Policy Options

INTRODUCTION

This document is the third basic paper prepared for the United Nations Water Conference. It comes under topic III of the provisional agenda approved for the Conference by the Economic and Social Council. The first paper deals with resources and needs and analyses present-day trends in supply and demand. In addition, it reviews the general situation and shows that in certain regions the water problem may assume quite serious proportions if it is not corrected.

The second paper* comes under topic II of the provisional agenda. It deals with the potential and limitations of technology and emphasizes the need for strenuous efforts to improve present utilization of available technologies and to adapt techniques of a type and scale appropriate for developing countries, in view of their manpower needs and their economic and social conditions. With regard to supply, it does not appear that revolutionary developments are likely to take place in existing technology.

I. NEED FOR A WATER POLICY

Before discussing the reasons why a water policy is needed and the alternatives that are available, it would be useful to recall a number of fundamental considerations. The traditional political and administrative organization of a country is based on the identification of the different functions to be carried out for the development of certain economic or social activities, for the exercise of options or for the achievement of a synthesis (justice, finance).

Generally speaking, specific and well-defined human preoccupations are used as a criterion, and it is only recently that ministries and public organizations have appeared that are more concerned with defending broader ideas or objectives already being dealt with by several ministries - the protection of the environment, for example, or of natural resources. Such ministries and organizations often find it difficult to gain a foothold in the existing system.

Water is a universal topic that involves almost the entire population and all ministries; it is a subject that gives rise to numerous practical activities and legal texts. It might therefore be asked why questions of water reform are constantly being discussed.

A. Omnipresence of Water

Water is everywhere, but it is limited in quantity and quality. It is everywhere, but it is constantly in motion, passing from one state to another and from one place to another.

Water problems vary enormously from one region to another, from one season to another and from one year to another. Water shortages have always existed in desert areas, whereas it is only more recently that they have occurred in temperate regions. Such climatic extremes have nevertheless brought about tragic consequences since time immemorial.

*See *Water Development and Management*, edited by Asit K. Biswas, Pergamon Press, Oxford, 1978.

B. Multiplicity of Uses

The uses of water are countless but may be grouped under two main headings. Firstly, water is an integral part of a certain number of entities, whether mineral, vegetable or animal. Secondly, it serves as a vehicle in almost all the uses it is put to by man — for personal or household cleanliness, for cooling automobile or factory motors, or for extracting useful substances contained in minerals or other products.

C. Variability of Quality

The quality of water varies greatly. When water is used as a vehicle it can easily absorb all kinds of products either in dissolved or suspended form.

Nature has built the world in this manner, and man has merely imitated it in his industrial and social uses. However, nature is equipped with regenerating processes so that, as long as population density is not too great, natural self-purification is able to maintain a biologically living and healthy environment. Nevertheless, urbanization, industrialization, expansion of the use of synthetic products and destruction of the living environment by ruthless interference have entirely upset this balance with the result that the power of self-purification of waterways is no longer sufficient; rivers have died and pollution has come into being.

Even here we are faced with a contradiction, since most of the time, as we have seen, water is used exclusively for disposing of waste products, which automatically alters its quality and makes it unfit for other uses. To prohibit waste disposal, however, would in fact prohibit all water use.

In certain regions the harmful effects of water assume catastrophic proportions. Cyclones, floods, soil erosion and drought are some of the so-called natural calamities. A large number of measures must be taken to protect man from such calamities, measures that sometimes run counter to certain soil or water uses and to other imperatives of national policy.

D. Multiplication of Conflicts

Water is thus the source of innumerable conflicts that may arise at every turn. For example, when a new well dries up a neighbour's well; a stable pollutes a neighbouring source of water; there is not enough water in the dry season in a given region; a city or factories pollute the water downstream; an underground sheet of water is no longer fed because a canal has been dug that diverts the water from its natural bed; the establishment of factories and their industrial uses spoils the shores of a river and prevents fishing, bathing and recreation; a large metropolis obtains its water supply from increasingly further distances and robs the resources of neighbouring rural regions, and at the same time the impermeability of its soil causes more frequent flooding; and even the biological life of the sea is threatened by polluted rivers, by port areas or by large industries established on its coasts.

In all places and at all times large or small-scale conflicts set neighbours or

the members of the same profession against one another and set cities against rural areas, industrialists against fishermen, agriculture against electrification and upstream areas against downstream areas.

E. Role of the Public Authorities or of the Community

The role of public Powers is to settle such conflicts. The usual means of settling conflicts in human societies is to resort to the arbitration of a wise man or to the courts. The same has been true historically with regard to water, as evidenced by the famous water court in Valencia, Spain, and the renowned Kelian Subak in Bali.

However, when conflicts become extremely numerous and involve forces as powerful and necessary as the development of agriculture, cities, industry and recreation, flood protection or the development of mountain areas and consequently require enormous investment for their satisfactory solution, simple arbitration is no longer sufficient. The public authorities should therefore promote a positive and cohesive policy for developing water resources that will in turn make it possible to develop all the components of national life both in their own right and in respect for others.

This gives rise to the need for direct governmental intervention, whose objectives and means will now be analysed.

II. OBJECTIVES OF A WATER POLICY AND PHYSICAL PLANNING

A. Objectives of Economic and Social Forces with Regard to Water

A Government, faced with the problems which arise for its people, first sets very broad objectives of economic development, social progress and interregional balance. These objectives are achieved by very varied means such as intensification of agriculture, establishment of industries, promotion of tourism, growth of cities, modernization of rural areas and so on.

These economic forces use water and then, after use, discharge it as waste. Traditionally, they tend to regard water as a gift from heaven and hardly give any thought either to the quantity used or to the quality of their discharges.

These forces would suggest, explicitly or implicitly, that an adequate supply of clean water in rivers and lakes does not entail any economic cost.

Experience has long showed that, to the extent that "needs" exceed "available resources", far-reaching and costly collective actions are essential to ensure a balance in the water system at all times.

These collective actions are not the only ones possible and the range of technical means available to ensure stability will first be briefly discussed.

B. Technical means of Ensuring Stability

Quite briefly, these technical means can be applied to achieve the following:

Increase of resources

This can be done by the following means: regularization over a period of time (dams); intra-basin and inter-basin transport; combination of the use of surface water and ground water; planning of vegetation cover; recycling of water after first use; more sophisticated techniques such as desalination of sea water, artificial rainfall, control of evaporation and so on; reduction of "needs".

The concept of need of water for a given use has only a relative value and experience shows that in order to fulfil a given economic function, the flow of water to be drawn off in nature can vary greatly depending on the scarcity of supply and the acceptable costs within the system which carries out that function.

This is true regardless of whether we are producing steel, beer or rice, cooling generating stations, or transporting merchandise, because in all cases the amount of water to be incorporated in the product is infinitesimal in relation to that used to dissolve or discharge useless by-products to generate heat, or to carry ships. The technology exists to reduce considerably these quantities of water by recycling after purification and, in some cases, water can even be dispensed with, for example, in air cooling or road transport.

Purification of discharges

If, at the end of a given industrial process, in addition to the finished product, there are a number of useless elements which must be thrown out, it is quite possible to extract these elements from the "used" water in which they are found before reincorporating that water into the natural cycle. These purification techniques exist and are being improved daily. Of course, they entail costs, sometimes considerable, but the limitations are economic and not technical.

Reduction of water damage

Floods and cyclones are among the major scourges of mankind which has always sought protection from them by evacuating threatened areas and withdrawing into zones outside the area affected by the torrent.

The means to be used and the economic and social consequences of these means are obviously of far different significance. Thus, a technical solution may be found for any water problem affecting the economic and social development of a country but the difficulty arises from the fact that, depending on the method selected, the cost will vary greatly and, above all, the implementation and financing will be the task of different bodies.

Generally speaking, public agencies have the responsibility of increasing supply to meet increased demand or to dilute pollutants, undertaking projects for protection against the harmful effects of water or digging navigational canals. The Government must, in matters relating to water as elsewhere, define its policy and establish the machinery that will permit the optimum selection to be made. Before giving consideration to such machinery, however, it is still important to define the areas where governmental choices are to be made. For clarity in this report, a distinction will be made between "internal" and "external" options in matters relating to water.

C. Internal Options in Matters Relating to Water

Water is to be found on the earth in four forms: atmospheric water, surface water, ground water and the sea. Any decision taken in the economic field leads to modification of the following fundamental elements, which may be regarded as "internal" in matters relating to water, as opposed to use-related elements:

For atmospheric water: modification of the natural cycle; protection or planning of catchment areas.

For surface water: minimum flows; water quality; extent of flood areas; harmful effects of water.

For ground water: level of stability; degree of contamination.

For the sea: degree of pollution.

This breakdown of the internal elements is essential for two reasons; decisions on the limits to be respected in each case depend on development programmes, the needs which they imply and the available means, in other words, "external" elements; real decisions are rarely taken, even today, by making explicit reference to these limits.

Atmospheric water

It is increasingly clear that it is possible to modify the presence of the renewing cycle of fresh water by influencing the atmospheric phase of the water cycle. Artificial manipulation of the weather is rich in technical promise. Precipitation can be induced at times and in places where it would not occur (at least not in the same degree) under natural conditions. It is possible to prevent hail and to moderate storms by using certain techniques. Consideration is even being given to modifying the climate and, in particular, making permanent and substantial climatic changes. All these technical means, however, are at the research stage and a water policy must take into account only the facts which have been unequivocally established by science.

Surface water

(a) Minimum flows. There are several elements which affect the selection of minimum flow: protection of the living environment and the physical balance (erosion); utilization for leisure (sports,fishing) or navigation; aesthetic character of sites; need to replenish ground water; needs expressed downstream from the segment considered. The concept of level is thus added to that of flow. Since minimum flow is supposedly fixed as a result of all these considerations, only the surplus can be allocated to net riparian consumption, since the draw-offs that are immediately returned to the river are limited only in quality. The *a priori* setting of such minimum flows is of extreme complexity in view of a number of factors involved and can lead to very serious conflicts between different zones in the same basin; however, the fact remains that in one manner or another these flows evolve in terms of each decision and the problem cannot be avoided.

(b) Water quality. As far as principles are concerned, it would seem that it would not be too difficult to reach agreement in this field. To transform rivers into sewers can hardly be said to be one of the aims of modern civilization.

What must be done, on the contrary, is to establish a minimum quality standard which must be respected for each river. This is where the difficulties start. Choices have to be made and the limits of pollution have to be defined according to the places, the pollutants and the utilizations.

On the basis of this hypothesis, oligotropic lakes should be specially protected so as to prevent them from getting choked up, a problem that can be solved only with difficulty. Or would it be better to abandon the idea of quality targets and only set standards for the discharge of waste for each use, standards which could be identical for all identical uses? Whether it is considered as an objective or as a consequence, the quality of the water of a river or a lake at each point is a fact, and it would certainly be better to come to a clear decision about what is wanted.

(c) Harmful effects of water. In defining a water policy, there will be many options also with regard to the control of the harmful effects of water. These effects are related, *inter alia*, to floods, the submersion and deterioration of the banks, soil erosion, the environment and salination. In the case of flooding, for instance, a choice must be made between constructing protective works which are increasingly expensive depending on the area to be protected and the frequency of the risks against which protection is sought, on the one hand, and abandoning some forms at least of land use where protection would be too expensive or would involve damage to other parts of the basin, on the other hand. Such a choice goes well beyond the problem of water itself and it is one of the examples which shows very clearly the relationship between water policy and physical planning.

