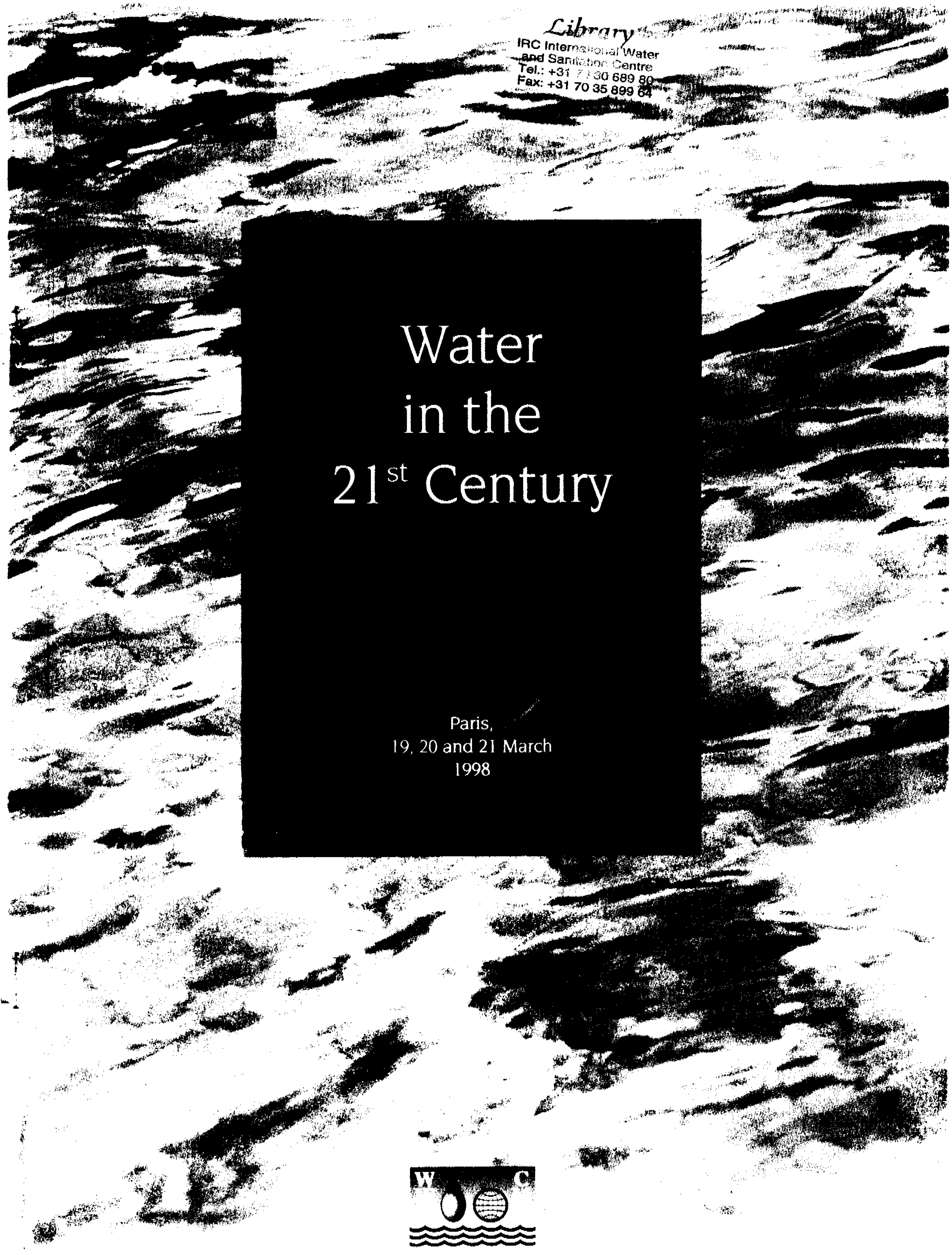

Water in the 21st Century

Paris,
19, 20 and 21 March
1998

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During the United Nations General Assembly, at its 19th Special Session in June 1997, President Chirac proposed to host an International Conference in France in March 1998 gathering all the actors involved in water policy. The "*International Conference on Water and Sustainable Development*", taking place in Paris from March 19 to 21, 1998, is organized within the framework of preparing for the Sixth Session of the Commission for Sustainable Development (CSD) which will be held in April 1998 and will have freshwater issues as the main item on its agenda.

The objective of the Paris Conference is to contribute actively to the elaboration of strategies necessary for improving freshwater resources management in rural and urban areas aimed at providing better water and sanitation services, ensuring food security, protecting the environment, and developing water resources for economic functions. The three themes of the Conference are:

1. Improving the knowledge of the resource to improve the sustainable management;
2. Promoting the development of new institutional capacities; and
3. Optimizing water management for the elaboration of national strategies and the mobilization of the appropriate financial means.

The purpose of this document, prepared for the International Conference on Water and Sustainable Development, is to introduce the three themes of the Conference by presenting the current status of water resources development for all uses in the world, the probable future situation, and the policy implications of the planning targets that would need to be put into place. The document builds on the various results obtained during previous international water meetings, and notably the "Comprehensive Assessment of the Freshwater Resources of the World" presented at the Fifth Session of the CSD in 1997.

The document is written on behalf of the World Water Council by Senior Consultant Robert Rangeley at the request of Executive Director Guy Le Moigne, with the assistance of Task Manager Arienne Naber and of Mr. Jean Verdier, Senior Water Management Expert. Preparation of this document benefited from consultations with members of the Council particularly of Council Vice-President René Coulomb. Messrs. Denis Baudequin and Pierre Strosser, Water Management Specialists, also contributed to the document.

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Water in the 21st Century

Paris, 19-20-21 March 1998

Document realised by the World Water Council

Water
in the 21st Century
Summary

"And from water we created every living thing", the Holy Quran Says. Water is life in all its forms for humans, plants and animals alike. In this respect water is unique and it has no substitute.

Amongst global natural resources water is the most critical. Water is essential for food and commercial production, for sustaining a healthy ecosystem and viable human enterprises.

Water is an important element for many cultural and religious aspects. The planet earth drives its color because of water. The feeling that water is abundant in many parts of the world led to inefficient management and misuse and abuse. The over-exploitation, pollution and depletion of available resources threaten our global society in its own fundamental existence.

This background paper is prepared to highlight the complex dimensions of World Fresh Water, its fragility as resource and the prediction for the near future in the next century.

These issues have been in discussions for several decades, especially after the Mar del Plata in 1977. We have since made some progress, however population growth and lack of proper management mechanisms, public awareness and sustainable commitment to preserve, conserve and improve the situations have contributed to the present crisis.

It is hoped that with renewed vigor and interest in world fresh water issues concrete action will follow to reverse decades of neglect and mobilize world effort to deal effectively with the critical issues.

The ultimate challenge for all water professionals, decision makers and politicians is to put into practice what we all very well know. It is essential that we translate the ideas, conclusions, recommendations to action on the ground. We should endeavour to ensure that our actions will have concrete results in improving the prospects for managing world water to meet the requirements of future generations as well as all the needs of other forms of life on this planet.

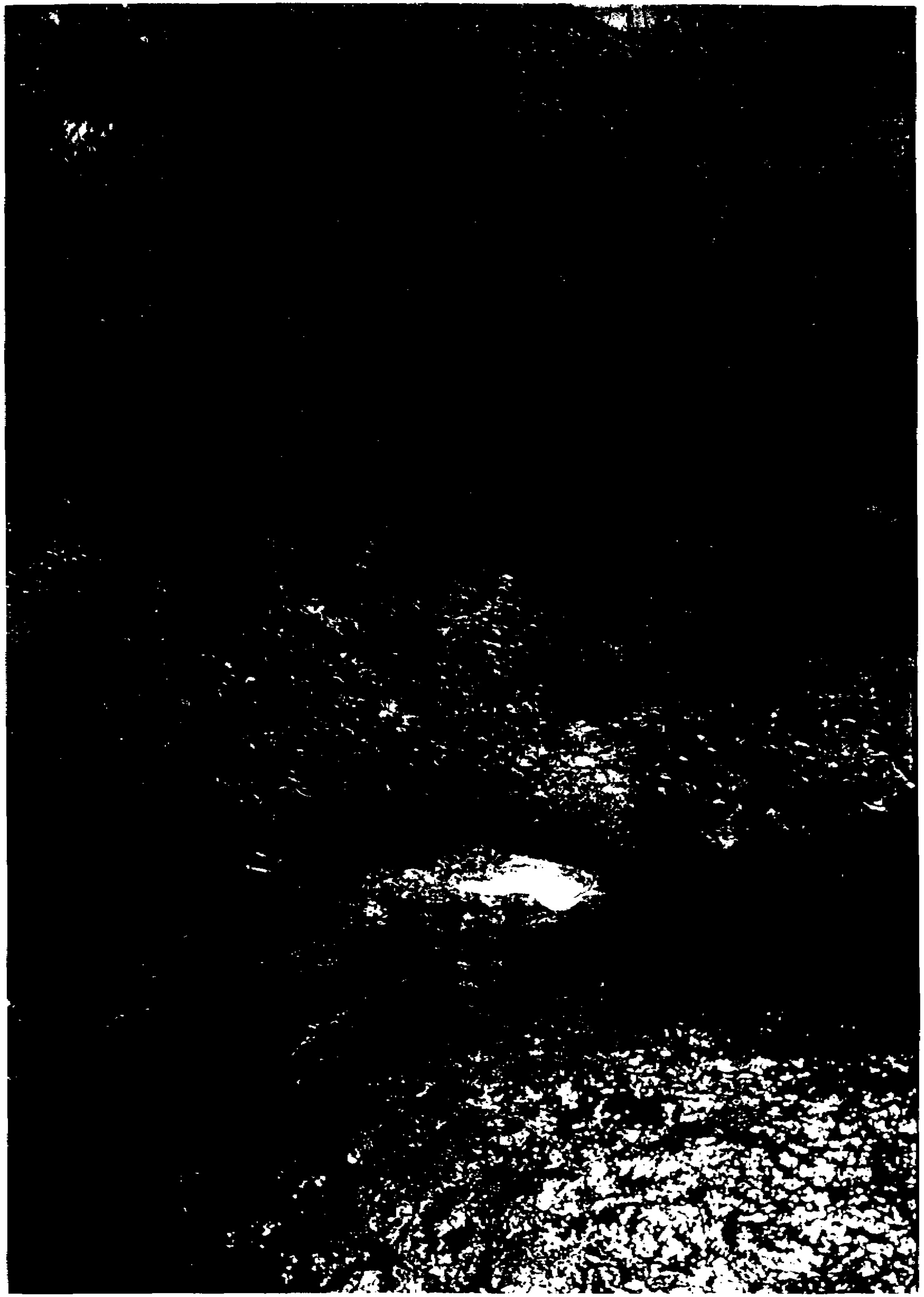
Our contribution to better understanding and to the dissemination of the information to a wider public is of crucial importance if we are to succeed in meeting this formidable challenge.

We hope this report will stimulate many discussions and provide adequate background materials for a fruitful dialogue among many of the stakeholders.

Dr. Mahmoud A. Abu-Zeid

President of the World Water Council

Minister of Public Works and Water Resources, Egypt



Introduction

The rapid growth in the several uses of water over the last half century has precipitated a universal awareness of the need to take stock of the present situation and examine the options for the future. As a consequence, many organisations have been researching the situation. Some have a multi-purpose interest and others are concerned with separate aspects of water affairs such as geographical water balances, environmental preservation, pollution control and the socio-economic consequences of building future infrastructure (dams and conveyance systems to increase water supplies to meet ever increasing demand) and also with policy reforms.

With the aim of making objective contributions to the formulation of strategies required for a better protection and management of water resources, the French Government has organised this international conference on "Water and Sustainable Development" to be held in Paris from 19 to 21 March 1998. Invitations have been extended to the principal persons responsible for water policies in 80 countries.

The World Water Council (WWC) was founded recently in order to constitute a forum for penetrating reflection on the long term policies and strategies on water affairs. Acting within the framework of the declaration made at the meeting in Marrakech on 22 March 1997, it is preparing a Long Term Vision for "Water, Life and the Environment" which will be presented at the Second World Water Forum in The Hague, the Netherlands, in March 2000.

In setting the scene for the three Workshops, that form the programme of this conference, it is appropriate to reflect on:

- the present status of water development for all uses in the world;
- the tools that might be used to assist improved use of existing services and expansion into new services;
- the probable future situation, with viable planning targets, over a period of conceptually 25 years - including consideration of the policies and strategies that would need to be put into place; and
- policy implications

The Paper is discriminating and thus its framework has been designed to focus on the issues that seem to be most at stake. At the same time, it aims to assist decision makers, practitioners and users in the achievement of improved management of water resources and preservation of the environment whilst, at the same time, satisfying future human needs.

Main organisations consulted in the preparation of this Background Document

Agence de l'Eau Seine-Normandie ; British Geological Survey ; Canadian Agency for International Development ; GIBB ; HR Wallingford ; IH Wallingford ; International Association on Water Quality ; International Commission On Large Dams ; International Water Management Institute ; International Water Service Association ; Ministry of Public Works and Water Resources of Egypt ; Mott MacDonald ; Suez-Lyonnaise des Eaux ; UNESCO ; United Nation Development Programme ; Warren S., Water Quality Consultant ; World Bank

Present situation

Each year, about 40,000 km3 runs off the lands areas of the earth into the sea but the resources readily available to man do not amount to more than about 13,500 km3/year (of which 2,000 km3 are groundwater). The net consumption is estimated at 20 % of the readily available resources. However, the disparities between countries are wide and some are already faced with constraints in meeting domestic demand owing to physical, socio-economic and political factors. These disparities must be reduced in a manner that will ensure that essential demands are met whilst retaining a sustainable mode of development.

1.1 Water availability

1.1.-1 *World water balance*

A consideration of the general world wide water balance and its current trends provides an informative background for countries wishing to set their own detailed balance sheets into a wider perspective. Otherwise for regional and more local planning purposes, world-wide data has limited value. With that understanding, it is worth while looking at the total renewable resources, estimating availability in time and space and making preliminary judgements on those countries that might experience special problems of water scarcity over the next 25 years.

There have been several attempts to evaluate the status of water resources on a world-wide basis. The most recent is the "Comprehensive Assessment of the Freshwater Resources of the World", published in 1997 by the WMO. Another is the FAO "Food Production : the critical role of water". Both documents present estimates of withdrawals or (abstractions).

In order to get a clear comparison between availability and demand, it is, however necessary to arrive at some estimate of net consumptive use, a concept introduced by two recent studies : one by I A Shiklomanov and the other by the International Water Management Institute (IWMI). To keep the concepts of water abstraction and water consumption clearly separated it is better to avoid, where possible, the general but ambiguous term "water use". Abstractions cover all withdrawals from the source including both surface and groundwater. Consumption covers all water that is irredeemably consumed in the relevant process, such as evapotranspiration of the crop in irrigation and the evaporation losses in a power plant cooling tower.

Some workers have criticised attempts to prepare global balance sheets on the grounds that the data is too inaccurate for presentation. Others hold the view that it does not much matter because the figures are used only for the general types of comparison mentioned above. In any case the figures of both abstractions and net consumption will remain imprecise if only on account of the extensive reuse that takes place in the hydrological cycle. For more precise balance sheets studies such as "Water in the Mediterranean Region" need to be prepared for selected countries.

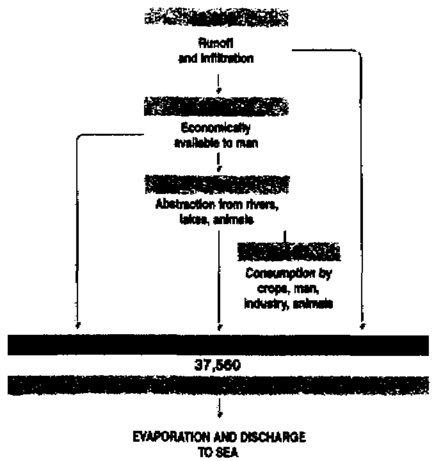


Figure. 1 - **Global water balance 1997 (km3/y).**
Based on the figure of 4,000 km3/year shown in fig. 1, the global abstraction amounts to 30 % of the total readily available renewable resources

Table 1 - Water use by continents

[illegible]	[illegible]	[illegible]	9	544	245
[illegible]	[illegible]	[illegible]	8	1531	519
[illegible]	[illegible]	[illegible]	26	354	1280
[illegible]	[illegible]	[illegible]	54	359	713
[illegible]	[illegible]	[illegible]	42	697	1861
[illegible]	[illegible]	[illegible]	2	23	905
[illegible]	[illegible]	[illegible]	73	133	476
[illegible]	[illegible]	[illegible]	23	3240	644

The abstraction from groundwater is approaching its limits.

The abstraction figures discussed above include large amounts of groundwater. About one third of the world's population is entirely dependent on groundwater for domestic purposes and much of the rest is partly dependent on it. In addition, groundwater is widely abstracted for irrigation particularly in the Indian sub-continent where it provides some 40 per cent of the deliveries at field level. In France, Germany and the Netherlands groundwater forms over 60 per cent of total abstraction. Taking these facts into consideration, as much as one third of all water abstractions and of consumption might be derived from ground sources albeit, in surface irrigated areas, the original source of groundwater is the infiltration of imported surface water and in making abstractions of alluvial aquifers an important part of the withdrawals derive from the infiltration of river flows.

1.1.-2 *Quantity of available water per person*

Although, on a global basis, the amount of water per capita (average about 2,300 m3/cap/y) is a very comfortable level of availability compared with consumption (or even abstractions), there are many countries of the world where the variations in hydro-meteorological conditions are wide and, as is well known, a number of countries suffer water scarcity and many more will do so as population pressures and economic growth stimulate further demands.

It is difficult to arrive at reliable national figures for water availability for a number of reasons. Firstly, any country-based approach involves assumptions concerning the controversial matter of international water entitlements. Secondly, water demands are strongly influenced by atmospheric water. For example, several arid zone developing countries with extensive irrigation have current abstractions exceeding 1,000 cubic metres/person/year compared with, say, 250 cubic metres/person/year in the United Kingdom, where owing to favourable atmospheric conditions, there is little need for irrigated crop production. The influence of atmospheric water is a matter which has received little attention. It has been debated but not included in the evolution of the Helsinki rules on the sharing of international waters.

