ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA

SECTORAL WATER ALLOCATION POLICIES IN SELECTED ESCWA MEMBER COUNTRIES

AN EVALUATION OF THE ECONOMIC, SOCIAL AND DROUGHT-RELATED IMPACT

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Preface

Water resources in the ESCWA region are scarce—not only that, they are being depleted rapidly and demand for them is increasing. The present study has been prompted by this situation: there is an urgent need to analyse how reallocating water away from the agricultural sector (the largest user of water in the region) to meet the needs of other sectors (particularly the industrial and domestic) would affect the overall performance of individual sectors and, more generally, the economies of ESCWA member countries. In conducting the study, relevant data and information were collected, and eminent experts of the region were co-opted (for the preparation of the two case studies on water allocation in Egypt and Jordan).

It is intended that this study constitute both a reference document for policy- and decision-making processes relating to the management of water supplies in the ESCWA region, and an evaluation tool for decisions that have already been made regarding the allocation of water resources to various sectors. As such, its beneficiaries will be primarily policy and decision makers involved in the daily management of the ESCWA region's diminishing water resources. It is hoped that the study will also be of use to other professionals in the field, and will inform the general public on the issues surrounding sectoral water allocation and how optimal allocation can ensure sustainable, equitable and efficient use of the region's water resources.

The main part of the study is organized into seven chapters. Chapter I acts as an introduction and provides relevant background information. Chapter II provides an overall picture of the water situation in the ESCWA region and highlights the projected demand for water in the area. Chapter III reviews the major concepts and concerns in sectoral water allocation, assesses the urgency of implementing water-allocation policies, and investigates the economic, social and drought-related issues. Chapter IV provides a review of water-allocation mechanisms, and supporting policies and measures that may be used to enhance sectoral water allocation. Chapter V contains a cost-benefit analysis of water allocation that may be applied to the agricultural, domestic and industrial sectors. Chapter VI provides current and anticipated sectoral water-allocation policies in Egypt and Jordan, as well as a brief overview of the situation in selected other ESCWA member countries. Chapter VII concludes the study and presents some recommendations.

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Executive summary

Ensuring adequate water supplies for all raises difficult allocation issues. Agriculture is the largest user of water resources in the world, accounting for 72 per cent of average per capita diversions, with the industrial and domestic sectors accounting for 19 per cent and 9 per cent respectively. In the coming years, industry will remain a high economic priority; agriculture, with two thirds of its production dependent on irrigation, will remain dependent on water; and society's water requirements for domestic use will be greater than ever.

The situation will become graver in the ESCWA region, because the population is expected to increase by some 40-50 per cent over the next two decades. This population growth will be accompanied by major changes in the composition of demand resulting from rising incomes, urbanization and industrialization, even though the region's finite and fragile water resources are already stressed and depleting rapidly. Water-resource development has reached or is fast approaching its potential limit in most ESCWA member countries, and in those areas where undeveloped water-resource potential still exists, further resource development is constrained by technological inadequacy, and environmental and budgetary concerns. The demand-supply gap is growing rapidly, and intersectoral and interregional water conflict is intensifying as a result.

The volume of water currently available within the ESCWA region currently amounts to about 197.61 billion cubic metres per annum, while the region's total requirements are estimated to be 170.17 billion cubic metres per annum. However, if population increases remain in line with current projections and there are no changes in water availability, it is expected that most ESCWA member countries will face severe water shortages by 2025. Only five ESCWA member countries are currently above the water poverty/scarcity line of 1,000 cubic metres per capita per year. Better water allocation between various uses and users is required in order to adapt to the constraints imposed by water scarcity and drought.

Agriculture consumes more than 80 per cent of the water used in the ESCWA region. Small reallocations of water away from agriculture could be translated into very high increases in water availability in other sectors; in some countries of the region, the reallocation of a small percentage of water from agriculture could almost double the total amount of water available in another sector. For example, a transfer of 5 per cent of the water used in agriculture in Jordan away from agriculture could nearly double the amount of water available for domestic consumption there. Since agriculture is by far the largest consumer of water in the ESCWA region, it is envisaged that most, if not all, sectoral water reallocations will involve reducing the amount of water made available for agricultural purposes and reallocating it to other sectors. Reallocation will have a substantial impact, particularly on the domestic and industrial sectors, and could lead to an increase in gross domestic product (GDP) and to the creation of more jobs within the industrial sector, thereby helping to combat unemployment.

Efficient sectoral water allocation cannot occur if prices fail to reflect the true costs of water provision and the scarcity value of water itself. Getting the price right at the subsectoral level is fundamental to achieving optimal water use, not only within but also between sectors. There are many instances where water pricing in one sector has had a negative impact on the availability or quality of water in another sector. For instance, in the case of groundwater, subsidized electricity and fuel charges have resulted in the indiscriminate withdrawal of water for agricultural use and, in many parts of the region, this has also led to the contamination of domestic water supplies. Conflicts over water use between hydropower and irrigation can also be largely attributed to the subsidization of water in the agricultural sector.

As well as revising the pricing regime, reforms will also have to target allocation mechanisms themselves. Key reform areas are: (i) improving the administrative allocation of water by incorporating economic or value-based criteria into decision-making; (ii) developing administrative brokering of compensated trades; and (iii) developing formal water markets, including the establishment of institutional, legal, regulatory and technological frameworks. Reforms in these three areas are based on the common rationale that sectoral water allocation should incorporate an economic dimension without overlooking social concerns, whether this occurs through negotiation or through 'automatic' market exchanges. The suitability of one allocation mechanism over another will depend on circumstances, but the end result should be one of mutual benefit to all parties.

The solution to water shortage is to make the use of water among sectors more efficient, using allocation policies that take the principles of economic efficiency and equity into consideration. These are the two guiding principles for decision-making compatible with social objectives. Economic principles should be applied in order to recover the true cost of water delivered, including the opportunity cost, the capital cost and the operation and maintenance costs. This study outlines several of the criteria used to compare appropriate means of resource allocation in order to achieve optimal allocation.

Water-allocation policies vary from one country to another. Each country has adopted its own mechanisms according to its natural conditions, social and economic structure, and political situation, and these policies should be evaluated for their environmental, economic and socio-political effects. Cost-benefit analysis is the most common method for evaluating different alternatives for a project, and it can be used as a decision-support device to suggest what water-allocation pattern is likely to provide the highest net social benefit to society as a whole. Cost-benefit analysis is undertaken for Egypt and Jordan in this study, and results suggest that the net benefit to society could be greatly improved by reallocating water away from agriculture to other sectors of the economy.

All types of allocation policies are found in the ESCWA member countries, including marginal-cost pricing, public allocation, user-based and market allocation. The implementation of each type is dependent on certain circumstances, but no single type is best for all conditions. Although user-based allocation is more flexible than public allocation, its application in the region is still in its infancy and is limited to small-scale projects in Egypt and Jordan. So far, water-user organizations have not been able to provide services to users in a sustainable manner.

Water-market allocation principles, which are generally applied during crises or periods of scarcity, are applied in a few countries in the ESCWA region, despite the advantages of the incentives they provide for users to seek the highest-value application of water resources. Few cases of tradable water rights can be found, apart from the southern Ghors of Jordan, where farmers prefer to sell their rights to industry. The practices outlined are not regulated, so government should be committed to developing and supporting water-market and tradable water rights legislation.

In general for the ESCWA region, the following can be concluded:

1. Agriculture is the last and residual claimer of water, and proper regulations should be put in place to encourage water-use efficiency in order to save water that could be reallocated to other sectors.

2. The implementation of new water-pricing policies should be used as an incentive for improving water-use efficiency and water productivity.

3. Appropriate pricing and market-mechanism policies should encourage farmers to grow crops that have higher net returns per cubic metre of water and which are in demand in domestic and export markets.

4. The formulation of national water strategies should include strategies for increased water-use efficiency and reallocation of water between sectors. National strategies should put special emphasis on the support of target stakeholder groups, such as water-user associations.

5. New strategies should better define the role of governments in regulation, control and support, such as extension and research development to enhance water-use efficiency and water allocation.

I. INTRODUCTION

Global trends in water use during the twentieth century show that water consumption has increased almost tenfold. At present, around 35 per cent of the world's available water supplies are in use, compared with less than 5 per cent at the turn of the twentieth century. However, water scarcity is reaching alarming levels in some areas, especially arid and semi-arid regions, and this increasing scarcity has highlighted various water-related problems, such as conflicts between different uses and users. Conflict between the demands of the three major sectors (agricultural, domestic and industrial) is becoming fierce, but other sectors (such as energy, environment, flood control, navigation, fisheries and recreation) are increasingly affected as well. These conflicting demands are the result not only of a shortage of water, but also of society's inability to develop equitable allocation of water between different uses and users. However, there are positive developments: there is a growing awareness of the problem, and conscious efforts are being made to develop sustainable and favourable trade-offs.

In many parts of the world, the 1990s witnessed a dramatic shift in priorities for water-resource allocation and development. Irrigation, which was once seen as an essential step towards the achievement of self-sufficiency in food production, is now seen as a low-value use for water, when compared with municipal, industrial or even environmental uses. Not only are fewer funds being allocated for irrigation project development, but in an increasing number of cases, water is being transferred away from agriculture to meet growing demands in other areas. Sometimes the farmers holding water rights in these cases are compensated; on other occasions, they do not need to be compensated, nor does their consent need to be sought. The following should serve as an example: 15,000 cubic metres of water are necessary to irrigate 1 hectare of rice, but the same amount of water can supply 100 nomads and 450 heads of livestock for 3 years; or 100 rural families with piped water for 4 years; or 100 urban families for 2 years; or 100 luxury hotels for 55 days, etc. Industry requires large amounts of water, but about 85 per cent of it is returned to the water system, albeit heavily polluted with various waste materials, including chemicals and heavy metals. Demand for water from the domestic sector is moderate in comparison with that from the agricultural and industrial sectors, but its quality requirement is much higher (Richards 2001, Saleth and Dinar 1999).

