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UTILIZATION OF RESOURCES

THE ROLE OF WATER IN THE DEVELOPMENT OF HUMAN SETTLEMENTS IN AFRICA

CONTENTS

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CONTENTS (Cont'd)

INTRODUCTION

The pattern of water use and related pollution problems is changing very rapidly and the availability of inexhaustible or unlimited water resources is now a thing of the past. Sooner or later in many African countries and, for that matter, in many other developing as well as developed countries, water shortage will become or is already becoming an important problem. The recent drought in many countries of Africa and its deleterious economic and social effects have perhaps helped to highlight the importance of adequate water resources for a country's development.

That no life exists without water is not an overstatement; with the current increased demand for water and the limited availability of water, the survival of life may in fact be at stake. It is, therefore, important to direct every available effort towards the planning, supply and management of water systems in order to ensure adequate water quality, prevention of disease, enhancement of comfort, protection of livestock, etc.

Water management, especially in the water-shortage countries, will become an important factor in future development and economic planning. Proper management will be required; due consideration will need to be given to such techniques as re-use of water, the use of non-conventional sources of supply, the establishment of national as well as regional water grids and the review of water rate structures. There will also be pressure for more efficient methods of water usage.

Governments will have to play a more effective part in the planning, design and proper management of water systems, including shouldering the major share of costs when water is publicly supplied, and in formulating rate structures that reflect demand and supply constraints. There will also be a need for Governments in conjunction with the relevant bodies, to formulate more up-to-date and effective policies to ensure the best use of water resources.

This implies that Governments will have to make an assessment of the foreseeable demand for water so as to enable them to anticipate water problems in specific geographical areas or sectors of the economy, recognize the factors that might be changed in order to forestall problems or avoid worsening the situation and re-cognize the factors that may be implicit in current social objectives (where these exist) and practice, which may have a significant effect on water use but which have not generally been considered to require management and control for the purpose of influencing water policies or practices.

The main causes of ever-increasing demand for water are: population growth, compounded by the accelerating influence on consumption of improved standards of living arising from increased urbanization rates; and the increase in growth taking place in commodity production and service industries in both relative and absolute terms.

WATER DEMAND FOR HUMAN SETTLEMENTS (1)*

Daily water demand per human being varies between 15 and 200 litres, depending mainly on climate and physical activity. Daily per capita domestic consumption averages 15-20 litres in rural areas supplied by public wells and about 100-150 litres in residential urban areas supplied by house connexions.

In addition, rural settlements need water for livestock and irrigation which may in quantity considerably exceed that required for domestic uses in arid and semi-arid regions. The significance of adequate water supply for health and welfare needs no emphasis. This applies particularly to conditions in the developing countries of Africa where scarcity of capital precludes the transport of water from distant sources.

Four major factors influence the level of water demand in a given locality: (i) the income level of the inhabitants and its distribution among the various groups; (ii) the facility supplying water to users; (iii) customs and traditions in water uses; and (iv) the charges for water, where levied. These factors should always be taken into account by the planners in order that an effective water system supply is developed.

The major categories of water demand are given below.

MAJOR CATEGORIES OF WATER DEMAND

The main components of water demand are usually grouped as municipal, agricultural and rural, and industrial (see attached figure). There is no universally accepted classification of these components as there is usually some degree of overlap among the categories in addition to differences in definition and interpretation. Some categories do not fit under any of the above three groups for example, recreation, the preservation or extension of swamp and wetland habitat and conservation or utilization of estuaries.

The above categorization refers directly to human use of water; however, water is also needed and used in the preservation or restoration of the environment which is indispensable for human well-being and survival. These requirements are of paramount importance not only for individual nations or regions, but also for the entire world. Water is also needed for the well-being of plants and animals, which bears directly or indirectly on the well-being of man, who depends to a large extent for his livelihood on plant and animal life.

Agricultural water demand

Water is one of the basic input factors of agricultural production. Whereas in humid regions rainfall usually supplies water, in arid regions virtually all the water required for agricultural production is provided from external sources such as neighbouring rivers or ground-water. In intermediate climatic conditions, water demand for agriculture is frequently met by means of a combination of on-site and external sypply.