1.1.-3 *Efficiency in the use of water (agricultural, domestic, industrial uses and evaporation*

An appreciation of the processes that influence the efficiency with which water is used is essential to the understanding of a range of factors involved in water resource planning and management. Furthermore, in many parts of the world, a stage has been reached where new demands for water supplies can only be met through the use of economies derived from enhanced operating efficiencies. Apart from the simple benefits of water economy, efficiency of water use has an impact on investment in infrastructure, on the overall ground and surface water balance and on the

practical application of the principle of water as an economic good.

The global net consumption of water in irrigation is about thirteen times that in domestic and industrial supply. In the developing countries of Asia, the ratio is higher at about seventeen times

The greater part of the renewable supplies of water consumed in the world are devoted to irrigation. The efficiency of consumption in irrigation dominates any approach to water conservation. There are several definitions of efficiency used in irrigation practice and each is valid for different but complementary purposes. The two that are most useful as general performance indicators are:

- Irrigation Efficiency : net amount of water added to the root zone of the crop divided by the amount abstracted at the source (expressed as a percentage).
- Water Use Efficiency (WUE) : usable crop yield divided by the evapotranspiration consumed in its production (expressed as weight of usable crop per cubic metre of water consumed).

Irrigation efficiency is a good indicator of the quality of management, the condition of the infrastructure and the husbandry of farming in all irrigation projects. However, it is influenced by a number of factors such as topography, the size of farm holdings and the structure of the soil) and, more importantly, by the type of irrigation practices. Conventional surface irrigation, which is the most widely widespread method in the world, under well managed conditions provides efficiencies of 35 to 45 per cent (a little less than 40 per cent is average in the USA). Modern irrigation methods, such as drip and sprinkler, permit efficiency levels of 65 to 75 per cent to be achieved. The margins for improvement are thus considerable.

At the river basin level the efficiencies can be much higher given the right conditions for the re-cycling of seepage, run-off and drainage water. For example in the case of the good groundwater areas of the Indo-Gangetic Plains where, with the introduction of some conjunctive use of ground and surface sources, the irrigation efficiency can rise from about 40 per cent to 60 per cent and more.

In addition to measuring system performance, irrigation efficiency provides for the quantification of the water that is returning to the hydrological cycle: an important component in the regional water balance. Many writers on the economic and social aspects of irrigation have seriously misunderstood the meaning of irrigation efficiency. They have seen the non-productive proportion of the water applied to the crop as a wastage that is lost from the hydrological cycle. This may be a valid concept from a strictly project point of view but is not valid in the context of a river basin (except for a few coastal situations). In parts of Asia, where seepage losses can be usefully stored in the groundwater reservoir, low irrigation efficiency provides many advantages especially where groundwater storage is more economical and socially acceptable than surface water reservoirs.

Water use efficiency (WUE) is a valuable performance indicator.

Situated, as it is, on the interface between the water delivery and the crop, water use efficiency is a valuable performance indicator. It illustrates well the contribution irrigation makes to the food supplies of the world. To take the simple example of wheat, the WUE is now generally over 1.0 (kg/m3) and under good conditions can reach 1.5 to 2.0. Three decades ago the figure was about 0.5. (The new crop varieties grown in arid zones respond well to fertilisers and other farm inputs only where there is good irrigation and drainage).

In water short conditions, maximising WUE can make important contributions to production, something that has been known to farmers since irrigation began. Where the choice is available, the farmer will use his scarce water resources at points in the growing season when he can maximise the marginal WUE. In the Indo-Gangetic plains and many other regions farmers have traditionally been allocated more land than water for its irrigation (mainly to pro-

Farmers recognise that, when water is the main constraint, production per unit of water is more important than production per unit area.

vide for fallow and flexibility in crop husbandry) so they have deliberately over-cropped the available arable area and under-watered the crops. They found empirically that, for wheat for example, to apply only about 83% of the crop water requirements for maximum yield would give the maximum WUE.

In addition to the concept of WUE, there are methods of performance evaluation that link with economic parameters such as the production value per unit of irrigation water (expressed as gross margin or some other form) and calculated either for total farm production or for specific crop production (cotton, rice, sugar...). Such indicators can be helpful in guiding general strategies in irrigated crop production.

The application of the concepts of efficiency to domestic and industrial water supply, generally requiring much smaller water abstractions than irrigation, responds to a simpler equation than does irrigation. Here, the major consideration from the water balance point of view is the loss of water by leakage in the distribution system. Leakage of reticulation systems may be caused by improper installations, corrosions, damages due to road traffic, weak maintenance and often the neglect of the existing physical infrastructure which have not been properly maintained or rehabilitated.

The leakage reduces the amount of water effectively available to the customers. Although, in the event, the leakage can bring benefits to the downstream riparians (except in seaside situations) in that it recharges aquifers, the leaked water has incurred a production cost which cannot be recovered. Furthermore, the reduction of leakage contributes to the growth in demand and so defers the need to make additional capital investments in new sources (which tend to become more costly over time). In big cities, like London, leakage may also contribute to a rise of the water tables which is causing damage to the foundations of buildings. Thus, it is worth improving the technical efficiency of the distribution systems (ratio between the quantity of water reaching the customer and the quantity produced). The cost of leakage reduction rises with the level of efficiency achieved. Unfortunately there are cases where the amount of water reaching the consumer is barely half the water produced. It is generally economically worthwhile carrying out systematic leakage surveys and executing the necessary repairs to obtain an efficiency up to 80 per cent which is a reasonable standard for well maintained systems. In Paris, where water mains are installed within the sewer conduits, the mains can be easily inspected and, thanks to a rigorous programme of management and maintenance, the leakage from old pipework is kept at a very low level with an efficiency of over 90 per cent.

The total consumption of water by the world's reservoirs in the form of evaporation exceeds the total net consumption in domestic and industrial supplies.

Evaporation from open water surfaces, including man-made reservoirs and natural wetlands and lakes, represents losses that completely escape the hydrological cycle of the river or drainage basin. Conflicts of interest may arise. For instance, the intentional depletion of the Aral Sea served the need of irrigation in an arid, but otherwise highly fertile zone. Similar considerations apply to the marshes of the upper Nile basin where, by the construction of by-pass canals and other measures, some 10 km3 per year could be added to the usable flow in the Sudan and Egypt.

With small reservoirs, such as widely adopted for irrigation and general purposes in much of Asia, the overall efficiency (input divided by output) can be as low as about 25 per cent. For very large reservoirs, such as Aswan, it is about 90 per cent. It is illustrative to speculate hypothetically that a saving of less than 10 per cent in the evaporation from Aswan reservoir would be enough water to meet the total municipal net consumption of, say, Canada.

1.1.-4 *Demand Management*

Demand management refers essentially to ways in which the supply utility can influence the consumer to moderate his demands and avoid wastage.

Demand management has been an inherent part of irrigation planning at all times. In the vast irrigation systems of the world, the farmer receives a quantity of water that is largely predetermined but with inevitable variations according to availability. With the so called "on demand" systems some form of demand management has to be imposed but such systems are found essentially in industrial countries and occupy a very small part of the irrigated area of the world. This does not mean there is no scope for more demand management in irrigation in developing countries particularly where conjunctive use of ground and surface water is concerned.

When comparing demand management in domestic water supply with that in irrigation, it is important to keep in mind that much higher assurance of supply levels are attached to domestic water supply. Whereas the assurance level for irrigation may be between 70 per cent and 80 per cent domestic water supply should have a level of almost 100 per cent. The assurance level for industry depends on the type of activity and on the production processes.

For both domestic and industrial supplies, demand management is largely through the tariff structure (apart from common instruments such as periodic hosepipe bans). Physical restrictions on supply, such as periodic cuts, are no longer acceptable, yet, unfortunately, are still found in some urban centres. To take the example of Buenos Aires, the principal progress achieved in the management concession is to secure, for the first time in 15 years, a reliable supply of water. Additional demand management features, such as the introduction of small capacity toilet cisterns or of aqua-privies (flushed with kitchen and bath wastewater) have only limited impact.

The application of demand management instruments does not set aside the need to adopt comprehensive water management and planning principles. Such a comprehensive approach would embrace the allocation of scarce resources to different sub-sectors and the principles for new resources exploitation. The overarching consideration would be the national policy for land use (urbanisation, industrial estates, irrigation, etc.), all within a sustainable framework.

1.2 Water use

1.2.-1 *Big advance in urban and rural water supply*

Published statistics on domestic water supply in developing countries are unclear on a number of points of presentation. There is a lack of definition of the basic criteria : access to water of "reasonable quality". Secondly, there is even less clarity on the matters of reliability, efficiency and serviceability.

Supply security is essential at any time. It should not be accepted that some urban systems run only for a few hours a day with dangerously low pressures. The upper stories of small buildings may not receive water (high multistorey buildings have their own pumps) and the water may be polluted by the soil surrounding the pipes if they are in poor conditions and the pressure in the aquifer is higher.

Unfortunately, the same urban systems often have, at the same time, a poor quality high leakage (often higher than 30 per cent of the produced water) and water cuts during peak consumption hours.

In any consideration of the growth in domestic water supply it is important to bear in mind that all people obviously have access to some kind of water supply and therefore it is more of a question of enhancing standards of quality, quantity and reliability rather than simple expansion.

During the Drinking Water and Sanitation Decade (1980 to 1990), excellent progress was made in both urban and rural water supplies. The original targets set for the decade were quite unrealistic so it is no disgrace that they were not met. Over the decade the number of people in the urban communities of developing countries served with water of "reasonable" quality rose by 80 per cent from about 600 million people to 1,100 million. In the rural areas the growth was even greater from 650 million to 1800 million or 175 per cent. The proportion of the population of developing countries served with reasonable water supply thus rose to an average of 75 per cent, leaving about 1 billion people unserved.

In European countries the proportion of population served with piped water supplies has continued to approach full cover. Whereas in 1978 there were four countries with a supply rate above 98 per cent, there are now seven in that category.

The conveyance and treatment of water calls for major investments which depend largely on local conditions. Furthermore, the improvement of the quality of water abstracted from often polluted raw sources involves high costs. The relative lack of sensitivity to resource development costs, in the usual situation, is because such costs are often as low as 15 per cent or less of total capital costs. Its significance on the total production cost is further diminished because the expenditure on operation and maintenance of the raw water infrastructure is small compared with that on water treatment and distribution.

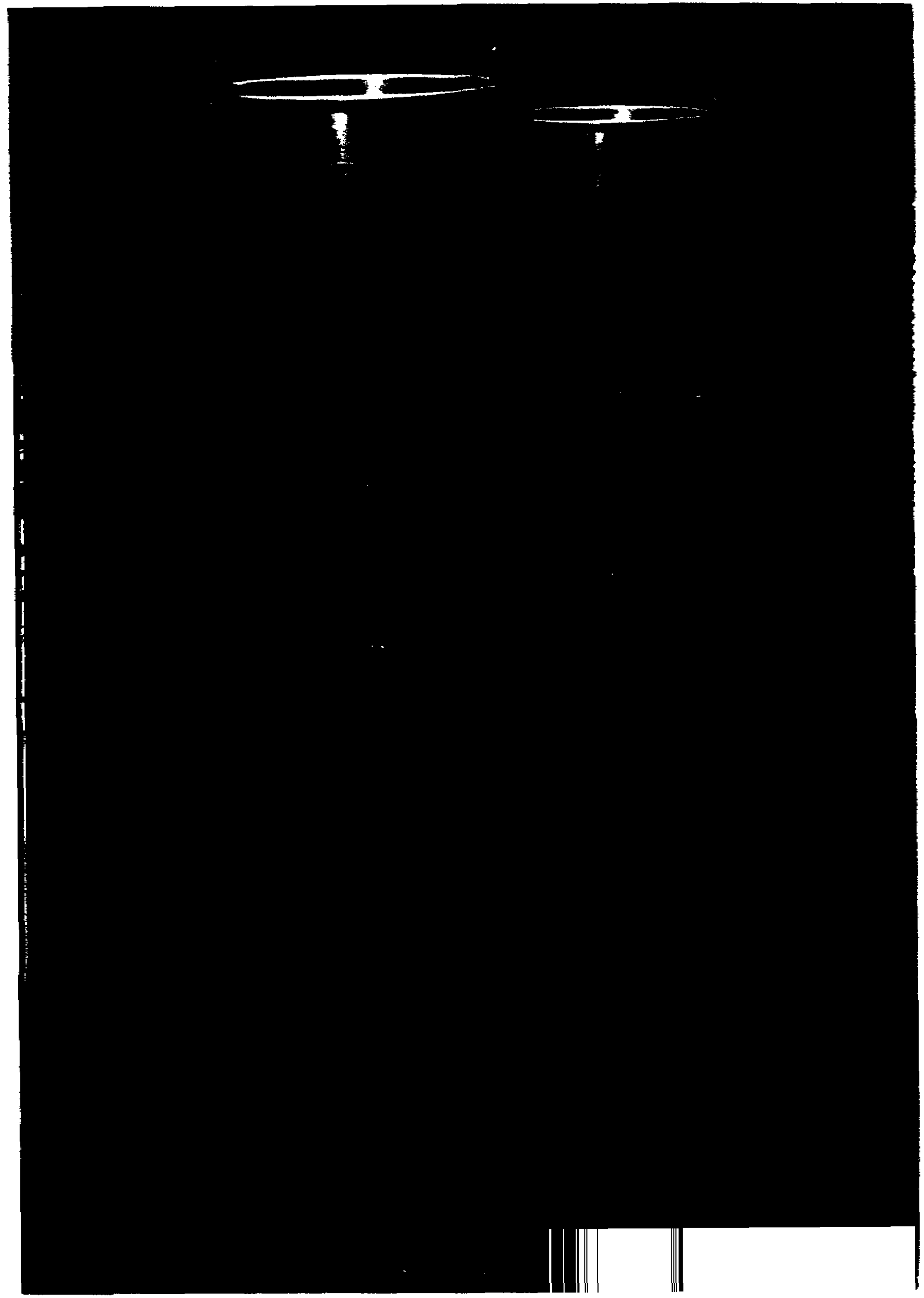
Average figures must be viewed with caution : for reliable, urban utilities of good standard, offering a piped delivery and a capacity of 200 l/p/day, the investment costs are about $250/p. This figure is indicative only and exclude special costs such as those of major environmental impacts, connections to houses, inside sanitary installation and sewerage and wastewater treatment.

Rural domestic supply costs in developing countries are, on average, much lower than those for urban because they are usually based on groundwater suitable for use without treatment and the amount drawn is modest at about 10 to 20 litres/p/day. However, in developing countries where rural areas are connected to the main networks, the capital cost may be higher than in urban areas for low density population far away from the central supply.

In any comparison between rural and urban investment costs, there is the crucial matter of sewerage costs to consider. Except in comparatively rare cases, a major urban water supply system cannot be safely introduced without a sewerage system for which the costs are likely to be some $350 per person, that is almost 50 per cent more than the water supply. A typical full urban water and sanitation infrastructure might thus cost about $600 per person or $2,500 per household. In difficult rocky terrain or with high quality sewage treatment standards, the costs of all services in an urban water supply and sanitation system, other than house connections and sanitary installations, might be $3,500 per household or even more.

Although difficult access to cheap sources of good quality raw water and any special treatment requirements to remove excessive silt, chemicals, algae or bad taste all clearly add to costs, it seems the dominant factor in high cost areas is inefficiency in management and operation particularly when this is associated with overstapping.

In Europe, data presented at the 1995 IWSA congress, based on a hypothetical household with 200 m3/year consumption, the operating costs were about $1 per m3 in ten out of thirteen countries. The three countries above that level were around $1.40 dollars . The average water demand in Britain was



recorded as 152 litres/p/day and the average household bill was $165 per year which was less than 0.5 per cent of average households income (less than one per cent if sewerage costs are added). The volumetric charge for water alone varied from $0.83 to $1.23 per cubic meter.

Thus water charges form a small part of the household budget and, nevertheless, water price is a sensitive issue among consumers. In addition to its basic purpose of providing a mode of cost recovery for the infrastructure and services provided by a utility, a tariff structure can provide an instrument for demand management and a disincentive to waste water. Even if an increase of 10 per cent in the price of water has little mere effect than a reduction of 1 per cent in household consumption, the consumers react unfavourably to rapid increases in their bills. When water is metered, it is observed in France and other countries that a reduction in household consumption continues over several years whereas, in the former times, in the same zones, the improvements in sanitary equipment and in standard of living caused consumption rise.

As regards water consumption for public buildings, such as schools and hospitals, it declines sharply when it is measured and charged. Industrial establishments linked to the public supply network adopt economy measures whenever water forms a significant part of their overheads. With tariff levels reached in Western Europe, it is observed that, despite the security provided by a public supply, some industrial firms endeavour to establish their own water supply or modify fabrication processes to reduce water requirements.

In the UK, although there is little use of water metering, the domestic demand, at about 152 litres/p/day, is lower than in most other European countries where metering is mandatory. However, metering trials in the UK indicate that a reduction in consumption of about 10 per cent can be obtained.

There is a need to continue the present major effort to enhance access to good water supplies and the tradition and cultures of the users must be taken into account.

Water vendors are active in many parts of the world. In some Asian and Middle Eastern countries, vendor supply is a cultural residue of the traditional system. They often operate in parallel with other modes of supplies and compensate for lack of predictability and reliability. In the majority of cases, water vendors offer a supplementary system designed to provide perceived good quality potable water and it occupies a place in many developing country markets. The cost of vendor supplies is generally much higher than the one of public supply (sometimes twenty to thirty times higher) but the quantities purchased are small. In Indonesian towns some 20 per cent of the population is said to use water vendors as a supplementary supply. In many parts of the Middle and Far East water is still abstracted from the traditional underground galleries. It is prized for its reliability, taste and perceived quality. Furthermore, except where conveyed by hired labour or vendors, it is almost a free good to the local community that owns the galleries.

Rural systems vary widely but since the development of low cost borehole technology, most current systems are based on shallow tube-wells with hand or mechanical pumps. In Asia many of these installations serve multi-purposes and provide irrigation and other agricultural supplies as well as domestic water.

