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WATER RESOURCES PLANNING, MANAGEMENT, USE AND CONSERVATION IN THE ESCWA REGION

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Foreword

The present document was prepared as a technical publication on the main issues highlighted during the Regional Symposium on Water Use and Conservation which was held in Amman from 28 November to 2 December 1993 in accordance with the 1992-1993 ESCWA programme of work. The document contains technical information and relevant data based on the national papers presented at the Symposium.

The Economic and Social Commission for Western Asia acknowledges the valuable assistance of Messrs Nizar El-Mir (Syrian Arab Republic), Mahmoud Abu Zeid (Egypt), Adel Bushnaq (Saudi Arabia) and Saqer Al-Salem (Jordan), who served as consultants during the preparation of this study.

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NOTES AND ABBREVIATIONS

BCM	Billion cubic metres
BOD	Biological oxygen demand
CM	Cubic metre (264 US gallons)
CM/sec	Cubic metre per second (22.8 Mgd)
COD	Chemical oxygen demand
Dunum	1,000 square metres
ED	Electrodialysis
FAO	Food and Agriculture Organization of the United Nations
feddan	.405 hectare
GW	Groundwater
ha	1 hectare (2.469 acres) = 10 dunums
km	Kilometre (0.621 miles)
km^2	Square kilometres
km^3	Cubic kilometres
l	Litre (0.264 US gallons)
l/c/d	Litres per capita per day
l/d	Litres per day
m	Metres
m3/s	Cubic metres per second
mg	Milligrams
ml	Millilitres
mm	Millimetres
mm/a	Millimetres per annum
MCM	Million cubic metres
MCM/a	Million cubic metres per annum
mgd	Million gallons per day
MED	Multi-effect distillation
MSF	Multi-stage-flash
O & M	Operation and maintenance
ppm	Parts per million
Q	Rate of discharge
RO	Reverse osmosis
SW	Surface water
TDS	Total dissolved solids
UNEP	United Nations Environment Programme
VC	Vapour compression
WHO	World Health Organization
WMO	World Meteorological Organization
WSP	Waste stabilization ponds
WWTP	Wastewater treatment plant

I. INTRODUCTION

A. General observations

The ESCWA region is within a semi-arid to arid region characterized by limited availability of water resources, and a growing demand for their use.

The region covered by the ESCWA member countries is about 4.75 million square kilometres and 97.7 per cent of this area is desert. Water is a valuable resource and its development and management require considerable investment. Climatic conditions, availability of water resources, socio-economic conditions, national borders, conflict of interest and politics play an important role in hindering development in many countries of the ESCWA region. Water resources issues are probably more significant in this region than in any other part of the world.

It is possible to classify ESCWA countries into three groups. Group I countries are situated in arid zones and they lack sufficient natural water resources and fertile soil; in addition, they suffer from adverse climatic conditions. They have to desalinate sea water to obtain most of their fresh water needs and to reuse sewage effluents to meet the needs of their high rate of population growth and rapid development. All group I countries share the western coastline of the Arabian Gulf. Oman, the United Arab Emirates and Saudi Arabia have long coastlines on the Arabian Sea.

Group II countries are situated in relatively arid zones and include Jordan, Palestine and Yemen. These countries have a better natural water potential than those in group I, but they all face imminent water shortages.

Group III countries are situated in semi-arid zones and include Egypt, Iraq, Lebanon and the Syrian Arab Republic. The most important water resources problem of this group is that they share among themselves and with neighbouring countries a substantial percentage of their surface water. The water resources of group III are adequate only for the coming decade and if they conserve, develop and manage these resources.

Studies have indicated that countries in this part of the world are now, or are expected to be by the year 2000, at a point where total demand for water will be about equal or exceed the estimated available resources.

In some areas, water shortage is already a reality. In a number of countries in the region, resources have been depleted because of over-pumping; water quality has deteriorated owing to increased salinity, and return flows from irrigation are known to be taking place. Likewise, surface-water resources are increasingly vulnerable to pollution from agricultural chemicals, sewage from large cities and other wastes. In the long run, increasing demand for water is likely to bring about conflicting development plans among the riparian countries.

The expansion of irrigated agriculture under existing patterns of cultivation and water use cannot proceed without encountering water shortage problems. The demand for water for industrial purposes is also expected to increase significantly in a number of countries and is likely to generate

additional pressures on the overall availability of water resources, and on the related environmental aspects. The population is rapidly increasing and there is a need for more good quality water for drinking and domestic use, which are priorities.

Some of the major surface water and groundwater basins in the ESCWA region extend beyond national boundaries. Cooperation and coordination in developing and managing the shared watersheds and river basins are needed to formulate and implement comprehensive plans dealing with all measures to ensure rational development, taking into account the socio-economic factors prevailing in the concerned member countries. Establishment of regional bodies or joint watershed commissions will be a great help in planning the management and efficient utilization of the resources in various development sectors. These plans should aim at assessing water resources and their optimum utilization.

B. Background

Water issues have been emphasized in many meetings and conferences at regional and interregional levels. Among these are the First Regional Water Meeting, held by the Economic Commission for Western Asia[1/] at Baghdad in 1976. The Second Regional Water Meeting was held at Riyadh in 1979, and the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region was held at Damascus in 1989. The Regional Symposium on Water Use and Conservation was held at Amman, from 28 November to 2 December 1993.

All activities were aimed at working out ways and means to achieve water security in the region, and to provide a water strategy action plan for policy makers.

Several regional and interregional organizations have been involved in various water-sector-related activities through the following:

1. Exchanging views and experiences on the application of new and appropriate technologies designed to augment water supply, increase efficiency in the use of water resources and achieve optimum water use;

2. Reviewing institutional and legislative organization of Governments to formulate and implement policies and programmes for the management, development and conservation of water resources in the region;

3. Reviewing and identifying means of cooperation and coordination among Governments for the development and utilization of shared water basins;

4. Assessing methodologies and techniques used in the ESCWA member countries in water policy-making, planning, management and conservation of conventional and non-conventional water resources;

5. Developing water strategy action plans and formulating appropriate recommendations and proposals for the consideration of the national and regional organizations concerned.

1/ Designated the Economic and Social Commission for Western Asia by Economic and Social Council resolution 1818 (LV) of 26 July 1985.

C. Scope and objective of the present report

In accordance with the work programme of the Natural Resources Division of ESCWA during the 1992/1993 biennium, the regional Symposium of Water Use and Conservation was recently held at Amman. The Symposium was aimed at examining ways of facing the growing demand for water resulting from the rapid socio-economic developments, as well as problems aggravated by the limited water resources in the region. The Symposium provided a forum for government officials, experts, analysts and decision makers to formulate plans and policies for the development, conservation, management and utilization of water resources, and to exchange views on appropriate mechanisms for promotion of regional and interregional cooperation in the water sector.

The documentation of the Symposium included the following:

(a) Working papers prepared by the ESCWA secretariat;
(b) Papers of the regional and international organizations;
(c) Country papers;
(d) Papers prepared by experts in related fields.

About 40 papers were presented to the Symposium and categorized under the following main themes:

(a) Water utilization and efficiency;
(b) Water resources planning and management;
(c) Regional cooperation and coordination in the water sector.

The present report was prepared to highlight the main issues tackled and discussed at the Symposium. The preparation of this report was also based on the findings and information gathered through direct contacts with government officials during the field missions undertaken to ESCWA member States.

Chapter I below describes methodologies employed in water sector planning and management in the region. The patterns for such planning are outlined in chapter IV. Water resources availability, use and demand management in addition to the role of non-conventional water resources in the region are presented in chapter II. Integrated basin-wide management is reviewed in brief in chapter III. Notes on water resources utilization and planning in selected ESCWA member States are contained in chapter V. Finally the report concludes with chapter VI, containing key findings and recommendations based on the Symposium papers and discussions.

I. WATER RESOURCES PLANNING AND MANAGEMENT IN THE ESCWA REGION

A. General observations

The continuously increasing demand for water and rapidly diminishing water supplies emphasize the need for more rational water sector planning. The water sector planning should be carried out within the context of national development goals and objectives. The planning process must recognize that the development in the water sector and other sectors is interdependent and mutually supporting.

The planning process should proceed with a good understanding of the national development goals, sectoral objectives, and planning horizon. The sectoral review should be carried out with specific objectives to generate information and data needed for the planning exercise. Alternative strategies should be formulated and tested to determine the best option for attaining the sectoral objectives. The selected strategy should clearly spell out the policies, programmes and projects. The financial requirements to implement the plan should be assessed to test the viability of the plan within the context of macroeconomic budgetary constraints.

Water sector planning requires an enormous amount of data which can be translated into demand and supply. The scarcity of reliable data in the ESCWA region about these demand and supply variables may not facilitate efficient water sector planning.

B. The state of the art

A substantive knowledge of all aspects pertaining to the water sector at national level is a prerequisite for water planning. Once basic information is developed within a systematic framework, comprehensive planning is possible. Such knowledge can be achieved through acquisition of the already compiled basic data on water, land and manpower resources, in addition to the new data to be collected after establishment of a minimum required monitoring network throughout the country. This will furnish an initial database and thus permit substantive resources assessment.

In other words, water planning at national level is only possible if the following questions can be answered.

(a) How much water is available in the short, medium and long term?

(b) What are the present use and the future demands in the same ranges?

(c) To what extent may the available and potential water resources satisfy these demands for all sectors?

This supply and demand approach for planning formulation may lead to the proposal of certain measures to cope with the prevailing situation such as:

(a) Exploring new sources to be exploited;

(b) Reallocating resources among various users;

(c) Controlling per capita and/or irrigation consumption rates and water demand in general;

(d) Conducting feasibility studies on the basis of these findings to ascertain possible alternative strategies.

The first two above activities have some social and political impact which have to be carefully dealt with in the master planning. The third embodies financial and institutional arrangements.

In line with the above, the overall work plan for water master planning is presented below (see charts I to VIII).

The work plan should be as comprehensive as possible so as to include all envisaged activities to achieve:

(a) A comprehensive water database;
(b) A sound monitoring system;
(c) An assessment of the available resources (water, land and manpower);
(d) Water use demand projections;
(e) Plan formulation accordingly.

It is worth noting here that plan formulation reliability is totally dependent on the availability of water sector data, and their adequacy and reliability. Therefore, the work plan will focus on data acquisition. Sound cooperation between public and private institutions active in the water sector at national level is required during the planning process. In addition, it must be kept in mind that water planning should not be rigid, so as to permit modifications and revisions in line with the availability of more data and/or the overall changes in socio-economic conditions at national level. This means that the final product of the work is a National Water Master Plan based on the available water sector data and socio-economic aspects prevailing during the master planning formulation.

In order to develop a water sector plan that is consistent with the overall national development plan, the following activities should be undertaken:

(a) Review of national development goals and objectives;

(b) Development of sectoral objectives and setting of preliminary growth targets to achieve national development goals and objectives;

(c) Carrying out of sectoral review, collecting relevant data and information, and revising growth targets;

(d) Defining planning horizon and making future projections about the sector's development;

(e) Describing and analysing alternative strategies for achieving planned targets for the sector;

(f) Formulating and analysing programmes to be carried out to achieve the sector's targets and objectives;

(g) Assessing financial requirements to implement the projects and programmes, including the yearly financial plan for the planned period and possible source of financing.

Although the above sequence of various activities provides a logical framework to prepare the sector plan, it does not mean that deviation from the suggested sequence cannot be made. The sequence only suggests that the information generated by one component can serve as an input to initiate and organize the work for the next component. The planning process can proceed simultaneously on more than one component, because the suggested components are interrelated and interact.

What follows is a brief review of each of the above required activities.

(a) <u>National development goals</u>

The term "planning" generally refers to the process of allocating scarce resources in a manner that will maximize the achievement of selected objectives. The development goals and objectives are most frequently defined in terms of high economic growth, better income distribution, less inflation, and high employment level.

(b) <u>Sectoral objectives and growth targets</u>

In order to accomplish the national development goals, the economy is divided into various economic sectors, and objectives and growth targets are set for each sector. There is a distinction between an objective and the target; the latter may be defined as the quantitative transformation of the former. The sectoral growth targets are generally rationalized on the basis of intersectoral relationships, the relative importance of a particular sector, and the potential availability of physical and financial resources.

(c) <u>Diagnostic surveys and sectoral review</u>

The diagnostic surveys and sectoral review studies to be carried out in support of water sector planning should collect and generate the following data and information:

(i) Data acquisition, analysis and review of the available literature;

(ii) Assessment of conventional (surface water and groundwater) and non-conventional water resources in terms of availability and reliability in quantity and quality;

(iii) Identification of water-consuming sectors, water requirements and projection of water demand;

(iv) Determination of the water supply/demand gap at national level;

(v) Provision of water development projects to bridge the gaps, considering the ongoing and planned water projects and scheduling of their financing;

(vi) Cost benefit analysis and feasibility studies considering the prevailing socio-economic conditions;

(vii) Survey of water losses and/or water use efficiencies in various water-consuming sectors and provision for possible water conservation measures including water legislation;

(vii) Identification of environmental impacts of water management practices;

(viii) Capacity-building infrastructures including institutional arrangements for water resources management, administration and master plan execution.

