Overview of Thematic Papers

INTRODUCTION

In an aide-mémoire dated 15 August 1975, the Secretary-General invited Governments to submit thematic papers, for presentation to the United Nations Water Conference, in addition to the national reports prepared for the regional prepatory meetings. Paragraph 11 of the aide-mémoire stated that:

> "Governments are invited to propose thematic papers for presentation to the Conference at Mar del Plata. It is suggested that these papers should concentrate on specific issues relevant to the main themes to be considered at the Conference. Such papers will deal in detail with national experiences in water management likely to be of world interest or with the results of the research undertaken by national institutions or scientists relevant to world water management."

By the end of November 1976, 215 thematic papers had been received in response to the aide-mémoire and the survey that follows is intended to facilitate their consideration by the Water Conference.

A. Geographic Coverage

The table below shows the region of origin of the 215 papers received, the regions being those of the United Nations regional commissions; for the sake of convenience, the papers from the United States of America, the Union of Soviet Socialist Republics and Canada are included in the total for Europe.

Europe including the USSR, the United States of America and Canada	136
Asia and Pacific	31
Africa	25
Latin America	21
West Asia	2
Total	215

*The present document was prepared by the secretariat of the United Nations Water Conference and subsequently reviewed, revised and endorsed by an intergovernmental working group convened at United Nations Headquarters from 6 to 10 December 1976 by the Secretary-General of the Conference. The names of the members of the working group are given in annex I.

**The numbers within brackets in the text of the present document refer to the serial numbers of the thematic papers and corresponding abstracts. In most cases, quotations are taken from the abstracts. For further information, see *Water Development and Management*, edited by Asit K. Biswas, Pergamon Press, Oxford, 1978.

Thus, 136 of the papers, or about two thirds of the total number of those received, are from the developed countries and this geographic coverage has a bearing on the subjects dealt with.

B. *Subject Coverage*

The wide spectrum of water resources development includes water policy, planning and management, the assessment and appraisal of water sources and uses, and supportive technology, research, education and training etc. From this spectrum, based on the topics covered by papers presented to the Conference, the following picture emerges.

	Number of papers
Water policy and planning objectives, including institutional and legislative problems	81
Assessment of water availability, including surface and ground waters	42
Water quality	6
Improvement in the management of water demand	3
Community water supplies	19
Use of water in agriculture	17
Use of water in energy and industry	11
Problems in the development of technology and research	9
Environment and health considerations	20
Flood loss and drought management	6
Utilization of shared water resources	11
Education and training	5

From the geographic and subject coverage of the papers, it will be seen that:

(a) The great majority of the papers deal with questions relating to policy formulation and planning objectives, including institutional and legal problems;

(b) Various aspects of the assessment of water availability, including surface and ground waters, have received more attention than problems of water use and development; here again, the assessment of ground-water availability and the monitoring of water quality are given more attention than questions pertaining to surface waters and non-conventional sources such as the sea or brackish waters;

(c) A good number of papers deal with the environmental impact of water development, both in the developing and the developed countries;

(d) A preponderant number of papers deal with the problems associated with the provision of community water supplies to both urban and rural communities;

(e) After community water supplies, problems associated with the use of water in agriculture come next in priority;

(f) Although a large number of papers deal with community water supplies, problems associated with excreta disposal have not received commensurate attention;

(g) On the whole, there has been relatively little coverage of important subjects like rural water supplies (only five papers), the development of appropriate or intermediate technology and other related aspects such as the transfer of technology, inland navigation (only one paper) and recreation and fisheries (a few papers refer to these questions); neither has much attention been paid to strategies for combating water-related diseases (one paper only); floods, droughts and earthquakes (six papers), problems of education, training and specialization (five papers), and salination and salinity problems (only two papers);

(h) There have been no papers as such on pricing mechanisms, financial problems or capital needs.

The desirability of focusing on new ideas, concepts and techniques and on aspects of national experiences that are likely to be of much wider and more general interest or validity to many other similarly placed countries or regional groupings have been important criteria in preparing the following broad overview of the principal points covered in the thematic papers.

I. PROBLEMS OF PLANNING AND POLICY FORMULATION

A. Policy and Planning

1. Policy

Increasing attention is being paid in many countries to formulating and strengthening water policy and planning objectives. The definition of objectives and the setting of goals and targets to be achieved over specified time-spans is the essence of the planning process. It would be pertinent to take into account objectives for different sectoral uses of water, such as the provision of community water supplies, rural as well as urban, the provision of water for the production of food and other agricultural products, water for industries and for the generation of hydropower, strategies for mitigating losses arising out of extreme conditions like floods or droughts or, in the most general sense, the use of water for the benefit of man. In the formulation of water policies and short-term and long-term plans, this basic human dimension should be considered as the key element and the main motivation for water resources development. Such an over-all human perspective has been counselled by the Holy See (61).* In considering any aspect relating to the planning and development of water resources, France (181) has also drawn attention to the fact that it is necessary to have this broad approach to the role of water as the basis for the sustenance of life and as the foundation for the civilizations that have grown up on the banks of rivers throughout the history of man.

Some notable examples of comprehensive water resource planning on a national scale are provided in the thematic papers by Denmark (207), the United States of America (92), Iraq (204), Japan (76), the Ukrainian SSR (140), Iran (27), Mexico (100, 102 and 103), Canada (157), Yugoslavia (58), the United Republic of Tanzania (153), Italy (98), Romania (45), the Byelorussian SSR (47) and the USSR (128, 130, 131, 132, 133, 166).

The abstraction of water in Denmark is presently estimated at 770 million cubic metres a year — 290 million cubic metres for industry, 10 million cubic metres

*The number in brackets indicates the number given to the paper referred to at the Water Conference. For the papers, see *Water Development and Management*, edited by Asit K. Biswas, Pergamon Press, Oxford, 1978.

for thermal power plants, 140 million cubic metres for agriculture and 330 million cubic metres for the population. In the year 2000, these figures are expected to increase to 1150 million cubic metres for the country as a whole, 380 million cubic metres for industry, 50 million cubic metres for thermal power plants, 170 cubic metres for agriculture and about 550 cubic metres for the population. In contrast, similar national data developed by the United States of America's New Water Assessment and Appraisal Programme indicates that between 1975 and 2000, total water withdrawals will decline by about 14 per cent, while total consumptive uses will increase by about 20 per cent.

This illustrates the sound basis for undertaking long-range planning on the basis of demand projections.

Iraq (204) has also created a scientific basis for the development of water resources by estimating the projected requirements by 1995, totalling to 67.6 billion cubic metres per year, of which irrigation alone accounts for 52.1 billion cubic metres. Estimates have also been made of the total water resources of the country (106 billion cubic metres) and the hydropower potential (56.1 billion kilowatt hours). Similar estimates for the Ukrainian SSR (140) show that the total stream discharge is 80 billion cubic metres (49 billion in a dry year) and the demands of the people and the economy are estimated at 32 billion cubic metres.

Considerable importance is attached to the creation of adequate storage capacity to help use this available resource for national needs. Since 1948, 13 large dams and reservoirs have been constructed in Iran (37), regulating more than 22 billion cubic metres of water, annually irrigating 4 million hectares and ensuring an installed capacity of 1800 megawatts, and six additional large dams are under construction, regulating an additional 1 billion cubic metres annually and generating 134 megawatts of power. The fourth plan started in 1968 and is scheduled to continue through to the eighth plan, which will be completed in 1993.

Estimates of national resources are not in themselves adequate indicators of sufficiency of supply. Mexico (100) points out that "although the supply is sufficient to meet future requirements, this will require new action involving more efficient use of water for the prevention of pollution and control of water quality". Based on this concept, Mexico (102) viewed the planning process as a process for determining targets, in respect of quantity as well as quality, both at the regional and central levels, in the short, medium and long terms. The design of an information system to support the planning process on a continuous basis is an important feature of the planning mechanism. It is therefore pointed out that "Mexico's National Water Plan is a pioneering effort in the world". Canada (157) also offers an interesting experience in comprehensive river basin planning initiated over the past five years for the Canadian river basins under the provisions of the Canada Water Act of 1970. The USSR reports on its long experience in the comprehensive and integrated planning of water resources development, the preparation of "water economy budgets" for river basins (128, 133, 166) hydrological forecasting for operational planning (131) and economic and organizational principles that are adopted (132). Yugoslavia (58) reports on its experience in the preparation of comprehensive water management plans for individual river basins in the country and their planned integration into a national plan, taking into account the regional imbalances and priorities in the national, economic and social plans. The United Republic of Tanzania (153) adopts a similar approach for the preparation of a long-term national plan as the synthesis of several subplans for different regions of the country. The planning process, which started in 1971, is expected to be concluded in 1978, culminating in the formulation of a national plan.

The importance attached to the formulation of a national water policy in Italy (98) is evidenced by the legislation adopted by the Senate on the problems of water supply, conservation, regulation and pollution control and the decision to convene a National Water Conference to discuss and adopt appropriate policies to achieve national objectives. The long-term national programme adopted in 1976 by Romania (45) is estimated to span 30 years, by which time the multipurpose development of the river basins in the country is expected to be completed. The goals for a 15-year period have already been established. On the other hand, a number of countries, such as the Byelorussian SSR (47), formulate development plans on the basis of both one-year and five-year periods.

Thus, it will be seen that long-term planning practices vary from country to country. In some countries, the formulation of perspective plans indicates the ultimate potential in different river basins, while in others the periods of planning are taken as 30 years, 15 years and five years, in addition to which there are annual plans. Evidently, the plans for shorter periods (e.g. five years) are more closely integrated into the over-all economic and social development plans than are the plans for longer periods.

2. *Regional planning*

The regional concept discussed below includes both intranational and transnational regions and comprises three types of zones, namely (i) river basins; (ii) distinct homogeneous geographic zones like the karst, coastal or arid zones; and (iii) administrative units, such as states, in countries with a federal structure.