Apart form the conventional shallow well (open dug well of borehole) equipped with a simple pump, there are many other variants in domestic water supply. In places, deep wells have to be used and occasionally there are opportunities to use artesian wells for rural supplies. Classical springs are widely used in hilly areas for both urban and rural supplies (e.g. Ethiopia). In some situations simple surface off-stream ponds are dug (the tanks of Asia or the hafirs of the Sudan).

These examples serve to underline the need for flexibility in planning with due regard for the merits of some of the traditional systems and for what the people want.

Management and ownership

In almost all rural societies, the village pump, fountain or gallery has always been adopted with a strong sense of ownership, something which should contribute to the care and maintenance of the system. For this and other reasons the present trend is to hand over to the rural communities as much responsibility as is feasible for the operation and maintenance of the facility and for the collection of funds (or labour in kind) to meet costs. In the case of some social development projects most of the essential village infrastructure is rolled into a single package and is implemented with participation and contribution from the local community and then handed over to them. However there are some components, such as small dams, where government intervention is necessary to ensure the conservation of the infrastructure and the safety of the community.

There has been a rapid movement to mobilise a greater participation by the private sector. The main objectives are to harness the management efficiency perceived to reside in the private sector and also, to mobilise private financial resources. Given a strong regulatory body (independent, central government, local government or other local body) such a mode of operation seems to afford governments equal if not more power, albeit, with less accountability.

The private sector is more and more involved in urban water supply. The use of the private sector takes one of three broad forms: (i) Full privatisation by the disposal of both statutory liabilities and ownership of infrastructure to newly created water companies, (ii) a management lease (usually about 15 years) to maintain and operate the system in return for a defined stream of revenues with commercial responsibility except for risks associated with large investments, and (iii) a concession with features similar to a lease but with full responsibility for investments. There are a number of variants with a mix of responsibilities and ownership. There are also arrangements to use the private sector in limited ways whilst retaining public control such as individual contracts for meter-reading and for specific services. There are in effect a wide range of options used today to mobilise the private sector in the water industry for operations, finance and construction. The system in the UK goes the furthest with complete privatisation. The appointed company is awarded an operating license for re-negotiable periods of 25 years but, being at the same time owner of the utility, this virtually implies perpetual rights. France has long adopted a leasing system and has moved to concessions. The French system adopts some important characteristics including the retention of powers by a local public authority, endowed with political legitimacy and having close contacts with the consumers. A further important characteristic is that the ownership of the infrastructure remains in the public domain. A number of developing countries have also mobilised the private sector generally with a leasing or concession system (e.g. Argentina, Côte d'Ivoire, Guinée, Macao and Malaysia).

Monopoly markets in water supply must be controlled (or regulated) to ensure that the appointed water company, whether by privatisation, lease or concession, does not abuse the dominant position. The French system favours a variety of regulatory mechanisms which avoid a single mode of action and which, at the same time, preserve some political influence from users and elected officials. The British system makes a special point of creating an independent regulatory body in the belief that independence strengthens its powers. However, in December 1997, the National Audit Office of the British government criticised the regulator with the allegation that he did not use his independent views to create his own industrial standards but arrived at conclusions "by comparison among the 29 water companies who still enjoy almost complete monopolies".

For important urban water supply developments, the strongly emerging pattern of global capital investment offer opportunities with such formulae as Build, Own and Transfer (BOT). The appointed private company finances and builds the infrastructure works, then manages them for a period of time long enough to make the investment profitable.

In developing countries, the proportion of GDP allocated to water and sanitation rose from 0.25 per cent to about 0.4 per cent over the decade 1980/90. Investment funding has been very dependant on external finance at about 55 per cent except for Africa at about 80 per cent. Contributions to funding by the utilities themselves have been disappointing, especially in Africa and Asia, and fell from about 20 to 10 per cent. Compensation for the fall appears to come from the increased allocations from public investment (despite its overall decline) and from external sources (Fig. 2).

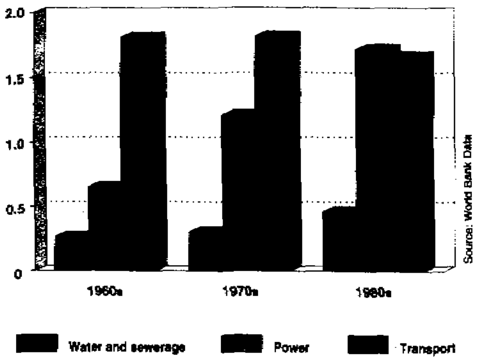


Figure 2 - **Investments in infrastructure in developed countries over 30 years - percentage of GDP.**

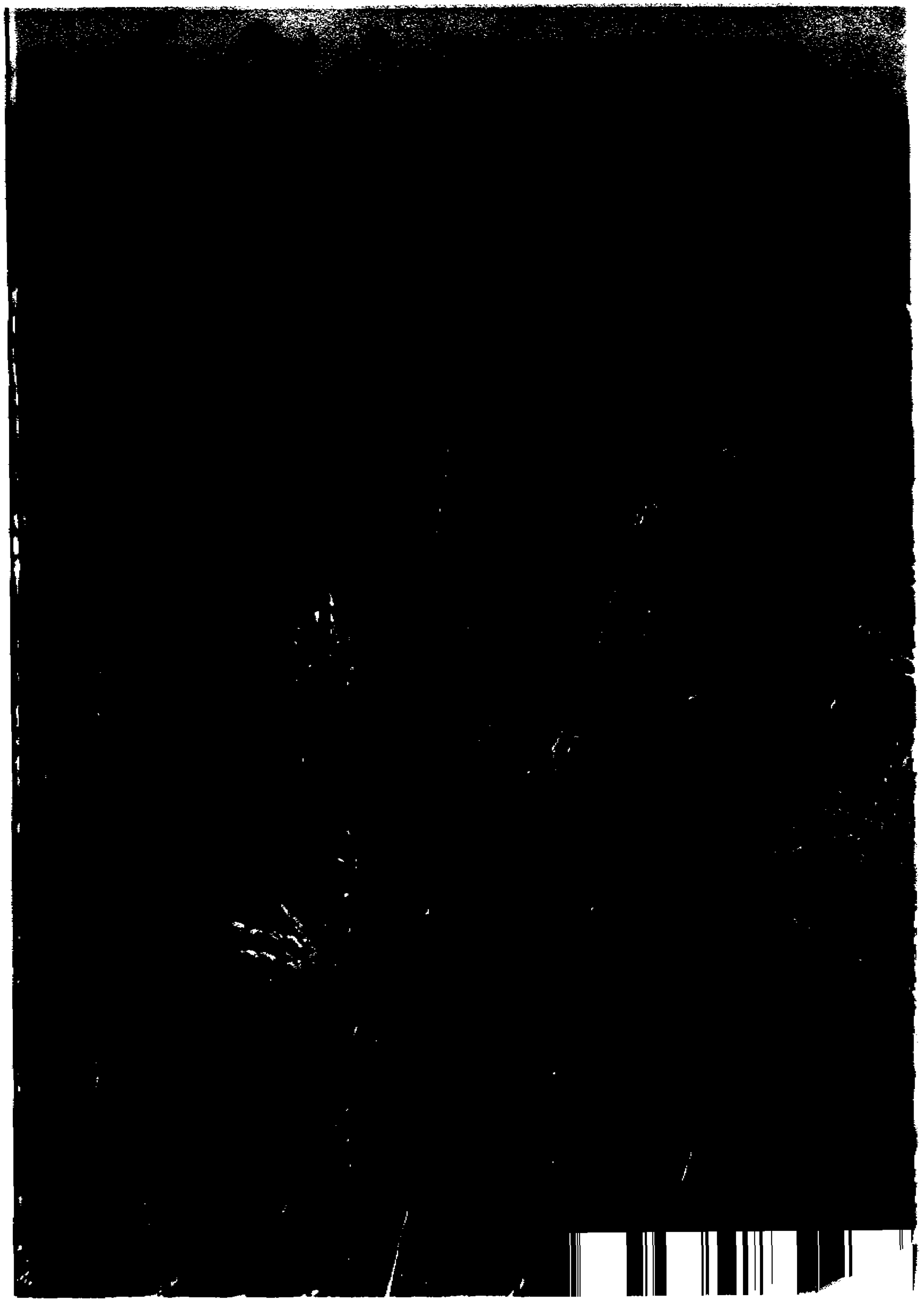
1.2.-2 *Irrigation: an era of rapid expansion*

In the last half century there has been a rapid expansion of irrigation both laterally, through geographical extension, and, vertically, through more intensive cropping. The methods of recording the statistics of irrigated areas vary from country to country with several different criteria for measurement. However, if irrigated area is defined as the gross geographical area of land equipped to deliver water to any part of it, the best available figures show that the total area in the world is over three times that had been developed by 1950. The global total is about 273 million hectares of which about 185 million are in developing countries.

The drive for rapid expansion of irrigation in developing countries came out of the fear among politicians in the newly independent states of Asia that there would be famines - something well known in their then recent history.

Table 2 -
Comparison of estimated abstraction and consumption (1998) - Km3.

[illegible]



Like the farmer, the politician knew that the incremental production to be obtained from additional land was more certain than what could be expected from increased yield, so rapid lateral expansion became a widespread strategy. In developing countries, to speed the process of development and so settle more of the growing poor population on irrigated land, decision makers adhered to the existing low cost, well tried irrigation technology. There was little attempt to adopt improved technology other than the addition of storage reservoirs which, for example, entered the Indian sub-continent for the first time in the 1950's. Simplicity and low cost were overarching objectives but that inevitably led to canal networks with few hydraulic controls and thus limited operational flexibility. In the meantime, the 1960's made available modern farm inputs including high yielding varieties (HYV) of staple crops and irrigation technology was soon found to be lagging behind modern crop husbandry.

By contrast, in the developed countries, irrigation technology advanced in line with agricultural technology. Here the main objectives were to reduce labour inputs and improve efficiency with the introduction of various overhead sprinkler methods and, recently, by the adoption of drip lines and micro-sprinklers. In the 1970's the oil crisis precipitated the introduction of low energy methods which have survived the subsequent fall in oil prices. These modern methods are being slowly adapted to conditions in the developing countries but there are many problems to be solved by research before irrigation in developing countries will catch up with agricultural technology.

Taking account of both lateral and vertical expansion, the cropped irrigated areas of the world increased about four times over half a century and the water consumption went up at least in proportion to what is estimated to be about 2,000 km3 today

At its peak, in the 1970's, the rate of horizontal expansion reached between 4 and 5 million hectares a year with about 40 per cent of that being in two countries, India and China. By the end of the 1980's the growth rate had dropped to about 2 million hectares per year and is no more than that to-day. The intensification of cropping came about later and accelerated from the mid-1960's, stimulated by the advances in groundwater abstraction technology and the many other farm inputs that became readily available to developing countries for the first time, including the new high yielding short maturation period crop varieties (HYV). This opened up the possibility for higher cropping intensities without the need for major canal remodelling. For example, in the twenty years 1965/85, the cropping intensity in Pakistan increased by about 23 per cent and, at the same time, there was a lateral expansion by about 22 per cent . On a global basis, irrigation now contributes about 650 million tons of cereal (or its equivalent), or almost 40 per cent of the world food supply (about 1,800 million tons per year) from about 16 per cent of the cultivated area. In the period 1950 to 1985, the increment in food production attributable to irrigation is estimated at over 50 per cent but in recent years it has been much higher and some experts have judged it to be as much as 80 per cent at present.

In developed countries, the post World War II growth was essentially in high value crops to respond to the demands driven by the purchasing power of the ever expanding affluent urban communities. Mediterranean countries, notably France, Italy, Spain and Israel, were well placed to develop and apply advanced irrigation technology to produce a range of high value crops for both domestic consumption and export. In the USA, most southern hemisphere countries and the Mediterranean regions and eastern Europe, there were similar trends. The vast Aral Sea catchment schemes were launched ultimately to supply the former Soviet Union with about 90 per cent of its cotton demands and fill almost 40 per cent of its domestic rice and fruit markets.

Food production expanded at a rate that kept pace with and indeed slightly exceeded demographic growth in all countries that enjoyed substantial irrigation facilities - provided, of course, they were not disturbed by wars and unrest. As a consequence of high production, there has been a long term downward trend in real cereal price broken only by two minor short lived surges in the 1970's. By common consent the supply of adequate food at affordable prices has made an enormous contribution to the alleviation of poverty and thus to improved nutrition and public health.

The hydraulic impact of the rapid expansion of irrigation on the world's water resources is becoming a matter of considerable concern. Some major rivers of the world are approaching full development, including most of the rivers of the Middle East, the Mediterranean region, the Indus, southern India and southern Africa. Other rivers, like the Ganges, are less than half developed in hydrological terms but present onerous engineering problems to achieve higher levels of utilisation. By contrast, other than the Nile and some southern African rivers, the major African rivers are very little developed, except for hydro-electric power, but their irrigation potential is, in any case, limited by the lack of large entities of irrigable soil as found in Asia and the Middle East.

Irrigation has enabled world food production to keep up with population growth but with impacts on world water resources and on salt balance that now give rise to concern

The rapid exploitation of groundwater resources for large and medium scale irrigation in developing countries is rapidly reaching its limits of safe yield and in some places has gone beyond it. There is also evidence of a further constraint in that intensive pumping and recirculation of groundwater is leading to slow deterioration of the structure and chemistry of the irrigated soils and to adverse effects on the quality of the local drinking water.

Much more water has to be drained from the intensively irrigated land and, as rivers in arid zones approach full utilisation, there are enormous problems of controlling the salt balance at affordable cost.

In many irrigation systems, the total amount of water applied to an area of land has increased by over 50 per cent in a matter of two or three decades. In arid zones these applications have sometimes been further increased in order to preserve soil quality by leaching out the salts that would otherwise accumulate in the crop root zone. Thus, land drainage is a theme which, in many parts of the world, now dominates the thinking of all irrigation stakeholders from the small farmer to the top decision maker.

Classic examples of salt balance problems are found in the Indus valley, the Aral Sea and the Murray basin in Australia. The problem of salt balance presents itself in two stages. The first is to leach the salt from the upper soil profile and drain it from the cropland. The second is to dispose of the saline drainage effluent. In the early stages of river basin development, it is feasible to use low cost effluent disposal methods such as holding basins (discharged during flood flows), evaporation pans or simply dumping into the adjacent desert. In the later stages of basin development, as in the Indus and Aral Sea catchments, saline effluents need to be diverted away from the main course of the river through large outfall drainage channels directly into the sea.

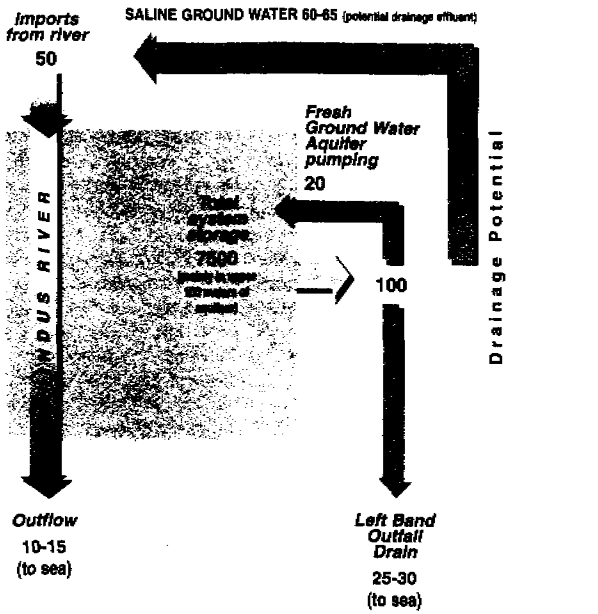


Figure 3 - **Diagram showing projected salt-balance in the Indus basin of Pakistan after completion of the on-going Left Bank Outfall Drain (LBOD). Note the high magnitude of salt stored in the system compared with inflows and outflows - million tons per year. Source: Mott Mac Dolnald**

WUE is likely to become more widely used by engineers, agriculturalists and others as a measure of performance as new sources of water become depleted.

Raising water use efficiency

Most countries now accord priority to the raising of both irrigation efficiency and WUE. This topic is high on the agenda of the Intentional Commission on Irrigation and Drainage through its current WATSAVE programme.

As already stated in section 1.1.3., there has been a big improvement in WUE in the last 50 years largely attributable to the higher harvest efficiencies of the new cultivars (simply expressed as a better grain to straw ratio). For example typical wheat figures of 0.48, 0.54 and 0.92 kg/m3 are quoted for 1950, 1960's and 1979-82 respectively. In the interest of water economy, the concept of optimising WUE in water deficit situations has long been recognised by farmers on the Indian sub-continent where figures as high as 1.5 kg/m3 have been reported. If the present growth rate in irrigated crop production is to be sustained, there is a need to continue to raise the level of WUE.

Irrigation : the pace of change

In developing countries many irrigation systems, both new and old, have remained little changed over the years. This was both a tribute to the original designers and part of a conservative attitude.

The main transformation in the major irrigation systems of Asia has been the wide introduction of ground water facilitated by advances in well technology and, perhaps more importantly, by the availability of rural electrification and the mass produced small internal combustion engine. The tube-wells allowed intensification of cropping without the need for costly and difficult large scale canal remodelling. At the same time the private tube-well gave the farmer a better stake in water management and allowed him greater flexibility in cropping. In some regions there have been large scale irrigation developments based simply on shallow ground water and low lift pumping, as in Bangladesh.

Irrigation systems, once built, become part of the socio-economic geography and changes must be introduced with care and full consultation with all stakeholders and all this may take considerable time.

At one time it was hoped that the use of ground and surface water on the same systems could be better integrated than has been the case. It would have reduced, but not eliminated, the need for large storage reservoirs but the evolution of such conjunctive use of the two sources is to-day constrained by prescriptive water rights and private ownership of the wells. New formulae for the better integration of use must be sought. It should be noted that the rapid evolution of pumped irrigation has made irrigated crop production more vulnerable to any large increase in oil prices.

Although progress has been made in the establishment of enhanced standards of maintenance for irrigation infrastructure, the capacity to implement the necessary action is weak although the conservation of infrastructure is one of the most pressing needs of our time.

Modern irrigation technologies, as widely used in developed countries, are slowly being introduced in developing countries. At present overhead and micro-irrigation occupy about 5 per cent of the 185 million hectares of irrigated land. The modern equipment is generally applied to high value crops and particularly estate crops as in South Africa, Swaziland and Brazil.