(d) Planning horizon and future projections

The planning exercise can be carried out for the planning horizon, which could be either short-term (annual plan), or medium-term (five-year plan), or long-term (10 years or longer plan). In most of the ESCWA member countries, medium-term planning is a common planning horizon. The medium-term plans can be reviewed periodically and adjusted to reflect changes in overall economics over time.

(e) Alternative strategies

In order to achieve an objective, or a target, or both, a development strategy is needed. The development strategy may be defined as a framework that consists of different policies, programmes, projects, and measures which help to attain a particular objective.

The selection of a particular strategy is mainly guided by the nature of the objective; therefore, before adopting a particular strategy, its usefulness must be examined and compared with other possible strategies within the context of the time horizon.

(f) Programmes for water resources development projects and policy formulation

The next step is to prepare a detailed programme of policies and projects which is consistent with the overall development strategy. In the whole planning process, policy making is a relatively complex and difficult task. Policy reforms introduced in one sector can easily influence the performance of other sectors. Therefore, before a policy is implemented, it is important to analyse its possible economic effects on other sectors of the economy. The projects proposed can be viewed as another variant of the policy. Sometimes projects are conceived and prepared in support of the policies formulated to achieve sector objectives. As such, the project can be viewed as an action measure to implement a policy.

(g) Financial assessments

The financial resources required to implement the plan during the planning horizon have to be assessed. Financial requirements should be projected over the planning period to identify the amount needed to implement plan activities and development projects in each year to facilitate annual updating of the sectoral budget, if needed, and to make intersectoral comparisons in terms of funds needed and development projects to be implemented. In the ESCWA region generally the financial resources are scarce; hence it is important to identify the possible sources of funding for

each activity defined in the plan. In addition, financial requirements should be examined against the national budget within the context of the socio-economic development goals and priorities.

C. Guidelines for diagnostic surveys and sectoral reviews

In order to work out a National Water Master Plan (NWMP) the following are the subjects of the main diagnostic surveys which have to be carried out:

1. Data acquisition and inputs;
2. Water resources monitoring;
3. Water resources assessment in quantity and quality including non-conventional resources;
4. Socio-economic and environmental analysis;
5. Water use and demand projections;
6. Water legislation and water rights inventory and assessment;
7. Institutional set-ups involved in each of the above activities.

These diagnostic surveys and their envisaged outputs as described in the following charts would lead to the formulation of a National Water Plan, with water use strategy based on adopted national water policy as well as the establishment of a Water Resources Database.

The components of the outlined diagnostic surveys are interrelated (see chart VIII).

Chart I: Activity I: Data acquisition, analysis and input

SUBACTIVITY	OUTPUT
Collection and analysis of data, reports, maps, aerial photos, satellite imageries (hydrology, meteorology, hydrogeology, geology, topography)	Creation of a comprehensive water database with nationwide coverage
Identification of computer facilities users, hard and software, methodology and manpower involved	Standardization of water data collection, processing, analysis, storage and retrieval
Inspection of data flow mechanisms	Computerized data flow system
Review and appraisal of adequacy, reliability of water data with relevance to water master planning	
Establishment of a comprehensive water data bank	Water data periodic dissemination

Chart II. <u>Activity II: Water resources monitoring</u>

SUBACTIVITY	OUTPUT
Description of existing monitoring systems for surface and groundwater (instrumentation, network density, operation and maintenance)	Report on current monitoring methods
Design of new system network, data collection and processing)	Proposal for physical extension of monitoring system
Identification of efficient monitoring system requirements (instrumentation, manpower, workshops)	Proposal for institutional set-up to maintain and operate the system
Final design, tender documents for station rehabilitation and construction of new stations	Construction of minimum required observation stations

Chart III. <u>Activity III: Surface water assessment</u>

SUBACTIVITY	OUTPUT
Identification of institutions, manpower involved, previous studies, available SW data, major surface water structures Review, assessment and evaluation of relevant literature and available SW data Field survey to check existing SW gauging stations Construction of relevant thematic SW maps onto earlier prepared base maps Analysis and interpretation of SW data and writing of technical reports	Surface Water Resources Report - Hydrology (rainfall, run-off, evaporation, sediment loads, water quality); - Present and potential use of SW resources; - Proposal of action programmes: . Further studies; . SW development projects; . SW legislation, administration and . monitoring; - Annexes and maps

Chart IV. Activity IV: Groundwater assessment

SUBACTIVITY	OUTPUT
Identification of institutions, previous studies, available GW data, drilling activities	
Inventory, evaluation and appraisal of relevant literature and records and of hydrogeological set-up in each basin within the country	Groundwater Resources Report
Conducting complementary studies (geophysics, pumping test, simulation modelling) as needed	- Geologic set-up - Hydrogeology - Groundwater quality - Constraints and problems in the field of GW development, management and administration
Construction of relevant thematic GW maps onto earlier prepared base maps	- Proposal of action programmes: . Further investigations; . Legislation; . Control measures;
Analysis and interpretation of GW data and writing of technical reports	Annexes and maps

Chart V. Activity V: Socio-economic survey

SUBACTIVITY	OUTPUT
Identification of major factors governing socio-economic development and prospects; delineation of the various development regions and population centres	Report on: Aspects of regional development; - Presentation of regional structures and their socio-economic properties
Cost-benefit analyses of major projects envisaged in the development plans (with special attention to water availability on a national scale	- Criteria for project priorities (in the light of project water demand and local water availability);
Interpretation and analysis of socio-economic data and report writing	- Description of major development projects and explanation of their priorities.

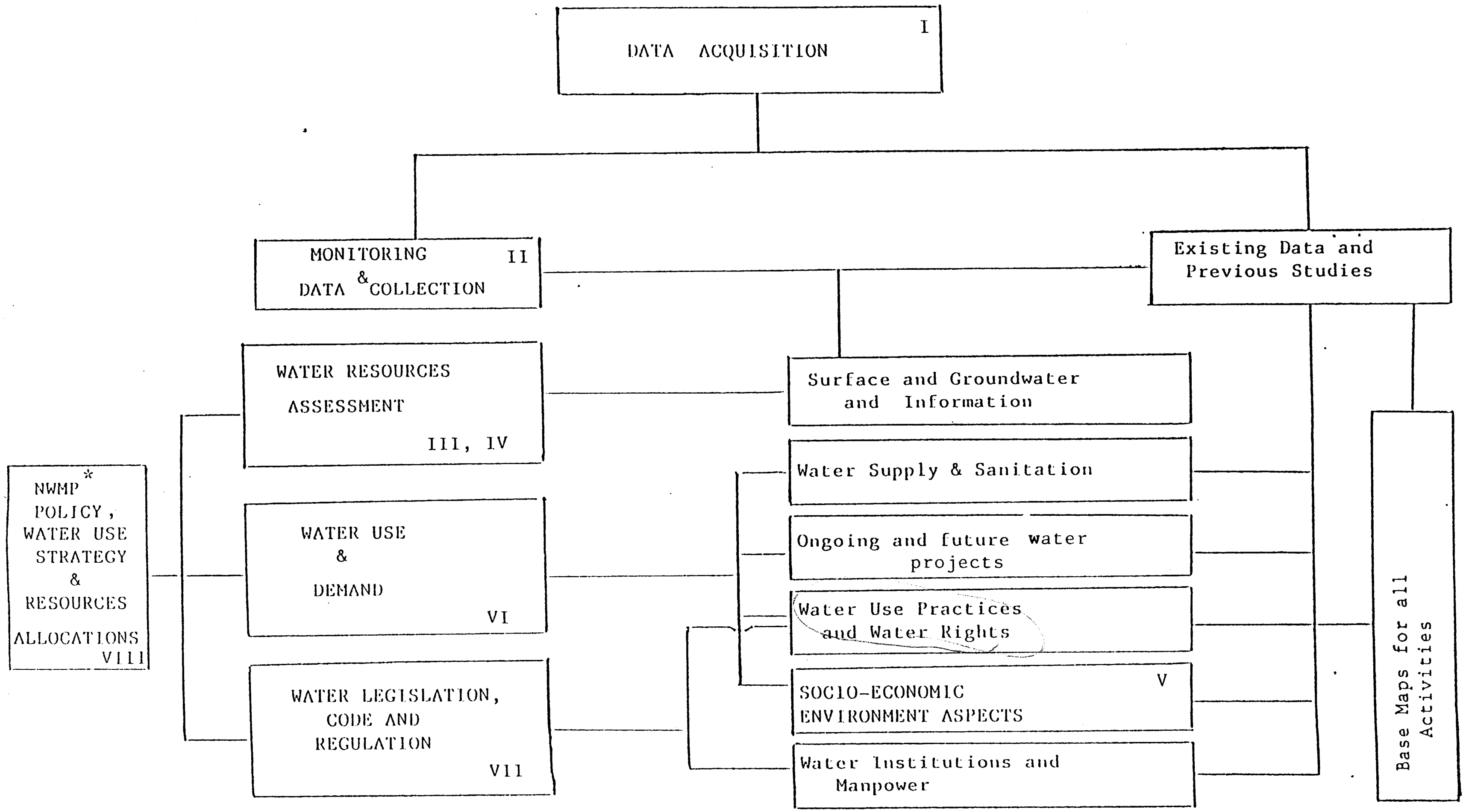
Chart VI. Activity VI: Water use and demand

SUBACTIVITY	OUTPUT
Determination of per capita, irrigation (per ha) and industrial water demand. Estimation of present and future water use and demand in line with socio-economic prospects, up to certain planning horizons	Report on: - Domestic/industrial water demand; - Present water consumption and projected demand; - Net and gross irrigation water demand, irrigated acreages, total usages (present, projected)
Description of the existing public and private water supply systems (sources, consumption centres, institutional set-up, O&M mechanisms)	- Existing water supply system
Description of waste disposal/treatment facilities (institutional set-up, O&M mechanisms, possibilities of water reuse, identification of protection areas)	- Sewage disposal and treatment plants - Water pollution and control measures for environmental protection
Overall assessment	- Description of major agricultural projects in terms of long-term water availability - Action proposals for water resources allocation to meet water requirements

Chart VII. Activity VII: Water legislation

SUBACTIVITY	OUTPUT
Identification of existing water use systems, allocations, traditional practices and water rights	
Assessment and evaluation of registered water rights, their constraints, problems and possibilities for improvement	
Review of the existing institutional set-up for water resources management from a legal point of view	Setting up rules, water code and regulations to conserve, manage and administer the national water resources within the framework of the Master Plan
Drafting of water legislation, water code, regulations and appropriate protection measures	Proposing a draft legal process and procedures to be adopted by the public and private sectors

Chart VIII. **Interrelationship of the main activities for water sector planning**



* National Water Master Plan.

<u>Note</u>: I-VIII denote activities in charts I-VIII at the present study.

II. WATER USE AND CONSERVATION

A. Available water resources in the region

The estimated available water resources, based on the various hydrological and hydrogeological investigations carried out in the region, may be summarized in table 1 below.

Table 1 provides an idea of the importance of the close relation that exists between water resources availability and present and future water demands. Many member States in the ESCWA region will reach their development limits by the year 2000, owing to the acute water shortages which are even now a reality in the GCC member countries, Jordan and Yemen. In other cases, the estimated demand for agricultural water will not be met at all, preventing some countries from achieving food self-sufficiency, if present regional water-use practices continue.

It is worth mentioning here that the available surface-water resource figures shown in table 1 for both the Syrian Arab Republic and Iraq, and to a certain extent for Egypt and Jordan, may not apply in future, owing to the water-resources development activities which are being practised in the neighbouring upstream countries sharing the same water sources and to the absence of registered riparian rights.

The volumes of the available groundwater resources shown in table 1 are based mostly on reconnaissance investigations. Groundwater over-exploitation due to excessive and uncontrolled pumping, as well as deterioration in water quality, are common features observed in many regional basins such as those in Jordan, the Syrian Arab Republic, Saudi Arabia and Yemen. Groundwater quality is deteriorating due to sea water intrusion into the coastal plains aquifers in Yemen, Oman, Bahrain, the United Arab Emirates and Qatar. All these factors have resulted in a progressive reduction in available groundwater resources in the ESCWA region, to the extent that sustainable agricultural development may be hindered in the future. Expensive non-conventional water resources are being produced in desalination plants to meet the increasing water demands in the region, particularly in the GCC member States. Surface water resources are increasingly vulnerable to pollution from agricultural practices or waste disposal.

Great efforts are being made in the ESCWA region to develop additional water resources. In all large river basins, major storage reservoirs have been built or are under construction (the Euphrates, the Nile and the Tigris); in other parts of the region (the Syrian Arab Republic, Jordan and Saudi Arabia) a number of smaller dams are at different stages of planning or execution. In addition to the large river basins shared by several countries which form the main water resources for these countries, there are 37 groundwater basins considered as shared basins.

In the ESCWA region, as mentioned above, water is a strategic resource. The interrelatedness of the region's water resources makes cooperation imperative but, unfortunately the countries involved have a poor record of regional cooperation.