Underground water

Underground water is of special interest because of the regular flow it provides and the quality of the water in many cases. Here again, it is not possible to draw off unlimited amounts and, if the reserves are not to be exhausted, the maximum flows to be drawn off must be established, bearing in mind the natural or artificial replenishment of the reserves. As all movements involving underground water are extremely slow, pollution appears only insidiously, but when it has occurred it is very often irreparable on the human scale of time. Such water must therefore be vigilantly protected.

Something that must be emphasized here is the problem of the intrusion of sea water into the water-bearing strata along coasts. Over-exploitation of underground water located near the sea may create a disequilibrium which results in the infiltration of sea water into the underground reserves, making the water unusable.

The sea

The sea is the collector of all water that runs off the surface of the earth and it therefore receives also all the wastes discharged into rivers and lakes and on its own shores. There are therefore certain differences which distinguish it from running water and which are due to its role as a collector: microbiological pollution, the discharge of stable and toxic substances which are concentrated along the trophic chains and accumulate in the sea and in lakes; they become more dangerous with time and may cause irreparable harm to the flora and fauna and eventually to man.

The definition of an objective for a given *milieu* - quality, for instance - is

a policy decision based on objective data (the natural quality of the water, its present quality, the cost of reducing pollution, the quality level required for certain uses) and it must also comprise many subjective factors, such as the uncertainties of science, aesthetic considerations and irrational attitudes on the part of the public. Thus, there is an infinite variety of possible procedures for establishing such objectives. On the other hand, a policy of water management according to quality objectives has no meaning unless it is closely linked to physical planning and is applied in a coherent manner within a single hydrographic basin.

Many conflicts may arise in this connexion, and they will be all the more serious the more the different parts of the area concerned come under many different political and administrative authorities and the more independent they are of each other.

D. External Options: Water and Physical Planning

The internal options described above form the basis on which a coherent water policy may be built. In practice, the practical programmes give prominence essentially to the satisfaction of the growing needs of the developing sectors, i.e.:

Water supply for towns and rural communities;

Irrigation;

Drainage of swampy or floodable areas;

A great diversity of industries, navigation, production of hydroelectric and thermal energy;

Satisfaction of needs in the area of sports, recreation and relaxation.

The usual approach to these problems, at least in regions which are rich in water resources, is to find as it were, *a posteriori* solutions. A town that is expanding, an agricultural area that is being modernized, an industrial complex that is developing, all seek the nearest water resources and carry out whatever works seem the most appropriate, perhaps with financial assistance requested from the public authorities.

When, on the contrary, what is envisaged is the deliberate development of a region or a country, the first thing to take into account, before taking any action, is what the different development sectors want from the country's resources, including its water resources. It is usually necessary to modify the initial projects to allow for the constraints imposed by water and to orient the choices on the internal options relating to water in directions which were not originally foreseen. The actual scheme for physical planning that is finally reached in this way includes the problem of water and takes account of its regional characteristics, but at the same time imposes its own guidelines.

This idea of combining physical planning with the planning of water resources is really somewhat idealistic but this is a goal that should be sought. One of the most pragmatic ways of avoiding too many mistakes while permitting a constant

adaptation to human and material changes is to draw up several alternative schemes, and measure the consequences, advantages and disadvantages of each one; in this way the repercussions of every day decisions may be correctly assessed.

E. Conclusion

Finally, what may the objectives of a water policy be? They will be set down here in a style which is deliberately telegraphic but which is intended to combine all the concerns that have been expressed.

To ensure, on a continuing basis, a balance between the supply of water and the demand for it, for all uses, by dual action: improvement of the resources and adaptation of its uses;

When necessary, to direct economic and social activities towards the optimum use of water and other resources;

To provide the country with clean rivers and clean underground water and to ensure that the quality of the coastal sea water is satisfactory.

"By what means can this be achieved?" will be the subject of the next section.

III. MAIN OVER-ALL OPTIONS AND MEANS OF ACHIEVING THEM

The heart of the issue

This chapter takes us to the heart of item 3 of the provisional agenda for the Conference. Its aim is to invite discussion not to lay down precepts. Thus it contains a series of open choices rather than definitive answers. These choices are by no means exhaustive, since the subject is too vast; nor are they perfectly adapted to world problems which are too varied. This chapter is simply an effort to present options which require a decision at the highest legislative and executive levels of the State and which will influence over-all water policy.

A. Inventory and Collection of Data

An inventory of information on water and the collection of basic data are prerequisites in the formulation of water policy and an integral part of that policy.

Available documentation, particularly with regard to urgent decisions, is often limited, incomplete and heterogeneous. According to over-all statistics recently collected by the World Meteorological Organization and submitted to the Conference, there are many important gaps in the measuring stations network, particularly in the developing countries. Consequently, it should be recognized that data are still very fragmentary in vast areas of the globe and in all countries. In particular, little is known about dry periods, although it is essential to be able to forecast such periods in order to establish a balance between the supply of and demand for water and determine the extent to which it is possible

to draw on underground sources over a long period without exhausting them. Finally, in most countries, with certain very recent exceptions, virtually nothing is known about water uses or the quality of surface water. Thus, strenuous efforts are required in order to elaborate a sensible water policy.

Many bodies collect data which is useful in the preparation of water policy. Such bodies consist mainly of meteorological and hydrological services but also include electricity-generating stations, navigation services, ministries of agriculture and other public and private bodies. The task of making the complex structure work is complicated by the fact that these bodies also use the data, value their prerogatives, and regard the possession of data as one of the bases of their power.

Thus, it is imperative to improve the system of gathering and processing basic data. In the case of decisions relating to water policy, there is an obvious need for all available data, not only that which relates to the quantity and quality of water but also economic data (amount of investment, costs, etc.), legal data, (legal documents relating to water such as utilization statements, licence registration, etc.) and other data. However, although this information may be gathered in a relatively short time, hydrological and meteorological data, which is perhaps the most useful, requires long years of observation. Those responsible for water policy do not always realize that it is absolutely impossible to base decisions on only one or two years' observation of a hydrological system, particularly in highly variable climates, since such a short series of data is susceptible to an error factor of up to several hundreds per cent. Lack of data or imprecise data create great uncertainty and unnecessary risks with regard to the necessity, profitability or legality of certain projects or with regard to the date on which they will be necessary or profitable. Nobody would dream of putting an oil-field into operation without having very definite information concerning its capacity. Unfortunately, such things are daily practice with regard to water. In developing countries, particularly those in tropical regions where life is closely linked to natural conditions, efforts to prepare inventories are even more important than elsewhere.

In the limited sphere of inventory problems, the interplay of the different forces affecting water and the outlines of the main structural options open to Governments become clearly visible. Inventories and basic data must therefore be overhauled. It is often necessary to establish co-ordination between different bodies dealing with the problem and to ensure that the co-ordinating body has sufficient power to define methods, allocate tasks, control implementation and ensure adequate distribution of results. In the first instance, in view of the requirements in the field of long-term observation of hydrological systems, each Government should ensure that the services responsible for hydrological and meteorological observation networks work efficiently.* Within the framework of a water policy, the structure of such services should correspond to the requirements of all users of the data and not just of one particular user or a single economic sector, however important.

B. Formulation of a Water Policy

All Governments should formulate water policies. All water policies should be based on sectoral policies linked to the different activities in respect of use, conservation and development of water resources or applied to different geogra-

* More details about statistics on networks and organizations of these services will be found in the supporting document on the subject.

phical areas. The problem is particularly acute in big countries with marked climatic variations and highly dissimilar economic development regions and even different populations.

In countries with a federal structure, this question has a bearing on the definition of the respective roles of States and the Federation with regard to water and, in other countries, on regional rights and availability.

On the other hand, choosing and maintaining future lines of action is the essence of any water policy. Frequent changes of policy are equivalent to no policy. However, it must be recognized that we live in an era of rapid change. Policies should be adapted to local conditions and there should be room for a certain amount of flexibility to cope with changes in the nature of problems and in customs.

The objectives of water policies vary widely and each country should formulate its own. However, the main objectives should include optimum utilization, conservation and management of available water resources, maximization of the benefits deriving from water conservation and utilization, valuation of water, and the satisfaction of present and future water requirements for all purposes, in the light of water availability, population increases and advances in technology.

With regard to content, an over-all water policy might include, *inter alia*, the following: the integrated management of land and water; the establishment and fulfilment of priorities in the different fields of utilization (domestic, agricultural, etc.); the adoption of measures to forestall and counteract the harmful effects of water (flooding, drought, soil erosion, spread of disease) and to control the quality of water so as to protect the environment and public health; and the adoption of guidelines concerning the economic and financial implications (prices, costs, reimbursements, subsidies and exemptions), the education of and participation by the public, and international co-operation. Certain countries have also stated that they will take account of the effects which their national water policies might have on other countries.

Institutional, economic, financial, technical and legal machinery should be established in order to implement water policy.

In most countries of the world, water problems have been tackled as a result of difficulties encountered by the different categories of users; legislation, administrative structures and financing have been based on this concept. Fears of future shortages under present operating conditions have prompted a number of countries to adopt a water management policy.

It is generally considered that the difficulties of formulating and implementing a water policy are derived mainly from increased living standards, the demographic explosion and the persistence of poor social attitudes where water is concerned. However, these three main causes cannot fully explain the increase in water problems. In seeking other explanations for the rapid and recent deterioration in the water situation, many specialists, including Barry Commoner and Philip Saint-Marc, have finally blamed the poor application of certain technologies.

Those responsible for water policy will evaluate new technologies and decide which of them should be encouraged and which should be limited and even eliminated. They will exercise this discretion in the light of fixed objectives.

Society has always had to judge science and technology on the basis of criteria other than purely scientific ones and in the light of cultural, social or political values. The importance of environmental protection is becoming more and more apparent. Evaluation of technology has become a highly topical issue and the fact that technology can provide a solution to certain difficult water problems is no longer regarded as the ultimate test of its acceptability. New technology must now pass other tests: economic (reasonable cost), ecological (no effects on the environment), social and even cultural tests. In addition to being proved effective from the point of view of quality, it must prove that its effects on the environment are beneficial.

C. Water Policy and Water Planning

While the purpose of a water policy may succinctly be stated as the achievement of maximum benefit from water resources development and conservation, one or more of the following goals generally constitutes the underlying objective of water resource development: (a) to increase the national or regional income; (b) to redistribute income among regions; (c) to redistribute income among various social groups; (d) to improve environmental quality. Water resource planning is an input into the general process of policy-making. Broadly speaking, it constitutes the link between the formation of the goals which society seeks to attain on the one hand, and the selection of the best means of attaining them on the other. The two processes are closely interrelated.

The actual role played by the planner in the policy-making process varies considerably from one country to another. In some cases, planners act mainly in the capacity of analysts and technical advisers, and there is a reasonably sharp division between the planning and policy-making functions. In other cases, as for many developing countries, considerable reliance is placed on planners not only to recommend solutions to problems but to identify goals and participate actively in the final decision concerning the action which should be taken. Although there is doubtless considerable merit in having the planning function closely linked to the policy-making function, there is a possibility that, in such cases, goals may to some extent reflect agency traditions and professional training. The same may be true of the means selected for dealing with the problems identified.