A. BACKGROUND

The value of water to individual users is linked to its location and quality, and the timing of its availability. Its location determines accessibility and cost, its quality whether it can be used at all, and if so, at what treatment cost. The timing of the availability of water dictates its reliability and value for power production, irrigation, environmental or domestic use. However, the value of water, especially in agriculture, is also inextricably linked to the land to which the water is applied (FAO 1993). Furthermore, water has particular attributes that distinguish it from other economic goods: it is a basic human right, and the connection between water and human life is best exemplified in arid regions, where lack of water leads to famine and death. Yet only a small fraction of the water utilized by most societies is actually used for preserving life; a large proportion is used for convenience and comfort, for example in some developed countries, where daily household water use exceeds 400 litres, with half of this amount being used to water lawns and gardens, and most of the remainder being used to flush toilets, bathe and wash cars. The time is therefore ripe to review how water resources are being allocated, so as to achieve greater economic efficiency, as this should be the driving force behind the management of water resources.

In order to improve the management and allocation of water resources, it is also necessary to acknowledge that as a commodity, water can function in both a monopolistic and a competitive market. Water projects that compensate for seasonal variations such as floods and droughts require enormous investment, and economies of scale are such that a single organization is the most economically efficient arrangement. At the other extreme, most economies of scale for pumping groundwater can be achieved with relatively small outputs, with the result that many suppliers can operate efficiently simultaneously; this necessarily complicates the management of water resources. There is therefore an urgent need to manage water resources properly by establishing policies that will regulate, manage and allocate them in an integrated and holistic manner, maximizing the benefit to society as a whole.

B. JUSTIFICATION FOR THIS STUDY

Agriculture is the largest user of water in the world, accounting for 72 per cent of average per capita diversions, with the industrial and domestic sectors accounting for 19 per cent and 9 per cent respectively (Meinzen-Dick and Bakker 1999). Water-allocation problems in these three sectors will worsen in coming years: industry will continue to be a high economic priority; agriculture, with two thirds of production dependent on irrigation, will remain dependent on water; and society's water requirements for domestic use will be greater than ever. Many countries of the ESCWA region share the same water supply, and ensuring adequate water supplies for all will raise difficult allocation issues. The conservation of such supplies will require regional cooperation, and ESCWA member countries should seek opportunities to resolve conflicts over shared water resources.

The reason problems are likely to worsen is that the ESCWA region's population is expected to grow by some 40-50 per cent in the next two decades. This increase will come hand in hand with major changes in the nature of water demand, resulting from rising incomes, urbanization and industrialization. However, the region's finite and fragile water resources are already stressed and being rapidly depleted. In most ESCWA member countries, water-resource development has either reached or is fast approaching the limit of potential water utilization. Even in areas with undeveloped water-resource potential, further resource development is hampered by technological inadequacy, and environmental and budgetary constraints. The main result of this growing demand-supply gap is the intensification of intersectoral and interregional water conflicts.

In the ESCWA region, inappropriate policies are partly to blame for excessive water consumption and degradation in the quality of water. The fact that irrigation water charges are low or non-existent leads to the overexploitation of groundwater, an increase in water salinity, and waterlogging problems, which in turn result in lower crop yields. There are serious problems in Jordan, Palestine and Yemen, and the countries of the Arabian Gulf (including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates), which are currently facing severe water shortages, and a significant portion of the region's water is polluted owing to inadequate handling of human and industrial waste. If the region's aspirations to continued and sustained economic growth and improved social and environmental conditions are to be realized, fundamental changes in how water resources are allocated, planned and managed need to be made urgently by stakeholders (Richards 2001).

C. GOALS, OBJECTIVES AND METHODOLOGY

1. *Goals and objectives*

This study intends to define the concept of sectoral water allocation; to identify the mechanisms and policies involved; to evaluate the social, economic and drought-related issues; to analyse the benefit of sectoral water allocation to economies; and to examine how sectoral water allocation can best be achieved—and how applied—at the ESCWA member-country level, by suggesting suitable strategies. The study will review and assess these issues critically, so that policy and decision makers who face the task of managing dwindling water supplies and evaluating how best to allocate water resources to various sectors may understand what is at stake and what is expected. Policy and decision makers will have a comprehensive overview of the information available, and a practical, yet theoretically sound, analytical tool.

Agriculture is by far the dominant sector as far as water consumption is concerned, and in the ESCWA region it accounts for more than 80 per cent of water allocated and used. In the near future, it is envisaged that most, if not all, sectoral water allocations in the region will involve reducing water consumption in the agricultural sector and significant reallocation to other sectors. This reallocation will have a substantial impact on the domestic and industrial sectors that could lead to increases in the gross domestic product (GDP), provide more water for rural communities, and create more jobs within the industrial sector, thereby helping to combat unemployment. Agriculture will therefore be the main focus of this study, since it will be greatly affected by the reduction of water available to it. Better management of water in agriculture, including changing crop patterns and the adoption of modern irrigation technologies, will help agriculture deal with the reduction in its water share.

2. *Methodology*

The reviews, assessment and analyses undertaken in this study are complemented by a review of practical cases from selected ESCWA member countries. Part of this review is focused on the regional level, and part, including the economic analysis, at the level of the countries selected. The economic analysis is based on a cost-benefit analysis specifically developed for this study, which gives the costs and benefits derived from or generated by each major water-using sector. Water-benefit functions are developed, based on models taken from similar studies of major water uses, subject to a series of constraints and assumptions. Costs and benefits are then compared, taking as the economic objective the maximization of the net present value or the internal rate of return from various water uses.

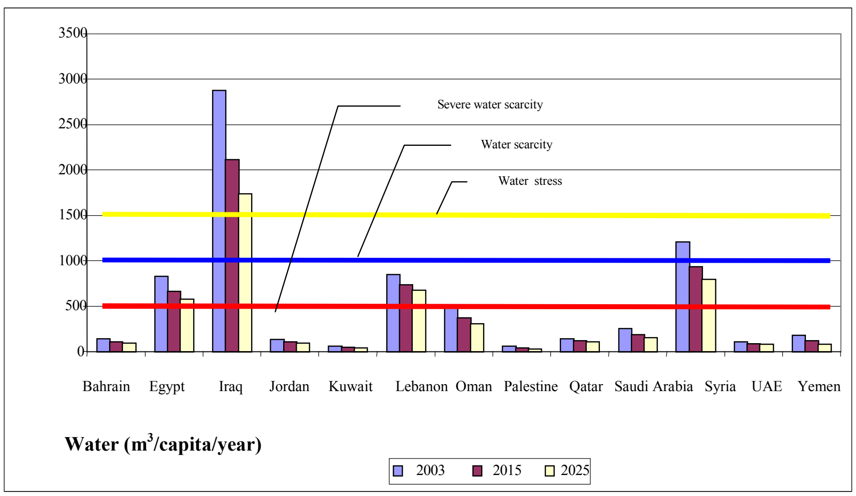
II. THE WATER SITUATION IN THE ESCWA REGION

A. AVAILABILITY OF WATER

World freshwater resources are limited, more so in arid and semi-arid regions. Sectoral competition to meet basic social and economic requirements is growing, and increasing development activities are creating even more competition for freshwater resources. Freshwater constitutes only 2.5 per cent of water in the world, but even this small amount is not entirely accessible for consumption: natural and technical limitations allow only 30 per cent of it to be extracted.

The ESCWA region covers about 4.750 million square kilometres, of which about 97.7 per cent are classified as arid or semi-arid. Though the region constitutes 3.6 per cent of the total area of the world and is home to 2.6 per cent of its population, its water resources amount to only 0.38 per cent of the world total. Water is therefore very scarce in the region, and the average per capita water share is just above the international water poverty/scarcity threshold of 1,000 cubic metres per capita per year. Furthermore, eight ESCWA member countries have a per capita water share of less than 500 cubic metres per capita per year (Bahrain, Jordan, Kuwait, Palestine, Qatar, Saudi Arabia, the United Arab Emirates and Yemen); six of these eight countries (Bahrain, Jordan, Kuwait, Qatar, the United Arab Emirates and Yemen) have a per capita water share of less than 200 cubic metres per capita per year and are among the world’s 15 countries poorest in water (see figure I).

Figure I. Per capita water share in the ESCWA region



The cost of developing new water sources is spiralling as a result of increasing water scarcity combined with continually increasing demand for water. Countries in the ESCWA region are being forced to invest in new technologies and infrastructures to access uneconomical water sources, or to purify and deliver brackish and sea water (ESCWA 2001a). Thus in Amman, Jordan, for example, the average incremental cost of developing water from groundwater used to be US$ 0.41 per cubic metre. Now that this groundwater has been depleted, it is necessary to bring water to the city from a site 40 kilometres away and to lift it some 1,200 metres at an average cost of US$ 1.33 per cubic metre. It is anticipated that as water becomes increasingly scarce, these costs will go as high as US$ 1.50 per cubic metre in the near future (Rosegrant 1997).