Table 1. Estimated water resources supply, demand and balance in the ESCWA region
(In million cubic metres [MCM])

country	1	2	3	4(1-2)	5	6	7(1+5)	8(1+6)	9(7-2)	10(8-3)
		Estimated			Non-conventional water resources		Total available water resources		Estimated balance	
	Available water resources	Water use (1990)	Water demand (2000)	Water balance (1990)	1990	2000	1990	2000	1990	2000
Bahrain	220.00	308.00	400.00	-88.00	71.00	186.00	291.00	406.00	-17.00	6.00
Egypt	59 000.00	60 100.00	70 609.00	-1 100.00	7 000.00	7 500.00	66 000.00	66 500.00	5 900.00	-4 109.00
Iraq	43 500.00	49 420.00	53 830.00	-5 920.00	..	..	43 500.00	43 500.00	-5 920.00	-1 0330.00
Jordan	910.00	917.00	1 548.00	-7.00	37.00	87.00	947.00	997.00	30.00	-551.00
Kuwait	217.00	329.00	675.00	-112.00	356.00	547.00	573.00	764.00	244.00	89.00
Lebanon	2 800.00	1 002.00	2 300.00	1 798.00	..	..	2 800.00	2 800.00	1 798.00	500.00
Oman	1 658.00	1 231.00	1 255.00	427.00	66.00	86.00	1 724.00	1 744.00	493.00	489.00
Palestine (PLO)	710.00	..	520.00	..	..	..	710.00	710.00	710.00	190.00
Qatar	112.00	196.00	286.00	-84.00	198.00	274.00	310.00	386.00	114.00	100.00
Saudi Arabia	5 546.00	8 670.00	14 627.00	-3 124.00	1 160.00	1 534.00	6 706.00	7 080.00	-1 964.00	-7 547.00
Syrian Arab Republic	26 640.00	9 000.00	26 152.00	17 640.00	177.00	177.00	26 817.00	26 817.00	17 817.00	665.00
United Arab Emirates	1 962.00	1 986.00	2 170.00	-24.00	402.00	402.00	2 364.00	2 364.00	378.00	194.00
Yemen	2 265.0	2 899.00	3 971.00	-634.00	9.00	12.00	2 274.00	2 277.00	-625.00	-1 694.00
Total	145 540.00	136 058.00	178 343.00	16 538.00	9 476.00	10 805.00	155 016.00	156 345.00	18 958.00	-21 998.00

Sources: Economic and Social Commission for Western Asia, "Progress Achieved in the Implementation of the Mar del Plata Action Plan in the ESCWA Region" (E/ESCWA/ENR/1992/5), updated; National papers submitted to the Fifth Meeting of the Permanent Arab Committee on the International Hydrological Programme (IHP), Cairo, 9-11 November, 1992; and Direct consultation with government authorities during missions undertaken to ESCWA member States.

Notes: Brackish groundwater predominates in the Arabian Peninsula. The flows of the Tigris and Euphrates rivers will be reduced by upstream abstraction in Turkey. Some figures on water resources and water demand are not confirmed, but are based on reconnaissance surveys.

B. Conventional water resources

It is becoming more and more evident to decision makers in the countries of the ESCWA region that conventional water resources, surface and groundwater constitute potential national assets that are vital to almost every phase of the economy.

1. Surface water resources in the ESCWA region

Surface water comes out from rainfall, rivers, springs and lakes. Surface run-off amounts to only about 15 per cent of rainfall. Only 3 per cent of this amount can be developed by constructing dams and water structures.

Main rivers in the ESCWA region receive 60 per cent of their water from outside the region. Because of this and for political and economic reasons, the full utilization and development of potential resources of such rivers are not possible.

Surface water resources yield produced internally in the ESCWA region is about 39.8 billion m^3 (8 per cent of the total annual rainfall). To this amount is added 136.5 billion m^3 from international rivers originating from outside the region. The amount of surface water thus totals 176.3 billion m^3 as shown in table 2 below.

Table 2. The surface water resources in the ESCWA region

ESCWA region	Internal yield (billion m^3)	Yield from outside ESCWA region (billion m^3)	Total (billion m^3)
Syrian Arab Republic, Iraq, Jordan, Lebanon and Palestine	30.8	81	111.8
Arab Peninsula (United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar, Kuwait and Yemen)	9 from seasonal wadis	..	9
Egypt		55.5	55.5
Total	39.8	136.5	176.3

Source: M.A. Abu-Zeid, "Evaluation of existing status for water resources in Arab nations", paper prepared for ACSAD (Arab Center for the Study of Arid Zones and Dry Lands), June 1993.

Seasonable flow in wadis is limited and irregular. It is not subject to regular water measurements, and is not evaluated. There are not many national lakes in the ESCWA region; some of them are connected directly to the sea; others are isolated. Excluding Lake Nasser, in general these lakes have high saline water content. Water gets to these lakes from seepage of groundwater and rainfall.

2. Groundwater resources

Groundwater exists in different aquifer systems; the amount varies depending on the aquifers' geological structure, hydrological and hydrogeological characteristics and the extent of their areal distribution. It has been noted that some of the hydrogeological groups in the ESCWA region are connected to each other and feed some other aquifer systems according to the piezometric pressures in each of them. Physical feeding resources are different from one aquifer system to another and from site to site according to the difference in porosity, recharge and yield.

In the ESCWA region, there are shared groundwater basins which vary in the range of their geographic extensions. Some of them have limited extensions, some have medium extensions, and some have large extensions. The most important shared basins with a huge groundwater reservoir are:

(a) East Mediterranean Basin: This basin covers an area of 48,000 km^2 extending through the Syrian Arab Republic, Lebanon, Jordan and Palestine. This basin feeds rivers: Lebanese rivers (Orontes, Litani and others) and the Jordan River, which represents the major drainage area of this basin.

(b) Horan and Arab mountain basin: This basin covers an area of 15,000 km^2 extending through the Syrian Arab Republic, Jordan and Saudi Arabia. The Golan plateau constitutes the physical water resources for this basin which is considered as a main source of the Yarmouk and Azrak basins through the springs of Mazreeb, El-Hamza and El-Azrak.

(c) East Arab Peninsula Basin: This basin covers an area of 1.6 million km^2 extending through the Arabian Gulf, the Syrian Arab Republic, Iraq, Jordan and Yemen. Rainfall is the main water resource at the north of the basin and feeds the eastern section of the basin.

(d) Nubian Sandstone Basin: This basin covers an area of 2 million km^2 extending through Egypt, the Libyan Arab Jamahiriya, the Sudan and Chad. It has a huge groundwater reservoir though limited feeding from Chad and the Sudan, and perhaps the Ethiopian Plateau. Springs, oases and depressions represent the major drainage areas of this basin.

C. Non-conventional water resources

ESCWA countries in general, and especially the GCC member countries, are heavily dependent on non-conventional water resources for their water supply, particularly on expensive brackish and sea water desalination and treatment of sewage effluent to meet the excessive demand for water.

Table 3. Groundwater resources in the ESCWA region

ESCWA region	Yield recharge (billion m^3)	Underground storage (billion m^3)
Syrian Arab Republic, Iraq, Jordan, Lebanon and Palestine	5.75	12
Arab Peninsula (United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar, Kuwait and Yemen)	4.71	859.5
Egypt (from Nubian Sandstone basin)	4.5	6 500
Total	14.96	7 371.5

Source: M.A. Abu-Zeid, "Evaluation of existing status for water resources in Arab nations", paper prepared for ACSAD (Arab Center for the Study of Arid Zones and Dry Lands), June 1993.

In the light of the limited water resources available in most member States of the ESCWA region, the augmentation of the conventional water supplies by non-conventional water development techniques has become an overriding concern in the region. Present technologies have made desalination viable, matching to a great extent the high quality of freshwater resources. Therefore, brackish and sea water desalination can substantially reduce the overall water scarcity in the region.

1. The use of desalinated water in the region

Under the prevailing economic and technical conditions, sea and brackish water desalination is to be a viable means of increasing the supply of freshwater. Hence, desalination offered an expedient solution to help to bridge the gap in areas short of water in oil-producing countries, and in meeting the excessive demand for water over the last decade. Raw water delivered to a desalination plant may be divided into the following broad categories:

1. Sea water, which generally has a constant composition ranging from 35,000 to 45,000 mg/l of dissolved solids;

2. Brackish water, which is defined as having no more than 10,000 mg/l of dissolved solids;

3. Wastewater, which is available from a variety of sources and has a wide range of both types of dissolved impurities and their concentrations.

The largest desalination centre, on a global scale, is situated in Al-Jubail in the eastern province of Saudi Arabia. In this location alone, more than one third of Saudi Arabian desalinated water, and 7.6 per cent of

the total world capacity is produced. In addition, in this centre lies the world's largest desalination facility in operation, consisting of 40 MSF units producing close to 1 million cubic metres. In the RO field a (34 MGD) plant is under construction, in Yanbu. From the Jubail Desalination Centre, desalinated water runs in two huge transmission pipelines (60 inches in diameter). The first has a capacity of 830,000 m^3/d, that goes as far as Riyadh (465 km from Jubail). The second, 389 km long, delivers water to Qassim with a capacity of 380,000 m^3/d, unique in this respect. Saudi Arabia has water pipelines that have a total length of over 3,000 km, and total capacity of 1.8×10^6 m^3/d (475 MGD).2/

Out of 15.58 million cubic metres per day, worldwide installed desalination capacity, GCC member countries contribute almost half (49.5 per cent) of the total (see table 4). Saudi Arabia alone houses about half of the GCC desalination capabilities amounting to about one fourth of world capacity. Three of the GCC member (Saudi Arabia, Kuwait and the United Arab Emirates) rate first, third and fourth respectively with regard to their desalination capabilities, with the United States coming second.

With respect to individual processes, more than 80 per cent of GCC desalinated water is produced by MSF distillation units, followed by RO which contributes 16.1 per cent. This corresponds to more than three fourths of total MSF world capacity and about one fourth of that of RO. However, the GCC countries' share in MED, ED, VC and other processes are 4.5 per cent, 16.4 per cent, 16.6 per cent and 5.5 per cent respectively.

New technologies such as membrane distillation are coming into the desalination market-place. It is claimed that membrane distillation can produce permeate of 0.2 to 0.6 MS/cm regardless of the feed water quality. Ceramic RO membranes are said to tolerate very high amounts of suspended solids in the feed water. These technologies are very promising and can widen the application of desalination to include wastewater and raw sewage.3/

Water obtained by desalination of sea water is considered a net addition to the water budget of a country or a region. Therefore, it is prudent to take this important factor into consideration when making financial evaluations of the cost of water desalination. Any quantity of high quality freshwater that is added by desalination to a water-use system can be considered to have multiplied reuse effects.

Desalination of brackish water is less costly and more flexible especially with regard to removal of dissolved salts. This means better management of the water product and can permit multiple reuse cycles in industry and then for irrigation. Even more than two reuse cycles for the water are possible: namely, first as potable water, then as treated sewage for industrial cooling and other uses, and finally for irrigation.

2/ ESCWA, "Water desalination, the experience of GCC countries", paper presented at the Regional Symposium on Water Use and Conservation, Amman, 28 November-2 December 1993 (E/ESCWA/NR/1993/WG.1/WP.10).

3/ Murad J. Bino, "The role of nonconventional water resources to augment conventional ones in ESCWA region", paper presented at the Regional Symposium on Water Use and Conservation, Amman, 20 November-2 December 1993 (E/ESCWA/NR/WG.1/WP.9).

Table 4. Installed capacity of desalination units worldwide and in GCC member countries

	MSF m^3/d	%	RO m^3/d	%	MED m^3/d	%	ED m^3/d	%	VC m^3/d	%	OTHERS m^3/d	%	TOTAL m^3/d	%
Worldwide	7994244	513	5080207	32.6	882254	4.7	727940	4.7	583270	4.3	221534	1.4	15582443	100
GCC countries														
Saudi Arabia	2678135	33.5* / 70.5**	954009	18.8 / 25.1	16456	1.8 / 0.4	95638	13 / 2.5	49578	8.5 / 1.3	7213	3 / 0.2	3800029	24.0 / 100
United Arab Emirates	1503745	18.8 / 90.9	93692	1.8 / 5.7	8266	0.9 / 0.5	5102	0.7 / 0.3	41552	7.1 / 2.5	2800	1.2 / 0.1	1655157	10.5 / 100
Kuwait	1350514	16.9 / 95.55	51783	1.0 / 3.7	4904	0.7 / 0.35	4493	0.6 / 0.3	150	- / -	1766	0.7 / 0.1	1413610	8.9 / 100
Qatar	386025	4.8 / 97	4715	0.1 / 1.2	3642	0.5 / 0.9	896	0.1 / 0.2	1994	0.3 / 0.5	917	0.4 / 0.2	398189	2.6 / 100
Bahrain	160820	2 / 54	119343	2.3 / 40.1	1175	0.1 / 0.4	13914	1.9 / 4.6	2589	0.4 / 0.9	-	- / -	297841	2.5 / 100
Oman	134645	1.7 / 83.9	19336	0.4 / 12	4200	0.5 / 2.6	719	0.1 / 0.5	1504	0.3 / 0.9	177	0.1 / 0.1	160581	1.0 / 100
Total (GCC)	6213884	77.7 / 80.4	1242878	24.4 / 16.1	38643	4.5 / 0.5	119762	16.4 / 1.6	97367	16.6 / 1.2	12873	5.5 / 0.2	7725407	49.5 / 100

Source: Economic and Social Commission for Western Asia, "Water desalination and the experience of GCC countries", paper presented at the Regional Symposium on Water Use and Conservation", Amman, 28 November - 2 December 1993.

* Percentage of world capacity.
** Percentage of total capacity produced in a GCC country.