In the context of regional planning, the comprehensive development and use of the Volga basin reported by the USSR (133), the Dnieper river basin, reported by Ukrainian SSR (139), the Vistula and Odra river basins in Poland (10), and the Tone and Ara river systems in Japan (76) are examples of the comprehensive planning of individual river basins. In the same context, Zaire (184) emphasizes the importance of the multipurpose development of the potential of the Zaire river basin not only for the benefit of the country itself but for the basin as a whole, such development comprising drinking water supply, navigation, fisheries, agriculture and energy development (the dam at Inga on the Zaire has one of the most powerful hydropower potentials in the world). Finland (51) has valuable experience in regional planning for the development of water resources. On the other hand, there are examples of regional plans evolved in a comprehensive manner for regions with common geographic or other features. The Dinaric karst region in Yugoslavia (54) is a good example of planning for the development of multipurpose water resources in a distinct geographic region, to be used for industry, power generation, etc. Remarkable results are reported to have been achieved in the construction of various projects, notably reservoirs and tunnels, under difficult and complex karst conditions. South Australia (114) and New South Wales (115) have reported on their integrated approach to preparing outline plans for the ultimate development of water resources. These are examples of planning at the state level in the context of a federal structure.

Another example of regional planning occurs in the coastal zones in the United States of America (190) and Canada (154). The geographic coverage of the management programme for coastal zones in the United States includes not only coastal waters, but the shore-lands whose uses have a direct and significant impact upon the coastal waters. Planning also takes into account "local concerns for the on-shore socio-economic impacts of off-shore oil and gas exploration and production". The Province of Prince Edward Island in Canada is cited (154) as an illustration of the importance of co-ordinating development based on multidisciplinary research.

Arid zones constitute another distinct category in regional planning. Israel (105) concentrated on the satisfaction of demands in the 1950s, management of demand in the 1960s and pollution control in the 1970s. In the case of the minor river basin of Gaja Creek (600-square kilometre catchment) in Hungary (6), the objective was to balance demand and supply, storage being a factor of fundamental importance in striking such a balance.

The above examples illustrate the variety and complexity of regional plans for the development of water resources and the need to consider certain specific regions, such as coastal or arid zones, apart from national and river basin planning.

3. *The integration of water planning into over-all planning*

In the formulation of long-term plans and regional plans, new innovative methods and techniques are being constantly developed. Planning is no longer unidirectional, neither is it limited to a single objective and there is an increasing recognition of the need to integrate water planning and management into national, social, economic and environmental goals; (USSR, 132, 166), Denmark (208, 209); the United States (92) also points out that such management should take into account both quantity and quality. Discussing the methodological aspects of water planning, Argentina (89) points out that the use of water "is clearly a question not of ordinary supply and demand, but rather of a derived demand". Quantification of demand and allocation of water, both quantitatively and qualitatively, become important components of water planning.

4. *New methods and techniques of planning*

This limitation of the river basin as a unit for planning logically leads to increasing efforts to effect interbasin transfers. The efforts by the USSR (165 and 166) to achieve a territorial distribution of water resources by redirecting northern and Siberian rivers towards the southern incline and establishing a unified water management system for the country are of interest in this context. The demonstrable feasibility, both technical and economic, of such interbasin transfers encourages reversals of the natural direction of river flows and would radically alter the basis and traditional concepts of planning and policy making.

The dynamic concept of the relativity of the water resources potential reported by Yugoslavia (55), which deals not only with conventional parameters of quantity and quality but also the parameter of potential energy (head) is an interesting analytical tool; the methodology indicated for eliminating waste in usage is also of interest. The use of pumped storage, increased reservoir construction on natural streams and the interbasin transfer of water are some of the planning and management techniques reported from Spain (63). Techniques to estimate the useful volumes of water for different purposes are also described by Spain (65). The conjunctive use of surface and ground water for integrated planning is emphasized by Iran (15) and the Sudan (27).

The use of mathematical models for the integrated development of surface water and ground water is reported by Iran (15), and the computerized optimization of power production from a reservoir system by the use of a mathematical model is cited by Austria (13). These are examples of the increasing use of the technique of mathematical modelling and computerization in the solution of a variety of problems involved in the process of planning.

B. *Institutional Arrangements*

In several countries a number of interesting patterns are evolving in the building of an appropriate institutional framework for the organization of multiple-purpose water resource development.

The establishment of 16,200 water authorities in the Federal Republic of Germany (142), 10,500 of which are "organized according to the legal provisions on water and soil authorities", are instances of this trend. The other interesting feature of this type of organization is the principle of "self-administration". It is also significant that the authorities are organized in "one of the most densely populated industrial areas of the world, the German Ruhr district". A somewhat similar principle seems to govern the organization of water resources development in Yugoslavia (56) within the context of its "self-management system". Representatives of citizens, water users and water-management enterprises govern the water-basin authorities.

Under a common agreement between the federal Government and the provinces, Argentina (85) has established seven river-basin committees which are inter-jurisdictional bodies. As there are 99 river basins in Argentina, this fruitful work will be continued. *Waterschappen* (water control boards) in the Netherlands (189) deal chiefly with dams and dikes and with problems of water control and water pollution in their districts. The interrelationship between the economic and organizational principles of water management is emphasized by the Union of Soviet Socialist Republics (132). The new water authorities set up in the United Kingdom for river basin management have facilitated an integrated approach to the problem of water development in that country. The authorities integrate all functions and are vested with powers to license all development and seek information about resources and demands. Romania (44) reports on the establishment of a water-management information and decision-making system, while Poland (12) follows system-oriented regional management patterns, as in the case of the urbanized and industrialized region of Upper Silesia and the agricultural region of the upper Notec river.

The problems of assuring national co-ordination and the development of a national approach to water assessment, research and management in a federal structure where the constitutional responsibility devolves on the states is reported by Australia (110). An important mechanism for achieving this national approach was the formation of the Australian Water Resources Council in 1963. More recently, a statement of water policy acceptable to all members of the Council was formulated. The collaborative intergovernmental basis evolved in Australia is of interest to countries with a federal structure, where an active role in the field of water development is assigned to individual states.

C. Legislation

The closely related question of providing a suitable legal and legislative framework for the development of water resources is becoming increasingly important not only in European countries like Poland (9) and Spain (67) but also in countries of the African region such as Botswana (73).

Poland (9) enacted a new Water Law in 1974 which is much more comprehensive than either the Water Law of 1962 or the Water Decree of 1922, and covers such questions as irrigation and drainage, as well as the water supply for cities and rural settlements.

Spanish water law (67) contains certain interesting premises, for example, while all running waters are public, "ground water brought to light by an individual on a property and rain water that falls on that property are private".

In arid countries such as Botswana (73), individuals who control ground-water rights and water boreholes acquire the ability to control vast communal grazing areas. The issues of water rights and land control are now closely interwoven and this has resulted in profound changes in the socio-economic fabric of societies traditionally based on the collective ownership of land, but where new features of individual ownership are becoming apparent.

Thailand (31) has prepared a Ground-Water Act providing "for the control of engagement in ground-water activities, which include drilling for ground water, the use of ground water and the disposal of water or liquids into the aquifer through a well". Under the Act, private ownership of ground water is permitted only outside the area proclaimed by the ministry as a "ground-water area". Moreover, the ownership of ground water is confined to "only depths not exceeding those stipulated in the ministerial regulations". A system of permits is contemplated. Excessive pumping of ground water in Japan (171) is known to lead to land subsidence, which is of the order of 10 centimetres per year in an area such as Osaka and legislation is therefore needed to control ground-water pumping.

Apart from legislation on such individual aspects of water use and development, the present trend is to promulgate a complete and comprehensive legislation in the form of a water code or water law. Australia (114) reports the recent enactment of a new Water Resources Act providing for the first time in Australia a complete water resources code in one piece of legislation, covering surface and underground water management and water quality control, and providing formal mechanisms for the co-ordination of planning and for the involvement of the public in the water resources management process.

Legislation, its form and content, is an integral part of the socio-economic structure and policies adopted by Governments. This intrinsic inter-relation between economic, organizational and legislative principles and regulations is emphasized by the Union of Soviet Socialist Republics (132).

II. ASSESSMENT OF RESOURCES AND NEEDS

The assessment of resources and the assessment of needs are dealt with jointly, since they are interrelated.

A. *Assessment of Resources*

The following aspects of the question are dealt with below: surface water, ground water, collection of data (an aspect which is common to both surface and ground water), non-conventional sources and matters related to water quality assessment.

1. *Surface water*

In recent times, there has been an increasing interest in the assessment not only of water resources at the national, subregional and regional levels but also of the resources of the earth and of the components of the water budget for the world as a whole. In this connexion, mention must be made of the outstanding contribution of the USSR (127) to the International Hydrological Decade, in the shape of a monograph which evaluates and calculates "the components of the water budget for Europe, Asia, Africa, North America, South America, Australia and Oceania, the Arctic and the Antarctic. At the same time, it evaluates the water budget of dry land, [57] lakes ... and [25] reservoirs ... the fresh-water budget of the Pacific Ocean and the water budget of the entire globe". The monograph also includes a forecast of changes in the earth's water resources under the impact of human economic activities in 1985 and 2000.

The techniques for forecasting changes include the establishment of indicators of the current use of water resources and long-term water requirements, the two components that go into the preparation of what in the USSR are termed "long-term water economy budgets for river basins" (128).

The USSR (125) also reports on the results of interesting research on the use of aerological observation data for 35 South American stations between 1966 and 1970 for the computation of the atmospheric water budget over the South American continent as a whole and, based on this, the computation of monthly values of precipitation minus evaporation, not only for the continent but for its various physical and geographic zones. Similarly, the monthly amounts of evaporation from the La Plata basin were estimated from a study of the atmospheric budget over the basin. This aerological approach offers interesting possibilities for an assessment of the water resources of other continents and water basins, particularly those where few records have been taken in the past.

Global evaluations of this nature contribute to an understanding of deficiencies and surpluses of different geographical regions and continents and, at the same time bring into focus methodological deficiencies in the techniques of resource estimations.

The estimation of available surface water resources involves not only an assessment of the total surface resources, but also a determination of their distribution in time and space. The requirements of assessment vary with the nature of the projects. The difference in the requirements for irrigation projects, hydroelectric projects and water supply projects is pointed out by Spain (65), which underlines the importance of such parameters as the percentage of inflow, the distribution of flow and precipitation and the physical geography of the basin. A lower rate of guaranteed success in the earlier stage is permissible in irrigation projects. In hydroelectric projects greater economic efficiency is assured only when a percentage of the mean flow is guaranteed, which in turn requires a greater rate of guarantee in studies on the exploitation of resources. A higher guaranteed flow is warranted in studies on water supply.