A series of questions which may help to identify the extent to which a plan truly reflects problems and new social values can be summarized as follows:

(a) Whether the goals accurately reflect current social values;

(b) Whether the problems identified by the planners are the same as those which are perceived by the public or other agencies;

(c) Whether the range of choice embraces alternatives beyond those which have been used in the past by the agency involved;

(d) Whether the weight attached by the planners to particular criteria for evaluation accurately reflects public preferences;

(e) Whether there is evidence to suggest that the recommended policy has been successful in the past, and whether it will not have ecologically

disastrous or publicly undesirable side-effects. Where such questions can be answered positively it is likely that the administrative framework has been flexible enough to respond to the new challenges of water resource planning. Where there is some doubt, it is possible that further adjustments may be needed.

As the rule to be followed is that of adapting water policy to the individual circumstances of each country, it is merely a basic precaution to be wary of global solutions. A study of the different programmes or efforts which have been devoted to developing water resources over the last 30 years indicates that the results obtained in the least developed countries have been rather poor. Water policy has failed to make the expected contribution to the struggle against those countries' most serious socio-economic problems, namely, unemployment and underemployment, malnutrition, uncontrolled urbanization and unacceptable sanitary conditions. The disappointing results of development efforts in those countries are apparently sometimes linked to the rather arbitrary application in developing countries of methods which have proved successful in the industrialized countries.

One cannot overemphasize the basic differences between industrialized and developing countries, differences which mean that any automatic transfer of solutions is bound to bring failure. The developing countries differ from the developed countries on points which are fundamental to water management in particular.

Firstly, in the industrialized countries individuals and institutions apparently adapt almost spontaneously to new means of production (for instance, new irrigation techniques), because of existing communications networks and already-established institutions. Secondly, the industrialized countries are societies which are economically homogeneous, while the developing countries are economically heterogeneous, with different economies existing side by side (modern sector and traditional sector). Furthermore, the main objectives of most developing countries must be defined in accordance with an integrated and intersectoral approach, while the industrialized countries have sometimes been able to determine their objectives project by project, or sector by sector. Finally, foreign currency, capital and skilled manpower resources are generally scarce in the developing countries. These differences, which have a bearing on the nature and the extent of the problems involved, take on special significance in the selection of a water policy. The tools available and, above all, the solutions which they provide, must be used in very different ways according to the individual circumstances of each country.

D. Physical Planning

Planning is an important stage in water policy.

The volume of investment required for hydraulic works, which can seldom be completed quickly (dams, canals, water-treatment plants), and the long lifespan of water-using installations (irrigation systems, factories, urban networks, electric power stations) call for extremely careful planning, and for strict execution of plans once they have been adopted. However, because of the immense difficulty in forecasting future developments, even over the relatively short term, and the need to leave room for innovation, for the reciprocal influence of economic forces and for the development of international trade flows, all

data and planning, while being as detailed as possible, must be extremely flexible.

National development plans should include a national water plan (water master plan). The national development plan would place each development option in its proper perspective in relation to the total needs of the population, by specifying time-limits, guidelines and priorities for detailed plans and for the preparation of sectoral projects. Such planning generally involves identifying the problem, defining objectives, proposing different plans, evaluating those plans and selecting one of them on the basis of the objectives to be met (economic development, regional development, social welfare, environmental protection), executing the plan, making a critical analysis of the results and, where necessary, correcting the plan. There can be no doubt that only a plan which is based on an accurate compilation of information and water resources can be realistic and thus have positive results.

A water master plan could take into account such elements as available land and water resources which are likely to meet household, agricultural, industrial, commercial, energy etc., needs; measures required to anticipate and minimize such harmful effects of water as floods, drought, salinization and soil erosion; measures to be taken to protect water quality, namely the prevention of pollution and water-borne diseases, etc.

Detailed feasibility studies and preliminary studies for specific projects should follow as closely as possible the programmes, objectives and priorities established by the plans for the drainage basin or region in question. Specific plans generally include technical feasibility studies, financial justifications, cost estimates, and the time-table for their implementation. Analysis of legal constraints is always required.

The water administration may then act, if necessary, on the basis of the national water policy and the water master plan, to approve projects for water use or conservation.

In the planning exercise, it is advisable to ensure that each element has been the subject of a comparative analysis of advantages and drawbacks, of a cost-benefit analysis which includes analysis of both the economic and social advantages and the benefits for environmental protection and resource protection. However, it must be acknowledged that such a diversified planning procedure requires more and better information than many countries possess, and also a considerable amount of time, which may delay the selection of the plan and thus threaten the economic profitability of a project.

Generally speaking, a plan is never fully completed. A possible solution might be to establish such guidelines as: rational use, State control, system of user permits, etc., or to establish goals and proceed directly with development on the basis of available knowledge, on the understanding that any activity can be changed to bring it into line with the planning exercise as it progresses.

Finally, one of the most important areas of future research is the perfecting of multiple-objective planning techniques. An exchange of information on those techniques among States would be most valuable.

In many countries, the drainage basin has been regarded as the ideal unit for land and water planning. Sometimes, as in the case of inter-basin water trans-

fers, regional planning may yield better results. Such basin or regional plans should be formulated within the framework of the national water master plan and allow for current needs and final objectives. Resource planning must obviously include planning to meet certain needs (food production, energy production, public health protection, etc.).

The distinction which has to be made between the geographical unit which is suitable for water planning and exploitation and that which is suitable for physical planning or for development in general becomes really important in certain specific cases. This is true for instance, of certain federal States and also in situations where it is more profitable to treat several small basins as one unit, where one basin is particularly extensive or, finally, where political and constitutional constraints make it very difficult for the basin to exist as a single, separate unit. In recent years, the growth of major urban centres has shown that such centres constitute more appropriate planning units than the basin to which they belong. The concept of drainage basin* as a planning unit cannot therefore be an absolute, and must in many situations be reduced or expanded in the light of individual circumstances and needs.

E. Forces Involved

It is useful to summarize briefly the different forces involved in water problems. They include the following: individuals, associations and companies who may use and discard water, build wells, install pumps, establish themselves in areas where flooding rarely occurs or use rises and falls in the water level for agricultural production; communities which install water supply and sewage systems, which make the soil impermeable or block the advance of floods; industries and industrial complexes, which use or pollute water on a large scale; energy producers, who build dams and sometimes harness entire rivers to meet their needs, or who heat up river water to cool the engines in their power stations; agricultural, irrigation or drainage complexes; complexes which provide protection against water; shipping organizations, canal and dam builders; organizations dealing with broader issues, such as regional development; and which take action with regard to water; national civil service departments, each of them responsible for promoting the progress of a given sector of the economy, and which often espouse the cause of those under their administration; finally, public opinion which, although divided and fickle, is powerful and whose support is vital.

F. Institutional Options

The institutional framework may be studied according to the functions of these institutions and the geographical area which they administer.

A national administration can and must intervene in water-related issues chiefly with the aim of:

Keeping abreast of developments regarding resources, consumption, effluents and floods and maintaining an up-to-date inventory of the situation;

Anticipating future developments, evaluating the consequences of various

* An international drainage basin is a geographical area extending over two or more States and determined by the limits of the area fed by the surface-and ground-water system flowing into a single river mouth.

alternatives, and formulating a water policy;

Supervising implementation of these decisions, co-ordinating, and occasionally settling disputes;

Intervening at times directly in certain works or programmes, for example through administrative or semi-public bodies established for exploiting a region or basin.

The geographical basis of management may be international, regional, basin-wide, sub-basin-wide, local or project-related; political options should define clearly the various functions and relative powers at each administrative or management level.

At the national level, it is usually found that a number of ministers have responsibility for one aspect or another of water-related problems. There is a great temptation therefore to create new super-agencies to develop and/or implement a coherent water policy. Since water is one of the natural resources and since exploitation and conservation of all natural resources have a certain number of common characteristics, there is also a great temptation to establish a super-agency for natural resources or the environment.

All actions require an authority which can decide on the line to follow and to ensure that its decisions are respected and implemented. The water sector is no exception to the rule and the choice of an agency to wield this authority is extremely important. The choice will, of course, depend on the solutions adopted to the above-mentioned geographical problems, on the general political structure of the country and the organization of its Government, and on the functions of the authority.

At the highest government level, the question is especially delicate. A search for the best theoretical division of ministerial competence reveals very quickly that there are many possible options, some respecting the unity of one problem, some another. The responsibilities of each and the external restrictions to which it is subject must be clearly defined, bearing in mind the nature of the problem.

In water-related issues, it is clear that the various ministries (of agriculture, industry etc.....), which are responsible for an activity using water, must pay special attention to the "water" aspect of their problems (irrigation development, etc.....) and participate fully in the elaboration of a general policy on resource management. Also, it is clearly indispensable to initiate a dialogue between these users and those responsible for the resource which must be protected by an "awareness". But who should hold the authority? To avoid proliferation of machinery, it seems logical to vest the authority for water problems in a special minister.

The choice of minister depends on governmental organization and the major problems in the country. It may be possible to entrust this role to one of the ministers responsible for a water-related sector, such as the Minister of Agriculture, especially in predominantly rural countries. But there is the risk of conflict of interest, even in cases of the greatest integrity, when the same minister manages resources and user activities also fall within his competence.

Where there is a minister responsible for regional development or physical planning, authority on water problems may be entrusted to him.

Where a ministry for natural resources or for the environment is set up, it may also be logical to include water-related issues. The affinities between water and the other natural resources must, however, be taken into account, in relation to requirements, at various stages in the life of a country. If a ministry for physical planning and a ministry for the environment are both set up, the prime minister will decide between the two.

In any event, a water policy is so closely linked to land utilization and, more generally, to physical planning that there must be close organic links between the agencies responsible for these activities in order to avoid new sources of dispute.

The powers of a "new" minister for water are also of crucial importance. Most of the time, as we have seen, the various ministries have a share of the power in managing the resource. The question is whether each ministry should retain that proportion of power and the "new" minister should merely co-ordinate, or whether he should be given all the power. Given that power, should he retain all of it, or part of it, or delegate it, under his responsibility, to the "former" ministries.

In any institutional analysis and review, all options should tend to ensure that the institutional and administrative framework can co-ordinate or prepare an over-all water policy, and ensure rapid and effective implementation at all levels.

Below the national level, there is what might be called the "intermediate" level which covers inter-State (in federal countries), regional, provincial or basin levels, according to the country involved.

At the level of the provinces or States of a federation, problems vary enormously according to the political organization of the country. Options at national level may serve as a guide for the allocation of responsibilities and the determination of their size at the provincial or State level.

At the level of the basin, or any other geographical planning unit, similar problems arise but sometimes in different terms. It is generally recognized that the powers of a basin organization are of prime importance. Data collection and physical planning would seem to be the minimum acceptable for this geographical level. At international levels, certain bodies are responsible for these tasks for a particular international basin.

Another question is whether water management agencies should be purely technical or whether they should be directly concerned with policy-making. Where water management is often integrated into local or regional development structures it is possible that the water agency has only policy-making power.

There are two major hazards in water administration, which, as we have seen, is a sphere *par excellence* for real and profound disputes:

Paralysis and disorder in co-ordination because of the impossibility of coherent decisions owing to the number and incompatibility of the forces concerned.

The absence of contact with the real situation where there is a structure specially for water management, which is apparently effective but would not be if it were isolated from the active elements of the country.

Like the law which created them, the administrative institutions responsible for applying legal texts, decisions and recognized customs, are an essential element in the success of water resource management. Interactions between the law and the administration are innumerable; the good qualities of the administration benefit the law and the defects of the law are harmful to the administration. The effectiveness of a water law will depend on the administration and the power of the administration responsible for water resources will depend on the water law. There can be no effective regulation of water pollution, for example, if the inertia or weakness of the administration results in measures not being implemented; nor can there be good water management if the law leaves it in the hands of institutions which are divided, dispersed or even in competition.