The salt content of water is the most important single parameter that affects the cost of water desalination and limits its reuse cycles. This is especially true in arid and dry countries. The soils in an arid climate are considerably more saline than soils in humid countries. The impact of all this is when the water is reused. Therefore, the salinity and alkalinity of non-conventional water in relation to agricultural reuse are also important factors.

Desalination, especially by RO, is always accompanied by a disposal of a reject concentrated saline stream. This is not a serious problem when a desalination plant is located at the seashore. Inland desalination of brackish water can create disposal limitations and if the brine or reject stream is not managed properly can affect nearby shallow aquifers. This is a typical problem faced by power generation plants and petroleum refineries in Jordan and other countries in the region.

Desalinated water is considered the main source of non-conventional water in ESCWA member countries classified in group I. It will be the only freshwater source in Bahrain, Qatar, and the United Arab Emirates. Jordan will soon have to desalinate brackish groundwater on an ever increasing scale in order to supply drinking water.

2. Wastewater reuse in the ESCWA region

The practice of reclaiming wastewater for reuse is not new in ESCWA countries. The disposal of sewage effluent into a river is frequently followed by abstraction from the same river at a downstream location for water supply purposes. This is despite the fact that the river flow has removed any natural purification, as the majority of the contaminants are discharged with the effluent. This type of indirect reuse is practised in Iraq, Egypt, Jordan, Lebanon, the West Bank and the Gaza Strip. But in the Gulf countries, where there are no rivers, such conditions would lead to the use of reclaimed water directly.

It is not known if there is any country in the region where wastewater reuse is not acceptable, because the use of running wastewater in wadis is widely acceptable as a cultural norm. However, residents living in a locality where wastewater treatment plants are proposed may raise objections. The reasons for their objections are mostly economic and environmental and are not based on social, or cultural norms, because the treatment plants will reduce the value of the land adjacent to the treatment site. The landowners usually do not receive fair compensation for the reduced value of the land nor are they given priority either to use the final effluent or to be employed at the project even though the aesthetic appearance of the area deteriorates and there are the inconveniences of the unpleasant odour and other environmental nuisances.[4/]

The religious authorities have ruled that the use of reclaimed water is an acceptable practice in agriculture and in industry as well as for all other purposes excluding domestic uses.

4/ ESCWA, "Potential and existing treated wastewater reuse in selected ESCWA countries", paper presented at the Regional Symposium on Water Use and Conservation, Amman, 28 November - 2 December 1993 (E/ESCWA/NR/1993/WG.1/WP.8).

At the end of the International Drinking Water Supply and Sanitation Decade, sewer services coverage in the region was as shown in table 5 below, which shows the percentage of wastewater as projected by the year 2025 compared with renewable water resources. In Saudi Arabia, Jordan and Yemen, the percentage is 142, 28, and 18 respectively and all of the quantities in Kuwait, Bahrain and Qatar are produced through desalination. From the chemical point of view, this means that the reclaimed water will be of good quality for agricultural production. The water quantity to be produced in 2025 would be sufficient to produce food for 17 million people which would be equivalent to 6 per cent of the population in 2025.5/

(a) Types of wastewater reuse in the region

In most of the ESCWA member countries sewage effluent provides a convenient and economic source of water for irrigation. In the last decade there has been a significant move to minimize health risks and use the treated effluent with the highest possible efficiency. In addition to the wastewater being reused, the nutrients can be recycled through irrigation. This will protect water bodies from eutrophication and will at the same time use the fertilizer value in the reclaimed wastewater to meet the fertilizer requirements of a wide range of crops, but care needs to be taken that the fertilizer value should not be too high for some supplementary crops. It is noteworthy that at least eight ESCWA member countries operate modern wastewater reuse facilities to yield agricultural products; a great effort is being made to expand these facilities to bring more land under cultivation. This will also contribute to combating desertification by irrigating green belts, roadside trees, public greenery in parks, landscaping, forestry, ornamental trees and bushes to beautify cities.

All countries are practising wastewater reuse for irrigation, and at least 6 out of the 13 countries in the region are currently practising wastewater reuse in an unplanned, uncontrolled, direct reuse for irrigation. In Yemen, Lebanon, Palestine, the Syrian Arab Republic and Egypt, raw sewage is being applied to farms including those producing salad vegetables; this practice, of course, has been condemned by the health officials in these countries and will produce adverse effects on public health in addition to other environmental impacts.

Two thirds of the population of Lebanon reside in the coastal settlements. These settlements are polluting the adjacent Mediterranean seashore and causing health hazards by discharging raw sewage into the coastal front. All sewer networks, which serve about 50 per cent of the population, have been poorly maintained for the last 18 years. Sewers have been blocked and damaged; they are overflowing and leaking, thus polluting ground and surface domestic water and causing health risks. Similar conditions exist in the West Bank and the Gaza Strip.

In the Gulf States, however, the aim is to achieve a high quality standard effluent for irrigation for gardening through secondary and tertiary treatment.

5/ Ibid, p. 6.

Table 5. Wastewater production in Western Asia

Country	% Urban population	Sewage generation L/cap/d			% population served			Sewage generation MCM/Ar		
	2000	1995	2000	2025	1995	2000	2025	1995	2000	2025
Bahrain	87	415	430	450	58	65	90	53	69	148
Egypt	55	130	187	200	45	55	65	1264	2353	4287
Iraq	79	110	115	125	40	50	75	360	558	1710
Jordan	74	80	85	100	52	60	85	76	102	307
Kuwait	97	200	210	250	85	90	95	146	190	328
Lebanon	87	150	155	165	50	55	75	33	47	142
Oman	35	192	200	250	15	18	32	26	73	139
Qatar	91	220	225	235	65	70	92	23	29	68
Saudi Arabia	82	200	225	235	70	72	85	875	1219	3263
Syrian Arab Republic	68	150	155	165	55	65	80	451	650	1642
United Arab Emirates	78	200	210	225	70	85	90	91	127	196
Yemen	50	40	55	65	30	35	55	61	116	451
West Bank and Gaza Strip	80	70	75	85	30	35	70	12	18	66

Source: Economic and Social Commission for Western Asia, "Potential and treated wastewater reuse in selected ESCWA countries", paper presented at the Regional Symposium on Water Use and Conservation, Amman, 28 November - 2 December 1993 (E/ESCWA/NR/1993/WG.1/WP.8).

Modern operational wastewater reuse facilities are currently functioning in seven countries of the region, namely Bahrain, Jordan, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. Egypt was the first country to use primary treatment sewage in a direct and planned manner. This operation was started in Cairo in 1911 and has been used ever since to irrigate Jabal Al-Asfar, covering an area of about 1,260 hectares.6/ The first planned and monitored reuse facility in Kuwait started operations in 1970.

In Jordan the major indirect reuse scheme was started in 1969 when the sewage treatment plant at Ain-Ghazal was established. Later the activated sludge system at Ain-Ghazal was replaced by the largest waste stabilization pond system (WSP) in the region. The effluent from the Al-Samra WSP treatment plant is blended with rainwater in King Talal Dam. The proportion of treated effluent is more than 30 per cent of the total yield from the Zarqa river feeding the Dam. The water from the Dam is released through a network to irrigate parts of land in the Jordan Valley without any restrictions on crop selection or types of irrigation systems. The cropping pattern of these lands is 70 per cent vegetables, 18 per cent cereals, and 12 per cent fruit trees. In addition, a portion of water from the Zarqa river upstream of the Dam is used for restricted irrigation of about 500 hectares.7/

Using reclaimed wastewater in urban areas is not practised so far, but it appears that reclaimed wastewater reuse in urban areas for toilet flushing and street-cleaning is feasible, especially because the majority of ESCWA member countries face an increasing growth of high-rise buildings, where reuse for toilet flushing is a promising option, since it is the most economic application method for highly populated urban areas, if there is no agricultural area nearby. In the ESCWA region there are three cities of over 3 million people, according to 1992 statistics, where this method can be applied.

Another method of reusing reclaimed wastewater in the region is by recharging the groundwater resources directly or indirectly. This method involves injection or surface spreading, thus permitting the water to percolate into the unsaturated groundwater zone. By this method the groundwater supply may be replenished in the vicinity of metropolitan and agricultural areas, where groundwater overdraft occurs, or where sea water intrusion exists. This method is an effective barrier, but intensive precautionary measures should be taken to prevent health hazards and the contamination of the aquifer.

The Egyptian cities of Ismailia and Suez have waste stabilization pond systems with a capacity of 90,000 cubic metres per day; the Jordanian city of Aqaba also has a pond system with a capacity of 9,000 cubic metres per day. The final disposal system for all these cities is to the aquifer via rapid infiltration basins. In Oman recharge via infiltration is also planned. It is anticipated that withdrawal will be made from the aquifer for agricultural use.8/

6/ Ibid., p. 7.

7/ Ibid., p. 8.

8/ Ibid., p. 9.

Table 6 summarizes current types of reuse in the Western Asia region and describes the level of treatment and restriction regulations on the crop selection and whether or not there is a discharge into the sea of raw or treated wastewater.

(b) Regulation and guidelines for wastewater reuse in selected ESCWA member countries

Wastewater reuse was always a side benefit gained from sanitation projects. There were a few projects where reuse was considered from the beginning as an integral part of the sanitation project. Owing to this fact, most of the guidelines concerned effluent standards to control the quality of discharge and were thus an indirect restriction on effluent discharges.

In most cases these guidelines to guarantee a minimum quality of water are easy to administer; however, a major criticism of effluent standards has been that the application of a uniform effluent standard can be uneconomical, because of the great variations in the final beneficial usage.

The standards adopted in most ESCWA countries are based completely on the State of California standard. Their validity is not checked or reviewed according to the current situation in the country. They are, therefore, considered inappropriate, too stringent and not sound environmentally or economically.

Stream standards must be imposed, especially if a sizeable population downstream from the wastewater discharge point depends on a river for their potable water or the water is used for recreation or fish-raising. The stream standards are applicable in Egypt, Lebanon, the Syrian Arab Republic and, to a lesser extent, in Jordan. However, these standards must be based on using the total assimilative capacity of the river or wadis as well as the minimum water quality level for the predominant water reuse. The regulations and guidelines to direct the reuse of reclaimed water have only lately been given proper attention, after it was realized that there are health and environmental problems associated with the reuse of raw or improperly treated wastewater. Therefore, water reuse standards must protect the public and the environment.

In 1982 (one year before the use of irrigation with treated water was put into practice) the Saudi Arabian Ministry of Agriculture and Water in Riyadh put forward a proposal for guidelines to be followed by farmers using the water. The guidelines were basically for a restricted use to irrigate non-vegetable crops--wheat, fodder, date palms and fruit trees--and were aimed at protecting the public from any adverse effect from contaminants and transmission of diseases during water reuse.

The following points summarize the guidelines:

(a) No vegetable can be irrigated with treated wastewater, including vegetables eaten fresh or cooked;

(b) Farmers who wish to grow vegetables on the same farm where wastewater is used are obliged to have a separate irrigation network for the vegetables, and preferably an underground piping network;

Table 6. Summary of existing and proposed reuse installation in Western Asia

Location	Reuse application						Level of sewage treatment			Policies	BOD:
	Roads	Parks	Industrial	Aquaculture	Agriculture	Aquifer recharge	Primary	Secondary	Tertiary		
Bahrain					*				*	O_3+ restrict	10:10
Egypt				*	*	*	*	*		Not decided	--
Iraq							*	*		To river	40:60
Jordan					*	*		*		Restricted	30:30
Kuwait					*			*	*	Restricted	10:10
Lebanon					*		*			Not decided	--
Oman	*				*	*		*	*	Restricted	10:10
Qatar	*	*			*				*	Trickle irrigation with public access	10:10
Saudi Arabia	*		*		*			*	*	Restricted; O_3	10:10
Syrian Arab Republic					*		*	*	*	Not decided	--
United Arab Emirates	*	*			*		*	*	*	O_3+	10:10
Yemen					*		*	*		Not decided	--

Source: ESCWA, "Potential and existing treated wastewater reuse in selected ESCWA countries", paper presented at the Regional Symposium on Water Use and Conservation, Amman, 28 November - 2 December 1993 (E/ESCWA/NR/1993/WG.1/WP.8).

Note: O_3 = Ozonation.

(c) The farmer signs a document that he understands these rules, and any violations on his part would lead to the cut-off of the treated water for his farm until the vegetable crop is removed;

(d) The treated water is distributed to farmers free of charge and the farmer is expected to cooperate with Ministry officials by giving information on cropping patterns on the farm and any changes that might take place.

In Egypt, Water Law 48/1982, and Ministerial Order No. 8/1982 for the protection of the Nile River provide a legal framework for treated wastewater guidelines. The code prohibits the use of raw sewage in agriculture and in irrigation of vegetables eaten raw. The Ministry of Irrigation is authorized to impose discharge standards for discharge into the river and canals.

III. INTEGRATED BASIN-WIDE MANAGEMENT

Given the lack of available water, management of water utilization is essential. Basin-wide management should be established through appropriate institutions responsible for the formation, measuring, forecast, distribution, reuse, control, protection and development of water resources (surface, underground, etc.) within the boundaries of the basin. Management includes collection of all information about the water resources and water requirements, control of operations, and taking into account changes caused by economic, social, climatic and hydrological conditions. Organization of such activities should consider the consumption of the different users.