But whatever the nature of the project and the guarantee of success in the exploitation of resources, the basic requirement for planning is the collection of hydrological data. In view of this, a number of countries have been attaching considerable importance to making an inventory of the surface-water resources by strengthening hydrometric networks. This activity has received an enormous impetus in the International Hydrological Decade, which ended recently, and it is to be hoped that this aspect will continue to receive the attention it merits in the International Hydrological Programme, which has succeeded the Decade. In addition to traditional hydrometric networks, the successful utilization of complexes of representative basins has been reported by France (174), particularly in the calculations of flood levels and annual run-offs in the Sahel region of Africa. The concept of representative basins is recommended as a useful tool in the assessment and inventory of surface-water resources in developing countries (174).

In several countries, in addition to rainfall, snow-fall acts as an important source of river waters and a number of countries have therefore been actively engaged on snow surveys and forecasting the total annual discharge of the streams, based on the measurement of snow accumulation and the computation of snow melt run-off. Argentina (82) reports on its experience of 25 years of snow surveys conducted by the Argentine Water and Electric Power Agency, which uses the forecasts of stream-flow based on snow surveys in the operation of projects for the generation of power and for irrigation. Similar is the case with USSR (131) where the main source of water for most of the country's rivers is snow melt, which accounts for between 60 per cent and 90 per cent of the annual run-off of the rivers. Seasonal forecasts of stream-flow from snow-melt made at the beginning of March have a "lead time" ranging from three to seven months. Statistics show that the probability of maintaining a marginal error of no more than 20 per cent ranges from 75 per cent to 90 per cent. The Ukrainian SSR (138) also reports on its experience of hydrological forecasts and their use in day-to-day water-management planning. Not only is forecasting a useful tool in the operation of reservoirs and, in the more general sense, in system operation, but long-term forecasts are issued giving the volume and maximum or minimum flow of regulated and unregulated rivers. This aspect of long-term forecasting is particularly useful in predicting impending droughts or floods.

Successful water planning and management require not only adequate and well-distributed hydrometric networks in the field, but also sound, scientific and systematic arrangements for the collection and processing of the hydrological data that are collected from such networks. In this respect, methods of electronic data-processing using computer facilities are becoming more and more popular in many developing countries. For instance, Kenya (168) and the United Republic of Tanzania (152) report on their initiation of computer systems for data storage and retrieval, including the preparation of magnetic tapes. Argentina (83) reports on the setting up of a multidisciplinary working group to analyse hydrological data, with powers to establish commissions composed of specialists in different subjects. As a result of the efforts made by the working group, a number of studies have been made and 83 working papers covering a variety of subjects have been prepared.

The experience of the United States (161) points to the desirability of having a principal fact-finding agency for data collection "that is independent of the missions of water-management agencies", at the same time ensuring communication between the data collector and the data user. Further, there is a reciprocal influence between the data base and water policy.

The ever-increasing demand on available surface-water resources and the growing need to explore ways and means of augmenting traditionally available supplies is illustrated by the Jonglei Canal project in the southern part of the Sudan. An enormous quantity of water is lost in the extensive swampy areas of the Sudd. It is estimated that 42 billion cubic metres of water are lost annually, half of the quantity of water at Aswan, on the Nile, which is 84 billion cubic metres. Considerable importance is attached by Egypt (16) and the Sudan (30) to the projects for increasing the Nile yield. The first phase of the Jonglei Canal project is expected to save 4 billion cubic metres of water.

2. *Ground water*

There is increasing interest, in almost all parts of the world, in a systematic extensive and comprehensive investigation of ground-water prospection, use and development. Examples of such interest are afforded by a number of countries in Europe, Africa, Asia and Latin America. The following aspects of ground-water development have to be considered:

(a) Use;

(b) Planning and prospection;

(c) Problems associated with the artificial recharge of aquifers;

(d) Advanced methods for prospection and development;

(e) Some special categories of ground water, such as mineral and thermal waters.

(a) Use. At the present time, ground-water consumption in the Soviet Union (129) amounts to approximately 700 cubic metres per second, i.e. only about 7 per cent of the estimated recoverable resources of 10,000 cubic metres per second. Of the present use, approximately 320 cubic metres per second are for urban water supply, about 190 cubic metres per second for agricultural water supply and pasture watering and 160-170 cubic metres per second for the irrigation of cultivated land. Ground water is used to supply approximately 60 per cent of the Soviet Union's total urban water supply needs and 80 per cent of its agricultural water supply needs (129). Similarly, at present "about 90 per cent of the stable water resources which are formed on the territory of the German Democratic Republic are already used in an average year. ... Twenty-five to 30 per cent of the water demand is covered by ground water" (60).

Finland (48) made a detailed survey of all aquifers with a daily yield of more than 250 cubic metres to help communities within reasonable distances which might possibly resort to this source for their water supply needs. It is anticipated that all the available ground-water areas would be put to use by the year 2000; the amount of ground water obtained would be 1.6 million cubic metres per day — making use of about 40 per cent of the known ground-water resources for the whole country in place of the present 22 per cent.

The USSR (120) reports on the various methods being taken for protecting ground waters against pollution, including the proper location of industrial enterprises, the establishment of sanitary protection zones, pumping tests, the injection of water into strata in order to extract the polluted water, the burial of highly toxic waste in deep strata, comprehensive monitoring, etc.

(b) Planning and prospection. In order to facilitate rapid increases in the use of ground water, extensive planning and prospection is undertaken in almost

all countries in the different continents. The use of ground water is particularly important in the arid zones of the world. The Federal Republic of Germany (145) points out that "in humid zones, for example, a discharge rate of 1000 cubic metres per day demands a catchment area of 1 square kilometre in a sandy aquifer with a recharge rate of *circa* 50 per cent of 730 millimetres per annum precipitation. In an arid zone with an annual precipitation of only 73 millimetres and a maximum recharge rate of 5 per cent of the same discharge of 1000 cubic metres per day demands under the same hydrogeological conditions a catchment area of 100 square kilometres." This points to the comparability of 100 square kilometres in an arid area to 1 square kilometre in a humid area, which underlines the importance of ground water in arid zones.

Ground-water prospection is carried out in almost all African countries. Extensive drilling is reported from the Ivory Coast (46); 150 bore holes totalling 8500 metres of drilling were done in one year, ending 1 April 1976.

Mapping is in various stages of progress in the African countries; for instance, 1:1,000,000 maps covering 15 hydrological units were prepared in Somalia (38). Prospection has been in progress in the sedimentary basins of the southern and north-eastern parts of Benin (99). A systematic regional assessment has been taken up in individual river basins in the Sudan like the Gash at Kassala (26) and also for the country as a whole (27). In the Sudan, the total rural water demand is estimated at 275 million cubic metres, ground-water resources at present providing 23.2 per cent of this amount. The total annual recharge is estimated at 1381 million cubic metres, of which 143 million cubic metres represents use. There is considerable interest in ground-water development in Egypt (18) including the Nile valley, the delta, the coastal areas and the desert. The construction of the Aswan Dam is known to have introduced profound changes in the ground-water régime of the country. France (176) carried out a comprehensive hydrological study in the Sahel which resulted in the production of three types of maps on the scale of 1:500,000, showing: (i) initial flow-rates of ground water; (ii) the average cost of ground-water exploitation; and (iii) the suitability of water for irrigation. A comparison of these three maps would make it possible to choose the most suitable regions for agricultural development.

In Latin America, Argentina (79) reports that, although general hydrological exploration is fairly well advanced in the country, extensive areas remain to be appraised. Also in Argentina, the ground-water potential in parts of the pampa plains was evaluated by the Federal Republic of Germany (146), using modern methods of exploration, including interpretation of air-borne photography, remote sensing and geophysics, to prepare maps on the scales of 1:50,000, 1:100,000 and 1:500,000.

In Sweden, hard rock aquifers play an important role. Techniques, based on geological, tectonic and geophysical methods, are used to find areas in hard rocks with a proper fractual pattern with enough free space to store infiltrated water. The methods and experience of Sweden (71) would be of interest to areas in Africa, the Arabian shield, the Indian subcontinent, Australia, Brazil and other similar parts of the world.

Some of the problems encountered in planning the development of ground-water resources are the reconciliation of possible conflicts in their potential use and prevention of the pollution of natural resources. Australia (113) points out potential conflicts between urban and industrial use, irrigation, wild life and recreation interests in the case of the Swan coastal plain. Although these have not yet developed into major problems, it is obvious that careful management will be required as development takes place in the future.

(c) Artificial recharge of aquifers. Considerable interest has been shown in problems relating to the artificial recharge of aquifers. The USSR (134) reports on two main trends, regional and local. The main types of research reported from the USSR are experimental infiltration in basins, the injection of water into absorption boreholes and experimental work on filtration columns. The Ukrainian SSR (136) also reports on the use of open infiltration works (basins, channels), in addition to water injection boreholes to assist in artificial replenishment. In the case of the Burdekin delta in Australia (118) surplus water from the river was pumped to recharge the ground-water supplies and the scheme involved the construction of pumping stations, distribution channels and excavated recharge pits.

Sweden (71), when reporting on its 80-year experience in artificial recharge, points out that the most suitable geological formations in arid and semi-arid areas are coarse alluvial deposits and sedimentary rocks. The infiltration process is simple and can be operated by unskilled labour under limited supervision.

(d) Advanced methods for prospection and development. An interesting new approach has been evolved by Hungary (2), which postulates that the water balance "is a socio-economic-hydrogeological estimate of the hydrogeological consequences of withdrawal rather than a comparison of water demand with some resources figure regarded as constant". Mathematical modelling techniques are being developed in Hungary for the determination of safe yields according to this dynamic concept. Modelling as an aid in the problems of ground-water exploration and development is also reported from the German Democratic Republic (59). The use of natural and artificial tracers and salt injections in the investigations of karst waters is reported from Austria (43). Airborne photography, remote sensing, geophysics and nuclear techniques are among the advanced techniques that have to be used, particularly in the developing countries, to a greater extent than hitherto for ground-water exploration and development.

