E/A 0807

Distr.
LIMITED

E/ECWA/NR/CONF.3/8
1 December 1978

Original: ENGLISH

UNITED NATIONS

ECONOMIC AND SOCIAL COUNCIL

ECONOMIC COMMISSION FOR WESTERN ASIA

Second Regional Water Meeting
30 December 1978 - 3 January 1979
Riyadh, Saudi Arabia

Item 4.7 of the Provisional Agenda

THE PROJECTION OF WATER DEMANDS FOR ECWA COUNTRIES BY THE YEAR 2000

Prepared by ECWA Secretariat

78-2234

TABLE OF CONTENTS

		Page
LIST OF TABLES		ii
LIST OF ILLUSTRATIONS		iii
I.	INTRODUCTION	
	A- General Outlook	1
	B- This Study	2
II.	CATEGORIES OF WATER DEMANDS	
	A- Overall Demands	3
	B- Water Demands of Human Settlements	5
	C- Agricultural Water Demands	9
	D- Industrial Water Demands	12
III.	METHODOLOGY	
	A- Background Information	16
	B- Specific Studies	16
IV.	PROJECTION OF WATER DEMANDS	
	A- Objectives	21
	B- Data Used	22
	C- Methods of Analysis: Stepwise Regression	22
	D- Discussion of Results	25
	E- Sample Calculations for Forecasting	34
V.	CONCLUSIONS AND RECOMMENDATIONS	
	A- Conclusions	50
	B- Recommendations	52
VI.	REFERENCES	55
APPENDIX (A)		
	Data Used by Each Country	57
APPENDIX (B)		
	Definition of Basic Terms	72

LIST OF TABLES

Table Number		Page
II-1	Water Costs in relation to Aggregate Industrial Production Costs, State of Washington, U.S.A......	14
III-1	Water Use in Metered and Flat Rate Areas. October 1963 - September 1968	17
IV-1	Definition of all variables used in the study.....	36
IV-2	Comparison of ECWA countries	38
IV-3	Municipal Coefficients	40
IV-4	Industrial Coefficients	41
IV-5	Agricultural Coefficients	42
IV-6	Water Demand Projections in gallons per capita ... per day for Lebanon	43
IV-7	Projections of the Year 2000 of Significant variables	44
IV-8	Water Demand Projections in U.S. Gallons per capita per day for the year 2000	46
IV-9	Estimated Future Trends in Water Demands in selected Countries	47

LIST OF ILLUSTRATIONS

Fig. Number		Page
II-1	Principal Categories of Water Demands	4
II-2	Range of Daily Domestic Water Use per capita	6
II-3	Consumptive Use of Water in Major Sectors of Industry, United States of America	15
IV-1	Population Projection "Lebanon"	48
IV-2	Enrolment Projection "Lebanon"	49

I - INTRODUCTION

A - General Outlook

Water is the essence of life. Actually, everything we use is, in one way or another, related to water. Because of this, early civilization were, to a large extent, guided by the availability of such water resources as the Nile, Euphrates, and the Indus Rivers.

Although generally there may be enough water to meet human needs, it is not evenly distributed around the globe and, sometimes, it tends to be in the wrong place or at the wrong time. Furthermore, the projected increase of the world population along with the proliferation of industrial and agriculture developments are causing a sharp rise in the demand for water. In addition, water use is sometimes inefficient and wasteful. In fact water shortage is not always due to lack in water supplies. Water shortages can occur even in the presence of abudant supplies. In general, the determining factor in the progress of the human race is not the abundance of natural resources. Rather, it is the ability to use them effectively. Despite repeated droughts in various parts of the world, food production has been on the rise. This, at least in part, is due to an improved management and allocation of water resources.

Water management in the past used to be supply oriented with little or no regard to managing of demands. However, the emerging scarcity of supplies coupled with the increase in costs of supply in many parts of the world water, management strategies are gradually being shifted towards management of demands.

Needless to say that the first step in managing demand is the assessment of those demands over a period of time. Governments must, therefore, take upon themselves the task of assessing and projecting of water demands within the context of national planning and technical development.

Traditionally, forecasting of water demands has not been given enough significance -much less than for the case of other resources, for example, energy and minerals due to the misconception that water was free and plentiful. This, of course, is an old-fashioned policy, which, if pursued, will lead to national disasters. Today, the availability of water can no longer be taken for granted, and it is becoming increasingly clear that water is a factor input of socio-economic processes. At the same time, its demand is a function of these processes which it helped to create.

ECWA region, being endowed with an abudant supply of crude oil, is going through an unparalleled economic growth. Unfortunately, however, the region, being in the arid or semi arid zone, is suffering from inadequate supplies of water. These limitations in water resources coupled with ambitious plans for urbanization, industrialization and intensification of farming with emphasis on the expansion of irrigated land, make it necessary to work out plans for the development and management of their water resources. This involves, inter alia, the evaluation of current use and consumption, potential supplies, and future demands.

B - <u>This Study</u>

In view of what has been mentioned above, and in order to enable its member states forecast their long range water demands, ECWA has undertaken this study which aims at the projection of water demands for these countries by the year 2000. Projections have been performed, using mathematical models with the help of an outside consultant 1/ for domestic, agricultural and industiral water demands.

Input data Annex A, used in the study covered trends in water use and consumption, and socio-economic as well as economic factors. These data were collected from various sources such as 5-plans (for certain countries only), UN Statistical Bulletins, National Publications, and Consultants' Reports-covering the period 1968-1976.

In addition to the projections (Chapter IV), basic categories of water demands as they relate to National and Regional Planning are discussed in Chapter II. Chapter III, on the other hand, reviews, in general terms, methodologies in projection of water demands. Chapter V includes some conclusions and recommendations.

1/ Professor/Regent George W. Reid, Chairman, Bureau of Water and Environmental Resources, University of Oklahoma, Norman, Okl., U.S.A.

II- CATEGORIES OF WATER DEMANDS*

Although this chapter is not necessarily a prerequisite for arriving at the projection models presented in Chapter IV, nonetheless, the principles and concepts disussed here encompass the analysis and understanding upon which the models were constructed. For example, municipal demands as intended in Chapter IV include every demand associated with municipal distribution system. The breakdown of this "definition" will give a list comparable to the components listed on pages seven and eight.

The same can be said for agricultural and industrial demands more or less.

A- Overall Demands

The principal components of water demand are listed in figure II-1. In procedures and statistics of regional or national surveys, these demands are usually grouped as municipal, agricultural and industrial, according to the main categories of economic statistics and planning. A usual means of subdividing these three major categories is indicated on the left-hand side of figure II-1. It should be emphasized that there is no single or standardized way of undertaking this subdivision. In fact, overlaps among the categories as well as differences in definition and interpretation necessitate arbitary decisions in several respects. The scheme also indicates that, beyond the above-mentioned four major categories, water demands arise in other fields of regional and national planning, such as transportation, recreation, preservation or extension of swamp and wetland habitat and conservation or utilization of estuaries.

On the right-hand side of figure II-1 the various components of water demand are grouped according to their relation to and effect on the sources of water supply such as withdrawal and in-stream and on-site uses. Here again the scheme indicates one of the customary subdivisions. The level of consumption, which is also tentatively indicated in the figure, is a third aspect related to grouping or classifying the various components of the demand for water.

---

* This chapter is based mainly on chapter II-IX of Ref. No 26 UN Doc. ST/ESA/78 pp. 9-165. Information from other sources is indicated.

FIGURE II-1 Principal Categories of Water Demands

Municipal and rural demand	M
Agriculture	A
Industry	I
Infrastructure	F

M	Drinking	W
M	Domestic uses	W
M	Public uses in settlements	W
A,M	Livestock	W
A	Fish and wildlife	
M,A,F	Flood loss management	N,O,W
M,A	Drainage	O,W
A	Swamp and wetland habitat	O
A	Utilization of esturaries	N,O
A	Soil moisture conservation a/	O
F	Navigation	N
F	Hydropower	N
A,M	Irrigation a/	W
I	Mining b/	W
I,M	Steam power b/	W
I,M	Cooling b/	W
I,M	Processing b/	W
I,M	Boiling b/	W
M,I,A	Waste disposal b/	N
M,F	Recreation	N
M,F	Water sports	N
M,F	Aesthetic enjoyment	N

W	Withdrawal
N	In-stream use
O	On-site use

a/ Highly consumptive uses

b/ Heavy impact on water quality

B - Water Demands of Human Settlements

The daily water demand of a human being varies from place to another, depending mainly on climate and on physical activity. Domestic water uses range from 10 and 30 litres per capita per day in rural areas supplied by public wells and about 20 to 150 litres in residential districts of urban areas supplied by house connections Fig. II-2. The major categorites of urban water demands, in addition to domestic uses, are public facilities and services (street cleaning, fire-fighting, parks, schools, hospitals, etc.) and industrial establishments. Rural settlements need water for livestock and irrigation.

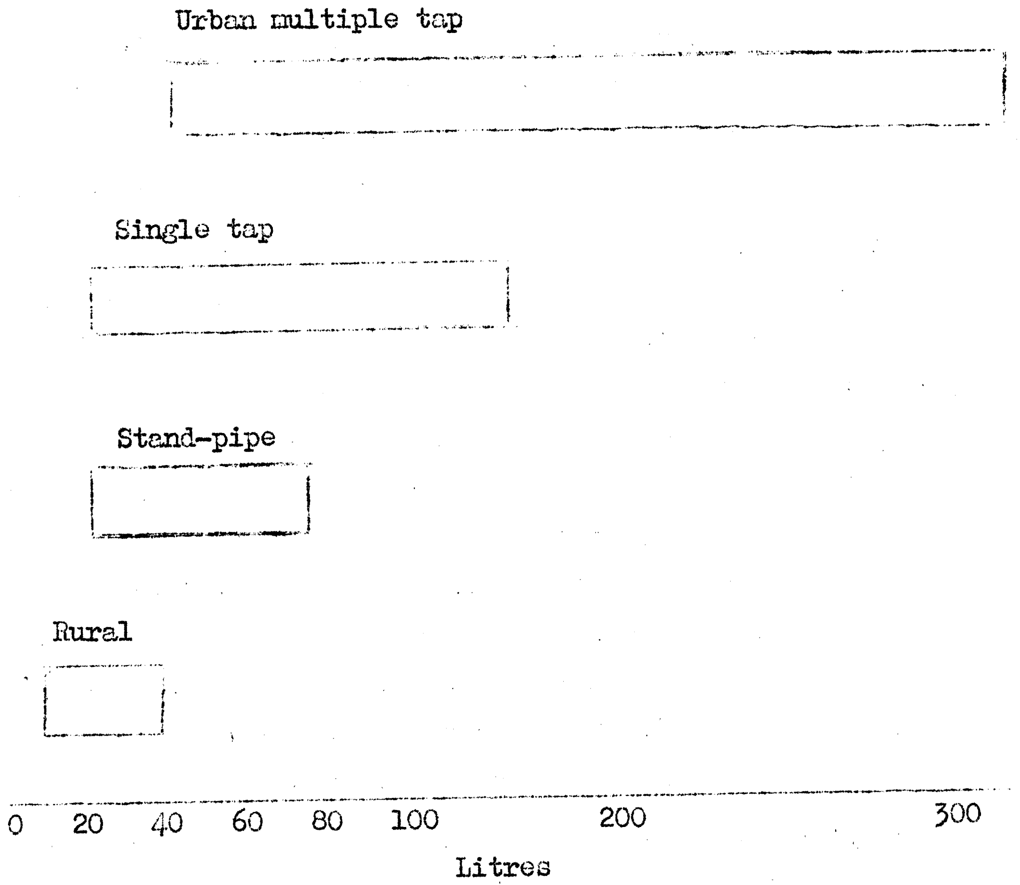
The importance of an adequate water supply for the health and welfare of the inhabitants of human settlements is generally recognized. What is not recognized is the fact that water is a main factor in site selection in both urban and rural planning, particularly in the developing countries, where scarcity of funds hinders transportation of water from faraway sources.

There are four major groups of factors influencing the level of water demand within a given locality: (i) the facilities supplying water to the users (e.g., in-house plumbing or the distance between public taps); (ii) the income level of the inhabitants and income distribution among the various groups; (iii) customs and traditions in water use; and (iv) the price of water. The following guidelines may be recommended when considering price policies and rate structures or tools for controlling water demand:

- Prices have controlling effect only if related to metered users;
- Flat rates usually stimulate inefficient use and wastefulness; and
- the potential role of price as a controlling factor is particularly significant in high-income residential districts and in periods when demands are approaching the maximum capacity of supply.

The distribution of population between urban and rural is as important as knowing the absolute size of population, since one urban person served by a municipal system may need much more water for domestic purposes as compared to a rural person whose supply is inconveniently located. In most countries, the division of population between rural and urban is changing. In some, the change seems to be reasonably predictable; in others, conflicting forecasts are at work and prediction is hazardous but unavoidable.

Figure II-2 Range of daily domestic water use *per capita*



Source: UN Doc. E/CONF.70/CBP/1
Resources and Needs: Assessment of the
World Water Situation. 2 July 1976

The following list of the components of urban water usage is indicative of the complexity of planning an urban water supply:

1. Domestic
   - Washing and Cooking
   - Toilet
   - Bath and/or shower
   - Laundry
   - House cleaning
   - Yard and/or garden watering
   - Car washing
   - Other personal uses (hobbies, etc.).

2. Small Industry and workshops
   - Dry industry
   - Small industry
   - Workshops
   - Laundries

3. Construction and public works
   - New buildings
   - Paving roads and sidewalks, installation of sewers etc.

4. Commerce
   - Trade in goods (various shops)
   - Office-conducted commerce (banks, insurance companies, private offices, agents, engineers etc.).