* For references, see Page 14.

Irrigation may be expected to become the decisive issue in water resource development. Firstly, food production for growing population and rising living standards calls for the intensification and expansion of agriculture, for which irrigation may be a basic tool and pre-requsite in the arid and semi-arid zones; secondly, irrigation is a consumptive use of water which unfortunately excludes or largely reduces the possibilities for recycling and multiple use; and, thirdly, large-scale irrigation schemes and their supply systems have a significant impact on the rural environment with potential long-term effects on regions far from the site of the schemes.

Agricultural water demand also includes drinking water for livestock as well as water for fisheries and poultry. In many instances, the filling and replenishing of fish ponds may require significant amounts of water, if such ponds are a basic source of fish production and if evaporation losses are high. Forestry is basically an on-site water use and forest management practices may considerably affect the overall availability of water resources.

Another use of water in agriculture is for domestic supply. Domestic water use is a function of population, accessibility of water supplies and the number of water-using household appliances.

In some countries the population employed in agriculture is dispersed over the land; in others it is concentrated into villages that are served by communal water system.

Rural water requirements

The amount of water required for domestic purposes in rural areas is usually a very small percentage of that needed for irrigation and stock watering. Health is an important consideration in rural water supply, since it is in rural areas that water-borne diseases are a serious problem.

Whereas the magnitude of the cost of rural water supply may be negligible in some countries, in others with large areas and a bigger and widely dispersed population the problems can reach staggering proportions. In such circumstances the planning of investment in rural domestic water supply must be an integral part of the planning for capital infrastructure in general.

Municipal water requirements

Municipal water use is itself a mix of household, public, commercial, industrial and other uses. Major uses include manufacturing, waste disposal, domestic uses and public uses. Municipal water requirements for manufacturing will be dealt with in the section on industrial water requirements, while those for domestic uses are covered below.

With the increasing awareness of environmental factors in urban areas, demand for water for waste disposal is likely to assume considerable importance; because of its very nature, water for waste disposal purposes should increasingly be controlled by the Government as waste disposal, like irrigation, conflicts most with other uses. In contrast to the sphere of irrigation, however, the range of technology for the disposal of water-borne waste is relatively wide.

For most municipal purposes, water is needed in relatively large and continuously or frequently renewed quantities. In most cases investment and maintenance costs as well as technical, managerial, and institutional difficulties associated with long distance dictate that the sites where water is drawn from natural sources should be within reasonable distance of the locations where it is to be used.

At present the relative abundance or scarcity of local water resources is by far the most important factor determining patterns and trends in water use. If local resources offer an abundant and inexpensive supply for all uses, population growth and economic expansion will be reflected in a rapid increase in the supply of water for different uses.

Demand for community water supply (2)

Over the last quarter-century, there has been a substantial increase in the movement of people from rural to urban areas in the developed as well as the developing countries. This shift in population has taken place at an unprecedented rate. Inevitably water use increases with urbanization: ways of life change, population density rises, industrialization increases and water users multiply.

In almost all parts of the world, including Africa, these changes are accompanied by rapidly rising consumption of water for public purposes such as fire fighting, street cleaning and watering of public parks.

The task of supplying water to urban communities, though it poses many problems, is far simpler and cheaper than that of providing water to rural inhabitants. One unit of expenditure covers a greater number of people in urban areas than in scattered villages or even more widely dispersed individuals in the countryside. Nevertheless, it is on these scattered villages or widely dispersed rural dwellings that the major emphasis in water supply will have to be placed; the bulk of the population in Africa is to be found in the rural areas, which are also worse hit by most diseases and health problems, and consequently rural water supply should meet the highest standards of quality consistent with the economics of supply.

Stages and trends of rural and urban water demand

In any given location the development from an absence of piped water supply towards a community service with up-to-date in-house connexions and plumbing usually takes a long time and is phased over different stages of supply. This gradual development reflects the basic principle of allocating scarce capital resources to provide social benefits for the whole region or country.