(e) Mineral and thermal waters. The USSR (124) reports interesting research on the use of mineral, thermal and industrial water resources "for heat-power engineering and as a source of useful substances". Carbonaceous mineral waters have been exploited in the south of the country and nitric thermal waters in the neighbouring areas. Known supplies of thermal waters amounting to 3.5 cubic metres per second are reported to have been used to produce electrical energy and to supply heat. Mineral and thermal waters are also reported to have been used in the industrial production of iodine and bromine. There are a number of countries that have such mineral and thermal springs and the work reported by the USSR would be of value to those interested in using such water resources not only for spas but for other economic purposes, such as those cited by the USSR in its paper.

3. *Collection of data*

The USSR (130) reports on an integrated national recording system for water and water use consisting of three subsystems, one for recording surface water, one for recording ground water and a third for recording water use. An integrated system of this kind, comprising not only data on available resources of surface water and ground water but also including the details of its utilization for development purposes, will be of interest to many countries that are in the process of building up data collection systems to help in their national planning.

4. *Non-conventional sources*

In addition to the conventional sources of surface and ground waters, non-conventional sources such as sea water and brackish water, induced precipitation and geothermal waters, are increasingly being used for a variety of purposes, for example, for community supplies or for industry.

Sea water and brackish water. Reporting on its use of desalting technology to meet its fresh-water needs, Kuwait (25) mentions the results of the experiments on the various desalting processes, leading to the conclusion that "the multistage flash is the most reliable method for large-scale plants, both technically and economically". The plants in Kuwait serve the dual purpose of satisfying demands for both power and water. There does not seem to be any irrefutable evidence to warrant the conclusion that the multistage flash is indeed technically and economically the most reliable method. For instance, research is now being undertaken in experimental plants in Japan (173) employing the reverse osmosis technique, with a view to providing pure water while using a more practical sea-water desalination method at lower cost and with less energy consumption. Another interesting example of the use of desalinated water comes from the Colorado river basin in the United States of America (191). A desalting plant with a capacity of 104 million gallons per day (4.6 cubic metres per second) is to be constructed in Arizona for the purpose of improving the quality of the Colorado river water delivered to Mexico.

Induced precipitation. Considerable interest has been evinced in research and experimentation on weather modification, including precipitation management technology and anti-hailstorm plans. Studies in the United States (191) show that precipitation management technology could increase the annual runoff in the upper Colorado river basin by 15 per cent, at a cost ranging from $1.50 to $3 per acre-foot. Argentina (90) draws attention to the need for a careful cost-benefit assessment in the attempts at artificial weather modification.

Geothermal water. In the United States (191) studies are under way in southeastern California on the desalting of geothermal brine and the generation of electricity from geothermal energy. The water developed under this programme could be used to augment existing supplies.

The intensive research and experimentation being carried out with a view to augmenting traditional water supplies from non-conventional sources such as those described above are indications of the acuteness of the water scarcity in certain parts of the world.

5. *Water quality assessment*

Apart from the measurement of quantity, observations on the quality of both surface and ground water constitute an important part of the assessment of available resources. Thus, water quality measurements are introduced as integral parts of observational networks in many countries. The monitoring of quality is also considered to be one aspect of the fight against pollution.

France (175) has underlined the close interrelationship between quality management and quantity management, "which is achieved in identical fashion:

regulation and economic incentives". A similar plea is made by the United States of America (108) for a closer integration between water quality and water quantity planning both by State and local agencies. Under the terms of the Danish Environment Protection Act of 1973, Danish regional authorities submit water quality plans for streams, lakes and coastal waters (210), the primary purpose of which is to indicate for what uses the different water areas are suited.

The automatic monitoring of water quality forms part of the water management information and decision-making system in Romania (44). The case of the pump-storage project in Austria (41) is somewhat unique in the sense that the monitoring of quality of waters in the reservoirs of manifold origin has for its aim the determination of stratification and flow superposition of waters of different quality in the reservoir.

As in the case of surface waters, great care is necessary in the determination and preservation of the quality of ground waters. For instance, in Finland (48), there are varying amounts of iron and manganese in the ground-water resources and various methods are developed for their removal.

Australia (109) points out the need to establish some mechanism for continually updating any set of water quality criteria, since even for the relatively well studied agents there are still many unknowns, such as the effect of critical receptors. Although in Norway (185), "most of the land area and most water basins are still at the stage of no industrial activity going on", the Government is preparing three new laws — a planning law, a comprehensive pollution law and a product control law — as new instruments for the water quality management of unpolluted and slightly polluted water resources. As the situation in many developing countries is comparable in the sense that many of the streams are still unpolluted or slightly polluted, the experience of Norway will be of interest to such countries.

B. *Assessment of Needs*

An essential element in the process of planning, besides the assessment of resources, is an assessment of needs. Estimates of needs have to take into account not only present requirements for various sectoral uses but also projected requirements for the future, so that reasonable demand projections for the foreseeable future may provide the necessary perspective for planning. A number of countries have been making estimates of present and future demands for water for different purposes. There appears, however, to be a need to rationalize the basis for such estimates and also to introduce an element of uniformity in order to make them as far as possible comparable, at least in the same international river basin.

At the same time, the keen competition for water has made it necessary, at least in countries where future prospects are extremely competitive, to foster the concept of management of demand as distinct from management of supply. Management of demand proceeds from the premise that "no supply system can be dimensioned economically for covering completely the peak demands, but certain restrictions in supply must be anticipated". Proceeding from this, concepts have been evolved in Hungary (5) of "supply restriction indices", "shortage tolerances", and the "determination of risk indices", etc.

III. COMMUNITY WATER SUPPLY

This question may be considered under three broad headings, namely, urban water supply, rural water supply and sewage disposal and treatment.

A. *Urban Water Supply*

The increasing trend of urbanization in all the regions of the world is causing strain on metropolitan and urban water supply systems already in existence, as much in the developed world as in the developing world.

There are interesting papers on the problems caused by expanding water needs in large metropolitan areas like Madrid in Spain (66), Helsinki in Finland (50), Tokyo and Osaka in Japan (74 and 75) and Bangkok in Thailand (70).

The Madrid water-supply system (66) is extraordinarily complex, consisting of water resources drawn from eight rivers (two more rivers will be added to the system later), 12 reservoirs with a capacity of about 900 million cubic metres with plans to build four new reservoirs by the year 2000, with a capacity of 1500 cubic metres. In addition, there are 441 kilometres of major canals, six water treatment plants and a distribution network about 4000 kilometres long.

The Helsinki (50) metropolitan area is served by the Päijänne Tunnel, 120 kilometres long, which, when completed, will probably be the longest tunnel in the world constructed through rock. The cross-section of the tunnel is 15 square metres and its discharge capacity will be 13 cubic metres per second. About 4 million cubic metres of crushed rock are involved in the construction work.

In Austria (77), "usually, centres of consumption can be supplied with ground water or spring water from the vicinity". The use of surface water is practically limited to industrial purposes. The problems of water supply in Austria are being met by encouraging the establishment of a water supply network through the construction of large-scale plants and the granting of public subsidies in this respect.

In large metropolitan areas in Japan (75), like Tokyo and Osaka, "water has willy-nilly become a factor restricting social and economic development". The principal water sources for Tokyo and Osaka are the Tone and Yodo rivers. It will be difficult to envisage further development after 1985, when the water resources development projects now under way will have been completed. A large-scale reorganization of water undertakings "was recently examined and promoted" in Japan (74). The purposes of the reorganization are to strengthen the financial and management basis of the undertakings, utilizing water effectively, equalizing water prices in wide areas and lowering water costs. Some new concepts are also being developed, such as the adoption of advanced water-treatment techniques, for example carbon absorption and ozonation, the use of low-quality water sources and the reuse of waste water for purposes such as toilet flushing.

In the metropolitan areas of Bangkok in Thailand (70), one third of the water supply is at present extracted from ground-water sources and two thirds from surface run-off diverted from the Chao Phraya river. The pumping of ground water has now exceeded the safe yield and consequently is lowering the ground-water level by 3 to 4 metres per year. Therefore, the policy is to use surface water as much as possible and this, in its turn, is making the preparation of a basin plan for the river necessary to facilitate a rational allocation of available river water for different purposes.

The enormity of the problem of a potable fresh water supply, even in the developed countries, is indicated by the feasibility studies reported by Norway (186), concerning the possibility of low-cost tow transportation of unpolluted, potable fresh water in large quantities from Norway to the Netherlands in very large (1 million cubic metres capacity) light-weight flexible containers. The economics of small containers are also included in the scope of the study. Tanker transportation of potable water could at best be a temporary solution to meet occasional periods of water shortage.

B. *Rural Water Supply*

The United Republic of Tanzania (151) has evolved a comprehensive policy for rural water supply in terms of which targets have been set to provide clean, potable water within easy reach to every individual in the rural area by 1991 and a crash programme is being implemented to provide every village with a permanent source of potable water within the next five years. The United Republic of Tanzania estimates that efforts must be made to provide water to 20 million people in the rural areas between 1973 and 1991. A concerted effort is being made to deal with the principal constraints arising out of shortages of trained manpower equipment, transport facilities and finance. Similarly, Guyana (183) plans to provide improved water supply to the entire country by 1985. A phased long-range water supply improvement programme has been undertaken to facilitate the achievements of this target. These are two examples of efforts being made by countries to implement the recommendations of Habitat: United Nations Conference on Human Settlements.

Thailand (35) is evolving a comprehensive policy and programme for the extension of water supply facilities for domestic use in rural areas, including pipe-distributed water systems, surface waters, ground water from deep-drilled wells, etc.

Argentina (88) points to the need for an efficient functioning of the financing machinery to assure the allocation of sufficient resources for this vital purpose.

C. *Sewage Disposal*

Although problems of sewage disposal and treatment have not received, on a global scale, the same attention as problems of water supply, some countries have been developing various methods for the treatment of urban and industrial sewage. For instance, the USSR (122) has been adopting a variety of methods which can be classified as (a) chemical and physico-chemical; (b) biological; and (c) mechanical.