The automation of canal control has found limited application but is likely to make more progress in the future. In India, the new Narmada system is being equipped with an advanced control system and the automated Syr system in the Aral sea catchment was in advance of its time when introduced 20 years ago. As with so many other operational processes irrigation should benefit from modern electronics.

Irrigation management, operation and maintenance

As part of the paradigm to make better use of what exists, irrigators must now give much more attention to the ever onerous problems of management, operation and maintenance.

There has been a world-wide trend to hand over responsibility for various stages of O & M to the farmers, directly or through farmer associations.

The existing infrastructure for irrigation represents one of the greatest assets of developing countries with a capital value in excess of 1,000 billion dollars and is now the dominant source of incremental food supply.

1.2.-3 *Water, energy and industry*

A large hydro-electric power potential remains in the world. In Europe and the USA the remaining prospects are few. They exist physiographically in countries like Norway but their viability is limited by environmental considerations and the availability of cheap alternative sources of energy. The main remaining prospects are now concentrated in Africa, the Himalayas, China, Indo-China (Mekong basin), sub-Saharan Africa, parts of Canada and parts of South America. In Africa, less than 5 per cent of the hydro-electric power potential has been developed. Costs are often high owing to the seasonal nature of the river flows which calls for large storage dams as at Kariba (Zambezi) and Manantali (Senegal) and the output needs to be transmitted over long distances to a number of relativity small load centres.

Industrial water supplies are poorly recorded, mainly because many factories are not connected to urban supply networks. Cooling water for thermal

The general trend in industrial water consumption seems to be towards no change or even a small decline in Europe but some large increases are foreseen in developing countries, particularly in the emerging industrial countries of Asia.

Although there appears to be a growing consensus that water is not entirely either a public or social good, there is much debate concerning the practical application of the concept of water as an economic good.

and nuclear power stations is an important industrial use particularly. In the Republic of South Africa, cooling water accounts for about 3 per cent of total water consumption. In some countries, like the UK and parts of the Middle East, there is a tendency to make more use of sea water cooling. In some arid regions, dry cooling is adopted but this reduces power plant efficiency by up to 8 per cent depending on climatic conditions and type of plant.

Industrial water consumption increases are foreseen in developing countries. One projection for India shows a four fold increase from 2000 to 2025.

Some countries that have exhibited rapid industrialisation at various periods between 1970 and the mid - 1980s have had high annual growth rates in industrial water demand such as Japan 11 per cent ; Chile 7 per cent ; Korea 16 per cent and Egypt 13 per cent.

Treating water as a social and economic good

There is much controversy around the treatment of water as an economic good.

The Dublin Statement of 1992 stipulates simply "water should be treated as an economic good". As IWMI said, "The proclamation was a compromise between those, mainly economists, who wanted to treat water in the same way as other private goods, subject to allocation through competitive market pricing, and those who wanted to treat water as a basic human need that should be largely exempted from competitive market pricing and allocation".

Although water as an economic good was a core principle emerging from the Dublin conference, it underwent significant modification at the Rio de Janeiro UNCED Conference a few months later. The Rio declaration (1992) was that water is "a social and economic good with a vital role in the satisfaction of basic human needs, food security, poverty alleviation and the protection of ecosystems. Economic valuation of water should be seen within the context of its social and economic implications, reflecting the importance of meeting basic needs ...". This might be seen as ambiguous and leave an important freedom to those in charge of water policies.

Several writers have drawn attention to the constraints that limit the practical application of market forces in the allocation of water for irrigation. Two of the most problematic of these constraints are firstly the lack of the right kind of infrastructure to measure water supplies and secondly the poorly established entitlements of water users. Whereas these and other constraints do not seriously inhibit the informal trading of water at the field level (which has gone on since irrigation began), they present serious impediments to the sale and transfer of water over long distances or with commitments for substantial period of time. There are a number of practical preconditions that must be in place to ensure that both the infrastructure and institutional framework are compatible with the intended objectives. This will generally include measuring devices which will prove difficult and costly to install in the irrigation systems of Asia, if only because silt laden water must be carried through to the field by unimpeded regime flows.

A problem with environmental implications arises in some situations. With the recognition that an irrigator may have an established right to abstract from a source a certain quantity of water for irrigation, it is implicit that his consumptive use would not exceed about half the abstraction. Does he have the right to trade the whole of the abstraction and deliver it to a buyer in another environment or only the portion that would normally be consumed? Some environmentalists and others hold the latter to be the case but there would

then be problems in deducing the proportion on a seasonal basis. In the USA this issue invokes the problem of harm to third parties and contractual protection against claims for damages to the original environment.

In domestic and industrial water supply, as with irrigation, there is considerable debate on the treatment of water as an economic good . In contrast to irrigation, the constraints listed above do not apply, in general, and the issues seem to relate to pricing and regulatory measures and equity in responding to human need.

Water markets

"Water markets" is a term used for the trading of water-use rights. The owner usually does not own the water, which remains the property of the state, but he owns the right to use it. In much of Asia the trading in water is illegal but the bartering of turns in the water sharing systems of India and Pakistan has been done since irrigation began. Such bartering is a short term informal arrangement and is not seen as a water market in its full sense.

Experience from existing water markets shows that some prerequisites to a successful trade are that there must be clear legislation to separate water-use rights from land to prevent monopolies and to allow social and environmental protection.

Chile and the USA provide true examples of water markets. In Chile markets developed in some regions in the early 1980's when laws were enacted to establish tradable water-use rights separate from land. It has been suggested that trading in water-use rights outside an irrigation system should be limited to the consumption portion of the right and the "return flow" portion should remain in the system. This issue is perhaps less important to Chile where rivers are short compared with the conditions in major rivers. California has the most highly developed water markets in the world. Local trading within water districts started in the 1980's and inter-basin trading soon followed. By 1991 it is reported that inter basin trades amounted to $ 111 million / year and related to 101 million cubic meters of water. Most water was traded from agriculture to higher value uses.

Virtual Water

It is occasionally suggested that water short countries currently give inadequate attention to policies that would favour the importation of "virtual water", such as the water "contained" in a cereal like rice. To produce a ton of rice in a dry climate, such as the southern and eastern Mediterranean region and southern California, can take about 2,000 cubic meters of irrigation water whereas the ton of rice might provide enough cereal equivalent for 3 or 4 persons for a year, the water would serve 20-40 persons depending on region (and much more if measured solely in terms of net consumption).

To some extent this policy is already being followed, for example, in Egypt where high value irrigated crops are exported and cereals are imported. In California the matter is partly addressed by "water markets" but there are people who consider more should be done at the policy level to release irrigation water supplies for rice production in the Central Valley for domestic use in the ever expanding urban areas. The subject has also arisen in the case of the Aral Sea region of central Asia with the objective to reduce the current level of water use but that would mean resettling people out of agriculture which is seen as sociologically unacceptable if not impractical.

1.3 Research and Development (R & D)

1.3.-1 *Water supply and sewerage*

Research in water supply has made sound progress since the 1950's. Technical breakdowns are now rare and installations, such as those serving Casablanca, have operated perfectly well over half a century. Sustainable progress has been made in the treatment technology of both water and sewerage and a greater degree of automation has been introduced.

The analyses of raw water, of treated water and of distributed water permit the identification of trace elements and all the constituents whether in suspension or dissolved. For this reason, the standards set by WHO, the US Environmental Protection Agency and the UE have become more exacting. Furthermore the long term effects of water quality on public health have received more attention.

In developed countries, the treatment processes for raw water, whether from surface or ground sources, are undertaken in several stages, namely settlement, filtration and sterilisation, and each stage is the object of revised specifications issued at frequent intervals. These procedures provide for the production of water of perfect potable quality, even from raw water that is significantly polluted. They also avoid the residual effects that can arise from the sterilisation process with chlorine and ozone.

Furthermore, in recent years, techniques have been developed for filtration by membranes with micro-filtration, ultra-filtration (with virus retention) and nano-filtration (to retain some dissolved salts). Each of these processes has specific applications. Ultra-filtration can be combined with active chlorine to eliminate micro-pollutants.

For developing countries the treatment of potable water adopts technologies that are simple in operation, yet viable in that they guarantee potable quality with full disinfection. The principal risk is from diseases arising out of inadequate sterilisation. Some risks call for the monitoring of treated water not only at the exit from the treatment works but also at the tap of the household.

Rural water supply in developing countries is also the object of considerable research. It is undertaken in collaboration with local research institutes and with the donors who support it. It is partly provided by the private sector, for example for the development of plants specially adapted to the distribution of domestic water to small communities.

Research in water treatment has made considerable progress in recent years, both in the production of water of high quality and in wastewater treatment. It is possible to foresee reliable treatment to recycle water for a number of uses (irrigated crop production, garden watering and golf course irrigation).

1.3.-2. *Irrigation*

A lack of research and adherence to convention have together resulted in almost stagnation in technology in the developing countries. Furthermore, there has been little adaptation of significant advances in developed countries to the specific local conditions found in the developing world.

Part of the problem has been in the lack of R & D establishments. Even where it once existed, R & D in irrigation seems to have given way to other priorities. In industrial countries most irrigation R & D has come from the private sector whereas, in the developing world, irrigation is almost all in the public sector. Furthermore irrigation, being linked closely to natural resources (soil, climate, water etc.) is a very site specific subject, so the research has to be local or at least adaptive of imported technology.

In the 1980's there was a growing realisation that irrigation technology was falling seriously behind the agriculture technology it served. It was noted that annual global expenditure on irrigation research was no more than about $ 300 million compared with about $ 8 billion in agriculture as a whole.

Faced with this situation the International Commission on Irrigation and Drainage (an 80 nation organisation based in Delhi) sought the support of the World Bank, United Nations and some bilateral donors, including France, Germany, Netherlands and the United Kingdom to create an International Program for Technology Research in Irrigation and Drainage (IPTRID). The aim of the organisation is to act as a facilitator to launch research programs in developing countries. The program is based on building local R & D capacity and not on the direct execution of international research. Since its creation in 1991, IPTRID has contributed to the launching of R & D activities with a total value of about $60 million and of a dedicated information network between researchers .

IPTRID and IWMI (International Water Management Institute) have made a large contribution to rebuilding the status of R & D in developing countries They have transformed attitudes to the finance of research, which hitherto was not seen as investment but rather as something that benevolent donors would provide through simple grants. The same attitudes were taken toward human resource development and capacity building. This is why such a limited number of developing countries offer valuable career opportunities to researchers. Nowadays, a new attitude to R & D is emerging in countries with substantial irrigation facilities and these countries should be able to adapt and take a better advantage of modern technologies.

1.3.-3 *Information and research output exchange*

The results of research in developing countries, although known to the industrial world, are often poorly accessible between developing countries themselves. This is partly attributable to the absence of good communications (which should be remedied by modern technologies) and to patent rights of private companies. For some developing countries the access to new technologies needs to be improved.

The move towards global investment by large companies offers new and effective means of access to modern technology, as now seems to be the case in Asia. A group like Suez-Lyonnaise des Eaux which, in France, has major research establishments in public water supply, wastewater and industrial water, has established other research centres in Europe, America and Asia. It aims to provide a network of laboratories and research centres working in collaboration with universities and public institutions.

Water and the environment

A consideration of the protection of ecosystems, and notably of the biodiversity in rivers and coastal waters is an essential part of the planning process. In irrigation, the two main challenging issues in sustainable development are waterlogging and salinity. Furthermore, chemical and biological pollution of groundwater is a pervasive problem which calls for renewed efforts.

2.1.-1 *Environmental provisions.*

Chapter 2 has been devoted to the development of water for domestic, industrial, energy and agricultural purposes. But water is equally essential for the preservation of the environment. Poor planning of water abstractions for the different uses can adversely affect downstream users, disturb ecosystems and even place the water resources themselves at risk. The market forces which are well suited to short term trading (for domestic, irrigation and industrial purposes) appear inapplicable to the collective long term associated needs such as the preservation of the quality of the environment. However, in a majority of countries, the meeting of these needs is assured by public authority which obliges all users to maintain stream flows and aquifer levels to meet certain minimum requirements.

The quantities of water to be allocated as environmental provisions depend on a number of local factors, including the opportunity value of water for other uses

There are no established methods for the evaluation of these requirements. In practice the choice depends largely on the physical, technical, economic and cultural context which is distinctly variable from one region to another. However, there is an overarching factor which pervades: the absolute priority given to drinking water for human and animal consumption. But the quantities involved are, except for rare cases (prolonged drought in the Sahel) very small compared with water demands for other purposes.

As the opportunity value of water increases (owing to enhanced demand or other reasons), so will more costly methods become justified to reduce environmental provisions.

Thus if the user is ready to pay for the treatment of his polluted effluents, smaller residual river flows need be maintained within the same general quality objective. This, in turn, would permit larger abstraction by upstream users to produce high quality crops. In coastal areas, where there is salt intrusion, protection of the land can be achieved by raising the river discharge with releases from reservoirs, diverting the effluent directly into the sea or by the construction of flap gates and anti-salt barrages (Mekong delta and wateringues in France).

In densely settled areas in developing countries it is often very difficult to bring about public acceptance, especially from low income groups, of the objectives of environmental preservation which inevitably infringe productive capacity.

2.1.-2 *The role of ecosystems.*

The basic objectives in planning water resource developments is to raise the quality of life by improving public health; increasing food supply; generating clean energy and responding to other human needs related to water.

Environmental preservation and economic and social development must be seen as mutually reinforcing goals. One without the other is a recipe for failure.

Numerous civil engineering works have been constructed to achieve the more intensive use of water resources in order to augment food production, supply potable water, improve navigation and generate electricity. The construction of these works and the manner of their operation has led to modifications in the response and productivity of the ecosystems in the fresh water channel, in the estuary and in the surrounding coastal areas. Some entire ecosystems have lost their specific functions and can no longer provide the same goods and services as they did traditionally.

The functions of ecosystems are defined as "The capacity of natural processes and components of natural or semi-natural systems to supply goods and services which respond to human needs (directly or indirectly)".

Ecosystem functions include regulation of water resource variability through storage and attenuation (e.g. floods, storms), provision of habitats for plant and animal species and maintaining biodiversity, production of food for human and ecosystem needs, and generation of information (e.g. for tourism).

Before embarking upon new water resource developments that would modify the environment substantively, it is necessary to identify alternative solutions that would best preserve the ecosystems and to evaluate the consequence of the possible degradation. Many development projects have produced disappointing benefits when full environmental costs have been taken into account. Furthermore their evaluation has often lacked a full intersectoral consideration.

2.1.-3 *Irrigation within the framework of sustainable development.*

The two most important adverse environmental impacts are caused by impeded drainage and salinity with all their ripple affects. Whereas in recent decades there has been evidence of some success in the struggle against both waterlogging and salinity, the future growth in demand for food production calls for renewed efforts to raise the current pace of such successes. At the same time irrigators must remain vigilant to ensure that their achievements are fully sustainable in the long term. On the positive side, the dominant benefit derived from the irrigation environment is improved nutrition which is well demonstrated by published statistics on food production.

The statistics on food production show that less than 10% of the population living in regions where 15% or more of arable land is irrigated, are on a declining nutritional cycle compared with as much as 40% of the population living in regions with less than 15% of the arable land irrigated.

Irrigation is by far the biggest consumer of water in most of the countries in which it is practiced. There are many questions that arise concerning the short term. To what extent can the development of new sources of water be exploited before the occurrence of negative effects on the environment, such as salinity, produces undesirable negative effects, as already witnessed in the river basins of the Tigris, Euphrates, Nile, Indus and Syr (Aral Sea)? What proportion of the mean annual discharge of a river will continue to reach the estuary, if not the sea, in order to preserve ecologically acceptable conditions? Already, the river basins mentioned, which approach or have reached full development provide some answers. It seems certain that the pressures on the land together with the need to increase food production and deliver more water supplies, condemn numerous river basins to a level of exploitation comparable to those flowing into the Aral Sea. Such a situation as now found there, has to be sustained if only because the alternative would represent the biggest involuntary resettlement programme the world has ever known. The region has recently been examined in depth by the world's greatest experts and the riparian states have embarked on a programme that will seek sustainability for the local population whilst accepting the fact that the Aral Sea will never recover to its former size. In the Indus basin the sustainability of further abstractions is being approached with vigilance in a country where expansion of irrigation is desperately required to maintain food security.

On a global scale, the abstractions from major groundwater aquifers are a matter of even more concern than the rapid depletion of river flows

Once the safe yield of an aquifer is approached or exceeded, a number of adverse things can happen such as salt migration and the loss of base flow in streams and rivers as recently witnessed in Europe. There is a move to apply more rigorous controls to groundwater abstraction. In a wealthy economy, such as California, it has proved possible to induce recharge into "mined" aquifers with imported surface waters: an improbable option in most situations. In general, it must be considered unsustainable to permanently "mine" aquifers for irrigation unless there is clear evidence of enormous long term storage, which for most aquifers in the world is not the case. It should be borne in mind that irrigation, once developed, becomes a "living system" and a permanent part of the socio-economic geography of the region. It thus becomes very difficult to introduce changes in development policies.

2.1.-4 *Water pollution*

A pervasive problem.

Water pollution is one of the most intractable problems faced by managers. At one time it manifested itself in different ways in developed and developing countries. It could be said that chemical pollution was the affliction of the rich and biological was the affliction of the poor. Although this dogma still largely holds good, the full strength of the assertion is beginning to be eroded. Developing countries with irrigation in arid zones, as well as some developed countries, are now having serious problems with salt balance as river flows become fully exploited. Notable examples are in the Middle East, Pakistan and the Aral Sea area. Many developing countries are becoming industrialised which is leading to the production of chemical pollutants. On the other hand biological pollutants are being commendably controlled in developed countries to the extent that chemical pollution now remains their main preoccupation.

Compared with the developing world, pollution levels in Western Europe are generally low despite the high incidence of industrial development, with its abundant potentially harmful effluents. Substantial progress has been made over the last few decades in the control of most forms of industrial effluent supported by widespread application of the policy that "the polluter pays". It is claimed that even nitrate pollution of groundwater is slowly coming under control except in certain areas where either the water has long "residence time" in the ground before abstraction or there is intensive farming with a large animal and human population. In the United Kingdom, the intensive agricultural use of land and other factors leads to special nitrate problems. Areas with long groundwater residence time are said to be suffering the environmental penalty of extensive land use change from pasture to arable farming during World War II. In Eastern Europe there are a range of pollution problems now being actively addressed. As with developing countries many rural areas are highly dependent upon abstraction from shallow wells.