It is tempting to think that, to be effective, the administrative machinery should be consolidated in a single central administration, a sort of ministry or national water agency. In fact, the important thing is to have coherent administration of the resource. This coherence has been achieved in some countries recently by the creation of a ministry of water or of the environment. In other countries, the same result may be obtained at much lower cost by the institution of interministerial co-ordinating machinery. The creation of a single authority may thus be an unnecessary, or even harmful, reform, when it disbands good work teams or requires reorganization which is ruinous to the State machinery. Nor is centralization necessary; it is sometimes even a serious obstacle to certain policy options which go beyond water management or to the organization of public participation in decision-making.

There seems to be no miracle solution but it is very useful to study the validity of various options.

G. Co-Ordination

Some countries believe that co-ordination will in itself solve the institutional water problem caused by the opposition between diversity of uses, and the historic division of management responsibilities on the one hand, and the unity of the resource on the other.

There is no doubt that, because of the many interrelated problems, water management requires close co-ordination at all levels. The idea of co-ordination need not be limited only to the preparatory stages but must apply also at the decision stage. A responsible minister would preside over a committee and arbitrate in case of disagreement.

It may be asked whether the committee's meetings should be limited only to governmental bodies. Undoubtedly, the answer would be yes where decision-making is concerned. But in the preparatory work, there may be great advantages in consulting the active elements affected by the decisions.

There are many other questions with regard to the organization of this co-ordination. They concern especially the geographic level at which it should be conducted. In addition, co-ordination is not concerned only with user-resource relations but also inter-State and interbasin relations and those between member States of certain federations. Similar problems arise when general development is prepared, planned and at least partly carried out at the level of autonomous regions. The choice of the power-holding body is more difficult when

the representatives of States or provinces are usually elected. Decisions may then be taken by vote, possibly with recourse to arbitration by the minister in unitarian countries. Where the structure is federal, problems may be even more thorny and concern the respective powers of States and the federation. To solve specific water management problems, intense co-operation or arbitration authority is necessary.

In the choice of bodies participating in co-ordination work, preoccupation with the environment may, in some industrialized countries, assume particular significance. It is important to analyse the possible mode of association and the methods of evaluation to be adopted in the face of options based largely on economic considerations or relating to subjects which do not easily lend themselves to financial quantification.

Research is under way but we must not deceive ourselves into thinking that any procedure, no matter how sophisticated, can take the place of quantifiable data.

H. Participation

Co-ordination and co-operation are closely linked to participation. To co-ordinate the work of several bodies is to encourage them to participate in a collective task and to enlist the co-operation of several provinces or States is to invite them to participate in a joint effort. The full extent of this notion of participation is involved where users have to be persuaded to take part in decisions concerning water policies. The organization of this popular participation must go hand in hand with an education and training programme, which is the long-term guarantee of any policy. Participation usually has most significance at local levels.

The problem is how to associate the active bodies concerned with water problems at the various co-ordination levels. It is easy to see that different categories of water users must participate in formulating water policy at all levels, but not so easy to see who represents these users and the public in general.

There is a problem as to whether representatives of user associations or professional groups or unions should be associated at the same level as ministries or at a more consultative level. The representatives of environmental protection bodies could also be included in this popular participation.

Problems concerning participation of active elements become increasingly important as the problems become increasingly down-to-earth rather than theoretical, as for example in the case of irrigators' associations.

Since any implementation of a water policy affects all individuals, it seems essential that the State should guarantee their co-operation so that they can be fully aware of the facts underlying the decisions taken.

I. Options and Economic and Financial Mechanisms

The formulation and implementation of a water policy also requires options relating to the economic and financial aspects of water management.

There is a wide variety of doctrines concerning the optimum management of a country's economy. Until quite recently, they have accorded scant attention to water problems. For some time now, however, numerous studies and some experiments have been carried out.

In market-economy countries, efforts have been made to determine the possibilities and the limits of incremental pricing applied to drinking water and energy, and possibly also to agriculture, combating pollution and the like. The concern has been generally to decentralize to the maximum extent the choice of investments in order to reduce their amount.

In planned-economy countries, more thought has been given to methods of planning, and the concepts of cost to the economy and pricing have been divorced.

Nevertheless, in some cases, these countries have studied and even established financial systems for encouraging the decentralized economic agents to make investments which are favoured by the central authorities but not solely determined or regulated by them.

Matters involving the economic and financial aspects of water management include firstly the criteria and the procedures for assessing projects and weighing their merits. In that connexion, the cost/benefit ratio of a project is a factor taken into account. In countries where there is a manpower surplus, for example, the undertaking of a project creates work, the value of which could be identified among the benefits. In the case of multi-purpose projects, the cost must be distributed equitably among the various purposes in order to assess their respective merits. In general, while in the industrialized countries the choice between various solutions may be based entirely on cost/benefit considerations in respect of specific and clearly defined projects, in the developing countries the choice must take into account social factors (overpopulation, poverty, level of living, health) and above all the fact that water becomes an instrument of economic development at the national or regional level. Accordingly, water's contribution to the solution of such specific problems as food production, health and social welfare must be determined. If the price of water is considered as a means of promoting the development process, it is necessary to be certain that this price will be able to:

(1) Ensure effective utilization and distribution of water;

(2) Meet specific criteria for controlling demand as a function of current and future supply;

(3) Promote the achievement of the country's economic objectives, especially in the agricultural sector.

The water manager cannot remain indifferent in the face of the multiplication of unfounded needs when essential needs suffer as a result. Managing demand for water therefore has become the cornerstone of a modern water policy. In managing demand, economic and financial mechanisms seem to be of unequalled effectiveness.

Most water-related projects require very considerable investments to cover the high costs of exploration, exploitation, distribution and other management operations. When the user or beneficiary of management measures does not bear the cost of use or protection, the State or other members of the community must bear

the cost either through taxation or other means.

Given the fact that prices influence use and, therefore, investment, one must consider the following criteria when evaluating policies from a purely economic point of view.

(1) *Allocative efficiency*. This deals with the issue of equating incremental benefits and incremental costs. The pricing policy that accomplishes this objective is one in which the price charged is equated to the incremental cost. The general policy implication of this rule is that water users should not be subsidized, but rather that they should pay the full incremental costs of the water they consume. If subsidies exist, water prices are too low and water is over-used at levels at which incremental costs exceed incremental benefits. On the other hand, water supplies should not be used as "taxing authorities", in other words, prices charged should not exceed incremental costs. If they do, water will be under-used.

(2) *Administrative costs*. Any system of measuring water use and charging a price that reflects incremental costs involves some administrative costs. In evaluating a pricing structure, one must evaluate these costs to ensure that they do not exceed the allocative efficiency gains made by selling at prices equated to incremental costs. Here again the allocative efficiency rule applies — one should continue to refine a pricing structure up to the point where incremental benefits derived from the refinement are equated to the incremental costs associated with making the refinement.

(3) *Equity*. Any pricing structure should be based upon a principle of equity. There are two basic principles that can be used. The first is referred to as the "ability to pay" principle. If strictly applied, this principle would charge high prices to those with high incomes and low prices to those with low incomes. It is clear that this principle is not consistent with the principle of allocative efficiency and the efficient use of water resources. Thus, in the developing countries in particular, it may be felt that equity considerations should be taken into account only in the case of domestic consumption. They should not influence the pricing of water supplied as a factor of production. If they do, the related consequences should be taken into account in the planning process. The reasons are clear:

(a) Subsidizing some level of *per capita* consumption is intended to assure a certain minimum level of personal and domestic water consumption which is regarded as desirable for social and health reasons. A direct subsidy to income would be ineffective for this purpose.

(b) Subsidizing water used in production leads to an insufficient allocation of supply and in addition is a very inefficient way of subsidizing the income of low-income producers.

The second principle which is consistent with allocative efficiency is the "benefit principle of taxation". This principle states that the beneficiaries of water resources projects (those who also impose the incremental costs on the system) should pay in proportion to the benefit received.

Incremental pricing has generally proved to be the most effective policy and is most in keeping with the concern for sound water management. It would, of course, be unthinkable to generalize regarding the applicability of a pricing system for

water based on the incremental cost. It is nevertheless true – and this is the essential point of this section – that every official must be aware of the cost of his policy. In choosing and implementing a water policy, price and other economic criteria, better than any other indicators, enable the official to become aware of the consequences and effects of various solutions.

*J. Water Law**

Policy decisions cannot be implemented successfully unless there is an adequate water legislation. Based upon the decisions made by the planner, water legislation has the purpose of ensuring, as far as possible, the most economic and equitable use of available water resources.

Water legislation, in turn, is strongly influenced by the legal system followed by each State and care should be exercised, in considering legal provisions affecting water, not to introduce concepts which do not comply with the over-all legal, philosophical, sociological and religious character of any particular country or region.

The philosophy of water legislation could take into consideration the availability of water in a country, basin or region; the environmental consequences of water use, particularly on the ecosystem and other resources; existing uses of water and the amount used, by whom and for what purpose; the cost of different sources of water; present and future water requirements of the country or region; and government water policies, including water planning.

Water law is the ultimate means of implementing and enforcing water resources policies. In many countries, legal provisions directly or indirectly affecting water resources are scattered throughout numerous texts, which are often fragmented, confused, and anachronistic. This is the result of historical developments which necessitated the enactment of legal provisions to regulate specific water problems as they arose. As a consequence, in many countries water legislation is not adequate to allow easy implementation of water policy decisions.

Although it may not be possible to formulate clear-cut indications regarding sound water legislation, mention could be made of the following subjects: definition of water policy objectives; ownership of other judicial status of water resources; mode of acquisition of the right to use water and limitation thereof; order of priorities (between uses and areas); terms and conditions for the various beneficial uses (domestic, municipal, agricultural, fishing, hydropower, industrial and mining, transport, recreational); provisions for controlling harmful events (floods, droughts, soil erosion, etc.....) and the quality of water (pollution, health and environmental preservation); special regimes regulating ground and atmospheric waters and coastal areas; measures to protect waterworks and structures as well as for declaring water resources development or conservation zones or areas, water rates and fees, financial contributions, special development agencies, implementation and enforcement of water legislation, including "water justice". Finally, water legislation is also the means through which it is possible to spell out the respective responsibilities and powers of government, ministries, agencies and institutions, with regard to the functions to be performed (policy making, planning, co-ordination, executing and operational) and the level of authority involved (national, basic, regional); of particular importance is the inclusion of the role of water users association

*See *Water Development and Management*, edited by Asit K. Biswas, Pergamon Press, Oxford, 1978.

in the administration of water.

It is the legal framework of each State which can determine the type and form of the legal enactment (code, act, regulation, ordinance). Some States have adopted the legislative technique of promulgating a consolidated water act or code containing basic principles and leaving it to subsidiary or subordinate legislation — not requiring parliamentary approval — to regulate provisions of detail or of a less permanent nature. Other countries have, on the contrary, included in one single text all the provisions relating to water.

One thing which seems to be required in many countries is to co-ordinate and consolidate the existing sectoral legislation on water resources conservation, development and utilization.

As far as options for national water legislation are concerned, the International Association for Water Law (AIDA), during its Caracas meeting in February 1975, has proposed a set of recommendations which are to be circulated at the United Nations Water Conference together with a supporting document.*

K. Conclusion

Fundamental political options and the means which can be employed

While the means to be employed depend, as has been seen, on the objective situation with regard to a region's water and its development prospects, they also depend on the fundamental political options chosen by each country.