5. Transportation and storage
   - Railways (stations, workshops etc.).
   - Buses, taxis and other conveyances (stations, garages etc.).
   - Ports (ports, airports etc.).
   - Storage (general warehouses, cold storage etc.).

6. Public services
   - Local, state and national government offices (including courts, police, army, foreign legations, mosques and churches, municipality offices, trade unions, political parties, posts etc.).

Fire department

Irrigation and care of public parks (including zoos, botanical gardens, cemeteries etc.).

Street cleaning and sewer flushing

Educational services (kindergardens, various schools, universities religious seminaries, dormitories).

Health services (hospitals, infirmaries etc.).

Welfare services (homes for the aged, orphanages, etc.).

Public services (public baths, public toilets etc.).

Other public services (libraries, museums, galleries etc.).

7. Personal Services

Entertainment and sports (cinemas, theatres, clubs, sports grounds etc.).

Swimming pools

Food and beverage services (restaurants, kiosks, buffets etc.).

Accomodation services (hotels, pensions, hostels etc.).

Barber shops and beauty parlours.

Infirmaries and private health services.

8. Loss

Real loss, including leakage, evaporation etc.

Loss in process of production (pumping, cooling etc.).

Loss or leakage in supply and distribution systems, including leaks in fittings, gates, valves, meters etc.).

Water department uses (flushing, cleaning, pressure tests etc.).

Fire department hydrant uses.

Unmetered supply

Evaporation in open reservoirs.

In urban areas the need for knowledge about uses other than household relates to decisions regarding the size of municipal systems and the possible effect on rates of use when such uses are serviced by a water utility rather than self-supplied. If service is by a water utility, the structure of prices charged for water or for the amount and quality of waste discharge or for both water and waste can affect rates of water use.

Some control over water use by self-supplied manufacturers may be exercised by regulations regarding quality and characteristics of effluent. The costs of water and waste disposal are not likely to be overriding factors in fixing the size of industry but may well determine the precise location and techniques of water use.

Generally speaking, the installation of meters and pricing by quantity tend to reduce household usage, although the results have a tendency to be transitory unless prices become quite high. Household use is usually sensitive to income and the number of household appliances, and, on the basis of this information, along with estimates of the change in the number of dwellings, a reasonably accurate projection of household water use can be made.

Information regarding the quantity, concentration and characteristics of wastes is as important as the estimate of water use, since special treatment or capacity may have to be provided for. As the practice of charging industrial users for both water deliveries and waste discharges become more common for commercial and industrial users of municipal systems, the accuracy of measurement will increase and the techniques of water use and waste treatment will improve.

Increased use of chemical fertilizer and pesticide, along with increases in the concentration of livestock andpoultry populations, may cause a problem of water pollution that may, in view of the total water picture, affect the nature and quantity of projected uses. The pollution of surface waters by overland run-off may be abated by changes in land use and methods of cultivation as well as by practices designed specifically to reduce erosion and sedimentation.

C - Agricultural Water Demands

The term agricultural water demands usually includes irrigation, drinking water for livestock as well as water for fisheries and forestry. In fact, filling and replenishing fish-ponds may require significant amounts of water if this is a basic source of fish production and evaporation losses are high. Forestry is essentially an on-site water use, and practices of forest management may affect the overall availability of water resources such as by influencing river flow, and groundwater recharge.

Food production is also closely tied to agriculture, and, therefore, **food production** has a significant role in agricultural water demands.

However, irrigation is and may be expected to remain the key issue of water resources development on a world-wide scale and in a long-range perspective. Such a conclusion is suggested by the following principal considerations: (i) food production for the growing population and rising living standards require intensification and expansion of agriculture on a world-wide scale for which irrigation is a basic tool and prerequisite in the arid, semi-arid and temperature zones; (ii) irrigation is an inherently consumptive use, excluding or largely reducing possibilities for recycling and multiple use (which are becoming basic requirements and can provide flexibility in almost all other water uses); (iii) large-scale irrigation schemes and their supply systems have a significant impact on the local environment with potential long-term effects on regions far from the sites of the irrigation schemes.

In view of this, the present discussion will focus mainly on irrigation. This is particularly so because 70 percent of the total agricultural production in the Middle East comes from irrigated land which accounts for less than 25 percent of the total cultivated area.1/

From a methodological point of view, the following lists may illustrate the problems to be analyzed directly or indirectly in order to estimate foreseeable future irrigation water demands within a given region.

On the end-product level, assessment should be made of:

(i) The total food requirement and its variety mix (which depend on foreseeable population growth, income levels, changes in taste and many other social and economic factors);

(ii) The expected ratio of local agricultural food production to other sources of food supply (imported food, inland and sea fish etc.).

(iii) The foreseeable local demand for industrial crops.

1/ A strategy for Plenty: The indicative world plan for agriculture (Rome 1970).

(iv) The outlook for exporting agricultural products.

At the input-factor level, foreseeable major developments should be assessed which might have an impact upon the role and extent of irrigated farming in total agricultural production. These include:

(a) Changes in availability of new farm lands;

(b) Changes in availability and prices of the various input factors of agriculture production which represent a substitute or prerequisite for extending or intensifying irrigation;

(c) Major changes in over-all availability and cost of water supply within the region;

(d) Expectations with regard to social and institutional resources needed for extension or intensification of irrigation.

On the level of the water supply system, estimates will be required of:

(i) The consumptive use of water, which is essentially a function of crop type, climate and management practices;

(ii) The foreseeable natural sources of water (precipitation during the growing season, effective ground-waste replenishment by winter precipitation etc.) and the net irrigation demand (difference between consumptive use and natural supply);

(iii) Transportation losses by seepage and by evaporation from storage.

(iv) Amounts of water required for maintaining or improving salinity of irrigated land.

(v) The efficiency in use of water in irrigation is a function of many factors. Waste of water in irrigation is common even in water-short regions. Such wastage is due, partly or totally, to such factors as over-applications, poorly designed distribution systems, undue losses in delivery, and uneconomic choice of crops.

The significance of efforts in water savings can be demonstrated by a detailed survey of irrigation water losses in the Vaksh Valley in the USSR. Before modern irrigation methods were introduced only about 21 percent of the total water intake was actually utilized within the crop fields. The remainder 79 percent were lost as follows 1/:

Water losses within the delivery system		39 percent
Unused bypass waters		15 percent
Deep percolation from crop fields		20 percent
Overflow from crop fields		5 percent
	Total	79 percent

In the western part of the United States of America, it is estimated that 50 to 60 percent of the gross water is lost. In the Eastern part, however, where irrigation is not as vital and where the amount per acre is a small fraction of that supplied in the west, about 90 percent of gross use is lost or consumed.

Wastage of irrigation water is common, even in water-short regions. This is mostly due to poorly designed or poorly managed distribution systems. Wastage may be in the form of over application, undue losses in conveyance, or uneconomic choice of crops. In general, wastage is either the result of carelessness or uniformed application methods.

D. Industrial Water Demands

There are great differences among the various branches of industry regarding the level and nature of their water demands. The major groups of water demands are:

(1) Cooling,
(2) Processing/manufacturing and
(3) Boiler water. Thus, in water resources planning attention is usually focused on a limited number of industrial sectors representing the majority of industrial water users such as cooling of thermal power plants, metal industries, manufacturers of chemical, petroleum refineries and paper products.

1/ p. 105 of UN Doc. ST/ESA/78

Cooling water may or may not recirculated depending on the relative costs and the gradient in temperature. If cooling water comes from its source at a relatively low temperature compared with recirculated water the benefits of once-through become obvious.

Manufacturing water demands are a function of such variables as the nature of the production process, the nature of the raw materials used, the product output mix, operating level, physical layout of the plant, and controls on gaseous and liquid waste discharges.

In developed countries withdrawal for cooling purposes rival the demands for irrigation, and may exceed them in certain highly industrialized countries. By contrast, water demands for irrigation purposes in developing nations surpass all other requirements.

In projecting the water requirements for manufacturing, the first problem is to estimate what will be produced. For the developing countries, investments in manufacturing facilities are likely to be relatively discreet events that can be identified, placed in their foreseeable locations and given a probable scale of output. Manufacturing activities that are small in size and relatively numerous can be projected as a function of GNP or population, based upon present conditions.

New plants are likely to use the best technologies available at the time of their construction unless some restriction on choice of technology is imposed by local conditions. The rate of water use for a new industry may, therefore, be different from that found in a country in which plants are older or reflect a range of ages.

Essential to any effort to forecast industrial water demand is an economic base study which includes projections of demands for the product outputs of the various industries using large amounts of water.

Given an economic base study, forecasting industrial water demand involves the following six steps:

(1) Classifying existing plants by process, region, product mix and size;

(2) Forecasting trends in production processes, i.e., forecasting technology;

(3) Analysing the alternative internal water utilization patterns and costs thereof, considering the impacts of in-plant water quality requirements in relation to product quality and the costs of other factor inputs such as fuel and heat exchangers;

(4) Forecasting political decisions relating to pricing policyfor water at the intakes and policies relating to waste discharges.

(5) Economics of recycling as compared to fresh withdrawals. Where recycling of water is a common practice consumptive use rather than intake is the critical factor in future water requirements for industry. As can be seen from fig. II-2, consumptive use may be more than 30 percent of intake.

(6) Nature of the water environment which takes into consideration the availability of water at the intakes and outlets of industrial users in terms of quantity and quality, effluent stands and charges and the availability of space for waste disposal.

Water is not a major input factor for industrial development. As Table II-1 illustrates, the cost of water supply represents only a very small part (usually below 1 per cent) of the total production cost or of the value of output, even if the cost of effluent treatment for satisfying the requirements of overall environmental management are taken into account.

Table II-1 Water Costs in relation to Aggregate Industrial Production Costs, State of Washington, USA

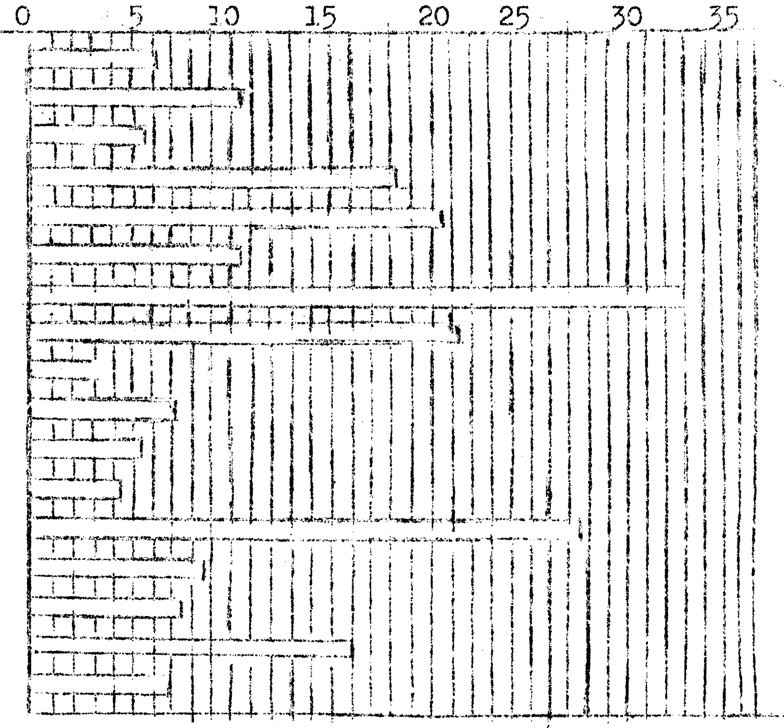
Product	Water Cost (percentage of total production cost)
Food and kindred products	0.02 to 2.58
Pulp manufacture	0.005 to 1.11
Paper	0.735 (maximum)
Aluminum	0.14 to 1.15
Petroleum	0.18

Source: State of Washington, Water Research Center, A First Estimate of Future Demands for Water in the State of Washington, vol. 1, appendix C (Pullman, Washington, 1967).

Figure II-3 - Consumptive Use of Water in Major Sectors of Industry, United States of America

Water consumption (percentage of intake)

Automobile	6.2
Beet sugar	10.5
Chemicals	5.9
Coal preparation	18.2
Corn and wheat milling	20.6
Distillery	10.4
Food processing	33.6
Machinery	21.4
Meat	3.2
Petroleum	7.2
Poultry processing	5.3
Pulp and paper	4.3
Salt	27.6
Soap and detergents	8.5
Steel	7.3
Sugar, cane	15.9
Textiles	6.7



Source: National Association of Manufacturers and Chamber of Commerce of the United States, Water in Industry (New York, 1965).

The previous paragraphs illustrate the great variety of factors affecting future industrial water demands. Several of these factors depend on future policies and decision which are not easily predictable in advance. One way of overcoming this difficulty is to identify a number of sets of possible future conditions and to assess the levels and ranges of water demands corresponding to these assumptions.

III - METHODOLOGY

A - Background Information

Until recently extrapolation based on previous trends was applied to forecast water demands. This approach suffers from two main disadvantages:

1. reliable basic data covering the whole range of water use and consumption is not always available, and,

2. they do not take into account changes associated with progress and the standard of living.

The advent of computers, however, has, for all practical purposes done away with this approach. Instead, mathematical models with many variables and parameters were introduced. The superiority of models over extrapolation techniques is their flexibility which enables them to incorporate various assumptions and options in addition to data base.

Programming models could be linear or curvilinear. However, linear models applying multiple regression techniques is more commonly used. As will be seen in Chapter IV, this methods has been adopted for this study.