The availability of water resources within the ESCWA region varies from country to country. On account of their comparatively high rainfall, the northern ESCWA member States have perennial surface-water sources of varying sizes, in the form of springs and major rivers (which originate both within and outside these States’ national boundaries). These ESCWA member countries also possess renewable groundwater reserves sufficient to meet their current water requirements. In contrast, a harsh desert environment characterizes the southern ESCWA region, which encompasses the Arabian Peninsula countries of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, the United Arab Emirates and Yemen. Water resources in this region consist of limited quantities of run-off from flash floods, groundwater in the alluvial aquifers, and extensive groundwater reserves in deep sedimentary formations. The region also relies on non-conventional water resources, such as desalinated brackish and sea water, and reused wastewater. The total water available to the ESCWA region for the year 2000, from both conventional and non-conventional sources, is shown in table 1.

TABLE 1. ESCWA WATER RESOURCES IN 2000 (*in million cubic metres*)[a/]

	Conventional water resources[b/]			Non-conventional water resources	
Country/area	Surface water	Groundwater recharge	Groundwater use	Desalination	Wastewater and drainage reuse[c/]
Bahrain	0.2	100.0	258.0	75.0	(3.0) 17.5
Egypt	55 500.0	4 100.0	4 850.0	6.6	(4 920.0) 3 800.0
Iraq	70 370.0	2 000.0	513.0	7.4	1 500.0
Jordan	350.0	277.0	486.0	2.5	61.0
Kuwait	0.1	160.0	405.0	388.0	30.0
Lebanon	2 500.0	600.0	240.0	1.7	2.0
Oman	918.0	550.0	1 644.0	51.0	23.0
Palestine	30.0	185.0	200.0	0.5	2.0
Qatar	1.4	85.0	185.0	131.0	28.0
Saudi Arabia	2 230.0	3 850.0	14 430.0	795.0	(24.0) 131.0
Syrian Arab Republic	16 375.0	5 100.0	3 500.0	2.0	(1 270.0) 1 447.0
United Arab Emirates	185.0	130.0	900.0	455.0	108.0
Yemen	2 250.0	1 400.0	2 200.0	9.0	52.0
Total	150 710.0	18 537.0	29 811.0	1 925.0	8 322.0

Source: 'Shared groundwater resources in the ESCWA region: the need, potential benefits and requirements for enhanced cooperation,' paper presented at the Expert Group Meeting on Legal Aspects of the Management of Shared Water Resources, Sharm El-Sheikh, Egypt, 8–11 June.

a/ Note that the totals do not reflect the figures in the columns owing to rounding errors.

b/ The flow of the Tigris and Euphrates rivers can be reduced by abstraction upstream in Turkey.

c/ Values in brackets are drainage water reuse.

B. SECTORAL WATER DEMAND

Historically, relatively plentiful water resources have been used primarily for irrigation, with demands from other sectors being insignificant in relation to resource availability. That situation is changing, as shown in table 2.

TABLE 2. CURRENT AND PROJECTED WATER ALLOCATION IN THE ESCWA REGION
(*in million cubic metres*)

	1990			2000			2025		
Country	Dom.	Agric.	Ind.	Dom.	Agric.	Ind.	Dom.	Agric.	Ind.
Bahrain	112	120	17	132	124	26	169	271	169
Egypt	2 700	49 700	4 600	2 950	59 900	5 350	6 300	69 100	10 900
Iraq	3 800	45 200	1 450	4 300	52 000	9 700	8 000	76 000	10 000
Jordan	190	650	43	388	791	63	700	900	160
Kuwait	295	80	8	375	110	105	1 100	140	160
Lebanon	271	875	65	312	950	150	1 100	2 300	450
Oman	117	1 150	5	262	1 500	85	630	1 500	350
Palestine	78	140	7	260	217	18	800	420	70
Qatar	107	109	9	147	185	15	230	205	50
Saudi Arabia	1 508	14 600	192	2 350	15 000	415	6 450	16 300	1 450
Syrian Arab Republic	650	6 930	146	1 280	15 370	480	2 825	19 430	1 300
United Arab Emirates	513	950	27	750	1 400	30	1 100	2 050	50
Yemen	168	2 700	31	360	3 150	61	840	3 650	134
ESCWA	10 509	123 204	6 600	13 866	150 697	16 498	30 244	192 266	25 243

Sources: Compiled by the ESCWA secretariat from country papers, regional and international sources, and questionnaire.

Points to note

(a) *Expanding domestic demand*. Domestic water use (both urban and rural) was about 13,866 million cubic metres, or around 8 per cent of the water consumed in the ESCWA region in 2000. This figure is expected to rise to about 30,244 million cubic metres by 2025. While domestic demand is relatively small compared with agricultural demand, it reflects a basic need that will continue to be a high priority;

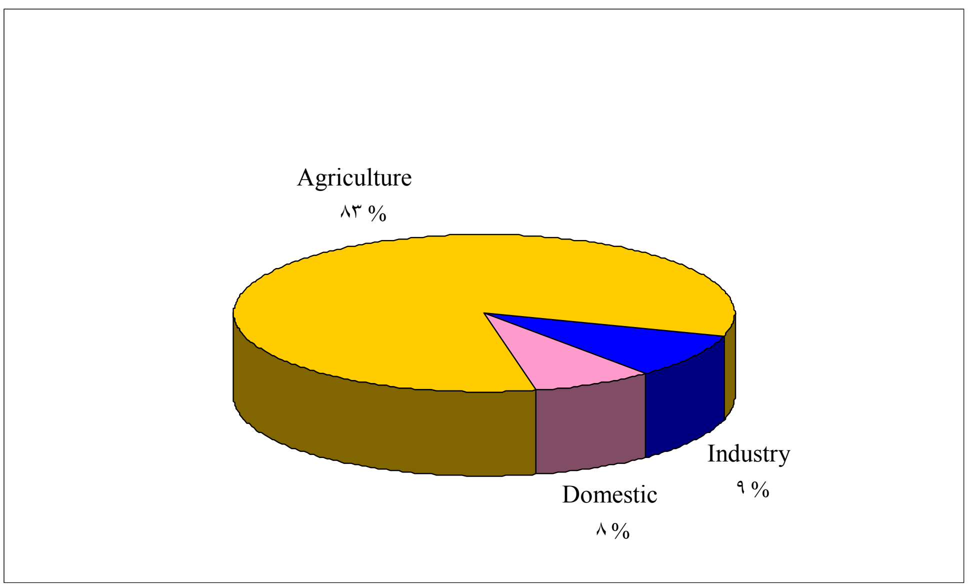
(b) *Rapidly growing industrial requirements*. The water demand for 2000 of 16,498 million cubic metres for the industrial sector and other related uses is projected to grow, reaching approximately 25,243 million cubic metres by 2025;

(c) *Continuing pressures from agriculture*. Agriculture accounted for approximately 83 per cent of total water consumption in 2000 and will increase by approximately 28 per cent to 192,266 million cubic metres by 2025;

(d) *Other uses*. Although not significant in terms of consumption, other uses (e.g., ecological, hydropower, navigation, fisheries, flood control, recreation) will nevertheless continue to be important and will require specific quantities and qualities of water.

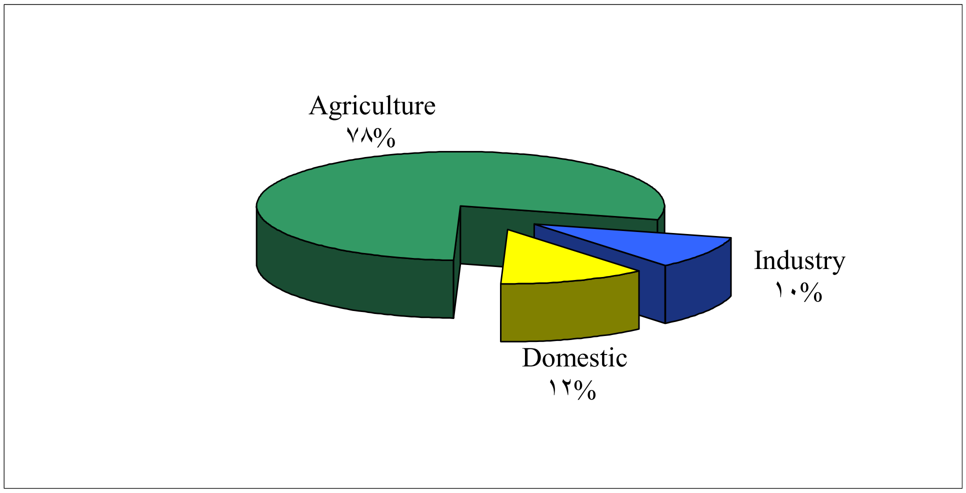
The agricultural sector is the largest water user in the ESCWA region, accounting for an estimated 83 per cent of the total water utilized; domestic water consumption and industrial usage account for 8 per cent and 9 per cent respectively of the total (see figure II). However, agriculture's share in the total is expected to fall as the strain on water resources increases and more water is diverted to satisfy the needs of other sectors, notably domestic and industrial.

Figure II. Sectoral water allocation in the ESCWA region in 2000



If the projected figures given above for the requirements for various sectors are correct, the total demand for water in the ESCWA region will increase from 181,061 million to 247,753 million cubic metres by 2025. This would represent more than 18 per cent of the region's utilizable resources, casting doubt on the region's ability to meet projected demand in all sectors. What is clear, however, is the rapid increase in non-agricultural demand: consumption in the industrial and domestic sectors is expected to increase, with domestic consumption expected to rise to 12 per cent of water utilized and industrial consumption to 10 per cent, leaving agriculture with 78 per cent (see figure III).