A. Management of water supply

Water utilities in the large Arab cities within the ESCWA region have in the past been notoriously inefficient, with enormous quantities of water "unaccounted for". Millions of people live in the margins of cities. Uncontrolled solid and liquid waste disposal has put an enormous burden on the ability of urban water utilities to keep up with the demand of those inhabitants for good quality water.

Water supply systems represent large capital investments which should be protected by adequate and effective maintenance procedure. Inadequate maintenance leads to a slow deterioration of facilities, and consequent unreliability, failure and/or need to replace large parts of the original investment. One of the consequences of poor maintenance practices is a high incidence of leakage throughout the distribution system. Although many leaks can be repaired in a cost-effective way, prevention is always preferable to repair. Visual evidence of such leaks is rare. Detecting leaks requires a systematic long-term programme using portable flow-measuring instruments and other technologies. After the entire distribution system has been checked using at least one method, the frequency of monitoring can be adjusted to needs.

Municipal water supplies can be categorized for the following uses: (a) residential (household) water use (bathing, drinking or cooking) and for outdoor use (watering lawns, washing cars or filling swimming pools); and (b) public water use including fire-fighting and maintenance of public buildings and grounds.

The International Drinking Water Supply and Sanitation Decade, 1981-1990, had as a goal access to clean drinking water and sanitation services for all by the year 1990. The first priority was to improve efficiency in municipal water utilities, which often have volumes of unaccounted for water amounting to up to 50 per cent of the total water supplied in some of the largest cities of the ESCWA region. Improving efficiency would make more water available to expand services, postponing the need for construction of new facilities.

Inadequate operation and maintenance procedures have been a major stumbling block in the improvement of water supply and sanitation services. An obstacle facing many countries is that financing and institutional capacity have not been available for operation and maintenance of installed systems.

For water conservation methods and pricing policies to be effective, the water systems must be perceived as reliable. Where water deficiencies or operational problems result in intermittent loss of water pressure, users are motivated to save water, and appeals for conservation may not be needed. The tendency is to use water liberally when available. Intermittent water supplies are common in many cities of the region, both because of maintenance breakdown and as a way to reduce peak demands and postpone major expansions of water supply.

Neglect or misuse of valuable and scarce water can adversely affect the prosperity of inhabitants and hinder the overall economic development of the region.

The most insidious result of increasing industrial demand is the thermal pollution and the discharge of untreated industrial waste into the streams of the region. Traditional industries, including food processing, tanneries, sugar cane milling, petroleum industry, and oilseed production, pose as much a threat to the countries of the ESCWA region as more modern industries do. Localized pollution from agro-industrial operations has contaminated huge amounts of freshwater and fisheries and has become a major problem in many countries. The rapid increase in the number of urban centres in many developing countries has created a severe strain on the availability of safe water in large cities.

Industries use mainly "once-through" processes, with little thought to recycling or in-house water treatment. Toxic effluents are often disposed of directly into the watercourses, causing existing water supplies to become contaminated.

Many industries could alter the amount of water used through process modification, water reuse and in-plant recycling. The recycling of cooling water in thermal plants could reduce the demand by 90 per cent. Therefore, there is a new trend of not granting licences or permits for new industrial plants unless they stick to the regulation on reusing the industrial water after treatment if needed, and avoiding any disposal of industrial water into the watercourse.

About 80 per cent of the ESCWA region's water use is in the irrigation sector. The widespread use of flood irrigation leads to low efficiency, poor crop yield and soil degradation. If the water wasted was made available for use through irrigation improvement projects, many water supply expansion projects could be postponed and much larger areas of agricultural land could be irrigated.

Modern irrigation methods have been adopted in some of the countries in order to save water by increasing the irrigation efficiency to a maximum. Optimum distribution of water with minimum losses can be realized by installing a complete and efficient network of irrigation and drainage. Poor farm water management leads to inefficient and ineffective use of water, including inadequate conveyance systems to and on the farm. Irrigation improvement programmes have to be planned and implemented carefully, and farmers' acceptance of new concepts and technologies and their active participation in those programmes are essential. An irrigation improvement

programme is currently being implemented in Egypt by the Ministry of Public Works and Water Resources with the participation of the Ministry of Agriculture and the farmers. The programme is extended to cover three activities: (a) improve and modernize the main secondary irrigation systems; (b) rehabilitate and modernize traditional irrigation systems; and (c) improve farm irrigation efficiencies. It is estimated that the programme will last for 15 years and cost about US$ 1 billion. The expected saving on water is between 10 and 15 per cent with an average increase in agriculture productivity of 30 per cent. Water saving will also help in reclaiming new lands.

There are several means of controlling water quality in a stream. Sometimes process changes can eliminate or reduce a residual waste, or the offending pollutant can be treated so as to render the effluent innocuous before it flows into the receiving waters. Alternatively, the wastes can be held for later release when natural dilution flow is high or the flow of a river may be regulated to provide appropriate dilution. It is necessary to know the quantity of dilution water over which to amortize the financial advantage of dilution. This requires information on the water quality in a given stream at different levels of dilution flow.

B. Management of water demand

Water has traditionally been provided to meet different demands. More complete demand information may be represented in a formal demand curve for a particular use of a resource.

The ESCWA member countries which have limited water resources, need to find viable and realistic water management strategies that can deal with the following:

(a) How to minimize water losses;

(b) How to allocate scarce water for desired socio-economic development;

(c) How to protect the environment from degradation and less productive capacity.

Preventing conveyance loss has always been an important factor in saving water. This is done through:

1. Improving efficiency in municipal water utilities by controlling water leakage from pipes and avoiding any breakdowns. However, users are to be motivated to use water rationally.

2. Control of excessive seepage from canals by lining.

3. Maintenance programmes to be provided for water channels, especially to control the growth of aquatic weeds in irrigation systems, which causes conveyance problems and reduces severely hydraulic efficiency in conveying water in canals.

4. Encouragement of the use of rational irrigation methods, improvement of irrigation efficiency, conducting studies on water requirements and improving farming systems, which can lead successively to water savings.

5. Saving water through utilizing pipe irrigation systems, and using recycled water.

6. Enhancement of the basic data collection, automation of the irrigation operation and refinement of research on dry land irrigation technology to help in saving water.

Database establishment should include all the necessary information in the ESCWA region including, but not limited to, the following:

(a) Quantifying and assessing the quality of available water in the various locations in the region;

(b) Classification of lands;

(c) Water data;

(d) Population and growth rates;

(e) Agricultural crops surveys: available and needed;

(f) Consumptive use of various crops within the various areas in the region;

(g) Scenario programmes about water availability and water demand under different conditions;

(h) Programmes on future water needs;

(i) Programmes for economical ways of managing water resources (conventional and non-conventional) within a framework of sustainable development.

In Egypt, as an example, a monitoring, forecasting and simulation (MFS) project was initiated in 1991 by the Ministry of Public Works and Water Resources (MPWWR). It has the following objectives:

(a) Establishment of a Nile Forecast Centre (NFC) within MPWWR;

(b) Implementation of a system for real-time acquisition of satellite images, hydrometeorological data and monitoring of weather conditions over the Nile Basin;

(c) Development of a monitoring, forecasting and simulation system for the Blue Nile Basin (second phase);

(d) Reinforcing of the National Forecasting Centre (NFC) to refine the forecasting and simulation system, to expand the first phase MFS to the whole Nile catchment area, and to integrate it into the Decision Support Unit of the Planning Studies and Models project component.

A telemetry system was also installed in order to automate measurement of the water levels at the main and secondary canals of the Nile.

The project installed 200 data collection platforms at selected sites across the country to record and transmit water levels to a master station. Identical copies of the collected data are sent to other ministry departments.

A computer Local Area Network (LAN) was needed to transfer data between a number of terminals.

Water pricing and cost recovery mechanisms have been identified as effective means to control water use and build the capabilities of countries to maintain and develop water resource systems.

In reality water is rarely priced at either its average or its marginal cost, and charges often bear little relation to the real cost and quality of water supplied. It is very difficult to determine marginal costs, since they change as sources of supply change. Nevertheless, the utility has to start charging higher rates.

There are four ways of calculating water prices: (a) direct volumetric charges which are the best suited for high-value water that needs to be allocated efficiently; (b) direct charges per share of stream or canal flows; (c) direct charges per hectare irrigated; and (d) indirect charges on crop outputs marketed or on inputs purchased.

Where there is no shortage of water, and the water utility just wants to maintain current standards, it is justified in charging customers the average cost of water production divided by the number of units produced. Because there is always a considerable amount of unaccounted for water, the total cost would actually have to be divided by the total number of units delivered. Average cost pricing allows the utility to maintain current service levels, but does not provide sufficient revenue for expansion. Consumers pay for the volume of water consumed. If conservation and efficiency goals are to be achieved, however, the price of water should reflect its true value for highest use. Economists generally recommend pricing water at its marginal cost. The short-run marginal cost will include all operational costs incurred in supplying the last unit of water without exceeding the capacity of existing institutions, while the long-run marginal cost reflects investment and recurrent costs incurred in supplying the next unit of water beyond the capacity of existing installations. All consumers would thus pay more as supplies become scarce.

When water scarcity is so extreme that people are faced with shortages of drinking water, the marginal value of water is certain to be greater for this use than for any other use. Less than 5 per cent of average household use is for drinking and cooking. Conservation can take place under direct regulation; it will be important for municipal water managers to implement rate structures to measure water used.

In formulating a pricing policy, the water utility or authority should consider: the level of recurrent costs; the current level of government subsidy; external funding available; categories of consumers and level of

demand; percentage of water unaccounted for; and the ability and willingness of the various users to pay for their water. The utility cannot justify imposing or increasing tariffs unless the level of service is adequate.

In Egypt, there have been periodic discussions on economic aspects of water allocation in general and water pricing and cost recovery in particular. MPWWR is responsible for operating and maintaining the irrigation networks. The farmers are not charged directly for irrigation water. It should also be noted that attempts at cost recovery from beneficiaries have not been easy, not only for irrigation but also for most other sectors. In reality the tax collected is a land tax on area irrigated, and not a waste tax. Accordingly, not surprisingly, such taxes have not improved water allocative efficiency or its efficiency of use by individual farmers. It has not been easy to develop a cost-effective system, especially in developing countries where there are large numbers of small farmers. Some have repeatedly said that pricing water is not in line with the rules and spirit of Islam since water is a free resource.

Only limited work has been carried out so far on irrigation water pricing and cost recovery in Egypt; some estimates do provide some indications but the estimates vary widely.

The Master Plan for Water Resources Development and Use in Egypt (1982) estimated that the average cost of irrigation water is LE 1.92 per 1,000 cubic metres.

The work carried out by the Egyptian Water Research Centre and Cairo University (1985) on the cost of delivery of irrigation water at different locations in upper and middle Egypt varied from LE 9.46 to LE 18.8 per 1,000 m^3 in 1984. The economic value of irrigation water was estimated by using the crop budget methods.

During the early stages of implementing an appropriate water pricing system, there must be continued strong political support; otherwise, based on experience in certain South Asian countries, total benefits that may occur from water pricing are likely to be minimal, and may not prove to be worth the trouble of developing and administering the necessary cost recovery systems.

There is always a need for the formulation of a national water policy within the framework of the overall economic and social policies of the country concerned. The necessary legislation must be enacted to promote an institutional set-up, and this set-up should be adequate to provide a framework on water allocation, use, quality, and health and safety concerns.

Various agencies dealing with different water uses often carry out their activities in isolation, each drawing water with no thought for the impact on the environment. In addition, in many countries of the region, private business, industries and farmers are pumping both surface and groundwater with very little overall regulation. This uncontrolled usage of water has led to imbalances in the hydrological cycle, shortages for some essential uses, lowering of the water table in many areas, salt water intrusion and increasing cost of exploitation.

The lack of a clear division of responsibilities between organizations for urban and rural water supply, between central and provincial or local activities and between public and private sector agencies results in the duplication of efforts without achieving national development goals.

Training is recommended at different levels. Research work, especially on desalination and wastewater reuse in ESCWA member States should be directed towards finding ways to minimize water losses, to allocate scarce water for desired socio-economic development, to protect the environment from degradation and decreased productive capacity and to reduce both costs and hazards.

C. Management of shared water resources in the ESCWA region

Because water is essential to health, agriculture, energy, science, industry, transportation, and recreation, in short, to human existence, water is an incredibly complex field which involves political, economic, legal, social and ecological considerations.

Water in the countries in the ESCWA region is also a determinant, fraught with conflict, of both the domestic and external policies of the region's principal actors. The severity of the ESCWA region's water problems will, unavoidably, increase significantly in the future. Given the lack of regional cooperation in the water sector among the ESCWA member States, it is remarkable that so few open conflicts over water have erupted. However, this state of affairs is changing rapidly. The closer each riparian State comes to depletion of its water resources, the greater the likelihood of conflict.

There should be relevant agreements between the countries sharing river basins and groundwater basins to ensure that each country can safely obtain its fair share. Upper river basin countries should not make any changes in the basin without studying carefully the effects on the other countries within the river basin. With respect to shared groundwater basins, especially those not subject to water replenishment or with a limited amount of water replacement, countries should work towards developing agreed development plans which would not seriously affect the efficiency of the groundwater basin. It cannot be easily assumed that aquifers will be consistently treated in the same way as surface water. The legal rules for groundwater are still in the process of formulation, and the issue of aquifers is already contentious.