In the following pages a short review of some application and case studies in the projection of water demands are presented.

B - Specific Studies

A number of studies have been directed toward describing the demand for water. These involved the manipulation of water use information and related economic data to provide some projection of future demand.

An interesting and detailed field examination of domestic water use in East Africa (Kenya, Tanzania and Uganda) was carried out by White, Bradley, and white (23). Although no predictive equations were given, the study attempted to relate per capita use to income, educational level, family size, source of available water, cost, culture and natural environment. Daily per capita use was found to range from a minimum of 1.4 liters in a farming household to a maximum of 660 liters in an upper income suburb of Moshi, Tanzania. The mean per capita use for piped supplies showed a low of 30 liters per capita daily and a high of 254 liters, while for unpiped supplies the mean per capita use showed a high of 21 liters and a low of 4 liters. In general, this study found that per capita use, where water is not piped into the household, is in large measure a function of the income level, the urban versus the rural situation, and the number of children within the household. Where water is piped into the household a major consumption in water occurs; the amount above that minimum is a function in considerable measure of cost, income level, family size and education. Finally, the study found that even where domestic water demand in the urban areas is relatively price inelastic, price is of measurable significance.

In 1969, Lee (19) selected thirteen sites in Calcutta and New Delhi in an attempt to measure and define the relationship between economic development and the provision or need for public water supply systems through the examination of domestic water consumption. He concluded without giving any predictive equations, that the demand for domestic water supply is a function of accessibility to water, housing conditions, levels of income and water using habits.

Hankes (17) pointed out that although there is little empirical evidence concerning the nature of price elasticity for water, he had observed that there was a thirty-six percent decline in domestic use of water in Boulder, Colorado, after meter insullation. He pointed out that within a metered systen relatively small price changes may not lead to substantial changes in water demand.

---

(23) White, G., Bradley D., White Anne, "Drawers of Water" Univ. of Chicago Press 1972

(19) Lee, T., "Residential Water Demand and Economic Development" Univ. of Toronto Press 1969.

(17) Hankes, S.,"Demand for Water Under Dynamic Conditions" Water Resources Research No. 5, Oct. 1970

In 1969, Meyer and Mangan (20) developed a model which is known as MAIN I for calculating water requirements by correlation with economic, social and climatic variables. Forecasts were completed for 141 Standard Metropolitan Statistical Areas (SMSA).

Recently, the Water Resources Bureau of Japan in collaboration with the Nomura Research Institute (a private organization) has developed a simulation model for forecasting Japan's water demands by the year 2000.

Their model consisted of five components or submodels projecting water demanded by economic development, industry, household, municipality, and agriculture.

Exogenous variable such as environmental considerations, policy options, change in lifestyle, and progress in urbanization were also incorporated into the model.

An interesting, though not water-related, model on World Dynamics was developed by Professors Forrester and Meadows of MIT in which the authors attempted to interrelate population, capital investment, geographical space, natural resources, pollution demography, agriculture and technology. The model states, among other things, that to bring the world system into equilibrium by 1980 would require the reduction of 50% in pollution, 40% in capital investment, 30% in birth rate, 20% in food production, and 75% in the utilization of natural resources. Based on these computer simulations the authors conclude that "A society with a high level of industrialization may be non-sustainable".

Finally, it should be emphasized that as water needs and strategy evolve there will be changes in the inter-relationship of physical and social structures of water management. Progressively from unregulated resources menagement that is supply oriented, structural in nature and usually handled on project by project basis,orientation shifts towards efficient use of resources and basic concept, and finally towards a demand orientation where in allocations are perceived in the broadest dimensions of social, economic, and even conservation concepts. In developing nations the demand orientation has not been reached. It is in this context that the models for ECWA Region described in Chapter IV were developed.

---

(20) Meyer, J; Mangan, G. "System Pinpoints Urban Water Needs" Env. Sc. & Technology No. 10, 1969.

In a study, Wolman (24) describes methods for making estimates of water demand for the United States as an economic model rather than as a set of formal projections. He does this because several important factors are necessarily excluded either because the basic data are still lacking or because some inter-relationships are not well enough understood to be handled with any confidence.

Howe and Linaweaver (18) developed a model relating price effects on water demands by residential areas. They also were able to defferentiate between domestic and sprinkling uses. Their major findings were:

1. Domestic demands are relatively inelastic to price,
2. Sprinkling demands are elastic to price,
3. Maximum day sprinkling demands vary from local to another and, therefore, may be inelastic at certain areas. They also found that the elasticity of total water demands averages about - 0.4 (weighted average) of the domestic and spinkling elasticities. Some of their findings are summarized in table 3-1.

Table III-1

Water Use in Metered and Flat Rate Areas

Oct. 1963 - Sept. 1968 Wash.D.C.

ITEM	Gallons Per Day Per Dwelling	
	Metered Areas	Flat Rate Areas
Leakage/Waste	25	36
Household	247	236
Sprinkling	186	420
Total	458	692
Maximum Day	979	2354
Peak Hour	2481	5170

(24) Wolman A "Forecasts of Water Use and Water Quality" A model for USA, 1970

(18) How C.W.,Lineweaver, Jr.F.P. "The Impact of Price on Residential Water Demands,and its Relation to System Design and Price Structure" Water Resources Research 1967.

Fout (27) performed multiple linear regressions to find relationships between water usage and price, number of days in summer, rainfall, average number of persons per meter and the total population served.

In another study, Wong worked with a set of twenty variables which he reduced to seven principal components. The most significant of these factors were community size, per capita demand, price, standard of living and industrial depletion.

In 1937, Capen (16) developed an equation for a well-metered water demands. His equation related water demand (gallons per capita per day) to the total population.

Although Capen's equation (16) is a good representation of the data from the fifty-two cities he surveyed, to suggest that population is the only variable relevant to domestic water demand is invalid.

In 1975, Reid (21) presented an approach to develop an aggregate mathematical model for water demands in developing countries using socio-economic growth patterns. The author used socio-economic inputs to identify four socio-technological levels. Levels representative of socio-economic development are in turn used to identify municipal, agricultural and industrial water requirements.

The most advanced statistical methods used have been correlation analysis and the development of estimating equations from the regression line. For example, Saki and Saki (22) developed a model for Tokyo, Japan, using this method. They found that water demand was a function of population, personal income, industrial production, and the sales of goods.

---

(27) Fout L. "Forecasting the Urban Residential Demand of Water: Agr. Econ. Seminar", U of Chicago, 1958.

(16) Capen C. "How Much Water Do We Consume? How Much Do We Pay?" Jr. AWWA 29, 1937

(21) Ibid.

(22) Saki, K; Saki, S "The Methods of Water Requirements Forecasting in Japan" UN/ESA 1972

IV - PROJECTION OF WATER DEMANDS

The previous chapter dealt with the overall approach to water demands projection. This chapter deals with the projection by the year 2000, of water demands by ECWA Member States.

The chapter covers five sections: objective of the project, data used method of analysis, discussion of results, and sample calculation. These are discussed below.

A - Objectives

The main objective of this study was to develop water demand models, and project demands, by category, for each country of "ECWA" Region. In other words, the objective was to develop the following models for each country:

1. Municipal Water Demand Model
2. Industrial Water Demand Model
3. Agricultural Water Demand Model

These models are developed considering socio-economic and environmental factors which are explained later in the following section.

Then, using the developed water demand models for each country, it was required to forecast water demands by category for each country for the year 2000.

"ECWA" Region consists of twelve Arab Countries which are all considered in this study. They are as follows:

1. Bahrain
2. Iraq
3. Jordan
4. Kuwait
5. Lebanon
6. Oman
7. Qatar
8. Saudi Arabia
9. Syrian Arab Republic
10. United Arab Emirates (U.A.E.)
11. Yemen, People's Democratic Republic (Y.P.D.R.)
12. Yemen Arab Republic (Y.A.R.)

B - Data Used

Time series data for each country of ECWA Region was collected to develop the demand models by category for each country. In most of the above twelve countries, data was used from year 1968 to year 1975. It should be mentioned here that the data collection part of this study was one of the most difficult tasks to achieve. Published reports and previous studies were used to acquire and collect socio-economic, technological, environmental, and water use data (References).

For some of ECWA countries, the data is available and was easy to find such as Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia and Syria.

However, for some of the countries, it was extremely difficult to acquire and collect data needed such as Bahrain and Oman.

It is worthwhile to note that unit conversion was necessary in order to compare the data of the twelve countries where unit systems are different.

As a result of a study of available field data and published values, all the data items which were used in developing demand models for each country are shown in Table IV-1.Included in Appendix A are, by each country and by water uses, all possible variables which were tried in development of each water demand model.

Table IV-2 shows a comparison for all "ECWA" countries in terms of variables considered in developing the required demand models.

C - Methods of Analysis: Stepwise Regression

The principle of analytical projection is simple. It requires a systematic examination of the factors that influence the variable to be projected, and then analysis of the relationship between these factors and the variable.

It is usually impossible to be certain beforehand of the form that the relationships should take. Linearity is the simplest assumption, but a "better" relation might turn out to be, for example, linear in the logarithms of the variables, or a polynomial form. Once a certain form has been decided upon, statistical methods (such as multiple regression) are used to estimate "best" values of the constants (defined by stringent statistical criteria), given the observed values available. Various tests exist to help assess the significance of the results in particular, of the estimated constant coefficients and provided these tests are passed, the precise relationship discerned may be used as a projection model. Projected values of the variable result from inserting assumed or known values of the casual or predictor factors.

It should be mentioned here that a systematic review of projection methodologies necessarily reveals the existence of uncertainty of projections. In short, there are two major groups of unavoidable sources of errors in projecting future levels of water demands:

1. errors of measurements and interpretation in the data base, and
2. structural errors of the projection model.

A third group of sources of uncertainty relates to the exogenous variables introduced into the projection exercise at various stages of its formulation and implementation. Many of these variables belong to the definition of selected future scenarios, and the respective variations in the projected levels of demand are to be interpreted as the impacts of alternative policy decisions rather than continuous uncertainties of the projection exercise.

To accomplish the objectives of this project, the analysis shall consist of two phases. The initial phase encompasses the identification of all factors from field data and published information to be involved in computing demand equations. In the second phase, attempts will be made to relate these factors to one another through the use of Stepwise Multiple Regression Computer Analysis.

Stepwise regression is a variation of multiple regression which provides a means of choosing independent variables which will provide the best prediction possible with fewest independent variables.

Typical stepwise regression uses a simple correlation matrix for the selection of the first independent variable, choosing the independent variable with the largest absolute value correlation coefficient with the ependent variable. The selection of subsequent variables in the typical stepwise regression is made by selecting from the independent variables the variable having the highest partial correlation coefficient with the dependent variable. The selection of subsequent variables in the typical stepwise regression is made by selecting from the independent variables the variable having the highest partial correlation coefficient with the response. The decision of acceptance or projection of each newly added variable is based on the results of an overall and partial <u>F - test</u>. Thenstepwise regression examines the contribution the previously added variables would have made if the newly added variable had been entered first. A variable once accepted into the regression equation may later be projected by this method.

The stepwise multiple regression used, as mentioned before, is a means of choosing independent variables which provide the best prediction possible with the best number of independent variables.

<u>The general model</u> will take the form of

$$Y_{i,t} = B_o + B_1X_1 + B_2X_2 + \dots + B_nX_n$$

Where

$Y_{i,t}$ = Unit demand of ith category (municipal, industrial, Agricultural, rural domestic) at time t

B_o = Regression constant

B_n = Regression coefficients $n = 1,2,3,\dots$

X_n = independent variables $n = 1,2,3,\dots$

The computer program (BMDP2R) is available at Oklahoma University and was used. It is a stepwise multiple regression programme. In this programme, variables are added stepwise to the regression line in order of their contribution to the variance ascribable to the regression line until no more variables can be added which could significantly reduce the error variance.

In principle, the stepwise regression program works as follows:

Step 1: Select first that X_1 which is most correlated with Y, say X_1, and compute regression equation $\hat{Y} = f(X_1)$

Step 2: From X_2 to Xp select Xe which has the highest partial correlation with Y; compute regression equation $\hat{Y} = f(X_1 + X_e)$

Step 3: Compute Fe (F - test for the entering variable Xe; F-test for the entering variable considers only that increase in regression mean square which is attributable to Xe) and if Fe > Fo (Fo is the F - value pertaining to preselected level of significance), enter Xe; otherwise go back to step 2. Next, compute Fℓ (F - value for the variable leaving; all variables already in the equation may potentially leave, if Fe < Fo remove Xℓ from the model and go back to step 2. When there are no Xe and Xℓ left go to step 4.

Step 4: Adopt model as "best"

D - Discussion of Results

This section of the report is a presentation of all developed regression equations using all possible and reasonable variables in each country. For each country developed are municipal, industrial, and agricultural water demand models. Refer to Table IV-1 for the definition of each parameter in the developed equations and for units of parameters.

1. Bahrain

a. Municipal Water Demand Model:

Y_1 = 35.35 + 20.15 (BEDS) + 0.3812 (ENRO)..................(28)

$R^2 = 0.9952$

Stand. error of estimate = 0.3567

Total number of hospotal beds and total school enrollment are the two significant variables in the municipal demand modell

b. Industrial Water Demand Model:

Y_2 = -30.79 + 430.31 (POP.) + 0.2127 (RP)..................(29)

$R^2 = 0.9170$

Stand. error of estimate = 0.26564

Population and total refinary production in Bahrain are the highly correlated variables with the industrial water usage.

c. Agricultural Water Demand:

$Y_3 = 38.59 + 10.29$ (POP.) $+ 0.4481$ (ENRO)..................(30)

$R^2 = 0.9809$

Stand. error of estimate = 0.6358

There is a significant relationship between population, total school enrollment and agricultural water demand in Bahrain. It should be noted here that there is a very few agricultural data available for Bahrain.