Industrial water requirements

The use of water in industry

The major groups of water uses in industry include: cooling, processing, boiler water and general uses (drinking, air conditioning and cleaning). The percentage shares of these major groups vary condiderably from case to case; cooling uses in power industry and manufacturing appear to be the major use in most of the countries.

Process water is water in manufacturing plant which comes into direct contact with the intermediate or final product and may be divided into two groups: (a) water

entering the product, as in canned food or beverages, and (b) water used for functional purposes, such as washing, flotation and transportation.

In the case of boiler water, a distinction should be made between steam generation for power production on the one hand, and water for manufacturing purposes on the other. In practically all industrial establishments water is used for more than one purpose. Prior to and in the course of its various uses, treatment of the water, such as softening, coagulation or iron removal, is frequently required.

Major water-using industries

There are great differences between various branches of industry in the level and nature of their water requirements. As mentioned above, water for use in cooling of thermal power plants and in manufacturing is usually the dominant requirement. In manufacturing industry the metal industries, the manufacturing of chemical products petroleum refining and paper production are usually the major water users. Mining, including the extraction of metallic compounds, oil and gas also uses significant quantities of water for washing and drilling.

Requirements for water in the production of thermal power are for boiler feed and cooling. Boiler feed requires relatively pure water, although in relatively small amounts; cooling, on the other hand, requires relatively large amounts of water which can be met with water which is not usable for other purposes.

In the drilling of oil and gas wells fresh water may be lost by being mixed with brine. Coal mining causes various pollution problems as a result of drainage of acids by water moving through coal beds that are exposed to the air. Generally, water requirements for mining and drilling are relatively small.

Considerable differences may be found between the various industrial water uses with regard to the ratio of the consumptive use of the total use as well as the amount and nature of the water-related wastes. Important distinctions may also be made among the various uses with regard to the level of supply required for uninterrupted and complete satisfaction of demand.

Water as an input factor for industry

Water is not a major input factor for industrial development, at least from the point of view of cost, since the cost of water supply represents only a very small fraction of total production costs or of the value of output. This may not, however, be the case of the future; as a result of pressure of demand for water and diminishing supplies from natural sources, coupled with lack of proper management, not only will water constitute a major constraint on industrial development but, in addition, the unit cost of water will rise substantially.

In-stream water requirements

In-stream uses occur when water is not drawn from its source of supply but is used as it follows a designated channel. Hydro-electric power generation, navigation, certain types of water-based recreation and waste disposal, fisheries and wild life habitat fall into this category. Certain of these uses compete with each other, while all of them compete with withdrawal uses.

Depending upon the distribution of economic activities along the river and according to the seasons (where this applies), certain flow uses may be complementary with each other and with withdrawal uses. The most troublesome pre-emption of water in areas of dense population or urban areas is waste disposal. On the other hand, in arid or semi-arid regions the main primitive use is likely to be irrigation.

Generation of hydro-electric energy

In areas endowed with water resources and other physical conditions suitable for hydro-electric generation, the amount of electricity generated from the hydro-electric source is determined by evaluating an alternative combination of generating facilities to meet the demand for the area at the least cost. For most African developing countries alternative types of generating facilities include fossil fuel (coal or oil), gas-turbine and conventional hydro, plus possible inter-connexions with other power systems.

It must be emphasized that an appraisal of the hydro to be used for electricity generation must also take into account all the possible multiple uses of river water. These include irrigation, navigation and flood control. The use of water for these multiple purposes involves some degree of complementarity (3). The production of hydro-electric energy and associated water requirements involve problems of assessment and estimation. First of all, it is necessary to establish the role of hydro power in the spectrum - i.e. whether the energy is for base load or for peaking, the seasonality of demand, and whether the generating plant is of a run-off of river or reservoir type. Information may also be required on whether the hydro-electric power generating plants are to remain unused during certain parts of the year.