Both in developed and developing countries groundwater pollution has become more menacing with the recent rapid almost uncontrolled exploitation of the world's limited aquifers. Anything that disturbs the natural equilibrium of groundwater bodies carries the risk of adversely affecting the sensitive pattern of mineralisation. Pumping in coastal areas has mineralized wells

Of all water pollution, that of groundwater represents the most persistent and the most difficult problem to treat.

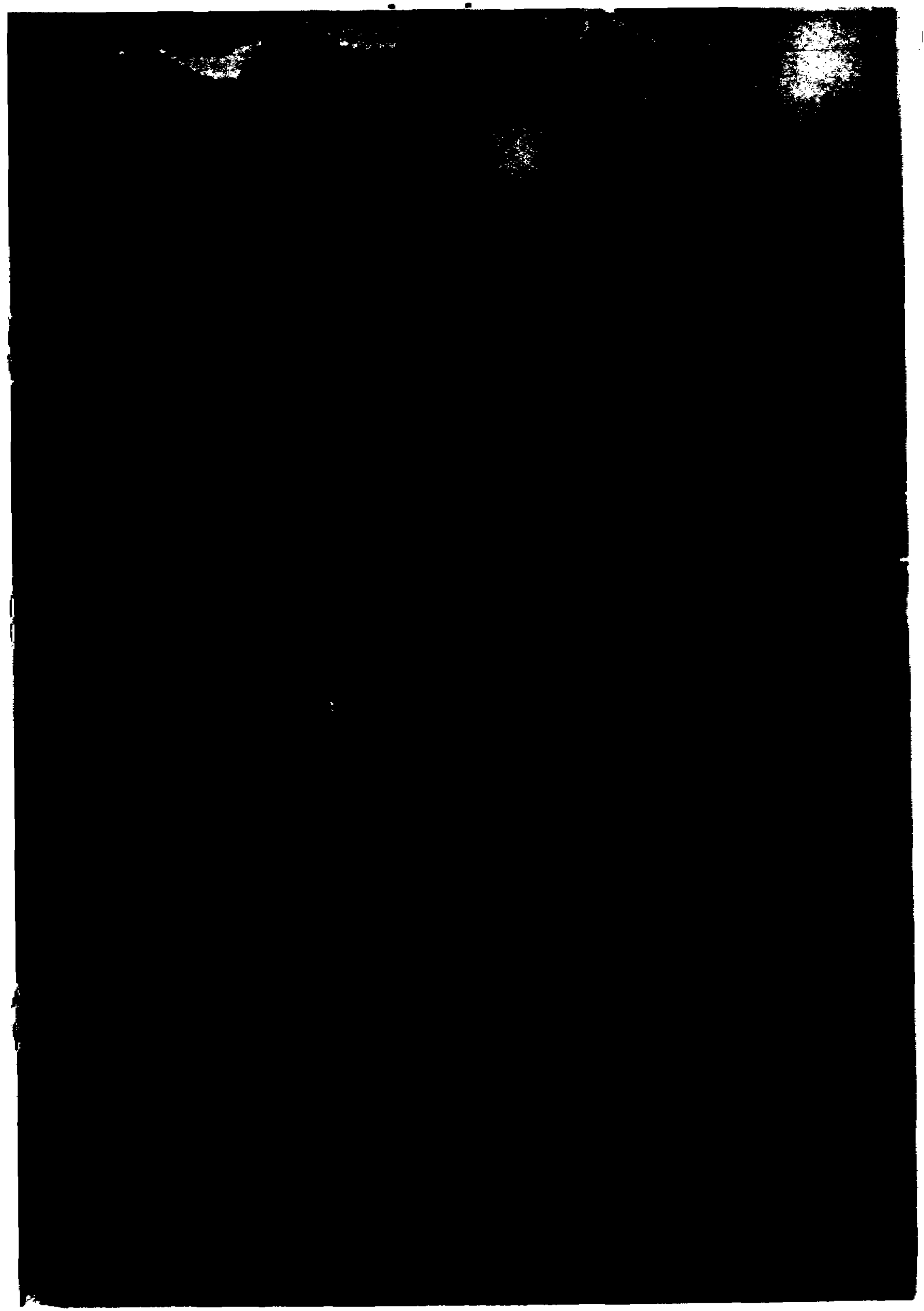
in parts of Europe and elsewhere. "Up-welling", or the lifting of an underlying saline profile is a common result of over-pumping. Over-pumping, on a permanent or temporary basis, can also increase the content of chemicals, such as arsenic, to clinically harmful levels. Irrigation in arid zones can raise the water table, promote the migration and concentration of salts and accentuate secondary salinity in the upper soil profile as in Pakistan. Land reclamation involving the leaching of salts out of the root zone of crops can seriously pollute the overlying surface waters unless major outfall drains are constructed, as is illustrated in the Aral Sea catchment.

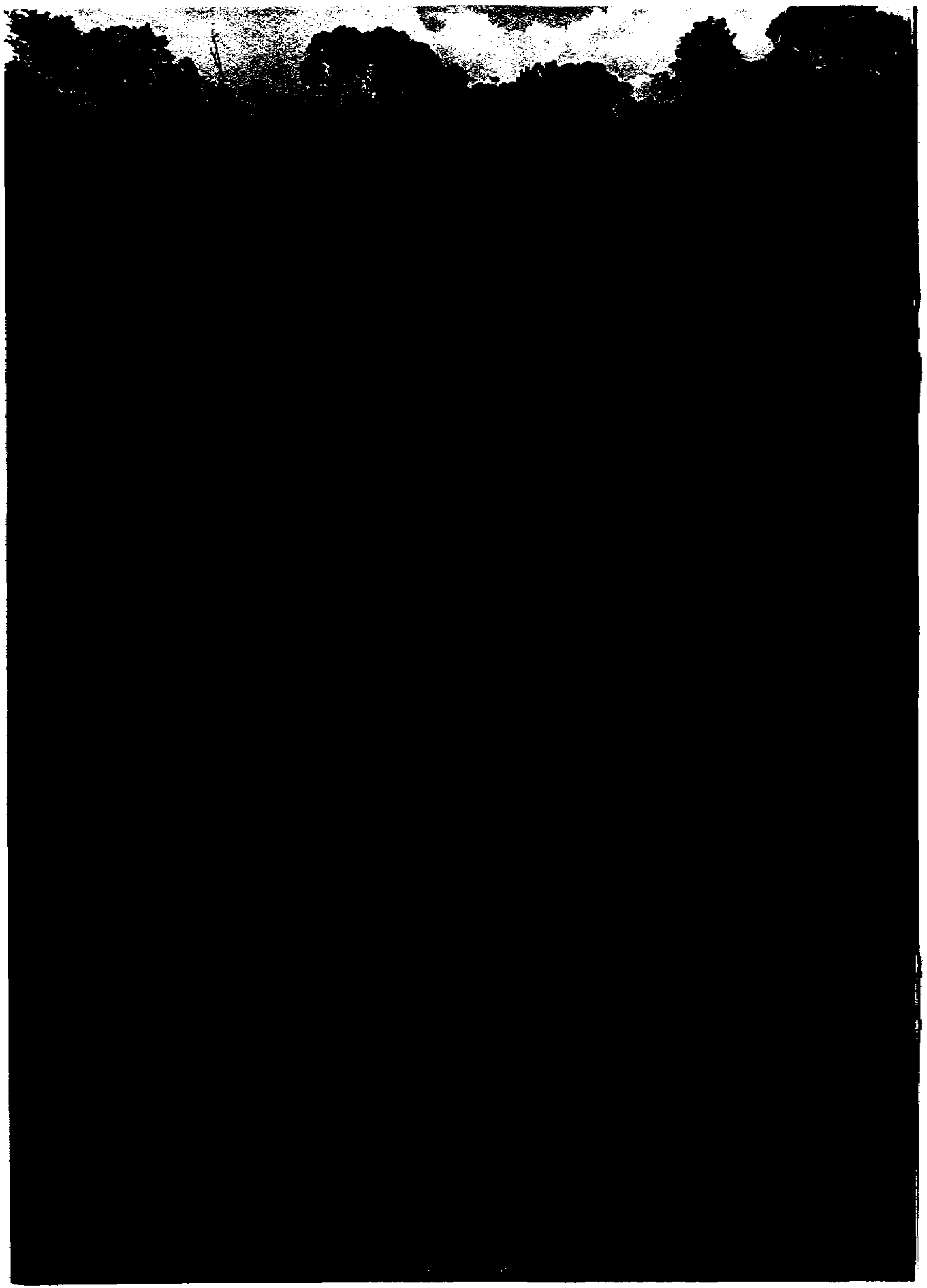
Over-pumping, or mining, of groundwater is one of the main causes of changes in groundwater flows and hence may be instrumental in the creation of undesirable patterns of mineralisation. It also aerates otherwise saturated zones and thus increases access to gas and radiation pollutants and induces oxidation of existing minerals. Around 60% of the aquifers serving urban and industrial centres in Europe are overdrawn and the picture may not be very different in other parts of the world. This situation appears even more alarming when one considers that of the 100,000 or so chemical compounds man releases to the environment, no more than a few have undergone a penetrating impact evaluation.

Nevertheless, many initiatives have been taken to combat pollution in developed countries. In Europe, the EU directive on the treatment of urban wastewater calls for all towns of more than 2000 inhabitants to have sewage treatment in the near future. The setting of limits for the discharge of pollutants from industrial plant and from communities together with the objective of better water quality in rivers will bring about a considerable improvement in the environment. The European community has asked all member states to give special attention to zones where the environment is fragile or where it is considered to have a particular value (sensitive zones) and may justify the application of more ambitious objectives..

The North Sea and the Baltic Sea are the subjects of specific programmes. Moreover, the Rhine, one of the principal international rivers of the EU, has undergone a marked improvement in water quality during recent decades, thanks to the provisions made by the International Rhine Commission and by the riparian states. The European example shows that even with major urban and industrial development the environment can be improved in most cases.

The problem of pollution from nitrates, pesticides and herbicides remains serious particularly in cases where there is intensive stock raising and crop production. However with the current state of awareness among farmers there is reason to hope that acceptable solutions will evolve.





Flood control

Sustainable development for an increasing world population does not imply that all the natural extreme events suffered by mankind should be effectively suppressed but rather that measures should be included to bring about reductions in the number of victims and in the economic losses. Even in France, where the population is effectively stable, there is a need to designate the mode of land use in the valleys, experience having shown that they constitute coveted locations for specific communities.

Decisions in these matters cannot be taken until the magnitude of the natural phenomena, against which protection is sought, has been defined.

Although natural disasters continue to occur throughout the world in a more or less continual manner, at a given point in time they are seen as extremely rare and man rapidly forgets them. Who knows the greatest flood in the last thousand years in a certain Saharan wadi or in a certain river in a monsoon region? Who knows the severest drought observed in the Sahel in the last two or three centuries?

Floods in France

To limit consideration to France, both national and departmental archives contain numerous documents, on events in the river Ternay in the 18th century; on the flooding of Saint Etienne in the 19th century; in the Eastern Pyrenean region in the 20th century without forgetting the Ouvèze or the Haute Loire to cite but a few examples. Furthermore, new techniques, now in the course of development, are helpful in filling data gaps and extending historical sequences back into periods of time with different climatic conditions through dendrochronology and the study of ice and pollens. Each of these is capable of providing some additional elements of knowledge on past hydrological regimes and, thus, on future events.

A programme of research could improve our influence on flood problems. It would lead to better formulation of hydraulic projects articulating, at the same time, the growing needs of the people and regard for the quality of the environment and sustainable development.

The value of damage caused by floods has a tendency to rise over time on account of increases in population density, in the value of plant and equipment that might be submerged and with the more frequent development of basements for occupation. If, in Paris, the discharge of the Seine reaches the levels recorded during the flood of January 1910 (a flood with a return period greater than 100 years and which exceeded all floods subsequently observed, but one that could occur again next year), the total resulting damage would be about 10 billion dollars for just one region and the city. Paris and parts of its surrounding conurbation would be paralysed (electricity thus lifts, heating and trains would cease to operate) and several public services would be severely affected over a period of weeks (something that did not occur in 1910). And all this would happen despite the fact that a number of flood control works have been built in the Seine basin in recent years, including storage dams on the Seine and its tributaries and embankments in the suburbs.

Flood control measures

The structural measures in flood control are primarily protective embankments; channel improvement works; by-pass channels and storage reservoirs.

Protective embankments have been used effectively for hundreds of years in many countries and notably in Egypt, India, China, Italy and more recently in the USA. They remain the most used and effective measure despite the criticisms that arise each time a major flood event occurs as in Bangladesh in 1987 and 1988 and in more recent years in the USA and Holland. In many situations there is no alternative cost-effective measure. Embankments may fail from time to time, but that does not unduly detract from their enormous protective value in flood prone areas.

The saying 'big problems need big solutions' is particularly apt in the case of flood control.

Channel improvement measures are usually limited to small rivers and streams. By-pass channels or "emergency floodways" have been effectively adopted in the lower Mississippi and in the Sacramento Valley in the USA. They are appropriate for the protection of cities and other high value areas.

Storage reservoirs are very effective in the attenuation of flood flows but are usually too expensive as stand-alone projects. They need to be multi-purpose for economic justification (Tennessee Valley, USA; Rio Negro, Argentina).

The construction of housing above flood level and within polders, control over the construction of buildings in the flood zone, the protection of railways and main roads to ensure access to the population in times of high flood, are some of the measures which provide an alleviation of the worst consequences of flooding. They are generally adopted to reduce the number of flood victims, limit damages and generally reduce the magnitude of disasters. Radio communication, use of satellite imagery and other modern tools, notably hydrological modelling assists in flood forecasting. Special dedicated control rooms are occasionally justified as in some river basins in the USA. Other provisions, such as schools built with upper stories, are made for refuge during flood events, especially in cyclone affected regions (Bangladesh).

Integration of flood control into a wider perspective

Attempts to tackle major flood problems on a piecemeal basis with small individual projects can lead to the investments being washed away at the next major flood event. Flood control projects must form part of a master plan for all aspects of water management taken as a whole. Bangladesh is an example where small scale measures implemented in the 1970's and early 1980's proved inadequate with the occurrence of major floods in 1987 and 1988.

Maintenance of flood control works presents special problems, because awareness of the dangers tends to diminish in the periods between major flood events. Maintenance services must be provided with capability for rapid action, rather like a fire service, with maintenance depots fully stocked with flood fighting equipment and materials. Furthermore access to flood control works, along embankments and elsewhere, must be kept open and free of buildings and human occupation which presents special problems in developing countries.

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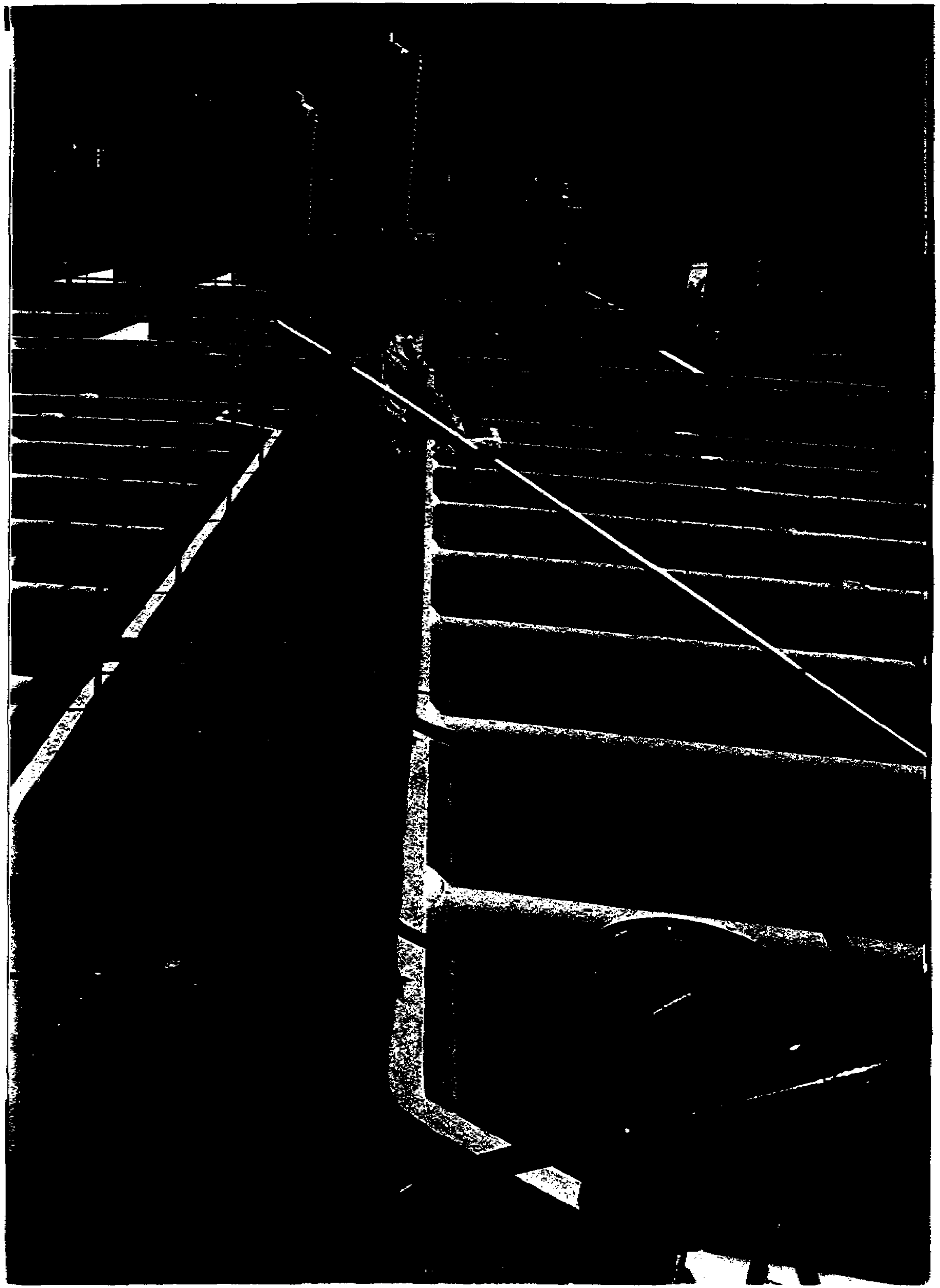
An enormous amount of flood control work has been done in the world and after long periods of time remains sustainable provided it has been undertaken in a comprehensive way including carefully planned drainage systems. Good examples are found throughout the world along most major rivers. In developing countries three notable examples of schemes that have stood the test of time area in the Mekong delta of Vietnam and the Cauvery and Godavari deltas of India. The last two systems were constructed 150 years ago and are multi-purpose including irrigation and navigation. The Mekong delta system, built by French engineers in the 1920's, was a large undertaking by any standard involving more excavation than did the construction of the Suez canal.