2. Iraq

a. The Municipal Water Demand Model:

$Y_1 = -20.76 + 5.072$ (POP.)..................................(10)

$R^2 = 0.9947$

Stand. error of estimate = 1.4793

The significant independent variables in the municipal water demand model of Iraq is population.

b. The Industrial Water Demand Model:

$Y_2 = 5.563 + 6.1769$ (POP.)..................................(11)

$R^2 = 0.9982$

Stand. error of estimate = 0.2223

Population of Iraq is the only important variable affecting the industrial water use.

c. The Agricultural Water Demand Model:

$Y_3 = -17.925 + 8.865$ (POP.) $+ 0.009$ (MMP)..................(12)

$R^2 = 0.9997$

Stand. error of estimate = 0.5909

Both population and total milk plus meat production were found to be highly correlated with the agricultural water use in Iraq.

3. Jordan

a. Municipal Water Demand Model

$$Y_1 = 11.58 + 3.03\,(POP.) - 0.0017\,(EXPE) + 0.0159\,(ENRO) \ldots \quad (7)$$

$$R^2 = 0.9966$$

Stand. error of estimate = 0.1126

Population, expenditure of the government, and school enrollment are the significant variables in the municipal model.

b. Industrial Water Demand Model:

$$Y_2 = -0.52 + 23.48\,(POP.) - 0.0113\,(EXPE) + 0.0098\,(TEE) + 0.0007\,(TIP) \ldots \quad (8)$$

$$R^2 = 0.9792$$

Stand error of estimate = 0.9858

Population, expenditure, total electric power production, and total industrial production are the significant independent variables in the industrial model.

c. The Agricultural Water Demand Model:

$$Y_3 = -25.87 + 22.48\,(POP.) \ldots \quad (9)$$

Population is the only significant variable in the agricultural water demand model.

4. Kuwait

a. Municipal Water Demand Model:

$$Y_1 = 43.67 + 11.54\,(POP.) \ldots \quad (13)$$

$$R^2 = 0.9970$$

Stand. error of Estimate = 0.1236

Population was found to be the only significant variable in the municipal water demand model. Both R^2 and standard error of estimate are reasonable values.

b. Industrial Water Demand Model:

$$Y_2 = 113.22 + 149.069\,(POP.) + 0.0122\,(TEE) + 0.0039\,(TGP) \ldots \quad (14)$$

$$R^2 = 0.9989$$

Stand. error of estimate = 1.52

Three independent variables were found to have good correlation with the industrial water use in Kuwait. They are population, total electric energy production, and total natural gas production.

c. Agricultural Water Demand Model:

$$Y_3 = 23.4618 + 46.4540\ (POP.) \quad (15)$$

$R^2 = 0.9900$

Stand. error of estimate = 0.6399

Out of five independent variables, only population was found to be the only significant variable in the projection equation.

5. <u>Lebanon</u>

a. Municipal Water Demand Model:

$$Y_1 = 28.32 + 2.57\ (POP.) + 0.0003\ (ENRO) \quad (4)$$

$R^2 = 0.9799$

Stand. error of estimate = 0.0872

Population and total school enrolment by all levels of school are the only two variables which are highly correlated with municipal water demand and have a significant impact on it.

b. Industrial Water Demand Model:

$$Y_2 = -35.5 + 39.38\ (POP.) \quad (5)$$

$R^2 = 0.9971$

Stand. error of estimate = 0.4295

Population is the only significant variable in the industrial model.

c. Agricultural Water Demand Model:

$$Y_3 = -5.051 + 18.6007\ (POP.) \quad (6)$$

$R^2 = 0.9906$

Stand. error of estimate = 0.3650

Population again was found to be positively related to agricultural water demand.

6. Oman

a. Municipal Water Demand Model:

$$Y_1 = -12.0165 + 96.98\ (POP.) - 0.0048\ (EXPE) + 0.0022(GRE) \ldots \quad (31)$$

$R^2 = 0.9979$

Stand. error of estimate = 0.2718

Population, government expenditure, and government revenue are the important independent variables in the prediction equation.

b. Industrial Water Demand Model:

$$Y_2 = -18.50 + 0.119\ (TEE) + 0.004\ (COP) \ldots\ldots \quad (32)$$

$R^2 = .789$

Stand. error of estimate = 0.2662

The only two independent variables which are correlated with the industrial water usage in Oman are total electric energy production and crude oil production.

c. Agricultural Water Demand Model:

$$Y_3 = -9.57 + 82.85\ (Pop.) - 0.0013\ (EXPE) \ldots\ldots \quad (33)$$

$R^2 = 0.9962$

Stand. error of estimate = 0.2922

Not enough data is available for agricultural water usage model in Oman. The only two independent variables which are significantly related to the agricultural water demand are population and government expenditure.

7. Yemen, People's Democratic Republic of Yemen (PDRY)

a. Municipal Water Demand Model:

$$Y_1 = 27.43 + 0.08\ (GRE) + 58.72\ (ENRO) + 6.48\ (BEDS) \ldots\ldots \quad (19)$$

$R^2 = 0.9938$

Stand.error of estimate = 0.4665

Government revenue, enrolment in schools, and total number of hospital beds are the important independent variables affecting municipal water demand in the PDRY. It is quite interesting that population was found to be a non-significant variable in municipal water use.

b. Industrial Water Demand Model:

Y_2 = -11.10 + 38.6 (POP.) + 0.131 (GRE) .... (20)

R^2 = 0.9931

Stand. error of estimate = θ.5846

The factors affecting industrial water usage were found to be population and government revenue. Values of R^2 and Stand. error of estimate are reasonable.

c. Agricultural Water Demand Model:

Y^3 = 6.24 + 18.94 (POP.) + 0.08 (GRE) + 0.05 (PCAP)
+ 0.0019 (PPC) .... (21)

R^2 = 0.9926

Stand. error of estimate = 0.4573

The independent variables which are significant in the agricultural demand model are population, government revenue, per-capital agricultural product (based on index No) and production of principal crops.

8. Qatar

a. Municipal Water Demand Model:

Y_1 = 31.47 + 0.0099 (GDE) - 0.0129 (EXPE) + 0.4267 (ENRO).... (34)

R^2 = 0.9972

Stand. error of estimate = 0.1378

Government deposit, government expenditure, and total school enrolment are the significant variables which affect the municipal water usage in Qatar.

b. Industrial Demand Model:

Y_2 = 232.18 - 0.0061 (EXPE) + 0.0003 (COP) + 0.0027 (TGP)
+ 0.0332 (TMP) + 0.0458 (GDE) .... (35)

Significant variables which affect industrial water usage in Qatar are expenditure, crude oil production, total natural gas production, total manufacturing production, and government deposit. R^2 is 0.9987 and the Stand. error of estimate is 0.1972.

c. Agricultural Water Demand Model:

Y_3 = -20.55 + 845.7 (POP.) + 0.10 (LS) .... (36)

R^2 = 0.9936

Stand. error of estimate = 0.5197

Population and total livestock are the two important factors affecting agricultural water use in Qatar.

9. Saudi Arabia

a. The Municipal Water Demand Model:

Y_1 = 22.85 + 4.66 (POP.) + 0.0002 (ENRO) .... (16)

R^2 = 0.9999

Stand. error of estimate = 0.0329

The above model is a very good model, both R^2 and Stand. error of estimate values are very reasonable. Population and school enrolment are the key variables in the prediction regression model for municipal water demand model in Saudi Arabia.

b. The Industrial Water Demand Model:

Y_2 = -122.53 + 25.33 (POP.) + 0.0016 (TGP) .... (17)

R^2 = 0.9999

Stand. error of estimate = 0.1944

The significant variables in the above equation are population and total natural gas production of Saudi Arabia.

c. The Agricultural Water Demand Model:

Y_3 = 5.36 + 7.32 (POP.) + 0.0071 (PPC) .... (18)

R^2 = 0.9928

Stand. error of estimate = 0.4493

Population and production of principal crops in Saudi Arabia are the only two variables which have high correlation and impact on the agricultural water use.

10. Syria

a. Municipal Water Demand Model:

Y_1 = -2.78 + 6.18 (POP.) - 0.0011 (EXIE) + 0.0017 (IMP) +
0.61 (BEDS) .... (1)

R^2 = 0.9958

Stand. error of estimate = 0.3447

Nine independent variables were tried in the beginning of model development. The above four variables are the only parameters which are significantly related to municipal water demand in Syria. They are population, government expenditure (negatively related), imports, and total number of beds in hospitals. From the statistical point of view, R^2 is very high (which is desirable) and the standard error of estimate is fairly low.

b. The Industrial Water Demand Model:

$Y_2 = 3.094 + 10.359$ (POP.) .... (2)

$R^2 = 0.9970$

Stand. error of estimate + 0.3160

The only independant variable which is highly correlated with the industrial water demand in Syria is population. Both R^2 and stand error of estimate are very reasonable values.

c. The Agricultural Water Demand Model:

$Y_3 = -0.984 + 3.99$ (POP.) + 0.0266 (AP) .... (3)

$R^2 = 0.9608$

Stand. error of estimate = 2.57

Both population and total agricultural production were found to be positively related to agricultural water demand and very significant variables in the projection equation.

11. United Arab Emirates (U.A.E.)

a. Municipal Water Demand Model:

$Y_1 = 39.58 + 11.34$ (POP.) - 0.0005 (EXPE) + 0.4709 (ENRO) .... (25)

$R^2 = 0.9945$

Stand. error of estimate = 0.1448

Significant variables in the prediction equation are population, government expenditure, and total school enrolment.

b. Industiral Water Demand Model:

$Y_2 = 184.39 + 14.47$ (POP.) + 0.015 (TEE) + 0.0006 (TGP) ...... (26)

$R^2 = 0.9899$

Stand. error of estimate = 0.6521

Important variables in the projection equation are population, total electric energy production, and total natural gas production.

c. Agricultural Water Demand Model:

$$Y_3 = 27.92 + 114.24\ (POP.) + 0.0045\ (PPC) \quad \text{(27)}$$

$R^2 = 0.9748$

Stand. error of estimate = 0.4598

Population and total production of principal crops are the highly correlated variables with the agricultural water usage in UAE.

12. <u>Yemen Arab Republic (YAR)</u>

a. Municipal Water Demand Model :

$$Y_1 = 6.75 + 3.0096\ (POP.) - 0.0414\ (EXPO) \quad \text{(22)}$$

$R^2 = 0.9857$

Stand. error of estimate = 0.1388

Population is positively related to municipal water usage in Y.A.R. while exports variable is negatively related to it.

b. Industrial Water Demand Model:

$$Y_2 = 21.08 + 3.94\ (POP.) + 0.0221\ (TIGDP) + 0.0853\ (TEE) - 0.0177\ (EXPE) \quad \text{(23)}$$

$R^2 = 0.9898$

Stand. error of estimate = 0.3780

Many variables are highly correlated with the industrial water usage in Y.A.R. These variables are population, total industrial gross domestic product, total electric energy production, and government expenditure. All of them are positively related to municipal water usage except the government expenditure.

c. Agricultural Water Demand:

$$Y_3 = -1.484 + 0.0166\ (PPC) \quad \text{(24)}$$

$R^2 = 0.8055$

Stand. error of estimate = 0.6316

Population was found non-significant variable in the projection equation. The only significant variable is production of principal crops.

Thirty six prediction equations are summarized in tables IV-3, IV-4, and IV-5.

E - Sample Calculation For Forecasting

The problem of forecasting water demand by category (municipal, industrial, agricultural) for each country is basically a matter of availability of projections or values of socio-economic variables which are found to be significantly related to water usage in each country. For example, if we want to forecast municipal water demand for Syria for future years (from 1980 to 2000), to apply the predicted model as explained in equation 1, we have to have projections of population, government expenditure, imports, and total number of hospital beds for the desired year that the forecast is required. There is no least doubt that using the prediction demand equations (from equation 1 to 36) in this study, and by inserting projected future values (Table 7), water demand by category and for each country can be forecasted for any desired future year.

The main objective of this section of the report is to take one country, say Lebanon, and explain the procedure of forecasting future water demand. The method used to determine future values for socio-economic variables was to plot each variable against years and expand the relationship to the year 2000. This is shown in Figure 1 and Figure 2 for future values of population and school enrolment.

(1) Municipal Water Demand Forecast:

The prediction equation

$$Y_1 = 28.32 + 2.57\ (POP) + 0.0003\ (ENRO)$$

where

POP = population in millions

ENRO = enrolment in thousands

$$Y_1\ (1980) = 28.32 + 2.57\ (3.3) + 0.0003\ (1650) = 37 \text{ gpcd}$$

$$Y_1\ (1990) = 28.32 + 2.57\ (4.00) + 0.0003\ (1840) = 39 \text{ gpcd}$$

$$Y_1\ (2000) = 28.32 + 2.57\ (4.8) + 0.0003\ (1960) = 41 \text{ gpcd}$$

(2) Industrial Water Demand Forecast:

The prediction model is

$$Y_2 = -35.5 + 39.38\ (POP)$$

where population is in millions.

$$Y_2\ (1980) = 35.5 + 39.38\ (3.3) = 94.5 \text{ gpcd}$$
$$Y_2\ (1990) = -35.5 + 39.38\ (4.00) = 122 \text{ gpcd}$$
$$Y_2\ (2000) = -35.5 + 39.38\ (4.80) = 154 \text{ gpcd}$$

(3) Agricultural Water Demand Forecast:

The prediction model is

$$Y_3\ (1980) = -5.051 + 18.6007\ (3.3) = 56 \text{ gpcd}$$
$$Y_3\ (1990) = -5.051 + 18.6007\ (4.00) = 69 \text{ gpcd}$$
$$Y_3\ (2000) = -5.051 + 18.6007\ (4.8) = 84 \text{ gpcd}$$

All the results are presented in Table 6.