There are many different political systems in the world and, hence, many different means employed by Governments to ensure that the efforts of the various economic agents converge on the goals pursued. Historical traditions, ancestral customs, political boundaries, the area of territories, the federal or unitary nature of the State, the desire to decentralize decisions or the pursuit of centralized planning, all these are general political factors which have a profound influence on the means employed, even when the specific problems faced are the same.

As regards legal principles, the options range from allowing private rights of water use to nationalization by the State of all water sources. However, the authorities must always intervene in individual cases whenever a general problem arises.

On the financial level, countries are often motivated by the desire to decentralize decision-making by providing each economic agent with information enabling it to exercise its own choice in pricing items, including, as has been seen, water or pollution. Conversely, some countries make centralized choices based on economic data such as the prices laid down in the plan, and determine prices on the basis of a wide variety of considerations, such as those of a social nature.

Administrative structures also vary tremendously even though in the various political systems similarities can be perceived among specialists as regards some institutional patterns such as basin organizations as a result of the very strong pressures of realities.

*See *Water Development and Management*, edited by Asit K. Biswas, Pergamon Press, Oxford, 1978.

The synthesis specific to each country

Of course it is for each country to make its own synthesis of its objective water situation, its general policy options, man's experience in water management and the goals assigned to its people for the future.

Before taking up the questions of administration, law and finance respectively, we would stress once again two fundamental ideas:

The means employed must be suited to the real nature of the water problem and not to the appearances, which so far have too often been the only elements taken into account; these means must ensure a close and daily link between water management and the management of the rest of the country's economy.

Options for international action

Two main categories of problems arise, one relating to the co-ordination of national policies, and the second to inter-State co-operation in the field of international water resources.

The first of the two sets of problems may be solved either by enacting parallel national legislations or by harmonizing them. Thus, a State may declare that it will take into account the effects of its national water policy on other countries, or may undertake an exchange of information on matters relating to water. Another question of concern to industrialized countries involves the acceptance by a group of States of common affluent standards for controlling water pollution and avoiding unfair competition.

The other category of problems concerns waters of an international nature shared by several States. As long as these waters remain within the territory of a single State, they tend to be treated as that State's sovereign resource. This has given rise to claims by individual States to the exclusive and unfettered control of waters that pass through their territories. On the other hand, the shareability of waters, reinforced by their hydrological unity, has pushed States to seek co-operation first in the use of common bodies of water and then in the use of entire drainage basins. This need for co-operation and accommodation becomes more pressing in areas and instances in which water use begins to approach or to exceed available capacity and in such instances it may even extend beyond the confines of a single drainage basin.

Because of this double character of water as a permanently shareable and temporarily sovereign resource, and because of the hydrological and, in some instances, political, economic and geographical distinctiveness of the drainage basin, the evolution of universally applicable rules for co-operation has been slow and confined to principles such as good neighbourliness, abuse of right, and *neminem laedere*, which however, lacked sufficient precision to be applied in particular situations. The effort to supply rules of general application was undertaken by international conferences and international associations. The International Law Institute and later the International Law Association, in its espousal of equitable utilization, attempted to establish flexible guidelines for what is an equitable share of each co-basin State in the use of the basin waters. The development and general adoption of these or similar guidelines is one way of putting co-operation between States on a firmer basis. If it appears that universal guidelines are premature or impracticable, they may be more easily applied by a regional organization on a regional basis. This is

already done by the Council for Mutual Economic Assistance, the European Economic Community and the Organization for Economic Co-operation and Development in the field of transboundary pollution, where common standards and the rules of State responsibility for damage are of prime importance.

Along with the effort to evolve regional or general rules of co-operation between States, there has been a parallel effort to define such co-operation through bilateral and multilateral agreements, beginning with boundary water treaties of limited scope and evolving into treaties of basin-wide application. The latter may generally be divided into agreements which apportion the basin waters between concerned States, as does the Indus Treaty, and those, such as the Columbia River and the Senegal Basin Treaties, which establish a basis for joint development. Treaties not only can be a means of implementing regional or general principles and guidelines, but also may and do substitute for these principles.

One of the most important requirements, if not the most important, for putting co-operation between States in the water resources field on a firm and durable basis is the establishment of an institutional framework for such co-operation. Many bilateral and multilateral treaties establish river or basin commissions or committees. The scope of their functions varies from the purely technical and supervisory to the judicial, in some (still rare) instances. Not only do these entities generally not have a decision-making role, they also lack power to make proposals. The power to initiate proposals (especially, but not exclusively, in the development of standards), along with data-collection, and the role of information clearing-house, is the most promising line of evolution of these institutions in all those situations in which it is not feasible to entrust to them a decision-making capacity. A joint hydrological data collection system and establishment of joint technical organizations for this purpose seems to provide a most flexible and progressive tool to solve at least the most acute problems of international sharing of water resources. Discrepancy in data on quantity and quality of water across State boundaries gives rise to conflicts which can be avoided by the above action.

There are as yet few general principles of universal acceptance in international water law. Two which have been put forward by scholarly bodies are: (1) the right to an equitable share for each co-basin State in the use of drainage-basin waters; and (2) the responsibility of States for water-related activities within their borders which may cause injury in areas outside their jurisdiction. In view of the slow development of general principles, the most promising avenues for the development of international water law are the basin or regional organizations. Common pollution standards and the elaboration of responsibility for damage to individuals outside a State's territory are already in an advanced stage of readiness in some regional organizations of industrialized countries. The appropriate international water administration is of prime importance for the effective and equitable use of international waters. Whenever possible, international water commissions should have the role of information clearing-houses and the power to propose and approve rules, standards and the construction of waterworks. The establishment and support of basin and regional water agencies should be encouraged. In this connexion, it is worth mentioning that the International Law Association has, at its fifty-seventh Conference, approved a report on "Administration of international water resources", with annexed guidelines, and this report has been presented as a contribution to the United Nations Water Conference.

Consideration could be given to the role that the United Nations system should

have in reviewing, collecting, disseminating and facilitating the exchange of information and experiences on the various questions discussed in this document through the preparation of studies or the preparation of expert meetings, working groups, as well as in supporting or arranging research, study and technical advisory programmes.

IV. SECTORAL OPTIONS

While planning should initially be viewed in a comprehensive national or regional context governed by specific government objectives, water management can help to achieve social and economic goals only through sectoral activities. The range of alternatives and choice of options which are presented in this context will now be reviewed briefly.

A. Rural and Urban Water Supply

Community water supply is an integral part of the socio-economic infrastructure of settlements which, apart from water supply and sewage disposal, includes such broad and diverse components as health and sanitary services, housing, supply of energy, public transportation, schooling, police services and many others. Although the immediate objectives of community water supply and sewerage are quite specific (to provide or improve the quality, quantity, availability and reliability of water supply and sewage disposal services) these are also inseparable ingredients of a number of broader infrastructural objectives, such as reducing the incidence of water-borne and water-related diseases, creating opportunities for learning and providing employment, and promoting greater self-reliance and better social organization for the community (particularly for the poor, the aged, women and children). Above a certain minimum level determined by health considerations, the "appropriate" level of water supply and sewerage services can only be judged for any given locality in the light of the development resources (social, economic and physical) available for establishing and maintaining such services, together with the other components of rural and urban infrastructure.

At present, in a world-wide perspective, the options are quite clear: on the one hand, the large cities of industrialized countries are provided with water and sewerage services for the majority of the population through large-scale networks and in-house connexions, built and maintained with a high level of technology, adequate financing and the necessary service personnel. At the other extreme are the isolated dwellings in the rural habitat of developing countries, where in many instances there is virtually no service of any kind for water supply and excreta disposal. Between these two extremes, in the majority of cases, there has been a tendency to transfer virtually unchanged the contemporary concepts, technologies, and social organizations for public water supply and sewerage from the highly industrialized to the developing countries. Following these efforts, there has grown a recognition over the last few years that in fact there exists between the two extremes a very wide range of alternatives with regard to both technology and social organization, and that the selection of appropriate solutions needs detailed analysis and careful experimentation based on and geared to the specific social, economic and physical conditions and objectives of the given location. Although the number of alternatives is

almost infinite as regards specific technological and organizational detail, the various alternatives are rather closely conditioned by one factor, namely, the scale of the system expressed through the number of inhabitants served by a particular public water supply and sewerage network.

In industrialized countries, the resources needed for the establishment of public water supply and sewerage as well as other components of urban and rural infrastructure, did not represent limiting constraints in developing these services. In fact, they have in most instances been able to meet in full the rising and changing levels of demand of the last 50 years. As for other fields of technological development and social organization, the general tendency has been to establish larger and larger systems in line with requirements and the tenets of economy of scale and favouring automation and centralized organization.

Although water supply and sewerage services are usually not among the primary causes and symptoms of the general breakdown of infrastructure experienced by many metropolitan areas in the industrialized countries, at least three major tendencies of increasing concern have been observed over the last few years and even decades. First, the rapidly growing pollution of rivers, lakes and ground water within and around such areas tends to impair the quality characteristics of community water supply. The fact that this quality degradation frequently goes unnoticed or that it may, at times, be accepted as inevitable can only be viewed as a reflection of a basic shift in the patterns of urban water use in these countries. By far the largest quantity of this water is now used for dishwashers, washing machines, lawn sprinkling, car washing, and municipal use. Drinking and washing, the principal original purposes of providing a potable water supply, have now been relegated to a secondary role in relative terms. A second alarming trend in urban water use is the extremely high level of losses in the distribution systems and the low level of efficiency in various domestic and public uses, even in regions which have experienced a general scarcity of water or which are facing this problem in the foreseeable future. This situation may largely be ascribed to cost and price structures, which attribute an incorrect value to water *per se* and tend to increase its demand and use rather than promote efficiency in the use of water. Thirdly, a by-product of attempts to cope with the consequences of pollution and wasteful usage by increasing the treatment of water and sewage is that the cost of providing water supply and sewerage services is beginning to reach alarming proportions in a number of highly industrialized metropolitan areas. This may necessitate a basic revision of existing policies, including the introduction of new cost and price mechanisms, which more nearly reflect the true cost of the health hazards and the environmental degradation involved, and which are likely to encourage a more efficient and rational conservation of water.

In most developing countries the present situation and outlook for public water supply and sewerage is typified by an increasing gap between the demand for capital and skilled manpower to provide the modern technologies and administrative structures required, and the actual scarcity of such resources in the developing countries. Estimates summarized in the report entitled "Resources and needs: assessment of the world water situation" (see pp. 49-50 of this volume) indicate that some $36 billion at least will be needed during the next four or five years, in order to achieve the revised 1980 targets set by WHO for the improvement of urban and rural water supply and excreta disposal in the developing countries. It is also noted in the above report that, even if funds of such magnitude were available, the small pool of trained personnel and limited organizational resources would impose serious limitations on the efficient use of the required capital. It should, furthermore, be borne in mind that the

improvement of public water supply and sewerage services are likely to reach desirable social and economic objectives only if other related components of the rural and urban infrastructure (housing, health and sanitary services, schooling, etc.) are improved, in step with water supplies and in a closely interlinked fashion. To the capital and trained manpower needed for the establishment of these services, annual requirements for maintenance, repair, and safe operation have to be added; frequently, these are also of great magnitude. Some modification in the current approach to technical assistance programmes and a significant broadening of the range of technological and organizational alternatives considered — with greater emphasis on small and medium scale systems — appear to be among the crucial elements in finding a solution to this seemingly insoluble dilemma.

