and among regions, in many of these fields of research.

4. TRAINING, AND THE TRANSFER OF TECHNOLOGY

The above issues all demand sufficient skilled human resources for their effective implementation. So too does the development and management of agriculture under irrigation and drainage, and other associated water-related activities. The requirements and facilities for training vary from country to country, and among regions, and therefore the needs are to some extent site specific. but there is an evident general problem of bringing knowledge to the level of the farming community and to the farmer. This calls for the wider extension of information on agricultural water use, in order to benefit from experience gained from research and from full-scale farming operations within the regions and individual countries. It is perhaps one of the most urgently needed forms of support, and one which will create a more responsive community as more complex and productive systems of farming are introduced.

There is already a massive global effort in the study and development of methods, techniques and equipment for the management of water resources per se, and for their use in agriculture. Some information and materials are of general application, some will be suited to particular regional, climatic or site conditions. All possible efforts should be taken to make this available to national agencies, through international institutions and initiatives, and to mobilize local facilities for the dissemination of material of special relevance to on-farm application, in appropriate forms and languages. The various agencies working in this field, including UN, FAO, the World Bank, regional development banks, IIMI, and bilateral organizations, have already established

operational bases and programmes, and it would be beneficial to supplement these activities with improved support through regional centres, and through regional offices of the UN system, to give easier access to material and to provide scientific and technical advice close to the areas of need.

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ANNEX I

Assessment of Progress in the Implementation of the Mar del Plata Action Plan and Formulation of a Strategy for the 1990s

UNDP-Funded Project

Consultant on Agricultural Water Use

TERMS OF REFERENCE

Duration: 6 weeks per region
Region Covered:
EOD: 14 January 1990

The essential specific duty is to ascertain why the Mar del Plata Action Plan has not achieved anticipated results at national level and to apply these findings in assisting preparation of a strategy for further implementation in the 1990s. Within this overall objective the consultant will visit one or more of the above regional offices of the UN, relevant regional officers of the specialized agencies, selected River Basin Commissions and national agencies, and carry out the following duties:

(a) Collect information concerning major achievements, future master plans, constraints which inhibited progress, in the development, utilization and management of water resources in respect of agricultural development with special reference to water use efficiency, waterlogging, salinity and drainage, agricultural water quality management and community oriented small-scale water projects.

(b) Provide case studies to illustrate specific examples which have led to successful solutions as well as failures which have resulted in inefficient water use and associated problems.

(c) Assess major problems and requirements to overcome them in relation to technical, economic, social, human resources and institutional aspects and, based on this assessment, develop recommendations which would form part of the overall strategy to accelerate progress in the implementation of the Action Plan.

(d) Prepare a list of projects and project ideas that are appropriate to selected countries within the framework of the action programme.

(e) Prepare a technical report concerning the various aspects of the agricultural water use in the region to serve as an input for the preparation of an action plan for water and sustainable agricultural development to be developed as one of the strategies for the 1990s.

(f) Participate in an informal meeting to be held in Rome in February 1990 in collaboration with regional commissions and UN organizations to formulate an action plan on water and sustainable agricultural development.