The same procedure of projecting socio-economic values was applied to determine future values for the year 2000. These values are shown in Table 7. The forecasted water demands by category (using the developed thirty-six equations) and the total water demand for each country are presented in Table 8.

For the sake of comparison, estimated trends in water demands in selected developed and developing countries is presented in table 9.

TABLE 6 : WATER DEMAND PROJECTIONS IN GALLONS PER CAPITA PER DAY FOR "LEBANON"

YEAR	MUNICIPAL	INDUSTRIAL	AGRICULTURAL
1980	37	94.5	56
1990	39	122	69
2000	41	154	84

TABLE IV-1: DEFINITION OF ALL VARIABLES USED IN THE STUDY

(1) Water demand per capita by cateogry uses

Y_1 = municipal water use in gpcd

Y_2 = industrial water use in gpcd

Y_3 = agricultural water use in gpcd

(2) Pop. = total population in millions

(3) TGDP = total gross domestic product in millions of U.S. dollars in market price

(4) TINC = total national income in millions of U.S. dollars in market price

(5) IMP = imports in millions of U.S. dollars in market price

(6) EXPO = exports in millions of U.S. dollars in market price

(7) INL = international liguidity in millions of U.S. dollars

(8) EXPE = total government expenditure in millions of U.S. dollars in market price

(9) GNP = gross national product in millions of U.S. dollars in market price

(10) GDE = government deposit in millions of U.S. dollars in market price

(11) GRE = government revenue in millions of U.S. dollars in market price

(12) ENRO = total student enrollment by all levels of education available, in thousands

(13) HOSP = total number of hospitals

(14) BEDS = total number of hospital beds in thousands as an indicator for health level

(15) TOUR = total number of tourists in thousands

TABLE IV-1: DEFINITION OF ALL VARIABLES USED IN THE STUDY - CONTINUED

(16) TGPM = total gross product of manufacturing in millions of U.S. dollars in market price

(17) TIGDP = total industrial gross domestic product in millions of U.S. dollars in market price

(18) TEE = total electric energy production in millions of (Kwh)

(19) COP = Crude oil production in thousands of metric tons

(20) TMP = total manufacturing production in thousands of metric tons

(21) TGP = total natural gas production in millions of cubic meters

(22) TIP = total industrial production in thousands of metric tons

(23) RP = total refinary production in millions of barrels

(24) EMPLI = total employment in millions by all industries

(25) TAGP = total agricultural gross domestic product in millions of U.S. dollars in market price

(26) PCAP = per capita agricultural product based on index numbers

(27) LS = total livestocks in thousands of heads

(28) MMP = milk and meat production in thousands of metric tons

(29) PPC = production of principal crops in thousands of metric tons

(30) AP = total agricultural production based on index numbers

(31) TAP = total agricultural production in thousands of metric tons

(32) EMPLA = total employment in agriculture in thousands

TABLE IV-2: **COMPARISON OF "ECWA" COUNTRIES**

COUNTRY	POP.	TCDP	TINC	IMP	EXPO	EXPE	GNP	INL	GDE	GREV	ENRO	HOSP	BEDS	TOUR
BAHRAIN	0.24	—	—	446	182	—	—	141.5	170	—	61.7	6	0.845	—
IRAQ	10.77	11282	10130	2338	94	2739	—	3273	—	—	2580	162	21.582	544.800
JORDAN	2.62	1084	1152	496	125	525	1186	349.7	—	—	501	28	2.170	554.900
KUWAIT	0.92	11142	10512	1570	403	380	—	4870	—	—	224	11	.417	3.896
LEBANON	2.78	3540	3500	1989	667	440	2500	674	—	—	1400	145	10.400	2261.8
OMAN	0.74	1398	—	1425	1692	541	—	—	—	903	49.315	13	0.934	—
PDRY	1.64	200	—	179	13	66	—	68	—	44	236	21	.230	—
QATAR	0.09	—	—	271	2015	91	—	71.7	43	—	27.137	—	—	—
SAUDI ARABIA	8.68	28064	23280	2862	31023	6432	23280	4028	—	—	750	58	9.070	—
SYRIA	7.12	3910	—	1202	766	1265	—	131.5	—	—	1680	98	6.753	85
United A.E	0.22	4926.1	—	567	6347	1731	—	—	—	3533	11.352	—	—	—
Y.A.R.	6.48	980	964	190	13	101	985	198.6	—	83	250	33	4.199	7.789

TABLE IV-2: COMPARISON OF "ECWA" COUNTRIES (CONTINUED)

COUNTRY	AGRICULTURE						INDUSTRY				
	TAGP	PCAP	MMP	PPC	AP	LS	COP	TEE	TMP	TGPM	TGP
BAHRAIN	---	---	---	---	---	---	3360	390	---	---	2833.4
IRAQ	755	101	818	3040	144	21700	87372	3255	14604	588	1300
JORDAN	173	64	96	660	91	1355	---	350	---	156	---
KUWAIT	14	---	---	---	---	13.42	138101	4092	16887	300	5300
LEBANON	340	124	225	8281	170	695	---	1975	5624	550	---
OMAN	50	---	---	---	---	416	14301	229.9	---	5.8	---
PDRY	48	99	48	514	134	1315	---	135	---	35.74	---
QATAR	---	---	---	---	---	149	25100	---	80	---	105
SAUDI ARABIA	350	112	142	914	152	5185	421400	1474	30128	1431	3300
SYRIA	801	---	569	3528	171	6745	6426	1367	11316	988	---
UNITED A.E.	0.3	---	---	301	---	---	69613	430	---	8	13063
Y.A.R.	511	81	316	2179	110	11604	---	39	---	46	---

TABLE IV-3: MUNICIPAL COEFFICIENTS

COUNTRY	INTERCEPT	POP.	EXPE	IMP	BEDS	ENRO	GRE	EXPO	GDE
BAHRAIN	35.35				20.15	0.3812			
IRAQ	-20.76	5.072							
JORDAN	11.58	3.03	-0.0017			0.0159			
KUWAIT	43.67	11.54							
LEBANON	28.32	2.57				0.0003			
OMAN	-12.0165	96.98	-0.0048				0.0022		
PDRY	27.43				6.48	58.72	0.08		
QATAR	31.47		-0.0129			0.4267			0.0099
SAUDI ARABIA	22.85	4.66				0.0002			
SYRIA	-2.78	6.18	-0.0011	0.0017	0.61				
UNITED A.E.	39.58	11.34	-0.0005			0.4709			
Y.A.R.	6.75	3.0096						-0.0414	

TABLE IV-4: INDUSTRIAL COEFFICIENTS

COUNTRY	INTERCEPT	POP.	EXPE	TEE	TIP	TGP	GRE	TIGDP	RP	COP	TMP	GDE
BAHRAIN	-30.79	430.31							0.2127			
IRAQ	5.563	6.1769										
JORDAN	- 0.52	23.48	0.0113	0.0099	0.0007							
KUWAIT	113.22	149.069		0.0122		0.0039						
LEBANON	-35.5	39.38										
OMAN	-18.50			0.119						0.004		
PDRY	-11.10	38.60					0.131					
QATAR	232.18		-0.0061			0.0027				0.0003	0.0332	0.0458
SAUDI ARABIA	-122.53	25.33				0.0016						
SYRIA	3.094	10.359										
UNITED A.E.	184.39	14.47		0.015		0.0006						
Y.A.R.	21.08	3.94	-0.0177	0.0853				0.0221				

TABLE IV-5: AGRICULTURAL COEFFICIENTS

COUNTRY	INTERCEPT	POP.	AP	MMP	PPC	GRE	PCAP	ENRO	EXPE	LS
BAHRAIN	38.59	10.29						0.4481		
IRAQ	-17.925	8.865		0.009						
JORDAN	-25.87	22.48								
KUWAIT	23.4618	46.454								
LEBANON	- 5.051	18.6007								
OMAN	- 9.57	82.85							-0.0013	
P.D.R.Y.	6.24	18.94			0.0019	0.08	0.05			
QATAR	-20.55	845.70								0.10
SAUDI ARABIA	5.36	7.32			0.0071					
SYRIA	- 0.984	3.99	0.0266							
UNITED A.E.	27.92	114.24			0.0045					
Y.A.R.	- 1.484				0.0166					

TABLE IV-6: WATER DEMAND PROJECTIONS IN GALLONS PER CAPITA PER DAY FOR "LEBANON"

YEAR	MUNICIPAL	INDUSTRIAL	AGRICULTURAL
1980	37	94.5	56
1990	39	122	69
2000	41	154	84

TABLE IV-7: <u>PROJECTIONS OF THE YEAR 2000 OF SIGNIFICANT VARIABLES</u>

COUNTRY	POP.	EXPE	IMP	BEDS	ENRO	GRE	EXPO	GDE	TEE	TIP	TGP
BAHRAIN	.47			1.25	145						
IRAQ	19.20										
JORDAN	4.70	1600			1250				1150	19500	
KUWAIT	2.15								13000		13500
LEBANON	4.80				1960						
OMAN	1.28	2000				2200			780		
PDRY	2.75			1.05	0.80	145					
QATAR	0.115	320			81			175			2400
SAUDI ARABIA	14.50				2000						6000
SYRIA	12.50	7819	2250	13.00							
UNITED A.E.	0.38	3800			42				1600		25000
Y.A.R.	9.50	340					43		127		

TABLE IV-7 - PROJECTIONS OF THE YEAR 2000 OF SIGNIFICANT VARIABLES (CONTINUED)

COUNTRY	TIGDP	RP	COP	TMP	AP	MMP	PPC	PCAP	LS
BAHRAIN		200							
IRAQ						3400			
JORDAN									
KUWAIT									
LEBANON									
OMAN			21000						
PDRY							1350	137	
QATAR			62000	300					320
SAUDI ARABIA							1400		
SYRIA					260				
UNITED ARAB EMIRATES							1100		
Y.A.R.	450						7000		

TABLE IV-8 - WATER DEMAND PROJECTIONS IN U.S. GALLONS PER CAPITA PER DAY FOR THE YEAR 2000

COUNTRY	WATER DEMAND IN GPCD			TOTAL
	MUNICIPAL	INDUSTRIAL	AGRICULTURAL	
BAHRAIN	116	214	108	438
IRAQ	77	124	183	384
JORDAN	43	117	82	243
KUWAIT	68	540	123	731
LEBANON	41	154	84	279
OMAN	107	158	94	359
QATAR	64	273	109	446
PDRY	93	114	79	286
SAUDI ARABIA	91	254	121	466
SYRIA	78	133	56	267
UNITED ARAB EMIRATES	62	229	76	367
Y.A.R.	34	73	115	222

TABLE IV-9 - ESTIMATED FUTURE TRENDS IN WATER DEMANDS IN SELECTED COUNTRIES

Country and year	Population (millions)	Total withdrawal (cu m/year per capita)	Distribution of withdrawals among major categories of water uses (percentage)		
			Municipal and rural water supply	Agriculture	Industry
Hungary					
1965	10.2	390	9	45	46
1985	11.0	1 150	8	39	53
India					
1968	530	600	3	96	1
2000	919	850	4	75	21
Japan					
1965	98	710	10	72	18
1985	121	970	18	50	32
Mexico					
1970	49	920	4	91	5
2000	132	1 100	8	77	15
United Republic of Tanzania					
1970	13	36	63	35	2
2000	34	200	20	80	...