Figure III. Projected sectoral water allocation in the ESCWA region in 2025



These changes in water requirements and the relative claims of different sectors are partly a reflection of the changing status of these sectors in national policy. Although industrial development has been quite slow in past decades, development efforts have been more concerted in recent years, with the result that growth rates have accelerated. Sustained effort will be required if the industrial sector is to continue to be a major driving force behind consistently strong macro-economic performance in the region. The role of agriculture in overall economic development is being reduced as a result of this industrial development. Nevertheless, irrigation is still seen as the main engine for growth in the agricultural sector and rural development, and as such its claim on water resources will remain crucial in the near future. Reallocation of water away from agriculture will require better water management in the agricultural sector, including changes to crop patterns and the adoption of modern irrigation technologies.

Current constraints on water resources can be expected to become more apparent in coming years, as population growth rates are still high and are not expected to slow down significantly over the next several decades. In addition, the composition of demand will continue to change as a result of rising incomes, greater urbanization and increased industrialization, with end-users requiring the availability of water to be highly reliable and its quality improved. These changes in demand will not necessarily coincide with the natural distribution of water resources, since sources close to the locations where water is required will become exhausted. In past decades, such changes in demand were less noticeable, available resources were less stressed and there was still substantial room for finding *ad hoc* solutions to meet specific needs. Now, as the gap between the availability of water resources and demands on these resources widens, such *ad hoc* approaches to water allocation, planning and management will no longer be sustainable.

Competition for water between the city and agriculture will be a major challenge in the forthcoming century, whilst water demands from further expansion in irrigation, industry and the domestic sector will have serious implications for competing non-consumptive uses, such as hydropower. Weaknesses and inefficiencies in existing institutional and operational mechanisms for allocating and reallocating water between sectors should be studied carefully. If present domestic consumption patterns continue unaltered, most countries of the ESCWA region will have to construct new hydraulic structures, distribution systems, and desalination plants and support facilities so that overall capacity can handle increasing demand.

C. Population

In 2003, the total population of the ESCWA region was just above 180 million. This population is concentrated in five countries: Egypt (41 per cent), Iraq (14 per cent), Saudi Arabia (13 per cent), Yemen (11 per cent) and the Syrian Arab Republic (10 per cent). During the ten-year period from 1990 to 2000, the average annual population growth rate for the region was 2.6 per cent, as compared with 1.4 per cent for the world. Population growth rates ranged from 4.3 per cent in Yemen to 1.8 per cent in Egypt. By 2025, the total population of the ESCWA region will have increased by about two thirds, to around 290 million. The greatest increases will be observed in Yemen, where the population will more than double. The next greatest increases will be in Iraq, Palestine and Saudi Arabia, where the population will increase by more than two thirds, as shown in table 3. It is expected that 7 out of the 13 member countries of the ESCWA region will record a population increase of more than half by 2025. In 2003, the population density in the ESCWA region stood at around 40 people per square kilometre. The least densely populated countries were Saudi Arabia and Oman with 12 and 13 people per square kilometre respectively. Bahrain was the most densely populated country, with 1,089 people per square kilometre, followed far behind by Palestine, Lebanon and Kuwait, with respectively 593, 357 and 141 people per square kilometre. All the remaining countries had fewer than 100 but more than 30 people per square kilometre. However, the density of the population would be much higher if the inhabited desert land were not taken into account.

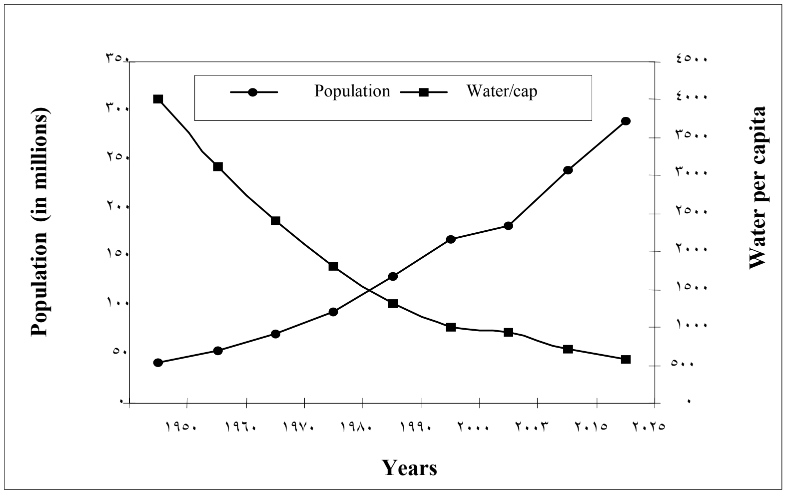
TABLE 3. POPULATION IN THE ESCWA REGION

	Population 2003			Population 2015		Population 2025	
Country	Total (1000s)	Urban (%)	Density ($/km^2$)	Total (1000s)	Urban (%)	Total (1000s)	Urban (%)
Bahrain	724	93	1 089	900	95	1 034	96
Egypt	71 931	46	72	89 996	51	103 165	57
Iraq	25 175	78	58	34 226	82	41 707	84
Jordan	5 473	75	60	6 982	80	8 116	82
Kuwait	2 521	98	141	3 352	98	3 930	98
Lebanon	3 653	90	357	4 207	93	4 554	94
Oman	2 851	86	13	3 908	93	4 785	96
Palestine	3 557	95	593	5 260	96	6 903	94
Qatar	610	93	53	711	94	790	95
Saudi Arabia	24 217	87	12	32 728	90	39 751	91
Syrian Arab Republic	17 800	56	97	23 018	62	26 979	67
United Arab Emirates	2 995	87	36	3 588	89	3 944	90
Yemen	20 010	26	38	30 677	31	43 204	38
ESCWA	181 517	60	40	239 553	64	288 862	68

Sources: UN Population Division 2001, 'World Urbanization Prospects: The 2001 Revision' (annex tables), in *United Nations Chronicle*, issue 3, UN Department of Economic and Social Affairs, New York; UN Population Division 2002, *World Population Prospects: The 2002 Revision* (annex tables), (ESA/P/WP.180), UN Department of Economic and Social Affairs, New York.

This growing population will continue to put a high pressure on already strained water resources, and the situation will only deteriorate with the anticipated improvement in living conditions. The per capita availability of renewable water resources was around 4,000 cubic metres per annum in 1950, but now stands at just over 900 cubic metres, just over 20 per cent of the water availability of the 1950s. By the year 2025, per capita water availability will have decreased to 600 cubic metres per annum, amounting to a mere 15 per cent of the water availability of the early 1950s (see figure IV). The situation is further exacerbated by the concentrated nature of human settlement and economic growth in each country. The average rate of urbanization in the ESCWA region is around 60 per cent, and the most populous areas are the few productive stretches of land, such as the Nile Valley and the Tigris-Euphrates plains. Despite this high rate of urbanization and the benefits brought by petroleum in the area, agriculture, which is still the largest water user of all sectors, remains important to most economies in the ESCWA region. One indication of this is the fact that agricultural and rural employment accounts for nearly 30 per cent of total employment—even more, if related activities such as transport and trade of agricultural commodities are taken into account.

Figure IV. Population and water availability in the ESCWA region



Sources: UN Population Division, 2002, *World Population Prospects: The 2002 Revision* (annex tables), (ESA/P/WP.180), UN Department of Economic and Social Affairs, New York; ESCWA, 2001, *Implications of Groundwater Rehabilitation on Water Resources Protection and Conservation: Artificial Recharge and Water Quality Improvement in the ESCWA Region*, E/ESCWA/ENR/2001/12, New York; and ESCWA 2001, *Progress Achieved in the Implementation of Chapter 18 of Agenda 21, with Emphasis on Water for Sustainable Agricultural Production: Case Studies*, New York (E/ESCWA/ENR/1999/22).

III. ISSUES RELATING TO SECTORAL WATER ALLOCATION

A. THE SIGNIFICANCE OF SECTORAL WATER ALLOCATION

1. *Definition of water allocation*

Water allocation may be defined as the optimal distribution of water by the appropriate authorities that meets society's needs, while maintaining economic efficiency and equity of distribution. Available water needs to be shared between competing uses and users, whether these are sectors or regions, while taking socio-economic development and environmental sustainability for the present and future into account. Before water allocation can be effected, it is important to consider: (i) the sources of supply and the amount of water each source is expected to supply; (ii) the various demands of each use or user and their size; (iii) the costs and benefits of supplying the allocated water to each use or user (World Bank 1998).

2. *The need for water allocation*

With water supplies dwindling all the time, both in terms of quantity and quality, and with population growth, socio-economic development, droughts and higher standards of living, etc., the competition for water resources is becoming fierce and will continue to be so in the foreseeable future. Factors affecting water availability may be summarized as follows.

(a) *Water scarcity and droughts*

Since, in becoming degraded, water from a particular resource becomes unavailable for uses that have stringent quality requirements, water scarcity reflects both the quantity and the quality of available water resources. Water scarcity may be the result of natural causes or human agency and it poses severe problems, which are exacerbated by the increasing costs of developing new water, the wasteful use of already developed water supplies, the depletion of groundwater resources, water pollution and its impact on human health, and the massive subsidies and distorted incentives that are being made. Sustainable use of water—resource conservation, economic viability, social acceptability, and the environmental friendliness and appropriateness of technologies—is a priority, particularly in the water-scarce ESCWA region. If sustainability is not prioritized, imbalances between availability and demand, degradation in the quality of surface water and groundwater, and intersectoral conflict will become the norm instead of the exception.