Another interesting approach has been the co-ordinated treatment of both urban sewage and urban storm-water drainage as in the case of Chicago in the United

States of America (162). The Flood Water Management Plan and the Tunnel and Reservoir Plan (TARP) interphase closely with the Waste Water Management Program. The Federal Republic of Germany (149) points out that the construction of about 1000 facultative anaerobic/aerobic lagoons in Bavaria represents a very efficient stage in a sewage treatment plan. Facultative aerobic lagoons combined with biological stages are inexpensive and do not need skilled maintenance, and hence are of interest to many other countries.

The above review of the problems of water supply and sewage disposal shows the enormous complexity of the problem and the wide variety of conditions in different countries of the world. The establishment by the Netherlands (169) of an International Reference Centre for Community Water Supply, which "operates as the nexus of a network of regional and national collaborating institutions in 30 developing and industrialized countries" is therefore opportune.

Over the last two decades, in a number of countries, bilateral, multilateral, governmental and intergovernmental organizations have done or are doing considerable work in the field of community water supplies, including waste disposal. The United States of America (94) calls attention to the adaptation and transfer of existing technology as well as the development of new technology and focuses upon the relationships of technology to the requisite human and financial resources and institutions in this most important sector of water use.

IV. THE USE OF WATER IN AGRICULTURE

A. *Irrigation Development*

One of the most important uses of water is in agriculture. Water is one of the most important inputs in current efforts to increase food production in many countries and parts of the world and, in general, to raise agricultural productivity and production, along with a variety of other related inputs. Moreover, the agricultural use of water is the most predominant; more than 90 per cent of the water used is in irrigation. In almost all the countries of the world, considerable importance is therefore attached to the development of irrigation.

The USSR (167) has cited the examples of the Kakhovka and Saratov projects for the production of grain, the Golodnaya and Karshinskaya projects for cotton and the Kuban and Kazyal-Orda projects for rice. Some major multipurpose storage reservoir projects were formulated and constructed in Thailand (34) but agriculture in about three quarters of the land is still rain-fed. Apart from major projects, a number of small projects are being undertaken in many countries to increase the irrigated area. Since 1968 Thailand (33) has initiated 11 electrical pumping projects on the right bank of the Mekong, the project areas being of a reasonable size, between 500 and 1,000 hectares. A programme of development of new irrigation networks has been taken up in Indonesia (24), covering the development of simple irrigation/reclamation systems of about 550,000 hectares. The individual areas range in size from several hundred hectares to 2000 hectares, which can be developed easily.

These examples point to the desirability of combining major, medium, and minor irrigation projects in the strategy for the development of irrigation.

An agricultural programme is reported by Guyana (182) involving gravity drainage into the ocean together with pumping into the Canje river to benefit an area of 50,000 hectares. The importance of irrigation in the economies of the Sudan (30) and Egypt (21) is illustrated by the giant Jonglei Canal, which is one of the projects undertaken in order to increase the yield from the Nile and promote the use of drainage water for irrigation in Egypt. In Egypt 50 per cent of the irrigation water becomes drainage water and is again reused in combination with canal water. At present, 4.8 billion cubic metres of drainage water are thus reused out of an estimated potential of 12.2 billion cubic metres.

B. *Management of Water for Higher Efficiency*

Apart from the extension of irrigation, one of the most important problems in agriculture is to improve the management of irrigation water and use it more economically and efficiently within the existing systems. In Egypt (19), intensive work is being undertaken on water requirements for crops, irrigation rotation, water losses, improvement of irrigation efficiency, integrated land and water conservation and management. Egypt (20) is also attempting to evolve remedial measures to combat the growth of weeds and hyacinth in the river and canal systems with manual and mechanical methods and through the use of chemical herbicides and biological controls. The same is true of the Sudan, which is currently engaged in intensive research on evaporation (28) and crop-water uses in irrigated and rain-fed agriculture (29), with a view to maximizing agricultural production.

Bangladesh (40) has reported the results of its experiments in adjusting the time of seeding in order to exploit the full potential of HYV rice in the irrigated areas. Seeding IR-8 in mid-January and transplanting it in mid-February was found to yield the best results.

In the Federal Republic of Germany (143) agricultural drainage is considered far more important than irrigation. Agricultural irrigation is basically supplemental irrigation, especially in dry years and concerted efforts are being made to cut down on water consumption in irrigated agriculture. The change-over to a sprinkler irrigation system is reported to have resulted in savings of more than 500 million cubic metres of water per year. The withdrawal of surface water has decreased considerably — to less than half the previous amount — whereas the use of ground water for irrigation has shown a marked increase.

Modern irrigation practices assure a highly efficient irrigation system in Israel (150). The agricultural output of irrigated crops per cubic metre in real terms increased in Israel from $US 8 in 1962 to $US 15 in 1973.

C. *Salinity Control and Drainage*

Irrigation projects have to cope with problems of salinity and waterlogging, thus making it necessary to incorporate measures for salinity control and drainage in an integral manner in the planning, design and operation of irrigation systems.

Irrigation development in Australia (111) over the past 90 years has raised naturally saline water tables in large areas and a $A 40 million (1975) programme is proposed to mitigate waterlogging and salination in areas in Victoria. Extensive economic and political factors are taken into account in the "multi-objective" planning procedures.

Another type of salinity problem is the one caused by salinity intrusion in estuaries. The Gambia has presented a case study (216) of the Gambia river, where the tidal influence is felt up to 520 kilometres inland because of low gradients; a mathematical model was formulated, based on field measurements, "to serve primarily as a prediction model and to determine from it a salinity control system within an integrated development plan".

D. *Soil Erosion and Conservation*

Another important factor in maintaining and increasing agricultural productivity is the undertaking of measures to combat soil erosion and conserve soil and water.

Kenya (23) underlines the need to conserve land and water resources by analysing the situation with regard to rates of erosion and sedimentation within some of the catchment areas in the country. River sedimentation is also a serious problem in Argentina (80), which is therefore undertaking not only a quantitative assessment of the transport of sediments but also an analysis of river dynamics and their effects on the various uses of the resources. The problem is so serious in the mountain regions of the Federal Republic of Germany (141) that the Government for the first time submitted the problem for discussion at an international seminar in 1974, and subsequently undertook remedial measures. The Federal Republic of Germany also implemented a project in Brazil (148) involving investigations in the Parnaíba basin.

E. *Integrated Land and Water Management*

The above examples emphasize the necessity for developing and conserving land and water in an integrated manner in the interest of agricultural production. The United States of America (96) also emphasizes the concept of integrated land management to achieve multi-objective goals.

In relation to the use of water in agriculture, the greatest imperative in the present situation is the formulation of a comprehensive and integrated policy involving the extension of irrigation and of rain-fed cultivation, improved agricultural efficiency, better management practices and other related measures. Also, as the United States (93) points out, "those institutions and land operators responsible for implementing and operating agricultural water resources projects must have a role in planning and decision-making, if full returns from the projects are to be realised". Water must receive prime consideration as an essential input in a well thought out over-all agricultural strategy to be implemented in accordance with the political and socio-economic conditions in different countries.

V. THE USE OF WATER FOR HYDROPOWER GENERATION

One of the significant uses of water is hydropower generation. Notwithstanding the many major hydropower projects being undertaken in countries and regions throughout the world, there exists a tremendous potential still to be developed and efforts are therefore being made in many countries to make a systematic study of regional and national hydropower potential. In Yugoslavia (54) considerable funds have been devoted to the development of the water power potential in the Dinaric karst region. Remarkable results have been achieved in the construction of various projects, notably reservoirs and supply tunnels, under difficult and complex karst conditions.

Even in the case of hydroelectric projects already constructed and in operation, studies are being conducted to facilitate optimization of power generation, and in this connexion a number of different and sophisticated techniques, such as mathematical simulation models are currently in use. In Austria (13), a mathematical model was developed to study the potential for optimization, using methods of non-linear programming. Although in this case the method was developed for a study of the problems in hydroelectric power production, it is applicable to any kind of reservoir operation in the field of water management. Simulation models in water management with special reference to hydroelectric production are the subject of detailed studies by France (178). In relation to hydropower production, the paper points out that analytical methodology has to take into account whether power generation is a high priority objective or of low or no priority in the case of the reservoir under consideration.

Discussing the problems it has encountered in the development of hydroelectric power, Thailand (32) points out that the demand for hydropower generation has been increasing very steeply during the last two decades. For instance, energy generation in Thailand increased at an average rate of 32 per cent from 1964 to 1970 and 15 per cent from 1971 to 1975. Rates of load growth will still be high for several years to come. This is true not only of Thailand, but of several other countries and regions of the world, notwithstanding the efforts to use other sources such as lignite, natural gas and oil, as well as non-conventional sources. The development of hydropower assumes particular importance in the context of the current energy crisis. In the United States of America (158) a number of different energy technologies are emerging to place new and significant demands on water and related land resources. Of particular relevance are coal conversion, shale oil, geothermal power and nuclear energy. Although, as a result of these new trends, the traditional "energy-development/water-demand relationships" are undergoing a change, in many of the developing countries with a still considerable unused hydropower potential, emphasis will continue to be placed on hydropower generation for a long time to come.

VI. THE USE OF WATER IN INDUSTRY

The high priority accorded to industrialization in the developing countries involves additional demands for water, which sometimes enters directly into the production process for consumptive use (in breweries, for instance) and in other cases has auxiliary uses. In the developed countries, where the rate of industrialization remains high even today, the demand for water is also great. Thus the use of water for industry is becoming increasingly important in every country of the world.

It is becoming more and more necessary to reuse and recycle water for industrial purposes. The Byelorussian SSR (47) reports that one of the main trends in the use of water for industry is the effort to introduce recycling for supply purposes and to achieve the maximum reuse of waste water. Austria also reports an increase in the use of water.