Navigation

Water requirements for navigation can be assessed either by determining arbitrarily where navigation shall be supported, or by ascertaining the relative merits of different forms of transport.

The use of barriers and locks will reduce water requirements for navigation to a very small fraction of what is normally needed in a free-flowing stream. Consequently, for a given increase in carrying capacity, the choice lies between diversion of water from other uses or a capital investment designed to reduce the use of water.

Water-based recreation

Recreational uses of streams are likely to imply requirements that coincide with those implicit in the maintenance of high environmental quality. Thus it may be possible for demand for water for recreation to be analyzed first of all in terms of the comparative merits of alternative economic activities such as tourism versus industry before attempting to measure intangibles. It should be noted, however, that some recreational uses of water, such as boating, may themselves represent sources of pollution, although such sources of pollution are likely to be minor compared with municipal and industrial wastes.

Evaluation of the recreational uses of water is relatively difficult because the water as such does not usually figure in the price system.

The demand for water for recreation varies widely in quantity and form; some needs are obvious and direct, for example for boating, while others are remotely connected to water such as the shooting of birds, on an area which requires wetlands for nesting many miles away. Some arise from a broad cross-section of the population, such as swimming.

On-site uses

On-site uses of water consist of those activities which reduce run-off rather than appear as an exhaustion of or charge against the water that is measured by run-off. On-site uses can be distinguished as (i) land use practices and structures designed to conserve soil and ground moisture, and (ii) uses of swamp and wetland habitat.

Water withdrawal is the physical diversion of water from a stream or body of water, including groundwater, for use.

WATER QUALITY

In the course of our discussions reference will be made, from time to time, to the question of water quality. It is worth emphasizing the fact that water quality will vary from country to country and within each country. The maintenance of health is a paramount consideration. Generally speaking, the provision of domestic water supply is a question of water treatment and delivery rather than a question of waste treatment. The discharge of poisonous industrial wastes must be prohibited or carefully regulated since many are not amenable to waste treatment or water treatment except at prohibitively high cost.

There is a relation between the cost of treating water and the cost of treating wastes, but in most circumstances, except where particular industrial wastes are involved, the cost of rendering water safe for human and animal consumption is not specially sensitive to the degree of treatment given to organic wastes. The quality of water in rivers and lakes, however, will be related to the support of high quality

aquatic life and the use of water for recreation and aesthetic purposes. The proper level of water quality will thus vary depending on the concurrent or sequential uses to which the water is put. In so far as these uses are measurable in economic terms, they will be part of the national bill of goods and it will be possible to make the selection of the quality standard part of the cost-minimizing or net-benefit-maximizing analysis. It is, however, doubtful whether many of the African countries have reached this level of sophistication or have the manpower capacity to undertake such an analysis.

Some of the major factors impinging on water quality are discussed in the next section.

Water-borne residuals (1)

Water-borne residuals may be classified according to their degradability; that is, their potential for being assimilated into, and redered harmless by, the environment. The degradability of a residual is a function of its resistance to decomposition into more basic natural elements.

Residuals are of a degradable nature when exposure to chemical or biological processes alters them or removes them from pollution or suspension. Some living organisms are also considered to be residuals, and their concentration is used as an index of the influence of water quality on human health, since pathogenic bacteria viruses may be included. Another kind of degradable residual is ammonia, which can be biochemically reduced to nitrate, assimilated in algal synthesis and consumed as a nutrient by animal life.

A second group of residuals are of non-degradable types; these are not decomposed or altered by biological or chemical processes, and are usually measured as a concentration within the water; they are generally inorganic and are of stable nature; the sodium ion is a good example.

A third group is made up of residuals which have a consistent or toxic nature or both; they may be organic or inorganic, degradable or non-degradable. The degradable residuals within these groups usually require a long time, of the order of decades or centuries, for decomposition. Typical examples are radio-active materials, some pesticides and various synthetic chemicals.

A fourth group consists of residuals of a physical nature, such as evaporation and heat. Evaporation concentrates deleterious residuals into a smaller quantity of water; higher waste heat can directly harm fish and aquatic plants, apart from reducing the dissolved oxygen of saturated level of water.