Agreements between riparian States can be reached through the assistance of United Nations agencies or regional organizations representing countries with shared water basins. Water use strategy and action plans for development of the shared water basins in the region can also be discussed in meetings or in ad hoc group discussions.

Egypt and the Sudan created a model for coopertion in 1959 through an agreement which not only governs the sharing of the Nile waters, but contains an instrument for settling controversies by negotiation. In 1959 Egypt and the Sudan signed an agreement to establish the Permanent Joint Technical Commission of the Nile River, which is the mechanism for proposing and implementing the mutual cooperation projects between the two countries as well as with other countries of the Nile basin. The Technical Commission has the

right to review the uses of the Nile water in the two countries as compared with their shares stipulated by the 1959 agreement. Since its establishment in 1960, the Technical Commission has been meeting regularly four times a year in
Cairo and Khartoum alternatively.

In 1964 the Technical Commission began to draw up a mechanism for cooperation with the countries of the Equatorial Lakes region. The idea was a success and resulted in the establishment of a project for a hydro-meteorological survey of the Equatorial Lake Plateau in 1967 (Hydroment). In 1977 the Technical Commission began formulating a comprehensive mechanism for providing continuous cooperation among all the riparian countries. In 1978 the draft by-laws of the suggested Nile Basin Commission were drawn up and sent officially to all basin countries.

The Nile, which is the lifeline of Egypt, flows through eight countries: the United Republic of Tanzania, Rwanda, Burundi, Zaire, Uganda, Kenya, the Sudan and Ethiopia, before it reaches Egypt.

Recently, under the aegis of the United Nations, efforts have been made to help the Nile basin countries to draw up a mechanism for overall cooperation to develop the Nile basin. It is believed that such cooperation may be achieved if the following points are taken into consideration:

1. Agreement on the historical rights of different parties;

2. Agreement on exchanging the required data which will be the basic ingredient for the development projects;

3. Acknowledgement of the prior agreements, especially those which dealt with shared water resources;

4. Acceptance of criteria for priorities of suggested development programmes;

5. Consideration of the possibility of using existing resources other than Nile water within each country.

A second example of rivers shared by different countries is the case of the Euphrates and Tigris rivers. The Euphrates and Tigris rivers get their water from the Anatolian plateau south-east of Turkey. This plateau has an annual rate of rainfall of about 1,000 mm.

These two river basins are international: Iraq and the Syrian Arab Republic share the Euphrates basin with Turkey and the Tigris basin with Turkey and the Islamic Republic of Iran.

The Euphrates river has a catchment area of about 444,000 km^2 within Iraq, the Syrian Arab Republic and Turkey. Some small rivers (the Sagour, Baliekh and Khaboor) join the Euphrates in its flow through the Syrian Arab Republic. The volume of the Euphrates discharge at its entry into Syrian borders is estimated at 26 billion m^3 of water, and the Euphrates total length from its source till it joins the Tigris is about 2,800 km.

The Tigris river has a catchment area of about 471,606 km^2 within Iraq, the Syrian Arab Republic, the Islamic Republic of Iran and Turkey. Some small rivers (the El-Zab El-Kabir, El-Zab El-Sagier, El-Shut El-Azim and Dialy) join the Tigris within Iraqi boundaries. Its discharge is 48.7 billion m^3 of water and its length is 1,800 km.

The Shatt al-Arab (190 km long) is the river where the Euphrates and the Tigris meet at El-Karnah. The Shatt al-Arab discharges 21 billion m^3 of water at El-Bagrah and 35.2 billion m^3 at its end when it drains into the Arabian Gulf. Several hydraulic structures have been already constructed on the two rivers (the Euphrates and the Tigris) by the four riparian countries to regulate floods, for power production or to implement irrigation schemes at national levels to satisfy each country's objectives but without effective cooperation between the countries.

Political agreements are essential to the creation of a broader array of legal instruments for solving international disputes over shared water resources. Important exceptions are Egypt and the Sudan, which have made a formal regulatory agreement. Riparian States in the ESCWA region do not usually resort to the law for the arbitration or resolution of water problems.

D. Water legislation to control water use and conservation

As noted above, the ESCWA region is already economizing on scarce water resources. Water sector planning, management and efficient allocation and utilization should be supported by appropriate water legislation at national and regional levels.

Regional legislative authorities and measures to control the implementation of the formulated water plans, and water use and conservation, are almost absent in the region. However, some agreements or treaties are registered regarding shared basins within the region but they are not enforced among the riparian States with the exception of the Nile Technical Commission.

Water legislation at national levels in the region is generally complex and outdated with regard to modern water management practices and techniques, and has resulted in the fragmentation of administrative responsibilities. Provisions which regulate water resources development and management are often contained in different laws and regulations, or have originated from traditional and customary uses which relate to the prevailing social structure of some member countries.

Countries including Jordan, the Syrian Arab Republic, Iraq and the Gulf States have recently critically examined their water legislation, rules, regulations, customs, decrees, ordinances and other measures of control in the water resources field.

Land and water legislation and regulations are enforced in Iraq for better management and conservation of both of these resources. Legislative measures were enacted as early as 1962, and were reviewed in 1971, 1981, 1983, 1986 and 1988.

In Jordan, all water resources are government property; the Ministry of Water and Irrigation controls these resources in accordance with articles 25 of the Water Authority of Jordan (WAJ) Law, and articles 18 and 24 of the Jordan Valley Authority (JVA) Law. Protection of water quality in Jordan is observed in accordance with article 6 of the WAJ Law and article 38 of the JVA Law. Other articles of the JVA and WAJ laws deal with water resources development, conservation and management on a country-wide scale.

The Gulf Cooperation Council charter considers national water resources worthy of special concern. Article 4 of the charter obliges the member countries to undertake measures to pursue technical and scientific development in all fields, including water resources. The Ministerial Committee for Agriculture and Water Resources is responsible for coordination and cooperation in the field of agriculture and water resources among the GCC member States, and has formed several technical committees. The Permanent Committee for Land and Water Uses is responsible for:

(a) Drafting unified water legislation;

(b) Coordinating groundwater research and investigation on the major shared aquifers;

(c) Proposing and convening symposia related to water resources development and conservation.

One of the main achievements of this Permanent Committee was the development of the Water Resources Conservation Regulation, which was adopted and enforced by the Higher Ministerial Committee in 1985.

Another group, composed of the Ministers of Water and Electricity in the GCC member States, has formed a number of specialized committees for: optimum use of water and electricity; unification of water and electricity specifications; exchange of information; and standardization of maintenance and operations methodologies. These four committees have drawn up common guidelines and legislative measures for water desalination, water supply and water quality standards to be applied in the GCC member States.

In the Syrian Arab Republic many water ordinances, decrees, regulations and other legislative measures have been issued, based on the main Water Law No. 165 of 1958. They are continually being revised to better control and conserve national groundwater and surface water resources, and to regulate irrigation and drainage. In July 1987, a draft proposal for water quality protection in the Syrian Arab Republic was submitted to the concerned legal authorities for review and approval.

In Egypt, Law No. 48, "Protection of the Nile River and watercourses from pollution", was enacted in June 1982. Another law, No. 12 of 1984, and its relevant executive charter, No. 14717 of 1987, were implemented in Egypt to control, manage and monitor irrigation and drainage activities.

In Yemen, the legal situation is at best confusing. While some reports refer to the existence of only basic and ineffective water regulations, other reports detail sets of sophisticated legal and administrative arrangements,

albeit at the local level and of a customary and traditional nature. The irrigation and communal settlement water supply rules and regulations are related to religious norms, and apply to irrigation, domestic supply and, to a certain extent, environmental problems. Operative rules and legal measures seem to be based on ad hoc situations, particular cases and pragmatic interpretations.

IV. PATTERNS OF WATER RESOURCES PLANNING AND UTILIZATION

In reviewing the available literature pertaining to water resources development plans and conservation in the ESCWA region, it can be noted that the patterns of these plans vary from one country to another. They rely on many factors related to the prevailing hydrologic and hydrogeologic set-ups, the overall socio-economic conditions, the objectives and goals identified, and the planning horizons. Table 7 below shows the various activities considered for water resources planning purposes in the region. It can be concluded that surface water impoundment for both water storage and/or flood controls is the most common practice for water planning in addition to the continuous conventional exploitation of surface and groundwater resources.

Appreciable efforts have been made to develop surface water resources at national levels. A number of surface water reservoirs have been built, while plans for new projects are being carried out. Iraq, the Syrian Arab Republic, Jordan, Yemen and Saudi Arabia have been the active member States in this respect during the past two decades.

The Iraqi Government plans to achieve a total live storage capacity of 55,000 MCM, an amount that does not include water from Lake Tharthar and existing marshes. The total storage capacity of the existing and future reservoirs (when completed) is estimated to be 95,000 MCM/year.

In Jordan, most of the floodwaters flow into the Dead Sea or evaporate in the desert mud-flats. About 15 reservoirs had been constructed in Jordan by 1988; the total capacity of these dams is about 126 MCM. A number of dam sites with a potential total storage capacity of about 387 MCM were identified in different localities in the country; studies and construction of some of these structures are under way.

In the Syrian Arab Republic, about 125 dams were recently constructed including the major Euphrates dam of which the storage capacity is 14.1 BCM. In 1991 the completion of nine dams added a storage capacity of 3.8 BCM. Currently, construction work is being carried out at 23 sites in the areas of the Yarmouk, Orontes, Al-Badiya, Barada, Euphrates and Al-Khabour basins. Projected storage capacity is around 2.6 BCM. The total storage capacity of all dams so far constructed or under construction in the Syrian Arab Republic amounts to 20.5 BCM.[9/]

About 199 small and large dams were constructed during the last decade in Saudi Arabia, with an estimated total storage capacity of 750 MCM. These dams

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9/ Syrian Arab Republic, Ministry of Irrigation, Planning and Follow-up Directorate, "Dams constructed in the Syrian Arab Republic" (in Arabic), February 1993.

Table 7. <u>Patterns of water resources planning in the ESCWA region</u>

Activity		Egypt	GCC countries	Iraq	Jordan	Lebanon	Syrian Arab Republic	Yemen
Surface water impounding	Storage	X	X	X	X	X	X	X
	Recharge		X		X			
	Diversion			X	X			X
Irrigation networks	Rehabilitation	X	X	X			X	
	Modernization	X		X	X		X	X
Reuse	Drainage water	X	X	X				
	Treated waste effluent	X	X		X		X	X
Desalination			X					
Efficient utilization	Irrigation	X	X	X	X		X	X
	Industry	X		X	X		X	
	Domestic	X	X		X		X	
Groundwater		X	X	X	X	X	X	X
Water transference		X		X	X		X	
Water quality control		X	X	X		X	X	
Technology applications		X	X	X	X		X	
Water legislation			X	X	X		X	X

Note: X = Activity under consideration for planning purposes.

are mainly for making use of flood waters for irrigation, livestock and/or artificial groundwater recharge.10/

Because of their limited water resources and the rapidly decreasing quantity and quality of the water, many oil-producing countries of the region have turned to the sea for their freshwater supply; considerable progress in desalination activities has been achieved in recent years.

In Bahrain additional desalination units designed to produce 50 MCM/a so as to have a total production of 125 MCM/a in 1998.11/ In Kuwait, more desalination plants were constructed at the Doha East and Doha West stations, raising the total production capacity to 365 MCM/year.12/ Six new plants were constructed in Saudi Arabia, bringing the total installed capacity of the Kingdom to 657 MCM/year.13/ In Oman, additional units were installed at the Ghabrah Station to increase the freshwater production capacity to 41 MCM/year.14/ In Qatar, the expansion of Ras Abu Aboud and Ras Abu Fontas stations, with a designed capacity of 96 MCM/year, was completed in 1986. Finally, total production of desalination water in the United Arab Emirates has reached 264 MCM/year.15/

Treated wastewater effluent as non-conventional means of augmenting water supplies has become an important developmental activity in the region. Wastewater reuse has been practised by some member States of ESCWA for a considerable period of time; however, its application has been limited, and plans have only recently been formulated for large-scale development of this non-conventional supply source. Lack of knowledge about the long-term effects of treated sewage effluent used for various purposes and the availability of other water resources has prevented the reuse of treated wastewater on a wider scale; however, the development of new technologies and the rising cost of desalinating water have led to a higher, more substantial rate of wastewater reuse in the ESCWA region during the past decade.

10/ Economic and Social Commission for Western Asia, "Progress achieved in the implementation of the Mar del Plata Action Plan in the ESCWA region: water resources management: institutional and legislative aspects" (E/ESCWA/ENR/1992/5), October 1991.

11/ Bahrain Country Paper, "Water resources plan for the Year 2000" (Arabic), presented at the Fifth Meeting in the IHP Permanent Arab Committee, Cairo, 9-11 November 1992.

12/ Arab Planning Institute, "Water crisis in the Arab world" (Arabic), Kuwait, June 1993.

13/ Ibid., p. 7.

14/ E/ESCWA/ENR/1992/5 and "The role of water resources management in combating desertification in Oman" (E/ESCWA/ENR/1993/2), January 1993.

15/ Arab Planning Institute, op. cit., p. 8.