Management tools

After a period of substantial growth culminating in the Hydrological Decade of 1970-80, hydrology declined in many developing countries. However there is some encouraging progress in developing countries in the operation of recording stations, as well as in data collection and processing. New technologies, especially those related to communication tools and management information systems, have applications of great interest. But the building and improvement of institutional capacity are essential to enhance planning and management of water resources.

4.1 Availability of data and information

4.1.-1 *Hydrology*

Hydrology went through a period of substantial growth beginning in the 1950's and culminating in the Hydrological Decade of 1970-80. Since that time, developed countries have consolidated their positions, made full use of modern tools, such as electronic devices. They have, furthermore, developed new spatial approaches to the evaluation of data, such as the FRIEND project, sponsored by UNESCO, which covers most of Europe and is being adopted in Africa.

In summary it will be seen that hydrology is at a crossroads where new strategies have to be adopted to hasten the compatibility of hydrological services to modern demands and to up-to-date technology.

Following the Decade 1970-80, the quality of hydrological services declined in many parts of the developing world, partly because of the expansion of the networks of recording stations and of over-ambitious regional schemes. In the first case the countries concerned did not always have the will and resources to maintain the expanded networks or indeed collect and process the recorded data. In the second case the creation of regional organisations detracted from the responsibility and accountability of the national hydrological services. These symptoms are examined in detail in a set of reports on the Hydrological Assessment of sub-Saharan Africa (HASSA), managed and sponsored by UNDP and the World Bank with support from the European Union, France and other donors. Executed in the period 1987-1993, HASSA provides very competent and objective reviews of the status of hydrology in 43 African countries . Many of the findings are equally applicable elsewhere.

The regional HASSA report for west Africa pointed out (i) that organisational and administrative weaknesses constrain performance rather than technical difficulties and (ii) that funding has been reduced to the extent that many agencies barely function and few function efficiently. If regional programmes sponsored by external support agencies are withdrawn in some countries, all surface water monitoring would effectively cease.

Encouraging progress has been made in the last five years but far too little. Most hydrological agencies realise that there is a need to review data recording strategies, consolidate networks (particularly to maintain continuity and the integrity of the regional long term recording stations) and take better advantage of modern technology across the whole spectrum of hydrological work but particularly in data processing.

In both developing and developed countries, more attention is being given to the use of conceptual models as a mean of reducing the onerous task of collecting field data from an intensive network of recording stations. From experience in southern Africa and elsewhere, such strategies can work very successfully. The development of conceptual models for catchment performance can be facilitated by the use of satellite imagery and remote sensing. One outcome of the HASSA studies is the introduction of several telemetry projects in Africa, the Aral Sea area and South America to enhance the ability to retrieve real time hydro-meteorological data (WHYCOS sponsored by WMO, the World Bank and other External Support Agencies).

4.1.-2 *Modern technology*

In making predictive scenarios, it is wise to take into account only modern technology that has already proved the viability of its application. Their likely impact to the several sub-sectors of the water industry is difficult to forecast as it was in irrigation at the time of the advent of the so called Green Revolution.

Prominent among technologies that answer this description is the information technology and the modern tools of communication. The development of more powerful computing and communication technologies is having a major impact on the data that is collected, analysed, and used. This is allowing a more complete integration of the technical aspects of water management with the human and economic aspects. It is reducing the time between an action being taken and the results being measured to the extent that real-time management of technical installations is now a reality. These developments are increasingly permitting predictive modelling and also management simulations that assist in testing a range of alternative solutions before action is taken. These tools are further reinforced through the application of artificial intelligence.

In the developing world much progress has been made in the application of more efficient irrigation methods and it is now expected that this trend will continue. Initially the applications will be to high value crops, as recently in south east Asia and Brazil

Other related advances in technology are the miniaturisation of sensors and the improvement of automatic control systems. The material is becoming cheaper, more readily available and simpler to use, although it becomes more rapidly obsolete

The power of computing is extending rapidly through the attendant revolution in communication systems. These extend from the Internet to dedicated systems for process monitoring and control.

In irrigation, the greatest advance of recent decades has been access to low cost ground water through development in tubewell technology, the mass produced small internal combustion engine and the spread of rural electrification. It is anticipated that progress in these directions will continue until ground water resources are exhausted which is already happening in many areas (a trend that might be halted by a rise, albeit unlikely, in energy costs).

Most irrigation research is in drainage, the management of saline soils and the salt balance. A better understanding of the physical and chemical processes is coming about and there are good reasons to expect advances in the general management of saline soils and waters. Among other things there will be improved methods in salt monitoring and advances in communications will permit the use of real time monitoring of salt profiles which should support better day to day management of salt disposal.

In Africa, the current research in the design of wells that will improve the output from sites in the widespread basement rocks is making encouraging progress in Zimbabwe and elsewhere. Such enhanced capacity wells yield 4 litres per second and more compared with about 1 or 2 litres per second for the classical well. Such an increase raises their capability from a single purpose, for human and animal supplies, to include small scale irrigation.

In many countries suffering shortage of available water resources, the pressure will be to apply technologies that will result in the more effective use of water and the conservation of its quality. This will prompt the need for better water control structures, including more storage dams, to ensure that supplies are delivered to the consumer in the right quantities at the right time. China has a major current program on these lines. Countries like Swaziland have been showing the way with better water control for irrigation. More accurate control of water deliveries must be encouraged to follow such examples. The basic technology is already available.

4.2 Institutional capacity building

4.2.-1 *The Initiatives of the 1980's*

In this Section reference is made to some of the issues in building institutional capacity and in training in existing organisations. It does not deal with the wider subject about what institutions should be created and in what form. That is part of the overall strategic framework of water resources planning. In any case, there has been too much tendency in the past to destroy an inefficient organisation when in reality the management was incompetent. That is where training needs assessment (TNA) studies can play a valuable role in that they identify whether a deficiency is attributable primarily to a skill-gap in management or to the inappropriate structure and objective of the organisation concerned. The TNA, if well done, will identify constraints on capacity building and human resource development (HRD) imposed by deficiencies in the enabling environment such as legitimisation of activities, regulation of the private and public sectors and weaknesses in accountability.

High priority should be assigned to HRD as part of a strategy to improve both management and design of irrigation systems.

A much higher priority should be assigned to HRD as part of a strategy to improve both management and design of irrigation systems. In the mid 1980s, institutional capacity building and associated training programmes were among the least successful of the technical assistance activities undertaken by external support agencies. Many features of the situation were common to other sectors including urban water supply. It is necessary to promote a holistic approach to training with systematic training needs assessments and result evaluations. Without that step, there is a danger of perpetuating one of the salient weaknesses seen in much of the existing training activities. It was considered that in the past there had been too much support of discrete training activities rather than of comprehensive programmes of human resources development.

Training, like research, has suffered from the false perception that is not a real investment and hence it is something for which a developing countries should seek grant funds. However, that perception is beginning to change. For example, India is investing large resources in the Water and Land Management Institutes (WALMI) which have been established in many parts of the country. These institutes combine training with research on which India also places a growing emphasis.

4.2.-2 *capacity development*

Training and capacity building is receiving special attention at farmer level coupled with the present to trend to «turn over» responsibility for the operation and maintenance of irrigation systems. The small schemes are turned over in their entirety and for the big schemes, the responsibility is transferred to the farmers only at the level of the tertiary distribution network. Farmers are required to form some kind of association which remains accountable in the whole community, collects fees and organises the execution of maintenance. In some cases (as in Turkey) the turn-over is to local authorities. The Economic Development Institute of the World Bank a running special courses and seminars for the training of farmers in the communities under its Participatory Irrigation Management Program (PIM).

4.2.-3 *Training the trainers*

Every trainee in receipt of an expensive foreign training should be seen as a potential trainer of the very many people who will have to be trained in their home country.

There are many cases where personnel from developing countries have received special training abroad only to find that on return in their country there is no institutional structure through which they can apply their newly acquired skills. There are cases where returning MSc. graduates have done no work for several years after return from abroad. In other cases, a trained water supply chemist may become the manager of a tobacco factory. From an economic point of view this may be an efficient allocation of scarce human resources if the chemist passes his acquired knowledge on to others.

4.3 Making better use of what exists

4.3.-1 *Poorly and under used infrastructure*

It merely underlines that the satisfactory conservation and efficient use of water infrastructure is something which has long eluded many robust efforts to address it.

The vast investment made in the infrastructure for water development over the last half century, has not been matched by an adequate effort to conserve the works after generally competent standards of construction. In many developing countries, the deterioration of infrastructure (irrigation, urban water utilities, rural water supply installations and hydro-meteorological stations) has become a matter of growing concern. In the worst cases, infrastructure is being allowed to deteriorate sometimes beyond the point of serviceability and at best it is being used well below its capacity. The sole exception to this generalisation is found in hydro- electric power plants where maintenance is generally satisfactory.

The problem does not relate to maintenance of infrastructure alone, although that is perhaps the dominant aspect. It concerns the need to improve all aspects of water use efficiency, including those in irrigation that are found at the interface between the requirements of the crops and the water delivery; the modernisation of irrigation systems to permit better water control; the reduction of leakage in urban distribution systems; the performance of rural water supply systems; the standards of service to the consumer.

4.3.-2 *Conservation of infrastructure*

Good maintenance of infrastructure can only come about where management is able to establish discipline and incentives among those concerned, together with a sound system of funding. So often these features are not found in many water organisations.

A first step in any effective maintenance program is to inspect the infrastructure and evaluate all maintenance deficiencies that interfere with the proper operation of the system. Then the maintenance work needs to be scheduled and funded systematically against a set of priorities for the relief on the identified operational constraints. This simple procedure is often not followed and the progressive actions become : normal or routine maintenance, gives way to emergency maintenance and deferred maintenance and finally rehabilitation.

There is a need perhaps for a "Maintenance Decade" to follow and complement the Hydrological Decade (1970-80) and the Drinking Water and Sanitation Decade (1980-90).

Funding is often claimed to be one of the main constraints on maintenance and, although it is inevitably true that underfunding leads to poor maintenance, the evidence that full funding leads to full maintenance is certainly not so. In some cases, cost recovery and the associated funding reaches dangerous levels: in the Punjab (Pakistan), the revenue receipts from users of irrigation were no more than 56% of the required operation and maintenance (O & M) expenditure. This gap was partly attributable to low charge rates but at the same time there was much underrecording of planted areas. Under such conditions, rapid degradation of infrastructure is inevitable and steps have now been taken to correct the reported problem. A common remedy for the maintenance problem today is that of "turn-over" of part or the whole of irrigation and water supply systems to user groups, usually organised in the form of farmer or water user associations, village communities or local councils.

The conservation and renewal of infrastructure is perhaps the most challenging of tasks. The funding agencies have rightly insisted that the cost of O & M, at least, is a contribution to be made by the recipients of the loan or grant if only as a confirmation of political and local commitment. In fact, there are many cases where the funding agency eventually undertakes deferred maintenance in the form of rehabilitation projects as described above.

4.3.-3 *Lateral versus vertical expansion of irrigation*

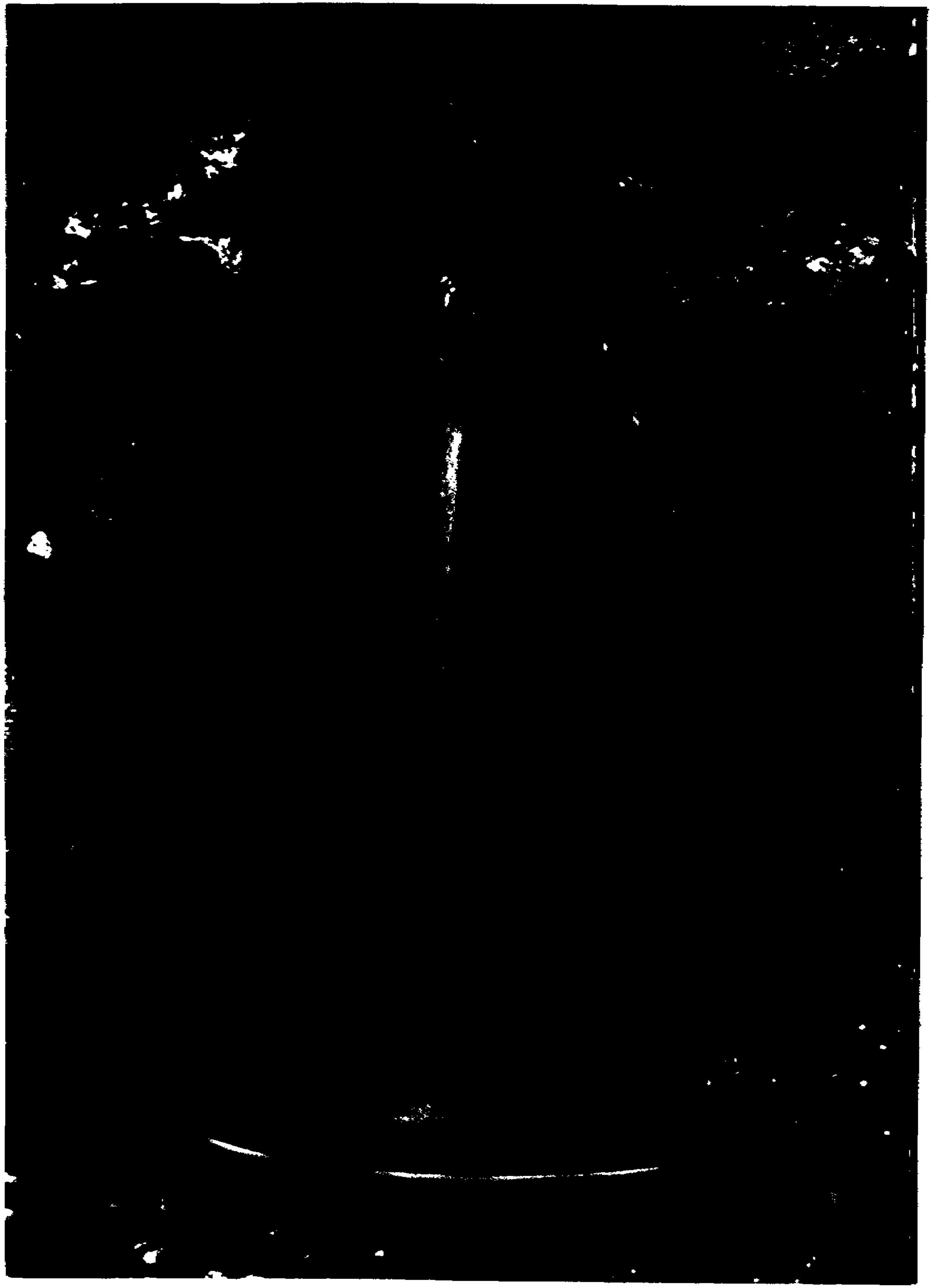
Vertical expansion should be introduced progressively with careful attention to environmental problems and the capacity of farmers to implement the necessary changes especially in Asia.

In recent years, several major irrigation systems have shown an increase in production faster through intensification (vertical expansion) than through expansion of gross system area. This has been done not only where arable land is a constraint but also where there is still plenty of potentially irrigable land, as in the Sudan. The main reason for intensification is clearly because the total infrastructure costs are lower.

4.3.-4 *Serviceability of rural systems*

The massive programmes that have been put into effect throughout the world to enhance the standards of potable water for rural communities has brought an inevitable burden of maintenance and other problems. It is of vital importance to take stock and institute measures to monitor the present situation in many parts of the world. The statistics on serviceability are poor and undocumented.

There is a risk that as the numbers of improved rural water points and systems increase, the numbers falling out of service could surpass the rate of new construction. There could be a point of diminishing returns on the near horizon. There are also concerns that many of the wells are abstracting water below potable standards as a result of mineralisation or biological or chemical pollution. The quality of ground water often changes with time particularly in the case of lowering groundwater tables due to overpumping, mostly for irrigation. Deeper groundwater has a longer residence time and is more mineralised as a result. In addition, the redox potential of minerals change as a result of subsequent depletion and replenishment of the aquifer. This is thought to be the cause, for example, of the occurrence of arsenic in the wells sited in the lower Ganges alluvium of Bangladesh.



"New" resources to develop in the 21ST century

A number of countries are already moving to more elaborate methods for the processing of wastewater and saline water. This includes the re-use of wastewater for irrigation and for domestic and industrial purposes in special situations.

5.1 The re-use of wastewater

The re-use of urban wastewater is an important element in integrated water management

Given the quality that can be obtained through the treatment of sewage and drainage effluents it is necessary, in many regions, to re-use them. The cycle – domestic supply - sewage effluent - re-use – could become part of normal practice.

Southern California is already developing a policy whereby the re-use of wastewater becomes an integrated part of planning. More than 200,000 m3/day of effluent is currently re-used for various purposes and there are long-term plans to extend it to 1 million m3/day. Israel already meets more than 15 per cent of its water consumption from re-use compared with 5 per cent from saline water. 70 per cent of urban effluent is re-used after treatment. In Libya, in a projection for the year 2000, it is foreseen that 40 per cent of domestic and industrial supplies will be derived from treated wastewater. Furthermore the integrated management of water of water resources is today a reality for several islands such as Hawaii, Japan and the Canaries.