Japan (170) has a system of industrial water supply utilities that is unparallelled elsewhere. In 1962, 8.2 per cent of the total industrial water (fresh water) was supplied by this system and the ratio increased remarkably to 26.4 per cent in 1973. At present more than 30 per cent of the industrial water in Japan is supplied by industrial water supply utilities. The industrial water supply systems making use of treated sewage that are now under construction in Japan are indicators of the difficulties encountered in securing adequate water sources. Japan (172) is naturally devoting thought and effort to stimulating the efficiency of industrial water use by increasing the extent to which recycling is practised. In 1958 19.6 per cent of the water used by industry was recycled and the proportion increased to 62 per cent in 1973. The capacity of waste-water recycling differs according to the scale and type of the industry concerned. For example, the recycling capacity of the iron and steel industry and the chemical industry in 1973 was 83.1 per cent; for the textile industry it was only 6.7 per cent. Thus, measures for new water sources are constantly under investigation in Japan, for example additional potential for recycling, the utilization of treated sewage, desalinated sea water, etc.

Different combinations of internal water re-use and waste recovery are being tried in the pulp and paper industry in Finland (49). Industrial production per unit of water in real terms increased in Israel (150) from $US 0.90 in 1962 to $US 1.8 in 1973. This has been mainly due to the enforcement of closed-cycle cooling systems. A great deal of interest has been evinced in conducting research on problems related to the use of water in industry, and water research in the United Kingdom (1) is partly financed by industry and partly by the Government.

The growth in the production of thermal and atomic energy has been accompanied by an increased demand for water in the USSR (121 and 126) and it is reported that in the case of ordinary thermal and atomic power stations, the total water requirements for cooling are comparable to those for irrigation. This fact brings out the importance of water even in the case of thermal and nuclear power stations.

VII. WATER FOR TRANSPORT, RECREATION, TOURISM AND CONSERVATION

A. *Transport*

The only paper on the theme of water for transport is the one presented by the United States of America (159). This underlines the need to pay greater attention in times to come to problems of water transport in the many rivers and lakes throughout the world. Water transport is of crucial importance to the economies of the land-locked countries in particular.

The many rivers, the Great Lakes and the protected coastal waters of the United States provide one of the largest and most efficient shallow-draught navigation systems in the world and it is expected that the barge operators will maintain, if not increase, their present share of traffic. A study needs to be made of the operation and maintenance of the shallow-draught system and the operation of the barge industry throughout the world and action should be taken to improve the situation in both developed and developing countries, but particularly in the latter. This is especially important in the present context of oil and energy crises, in which other modes of transportation would entail prohibitive costs.

B. *Recreation, Tourism and Conservation*

Here again, as in the case of water transport, the only paper is the one presented by the United States (164). This underlines the necessity for greater consideration to be given to these matters in future in the multiobjective planning of the development of water resources. The United States points out that "allocation of water to recreation, tourism and conservation of living resources should be a full partner in the planning process, along with kilowatts of hydropower, acre-feet of irrigation water, cubic feet per second of water supply or sewage dilution and minimum flow for navigation".

VIII. ENVIRONMENTAL CONSIDERATIONS

These may be considered under the following five headings:

(a) Environmental policy for water management;

(b) Industrial pollution;

(c) Regional environmental planning;

(d) Some special cases;

(e) Health considerations.

A. *Environmental Policy*

Environmental policy in the USSR (119) takes into consideration the impact of reservoirs on the hydrological régime, changes in the water and ground ecosystems and in the populations' social and economic living conditions. Every effort is made to ensure that the construction of reservoirs does not have undesirable consequences; increasing sums are being spent on such measures and their range is constantly being expanded. The main trends in the protection of reservoirs from surface run-off in urban areas of the Ukrainian SSR (135) are various systems of dealing with urban run-off and industrial effluents, including separate, partially separate, combined and multiple systems for the aforementioned two sources of river-water pollution.

A number of measures to this effect are being undertaken in the Ukrainian SSR (137), including legislative (regulatory) measures, state inspection, technological measures and measures for the planning of water-quality control.

Similar measures constitute the key elements of Swedish policy in the management of water quality (72); as a result, the pollution load of the waters, which are vulnerable because of the Swedish climate, has been considerably reduced. The policy is based on a system of permits, controls and State subsidies. The technological measures are far-reaching and include chemical purification as a standard requirement for municipal waste water and predominantly internal measures with respect to industrial processes.

Denmark (208 and 209) follows an integrated approach to the planning of water supply and waste-water discharge, as well as to physical planning (urban construction, industries, farm land, recreation areas, etc.). Environmental considerations in Australia (117) include such factors as eutrophication, the control of aquatic weeds, heavy materials, limological environment, collection of base-line data, etc. In the formulation of medium-term and long-term water and environmental policy, France (188) uses methods based on game-plan techniques.

The experience of Australia (109) in establishing quality criteria is of interest to many countries. In the first place the criteria serve two major purposes. They provide the basis for assessments of both the short-term and long-term consequences of any agent (pollutant) at any concentration in the aquatic environment. A second and more recent use is in the area of natural resource usage and environmental planning. At this point, it will be of interest to note that, while the establishment of criteria is considered useful in Australia, its absence is considered to have a beneficial impact in Sweden (72). This brings up the point that the principle of the establishment of criteria and the actual criteria fixed would naturally have to take into account the specific national characteristics and conditions in different countries.

B. *Industrial Pollution*

An interesting approach in the fight against pollution is reported by Finland (49), citing the typical case of the control of water pollution caused by the pulp and paper industry. There is a theoretical optimal resultant that can be regulated, involving different combinations of internal water reuse, waste recovery and the external treatment of effluents. A general model for the optimization of results is presented in the paper, along with a plea for a careful analysis of the cost-effectiveness ratio of the different measures proposed for pollution control, with priority being accorded to the method with the least cost.

Romania (44) has instituted a system that automatically monitors water quality and issues a warning in the event of accidental pollution.

Hungary (3) uses simulation models for pollution control and for the evaluation of pollution control alternatives. Pollution control is of great importance in Austria (77) in view of that country's importance as a recreational and tourist centre and its geographical situation as an up-stream country, in other words as a source of flow of surface water discharging into the Danube, the Rhine basin to the west and the Moldau to the north. Elaborate arrangements are made for the collection and treatment of waste water both from the public sewerage system and the industrial effluents.

The USSR (121, 126) reports on problems of water discharge from thermal and atomic power stations and their effect on the hydrobiology of water bodies.

Systems for cooling steam by means of combined aeration condensation equipment, methods for the purification and reuse of discharged water, "prospects for devising thermal power stations in which there is no discharge of water", using low potential thermal effluent for agricultural purposes, fish breeding and shipping and, in general, the design of hydrotechnical equipment with minimal environmental repercussions are among the trends to be seen in the efforts to protect water resources in the USSR.

The United States (97) deals with the problem of pollution from toxic substances and, in this, traces the evolution from the initial difficult attempts to list the toxics as a first step toward controlling them to the subsequent development of criteria for their identification. It is pointed out that the current concept of control is primarily built on an industry-by-industry basis rather than on a pollutant-by-pollutant basis. The fight against pollution is to be waged not only on a technological plane but also on the organizational and economic plane. The close interrelationship between the organizational, economic and technological approaches is emphasized by the USSR (123).

In the Byelorussian SSR (47) "biological purification installations are used to ensure the desired quality in waste water discharged into reservoirs in conformity with the regulations governing the protection of surface water from pollution by waste water".

In the field of technology, sophisticated techniques such as parametric modelling, as described by France (179), are being used to represent the growth of river pollution.

C. *Regional Environmental Planning*

A number of instances are reported of environmental planning of specific geographic regions, for example, of the Tejo estuary in Portugal (211), of the Danube river in Hungary (3) and of the Laguna de Bay basin in the Philippines (214). Both in the case of the Tejo estuary and the Laguna de Bay basin, environmental studies include protective measures including biological and ecological aspects along with the physical. Water quality studies in the Danube use simulation models.

D. *Some Special Cases*

Norway and Sweden (106) report an important case of long-distance transportation of air-borne pollutants, especially polluted acid precipitation. The acidity of the precipitation affects the chemical and biological conditions in fresh-water systems in southernmost Norway and in southern and western Sweden. The chemistry of the lakes and streams in the areas mentioned is influenced by the acid. There are also adverse effects on forest growth and fish production. Control of the emission of the relevant pollutants at the international and national levels is being considered as a measure to remedy the situation.

Elsewhere, the decision by Egypt (17 and 18) to construct the Aswan High Dam "was the result of thorough investigations and comprehensive studies (of the environmental impacts of the dam) conducted for several years by Egyptian engineers and experts, together with the world's most prominent dam experts and consultants".

An interesting aspect of the environmental effects of water control projects is reported from Austria (42). Extensive work on flood control, avalanches and torrent control is being undertaken there and is combined with the interests of town and country planning and environmental control. "Within the framework of area planning, alpine valleys endangered by avalanches have been divided into danger zones, where building is prohibited, zones endangered to a certain extent and safe zones." This is a good example of co-ordination between projects for planning water control and those for town and country planning.

Excessive pumping of ground water causes land subsidence in Japan (171 and 205), exceeding more than 10 centimetres per year in a place like Osaka. Controls on ground-water pumping rates are viewed as a part of the environmental protection of the regions involved.

E. *Health Considerations*

Although the importance of the implications of water development projects to considerations of public health are indirectly alluded to in a number of papers, a full discussion of the epidemiological considerations of drinking water and sewage disinfection is dealt with in a contribution from the Federal Republic of Germany (144). Not only has chlorination been one of the most widely used practices for the disinfection of microbiologically contaminated surface water for drinking purposes, but it is sometimes being resorted to in the treatment of sewage effluent, which is then used for recreational purposes. Recent experience is quoted to show that this cycle of chlorination (i.e. sewage effluent chlorination — river water — drinking water production with chlorination during treatment) "may give rise to epidemiological consequences, as the chlorinated organic substances may be carcinogenic. Therefore, there does exist a conflict situation, as on the one hand, chlorination of drinking water is usual and necessary to cut down the ... risk (of infection) and on the other hand may include the possibility of non-infectious epidemiological complications with regard to cancerogenity."

The rapid economic growth of Japan led to a deterioration in water quality as a result of the untreated discharge of harmful or organic substances. Such industrial effluents as mercury, cadmium, etc., were detrimental to human health and led to cases of minamata and other diseases. As a result, Japan (206) established strict standards for harmful substances such as mercury and PCB, in terms of biological accumulation rate, release from bottom deposit, diffusion in given waters and so on. As a result of these stringent over-all countermeasures against harmful substances, water quality has recovered remarkably.