There have been droughts in the ESCWA region, for example that in Egypt in 1987. In Iraq, Jordan, Lebanon and the Syrian Arab Republic, there were recurrent droughts between 2000 and 2002. Measures must be adopted to prevent drought recurring and to ensure that the region's human-social and environmental systems—and hence water allocation—are not affected. As with many other environmental issues, drought is principally a socially constructed phenomenon: while ecological systems may adapt to recurrent periods of water scarcity, this is not the case with human-social systems and the environments that humans have altered. Furthermore, the inability to forecast droughts means that we shall remain vulnerable to them, and that our response to them will be largely based on past experience. Pre-emptive measures are therefore essential to cope with drought in the future.

The objectives of water-management policies and practices during periods of water scarcity should depend on the causes of the water scarcity. When valuing water, a combined environmental, economic and social approach is necessary, and when dealing with water scarcity, an integrated technical and scientific approach is essential to develop and implement appropriate management practices. Water management under drought requires measures such as avoiding water wastage; reducing demand; making water use more efficient; and increasing public awareness of the proper use of scarce water resources. The requisite increase in water supply in periods of drought can be achieved through: (a) increased storage capacity; (b) improved conveyance and distribution systems that are specifically designed to reduce water wastage in the system; (c) enhanced operation and maintenance; and (d) the development of new sources of water supply, including the use of non-conventional water (treated wastewater, desalinated water, drainage water, etc.). Increases in water supply should be accompanied by an increased emphasis in systems operation on both delivery (with modern technologies applied to reservoirs and the operation and management of supply systems) and water conservation (with appropriate water-saving technologies).

(b) *Population growth*

The major determinant of the availability of water resources is population growth, since this affects the demand for water consumed by humans, livestock and industry. The high population growth rate of the ESCWA region exceeds by far the rate of water-resource development. As a result, the annual per capita share of water resources is decreasing at an increasing rate, with the per capita water share for the region already well below water poverty/scarcity levels (see figure I). Indications are that half the member countries of the ESCWA region have already exhausted their renewable water resources and are now exploiting non-renewable reserves. As a result, water policies in future will have to consider the population as the main target user of water resources, and any design for a water-allocation mechanism will need to satisfy both existing and potential demands.

(c) *Socio-economic development*

Water is a basic human need—central to survival, critical for human health and productivity, and a prerequisite for the alleviation of poverty; it is also an important input in production and a crucial environmental asset. Water resources and water-resource management have an impact on a macro-economic level, affecting both the structure and the performance of economies. Variability in water availability affects economic performance, with agriculture being the most acutely affected sector, though other sectors are also affected to some extent. Catastrophic events such as floods and droughts are the most obvious examples of how water can affect real growth, but an underlying shortage of water (together with the economic and political strains associated with it) also has a major impact on investment levels and as such is a considerable constraint to sustainable economic development.

As was noted above, the demand for water is increasing and will continue to increase in the near future, mainly as a result of rapid population growth and economic development. The population of the ESCWA region is expected to grow at a rate of above 2 per cent per annum, while the economy will be growing at an annual average rate of somewhere between 3 per cent and 5 per cent. The introduction of technologies that facilitate access to water resources and the distribution of water, and the expansion of insufficiently efficient irrigation in agriculture will contrive to deplete water resources further. Water will therefore be one of the most important resources to constitute a constraint on economic growth in the region, and optimal control of its allocation and the timing of this allocation will be critical issues for the region for many years to come. In almost all the countries in the region, current water supplies will not be able to support sustainable economic growth in the near future. Water scarcity is already hampering development efforts in Egypt and Jordan, and countries such as Lebanon and the Syrian Arab Republic, considered to be relatively resource rich, are also being affected increasingly, as water becomes more and more scarce (Oweis 2003).

(d) *Other factors*

(i) *Water quality*

Different water uses have different water-quality requirements. Although the *quantity* of water needed for some uses may be a small proportion of the water required for all uses, the *quality* requirements of these uses may be much higher than those of uses that require large amounts of water—satisfying the water quality requirements of one use does not mean that water-quality requirements of other uses are satisfied. For example, alluvial and nutrient-rich water is beneficial in irrigated agriculture, but a liability for domestic use, because of the negative health effects of high levels of nitrogen, phosphorus and bacteria. The industrial sector also requires large amounts of high-quality water. Water quality is therefore one of the major challenges in water allocation.

(ii) *Water wastage*

Generally speaking, there are high levels of water wastage. Grass and other vegetation that would otherwise perish in the region's arid conditions are watered. More water is used than is needed in agriculture and for a wide range of indoor uses, from toilets to dishwashers, showers and swimming pools. Much water is lost in irrigation and municipal water-supply systems. Water that could be re-used after it has been used once is not being re-used. We are also failing to take maximum advantage of opportunities to use surface water and groundwater together (for example, by storing surplus surface water in wet years in aquifers for retrieval in dry years). Water providers do not always coordinate their water-supply programmes with one another, resulting in the duplication of facilities and plans. Cities are also not collaborating sufficiently closely with farmers to improve efficiency in water use: a portion of the water used at the farm level could be salvaged and sent to cities.

(iii) *Conflict, complementarity and competition*

Issues of conflict, complementarity and competition arise when all uses draw their water from the same source (e.g., a river, groundwater). When water is abundant, water-quality problems are reduced: water available for agricultural use in the form of streams or groundwater is also available for fishing, transport, leisure, domestic use and other ends. However, when there is a shortage of water for irrigation, there is also a shortage for other uses. Levels of pollution and salinity in the remaining water increase, as do the levels of competition and conflict over it. The major types of interaction are summarized in table 4.

TABLE 4. CONFLICTS, COMPLEMENTARITY AND COMPETITION IN WATER USE

	Agriculture	Municipal/ domestic	Industry	Environment	Transport	Hydropower
Agriculture	•					
Municipal/ domestic	•/+	•				
Industry	•/+	•/+	•			
Environment	•/+	•/+	•/+	X		
Transport	•/+	•/+	•/+	X	X	
Hydropower	•/+	•/+	•/+	X	X	X

Source: Meinzen-Dick, R., and Bakker, M., 1999, 'Complementarities, competition and conflicts' in M. Bakker, R. Barker, R. Meinzen-Dick and F. Konradsen (eds), *Multiple Uses of Water in Irrigated Areas: A Case Study from Sri Lanka*, SWIM Paper 8, International Food Policy Research Institute/International Water Management Institute, Colombo, Sri Lanka.

Key

- • Conflict and competition.
- \+ No conflict or competition.
- X Complementarity.

Points to Note

(a) *Agriculture to itself*. Conflict and competition arise over the distribution of water for irrigation between different parts of the agricultural sector and increase as water supplies become short. Water quality is also an issue, because poor drainage increases the potential for a rise in salinity;

(b) *Agriculture to all other sectors*. Agriculture is complementary to all other sectors, since seepage water can be used to recharge groundwater and thus supply other sectors. However, in most cases, especially in drought years, agriculture competes fiercely against all other sectors for water, as certain quantities must be set aside to satisfy the needs of those sectors. Conflicts over water quality also arise between agriculture and the municipal/domestic, industrial and environmental sectors, because agrochemical run-off and the minerals leached through water seepage and percolation contaminate water, making it unsuitable for use in the other sectors named;

(c) *Municipal/domestic and industry to themselves*. Although the total amount of water needed for a particular user may be small, municipal and industrial requirements are growing swiftly, and it is important that they are met, in order to satisfy basic human needs and promote economic development. Any reduction in supply or use of water above what is required is a potential source of conflict between different users at tap level. Using more water than is required can lead to shortages and result in discomfort among users and an increase in costs;

(d) *Municipal/domestic and industry to all other sectors*. Complementarity arises because wastewater and surplus water spilled at the tap/pipe level can be channelled and used to supply other sectors. Over-exploitation is the main source of conflict with other sectors, but problems with water quality, and with contaminated domestic and industrial wastewater are growing, especially in developing countries;

(e) *All other sectors to themselves*. These have no or very little conflict or competition among them, as all are non-consuming water users. They are complementary in the sense that the water used is returned to the system and used by other sectors.

B. WATER-ALLOCATION POLICY ISSUES

1. *Policy formulation*

Water-allocation policies are intended to regulate the competing claims of agricultural, industrial and household water consumption against a background of population growth, increasing food requirements, industrialization and urbanization. Other important water claimants, such as hydropower, navigation, flood control, fisheries, recreation and the environment, need to be taken into account. The water dilemma—to produce more with less water—requires demand-management mechanisms that can reallocate existing supplies, encourage more efficient use and promote more equitable access.

Water-allocation policies also determine how water should be allocated between competing uses. Policies can be designed at the country or area/basin level; they can be made at the local level (e.g., for an irrigation or city network); and they can change over time, reflecting fluctuations in water supply (both when the water supply is adequate and in times of shortage). The water-allocation policies of any given country or area/basin are strongly influenced by the adequacy of the infrastructure and by the social, economic and political situation. The degree of flexibility to change from one water-allocation policy to another will depend on the water-distribution system and the social framework, especially at the local level (Burton 1993).