The issues of water re-use and the recycling of wastewater has already been linked with chronic water shortage or temporary shortages. In effect, for arid regions, wastewater represents a vital source not only for application to agriculture and industry, but also for the production, direct or indirect, of drinking water. Whereas the re-use of urban wastewater has the basic objective of providing additional resources for different users and for making up shortfalls, nowadays it is becoming part of the hydrological cycle where it provides a balance between that cycle and the preservation of the environment.

The integration of the re-use of wastewater with the hydrological cycle calls for the use of suitable treatment processes, a rigorous monitoring of quality together with a sound understanding of the risks associated with the different forms of re-use. Depending on the specific re-use requirements, several levels of treatment may be required:

- preliminary removal of suspended matter and undesirable objects by screening and primary settlement.
- biological oxidation of carbonated pollution, combined or sometimes followed by the removal of nutrients (nitrogen and phosphorus).
- additional reduction of suspended matter,
- oxidation by ozone or absorption on activated carbon of micro-pollutant (organic compounds such as pesticides),

- removal of heavy metal and dissolved salts,
- disinfection to deactivate pathogens, viruses and parasites.

The choice adopted for the level of treatment must be in accordance with the standards laid down for the type of re-use it is planned to adopt. The standards most used are those of California or those recommended by the World Health Organisation. These standards correspond to specific uses and embrace several indicators of the different levels of protection provided.

The integration of water re-use with existing water management practice could be used as a competitive variant such as:

- a unique and low-cost method of reducing pollution,
- a supplementary resource for coastal regions,
- alternative for the transport of water over long distances,
- balancing element in conflicts between different users,

an important element in the development of new urban areas.

In terms of the quality requirements of the users, there are two broad categories of re-use:

1. the direct or indirect production of potable water;
2. use for agricultural (irrigation), industrial and general urban purposes.

5.1.-1 *Direct and indirect production of potable water*

Technical progress makes possible the production of water of very good quality even from wastewater. The principal constraint for this type of use is essentially psychological and cultural, associated with the perception of wastewater as being dangerous and unhealthy. For this reason, the tendency today favours the indirect use of potable water after temporary residence of the treated wastewater in a natural environment. The unique historic example of the direct production of potable water is a plant at Windhoek, Namibia (4 % of used water diluted with water drawn from natural sources with a target of 25 % by the year 2000).

The indirect production of potable water from wastewater is an operational reality on a large scale (38,000 to 145,000 m3/day) in the USA; California (Los Angeles, Orange County, West Basin) and Texas (El Paso) and Washington DC. The intermediate storage of the water is provided by groundwater aquifers, lakes and artificial reservoirs. The Sussex and Suffolk Water Company, UK, and the Suez Lyonnaise des Eaux group has such a project under implementation (CNAS Project, 35,000 m3/day) which reuses disinfected wastewater for the production of potable water after flow through a river and a storage pond.

The sequences in treatment are complex, being based often on the principal of multiple stages. The object of treatment is not only the elimination of the usual pollutants and pathogens, but also the reduction of organic micro-pollutants by complex biological techniques with physio-chemical procedures like absorption/biodegradation on activated carbon after ozonation.

A high degree of effluent polishing, with the total abstraction of viruses, can be achieved with ultra filtration.

In a report published by the World Bank it was stated that «the remedial measures with the widest benefits in terms of controlling the quantifiable negative health effects of wastewater irrigation is wastewater treatment by means of stabilisation ponds, including multiple anaerobic and facultative aerobic ponds in series, with a total detention time of about 20 days». It was considered that this is the optimal system for tropical and semi-tropical areas. The World Bank report was largely focused on developing countries.

5.1.-2 *Irrigated agriculture and forestry*

In some arid and semi-arid countries, the re-use of wastewater provides a large part of irrigation requirements. For this purpose, the re-use of wastewater has the benefit that it brings nutritients which increase crop yields. France is currently the initiator of the largest project in Europe, at Clermont-Ferrand (10,000 m3/day). Spain has a considerable experience in this area. Several projects are in hand in Portugal (Lisbon 1,000 ha), in Greece and Italy.

It should be noted that most existing systems are not equipped with a disinfection stage. In future years, the use of disinfection will be obligatory at least for certain types of irrigation, in order to respond to new and stricter regulations (national and EU projects).

For countries in which the standards are already very severe (Australia, USA, Middle East), tertiary treatment is required. An example of a large scale project is the Taief treatment plant in Saudi Arabia (67,000 m3/day for 270,000 people) where the total available wastewater is used for urban sprinkler systems. In Mexico City, four large projects are in course of construction for physio-chemical treatment, filtration and disinfection of wastewater.

5.1.-3 *Urban and peri-urban uses*

This type of re-use of wastewater has developed rapidly and is now becoming a fundamental part of the policy of integrated water management in the large conurbations. Several municipalities in Japan and the USA have already constructed systems for dual distribution. The most common applications are the irrigation of open spaces (parks, golf courses and sports grounds), special features (waterfalls, fountains, ponds), street and car washing and fire fighting. The quality regulations are stricter than those for agriculture.

The main technologies applied to these uses are tertiary treatment by filtration followed by disinfection with chlorine or UV irradiation. This sequence of treatment meets with quality standards (200 fecal coliform/100 ml).

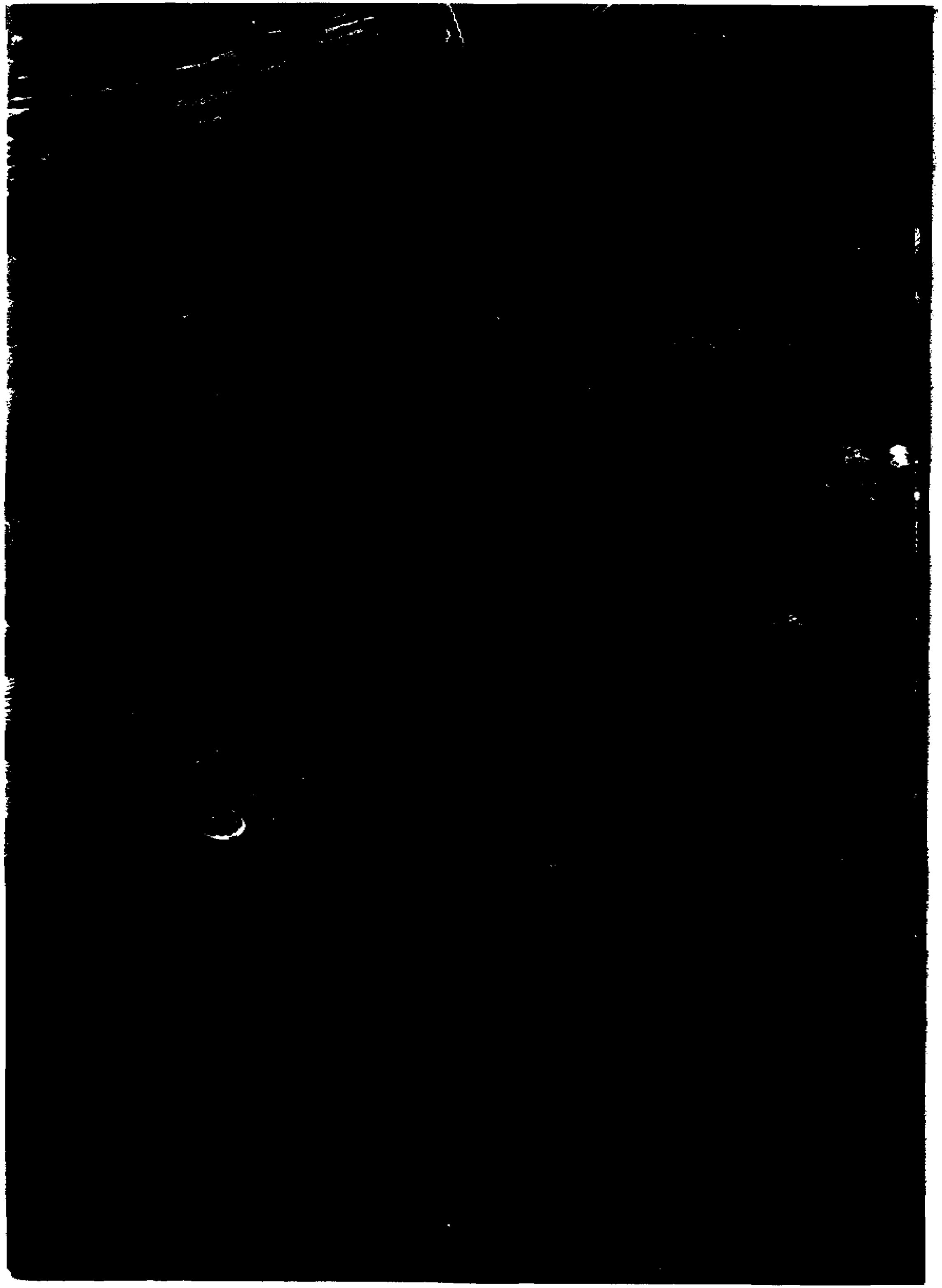
5.1.-4 *Industrial applications*

At the present time, the re-use of urban wastewater in the industrial sector represents only about 6-15 % of the total volume of water re-use. However it is important not to underestimate the potential for the integration of advanced procedures in the treatment processes.

5.2 The desalination of sea water and brackish water

For towns located near the coasts in arid zones such as the Gulf region or the Middle East and a number of islands, desalinated water forms a part or the totality of their water supply. It is produced in large quantities in the oil rich countries of the Middle East, where desalinated waters are sometimes transported over long distances, as in Saudi Arabia.

Distillation and reverse osmosis techniques are now both feasible given a supply of energy at reasonable cost. They represent a reliable and unlimited alternative resource for many towns, such as those currently using fossil water, as in Libya, or served by water transported over long distance of hundreds of kilometres.



Scenarios for the 21st century

The evolution of water resources development is beset with uncertainty. It is necessary to identify such uncertainty in order to formulate strategies and actions focused on a balance between supply and demand and with the concept of water as indispensable to man and to environment. Whilst the scenarios may be prepared in a global basis, they have national and regional significance. The approach used by the Mediterranean Blue Plan has revealed major gaps and provide decision makers with information for socio-economic development within which water plays an inevitable role without degrading the environment.

6.1 Water demand projections

6.1.-1 *The value of scenarios*

In the "Comprehensive Assessment of the Freshwater Resources of the World" report (CAFWR), it is stated "whilst we cannot know what will be, we can use scenarios to tell plausible and interesting stories about what could be". It goes on to state that "scenarios add to our insight which may lead to better informed and rational action".

Although this does not imply that large expenditure should be made to research these matters on a world-wide basis, there is a case to improve the quantity and quality of data on a selective regional basis such as in water short areas of Africa

The scenarios presented in this section are intended to provide insight not only concerning the crucial balance between demand for and availability of water but also concerning some of the important issues that call for consideration in policy and strategy formulation.

Any projection of demand for water is subject to considerable margin for error. Potential errors occur in the hydrological data base itself. The amount of re-cycling of abstractions and estimates of the true net consumption are very difficult to measure or calculate.

6.1.-2 *Global projections of demand for the year 2025*

The CAFWR report gives estimates of abstractions in the year 2025 at three levels:

- Low level : 4,500 km3/year
- Mid level : 5,000 km3/year
- High level : 5,500 km3/year

Other related studies fall mostly within the range of the above projections. For presentation in this background document, the figure of 5,500 km3 has been adopted. This amounts to 40 % of the 13,500 km3 deemed to be economically available.

The breakdown by sectors is expected to be approximately as follows:

- Domestic and small businesses: 600 km3
- Industry: 1,400 km3 (including evaporation from large reservoirs most of which have a dominant power purpose)
- Irrigation: 3,500 km3

The conversion of the projected abstractions for 2025 into estimates of consumption is very approximate. In the future, the return flows of usable quality are likely to be a smaller proportion of abstractions because the good aquifers, through which irrigation infiltration is recovered, are soon to become almost fully exploited and the conditions for re-cycling will diminish.

For these reasons it seems prudent to increase the proportion of 61 % for consumption adopted by Shiklomanov for 1990 to about 75 %. For abstraction of 5,500 km3/year the consumption would thus be about 4,125 km3 for 2025, or 30 % of the 13,500 km3/year judged to be available.

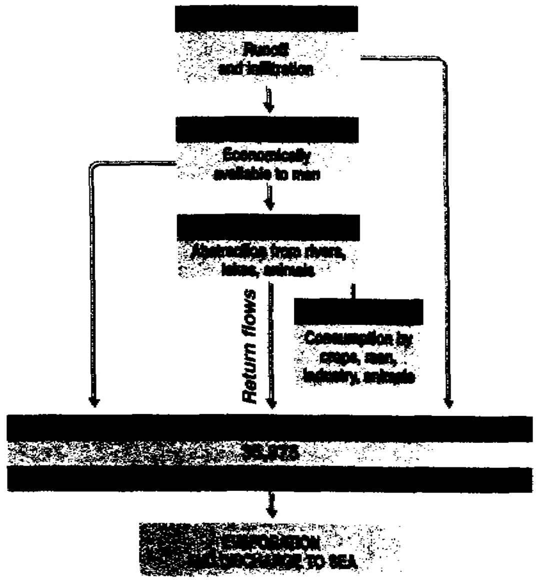


Figure 4 - **Global water balance - 2025 (Km3/y).**

Projections of water supply and demand for individual countries can only be achieved from detailed studies. Most developed countries and a number of developing countries have carried out studies of this type. An example of a developing country that has undertaken comprehensive water resource planning for three decades is Pakistan. This period is now long enough to judge the level of accuracy achieved in the projections.

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Table 4 - **Pakistan water ressources planning - A test of accuracy**

The example of Pakistan demonstrates the value of long term planning if it is comprehensive enough from the irrigation, agronomic and socio-economic points of view

It will be noted that the projection of both water abstractions and the response in terms of crop production proved accurate to within a few percent in all cases. The irrigated area served by the available water proved larger than forecast but with slightly greater growth in lateral expansion than in intensification. Planning into the 21st century is constantly under review in Pakistan. The total water resources of the Indus basin are already over 75 % utilised at about 130 km3/year (average diversion). With careful planning it is hoped to raise the abstractions for irrigation by another 20 to 25 km3/year subject to environmental considerations in the lower reaches. Another interesting example of long term planning is the Mediterranean "Blue Plan". It assembles the results of a number of separate country studies by riparian states into a regional framework .

6.2 The Mediterranean "Blue Plan"

6.2.-1 *Towards a socio-economic development preserving environment*

Prompted by concern for the rate of degradation in the quality of the sea in the 1970's, there was an initiative to mobilise appropriate action by riparian states to preserve the environment and socio-economic well being of this unique part of the world. A conference, backed by UNEP, was convened at Barcelona in 1975 when the decision was taken to adopt the Mediterranean Action Plan ; its main objective was the preservation of Mediterranean environment. In 1977, the Blue Plan team was given the task of evaluating the socio-economic window. Its mission was to place at the disposal of member states data and information relevant to the preparation to their national plans. Such plans have the overarching objective of optimising the socio-economic development of the region without degradation of the environment. Scenarios were prepared for projections to the reference years 1990, 2010 and 2025. As the studies covered all economic sectors it was wide and multi-disciplinary. This has constrained the depth and detail with which it has so far been pursued.

6.2.-2 *Water prospective in the mediterranean basin*

Of all the heavily populated regions of the world, the Mediterranean coastal areas are subject to the most severe limitations in water resources. The important aspect of the water "sector" has been the subject of major efforts resulting in a substantial report in 1992, followed by a report on "Water in the Mediterranean Region" for the Euro-Mediterranean Conference on Water Management of 1996.

The water abstractions in 1990 for a population of about 400 million is shown in Table 5., together with the sectorial distribution of demand. Table 6. shows the total water resources, abstractions and the percentage utilisation of the resources for 1990. The utilisation had already reached 76 % in the southern sub-region which leaves little scope for the future.

		Sectorial Abstraction %			
[illegible]	276	13	[illegible]	[illegible]	[illegible]
[illegible]	150	14	[illegible]	[illegible]	[illegible]
[illegible]	45	16	[illegible]	[illegible]	[illegible]
[illegible]	81	9	65	[illegible]	[illegible]

Ref Blue Plan 1996

Tableau 5 - **Mediterranean Region (1980) Present Water Abstractions and Sectorial Distribution.**

	1990	2010		2025	
[illegible]	34	50	38	63	40
[illegible]	177	219	165	244	157
[illegible]	27	45	33	53	36
[illegible]	36	56	44	68	39
[illegible]	150	183	136	188	117
[illegible]	45	76	51	103	87
[illegible]	81	112	72	139	98
[illegible]	276	370	274	430	272

Ref Blue Plan 1996

Tableau 7. **Future water production in the whole Mediterranean Countries (km³yr).**

Tableau 6 - **Mediterranean region Resources, Abstraction, Utilization.**

[illegible]			

Ref Blue Plan 1996

Two levels of water abstractions have been adopted, in the projections, a high and a low. They are wide apart and effectively present an envelope or bracket within which the eventual demand growth path is likely to fall. The domestic water demand projected for 2025 is as little as 10 % above the 1990 level in the low case and as much as 75 % in the high case.

[illegible]			

Ref Blue Plan 1996

Tableau 8 - **Mediterranean region Projected utilization of resources in 2025 - % renewable resources.**

All figures relate to abstractions and therefore there may be a degree of recycling within the hydrological system that may relieve the pressure on resources. However, the Mediterranean region offers less opportunity for recycling than many other regions because so many of the conurbations are sited by the sea. Drainage water recovery is important in the irrigated areas, especially in Egypt, and desalination should make increasing contributions, especially in periods of peak demand in domestic water supply.

Many parts of the Mediterranean region are approaching critical pressures on the limited water resources. Water saving in all sectors will become an overarching objective

The irrigated areas are unlikely to expand in the southern sub-region, except to the extent that there are operational savings from existing areas. This observation results from the mid-point demand projection of abstractions leading to a utilisation rate exceeding 100 per cent of the available water resources. In practice it is always difficult to go beyond about 80 per cent especially when environmental conditions are taken into account.

The Blue Plan and water in the Mediterranean region

In developing a picture of probable or desirable future perspectives for the Mediterranean, the Blue Plan has contributed to the identification of the margins of manoeuvre and the paths of sustainable development in the region. From now on, an economic constraint appears to exist in the degradation and shortage of natural resources. Water arises as a major issue on which decisions will be extremely difficult. The future is further obscured by the drier conditions that might arise from climatic change.