IX. NATURAL HAZARDS: FLOODS, DROUGHT AND EARTHQUAKES

Ethiopia (62) divides disaster situations into two categories: instantaneous and cumulative. Both floods and drought situations can be caused either by instantaneous or cumulative factors. Earthquake situations are perhaps more instantaneous than cumulative, although their ultimate occurrence is also the final outcome of invisibly accumulative factors operative over a long period prior to their visible eruption.

A. Floods

Five papers deal with the flood situations. The newly-approved Unified National Programme of Flood Plain Management in the United States (107) advocates mixing flood plain occupancy and flood control strategies, treating flood control, flood insurance, flood plain regulations, flood zoning and like measures within a common management framework. Canada (156) is undertaking to prepare flood-risk maps as a basis for joint agreement on designated flood-risk areas. Zoning and other restrictions on land use are also contemplated. Stressing the economic significance of the development of flood control, Hungary (7), where 30 per cent of the population lives in flood plains, points out the importance of cost-benefit analysis based on flood damage surveys, the calculation of risk and the economic significance of flood control development.

Austria (42) is threatened by avalanches, mud flows and floods and problems of control are looked upon as components of physical planning, as mentioned in paragraph 135 above. Argentina (80) discusses its approach to the problem of controlling floods within the context of its experience in river-basin management, erosion and sedimentation.

B. Drought

There are two papers dealing with the problems of drought. Ethiopia (62), in this connexion, draws particular attention to the cumulative disaster that occurred in the country in 1973 and 1974. In this specific context, the technology for improving the water supply is reviewed, with a discussion of the merits of capital-intensive and labour-intensive techniques, the use of modern synthetic materials and the need for proper co-ordinated surveys and investigations of different disaster situations.

The second paper, from Australia (116), discusses the response of ground-water systems to drought. One of the advantages generally claimed for ground water is that it is more reliable in situations of drought when surface-water resources become scarce as a result of failure of rainfall. Experience in Australia is quoted to show that in some areas, aquifers react markedly to drought — for instance, by a decline in water level and yield, an increase in salinity, a reduction in base flow of streams and increased time lag in response to recharge events. In order to evaluate this response, an approach is put forward involving the concept of storage/flow ratio to determine the likely degree of effect of a drought on an aquifer. "This is the ratio of the volume of ground-water storage up-gradient of any chosen section to the flow through the section and it thus has the dimension of time. Since the relationship between storage and flow is not linear, the ratio is not constant for a given system but it is particularly useful in characterizing the ground-water flow régime." This approach is of interest to many countries which are dependent on ground-water sources, particularly to meet drought situations.

C. Earthquakes

An Argentinian paper (91) describes the advances made in the study and application of earthquake-resistant arrangements in Argentine dams and also refers to the use of mathematical models to study dam dynamics, the assessment of the risk of damage and the extent of seismicity brought about by the filling of reservoirs.

X. THE USE OF SHARED WATER RESOURCES

Many of the major rivers in the world are international. It is, therefore, natural that their management and development presupposes close co-operation among the countries sharing a basin. A wide variety in the form and content of international treaties and agreements for the utilization of shared water resources is reported from a number of countries in Europe, America, Asia and Africa.

Finland (53) has a treaty with Sweden dealing with the Tornio river, providing for a system of joint administration covering all the different possible kinds of use of that watercourse and dealing with the whole of the drainage area of the river. A treaty with the Soviet Union deals with utilization of the watercourses bordering the two countries and provides for a joint commission to meet regularly but infrequently to deal with questions, as they arise, relating to all the rivers and lakes of common interest. Finland also has treaties with Norway in the case of one border watercourse.

Switzerland (69) informs and consults its neighbours before entering into negotiations with them on common matters pertaining to water use, flood control and pollution control. Treaties often provide for the establishment of joint commissions, whose recommendations are adopted unanimously and are generally followed. Switzerland distinguishes between "contiguous watercourses" (that is, where a river follows an international boundary) and "successive watercourses" (that is, where a river traverses two or more countries) and points to an interesting feature which is gaining in importance in international relations, namely the principle of interstate solidarity consistent with absolute territorial sovereignty.

Citing the example of bilateral and multilateral co-operation in which it is involved, Hungary (8) draws attention to the principles of absolute territorial sovereignty, the theory of rights acquired, absolute territorial integrity, easement laws, the principle of common property/common interest and good neighbourliness and points out that co-operation in the management and development of international river basins does not conflict with the concept of absolute national sovereignty.

Yugoslavia (57) urges international co-operation in research in such fields as pollution control, nuclear contamination, disposal of thermal wastes and water management, and advocates the development of an international legal framework for international co-operation.

From the North American continent, the United States and Canada (215) report on their experiences regarding the 1909 Boundary Waters Treaty between them, in terms of which a binational body, the International Joint Commission, was set up to deal with problems that arose along the boundary, and certain rules or principles were specified to govern the Commission in the exercise of its jurisdiction. Although the examples described are unique to Canada and the United States, many of the basic principles perhaps have potential for broader application to other countries facing similar situations along their common borders.

From Asia, Bangladesh (39) presents its experience regarding the development of its water resources in the basins of the Ganges and the Brahmaputra, both of which are international. Bangladesh urges that "the United Nations and the international agencies initiate a programme of assistance and collaboration in the realization of the great potential that exists in the development and use of the waters of international rivers".

Australia (112) reports on the problems it has encountered in the use of shared water resources. These are internal problems and are not international in the usual sense. Under the federal constitution of Australia, agreements have to be drawn up among the states for the administration of interstate rivers. For instance, the Murray-Darling system rises in the states of New South Wales and Victoria, forms the boundary between them and flows into South Australia. The Australian tradition is one of "solving potential disputes by political agreements between governments, which are then followed by parallel legislation in identical terms". The River Murray Waters Agreement of 1914 is one such agreement. The powers of the Commission are examined as a case study from the standpoint of their adequacy to meet current needs. The Australian experience is of interest to other countries with federal constitutions that encounter similar internal interstate problems.

To facilitate the use of shared water resources, joint intergovernmental institutions have been set up for data collection, planning and development in a number of countries. The plans and problems reported by Liberia (14) and the establishment of the Mano River Union are examples of this effort.

Egypt (22) cites the example of the hydrometeorological survey of the catchments of Lakes Victoria, Kyoga and Mobutu-Sese-Seko, which is jointly undertaken by all the countries sharing the Nile basin (Egypt, the Sudan, Uganda, the United Republic of Tanzania, Kenya, Rwanda and Burundi, with Ethiopia as an observer and Zaire likely to join the project) as a good example of international co-operation in the utilization of the shared water resources of the Nile system. The project, in which the technical personnel of all the countries pool their efforts in the field of data collection, is a good example of the way in which regional basin-wide projects of this nature facilitate the pooling of the scarce resources of all the basin countries for their common benefit, to help them to overcome critical constraints in respect of men, material and money.

XI. EDUCATION, TRAINING AND RESEARCH

Major emphasis has been placed in the United States of America (95) on utilizing the research and educational capabilities of the nation's universities. While, in general, this coupling of programme needs with the universities' abilities has been effective, certain difficulties are reported as having been encountered, particularly concerning the level of university activities in water-related programmes. Any generalization in attempting to answer this problem seems to be hazardous and the extent of involvement of the universities should naturally be dependent on specific national situations in the different countries, but, in general, at least in the case of many developing countries, there appears to be great need for a much higher level of involvement in water development activities on the part of the universities.

The traditional activities of hydrology, namely water measurements and the obtaining of data, are no longer enough to meet today's needs. As pointed out by Spain (64), many new specialized disciplines have entered into the domain of hydrology, automatically changing the face of the "future", for instance automation, mathematical modelling, systems engineering, environmental concerns, forecasting and prediction, pollution control, internal and international water law, and exploration of the possibilities of obtaining additional supplies from non-conventional sources such as desalination, weather modification, geothermal water, etc.

Another important development is in the establishment of international institutions for training and research especially related to water management and development. For instance, France (187) is planning to establish an International Water Management Training and Research Centre to train water management officials, both French and foreign. The Centre is to be situated "on the Mediterranean coast, where a complex of high-level public and private organizations for study, teaching and research is now being developed". Argentina (78) has played a leading role in joint Latin American efforts for nearly 30 years, starting with the establishment of the first Chair of Water Law at the University of Mendoza and, recently, through the establishment in 1970 of the Institute for Water Economics, Legislation and Administration (INELA), the only institution in the region that provides instruction and training in these subjects. In-service training and applied research are valuable tools for preparing staff to work efficiently at various administrative levels.

In addition to the research content of relevant programmes, the aspect of research management has recently been coming to the fore. The organization of water research in the United Kingdom (1) represents a machine in which the Government, the independent multipurpose water authorities and other interested parties work together to conduct research in accordance with the priorities of both water users and government expenditure. The Water Research Centre in the United Kingdom is controlled by the users and financed partly by industry and partly by the Government.

XII. PROBLEMS OF TECHNOLOGY

While there is considerable scope for the application of traditional and conventional technology to the solution of the problems of water management and development in many countries of the world, there is a great need for a systematic and concerted effort to apply and develop new technologies to help in finding solutions to the problems encountered in the water-related fields. Satellite and computer technologies are examples of the application of new methods and approaches to the solution of some intractable problems.

The United States and Argentina are pressing for the application of remote sensing methods and techniques in the field of hydrology and water resources management. In the United States (163), the NIMBUS, TIROS, NOAA and GOES satellite systems and related rapid data-processing systems have made it possible to develop an improved system of weather forecasting. Remote sensing can also supply information on problems such as the degradation of the environment, resources development, the planning and monitoring of river basins, weather modification and the development of hazard warning systems. Experiments have been conducted in an area of the Pampas in Argentina (87), using LANDSAT multispectral imagery. Infra-red colour imagery from SKYLAB was used for the same region and for a region in north-west Argentina. It was observed that the differences in ground colour were closely related to the depth and salinity of ground water. Computer technology is being widely used and developed to solve the problems of data storage and retrieval in many countries. The techniques of mathematical modelling are being extensively used to solve a variety of problems, both in the assessment of surface-water and ground-water resources and in the study of pollution problems. The use of numerical models is described by France (180) for the generation of long time-series of the natural temperature of river waters. Various aspects of seismic studies have been emphasized by Argentina (84 and 91), such as the determination of a "potential maximum earthquake"; studies on dam dynamics and the extent of seismicity brought about by the filling of reservoirs.