Source : UN.ST/ESA/38 p. 6

FIGURE IV-1: POPULATION PROJECTION
"LEBANON"

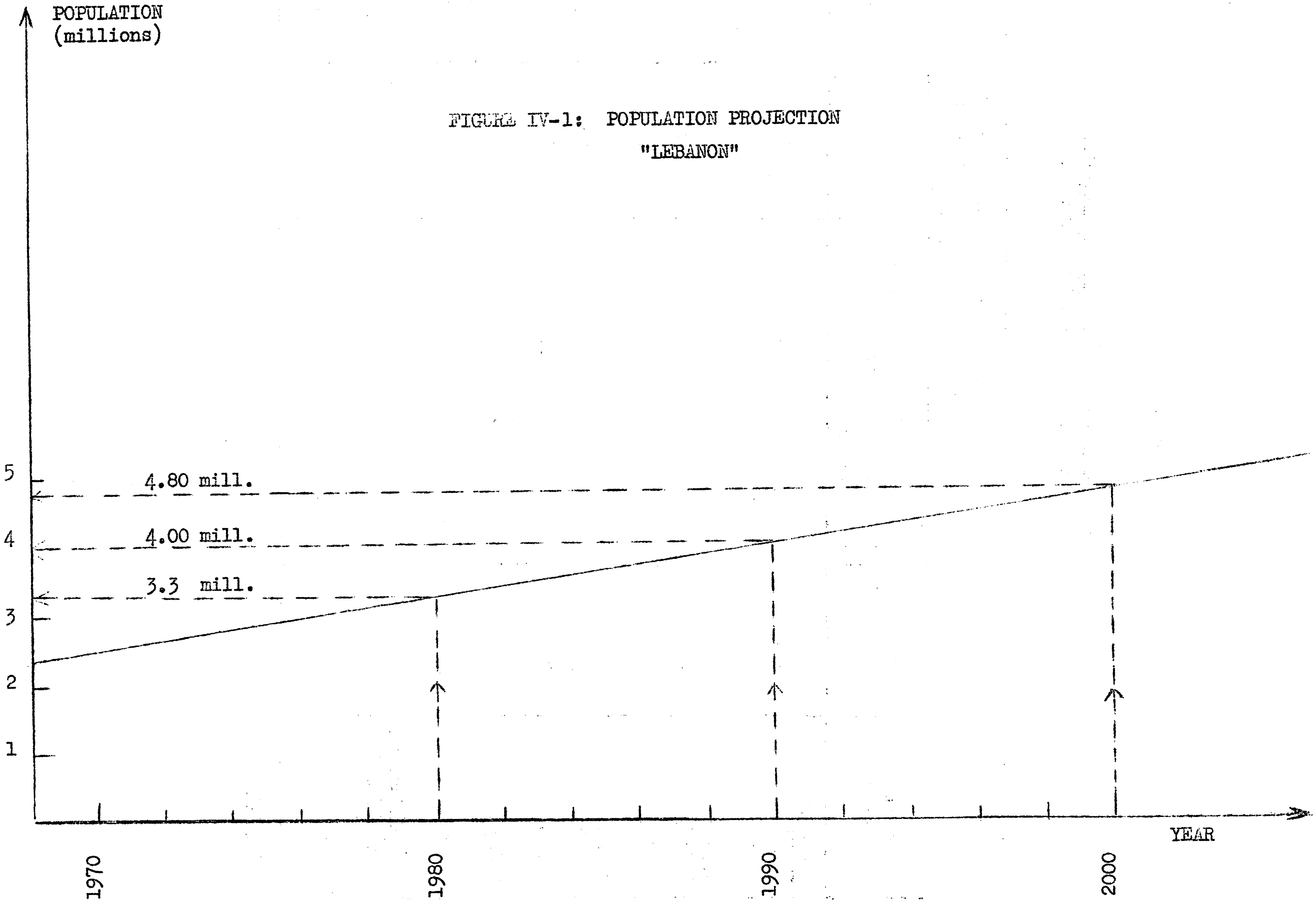
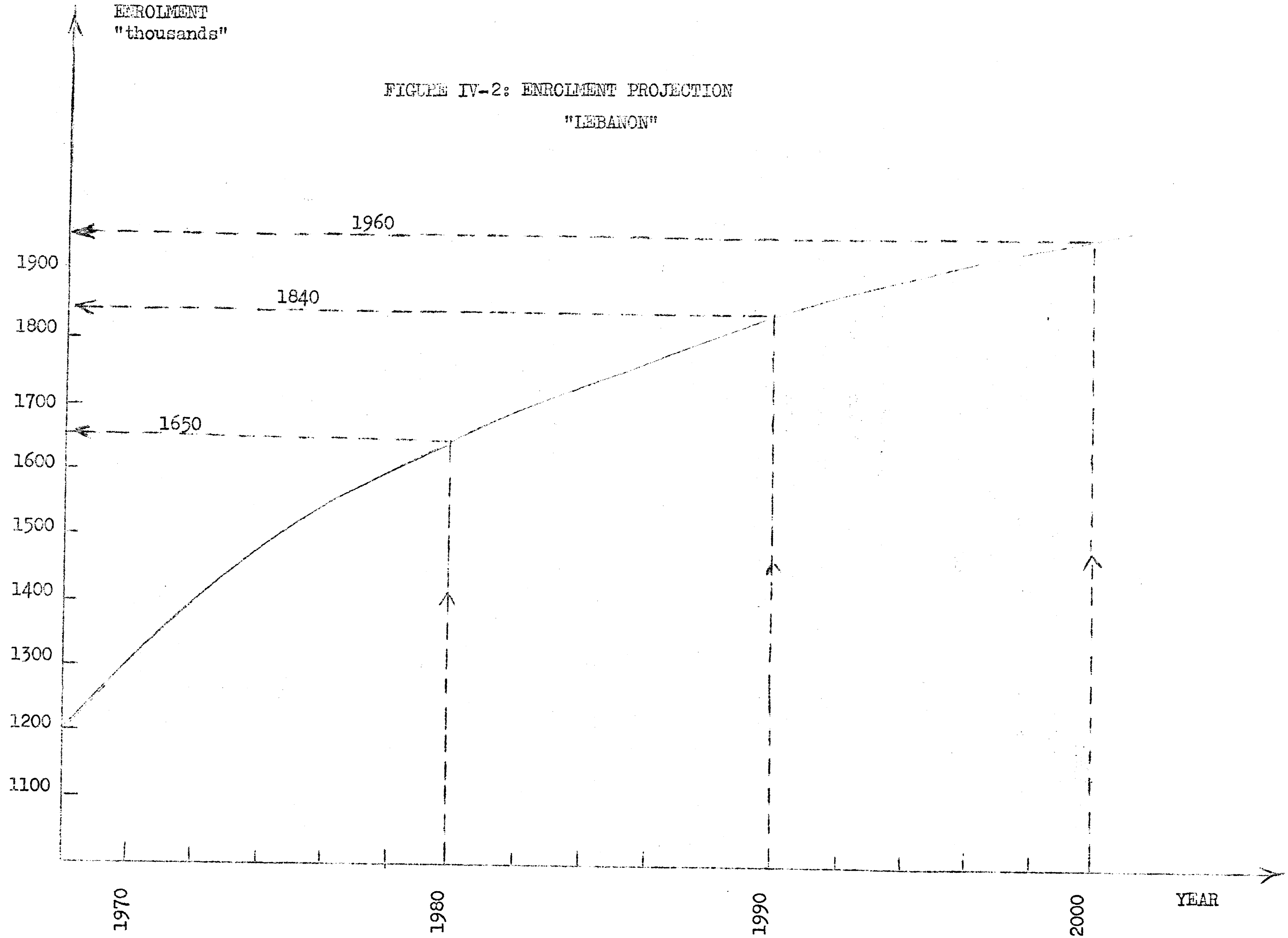


FIGURE IV-2: ENROLMENT PROJECTION
"LEBANON"



V - CONCLUSIONS AND RECOMMENDATIONS

A - Conclusions

In general, the objective of water demands projection is to plan water management measures in all sectors of the economy for sometime ahead. This, in turn, will influence the development of other aspects of the national economy such as the relocation of industrial projects with large water needs or large polluting effects.

The main objective of this report is to predict the water demands of the ECWA member states by the year 2000. Another objective of the study is to underline the fact that more effective integration of water availability and future needs should be taken into consideration within the framework of national planning. Few governments, within and outside ECWA Region, when considering their national planning, targets, and strategies are in a position to adequately account for the impact of their plans on future water demands. Furthermore, the period for which these projections is made will, more than ever, be governed by the ability to manage the fixed amounts of available water in such a way to meet the ever rising demands of societies.

It is hoped and expected that this study will lead to more effective integration of water planning consideration within the framework of national strategies, and that it will contribute towards assisting National and Regional Organizations in establishing and strengthening institutional arrangements and data base for projecting water demands on regular bases.

More specifically, the major finding of this study are:

1. According to these predictions, population is the most significant factor in most of the mathematical models. For example, if we examine municipal demand equations (Table IV.3) we find that population highly corrolates with municipal water demands except in People's Democratic Republic of Yemen, Bahrain, and Qatar. One explanation of this independence of municipal water demands from population is that the growth in the population of these countries may not be significant. In fact that is the case for these countries for the years 1968-75. The increase in population for Bahrain, PDRY and Qatar for that period is 0.06, 0.33, and of 0.01 millions respectively. Kuwait and Oman seem to be the exception to this postulate.

   Similarly tables IV-4 and IV-5 show that both industrial and agricultural demands corrolate with population.

2. Another independent variable influencing future water demands is the number of students enrolled at schools.

   The number of schools in the Region is mushrooming at a fast pace. Water requirements to cope with the cleanliness and beautification should, no doubt, be accounted for in the water demands formula.

3. Government expenditure is also playing a substantial role in the overall water demands. This, of course, is not a far-fetched conclusion. The region is going through an unprecedented industrial development with obvious changes in life style.

4. However, there are some obvious inconsistancies in the overall results in projections. For example, industrial demands in the region as seen in Table IV.8 exceed by far agricultural demands. This is not so at present, and it is unlikely that the trend will soon be reversed.

   Errors in projecting water demands for industrial purposes are not uncommon. This may be the result of one or a combination of:

   a - an unreasonably high estimate of industrial growth.
   b - too much emphasis on past trends.
   c - over-enthusiasm of planners, especially in developing countries, where industrialization, sometimes, is the yardstick for measuring national progress.
   d - seasonal fluctuations are over-emphasized.
   e - location of supply relative to points of demand is not given the proper attention. For instance, groundwater prices are very much related to the cost of transporting it.

   In this particular case the discrepancy may be due to all of these. Our estimates of industrial growth in the Region was, at best, an educated guess. Neither the type of industry by the end of the century nor its rate of growth is clear to us.

5. Although the area, in general, is either arid or semi-arid, domestic water demands seem to vary from country to another indicating that factors such as the standard of living, cost of water, type of commercial activities, and system management are as important as climate in the final analysis.

B - Recommendations

Based on the previous analysis the following recommendations are suggested:

1- Each country of the Region carefully examine the data used in these projections and make the necessary adjustment.

As we indicated in the first chapter, all the data used in this study were compiled at the Office. No data-collection missions were undertaken for this purpose. Only the countries themselves can verify the authenticity of the data at this time.

For example, population projections by our consultant differ from those by the UN "World Population Prospects- 1973", and neither one agrees with what we see done by the member states themselves, or their special consultants.

Similarly, FAO's projections of irrigated land are not in agreement with some of the figures given by the governments at the UN Water Conference at Mar del Plata, Argentina, 1977.

We have reasons to believe that inaccuracies exist in other categories of the data applied to the model.

2- In view of the above and due to the fact that the projection of water demands is a dynamic process which fluctuates with the changes in national planning, economic growth, life style, and population distribution it is necessary that:

a) Each country establish a data gathering programme for determining water use in all fields. This would include an assessment of water used for municipal, industrial, rural domestic and agricultural purposes.

Municipal use should be determined insofar as possible through customer metering. Industrial use should be determined by periodic surveys, updated as needed. Rural domestic should be determined by periodic survey, meters where possible, and other appropriate methods.

Agricultural use should be measured by gages, meters, with the responsibility on individual users to cooperate in obtaining use data.

Accurate and up-to-date records should be maintained on the amount of land irrigated in each country, with an indication of the nature of irrigation, whether perennial or supplemental.

b) Each country establish a programme for collecting and assessing data on special problems in resource evaluation such as ground water recharge, environmental problems, coastal and marine problems and quality and extent of total surface and ground water resources.

c) Each country establish systematic procedures for collecting, compiling and publishing social and demographic data needed for the demand model. Such information should contain totals of population, number of people residing in cities, number of people in rural areas, educational level of population connected to central water distribution systems in urban and rural areas should also be obtained. Such information should be obtained at periodic intervals in order to establish trends and growth patterns.

d) Each country should establish programmes for obtaining economic information needed for the water demand model. Information on gross national product, per capita income, industrial gross national product and agricultural production is needed. These data will also be useful in analysis of the economics and priority of use of water for various purposes.

All this is essential for arriving at meaningful projections.

3. Water management strategies should be equally concerned with management of demands as with the management of supply. So far, the most common response to water shortage is the expansion of supplies while the managing of demands is usually neglected. The rising cost of supplies in most parts of the world call for a policy of planning wherein attention is focused on the actual needs of the people rather the quantity of water as such.

4. Finally, it should be pointed out that whether we are dealing with projections or any other aspect of water demands, the issue of water resources development is a matter of awareness, sound management and careful planning. While there is no disagreement that the entire

population need not drink unsanitary water, both industry and agriculture should adopt water policies that are geared to the conservation and efficient use of water.

In this regard, a public awareness programme on water use should be undertaken. The traditional concept that water is plenty and free can not be accepted anymore.

VI - REFERENCES

(1) The Demand/Supply Relationship for Water Resources, United Nations, Department of Economics and Social Affairs, New York 1977.

(2) Water Demand Models for the Arabic Countries Included in the Economic Commission for Western Asia, by George W. Reid and Michael I. Muiga, United Nations, November 1976.

(3) The Demand for Water: Procedures and Methodologies for Projection Water Demands in the Context of Regional and National Planning, United Nations, Natural Resources/Water Series No. 3, New York, 1976.

(4) Leeden, Frits Van der, Water Resources of the World, Water Information Center, Inc., Port Washington, New York, 1975.

(5) Reid, George W., and Muiga, Michael, I1, A Mathematical Model for Predicting Water Demand, Waste Water Disposal and Cost of Water and Waste Water Treatment in Developing Countries, Agency for International Development, Department of State, Washington, D. C., January, 1976.

(6) United Nations Statistics Data, 1970, 1971, 1972, 1973, 1974 and 1975.

(7) World Bank Atlas, Population per capita Product and growth rates, International Bank for Reconstruction and Development 1972.

(8) World Health Organization, 1973, World Health Statistics Report, Vol.26,No. 11.

(9) International Conference on Water for Peace, Volumes 1-8, Washington,D.C.,1967.

(10) Lvovitch, M. I. World Water Balance, Proc. Reading Symposium, July 1970, IASH-UNESCO-WHMO.

(11) International Financial Statistics; Prepared by the Bureau of Statistics of International Monetary Fund, 1972, 1974, 1976 Series.