Types of residual generation (1)

There are two major types of generation of residuals: point and dispersed. Industry often produces and discharges residuals at a well designed location, whereas municipalities collect wastes at central points. These two are referred to as point source of residuals. The discharges from this point sources lend themselves to efficient waste treatment methods and only a small number of them are responsible for most of the water use under discharge of residuals.

Dispersed sources of residuals originate from agriculture, mining, lumbering, construction and natural resources. Dispersed agricultural pollution results from sediments produced by erosion of the land surface, animal feeding operations, especially in arid and semi-arid regions, pesticide compounds which are generally resistant to biological degradation and nutrient enrichment of waters by fertilizers, particularly nitrogen and phosphorus.

Acid drainage from mining operations is also a source of water quality degradation arising from a dispersed source; the greatest effect is on the biological life within the streams into which the drainage is discharged.

Effect of residual disposal on water quality

The ability of bodies of water to assimilate the degradable types of residuals varies greatly, depending, inter alia, on the physical character of the water, temperatures, existing residuals load, the manner in which the load is discharged (point or dispersed), and aquatic pollution. Non-degradable residuals such as dissolved salt and persistent residuals such as DDT will not easily assimilate; luckily small quantities of these can be rendered harmless. Nevertheless, their effect in a body of water varies considerably depending on the physical parameters of the system in the aquatic population.

Not much work has been done, especially in the tropical waters of Africa, to establish exactly the effect of disposal on water quality in the different types of water channels such as canals, lakes pounds, rivers, seas and oceans. This is an area which requires a great deal of attention, both from the national point of view and for the whole region. The extent of degradation may have not reached the levels of those of industrialized nations but sooner or later this may occur unless appropriate action is taken to ensure that the quality of water in these areas is as high as can be attained with minimum possible costs. It is apparent that the importance of water to development has not dawned on many planners and policy-makers in many developing countries, including those on the African continent. This may perhaps be the reason for the apparent laxity with regard to the maintenance of high water quality. The situation should be remedied as soon as possible: otherwise the price of negligence or lack of action will be dear indeed.

Effect of water quality on water demand

The use of rivers for disposing residuals frequently has a deleterious effect on water quality and other water users. Recreational and municipal users as well as commercial fishing are especially sensitive to water quality changes; these uses are often limited when a certain concentration of residuals is an important factor in determining the productive value of water in industrial and agriculture uses.

Water used in industrial process and boilers must, as we have indicated above, be generally of a higher quality than cooling water. However, depending on the length of the river, as more and more users recirculate water through cooling towers, the initial quality of the cooling system becomes very important. In fact, the quantity of water required for blow-down in a wet cooling tower is roughly proportional to the concentration of certain salts in the intake so that withdrawals for cooling

tower make-up requirements increase directly with the increasing salt concentration in the water supply. As the temperature of water supply increases, a thermal electric plant incurs penalty costs since it must withdraw more water per kWh generated - and hence the value of water as a cooling medium declines. Luckily for many of the developing countries of Africa, the level of power generation has not reached the proportions that would unduly affect either the salt concentrations of the river or unacceptable temperature rises.

A major detrimental effect on irrigated agriculture is that of high salinity levels. Irrigation salinity problems may be caused by salt loads contributed from natural resources, the concentration of existing salt by consumptive use of water in irrigation and by irrigation practices. Higher salinity levels in irrigation water tends to reduce crop yield. Salts dissolved in irrigation water tends to accumulate in the soil on which it is applied. In order to maintain productivity, therefore, additional water must be applied to flash out the salt dissolved. Hence decreased water quality necessitates increased water withdrawals in order to maintain crop productivity.

The overall cost of degraded water quality to a region can be sizable; it is possible to estimate this cost as a function of water quality. Although not much work has been done in this respect in Africa, some estimates have been done in such developed countries as the United States, where, for example, the total penalty of rising salinity in the Colorado River has been estimated. The cost consists of two parts: direct costs attributable to yield decrements in agriculture, increased water withdrawals, and treatment by industrial users and municipalities; and indirect costs attributable to overall regional economic losses due to decreased productivity. The direct costs are generally much higher than the indirect costs; the total penalty costs amount to over $25 million.