There is an imperative need to intensify scientific and technological research relating to water and to promote regional and international co-operation in hydraulic research, as urged by Argentina (81 and 86).

Mexico (101) discusses technological progress in the water resources field and calls attention to the need for new technology to be applied to ensure more efficient water management and for appropriate technologies to be designed to maximize the extent of water exploitation, as well as the need to determine the concept and content of appropriate technologies in the field of water resources. Mexico (104) also draws attention to the need to establish stronger ties amongst the countries of the third world to assist them in their efforts to combat underdevelopment. It therefore proposes the establishment of a committee on the transfer of technology among nations, especially to the countries of the third world. This points to the need to promote adequate institutional mechanisms to facilitate an effective transfer of technology not only between the developed and the developing countries but also among the developing countries themselves, within the framework of the arrangements being considered for economic and technical co-operation among the developing countries.

XIII. POINTS FOR CONSIDERATION BY THE CONFERENCE

From the body of abstracts and those papers available at the time this document was prepared, it has been possible to identify some policy suggestions for the consideration of the Conference. In some instances what amounted to essentially the same suggestions appeared in a number of different papers, while other papers made no policy suggestions and dealt only with technical matters. In order to avoid duplication, the suggestions listed below incorporate similar ideas and, for this reason, there is no reference to specific papers.

Problems of planning. (1) Efficient national water policy and planning should be based on the objective estimation of available water resources with a view to obtaining the maximum improvement of community water supply, agricultural and industrial requirements with regard to future needs and environmental protection. A number of countries have reported the methodology and techniques they use in formulating long-term plans for river basins and continents. The laying down of some basic guidelines, principles and procedures would help in the adoption of compatible methodology.

(2) Apart from river basin planning, efforts to undertake planning for geographically homogeneous regions like coastal zones or arid regions need to be encouraged.

(3) The main guidelines of water resources development must be in agreement with prospective economic and social growth. Long-term forecasting and planning methods facilitate a comprehensive solution of water problems and the co-ordination of the development of various sectors of the economy on different levels and make it possible to take full advantage of scientific and technological achievements.

(4) In planning studies the use of mathematical models and computerized methods to take full advantage of benefits from existing development need to be encouraged, particularly in relation to the conjunctive use of surface and ground waters.

(5) Apart from legislation on individual aspects of water use and development, the present trend towards promulgating complete and comprehensive legislation in the form of a water code or water law needs to be encouraged.

Assessment of resources. (6) Methods for the estimation of available water resources using aerological observations for the computation of the atmospheric water budget need to be developed for use in connexion with large river basins, regions and continents.

(7) Available hydrological data on surface and ground waters, which is continuously being collected at the national level, should be studied and analysed by multidisciplinary teams to provide adequate information for planning purposes and should be updated on a routine and continuous basis.

(8) In the case of surface and ground waters, an assessment is needed of present and potential use for different purposes, in addition to an assessment of economically exploitable resources.

(9) The assessment of resources should be improved by using modern means such as remote sensing, nuclear and geophysical methods, etc.

(10) In the case of ground waters, intensive work needs to be carried out on economical methods of artificial replenishment and of locating ground waters in fractured zones in hard rocks.

(11) Mineral and thermal waters need to be inventoried in the different countries which possess such resources and their industrial potential, in addition to their potential for use as spas, needs to be studied and developed.

(12) Work needs to be intensified on less costly methods of drawing on non-conventional sources of water, such as desalinated sea water or brackish water, and induced precipitation.

(13) The development of forecasting methods is of particular importance for developing countries and should be included as part of quantitative and qualitative assessment of water resources.

(14) Effective decision-making methods in the management of water quality should be based on techniques of natural water quality regulation that have been proved in practice and should be based on uniform methods and standard equipment for measuring characteristics of water quality and quantity.

(15) The establishment of quality criteria should take into account the specific national characteristics and conditions in different countries.

Assessment of needs. (16) There is a need to rationalize the basis of estimates of needs with a view to facilitating a greater measure of compatibility.

(17) A methodology for the management of demand needs to be evolved, refined and adopted, using such concepts as "supply restriction indices", "shortage tolerances", "risk indices", etc.

Community water supply. (18) Some countries have reorganized their water supply arrangements so as to strengthen the financial and management basis of metropolitan and urban water supplies, use water effectively, reduce losses, equalize water prices over wide areas and reduce water costs. New concepts are being developed, such as the use of advanced water treatment techniques, for example carbon absorption and ozonation, the utilization of low quality sources and the reuse of waste water for purposes such as toilet flushing. These trends (reorganization and the use of new concepts) need to be encouraged, where they are found to be necessary and desirable.

(19) Rural water supply projects and programmes for implementing them on a priority basis are being undertaken in some countries and should be encouraged in others to achieve the targets in the field of community water supplies set by Habitat: United Nations Conference on Human Settlements.

(20) The planning of community water supplies should envisage sanitary norms and drinking water standards fixed by the respective countries, protective measures against diseases, the organization of medical control, and skilled service for water supply and treatment works.

The use of water in agriculture. (21) In the strategy for the development of new irrigation facilities, a judicious combination of major, medium and minor schemes appears desirable.

(22) A more efficient use of water per unit of agricultural product is desirable.

(23) In the execution of schemes to combat salinity and waterlogging, economic and policy issues need to be taken into account in the planning procedures and the affected farmers need to be involved in the planning and implementation of schemes.

(24) Soil and water conservation measures are to be undertaken within the framework of integrated land and water management for increasing agricultural production.

The use of water for hydropower generation. (25) In addition to the undertaking of new hydropower projects, efforts are needed to optimize power generation from existing hydro projects by improved reservoir regulation.

The use of water in industry. (26) The recycling and reuse of water for industrial purposes should be practised to the fullest extent possible taking into account the scale and type of the industry; this is true even for industrial units where some degree of recycling is already practised.

(27) Water-saving technologies are to be encouraged in order to minimize the use of water in industry.

Water for transport. (28) A study needs to be made of the operation and maintenance of the shallow-draught system and the operation of the barge industry and action should be taken to improve the situation.

Water for recreation, tourism and conservation. (29) In the planning of water projects, greater consideration needs to be given to the interests of recreation, tourism and the conservation of living resources.

Environmental considerations. (30) The range of environmental considerations at present receiving attention in relation to water projects needs to be expanded in order to become more comprehensive and include not only physical, chemical or biological changes, but also the resulting social and economic changes.

(31) In combating industrial pollution, a careful analysis needs to be made of the cost-effectiveness ratio of the different measures proposed for pollution control and priority accorded to the method entailing the least cost.

(32) To mitigate adverse environmental repercussions of water discharge from thermal and atomic power stations, cooling systems and hydrotechnical design practices and procedures need to be improved to reduce potential hazards.

(33) Studies need to be undertaken to evaluate the best possible approach to controlling pollution on an industry-by-industry or pollutant-by-pollutant basis, in accordance with national requirements in the light of the nature and level of industrial development.

(34) Techniques like simulation, parametric modelling and computerized analysis need to be developed to facilitate solutions to problems in the field of pollution control.

(35) Environmental planning is being undertaken not only at the national or river-basin level but also at the level of specific geographic regions such as estuaries, coastal zones, etc., wherever such an approach is warranted by the nature of the problems inherent in such regional development. This should be done not only in relation to water projects in isolation, but in close liaison with other related activities like town and country planning or regional development.

(36) In dealing with problems of public health, a careful evaluation is needed of potential conflict situations such as the chlorination of sewage effluents and the chlorination of drinking water production so that epidemiological consequences are avoided.

(37) With relation to the long-distance transportation of air-borne pollution, especially acid precipitation, the different approaches to the control of the emission of relevant pollutants should be considered, bearing in mind the available range of technical solutions.

Natural hazards. (38) In the mitigation of flood loss, balanced consideration must be given to structural measures such as dikes and levees and also to non-structural measures like flood plain regulations, flood zoning, the preparation of flood-risk maps, flood insurance, etc. and measures for upstream watershed management should be integrated into the over-all flood control plans.

(39) In the assessment of the response of ground-water systems to drought, the effect of drought on aquifers needs to be determined, based on concepts like the storage/flow ratio, in order to characterize the ground-water flow régime in periods of drought.

(40) In seismic areas, earthquake-resistant arrangements for dams and other hydraulic structures must be duly provided in order to minimize the risk of damage. An assessment should also be made of the extent of potential seismicity brought about by the filling of reservoirs.

Education, training, research and technology. (41) National universities need to be more heavily involved in water development, but the actual level of involvement in each country should depend upon the specific features, characteristics and needs of the national situation.

(42) It is important that greater use be made of existing international institutions specifically dealing with water management and administration to impart education and training to water management officials from different countries throughout the world.

(43) Maximum use should be made of new technologies like remote sensing, computer technology, etc., to help countries to survey, explore and develop their water resources.

(44) There is an imperative need to promote greater co-ordination in the field of water resources research, including the design of appropriate technology, the adaptation of technology and an effective transfer of technology both between the developed and developing countries and among the developing countries themselves.

ANNEX I

MEMBERS OF THE INTERGOVERNMENTAL WORKING GROUP CONVENED BY THE SECRETARY-GENERAL OF THE UNITED NATIONS WATER CONFERENCE

Argentina	Juan Eduardo Fleming, First Secretary, Permanent Mission of Argentina to the United Nations
India	E. C. Saldanha, Member (Planning and Progress), Central Water Commission, New Delhi
Japan	Takashi Kuramata, Associate Director, Senior Researcher, Nomura Research Institute, Social and Economic Systems Department, Kamakura
Sweden	Malin Falkenmark, Ministry of Agriculture
Union of Soviet Socialist Republics	Boris V. Smirnov, First Secretary, Permanent Mission of the Union of Soviet Socialist Republics to the United Nations
United States of America	Frank Thomas, Professor of Geography, Georgia State University, Atlanta
Venezuela	José Luis Mendez-Arocha, Executive Secretary, Water Commission, National Development Plan