(12) United Nations Conference on Human Environment, Stockholm, Sweden, 1972.

(13) United Nations Statistical Data 1971, 1972, 1973.

(14) World Health Organization EH/712.

(15) United Nations, Urban and Rural ESA/P/WP, 33 Rev./N.Y.

(16) Capen, Charles, H. Jr. "How much water do we consume? How much do we pay? JAWWA 29, 1937.

(17) Hankes, S.H. "Demand for Water Under Dynamic Conditions". Water Resources Res. 6, No. 5 (Oct. 1970).

(18) Howe, C. W., Linaweaver, F. P. Jr. "The Impact of Price on Residential Demand and its relation to System Design and Price Structure". Water Resources Res. 3, No. 1, 1967.

(19) Lee, T. R. "Residential Water Demand and Economic Development" University of Toronto Press, 1969.

(20) Meyer, J. M. Jr., Mangan, G. F. "System Pinpoints Urban Water Needs" Env.Sc.T. 3 No. 10, 1969.

(21) Reid, G. W. "Multistructured Municipal Water Demand" JAWWA 7 No. 6, 1971.

(22) Saki, K., Saki, S. "The Methods of Water Requirements forecasting in Japan". UN/ESA, 1972.

(23) White, G.F.; Bradley, D. J.; White, Anne U. "Drawers of Water" University of Chicago Press 1972.

(24) Wolman, A. "Forecasts of Water Use and Water Quality". A model for the U.S.A., 1970.

(25) Wolman, A. "Assessing Water Use and Minimal Requirement", UN,ESA/RT/AC.3/14 Budapest 1972.

(26) The Demand for Water. UN Natural Resources/Water Series No. 3. ST/ESA/38.

(27) Fout, L. "Forecasting the Urban Residential Demand for Water" Agr.Econ.Seminar, University of Chicago, 1958.

(28) Huisman, L., "Groundwater Recovery"Winchester Press, 1972.

(29) UN Doc. E/CONF.70/CBP/1, 1976.

(30) McKee, J.E., "Better Tools for Water Resources" JAWWA 1966

(31) Holy, M.; Framji, K.K. "Assessment of the World Water Situation - Irrigation Systems in Total Water Management", March 1977.

(32) Report of the U.N. Water Conference E/CONF.70/29, March 1977.

A P P E N D I X A

"Data Used by Each Country"

BAHRAIN *

MUNICIPAL VARIABLES

Year	Pop.	GDE	INL	IMP	EXPO	BEDS	ENRO
1978	0.20	35	50	109	39	.78	41
1969	0.21	40	67.9	122	42	0.81	44
1970	0.22	37	71.1	168	53	0.82	47
1971	0.22	58	95	239	65	0.84	52
1972	0.22	69	92.5	228	74	0.845	53
1973	0.23	62	74	324	82	0.905	56
1974	0.24	170	141	446	182	0.845	62
1975	0.26	273	295.6	590	213	0.892	64

INDUSTRIAL VARIABLES

Year	Pop.	GDE	TEE	COP	TGP	RP
1968	0.2	35	216	3792	353.7	81.2
1969	0.21	40	249	3820	946.9	83.3
1970	0.22	37	248	3847	1226.3	88.3
1971	0.22	58	258	3761	1050	89.9
1972	0.22	69	276	3508	1837.5	83.5
1973	0.23	62	330	3411	2342.3	86.4
1974	0.24	170	390	3360	2833.4	88.2
1975	0.26	273	550	3060	2875.5	70.5

AGRICULTURAL VARIABLES

Year	Pop.	GDE	ENRO
1968	0.2	35	41
1969	0.21	40	44
1970	0.22	37	47
1971	0.22	58	52
1972	0.22	69	53
1973	0.23	62	56
1974	0.24	170	62
1975	0.26	273	64

Not enough data was available for agricultural variables.

* All variables are defined in Table 1.

IRAQ

MUNICIPAL VARIABLES

Year	Pop.	TGDP	TINC	INL	IMP	EXPO	ENRO	BEDS	TOUR
1968	8.86	3160	2539	453	403	64	1600	16.33	396.3
1969	9.15	3304	2675	476	440	62	1720	17.73	429.6
1970	9.44	3591	2918	462	508	63	1810	17.89	359.8
1971	9.75	4454	3561	600	754	64	1920	18.50	589.9
1972	10.07	4484	3809	782	713	69	2090	19.29	536.7
1973	10.41	5558	4972	1553	903	109	2290	20.91	488.3
1974	10.77	11282	10130	3273	2338	94	2580	21.58	544.8
1975	11.12	13435	13425	2727	4157	119	2920	22.09	600

INDUSTRIAL VARIABLES

Year	Pop.	TINC	EMPL	TEE	COP	TGP	TMP	TGPM'
1968	8.86	453	3.32	1600	73775	721	9826	265
1969	9.15	476	2.4	1772	74485	895	10140	288
1970	9.44	462	2.51	1909	76464	785	11781	3255
1971	9.75	600	2.59	2261	83464	870	11964	360
1972	10.07	782	2.69	2358	72348	934	13156	426
1973	10.41	1553	2.76	2919	99372	1210	12909	526
1974	10.77	3273	2.82	3255	87372	1300	14604	588
1975	11.12	2727	2.85	3800	109968	1350	15211	797

AGRICULTURAL VARIABLES

Year	Pop.	TINC	TAGP	PCAP	LS	MMP	PPC
1968	8.86	453	549	116	13823	400	3795
1969	9.15	476	535	111	15370	624	3268
1970	9.44	462	579	107	18190	669	3207
1971	9.75	600	646	100	19820	720	2555
1972	10.07	782	819	137	21520	779	5031
1973	10.41	1553	755	97	20980	797	2741
1974	10.77	3273	755	102	21190	818	3040
1975	11.12	2727	993	95	21700	838	2383

JORDAN*

MUNICIPAL VARIABLES

Year	Pop.	TGDP	TINC	EXPE	GNP	INL	IMP	EXPO	ENRO	BEDS	TOUR
1968	2.10	523	530	141	580	284	161	34	320	1.64	376
1969	2.29	615	630	248	610	263	190	33	340	1.69	339
1970	2.30	587	599	226	631	256	185	26	370	1.63	322
1971	2.38	625	639	233	662	253	215	25	390	1.79	357
1972	2.46	697	711	350	736	270	267	35	420	1.90	292
1973	2.54	816	856	484	886	312	329	43	460	2.2	307
1974	2.62	1084	1152	526	1186	350	496	125	501	2.2	555
1975	2.70	1081	1161	661	1197	486	709	122	526	2.02	650

INDUSTRIAL VARIABLES

Year	Pop.	TINC	EXPE	TGPM	TME	TIP
1968	2.1	530	141	56	156	2727
1969	2.29	630	248	65	200	3062
1970	2.30	599	226	55	165	2983
1971	2.38	639	233	57.4	230	3285
1972	2.46	711	350	71	275	3681
1973	2.54	856	484	87	315	4649
1974	2.62	1152	526	156	350	5395
1975	2.70	1161	661	164	407	7088

AGRICULTURAL VARIABLES

Year	Pop.	TINC	EXPE	TAGP	PCAP	LS	MMP	FPC
1968	2.1	530	141	77	51	1245	88	356
1969	2.29	630	248	102	58	1444	101	529
1970	2.30	599	226	80	38	1056	81	275
1971	2.38	639	233	106	53	1103	97	481
1972	2.46	711	350	119	61	1190	95	612
1973	2.54	856	484	97	30	1314	97	263
1974	2.62	1152	526	173	64	1355	96	660
1975	2.70	1161	661	105	40	1257	93	357

KUWAIT*

MUNICIPAL VARIABLES

Year	Pop.	TGDP	TINC	INL	EXPE	IMP	EXPO	ENRO	BEDS
1968	0.61	2663	1500	483	156	611	47	135.2	3.4
1969	0.67	2769	1660	510	169	646	65	209.8	3.5
1970	0.74	2923	2260	569	192	679	80	163.6	3.6
1971	0.78	4107	2945	806	221	709	105	178.[illegible]	3.63
1972	0.82	4765	3372	1104	270	800	151	193.[illegible]	3.8
1973	0.87	7116	5881	1524	326	1046	235	206.5	3.7
1974	0.92	11142	1052	4870	380	1570	403	223.5	3.9
1975	0.99	12500	1500	5759	430	2357	579	248.6	4.1

INDUSTRIAL VARIABLES

Year	Pop.	TINC	EXPE	TEE	COP	TGP	TGPM	TMP
1968	0.61	483	156	1659	131462	3339	104	15558
1969	0.67	510	169	2012	139325	3727	101	16244
1970	0.74	569	192	2213	150636	4041	116	20713
1971	0.78	806	221	2636	161436	4500	128	22968
1972	0.82	1104	270	3295	165443	5126	183	18140
1973	0.87	1524	326	3668	151804	5267	246	19702
1974	0.92	4870	380	4092	128101	5300	300	16887
1975	0.99	5759	430	4653	105120	5208	350	20123

AGRICULTURAL VARIABLES

Year	Pop.	TINC.	EXPE	TAGDP	LS
1968	0.61	483	156	14	10.01
1969	0.67	510	169	14	11.11
1970	0.74	569	192	12	12.87
1971	0.78	806	221	12	12.00
1972	0.82	1104	270	12	10.55
1973	0.87	1524	326	13	11.08
1974	0.92	4870	380	14	13.42
1975	0.99	5759	430	14	14.34

LEBANON*

MUNICIPAL VARIABLES

Year	Pop.	TGDP	GNP	TINC	INL	EXPE	IMP	EXPO	ENRO	BEDS	TOUR
1968	2.34	1367	1417	1332	332	172	504	144	1200	9.5	1118
1969	2.4	1461	1512	1426	349	181	550	168	1320	9.6	1119
1970	2.47	1499	1549	1465	386	194	566	188	1400	10.73	1210
1971	2.54	1728	1807	1700	547	216	696	252	1300	10.37	1603
1972	2.62	2113	2133	2087	675	245	891	359	1350	10.37	1664
1973	2.70	2826	2826	2798	862	349	1440	513	1330	10.38	1504
1974	2.78	3540	3540	3500	1674	440	1989	667	1400	10.40	2261
1975	2.87	4000	4000	3900	1579	540	2400	800	1500	11.20	2000

INDUSTRIAL VARIABLES

Year	Pop.	TINC	EXPE	TEE	TGPM	TMP
1968	2.34	1332	172	1035	177	9326
1969	2.4	1426	181	1139	195	10098
1970	2.47	1465	194	1230	204	9887
1971	2.54	1700	216	1375	240	10705
1972	2.62	2087	245	1548	293	11080
1973	2.70	2798	349	1791	413	11723
1974	2.78	3500	440	1975	550	12360
1975	2.87	3900	540	2159	740	13000

AGRICULTURAL VARIABLES

Year	Pop.	TINC	TAGP	PCAP	MMP	LS	PPC
1968	2.34	1332	140	118	219	663	685
1969	2.4	1426	138	93	213	664	573
1970	2.47	1465	137	99	224	723	653
1971	2.54	1700	149	113	225	715	769
1972	2.62	2087	209	125	225	710	856
1973	2.70	2798	269	114	203	692	789
1974	2.78	3500	240	124	225	695	828
1975	2.87	3900	300	112	225	700	735

OMAN*

MUNICIPAL VARIABLES

Year	Pop.	TGDP	EXPE	GRE	IMP	EXPO	ENRO	BEDS
1968	0.62	151	44	89	40	195	1	-
1969	0.64	187	48	96	50	204	1.007	-
1970	0.66	208	53	108	58	214	7.06	0.12
1971	0.68	252	62	120	193	231	15.46	0.216
1972	0.70	292	109	138	322	260	24.52	0.526
1973	0.72	372	183	199	498	357	35.65	0.664
1974	0.74	1398	541	903	1425	1692	49.32	0.934
1975	0.77	1767	962	1332	2096	2167	55.84	1.00

INDUSTRIAL VARIABLES

Year	Pop.	EXPE	TEF	COP	TIGDP
1968	0.62	44	95	11882	161
1969	0.64	48	99.6	16180	216
1970	0.66	53	104.9	16390	195
1971	0.68	62	110.9	14150	223
1972	0.70	109	130	14150	270
1973	0.72	183	172.5	13940	361
1974	0.74	541	229.9	14301	1341
1975	0.77	962	306.3	16842	1581

AGRICULTURAL VARIABLES

Year	Pop.	EXPE	TAGP	LS
1968	0.62	44	36	100
1969	0.64	48	38	120
1970	0.66	53	40	174
1971	0.68	62	40	214
1972	0.70	109	44	268
1973	0.72	183	48	336
1974	0.74	541	50	416
1975	0.77	962	51	500

PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN*

MUNICIPAL VARIABLES

Year	Pop.	TGDP	IMP	EXPO	EXPE	GRE	ENRO	BEDS
1968	1.36	165	203	103	35	20	0.111	0.01
1969	1.40	171	238	134	38	21	0.117	0.099
1970	1.44	170	201	135	37	25	0.152	0.091
1971	1.47	170	169	103	46	34	0.168	0.147
1972	1.51	175	149	98	54	42	0.185	0.158
1973	1.59	185	173	107	63	35	0.215	0.123
1974	1.64	200	179	13	66	44	0.236	0.230
1975	1.69	245	172	12	70	50	0.250	0.320

INDUSTRIAL VARIABLES

Year	Pop.	GRE	EXPE	TIGDP	TEE
1968	1.36	20	35	44	128
1969	1.40	21	38	47	130
1970	1.44	25	37	45	135
1971	1.47	34	46	32	142
1972	1.51	42	54	42	138
1973	1.59	35	63	32	136
1974	1.64	44	66	49	135
1975	1.69	50	70	52	144