Jordan, the Gulf Cooperation Council States and Egypt have practised wastewater reuse in agriculture and public gardening. The treated wastewater production is presently rated at about 1,290 MCM/a and it is planned to produce an additional 1,140 MCM/a for Bahrain, Egypt and Jordan by the year 2000.[16/]

Considerable attention was given to water-saving measures in water resources development plans in the region in recent years. Such measures were related to irrigation or agricultural water use and drinking water supply schemes.

In general, irrigation and agricultural water-use projects have received a lot of attention in ESCWA member States in recent years, particularly in Iraq, Egypt, the Syrian Arab Republic, Jordan, Saudi Arabia and Oman; about 60 projects were completed or are ongoing in the region. Modern irrigation projects have been executed extensively in Jordan and Saudi Arabia, while rehabilitation of the existing irrigation-drainage networks in Iraq and Egypt is progressing well. In the Syrian Arab Republic, several irrigation projects and parallel dam construction activities are also in progress. Studies to use treated drainage water are being considered in Iraq and Egypt, where the reused drainage water reached 12.168 km^3/year in 1989.[17/]

The oil-producing countries, in particular Oman, Saudi Arabia and Iraq, are proceeding with plans to increase agricultural production through the implementation of modern and efficient irrigation-drainage projects, to become as self-sufficient in food production as the available water resources will allow.

All member countries of ESCWA have undertaken drinking water supply projects aimed at improving the living standards of their populations, as a follow-up to the Mar del Plata Action Plan.[18/] It was reported that in 1980 about 92 per cent of the urban population in the ESCWA region and about 51 per cent of the rural population were supplied with safe drinking water. Most of the member States' national development plans have included a target date of the year 2000 to secure a safe and adequate water supply for the total population within the region.

In recent years, the GCC countries have carried out several drinking-water supply and sanitation projects aimed at raising the standards of these utilities and at making them compatible with the newly achieved economically developed status and improved living conditions. In Bahrain, Kuwait, the United Arab Emirates and Qatar, 100 per cent of the urban areas are supplied with piped water.

16/ E/ESCWA/ENR/1992/5, p. 30.

17/ Economic and Social Commission for Western Asia, "Water resources planning in Egypt: issues ahead to the year 2020", Meeting on Water Security, Damascus, 13-16 November 1989 (E/ESCWA/NR/89/WG.3/WP.8).

18/ See Report of the United Nations Water Conference, Mar del Plata, 14-25 March 1977 (United Nations publication, Sales No. E.77.II.A.12), chap. I.

More than 500 large and small water-supply projects in urban and rural areas were completed and/or are ongoing in the region.19/

The water supply projects vary from one country to another according to the water supply source, relying on surface water resources in Egypt (the Nile River), in Iraq (Tigris and Euphrates rivers) and equally on surface and groundwater in the Syrian Arab Republic (Euphrates, Orontes, and Al-Kabir rivers). The rest of the ESCWA member States depend largely on groundwater for their water supply. This source is not reliable, as it is a depletable source which deteriorates in quality when over-pumped, as a result of the increased water demand in large cities like Amman, Aden, Riyadh and Sana'a. Sources are also frequently distant from inhabited areas. There is poor-quality groundwater in the United Arab Emirates, Bahrain, Qatar and Kuwait; brackish groundwater is blended with desalinated water to provide adequate water supplies to these Gulf States.

Water supply projects are formulated in accordance with supply sources, then to fit individual needs. Examples include piping water from remote areas to distribution areas like Amman, Jordan; Riyadh, Saudi Arabia; and Aden, Yemen. In Jordan, Iraq and Egypt, the big cities are served by large and small plants for treating surface water. In Iraq the rural areas are also served by treatment plants.

19/ E/ESCWA/ENR/1992/5, p. 29.

V. NOTES ON WATER SECTOR PLANNING IN SOME MEMBER COUNTRIES (EXPERIENCE, ACHIEVEMENTS, ENVISAGED FUTURE PLANNING AND CONSTRAINTS)

Many member countries have recognized the need for concurrent development, conservation and management of their vital water resources. Water assessment and planning to determine the most appropriate resources allocation to various water users, as well as to formulate medium- and long-term policies and guidelines for the exploitation, utilization and subsequent management of the water resources, were the objectives and targets considered during the last decade in some member countries in the ESCWA region.

What follows is a brief description of water sector planning methodologies and patterns in some ESCWA member States.

A. Egypt

A Water Master Plan project (UNDP/EGY-73/024) was launched in January 1977. The project was executed by the World Bank and financed by UNDP, with the Egyptian Ministry of Irrigation acting as cooperating agency. The project was begun in October 1977 and the first phase was completed in December 1981; the second phase commenced in January 1982 and was completed in 1987.[20/]

The first part of the project involved the preparation and evaluation of development plans in which the water supply and demand were matched, while the second was concerned with supporting studies and analysis.

1. Part 1: Planning methodology

(a) Develop the agricultural sector. Three alternative planning methodologies were studied:

(i) Evaluate the available water supply, as well as present and new projects. Compute the water requirements for other users and deduct these figures from the available water resources totals. The remainder was for agricultural development to the year 2000, distributed at five-year intervals;

(ii) Determine the water requirements for all users including the agricultural sector (with an annual growth rate of 4.9 per cent, including 1.9 per cent for new lands development);

(iii) Determine the staging of new water supply development projects (including the Upper Nile conservation projects) to satisfy water demand;

20/ E/ESCWA/NR/89/WG.3/WP.8, E/ESCWA/ENR/1992/5 and "Integrated Water Resources Management and Planning in the ESCWA Region" by M. Abu Zeid, October 1993.

(iv) Determine water requirements, as in (ii) above, but with a 3 per cent rate of growth in the agricultural sector, 0.5 per cent of which must be for new lands development.

(b) Supply the growing demand for municipal, industrial and all other users.

(c) Evaluate and compare plans on the basis of the effective use of available water, economic performance in the agricultural sector, capital investment required, social and environmental impacts and energy requirements.

2. Part 2: Supporting studies

These studies are related to the following: cost analysis of the water supply and land development projects, and cash-flow expenditure during the planning period; water requirements to support agricultural development and economic evaluation for these projects; water demand and cost analysis for municipal and industrial uses, as well as wastewater quality investigations and treatment for possible reuse in agriculture; determination of the operation, maintenance and replacement costs for Nile River regulation, irrigation and drainage systems; and finally, the establishment of a database and development of an agro-economic model.

The Water Master Plan concluded that if the Upper Nile conservation project were completed, about 11.5 BCM of additional water would be available after 20 years (first alternative). This amount would be enough for developing an additional 2.7 million feddan, and the remaining 1.8 BCM of water would be available for land development after the year 2000. As regards the second alternative, and if new lands served by Nile waters were developed at the rate of 180,000 feddan/year, the developed water supply would be fully committed after 1997, and no further development would be possible unless additional water supplies were mobilized. If land development continued at the rate of 50,000 feddan/year, the increased water supply would exceed demand during the planning period. In this case, only the Jonjuli Project (part of the Upper Nile conservation project) would be required up to 1997.

The Water Master Plan project guarantees that there will be significant amounts of water used for agriculture independent of the supply-demand balance for the Nile. These will be drawn from the groundwater resources of the New Valley in the oasis areas, the shorelands along Lake Nasser, and treated wastewater in the Greater Cairo area.

The drought conditions prevailing in the eastern coastal regions of Africa, the halted Upper Nile water conservation projects and Government plans to increase the cultivated areas in Egypt at a rate of 150,000 feddan annually, have all led the Egyptian Government to reconsider its water use policy. Much progress has been made in Egypt's use of its national water resources. Conjunctive use of surface, ground, drainage and treated wastewaters has been successfully practised to cope with both the drought conditions which lasted from 1979/1980 to 1987/1988 and with the problems caused by the halted water conservation projects. These projects are expected to feed the High Dam Lake at a rate of 7,500 MCM/year in their first phase, and at a rate of 8,900 MCM/year upon completion.

The groundwater resources available in the eastern and western deserts and in Sinai provide about 2,700 MCM/year and are expected to increase to 4,900 MCM/year after development.

Treated sewage and industrial wastewater currently contribute a total volume of about 1,400 MCM/year, and the amount is expected to reach 2,200 MCM/year by the year 2000. Drainage water reuse is likely to be available at a rate of about 3,470 MCM/year for the five-year period 1987-1992 and should reach 6,500 MCM/year by the year 2000. A digital model was created in 1983 which simulates the changes that could occur in the quantity and quality of drainage waters over time after the drainage networks have been improved, the volume of reusable drainage water for irrigation has been increased, the crop pattern changed and short-span crops cultivated. This model was intended to be used as a tool to make appropriate decisions for future development and to optimize reuse of the available drainage water and record its limitations, taking all necessary precautions so as not to negatively affect soil and crop productivity.

The strategy of utilizing the potential groundwater resources in the Nile Delta and Valley, the eastern and western deserts and in the Sinai is mainly designed to achieve the following:

(a) Provide domestic water supplies;

(b) Irrigate newly reclaimed lands at the peripheries of the Nile Delta and Valley;

(c) Improve the efficiency of agricultural production and the existing irrigation networks.

The concerned government authorities have adopted a short-term water-use policy to overcome the Nile water shortage by:

(i) Using the largest possible quantity of groundwater, agricultural drainage water and sewage drainage for irrigation;

(ii) Rationalizing water in all fields and reducing withdrawal discharges from the High Dam Lake;

(iii) Considering consecutive years with continuous shortage in the Nile supply. Then the withdrawal will be as follows:

a. When the lake storage is 60-65 BCM by the end of July, withdrawal is to be reduced by 10 per cent;

b. When the lake storage is 50 BCM or less by the end of July, withdrawal is to be reduced by 20 per cent.

In the light of the above water policy, table 8 shows planned water use in Egypt, *vis-à-vis* the above-mentioned water policy, up to the year 2020.[21]

21/ Economic and Social Commission for Western Asia, "Water Resources Planning in Egypt: issues ahead to the year 2020", Ad hoc Expert Group Meeting on Water Security, Damascus, 13-16 November 1989 (E/ESCWA/NR/89/WG.1/WP.8).

B. Water resources planning and utilization in Jordan

Most of the industrial and municipal water supply systems in Jordan depend on groundwater and springs. Several aquifers are being over-pumped and water resources depleted. The distribution of water resources does not correspond to the areas of highest demand, particularly the densely populated urban areas. The Water Authority of Jordan (WAJ), under pressure to meet increasing municipal and industrial water requirements, has constructed a complex conveyance system. The feasibility of constructing pipelines linking the entire water system in northern Jordan to permit integrated resource management is under study. Pressure to develop new sources has sometimes led to the selection of costly solutions. One example is the Deir Alla pumping station, completed in 1985 and designed to pump, treat and convey 45 MCM per year to the Amman area (from 75 m to about 1,035 m above sea level and from a distance of 65 kilometres).22/

Modern irrigation started in the Jordan Valley with the completion of the King Abdullah Canal in 1965 and the construction of the King Talal Dam on the Zarqa River in 1979. Great progress has been achieved in many parts of the country in modernizing irrigation techniques designed to conserve the country's water resources. In general, non-conventional and limited conventional irrigation methods are presently applied in Jordan.

Because the Government has been well aware of the need for rational water resources planning, many developments have taken place since the implementation of the National Water Master Plan in 1977: the King Talal Dam has been used only for irrigation; additional limited groundwater resources have been identified and sewage network and treatment activities are under way.

1. Surface water utilization

Surface water resources originate in the Yarmouk and Zarqa rivers, which provide most of the irrigation water for the Jordan Valley. Present surface water consumption is currently estimated at 336 MCM. Plans to make use of desert flash flood water through small dams (for aquifer recharge, local irrigation and livestock) have been implemented. The main potential for further surface water development is through the construction of new water storage facilities on the Yarmouk River (Al-Wahdah Dam), and in the Jordan Valley (Karameh) and Rift-side wadis (Kufranja and Yabis dams). Jordan has had a lot of experience in the planning and utilization of surface water, to the extent that irrigated agriculture has developed and expanded from a few scattered, seasonally irrigated farms in the 1950s to about 550,000 dunums in 1988, of which 320,000 dunums are in the Jordan Valley and 230,000 dunums are in the highlands.

22/ E/ESCWA/ENR/5, pp. 40-51, and Jordan national paper on "Jordan Water Sector" by Hazim Al-Naser and Z. Elias, Ministry of Water and Irrigation, presented at the Regional Symposium on Water Use and Conservation, Amman, 28 November - 2 December 1993 (E/ESCWA/NR/1993/WG.1/4).

Table 8. Expected available water resources in Egypt balanced with water requirements (BCM)*

Year	Available water resources (expected)			Total (BCM)	Requirements (projected)		Total (BCM)	Irrigated land (feddan)
	Nile	Drainage	Ground		Municipal and industrial	Irrigation		
1992	53.5[a/]	7.0	3.5	64.0	10.4	52.8	63.2	600 000 new land
2000	55.5+2.2[b/]	7.5	4.9	70.1	10.7	58.3	69.0	Additional 1 000 000
2010	55.5+4.0	8.2	4.9	72.6	10.9	61.3	72.2	Additional 750 000
2020	55.5+8.2	8.6	4.9	77.2	12.6	64.2	76.8	Additional 650 000

Source: Economic and Social Commission for Western Asia, "Water resources planning in Egypt: issues ahead to the year 2020", Meeting on Water Security, Damascus, 13-16 November 1989 (E/ESCWA/NR/89/WG.3/WP.8).