The structure of any water-allocation system will be greatly influenced by existing institutional and legal frameworks, as well as the water-resource infrastructure. Some forms of allocation are likely to require specific sets of laws and regulations, specific organizations and a specific water-resource infrastructure to operate effectively. Water-allocation policies and their criteria come in numerous forms, ranging from complete control by the government to a mixture of market and government allocation, to predominantly market allocation (although even the latter requires some sort of government support and intervention).

A number of approaches to water-allocation policy are available to governments. These range from the option of ‘doing nothing’ or ‘postponing changes’, to the option of supply-oriented and demand-management policies that use economic incentives (prices, taxes, fees, markets), to the ‘command and control’ option, which imposes specific measures (regulations, quotas, instructions). The option of doing nothing or postponing action, which is in fact a rational choice in some cases, constitutes a point of reference for the impact of other policy actions, even though the cost of inaction could be great. If action is to be taken, the choice is between the supply-oriented and demand-management policies, or the command and control measures. In most cases, however, there will be a balance between the two options, both of which are necessary to a certain degree (FAO 1995).

2. *Factors affecting water-allocation policy*

The intrinsic characteristics of water make a large measure of public intervention inevitable. First, economies of scale in the collection and distribution of water tend towards natural monopolies, and these need to be regulated in order to serve the public interest. The fact that many investments in water are huge and long-term often discourages private capital, necessitating large amounts of public investment. Secondly, water uses in river basins or aquifers are inter-dependent, that is to say that users impose 'externalities' on others that they ignore in their own decisions (e.g., discharging polluting effluent into a river causes harm, inconvenience and cost to other river users). Thirdly, in some respects, water is a 'public good', in the sense that it is impractical to exclude particular users or beneficiaries, and therefore impossible to apply charges for such benefits that cannot be measured as improved navigation, flood control or reduced river pollution. Fourthly, water is prone to 'market failure', which implies that some public involvement is needed. Finally, water is vital to life, and certain water systems are of national strategic importance. Governments therefore have a responsibility to manage water for the welfare of the nation, and this being the case, appropriate laws, regulations, institutions and incentives should be put in place to underwrite the public interest, and appropriate investments made whenever the market is not willing to do so.

Comprehensive reforms in the water sector, especially in water-demand management, will be important in ensuring the success of water-allocation policies and measures in meeting new water demands. The most significant reforms will involve changing the institutional and legal environment in which water is supplied and consumed to one that empowers water users to make their own decisions regarding use of the resource, while at the same time providing a structure that reveals the real scarcity value of water. Key elements of these reforms will include appropriate water-allocation mechanisms (including the decentralization and privatization of water-management functions), incentives (including the creation of water markets and property rights), pricing reforms, reductions in subsidies, and licencing and regulations.

Critical for improvement in water-allocation policy is the recognition of water's multiple uses. Rules for allocation, water-distribution means, and designs for improvement require a better understanding of the present pattern of water use. This can be achieved through a water-accounting procedure, whereby the different uses of water are quantified and a better understanding of the relative quantities used by different sectors obtained. The procedure classifies the various components of water balance by sector and gives an indication of how water management is performing.

Another factor that has a fundamental impact on the formulation of water-allocation policy is human perception. The perception in ESCWA member countries that governments must provide water to all users free of charge is moulded mainly by religious belief, but also by the secular tradition of a long history of sufficiency in water resources. Other factors influencing water-allocation policies relate more specifically to the economics of water supply. Most analysts would argue that subsidies should be explicitly justified; that water tariffs should be designed to encourage conservation and not simply to recover costs (which implies that pricing should be at a sufficiently high level to move into the elastic portion of the demand curve); and that some form of lifeline pricing should be adopted to provide water for the basic needs of even the poorest households. This means that a sophisticated water-metering system must be in place if success is to be attained.

3. *Underlying principles*

Water-allocation policies should be aimed at maximizing economic efficiency and equity—both social objectives—so that water is available for consumption, sanitation and food production. Economic efficiency is concerned with the amount of wealth that can be generated by a given resource base, equity with the distribution of that wealth among the sectors and members of society.

The allocation of water to different sectors can be considered from a purely economic point of view, as a portfolio of investment projects where water is the limited resource (capital), and economic sectors use the capital and produce returns. In order to maximize the benefit to social welfare, the marginal value from the use of the resource in an economically efficient resource allocation should be equal across all sectors (that is, uses); in other words, the benefit derived from using one additional unit of the resource in one sector should be the same as that derived by any other sector. If resource allocation is not economically efficient, society can benefit by allocating more water to the sector where the benefits, or returns, are the highest.

Resource allocation can also take equity as its objective, with equitable allocation across economically disparate groups, whether or not this is consistent with the objectives of economic efficiency. In the case of domestic water, for example, equitable allocation of water implies that all households, regardless of their ability to purchase water, still have a basic right to water services. Meeting this objective will entail the government's providing subsidies or free service, or perhaps adopting a differential pricing structure based on income.

C. THE ECONOMIC VALUE OF WATER

1. *User value*

User value is the value that can be derived from a single, specific use of water. Evidence indicates that municipal and industrial users typically have the highest user values for water. Some urban households not connected to the water network purchase water from vendors and often pay extremely high prices per cubic metre for small quantities of water for domestic use. Increasing the amount of water supplied to such households would be of great economic value, because water is very scarce for such users, and they are willing to pay a great deal for it, even though their incomes are often quite low. (It should be noted, however, that this extremely high water value is likely to pertain only to the small quantities required for basic needs; figures should not be extrapolated for the greater quantities that would be used if cheaper water were available).

The range of user values for water in agriculture, on the other hand, is in a much lower bracket. The amount a farmer is willing to pay for water for irrigation is typically low and depends, among other factors, on the crop being cultivated, the amount of rainfall, the prices of agricultural products, and the prices of other inputs, such as fertilizer and labour. The user value for the large-scale irrigation of cereal crops such as wheat is at the low end of the range, while the user value for the irrigation of high-value fruits and vegetables is occasionally at the high end of the range, but depends to a great extent on market conditions and the transportation costs of delivering produce to market.

2. *Economic value*

The economic costs of water are often conceived as simply the cost of building and maintaining the infrastructure necessary to supply it; the water running through the system is generally not considered to have a separate economic value. The economics of water-resource development under circumstances of abundant supply focus on the least-cost analysis of water provision. Water scarcity, however, necessitates recognition of the 'opportunity cost', the benefit that could have been generated if a resource (here, water) had been put to its next best use, rather than being used for a particular purpose. For example, if a certain amount of water is used to irrigate crops, the opportunity cost of this water is the lost benefit that could have been generated, had that water been used for livestock, electricity production, or even to meet domestic needs, whichever has the highest value. Where water resources are scarce relative to demand, and utilization by one party precludes alternative uses by others, water-use decisions carry opportunity costs, sometimes referred to as 'scarcity rents'.

Water is in fact an economic good in itself, because it is both an element of production and a final consumer product. If it is treated as such, the value of water will be reflected in the opportunity cost. However, water should not be treated exclusively as an economic good: it is also a social good (because it is a basic requirement for sustaining life and fulfils basic human needs) and an environmental good (since it is a critical element of ecosystems). Treating water as an economic good simply acknowledges that water is a valuable, increasingly scarce commodity. The economic consequences of its use should be understood and weighed up, along with the social and environmental benefits, so that decision makers can grasp all the implications of a particular allocation policy. In fact, a call to recognize water as an economic good enhances rather than diminishes the importance of its social and environmental dimensions.

One solution would be to allocate water resources to those users who generate the greatest value for the economy, while charging them an economic price for the water. This revenue could then be spent in a transparent and targeted manner on poverty-alleviation programmes (assuming there is sufficient capacity to design and implement such programmes).

3. *User values versus system values*

The economic value of water is based on its user value, defined above. At basin level, the user can be an individual, a group of individuals, or a country using water for a specific purpose, and in a specific place and manner. User values may or may not be greater than system values. Optimizing basin management does not necessarily mean that every activity undertaken must be a high-return one: the unique characteristics of each basin and the interplay between activities in that area will govern water allocation. In particular, if options for high-value use are available downstream, low-value, non-consumptive upstream uses may be part of an optimal basin management plan.

The distinction between user values and system values may therefore be defined as one of scope. The former focuses only on single uses of water, without taking into account the externalities and opportunity costs that link water-use decisions to other activities in a basin. The latter aggregates all the user values generated under a given management scenario and then incorporates the interactions, externalities and opportunity costs that arise across the basin. The calculation of user values and system values can provide insights into the potential benefits of co-operative basin management. Where system values are greater than user values, there is strong incentive for co-operative management.

D. THE IMPACT OF SECTORAL WATER ALLOCATION

Reductions in water availability affect agriculture, municipal, industrial and other uses: wells dry up, crop and livestock production are reduced, domestic water supply becomes insufficient and unreliable, and the concentrations of pollution and salinity in the remaining water increase. Moreover, water scarcity as a result of drought or other causes increases the level of competition and therefore conflict over water.

1. *Economic impact*

Countries regularly faced with water shortages usually adopt policies designed to act as a buffer against the impact of shortages on their economies. For example, to reduce the economic impact of hydrologic variability (high fluctuations in water supply), countries adopt policies that promote food security (the capacity to secure food supply through trade or production) rather than food self-sufficiency (production of all food needed within the country itself). The structural shift away from agriculture production to trade, particularly if imports of water-intensive and drought-sensitive crops are increased, then mitigates the economic impact of fluctuations in water supply. Similarly, structural shifts away from water-intensive industries could decrease economic vulnerability to hydrologic variability.