Apart from and in addition to greater reliance on small-scale and medium-scale technologies, special attention should be devoted to using, as far as possible, of locally available labour and materials if economical and socially desirable. The fact that technologies of this type are not readily or easily available should not detract from the opportunities offered. An increasing number of encouraging examples illustrate the great potential for local adaptations if a careful analysis is made from both ends: the tasks to be performed on the one hand and the materials and skills available locally on the other. Indicative examples include the manufacture by local potters of aqua-privy fittings in Nigeria; rainwater catchment tanks in Swaziland with linings and internal structures which combine polythene sheeting with mud, sand and a little cement; coagulant aid for water treatment in India using local vegetation; and the use of discarded containers as the basis for chlorine dosers in Sudan. In other countries, development plans in the sector of water supply and sewerage are made in accordance with those of the national construction industry as a whole; they take into account the country's capacity to absorb additional demand for labour and construction materials, and to foster the development of all construction related sectors within the national economy. In Turkey, for instance, comprehensive urban and rural water supply programmes have resulted in the phased development of national pipe manufacturing industry. In Brazil, the national programme for the improvement of urban water supply is almost entirely based on the development of national resources to meet the demand created by this programme. Such comprehensive policies necessitate long-term planning, in order to avoid the creation of a temporary market, which would result in regression after the main works are built, and which would on the whole be detrimental to the economy. Also, it must be ascertained whether locally produced construction materials are reasonably competitive on the international market. Governments and donor organizations could help to promote the dissemination and exchange of local experience and initiate and support research and experimentation in tasks which are beyond local capabilities (e.g. the development of cheap pumps with local repair facilities or the small-scale local manufacture of plastic pipelines). The small and easily movable sanitation unit developed by Oxfam for emergency situations in Bangladesh is a good illustration of this concept.

B. Protection from Floods and Droughts

How to use lands exposed to natural hazards (floods, droughts, typhoons, earthquakes, volcanic eruptions, tsunamis, forest fires, locusts, etc.) and how to prevent or reduce the losses caused by such disasters are among the important policy issues at the local, regional and national levels, and are relevant to almost every sector of the economy. Among the numerous problems faced by dev-

eloping countries, an adequate adjustment to flood and drought hazards is particularly critical. Thousands of people drown annually and floods destroy more than 10 million acres of crops each year in South-East Asia alone, while in the Sahel region the recent drought took a toll of castastrophic proportions in human lives and suffering. Not only are the losses caused by floods and droughts large, but they have been getting larger every decade owing to the continuing movement of population and economic activities onto flood plains and drought-prone areas. The success or failure of strategies relating to natural disasters in general, and protection from floods and droughts in particular, is closely linked to the safety afforded by other infrastructural services, such as land-use planning and regulation, transportation systems, energy supplies, public information and education, and so on.

The basic challenge in meeting problem floods and droughts is to find a set of land-use regulations and management strategies which will permit a more intensive use of the endangered areas but minimize the associated losses. While there is ready agreement on the advisability of abandoning certain lands that are frequently and regularly struck by floods or droughts, there is in many instances complete indifference to infrequent but more serious risks. Thus, while rural inhabitants, particularly in developing countries, live in daily contact with nature and are ready to adapt their lives to its vagaries, town dwellers, particularly in the industrialized countries, live in an increasingly artificial psychological atmosphere and frequently refuse not only to take precautions against collective natural hazards, but also to face the consequences of their refusal. Partial protection from floods or droughts has, more than once, led to an increase of hazards and losses because it has encouraged unjustified encroachment onto the risk areas by housing developments and other economic activities.

In principle there are always four major ways of adjusting to flood or drought hazards: (a) by modifying the flood or drought event (e.g. by weather modification or, in the case of floods, by dykes, reservoirs or watershed management); (b) by modifying the susceptibility to damage (e.g. through land-use regulations, zoning ordinances, government purchase of land or property, flood-proofing, introduction of drought resistant plants, etc.); (c) by modifying loss burden through evacuation, disaster relief, tax write-offs, emergency operations during disaster periods, etc.); and (d) by bearing the loss. Two basic questions are relevant in selecting the actual measures for adjustments: What level of adjustment is appropriate and what is the most satisfactory combination of measures? Fundamentally these are economic questions, although several other considerations may affect the final decision. In some countries the intensive use of hazard-prone areas is the only possibility for economic growth because the whole area is exposed to risk, or alternatively all the available risk-free areas are already densely populated and fully utilized (as in several countries of South-East Asia). Developing countries with high levels of risk but low levels of economic growth should concentrate on those adjustments that can be accomplished with low capital investment, but which are highly effective in saving lives and minimizing property losses (emergency operations, land use regulations, flood warning and evacuation, etc.).

Frequently there is a large gap between what a country can technically attain by effective prevention and management measures with the resources already available to it, and what is actually achieved. Such discrepancies are generally the result of institutional inertia, tending to concentrate on measures that were perhaps appropriate at an earlier phase of development but are no longer satisfactory. Innovation in administrative structures or other types of instit-

utional innovation might, therefore, be one of the most effective ways of improving the efficiency of adjustments to flood and drought hazards. Lack of comprehensive information on the regions and areas exposed to various degrees of flood and drought hazard is also one of the most frequent and most significant obstacles in the formulation and implementation of long-term programmes and policies.

C. Water for Food and Agriculture

Community water supply, as well as protection from floods and droughts, are interlinked with other components of the social and economic infrastructure, mainly at the end-product level, i.e. although they are part of a broader infrastructural package, specific water management criteria and services can be established and rendered with a certain degree of independence. In the case of agricultural water development the interrelation with the broader socio-economic framework and with the over-all social and technological structures for food production and agricultural development, is a much closer one. In fact there is not a single detail or phase of agricultural water management and administration which can be planned, built or operated without close co-ordination with other input factors of the agricultural system. On the other hand, there is not a single change or decision within the agricultural and food production system that will not have water-related implications.

For the purposes of a brief overview, the internal relationships between water and agriculture might be grouped at three major levels: (a) the end-product level, within which the local, regional and global demand/supply situation for food and other agricultural products motivates and controls the over-all and long-term trends of agricultural water development through long-term planning, and/or general tendencies affecting the cost and price structures of these products; (b) the input factor level, within which the relative significance and specific water management approaches are determined and conditioned by the given climatic and soil conditions and the general patterns and levels of a region's agriculture; (c) the water supply and management level, within which the specific technological and organizational aspects of irrigation, drainage, fishery development, rural water supply and other components of agricultural water management are designed, constructed and operated on the basis primarily of the general availability of water and the over-all level of efficiency in its use and management within a given location. Needless to say, the above three levels are closely interrelated. Under conditions of general water scarcity, factors at the third level may influence decisions or developments at the second level and, in cases of irrigation of desert or semi-arid lands, the issues of water supply and management may become of major concern even with respect to considerations on the end-product level.

Since agricultural water development relates to man's most vital need for food, it is not surprising that the first clear examples of highly skilled and widely organized water management systems, the fluvial civilizations of antiquity, emerged essentially within this sector. Most of the remaining records and the systematically assessed historical heritage of ancient water management practices and organizations relate to irrigation, drainage and flood control in the valleys of the Nile, Tigris-Euphrates, Indus, Lower Mekong, Yellow and Yangtze rivers; it also seems very likely that fluvial civilizations of a similar type and scale must have developed and flourished for long periods in other arid areas of Africa,

Eurasia, Central and South America and the Pacific region. The history of agricultural water management, like that of other human endeavours, abounds in both successes and failures. About half of the world's total agricultural crop comes from irrigated lands, providing on an average several times the specific yields of dry farming. In many instances, however, irrigation has also brought undesired and unexpected consequences, such as the spread of water-related diseases or the deterioration of valuable croplands by water-logging, salination and alkalification. Social and institutional components or irrigation programmes have frequently been neglected, and the efficiency of water use and management is generally very low.

The rapidly rising levels of demand for food and the food shortages experienced during the last few years leave little doubt that food production must be increased considerably during the years to come, and that irrigated agriculture can and should contribute heavily to this objective. Most of the policy issues relating to the intensification and expansion of food production are, however, tied very closely to the immense intraregional and interregional variability of the physical, social, economic and technological conditions for agricultural production. It is an extremely long and difficult process to bring the end-product level pressures for more food and better nutrition in a global context (expressed clearly by the rapidly rising food prices in almost every country) to the input-factor and water management levels of the various regions and countries. This needs a set of well co-ordinated and highly differentiated efforts at all levels of national and international action. Agricultural production is almost everywhere at a relatively low level with respect to its full potential, and the quasi-industrial type of agriculture which emerged or is emerging in the industrialized countries raises a number of difficult questions regarding its long-term social and ecological impacts, including the high pollution risks for the neighbouring rivers, lakes and ground waters.

Proposals and requests for improved agricultural water supply and management relate mostly and necessarily to lands under less favourable climatic and/or soil conditions than other farmlands of the given country or region. This means that the investments needed for the improvement or extension of such services must be supported by other regions or population groups, through a carefully designed system of governmental policies (economic incentives and regulatory measures). On the other hand, a new irrigation project in one region of a country may adversely affect the welfare of producers in another part of the country. For these reasons, relatively large agricultural water management projects, which will have a significant impact on the market for a product, should be undertaken only after all effects have been taken into account.

In many countries irrigation water is used inefficiently because of inadequate water storage and delivery systems, improperly levelled land and poor choice of crops. In spite of low productivity per unit of land, there is frequently greater pressure to extend irrigable acreage than to improve the cultivation of land already irrigated. Although there might be valid reasons for both tendencies, efforts devoted to the cultivation of land already under irrigation usually deserve priority. In this context, medium-scale and small-scale projects have definite advantages over large-scale ones. They provide more flexibility for local involvement and more potential for experimentation and improvement in the implementation phase. If it is decided to expand the acreage of irrigated agriculture, a number of options usually emerge in relation to the degrec of concentration of available development resources. For example, these can be routed to areas exposed to severe droughts (where larger investments are required but where

greater crop production levels may be expected), or be dispersed over greater acreage in regions where supplementary irrigation only is needed. A reasonable selection among the emerging options and their satisfactory combination require a comprehensive assessment of development potentials in various regions with regard to both agriculture and integrated water management. In countries of humid or highly variable climate, e.g. in the tropical lowlands of Latin America and Africa, drainage and flood control are indispensable prerequisites for the intensification or expansion of agriculture and demand or opportunities for supplementary irrigation should be looked upon only as a subsequent aspect of agricultural water management. Drainage is, of course, indispensable to, and an integral part of, any irrigation scheme. Its neglect is one of the most frequent and most damaging causes of deterioration in soil fertility in many irrigated areas.

Since irrigated agriculture consumes a large portion of the water withdrawn from a source for that purpose, the selection of irrigated areas in the sequence of natural flow with respect to other uses which rely on the same resource is a question of great importance. If an irrigated area is situated downstream of a large town, it can utilize the return flow of municipal water supply (and eventually save part of the cost of the waste disposal and recycling system too). If, however, it is located upstream of the town it may pre-empt or decrease possibilities for municipal water supply. Such sequential allocation options are particularly relevant in planning for the development of virtually uninhabited areas.