* Billions of cubic metres.

a/ Represents Egypt's share in the Nile River water at Aswan High Dam.

b/ Represents Egypt's share in the Upper Nile water conservation projects upon implementation.

Surface water impounding activities are progressing well in Jordan. There are plans to make use of storm run-off water, and of flood water available during the rainy season. Water impounded by dams or retention reservoirs is used for domestic, industrial, irrigation and livestock purposes. By 1986, about 15 reservoirs had been constructed, with a total capacity of about 126 MCM.

A number of impounding reservoirs with a total storage capacity of about 387 MCM were identified in different areas of the Kingdom; the capacity of each dam varies between 2 MCM and 220 MCM.

The Government of Jordan has also begun to develop rain-water harvesting practices. Desert pools have been rehabilitated or constructed, and flood-water spreading has been undertaken. Artificial groundwater recharge using flood water was being practised in different localities (Shueib and Khalidiya dams) and, as of 1989, was under way in others (the Siwage, Al-Abyed, Jurdaneh, and the Azraq and Jafer basins).

2. Groundwater utilization

Groundwater sources close to population centres in Jordan have been extensively exploited for municipal and industrial purposes. Most of these sources are currently being extracted to or beyond the limits of reliable aquifer yields.

Replenishable groundwater is presently used for municipal, industrial and agricultural purposes. It is estimated that about 354 MCM of this water is currently being utilized in different localities in Jordan, resulting in the overpumping or depletion of Jordan's main aquifers at a rate of about 94 MCM (1989 estimates).

Fossil groundwater constitutes most of the stored quantity of available groundwater in Jordan. The main potential for increased production lies within the fossil aquifer of the Disi Basin in southern Jordan.

Abundant amounts of brackish groundwater are available in Jordan, particularly in the Rift Valley and desert areas. Brackish or slightly-to-moderately salty groundwater is present in different aquifer systems in Jordan.

Currently, three brackish-water well fields are being explored; water from them could be pumped and diluted in the King Abdullah Canal to increase the available surface water utilized for irrigation. These well fields include:

Adasiya well field	(25 MCM and salinity range 2,000-4,000 ppm)
Hisban well field	(10 MCM and salinity levels of about 2,000 and 4,000 ppm)
Ghor Safi well field	(7 MCM and salinity levels of about 2,250 ppm).

3. Treated sewage effluent reuse

The construction of sewerage facilities has rapidly increased since 1984. With the creation of the Water Authority of Jordan, 11 treatment plants were constructed and another 22 plants were planned and designed for urban and rural areas. Approximately 84 per cent of the population were served by sewerage networks in 1990 and 88 per cent should be served by 2015.

It is estimated that the production of treated effluent which can be used for irrigation will reach 116 MCM in the year 2005 and 165 MCM in 2015. Experimental irrigation using treated effluent has been applied in some areas of Jordan.

Other measures, such as improving skilled-manpower capabilities, applying computers in water science, establishing a comprehensive water-sector database, and establishing a regional centre for isotope analysis and interpretation in cooperation with the International Atomic Energy Agency, have been undertaken by the water-related institutions in Jordan.

C. The Gulf Cooperation Council member States experiences in water sector planning

Because of their limited water resources and an overdraft situation which has resulted in reduced quantity and quality, many of the GCC member countries have turned to the sea for their freshwater supply. Considerable progress in desalination activities has been made in recent years as mentioned above.

The Gulf States are generally considered world leaders in non-conventional water resources production, particularly in desalinating sea water and/or brackish groundwater. Since the United Nations Water Conference, substantial progress has been made in desalination techniques, and in improving skilled manpower capabilities to maintain and operate desalination plants, and the cost of desalination per unit volume of water produced has been progressively reduced.

In addition, treated sewage effluent reuse is widely practiced in the Gulf States for restricted irrigation or public gardening.

Non-conventional water resources production in the GCC member States has contributed substantially to meeting the countries' domestic, industrial, and, to a certain extent, irrigation water requirements. The national water resources (primarily groundwater) in some member States are no longer potable and can hardly even be used to irrigate certain saline-water-tolerant crops, owing to excessive water quality deterioration and sea water intrusion into the coastal aquifers. Treated sewage effluent, which normally provides about 60 to 70 per cent of domestic water supply, has helped maintain agricultural production in some areas in the Gulf States.

In the Gulf States, the concerned government authorities have considered, among other things, for water planning purposes the following:

(a) Construction of additional desalination plants to meet the growing water demands;

(b) Promotion of surface water impounding to make use of flash floods for storage and/or artificial groundwater recharge;

(c) Enhancement of wastewater reuse for restricted agriculture;

(d) Implementation of groundwater exploration, management and conservation projects;

(e) Modernization of irrigation schemes together with efficiently operating, maintaining and developing the conventional or traditional (aflag and springs) irrigation schemes.

In Bahrain, as elsewhere in the Gulf area, a long-term water resources development policy is to produce distilled sea water and blend it with brackish ground-water to bring the quality up to acceptable drinking water standards. Desalination plants water production was increased from 5 MCM in 1975 to 63 MCM in 1991 and is planned to reach 125 MCM/year by 1998.[23/]

A team of national experts in Bahrain has recently prepared a work plan for water sector planning and development. The proposed plan will be implemented in three main phases.

(a) The first phase (Diagnostic Studies), which will include review and collection of the previous studies and data, water resources assessment and potential water use for various sectors, water demands and projections, and the establishment of a water resources database;

(b) The second phase (Preventive and Control Measures), which will include studies related to water problems, and formulation of alternative strategies to overcome problems by the use of simulation modelling techniques;

(c) The third phase (Operational Phase), which will include the implementation of the master plan formulated and follow up of the proposed projects execution in coordination with the concerned authorities and evaluation of the impacts of these projects as well as continuous review and updating of the water master plan.

In Oman, a National Water Resources Master Plan was completed by the end of 1991. The Master Plan was aimed at:

(i) Strengthening the institutional and legal framework to provide effective management of water resources in the interests of the Sultanate's long-term development;

(ii) Giving priority to domestic and industrial water supplies, by using desalinated sea water, despite the high cost, to augment agricultural water use;

23/ Mubarak Aman, Bahrain water plan up to the year 2000 (in Arabic), presented at the Fifth Meeting of the IHP Permanent Arab Committee, 9-11 November 1993.

(iii) Managing domestic water demand and improving the efficiency of agricultural water use;

(iv) Restricting agricultural development in line with the available resources and cutting back on farming where resources are presently overexploited;

(v) Controlling development of non-renewable water resources;

(vi) Augmenting the resource wherever possible.

D. Water resources plans and policies in the Republic of Yemen

As elsewhere in the region, the demand for water is rapidly increasing in Yemen. The water demands are mainly met from groundwater. The available information indicates that the groundwater resources have been severely over-exploited, and in most cases, have exceeded the economic pumping depth. The Government has placed high priority on the development of this sector in an effort to overcome the water scarcity problem. The planned growth rate for the sector was 25 per cent during the Second Five-Year Plan (1982-1986), the highest among all the sectors. For the Third Five-Year Plan (1987-1991), the planned growth rate is 15 per cent, which is the second highest after the oil sector (80 per cent). The changing patterns of water demand, tight budgetary constraints, and the lack of intersectoral coordination suggest the need for more comprehensive and rational sectoral planning.24/

There is a growing awareness in Yemen that sustainable economic development requires efficient and effective management of the country's scarce water resources. At the same time, it is widely recognized that it is a difficult task to accomplish, given that water is traditionally considered a free commodity and given the decentralized political structures in many of the more seriously affected parts of Yemen. Despite these difficulties, the Government has already initiated appropriate action. In this context, a new water law designed to provide for the licensing of new wells and for a more orderly set of arrangements for water abstraction, is being considered by the Government. Moreover, to improve the institutional framework for water resources development and management, a proposal to integrate various water-related functions under one government institution is receiving serious consideration.

In order to improve the water sector planning in Yemen, the Government established the High Council for Water (HWC). The activities of HWC are being supported by a technical secretariat. The technical secretariat has been entrusted with the task of preparing a National Water Master Plan (NWMP) for the country. The secretariat has collected and processed a great deal of statistical data and information required for water sector planning. A number of sector review and research studies were initiated to assess water sector status in the country.

24/ UNDP/DESD, "Water resources management and economic development", Final report, vol. I (project YEM/88/001), September 1992.

The technical secretariat is supposed to collaborate and coordinate with different national and regional institutions to understand the nature and extent of their databases as an effort to develop a national database needed for the preparation of the NWMP. However, in recent years, a number of water projects in Yemen have collected and processed a great deal of water resources statistics. These databases were incorporated into the national database to support water sector planning at the national level.

In order to develop an efficient technical secretariat for the Council, a major project funded by UNDP and executed by the United Nations Department of Economic and Social Development has been implemented (1988-1992). The project on assistance to the technical secretariat of the High Council for Water (YEM/88/001) has generated a substantial amount of information in support of planning for water resources management. The final report of the project consists of 10 volumes dealing with the following:

1. Water resources management in the context of national economic development;

2. Legal and institutional issues related to water resources use and development;

3. Assessment of available water resources and their present and future uses;

4. Analysis of present and future regional water requirements;

5. Status and future development of water supply and sanitation;

6. Assessment of present and future environmental issues;

7. Two case-studies for the development of water resources management plans (Sana'a basin and Tihama).

In view of the different studies carried out under the auspices of the project, it was concluded that there is a water crisis in Yemen. There is insufficient water to meet the increasing water demands. Water levels have already declined below economic pumping levels in many basins in the country. In addition the fragmented nature of responsibility in the water sector and the absence of an appropriate legislative and policy framework have exacerbated the prevailing water crisis in Yemen. It is imperative for the concerned government authorities to undertake the necessary efforts and measures to achieve an equilibrium between net water withdrawals and renewable water availability and to identify how much groundwater mining is to be permitted. The country needs to gear its efforts towards the formulation and implementation of a water management plan for water resources conservation and optimal water allocations among various users.

The implementation of the formulated plan has to be entrusted to an efficient institution responsible on a country-wide scale and supported by the enforcement of appropriate legislation to control water supply and demand variables.

VI. CONCLUSIONS AND RECOMMENDATIONS

In general, good progress has been made in water resources management, development and conservation in the region during the last decade. In view of this progress which was briefly reviewed in the present document, it can be concluded that more efforts still have to be made in the region in order to achieve efficient water sector planning and water resources assessments at both national and regional levels. The following are major areas of concern which have to be considered during the 1990s, with regard to water resources management in the ESCWA region.

1. The focus should be on shared water resources issues and this should be considered a priority. The development and utilization of surface and groundwater resources at national level could result in serious tensions among riparian countries; those concerned should therefore be encouraged to develop these resources in cooperation with one another.

2. Manpower capabilities of multidisciplinary planners should be improved, as should those at managerial level in the field of water resources.

3. Activities to establish a comprehensive water sector database at national and regional levels should be enhanced. The use of computers and the latest software packages to upgrade knowledge about national water resources should be promoted. Because the water data for national water resources assessment are inadequate in many countries in the ESCWA region, research should be promoted in order to facilitate application of the information from limited water data for tentative assessments.

4. Water resources management should be considered as integral to regional security and stability, which would mean that water resources policies and institutions within the region would be designed in compliance with plans for integrated economic development.

5. Public awareness should be enhanced at national levels by promoting incentives designed to encourage people to abide by the drafted water legislation. Efficient water use policies cannot be implemented unless they are supported by appropriate water legislation which defines the ownership of water, water resources use, waste and reuse, as well as measures for the protection of the environment and the conservation of water resources.

6. Strict controls should be implemented with regard to industrial effluents and agricultural chemicals, and this should be one of the major policy thrusts in the ESCWA member States.

7. The application of new technologies should be promoted in the major areas of concern to augment available water resources within the ESCWA region. These are:

(a) The use of non-conventional energy resources to desalinate brackish groundwater resources in the non-oil-producing countries. In the meantime, further research should be carried out to reduce the cost of desalination

methods currently being applied in the oil-producing countries, as desalinated sea and/or brackish groundwater, is a major element of the national water resources of many ESCWA member States.

(b) The utilization of treated sewage and industrial waste has become one of the most important elements augmenting national water supplies. The utilization of such resources must be carefully monitored, in view of health considerations.

(c) Water-use efficiency in irrigation must be improved, as must the reuse of the resultant drainage water. Because this offers the greatest potential for augmenting the available water resources in the region, projects to enhance such efficiency must be given priority in the region, particularly in countries where misuse of water irrigation prevails.

(d) Water-supply networks and water-storage facilities must be rehabilitated. A good deal of water loss is reported to occur in many countries of the region from dam reservoirs, water-supply networks or conventional irrigation projects.

8. Economic development policy should be reviewed and private investment should be encouraged to contribute effectively to the different fields of development through the setting of standards for water use and water conservation quantitatively and qualitatively and also through the issuance of water resources regulations and laws and penalties for violations.

9. Suitable fees should be collected for various water uses (to be collected for each application including domestic use, irrigation, industrial recreation, tourism and other uses). This fee is to be increased directly proportional to the water consumption rate.

10. Priority should be given to projects pertaining to better management of sea water encroachment, as most of the major coastal aquifers in the region have been endangered, particularly in the Gulf States.

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