Water-demand management during periods of scarcity includes a variety of practices and decisions: process-related decisions (agronomic, industrial, etc.), economic and technical decisions (to reduce water requirements), and the adoption of practices leading to water conservation and savings (both of which reduce the demand for water while increasing the return per unit of water used). ‘Virtual water’ is an innovative approach to water-demand management; commodities that have a large amount of water ‘virtually’ embedded in them during the production process can be imported, so that production in the area to which the import is made can be focused on other commodities that require less water. However, the impact of policies on large, market-oriented businesses can be very different from that on small, family-run enterprises oriented to producing products consumed mainly locally. Such enterprises are in the majority in water-scarce areas. The businesses may easily adapt to new market conditions, but the enterprises do not generally have the means and flexibility to change their production systems. If virtual-water policies were implemented without appropriate support for the enterprises, the economic and social impact policies would be enormous.

2. *Social impact*

Water allocation will be a driving force behind the social policies of the ESCWA region in the future. The reallocation of water away from agriculture will displace the non-negligible portion of the labour force currently employed in agriculture. The high proportion of young people in the population indicates that there will be a substantial increase in the labour force over the next few decades, part of which will most likely be seeking employment in the agricultural sector. The creation of new jobs in agriculture, however, will depend on the availability of water resources. If water resources were to become available, this would assist in the reclamation of land and the establishment of new settlements. Reallocation of water that removes the constraints of hydrologic variability could also act as a powerful catalyst to economic development and investment, especially for small and medium-size industries. The creation of such industries would offer new employment and opportunities and therefore improve the general welfare of the population.

In order to avert the social unrest that could be generated by a scarcity of water resources, it is important that existing water resources be used and allocated more efficiently, by adopting sound economic decisions compatible with the twin social objectives of economic efficiency and equity. Indeed, many water-allocation schemes attempt to take these principles into account.

3. *Drought-related impact*

In drought-prone areas, investment patterns reflect risk-averse behaviour: individuals, entrepreneurs and States will make location, investment and production decisions that lessen vulnerability to water shocks. Many of these decisions will improve efficiency by citing activities where they are most economic and by adopting appropriate technologies, but others may act as a brake on investment, because the risk relative to potential returns will be high. Individuals will attempt to mitigate the risks posed by drought, or adopt strategies to cope with it, for example, farmers may shift crop mixes or alter production technologies. If, however, it is uneconomic or unfeasible to implement measures that substantially mitigate the risks posed by droughts and hence variability in output, farmers are less likely to invest in land improvements, capital-intensive inputs or production technologies. This will be compounded by the fact that most farmers have insufficient means and are often unwilling or unable to access capital to improve their lands or production techniques (Pereira, Oweis and Zairi 2002).

To address the risks associated with droughts, manufacturing and service industries are likely to be located in areas with sufficient, reliable water supplies and to adopt water-saving technologies when there are economic incentives for doing so. Fewer enterprises will invest where water supply is unreliable, and those that do will often construct their own water supplies. As standard coping strategies, these independent water supply arrangements raise the cost of production and affect competitiveness and profitability. Water is frequently drawn from groundwater without adequate regulation or monitoring, which can lower the level of the water table and compromise the quality of groundwater. In addition, when major users, such as urban industries and wealthy individuals, make their own water provisions, municipal utilities are not able to take full advantage of economies of scale in production and distribution. This results in poor maintenance and operation, increased tariffs, and the inability of utilities to extend service coverage. All of these factors affect the performance and structure of the manufacturing and service sectors.

Countries unable to mitigate the effects of droughts and minimize the risks they pose to their economies will see their economic growth, investment incentives and capital availability constrained. To break out of this trap, these countries will need to address the risks generated by droughts, by implementing a diverse portfolio of policies and investments. The structure of their economies will need to be strengthened in order to make them more resilient to the risks of drought. Strategies could include improving water-resource management (such as seeking conservation and efficiency gains and developing source and storage solutions); placing greater emphasis on food and energy security (rather than self-sufficiency); encouraging trade and agricultural production patterns less vulnerable to hydrologic variability; and seeking to generate employment and growth in less water-dependent sectors. At the same time, economically, socially and environmentally sound investments in river-management infrastructure could be made nationally and internationally, on shared river systems.

IV. WATER-ALLOCATION MECHANISMS, SUPPORTING POLICIES AND MEASURES

A. WATER-ALLOCATION MECHANISMS

1. *Criteria for water allocation*

Appropriate means of water allocation are necessary to achieve optimal allocation of what is a scarce resource. A number of criteria, which are often interrelated, come into play in planning and managing water systems, and the emphasis placed on any one of these criteria by different countries will vary (FAO 1995).

(a) *Flexibility* in the allocation of supplies allows water resources to be shifted from use to use and place to place, as demand changes. Flexibility in water supplies makes it possible to equate marginal values over many uses at the least possible cost.

(b) *Security* of tenure for established users is needed, so that these users can take the necessary measures to use a resource efficiently. Security does not conflict with flexibility, as long as there are reserves available to meet unexpected demands.

(c) *Paying the real opportunity cost* of providing a water resource is a requisite, as it allows externality problems to be internalized. Such a path would allow water allocation to take into account environmental uses that do not have a market value, such as providing a habitat for wildlife. It would also direct utilization of the resource to activities with the highest alternative values.

(d) *Predictability of the outcome* of the allocation process would allow allocation to be optimized and promote investment. It would also minimize uncertainty and therefore lower transaction costs.

(e) *Equity* in the allocation process is necessary in order to provide equal opportunity to every potential user of a resource. The burden of policy impact should be distributed fairly among the various socio-economic groups. Disadvantaged groups, such as women, poor households or small farmers, who previously received supplies considered to be inadequate or obtained at high personal or social cost, would benefit from policy reforms and would not find themselves worse off.

(f) *Political and public acceptability* are required in order for water allocation to be allowed to serve its purpose and accepted by the various segments of society. A policy is more likely to be acceptable if it is seen to be tackling a severe problem; if its costs and benefits are equitably distributed; if there is a strong lead from prominent political and community figures; if it is accompanied by adequate publicity; and if the population is well informed and public-spirited.

(g) *Efficiency* is required so that the form of allocation can change existing undesirable situations (such as the depletion of groundwater and water pollution) and assist in the drive towards desired policy goals. The efficiency criterion requires that the economic benefits of policies exceed their costs. For instance, in the case of the development of new water supplies, the value of the water produced should exceed the cost of production (including the environmental costs). As far as conservation measures are concerned, reduction in consumption is worthwhile, as long as the unit value of the water saved exceeds the cost of providing it. Efficiency applies also to policies involving the reallocation of water between different users, such as within the agricultural sector, or from agricultural to municipal or environmental use. Reallocation to higher-value uses will produce net social benefits corresponding to the difference between the value of water in its old and new uses.

(h) *Sensitivity*. Water is a sensitive topic in most societies, and reforming public behaviour towards water is a difficult task, with substantial political and administrative costs. It is therefore important that policies should have a commensurate pay-off in the form of effective fulfilment of their goals. To increase water prices, the clearest measure of response is the elasticity of demand in respect of price changes. Higher charges for water use could be accompanied by a campaign of public information and education, subsidies for the installation of water-efficient facilities, and free advice on reducing consumption and waste.

(i) *Public health and nutrition* should be ensured, as millions of poor people still lack access to safe water and do not have proper sanitation. Inadequate sanitation and the provision of clean water remain the most serious environmental problems, as far as human suffering is concerned. Public health should greatly benefit from good water systems that provide adequate coverage of water supply, sanitation, and safe disposal of used water.

(j) *Administrative feasibility and sustainability* should also be ensured, so that allocation mechanisms can be implemented and policy not only continues to be effective, but also increases in effectiveness. Operating a policy must be within the administrative capability of the public authority involved: new policies will be worthless unless their implementation is monitored and enforced. For instance, metering supplies requires staff to undertake household visits and billing. A drive for conservation needs to be backed up by qualified staff to advise households, industries or farmers on technology and better water management and use. By the same token, supply-augmentation schemes will not necessarily be as easy an option as first appears if they require intensive monitoring and maintenance. Policies that make a long-term impression on water use, such as technological adaptations and changes in user habits, are more sustainable.

(k) *Fiscal impact* should be evaluated, as many countries with serious water problems also have weak public finances. A sustainable policy would be one with a positive impact on the finances of central or local government, such as an increase in revenue, a reduction in subsidy, or the avoidance of major capital spending. The fiscal yield of a specific price adjustment will depend on the price elasticity of demand.

(l) *Environmental impact* should also be evaluated, as the supply, use and disposal of water are potentially major operations. Dams and reservoirs, aqueducts, river diversions, major irrigation schemes, industrial and municipal take-off, groundwater pumping and so on can have a major hydrological impact, which could affect both present and future generations and wildlife. The same applies to the disposal of wastewater and the contamination of bodies of freshwater through agricultural run-off, industrial effluent and unprocessed sewage.

(m) *Policy reforms* are required, particularly in agriculture, as sustainable agricultural development depends on sustainable water use. As private-sector discipline is applied to irrigation and more user participation occurs, policy makers are finding that (i) agencies are becoming more supportive of farmers' own efforts and less inclined to make all key decisions and then inform farmers of these decisions; (ii) managers are seeking more consensus on priorities, more information about the basis of decisions and a common view of external factors affecting management; (iii) irrigation schemes are seeking and receiving more autonomy; (iv) the financial responsibilities and accountability of managers is increasing; and (v) managers are focusing less on ministries and governments, depending on the amount of money they are able to generate through service fees.