Finally, and most important, it should be emphasized that agricultural water management has a vital role to play in cases where the land's natural water régime is not radically changed by drainage and irrigation; it remains one of the most important input factors under conditions of rain-fed crop production, which represents the backbone of food supply in many parts of the world. In fact, rain-fed agriculture is an overwhelmingly important on-site water use and related technological and managerial practices have far-reaching impacts on, and interrelations with, the availability and quality of water in the surrounding areas. Soil cultivation tools and practices are most significant factors in shaping the flux and storage of water within the soil and farmland areas, and they should be designed and used with a full awareness and recognition of this interrelationship. Similarly, research and experimentation for less water-consuming and more drought-enduring crops is a most important facet of agricultural water management; this might result in a replacement of costly irrigation systems and become by far the most cost-effective solution for increased food production, under dry-land farming conditions in many instances. In some cases where quasi-industrialized agriculture is practised, a reduction of chemical inputs or their replacement by organic alternatives could represent the most cost-effective or the only viable way to prevent or reduce pollution of the nearby aquifers.

It is in this broad context that the interrelations of agricultural water management with other input factors and managerial practices for crop production suggested in the opening paragraph of this brief review, should be viewed, as the corner-stone for the integrated development and management of land and water.

D. Inland Navigation

The establishment and maintenance of a transport system is a major component of

regional and national infrastructure, which should develop hand in hand with, or preferably in anticipation of, the growth in agriculture, industry, commerce, tourism and other sectoral activities. Throughout human history inland navigation has been in many regions the most important and in some areas and periods the only mode of transport. During the last few decades its significance has been greatly overshadowed in industrialized countries by the explosive development of railways and of road traffic by lorry and car. There are signs that during the decades to come inland navigation will regain a significant part of its historic role, most particularly in the developing countries and possibly also in Europe and other highly industrialized regions.

The historic usefulness of river systems as waterways and their potential for many developing countries cannot be judged in terms of their navigability for fairly deep-draught vessels only. From ancient Mesopotamia to the Mississippi of the eighteenth century, rivers were navigated much further upstream by exceedingly light, even flimsy craft. The most ubiquitous form of river transportation was the raft, which could be made of any handy material (timber or reed), could be floated downstream from the uppermost tributaries, and could be abandoned, sold, or used to build a house. In areas of dense virgin forest a navigable river was, and in many regions still is, the easiest if not the only means of entry. If the river is long and has navigable tributaries, the extent of penetration may be considerable and may result in a string of settlements and trading ports. An important factor in this connexion is the length and ease of transit between the headwaters of adjacent river systems. When compared with the construction of roads and railways, the major advantage of inland navigation by locally made small and medium-sized vessels, consists in its low investment cost adaptability to local skills and flexibility with repect to gradual expansion.

The continuing significance of inland navigation, which periodically reached outstandingly high levels of technical and social organization in subsequent periods, was motivated by two major factors: (a) the building of navigation canals and (b) the remarkable respect for freedom of navigation and the functional and commercial integrity of waterways within politically divided river systems. The outstanding examples of canal building of antiquity, particularly in Mesopotamia and China, were enthusiastically pursued in Europe and North America, reaching a culminating point in the eighteenth and nineteenth centuries. Ancient examples of basin-wide commercial and functional unity were emulated repeatedly in Europe during the Middle Ages (for example in the basins of the Rhine, the Elbe and the Oder) and the principle of freedom of inland navigation had already reached broad international recognition in 1815 at the Congress of Vienna.

Since transportation costs by inland navigation decrease considerably with the increase of distance traversed without unloading, the great potentials of large-scale interregional waterway systems for highly industrialized and mass-production-oriented societies were also recognized and took shape in the 1920s. This took the form of a proposal for a trans-European east-west waterway through the interconnexion of three river systems, the Danube, the Main and the Rhine. This giant undertaking, the realization of which is well under way and which will probably be completed by the mid 1980s, will permit the short-cut passage of large-tonnage ships (up to 1500 tons) between the North Sea and the Black Sea and it will directly interconnect 13 riparian countries.

The historic significance of inland navigation in general and its functional

integrity in politically divided river systems in particular, may be attributed primarily to the fact that the establishment and maintenance of navigable waterways is in most cases of common interest and advantage to all parties concerned. In the case of rivers navigable under natural conditions, the investment and maintenance costs (needed for the survey and marking of the navigation route within the channel, the construction of vessels and harbours, etc.) usually clearly lead to financial benefits and there are generally no serious obstacles to agreement among the parties or countries concerned regarding the sharing of costs and other issues of common interest (such as the standardization of signs and safety rules, custom agreements, unified information on water levels and ice conditions and prediction services, and others). This favourable situation is gradually changing with the increasing use of rivers for purposes other than navigation. Due to diversion for irrigation, for instance, the maintenance of the depth of the navigation channels may require continuing and costly dredging, and the construction of river barrages necessitates the construction of navigation locks (with extra costs charged mostly to navigation). All this slows down river traffic. Further development of stream-flow regulation and of river barrages turns the balance in favour of navigation once again, however, as soon as a situation of more or less complete "canalization" of the river is reached. Under such conditions the flow required for navigation drops to a negligibly small portion of that required under the natural régime, and water depths equal to or considerably greater than heretofore can be maintained by the barrages, even during low flow periods. National or federal Governments, to whom the jurisdiction over navigable rivers in most countries pertains, have an important role to play in harmonizing interests and sharing costs relating to river development under this type of multipurpose setting.

E. Hydropower and Industrial Water Uses

Water is one of the essential input factors for industry. The manifold functions of water within industry may be grouped into three major categories: (a) water provides energy for industry through hydropower development; (b) it helps industrial production as a process medium in a great number of functions (cooling, washing, boiling and transportation being the most frequent ones); (c) river systems and the hydrosphere are used to dispose of industrial wastes. In earlier periods, the major role of water for industry was to provide a cheap and easily manageable source of energy for a great variety of manufacturing and mining activities. Very recently (during the last 50 years or so) water power has been largely replaced by the use of coal, oil and nuclear power facilities in most highly industrialized countries, and the disposal of wastes has become the major use or function of water for industry in those regions.

Water-wheels were already in rather wide use in antiquity and water-power, together with wind-power, soon became the major substitute for human and animal power as the demands for flour milling and for manufacturing cloth, paper, iron, beer and other products increased. More than 5000 grist mills were in use during the eleventh century in southern and eastern England alone, and the Bisenzio river in Italy was made to flow through the city of Prato (near Florence) in a network of small canals, so numerous were the mills using this source of power. During the eighteenth and nineteenth centuries the large-scale application of power for mass production in spinning, weaving, pottery and other large factories came primarily not from steam-engines but from an increased use of water-mills and from the invention of the water turbine in 1825 from hydropower plants.

It was only during the first decades of this century that the "economy of scale" principle, and the assumption that the earth's resources for power production from natural resources were virtually inexhaustible, overrode all other considerations, leading to the neglect and abandonment of small and medium-size water-power plants; on the other hand, the development of thermopower plants and systems with sizes and capacity greatly surpassing hydropower potentials took place in the most highly industrialized regions. It seems likely that, owing to the rising costs of energy production and the related waste-disposal problems, the interest for water-power, including its small and medium size applications, will increase again during the decades to come, even in the industrialized countries. For most developing countries, where capital and skilled manpower are scarce and energy development is to be looked upon in the context of achieving self-reliance, hydropower in general and its small and medium-size potential in particular, are among the possibilities that offer the greatest promise. This is the lesson learnt from the history of industrialization in Europe and North America, also supported by recent achievements in the People's Republic of China, where rural development is being promoted through the use of about 50,000 small-scale hydroelectric plants.

Regarding the use of water as a medium for industrial processing and waste disposal, the great diversity among various branches of industry is a first striking feature. In view of the multitude of specific industries using water in one form or another, one is tempted to focus attention and effort on a few principal uses. This is a reasonable and practical solution as far as the quantitative side of industrial water uses is concerned. Unfortunately, it is very difficult to adopt such a selective approach on issues concerning the chemical, biological and radiological qualities of water, because the presence of negligibly small amounts of some trace elements, toxic substances and viruses in sewage can lead to disastrous large-scale consequences for the aquatic life of the recipient waters. The difficulty in keeping a reliable account of the risks involved is further increased by the fact that, in many cases. the impacts are not directly attributable to one single pollutant but to a combination of several physical, chemical and biological factors, originating from various natural or man-induced sources and relating to various parts of the water system.

Another set of policy issues concerns the striking difference between the gross amounts of water needed for various industrial processes and the amounts that are actually "consumed" (incorporated into the product, or lost through evaporation or seepage) in those processes. This means that through in-plant recirculation and intermediate treatment the net amount of water to be withdrawn from and disposed into the aquifers can be reduced to a very small fraction of the amounts needed for simple "through-flow" technologies. As indicated in the report on resources and needs, the tendency towards more extensive and intensive recirculation of water can already be observed in several industries, particularly in regions where competition for water of acceptable quality is rapidly increasing, but actual achievements still have a long way to go in this regard (see pp. 52-53 of this volume). This slow progress towards a more efficient use and rational conservation of water in industry is especially regrettable in the light of the relatively low level of water-related costs for investment and operation in industry, which rarely surpass 1 per cent of the total costs involved (in striking contrast to agriculture, where water-related costs frequently reach significant proportions). With the technological options available and given the favourable conditions, local, economic, regional and national governments have an efficient, and largely unexploited, tool for influencing industrial development according to broader social interests.

Although complaints and conflicts raised by water pollution of industrial origin date back to mediaeval times, such occurrences were until recently sporadic and localized. It was only during the last three or four decades that industrial pollution has reached such proportions that aquatic life has become extinct in whole rivers and lakes, and large segments of fresh water resources have been made unfit for any human use in several highly industrialized regions. There are at least three major aspects in which industrial pollution differs from all other sources of water pollution and they are largely responsible for recent deterioration in water quality at scales never before experienced: (a) industrial wastes contain a number of new chemical components which are not formed under natural conditions, and consequently there are no natural organisms and processes for their decomposition; (b) whereas an increase in domestic and agricultural wastes for any given location is conditioned rather closely by the number of people in the area and other ecological constraints, there is virtually no such limitation in the amount and the growth of industrial wastes; (in this context quasi-industrial agriculture based on high levels of chemical utilization is closer to industry than to organic agriculture); (c) industry introduces new chemicals and new technologies in such vast numbers and differing so much from year to year that it is virtually impossible to assess and analyse in a reliable fashion their potential impact on water pollution. Success or failure in rationally managing and conserving water resources in the industrialized countries will greatly depend on how far local, regional and national governments will succeed in curbing and remedying industrial pollution.

V. GENERAL CONCLUSIONS

As in the case of other aspects of socio-economic development, there are increasing differences between the highly industrialized and the developing countries in their current approaches to water management. Although there exists a common conceptual framework. and national policies may be expected to tend towards interlinked global strategies, the present and the immediate future are typified by various issues requiring different approaches in these two groups of countries.

In the industrialized countries, water planners and managers are primarily concerned with problems and uncertainties created by pollution and other undesirable environmental impacts. On the other hand, in the developing countries current issues of water management are related to some extent to the benefits and limitations of a somewhat mechanistic transfer or acceptance of concepts, technologies and institutions from the industrialized countries. Within and beyond these polarized patterns, each country and each river basin is, of course, a unique entity, not only in its physical characteristics and hydrologic régimes but even more so with respect to the social evolution and economic activities taking place within and around its boundaries.