WATER DEMAND AND THE HEALTH STANDARD

As we have said above, adequate water supply has a direct bearing on the level of helath of the inhabitants. The level of water supply may affect the health standards of human settlements in two main ways: (i) the quality of drinking water has a direct health effect and (ii) the uses of the water available, e.g. bathing, cleaning, have an indirect effect upon the health conditions of the users.

It is, however, difficult to give an overall quantitative criterion on what constitutes an adequate level of water supply, partly because of the wide range of adaptability of human organisms to a given local condition; for example, water of not more than 500 ppm (parts per million) of dissolved solids is used as standard drinking water in most humid and temperate regions, whereas waters of 1500 ppm are used without apparent harm to local inhabitants in the desert regions where only water of that salinity is available. The cumulative character of some of the health factors as well as their interrelation with other factors affecting human health are also partly responsible for the difficulty in giving a quantitative criterion.

Many diseases can result, or do result, not only from the lack of water, but also from its unhygienic character. This include acute bacterial conjunctivity, amoebic dysentery, hookworm disease, bilharziasis, cholera, infection hepatitis, typhoid fever. The list is by no means exhaustive.

All these diseases, and more, are still prevalent in practically all African countries, a testament to the fact that water supply systems in many of these countries, especially in the rural areas, and to a large extent, in the urban slums, need further development and improvement.

It is practically impossible to estimate the toll of these diseases because of the lack of adequate data in many of the developing countries of Africa. The effect of such infections, essentially due to poor sanitation and consequent poor hygiene, is that they create undesirable waste and inefficient utilization of human energy. This is in turn reflected in the inability of the affected people to contribute to the country's development.

Although no records of similar studies are readily available in Africa, studies from other parts of the developing world concerning the effect of the level of piped water supply upon health indicate that during the period with the increase of per capita water supply, there has been a significant fall in deaths occurring from certain water-borne diseases like gastro-enteritis or dysentery (1).

Although it is difficult to estimate the actual money values resulting from the development of rural water supplies, or the lack of it, they are substantial. The manufacture of materials and equipment, much of it local, the employment of labour during construction and for subsequent operation and maintenance, the improved health and standard of living, increased agricultural productivity and, indirectly, the stemming of the unidirectional migration to the urban areas with its consequent socio-psychological strains - all these are desirable and tangible positive outcomes of the proper development and management of rural water supplies.

COST OR PRICE OF WATER SUPPLY

The most easily accessible sources of water will be used first, so that the cost of water supply will normally manifest a steadily increasing trend in a given location. The rate of increase is usually relatively small as long as conditions of overall abundance of local water resources prevail. However, continuous increases may be experienced in periods when increases in water uses approach the physical limits of the water supply locally available (4).

A regime of increased rising costs is the inevitable result of having to look for solutions based on more efficient use and augmentation of supply within the area and diversion from other locations and regions enjoying more abundant supply.

Effect of technology and cost on the level of demand

Because of the overall scarcity of capital, the specific cost of water supply services and the technological solutions for lowering these costs are major influences on the level of water demand in the developing countries. As we have said above, in the rural areas the distance between the stand-pipes and the number of persons served by the single tap or well are the decisive factors controlling the level of demand. The number of persons so served varies widely from country to country and from area to area within a country. The small size of rural communities, which are frequently widely scattered, causes problems in providing service. It has, however, been evident for some years that more rapid progress in affording

rural water supply could be achieved if major advances were made in planning, design, construction and proper management as a result of technological innovation in these areas.

This may include simplification of the systems and of equipment and the use of universal standard specifications. It may also mean an ingenious use of local materials, as is well illustrated by the practice in Indonesia of using bamboo pipes for distribution; construction and maintenance costs were thus reduced considerably.