Two recent initiatives have led the Blue Plan team to contribute to a better awareness of the problem of water resources and of the solutions that might be applied in relation to national situations. The first is through the preparation of a document for the Euro-Mediterranean Conference on Local Water Management (1996). This shows that, by the year 2025, the water demand will not be satisfied without a drastic revision in resource allocation, notably for agriculture (irrigation), and without the mobilisation of alternative sources of water by reuse of wastewater, recycling irrigation return flows, desalination and long distance transfer. The second initiative deals with "Demand Management", a priority adopted by the Mediterranean Commission on Sustainable Development at Rabat (1996) and for which the recommendations have been taken up by the parties to the Barcelona Convention (1997). They are underpinned by a general concept : «Demand management and supply management, with the improvements that can be applied to them, should be undertaken in an integrated way. Savings of large parts of lost or wasted water is technically possible and would cost much less than the cost of exploiting further resources to meet future needs. This constitutes a primary policy objective.»

The comprehensive analytical approach has therefore enabled light to be shed on the magnitude of the issues and the needs for regional co-operation in the domain of water. This approach could be applied to other regions of the world.

* Recommendations by the MCSD adopted in 1997. Available at CAR-PB, 15 rue Van Beethoven Sophia Antipolis 06560 Valbonne

6.3 Planning in Europe

In addition to global studies, it is necessary to look to scenarios that are adapted to local conditions and to follow a multidisciplinary approach. The needs of man must be at the centre of water policy for the world within a framework of sustainable management but he must find specific solutions at the level of his own country. Water can only be transported at considerable cost. In France, the first planning level is the river basin where there is solidarity among stakeholders as demonstrated by the Agences de l'Eau. Planning can also be accomplished at sub-basin level where SAGE (local water management plans) are established.

The European model demonstrates that the river basin approach does not detract from a comprehensive integrated action at the international level. The EU has not postponed action, pending the publication of its directive on water resources which is still in course of preparation. It has proceeded to define its policies and it is appropriate to recall the definition of the principles for sustainable policies that the EU enunciated in its communication of 1996.

For environmental preservation, some challenges have to be faced, including notably (i) pollution, both point and non-point, and (ii) water shortages.

The principles of the EU policy aim to underpin a sustainable environment. Enunciated in Article 130 R of the Treaty :

- 1. A high level of protection.
- 2. The principle of precaution.
- 3. Preventive action.
- 4. Correction of environmental damage at its source.
- 5. The principle of "polluter pays".
- 6. Integration of the policies of the EU and local and national policies in a way that land development and management of watercourses bring together the different needs and take into consideration the particular local conditions. Given the amount of pollution that arises out of agriculture and the abstraction of water for irrigation, there is an obvious need to integrate water and agriculture policies.
- 7. Use the available scientific data.
- 8. Take account of the diverse conditions of the environment in the regions of the EU. Care should be taken to avoid stipulations that are either not adaptable or unnecessarily severe in the simple interest of harmony.
- 9. The cost/benefit ratio. It is necessary to ensure a certain proportionality between the proposed measures and its effect on the environment.
- 10. The economic and social development of the EU and the balanced development between regions.
- 11. International co-operation, notably in relation to the international river basins and the marine environment.
- 12. The principle of subsidiarity should be given greater emphasis in that the use of water depends largely on historical and cultural patterns in the different regions of Europe. Problems should thus be solved at the institutional level where they occur.

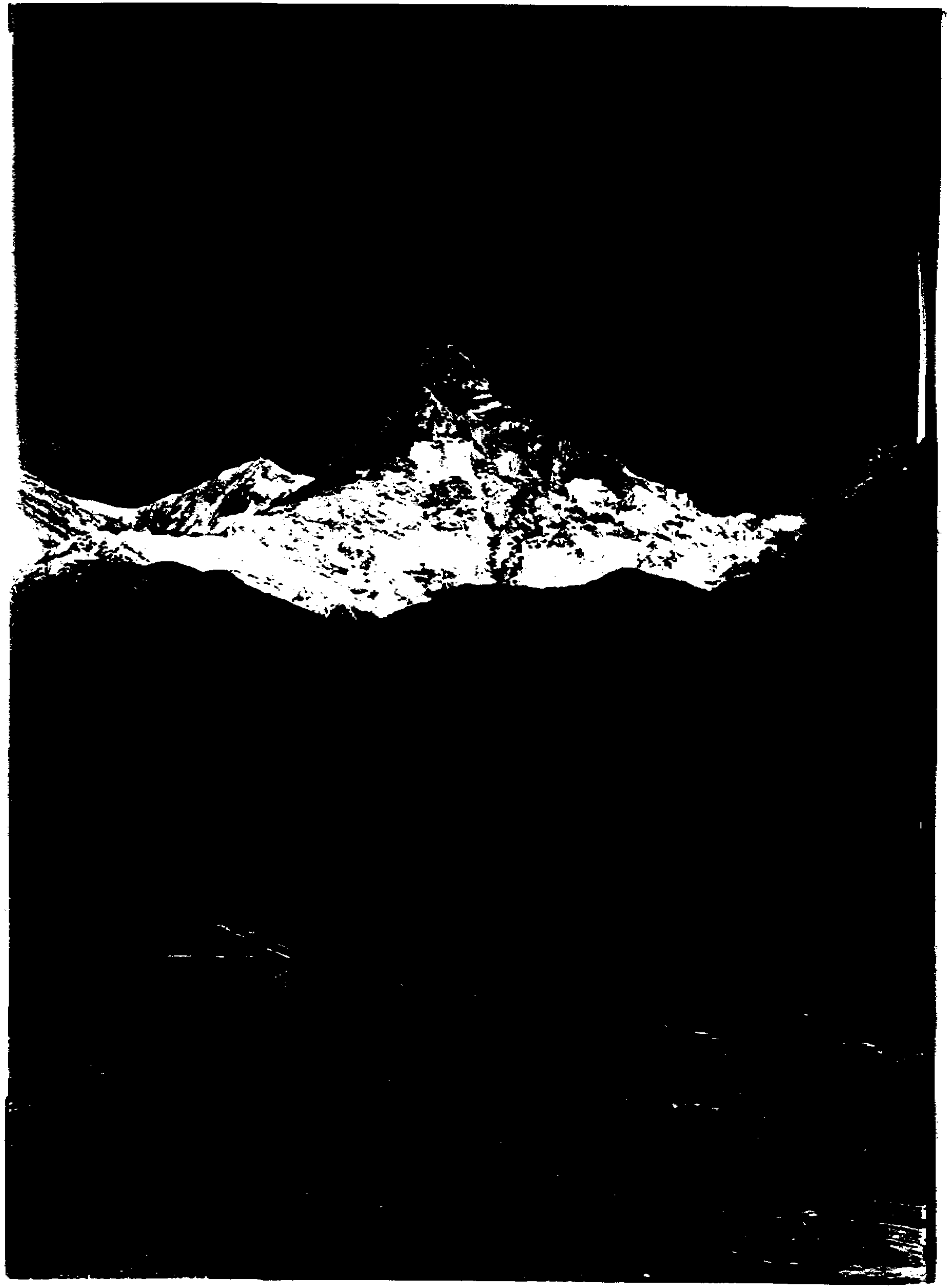
For pollution, the EU proposes an approach which combines severe criteria for environmental preservation and quality objectives for river discharges. In that context, it is appropriate to have a broad policy with increasing protection to zones that are particularly vulnerable and which, at the same time, distinguishes between the more and less sensitive zones.

The EU also stresses the importance of good management of river basins.

The French system of Agence de l'Eau, which provides a certain financial linkage between the several users in a given basin has a sound record of service spanning almost 30 years. Whilst the EU seeks a mode of management of river basins that includes the protection of groundwater and coastal water, it should be noted that the French management system permits a maximum efficiency in both the allocation of resources and the planning of the investments.

Clearly, treaties are necessary for the development and management of transboundary river basins. In most cases they already exist in Europe.

Management by river basin units does not exclude the possibility of river basin transfers in order to satisfy water supply priorities, at least on a domestic basis. By virtue of the principle of subsidiarity, mentioned above, the state remains the administrative authority in which any arbitration ultimately resides.



Suggestions for action

The First World Water Forum, held in Marrakech in March 1997, mandated the World Water Council to prepare a Long Term Vision for Water, Life and the Environment. The Vision will be presented during the Second World Water Forum, to take place in The Hague, Netherlands, in March 2000. The present document and the Paris Conference will contribute to the formulation of recommendations for the action that decision makers should take at the beginning of the next century in order to address the needs of future generations, notably in world food security and in urban and rural water supply.

7.1.-1 *Overarching Issues*

The rapid rate of development of new water supplies for all purposes over the last half century has reached a situation which now calls for a careful re-examination of the policies and strategies that have been followed through much of that time. This is not a situation precipitated solely by the narrowing of the margins of water availability, which is still an affliction of only a limited number of countries. There is also a major challenge of how to make water of good potable quality available to almost all people, whilst over one billion people still do not have access to it.

A more immediate attention should be given to the role of water to develop and secure world food security

Thus, there are two overarching resource constraints that confront the world of water. One is simply water scarcity and the other is the abyss that exists between social needs and affordability. Against those two basic needs – irrigation water and potable water – water for other purposes (hydro-electric power, industry and navigation) are minor issues.

7.1.-2 *Food security: A primary consideration*

In the developing countries 80-90 % of incremental food supplies must continue to come from irrigated crop production. Irrigation, on the scale required, takes decades to plan, build, settle, and bring into production. In contrast, all people already have an existing supply of water, except during special drought events in limited regions. Although irrigation development has fallen to almost half its peak rate, development achieved in the early 1980s being now about 2 Mha/year lateral expansion and about 1 Mha/year from intensification, the total growth in cropped area should be enough to meet the contribution of irrigation to world food supply for the year 2025. The water balance shown in Fig. 4 is consistent with that rate of development.

Limitations on water resource availability and suitable land will largely determine the distribution of the irrigation expansion

The main opportunities will be from the abundant flows from some of the Himalayan rivers and from the Chinese rivers in Asia, which is fortunate because that is in the main region of incremental food demand. By contrast, the Middle East and North African countries have severe problems . In southern Africa there are some severe local shortages especially for township supplies but for the long term the Zambezi remains an abundant reserve for such purposes. Sub-Saharan Africa presents special problems in food security for the next century. The potentially irrigable areas are small and dispersed. The perennial water resources, outside the Zaire basin, are widely spaced.

The funding of capital investment in irrigation has not in the past presented major problems. Public irrigation has traditionally been seen as the foundation of the rural economy and has received a major part of development budgets and good support from the international banks and other external support agencies. Agricultural credit banks now play an important role in financing small farmer owned irrigation in much of Asia and have, for example, supported extensive credits to Bangladeshi farmers. Some countries are pursuing prospects for the use of the private sector for large scale irrigation.

7.1.-3 *Water supply: A financing challenge*

The policies and strategies in both urban and rural water supplies revolve around the issues of funding, management, operation and maintenance. Water availability is also an issue but limited to specific areas usually around cities and towns in arid zones and around the south Mediterranean coast. The most fundamental problem in water supply is the funding of capital costs.

In addition to funding, either directly or by assistance, private participation can help to solve a number of problems and constraints mentioned in this paper. These include the adoption of modern technology; access to the results of current R & D; human resources development and assistance in the achievement of better cost recovery from consumers.

Private participation in urban and rural water supply can bring a range of advantages.

In developing countries a transition from public to private financing is making progress. Cost recovery by the investor may need to be considered long term but on the other hand revenues may be more certain and less variable than with investment in industrial projects.

Water supply embodies much greater financial challenges than irrigation. With irrigation, once a scheme is constructed, it will remain sustainable, provided it is financially viable for the user, even if it may not be economically attractive for the state. If it is financially viable for the user, a framework for the recovery of user charges for operation and maintenance is generally feasible, given the political will of the government. With water supply, cost recovery from the poor is very difficult for a range of reasons and usually gives rise to cross subsidies in developing countries and income support supplements in developed economies. There seems to be no viable alternative. For small rural schemes private ownership, operation and maintenance is the main option being pursued. In some cases local banks will finance private operators of water supply tubewells (Grameen Bank in Bangladesh). An alternative option is to provide the water supply facility to the community, with some contributions in cash or in kind, and require the community to operate and maintain it as, for example, in the social development fund projects sponsored by the World Bank. Indications are that, if well set up in the first place, such initiatives offer satisfactory ways of developing infrastructure for small communities and might be extendible to large ones. They may need to be backed up by reserve funds to cover droughts and similar emergencies.

Decision makers would be wise to investigate a range of financing options for the financing of water supply projects taking account of a wide range of factors as implied in this paper.

The future has already started

There is no presentation of conclusion in this document. It has not been found possible to address all the problems and, furthermore, reality in the 21st century may be different to what has been perceived if only because some countries are approaching a demographic transition and the greenhouse effect may have impacts on climates and hence on water policy. It is however clear that there is a need for the formulation of a sound water policy linked with the development of land resources and emanating from dialogue between experts, elected officials and other stakeholders. This process has already begun in many countries having taken steps to adopt a balanced programme between environmental protection and human needs.

The three workshops of the Paris Conference, given their selected themes, the "parallel" workshop of the International Network of Basin Organisations and the one jointly organised by the World Water Council and the Global Water Partnership have the objective of enriching the above reflections and illustrating them through the presentation of actual examples.

Glossary

Crop intensity :
Number of crops annually grown on the same plot

Irrigation Efficiency :
net amount of water added to the root zone of the crop divided by the amount abstracted at the source (expressed as a percentage).

Net consumption :
all water that is irredeemably consumed in the processes, such as evapotranspiration of the crop in irrigation or the evaporation losses in a power plant cooling tower.

Water abstraction :
all withdrawals from a natural source, including surface and ground waters.

Water demand :
determined by the requirements of user activities and the conditions of water supply, it is covered by water sources : abstractions, non conventional resources, fossil aquifer, imports.

Water requirements :
concept independent from the offer, deriving from standards and used for predictions; it is linked with the requirements and objectives of the activity generating it.

Water Use Efficiency (WUE) :
usable crop yield divided by the evapotranspiration consumed in its production (expressed as weight of usable crop per cubic metre of water consumed).

List of acronymes used

ASA: American Society of Agronomy

BOT: Build Own, Transfer

CGLAR: Consultative Group for International Agricultural Research

WWC: World Water Council

EDI: Economic Development Institute (of the World Bank)

ESA: External Support Agency

FAO: Food and Agricultural Organization

FRIEND: Flow Regimes from International and Network Data

GDP: Gross Domestic Product

GWP: Global Water Partnership

HASSA: Hydrological Assessment of Sub-Saharan Africa

HRD: Human Resources Development

HYV: High Yiels Varieties

IAWQ: International Association on Water Quality

ICID: International Commission on Irrigation and Drainage

ICWS: International Centrre for Water Studies

IIMI: International Irrigation Management Institute

IPTRID: International Program for Technology Research in Irrigation and Drainage

IWMI: International Water Management Institute

IWSA: International Water Services Association

O & M: Operation and Maintenance

OECD: Organization for Economic Cooperation and Development

OFWAT: Office for Water Services (regulating body in England and Wales)

PIM: Participatory Irrigation Management

R & D: Research and Development

TNA: Training Needs Assessment

UNCED: United Nations Conference on Environment and Development

UNDP: United Nations Development Programme

UNESCO: United Nations Educational, Scientific and Cultural Organization

USAID: United States Agency for International Development

WALMI: Water And Land Management Institutes

WATSAVE: ICID Standing Work team on water saving in irrigation

WHYCOS: World Hydrological Cycle Observing System

WMO: World Meteorological Organization

WUE: Water Use Efficiency

Notes

Water is essential to all life, all ecosystems and all human activity;

Wisely used, water means harvests, health, prosperity and ecological abundance for the peoples and nations of the earth; badly managed or out of control, water brings poverty, disease, floods, erosion, salinization, waterlogging, silting, environmental degradation and human conflict;

The effective management of the world's water resources will contribute to the strengthening of peace, security, co-operation and friendly relations among all nations in conformity with the principles of justice and equal rights. Amongst the natural resources, water is the most critical. It can and should be used to promote the economic and social advancement of all peoples of the earth, in accordance with the Purposes and Principles of the United Nations as set forth in the United Nations Charter and the Declaration of Human Rights.

However authority over the world's water is fragmented among the nations of the world, hundreds of thousands of local governments, and countless non-governmental and private organizations as well as a large number of international bodies.

In response to this fragmentation and following the 1992 recommendations of the Rio Earth Summit, the Ministerial and Officials Conference on Drinking Water and Environmental Sanitation held in Noordwijk, the Netherlands recommended in March 1994 the establishment of a World Water Council. This recommendation was subsequently endorsed by the Commission on Sustainable Development and the General Assembly of the United Nations. A Founding Committee was formed by the International Water Resources Association in November 1994 and the World Water Council was formally established in Marseille on June 14, 1996.

The objectives of the World Water Council are:

- to create a platform for information exchange for all the stakeholders in the water sector;
- to identify critical water issues of local, regional and global importance on the basis of ongoing assessments of the state of water;
- to raise awareness about critical water issues at all levels of decision making, from the highest authorities to the general public;
- to provide the forum to arrive at a common strategic vision on integrated water resources management on a sustainable basis, and to promote the implementation of effective policies and strategies worldwide;
- to provide advice and relevant information to institutions and decision-makers on the development and implementation of comprehensive policies and strategies for sustainable water resources management, with due respect for the environment and social and gender equity; and
- to contribute to the resolution of issues related to transboundary waters.

At the First World Water Forum held in Marrakech in March 1997, the Council was mandated to prepare a Long Term Vision for Water, Life and the Environment. The Marrakech Declaration states: "Building on past international efforts and relying on the collective wisdom and resources of the international water community, the process leading to a Vision will include research, consultations, workshops, print and electronic publications and many other means for absorbing, synthesizing and disseminating knowledge. At the conclusion of this process, the Vision will offer policy-relevant conclusions and recommendations for action to be taken by the world's leaders to meet the needs of future generations." This document is a step towards the preparation of the Vision that will be presented at the Second World Water Forum, to be held in The Hague in March 2000.

World Water Council

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