In the 6000 years of recorded human history, river basin development and water management have been important catalysts in the emergence of major periods of social and economic development, such as those characterized by (i) production within the great fluvial civilizations of antiquity; (ii) long-distance interregional commerce by inland navigation (which flourished in ancient Mesopotamia and continued until the eighteenth century in Mississippi); and (iii) the evolution of mass-production-oriented industries fuelled by water-power from the early mediaeval periods until the late nineteenth century. Water management is

a good indicative example of how far the basic concepts and tendencies of earlier times with regard to technical and socio-economic development have evolved in Europe and North America over the last 60 years. Earlier technological developments had aimed at a better use of natural resources, whereas modern technologies tend to replace these by man-made ones: natural soil fertility by chemical fertilizers, inland navigation by trucks and railways, hydropower by coal, oil and nuclear-fired generation. Although, in essence, all these new technologies rely on natural resources, they induce two most significant alterations: (a) they tend to replace renewable natural resources by non-renewable ones; (b) they require more energy and produce more wastes. The rapidly rising concern about water pollution and the growing scarcity of good quality water in many industrialized countries are clear indications that technical and economic efficiency are an acceptable motivation for development only if supplemented and controlled by ecological considerations and constraints. The recent renewal of interest in the conservation and better utilization of natural soil fertility, and in the application of less energy-consuming and less polluting industrial and transportation technologies, constitutes an important point of departure for achieving social goals based on a common set of interests and policies both for the developing and the industrialized countries.

The "economy of scale" principle, the strongest motivation and argument for the acceptance of large-scale technologies, has its place and role in water management. There are, however, at least four major considerations which suggest the desirability of a cautious attitude with respect to the general and limitless acceptance of this principle: (a) beyond a certain range of size the stability and safety of large structures (dams, reservoirs, pipelines, etc.) could become questionable — even with the most careful technical design — as has been tragically documented by a number of catastrophic failures of large structures during the past few years; (b) large-scale structures and projects provide less opportunity for gradual implementation and feedback from on-site experimentation than smaller ones; this is an aspect of particular significance in water development, where uncertainties with regard to physical design, economic justification and social response to new initiatives are usually both inevitable and of considerable magnitude; (c) centralized decision-making and management give rise to specific difficulties and inherent conflicts in many water-related development programmes; this occurs because both the socio-economic and the physical components of such projects vary considerably at the local level and the continuing involvement and support of the local population throughout all phases of planning and implementation are key factors for success; (d) associated and partially unforeseeable social implications and consequences of large-scale structures and projects (e.g. in terms of relocation of population or the spread of water-related diseases) often become significant and make the justification of projects based on directly accountable benefits questionable.

Thus, the replacement of technologies where "economy of scale" dominates by more broadly based and locally diversified intermediate technologies is one further common factor upon which there can be a convergence of interests for both developing and industrialized countries.

Owing to geographical and climatic conditions, the technological, economic and institutional differences between the industrialized and the developing countries are accentuated by the fact that concepts, technologies and institutional structures for water management were evolved in the industrialized countries during the last hundred years or so under conditions of relative abundance of water. Moreover, resources needed for water development were made available as

needed without undue stress. On the other hand, most developing countries face the same issues of social and economic development under far greater pressures of scarcity, either with respect to water as a physical resource, or with respect to the financial and institutional resources needed for water development, or both. This is one of the major reasons why many of the concepts and solutions successfully applied in the industrialized countries over the past decades have resulted in some failures and disappointment when transferred to developing countries. There has in fact been a recent recognition in many industrialized countries of the need to introduce new technologies and new institutional frameworks favouring more efficient use and rational conservation of water resources both in the industrialized and the developing countries.

In the light of the preceding paragraphs, it might be concluded that, apart from a decreasing number of areas exceptionally well endowed with water resources and experiencing relatively low levels of demand for water and water-related services, both the developing and the industrialized countries are facing or rapidly approaching the stage of water demand management. In contrast to the supply-oriented or resource-oriented stages, this stage is characterized by high marginal costs for water supply and other water-related development projects. Of course, depending on local conditions, supply and demand management stages of development may coexist at any one moment in different areas of a same country. In the industrialized countries, situated mostly in the temperate and humid zones with a favourable water régime, this development has resulted primarily from industrial and agricultural technologies applied during the last few decades, leading to large-scale pollution and wasteful use of water resources. In most developing countries, which occupy the largest parts of the arid and semi-arid zones with inherent scarcity of water supplies, the stage of water demand management is not new. The urgent need to seek rational solutions has been further increased following the rapidly rising levels of demand for agricultural and community water supply.

There are many specific ways in which various countries and regions may reach the stage of water demand management. Historical precedent and present issues are as diverse and site-specific as the general socio-economic and physical environment within which further evolution will take place. There are, nevertheless, a few characteristic features which in one way or another will become constituent ingredients of water demand management in most cases:

(a) *Broadening of available options.* Under conditions of relative abundance of water (in the supply-oriented and the early period of resource-oriented stages of water management) an increase in supply is virtually the only choice for development. With an increasing scarcity of water and the ensuing rapid rise in the marginal cost of water supply, two further groups of development options emerge and gradually override the previous one: increase of efficiency in using the water and water-related services already provided, and adjustments in the development programmes and technologies of water-related economic factors.

(b) *Exploratory planning.* Where and as long as water is abundant and the marginal cost of water development is relatively low, definitive and normative types of water planning are usually reasonable and practical. Under conditions of increasing scarcity of water, however, the number of structural and non-structural development options increase greatly and normative planning must gradually give way to exploratory projections and plans. These are geared to the identification of the constraints and consequences of foreseeable (or assumed) trends of socio-economic development in general, and those relating to various water pol-

icy options in particular.

(c) *Emphasis on non-structural measures*. While major structural measures available within a country or region to cope with the supply of water and water-related services are provided within the supply and the resource oriented stages of water management, non-structural measures (legislation, licensing, pricing, setting of standards, forecasting and warning services, etc.) which aim at a more efficient operation of the water resource system and a socially and economically desirable conservation and continuing reallocation of water are of primary concern during the stage of water demand management.

(d) *Multidimensional organization and policies*. The objectives and functions described in the previous subparagraphs cannot be realized without an appropriate reorganization of structures and procedures for administration and policy formulation. The interrelation between the water management system and the socio-economic system is rather limited in scope and technical in nature when supply is abundant. It gradually becomes broader and more heavily economic in nature during the stage of resource management, and becomes most complex and diversified in the stage of demand management, when a policy orientation prevails. This process involves not only changes in governmental organization, but also requires a large degree of expansion and diversification in educational background and administrative skills for water planning and management.

(e) *Emphasis on research*. All the major features of demand-oriented water management can essentially be summed up by emphasizing the need for a very close and intense linkage between policy formulation and applied research. Under conditions where innovations in technology and social organization become of overriding concern to water management, projection, planning and policy formulation themselves frequently extend into the realms of experimentation and applied research, and cannot be carried out successfully without the continuing support of an interdisciplinary research team.

To sum up, there is no single policy option best suited for all times and all places, and choices will increasingly have to include a judicious blend of structural and non-structural measures. These will, in turn, have to be closely interlinked with a country's or region's planning process. In particular the following considerations will have to be borne in mind:

(1) A complete inventory of waters furthers effective planning and the establishment of priorities.

(2) The same can be said of a complete inventory of water rights.

(3) Water planning should be adequately co-ordinated with planning for the land use that water resources development is expected to serve. Moreover, wherever and whenever any water project is contemplated, an impact statement should be prepared, indicating the potentially adverse as well as the potentially beneficial effects on the hydrological régime, on the ecology, on other water uses and users on local populations in the project area, on related land use, and on the economy in general.

(4) One of the guiding criteria for effective water planning is to determine water demand by successive approximations for the various sectors of the economy, on a basin or regional basis. This activity will have to be co-ordinated with and guided by general economic objectives, and will condition allocation

of the water resource itself and of the required financial resources. Machinery to collect and store the needed information for projection methodology should be established as a priority item.

(5) Physical forecasting and warning services are also an indispensable adjunct of the management process, particularly in situations where extreme conditions (droughts and floods) occur with some regularity.

(6) Consolidation and co-ordination are means of modernizing water administration. One way to achieve this is when the execution of projects is consolidated in regional agencies and the co-ordination and decision-making functions are entrusted to and centralized in one water agency of national scope. The participation of the public is of great importance. It should be provided with avenues of expression at the planning stage so as to obviate an adverse reaction to new legal constraints, and subsequently so as to provide safeguards against an arbitrary exercise of administrative power. The administration should have the power to exert control over all types of water within the hydrological cycle, as well as over waters contained in man-made structures. Ground water and groundwater reservoirs should be fully integrated into the legal régime in view of the hazards of pollution and the possibility of excessively rapid depletion. This control should be as flexible as is necessary to assure effective use of water and to minimize waste. Therefore, latitude should be given to the administration with respect to duration and quantity of the water right, priority of right, and transfer of water and water rights from one place to another and from one use to another. The limitation of use to a definite period of time allows for the correction of past mistakes and enables individual water uses to be fitted more easily into the general scheme and made to correspond to changing technological interpretations of efficiency. Constraints on the transfer of water may be relaxed by eliminating the requirement of appurtenance to a particular piece of land or to a particular use. Quantification of water rights appears essential to the rational and equitable allocation of the resource. Possible abuses of power might be eliminated or minimized by providing administrative or judicial recourse from the decisions of the water administration.

(7) The enactment of comprehensive water legislation to replace or complement the sectoral legislation dispersed in many separate enactments should make the working of the law more efficient. Generally, it should provide for the assimilation of pre-existing water rights into the new legal régime within the shortest period of time consonant with the users' ability to make the transition from the old to the new pattern of use without undue hardship. In an intersectoral context, such legislation should make it possible to view water supply and water requirements as two aspects of a single problem. Thus, it should minimize conflicts between uses, integrate the water demands of all sectors of the economy, facilitate the transfer of water between sectors when this is beneficial to the economy, and encourage the search for appropriate uses for the suitably treated effluent of one sector as part of the supply of other sectors whenever this is technically and economically feasible and advantageous.

(8) Water should not be supplied free of charge. In fact, water charges for water supply and effluent systems can become a most powerful mechanism for allocating water to various sectors of the economy and managing quality, thus influencing demand. When this happens, however, Governments should be aware of the resulting implication with respect to the economy of the basin, region or country concerned. However, the charges need not necessarily reflect the market value of water, but may be geared to social and economic objectives.

(9) In agriculture, the water law should assure a well co-ordinated distribution of water supply, whether from a central government agency, a river basin authority, a district or project organization, a users' association, or a combination of all or any of them. But the construction and maintenance of works down to the field level should be the responsibility of the entity in charge of water distribution. There should be a minimum of return flow; in practice there is bound to be some, and the law should regulate its ultimate disposition.

(10) For domestic and municipal water use a good law should help to solve the problems of securing and protecting an adequate water supply, regulate consumption and regulate disposal of the effluent at the most reasonable cost. The assurance of safe drinking water to rural populations should be as much a responsibility of government as is that of water supply to municipalities, even if no piped water supply exists. This requires, in particular, the establishment of protective zones around wells and springs and along watercourses, and regulation of activities (including effluent disposal) within such zones and, where necessary, on watersheds and across ground-water aquifers. Furthermore, priority of domestic use needs to be reinforced by quantitative as well as qualitative control of industrial consumption which might endanger potable water supplies.

(11) In the industrial sector, in addition to the distribution of water, adequate pollution control is of particular importance. Here effluent charges or effluent limitations geared to the desired level of technology or to water quality standards can be included in the legislation. Power development, especially in the context of its nuclear aspects, which may impose a heavy environmental burden on future generations, may require the inclusion in the legislation of provisions concerning environmental impact statements, consolidation of licensing in one agency, and the establishment of strict safety standards for the operation of power plants and their monitoring for the discharge of effluent. The use of dry cooling towers may be considered wherever feasible in order to minimize adverse impacts on the environment.