AGRICULTURAL VARIABLES

Year	Pop.	EXPE	GRE	TAGP	PCAP	LS	MMP	PPC
1968	1.36	35	20	30	90	1190	45	77
1969	1.40	38	21	32	100	1200	46	127
1970	1.44	37	25	32	93	1218	46	379
1971	1.47	46	34	38	97	1245	48	386
1972	1.51	54	42	40	89	1267	48	435
1973	1.59	63	35	47	98	1291	48	445.4
1974	1.64	66	44	48	99	1315	48	514
1975	1.69	70	50	50	95	1327	49	575

QATAR*

MUNICIPAL VARIABLES

Year	Pop.	GDE	EXPE	INL	IMP	EXPO	ENRO
1968	0.08	2	30	14	50	240	15.11
1969	0.08	2	32	15.9	53	255	16.62
1970	0.08	5	28	17.8	64	259	17.93
1971	0.08	15	39	21.6	118	338	20.29
1972	0.08	10	52	28.7	138	397	22.74
1973	0.09	17	63	75.5	197	625	24.82
1974	0.09	43	91	71.7	271	2015	27.14
1975	0.09	68	156	80	408	1782	30

INDUSTRIAL VARIABLES

Year	Pop.	EXPE	COP	TGP	TMP	GDE
1968	0.08	30	16400	513	28	2
1969	0.08	32	17200	350	33	2
1970	0.08	28	17400	1002	34	5
1971	0.08	39	20400	1005	34	15
1972	0.08	52	23500	1103	35	10
1973	0.09	63	27700	1250	44	17
1974	0.09	91	25100	1050	80	43
1975	0.09	156	21200	1300	100	68

AGRICULTURAL VARIABLES

Year	Pop.	EXPE	LS	TAP	GDE
1968	0.08	30	100	35	2
1969	0.08	32	120	42	2
1970	0.08	28	145	158	5
1971	0.08	39	165	215	15
1972	0.08	52	188	216	10
1973	0.09	63	122	207	17
1974	0.09	91	149	220	43
1975	0.09	156	155	230	68

SAUDI ARABIA*

MUNICIPAL VARIABLES

Year	Pop.	TGDP	TINC	IMP	EXPO	INL	EXPE	ENRO	BEDS
1968	7.32	3225	2557	556	2006	146	1171	400	6.396
1969	7.54	3515	2800	727	1972	134	1297	444	6.787
1970	7.74	3828	2986	686	2399	146	1313	484	7.165
1971	7.96	5501	4139	870	4152	347	1570	524	7.942
1972	8.19	6782	4941	1119	5462	600	2588	598	8.132
1973	8.43	11436	8487	2050	9389	1093	3280	165	8.870
1974	8.68	28064	23280	2862	31023	4028	6432	750	9.070
1975	8.93	38084	38490	6830	27515	6576	12899	846	9.250

INDUSTRIAL VARIABLES

Year	Pop.	TINC	TGPM	TEE	COP	TMP	TGP	EXPE
1968	7.32	3225	274	528	151400	23201	1600	1171
1969	7.54	3515	301.4	631	159500	24020	1700	1297
1970	7.74	3828	369	700	188400	31813	2300	1313
1971	7.96	5501	470	780	238700	31130	2600	1570
1972	8.19	6782	476	978	299900	32973	2800	2588
1973	8.43	11436	686	1186	377500	31441	3100	3280
1974	8.68	28064	1431	1474	421400	30128	3200	6432
1975	8.93	38490	1875	2014	352200	35000	3300	12899

AGRICULTURAL VARIABLES

Year	Pop.	TAGP	TINC	PCAP	LS	MMP	PPC
1968	7.32	194	200	104	5235	150	771
1969	7.54	211	246	103	5467	160	797
1970	7.74	916	308	108	5630	170	829
1971	7.96	244	433	106	5110	180	840
1972	8.19	254	522	102	5130	186	851
1973	8.43	322	699	103	5143	194	839
1974	8.68	350	964	112	5185	205	914
1975	8.93	392	1129	110	5285	219	914

SYRIAN ARAB REPUBLIC*

MUNICIPAL VARIABLES

Year	Pop.	TGDP	INL	EXPE	IMP	EXPO	ENRO	BEDS	TOUR
1968	5.87	1450	17.61	480	314	177	1060	6.14	12
1969	6.06	1577	15.52	500	371	208	1130	6.16	15
1970	6.30	1679	14.47	530	359	202	1200	6.22	16
1971	6.46	1944	23.14	606	445	206	1320	6.49	20
1972	6.68	2320	35.51	697	543	298	1450	6.85	38
1973	6.89	2476	108.36	878	616	353	1590	6.68	56
1974	7.12	3910	131.5	1265	1202	766	1680	6.75	85
1975	7.35	5453	200	2819	1667	929	1750	7.43	95

INDUSTRIAL VARIABLES

Year	Pop.	EXPE	COP	TER	TMP	TCIM	EMPLI
1968	5.87	480	1033	773	8492	290	1411
1969	6.06	500	2620	934	3147.9	310	1440
1970	6.30	530	4243	947	5684	330	1500
1971	6.46	606	5299	1049	8229	378	1523
1972	6.68	697	5862	1223	9749.9	451	1534
1973	6.89	878	5543	1153	9296	511	1611
1974	7.12	1265	6426	1367	11316	988	1651
1975	7.35	2819	9572	1673	13825	1252	1750

AGRICULTURAL VARIABLES

Year	Pop.	EXPE	TAGP	AP	LS	MMP	EMPLA	PPC
1968	5.87	480	275	108	6916	594	790	2058
1969	6.06	500	300	138	7614	602	810	2647
1970	6.30	530	360	100	7584	500	850	1853
1971	6.46	606	425	111	6947	496	692	1892
1972	6.68	697	614	156	6593	517	908	3836
1973	6.89	878	449	103	6190	464	850	1733
1974	7.12	1265	801	171	6745	569	864	3528
1975	7.35	2819	967	171	7413	637	895	3421

UNITED ARAB EMIRATES*

MUNICIPAL VARIABLES

Year	Pop.	TGDP	GRE	EXPE	IMP	EXPO	ENRO
1968	0.18	300	116	125	45	300	3.0
1969	0.18	350	143	172	60	400	3.8
1970	0.19	452	180	151	70	550	4.9
1971	0.20	764	380	254	121	979	5.8
1972	0.20	986	502	399	162	1167	7.6
1973	0.21	1788	805	848	255	1928	9.2
1974	0.22	4926	3533	1731	567	6347	11.4
1975	0.22	5900	3737	2843	949	6812	13.5

INDUSTRIAL VARIABLES

Year	Pop.	EXPE	TGPM	TEE	COP	TGP
1968	0.18	125	180	150	24600	4200
1969	0.18	172	210	200	29602	5432
1970	0.19	151	289	215	34198	7538
1971	0.20	254	522	225	46093	10310
1972	0.20	399	642	230	51905	11177
1973	0.21	848	1288	341	64341	13643
1974	0.22	1731	4072	430	69613	13063
1975	0.22	2843	5500	598	69342	12167

AGRICULTURAL VARIABLES

Year	Pop.	EXPE	TAGP	PPC
1968	0.18	125	0.016	32
1969	0.18	172	0.019	38
1970	0.19	151	0.021	40
1971	0.2	254	0.023	49
1972	0.2	399	0.092	189
1973	0.21	848	0.175	295
1974	0.22	1731	0.300	301
1975	0.22	2843	0.41	350

YEMEN ARAB REPUBLIC*

MUNICIPAL VARIABLES

Year	Pop.	TGDP	TINC	IMP	EXPO	EXPE	ENRO	BEDS
1968	5.5	205	200	20	2	22	70	3.450
1969	5.63	255	246	29	3	23	77	3.470
1970	5.77	318	308	32	3	22	94	3.670
1971	5.91	445	433	39	5	49	127	3.875
1972	6.06	535	522	80	4	58	165	3.905
1973	6.29	714	699	124	8	71	192	3.878
1974	6.49	980	964	190	13	101	250	4.119
1975	6.47	1142	1129	294	11	125	300	3.317

INDUSTRIAL VARIABLES

Year	Pop.	TINC	TIGDP	TEE	EXPE
1968	5.5	200	20	17	22
1969	5.63	246	26	18	23
1970	5.77	308	32	18	22
1971	5.91	433	45	30	49
1972	6.06	522	58	29	58
1973	6.29	699	86	32	71
1974	6.48	964	93	29	101
1975	6.47	1129	116	45	125

AGRICULTURAL VARIABLES

Year	Pop.	TAGP	TINC	PCAP	LS	MMP	PPC
1968	5.5	110	200	86	12124	274	900
1969	5.63	135	246	80	10013	231	964
1970	5.77	176	308	68	10148	233	1339
1971	5.91	237	433	87	12229	277	1479
1972	6.06	269	522	90	11182	290	1347
1973	6.29	346	699	87	11014	308	1267
1974	6.48	511	964	81	11604	316	2179
1975	6.47	507	1129	107	12000	318	2258

A N N E X B

"DEFINITION OF BASIC TERMS"

DEFINITION OF BASIC TERMS[1]

In discussing procedures and methodologies, the Expert Group found it essential to formulate definitions of some fundamental terms in order to have a common frame of reference for communication. Different terminologies had evolved over the years in various countries because of the different conditions and backgrounds of the people using them. Linguistic difficulties inherent in translations as well as different interpretations in various countries of the same words in the same language raise further obstacles to clear understanding. In fact, such terms as "use", "needs", "requirements" and "demands" have often been used interchangeably. So also have the terms "water supply", "available water" and "water resources".

In order to facilitate clear and easy interpretation of the discussions of the present report, some fundamental ideas and concepts should be explained. The definitions and explanations that follow were adapted from a recent report of the National Water Commission of the United States of America;[2] although they may not conform to the usage of any one discipline, it is believed that they will promote better understanding of the present report and minimize misinterpretation.

Water use refers to ways in which water is utilized by man. Water uses include drinking, cooking, irrigating, industrial cooling and processing, generating electricity, transportation and recreational boating, swimming, fishing, aesthetic enjoyment, and other activities and processes constituting the elements of the major categories of use reviewed in table 1.

Water withdrawal (or intake) is the physical diversion of water from a stream or body of water, including ground water, for some use.

Return flow is the quantity of water returned (after use) to a stream or body of fresh water; this quantity may, of course, be withdrawn again for subsequent use if desired.

1/ Natural Resources/Water Series No. 3, UN Doc. ST/ESA/38. The Demand for water.

2/ Forecasting Water Demands, compiled by R.G.Thompson and others, Report No. PB 206 491 (Springfield, Virginia, 1971), pp. 16-20.

Water consumption, or consumptive use, is the difference between withdrwal and return flow and generally consists of water that is consumed by plants, animals, industrial processes or evaporation.

In-stream use is a use made of a body of water without withdrawing water from it. In-stream uses include navigation, hydroelectric power generation, the provision of habitats for fish and other wildlife, and aesthetic enjoyment.

On-site uses of water include maintaining swamps and wetlands for wildlife habitats and ditching and ponding for soil management.

Demand is used in the economic sense and is the amount of a commodity, in this case water or water-related products and services, that would be purchased or used at a given price.

The demand schedule is the functional relationship between various prices for water and the quantities that would be used at those prices.

The demand curve is the graphic presentation of the demand schedule.

Shifters of demand are factors that change the demand schedule, typically by increasing or decreasing the demand at given prices (see figure I-1); for example, an improvement in a water-use technology might result in decreasing the demand.

Supply is the amount of a commodity, in this case, water, that is available for sale or development at a given price.

The supply schedule is the relationship between various prices for water and the quantities that would be provided at those prices with the present state of technology. Because the supply of water may vary from time to time, the supply schedule is presented as those quantities (net flows) that would be made available at various prices with a given degree of certainty, for example, 95 per cent of the time.

Shifters of supply are factors that change the supply schedule, for example, a technological development decreasing the evaporation of a reservoir might make it possible to increase the supply of water at every price.

Water resource (resource used in the sense of "something that lies ready for use or can be drawn upon for aid") represents that part of the physical amount of water that is available from natural sources within a given region. Water resource is frequently regarded as the expected annual run-off, although additional supplies can be made available for a specific period of time by mining ground water.

Dependable water resource represents the portion of the available water resource that can be depended on for water development for a specified percentage of the time. It can be expressed either in terms of total volume or as a volume in a given period of time.

An augmented source of water supply is a source that provides a quantity of water over and above the dependable water resource at a price; examples are desalination, modification of precipitation, reclamation of waste-water plant effluent by advanced treatment processes, forest management and interbasin transfers.

Projection designates a delineation of future conditions, including water demands, supplies, prices and qualities in specific water resource regions at one or more points of time in the future.

Alternative scenarios refer to an approach in which projections are dependent on the possible policies countries and governments may choose to adopt, as well as possible socio-economic, technological and demographic developments. Thus, consistent alternative combinations of assumed sets of future conditions, which may significantly affect the demands for water and supplies of it, are termed alternative scenarios.

A residual is a discarded material or a waste by-product of some process and is commonly thought of as a pollutant. It may be in the form of a gas, liquid or solid, or may be a form of energy, such as heat. Release of a residual into the waterways is often detrimental to subsequent use of the water.

Externality is an economic effect that one water user's decision may have on another user, which may not be taken into account in the first user's decision. For example, users discharging wastes into the water may not take into account the effects of their discharges on others. The effects are external to the user's decisions, unless the pricing system is modified to account for them.