GENERAL COMMENTS

Water resource potential for development

Extensive droughts and accompanying shortages in water are repeated occurrences in both the developed and the developing areas of the region. The shortages in some cases may however reflect not shortages in water but rather shortages of capital available for water resource development; they may also reflect the lack of foresight and co-ordination underlying water resource development. Water resources will play an increasing role in development, but will not constitute a limiting factor for development.

When dealing with water resources, it is necessary to bear in mind the following important considerations, relating to (a) availability of water supplies, (b) the efficiency of their use and (c) the role of water development.

Some of the factors that relate to the development of and the raising of the potential availability of, water supplies have already been discussed above. Suffice it to say that facilities for the long-distance conveyance of water as well as regional and national water grid systems are gradually weakening the location constraints of available fresh water supply within and among the major river basins. There are very considerable possibilities for satisfying the rising level of water demands by increasing efficiency of water use. The relatively low rate of consumptive water use in manufacturing and in in-stream power generation offer far-reaching opportunities for decreasing withdrawals of water for industrial use through recycling and improved in-plant water management.

The foreseeable overall intensification of agricultural production, and the advance in irrigation technologies, open ways to achieve a significant increase in the efficiency of water use in irrigated agriculture, where efficiency is currently extremely low.

Recent experience in arid regions indicates that recycling treated waste water and other measures increasing the efficiency of water use may be expected to play an important role in municipal water supply as a result of the rising cost of supply in the latter sector.

The need for, and the possibility of, integrating the physical, economic, engineering, social, institutional and political aspects of water resource development has been clearly defined and its particular relevance to conditions of developing countries including those of Africa is well documented (5). Such an approach to development may be expected to replace, albeit gradually, the presently prevailing practices characterized too frequently by structural and managerial failures contributing, *inter alia*, to low efficiency in water use.

It should be emphasized that water resource potential for future growth and development must be viewed in the light of its interrelationship and interdependence with other resources (6). One such interdependent development in relation to irrigated agriculture has been mentioned above. Similar interrelations may also be found with regard to long-term perspectives of economic development. These include:

1. Energy, which is a basic resource requirements for both large-scale water grid systems and desalination. Future potential of power generation, including geothermal and solar energy systems, can therefore greatly affect the feasibility of water grids in many countries of Africa in the years to come;

2. Combined resources exploration and utilization may offer a significant reduction in the cost of supplying each of the resources involved; for example, extraction of chemicals from sea water or geothermal brine in combination with water desalination or the utilization of geothermal and geopressure resources for energy and water production;

3. The reasonable and feasible resource combination varies from site to site and from case to case; irrigation with brackish water might cause, for example, deterioration of certain plants and soils, on the one hand, and might lead to success as applied to the other plants and soils on the other.

Government strategies

Assessment of present and future water demand is closely interrelated with governmental strategies. In fact the task of assessing present and future demands for water orginates from the responsibilities of local, national and regional governments in formulating development programmes and policies.

Water is one of the resource factors to be assessed and considered when decisions are to be made among possible development alternatives. The different levels of Government hierarchies have important roles to play in continuously relating and guiding the demand for water through legislation, cost and price structure, research and development policies, and other measures considered within development and management strategies. Governments have to establish and maintain the institutional framework invested with the task of assessing present and future water demands, which should include, in a closely interlinked framework, data acquisition systems, research units for elaborating and improving methodology and operational units to undertake, revise or repeat the present and future assessment exercise at appropriate intervals.

The range of alternative patterns of water use and alternative ways in which supplies are developed is likely to be quite large for a country as a whole. Decisions regarding water resource development should be very closely related to other forms of investment such as transport, storage and marketing facilities, the processing of raw materials and manufacture of final products, and education and health. The decisions should also be closely related to the availability of capital resources to individual water users.

A national policy for population growth and dispersal may play a vital role in establishing the ultimate limit of water resource development, the speed with which these limits will be approached and how these limits will differentially affect each area region or basin. Decisions regarding activities, areas or regions that are to receive favoured treatment will usually be made at the governmental level.

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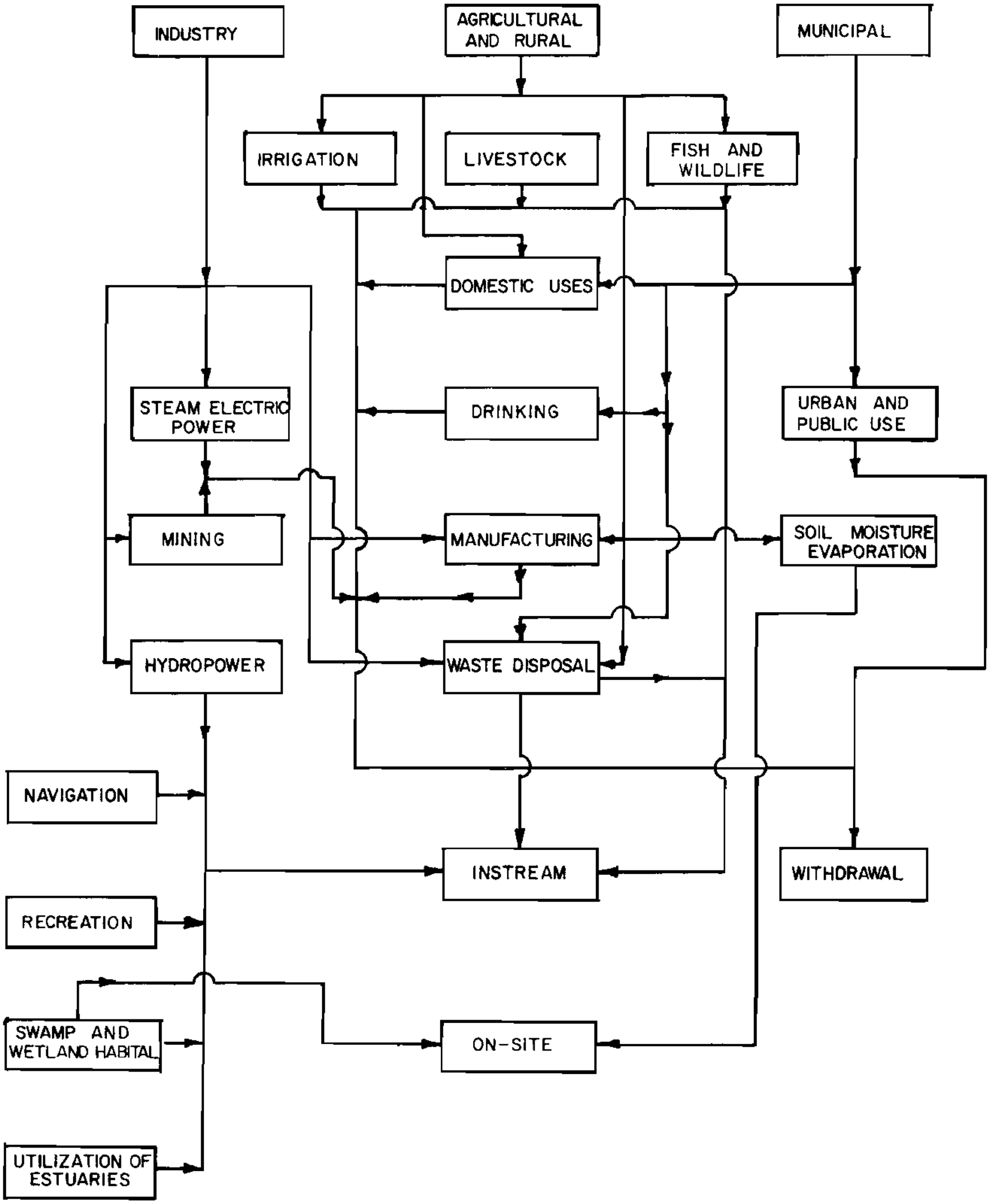
Figure 1: **PRINCIPAL CATEGORIES OF WATER DEMANDS**



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