Other criteria may also be relevant in particular circumstances, such as the impact on food self-sufficiency, regional development, the urban-rural balance, a desire for self-sufficiency in water, etc.

2. *Water pricing*

Water pricing is among the various measures that are used to encourage the efficient use or allocation of water resources, and many countries are already engaged in water-pricing reforms. These reforms have encompassed all areas, from irrigation to urban and rural water supply. Generally speaking, existing methods of water pricing can be classified into volumetric and non-volumetric methods. Volumetric methods, such as single-rate, tiered (multi-rate) and two-part tariffs, or market-based prices, rely in one way or another on the quantity of water used, and hence require a water-metering facility. Non-volumetric methods are based on outputs or inputs other than water; per area pricing, which is based on the area cultivated or irrigated, is an example of this (Tsur 2000). Among the pricing reforms often suggested is pricing water at its marginal cost, which involves setting the unit price of water to equal the marginal cost of supplying its last unit.

Water supply charges typically include the collection of water, its transport to a treatment plant, its treatment to meet quality standards, distribution to customers, and monitoring and enforcement. If there are higher costs in allocating water to some uses as opposed to others, then the price needs to be differentiated so that it can be equivalent to the relevant marginal cost of providing the water to each type of use. Efficient intersectoral water allocation can be realized with value-based pricing at the subsectoral level. Major change is therefore required in the pricing systems and other economic incentives affecting water demand and supply.

Desirable practices such as conjunctive use, water-saving agriculture and industrial technologies, water transfers and water recycling—in other words, water conservation and optimal water utilization both within and between sectors—only emerge when an individual or decision-making entity (water-user associations, industry, etc.) perceives that there is a constraint on the water available to it. For this reason, economic instruments that provide appropriate incentives for both service providers and users should be put in place. Water charges should ideally be based on the full cost of development and supply of water (both capital and operation and maintenance costs). If this is not possible, the water charge should at least cover operation and maintenance costs, while keeping the covering of capital cost as a long-term goal.

Most member countries of the region use so-called ‘increasing-block tariffs’, which allow customers who use small quantities of water from a connection to a piped network (and who are often poor) to benefit from low unit tariffs, while customers who use large quantities from the network (and who are often wealthy individuals, hotels, businesses and small industries) pay higher unit tariffs. Tariffs are set at an appropriate level for families, depending on their level of water consumption. For some cities in the ESCWA region, such as Sana’a (Yemen), where water consumption is much lower, the actual average tariffs are much lower than the tariffs typical in the region. Tariffs are highest in Ramallah on the West Bank, but more than ten times lower in the Syrian Arab Republic and Egypt. In Egypt, the monthly water-utility bill can be as low as US$ 1, while in Ramallah it is close to US$ 20. Municipal water use is metered in most countries, with the exception of Lebanon where most cities do not have water meters and a countrywide levy is applied. This levy is a flat-rate tariff that is independent of the level of water use and provides no incentive for conservation. Sewerage tariffs throughout the region tend to be even lower and are typically only a fraction of water tariffs.

The key areas where subsectoral reform is required are as follows:

(a) *Irrigation pricing*. The most pressing need for subsectoral reform is within agriculture, which is responsible for more than 80 per cent of water use in the ESCWA region. Although the problem is well known, irrigation water charges are still extremely low, stagnant, and not set in a volumetric manner in most countries in the region. There is therefore a need to set up proper water charges, and there is no avoiding this difficult step. The first essential objective should be to raise water charges so that they can cover operation and maintenance costs. As a longer-term objective, water charges would also need to be increased to cover depreciation and interest on capital, but covering operation and maintenance costs would be a sufficient target in the short term.

(b) *Water supply pricing in urban and rural areas*. Urban areas could benefit from a review of existing tariffs and subsequent implementation of a programme that improves incentives for water conservation and enhances revenue from domestic consumers. Volumetric charging should be applied, including practical mechanisms to apply metering more generally. In rural areas, new water-supply and sanitation strategies should be formulated to rectify problems that arise from current water-subsidization policies, such as a lack of community involvement and the centralization of water management in rural areas.

(c) *Groundwater pricing*. Charges for groundwater are currently not properly established in all countries of the ESCWA region. Moreover, such charges are not volumetric and are well below the cost of provision; they are even set at zero in some countries. In addition to the enormous fiscal burden this entails, such policies have also contributed to water wastage and misuse. Features of reform programmes relevant to groundwater management should include tariffs that cover the energy costs of retrieving the water and the installation of meters. Options to make volumetric charging easier could include a block approach—selling water to water companies by volume and leaving them to arrange distribution and charging amongst their clients according to usage. It would be much easier to implement changes in groundwater pricing if the public were better informed about the environmental and fiscal issues involved, and the risk of unsustainable consumption resulting from overextraction from groundwater resources. Jordan, Bahrain, Saudi Arabia, the Syrian Arab Republic and Yemen have installed a metering system for groundwater use.

3. *Public allocation*

Public or administrative intervention in the development and allocation of water resources is required because (i) it is difficult to treat water as a market good; (ii) water is usually perceived as a public good; and (iii) large-scale water development is generally too expensive for the private sector.

The majority of large-scale irrigation systems rely on public allocation, with the State deciding what water resources can be used by the system as a whole, and allocating and distributing water within different parts of the system. Public water-allocation mechanisms in the domestic sector include both municipal water-supply providers and many rural water-supply and sanitation programmes. Public allocation also dominates industrial water uses through the granting of permits, and the regulation of water withdrawal and effluent discharge by individual companies and industries. In Egypt, the Syrian Arab Republic, Oman and Yemen water-user associations have been involved in the public allocation process, which has enhanced the water share of various parties and hence improved water allocation overall.

Some issues relating to water that establish a role for government intervention and action in water allocation are as follows:

(a) The large capital requirements and economies of scale achievable in a water infrastructure tend to create natural monopolies, which will require regulation to prevent overpricing;

(b) The large size and extremely long-term nature of some investments, given underdeveloped capital markets and the potential for political interference in many water infrastructure investments, reduce incentives for private investment in the sector;

(c) The uses of water within a river basin or aquifer are interdependent. Withdrawals in one part of the basin reduce the availability of water for other users; groundwater pumping by one user may lower the water table and increase pumping costs for all users; and pollution by one user affects others in the basin, especially those located downstream;

(d) Some activities relating to water, such as the control of floods and water-borne diseases, are public goods for which individual uses cannot easily be charged;

(e) Water resources are often developed because of their strategic importance for national security and for regional development. Governments typically maintain ownership of water thoroughfares, providing services such as protection and traffic regulation.

Any public water-allocation mechanism will therefore have no single objective. Although a national or State agency may consider other approaches, public water-allocation mechanisms are far more likely to be preoccupied with equity, sovereignty, and an overwhelming concern to satisfy the greater public good.

With public allocation, market mechanisms of water supply via transfers of water titles are replaced by subsidized water-supply development, with the result that prices do not reflect either the cost of water supply or its value to the user. Furthermore, while the State as a whole may have responsibility for overall water use, most agencies dealing with water resources have responsibility only at a sectoral level (e.g., dealing with irrigation, or drinking water, or industry, or the environment). Such executive agencies have neither the mandate nor the incentive to create integrated projects, or to balance the needs of various users.

4. *User-based allocation*

Farmer-managed irrigation systems provide one of the clearest examples of user-based water allocation. Studies have shown a wide variation of rules for allocation within such systems: by timed rotation, depth of water, area of land, or share in water flow. In the domestic water-supply sector, user-based allocation is seen in community wells and hand-pump systems, as well as in the growing number of more complicated systems managed by water and sanitation associations. Intersectoral user-based allocation is seen in the management of village tanks (ponds) or other local water sources used for domestic water, irrigation, and even animal watering.

User-based allocation has the potential to achieve high efficiency of water use. It requires institutions that are capable of collective action and have the authority to make decisions on water rights, and its effect on water conservation depends on local norms and the strength of these institutions. It is easier for such institutions to organize collective action to increase their water supply (which represents a positive-sum activity) than to distribute water amongst themselves (which is at best a zero-sum activity). However, if the institution does not actively promote efficient use of water, the allocation mechanism will have little effect in the area of water-demand management.

A major advantage of user-based allocation is its potential flexibility to adapt water-delivery patterns to meet local needs. Because those directly involved in water use, whether for agriculture, home consumption, or industry, have more information on local conditions than the agency staff possess, they do not have to rely on rigid allocation formulae. For example, certain fields may be given more water than others, depending on the water-retention capacity of their soil. User organizations may also take into account local needs, such as watering animals, washing clothes, bathing, or other small enterprises—needs that a sectoral agency would have no mandate to meet. The result can be an improvement in output per unit of water, or in equity, or both. Further advantages of user-based allocation may be summarized as political acceptability, and administrative feasibility and sustainability.

For user-based allocation to operate, institutional structures need to be very transparent, which may not always be the case. Local user-based institutions can be limited in their effectiveness for intersectoral allocation of water, because they do not include users from all sectors. For example, a village community may readily identify with the needs for domestic use, animals and irrigation (though the particular interests of different groups within the village—women's greater interests in domestic water, pastoralists in supplies for animals, farmers in irrigation—will differ). Industrial demand, however, is often seen as 'outside' the local community, and therefore not amenable to user-based allocation. Even when there is no intersectoral competition in a particular location, but municipal and industrial demand in one area needs to be co-ordinated with irrigation in another, user-based allocation can work, through federations of user groups.

5. *Transaction costs*

A fundamental determinant of the effectiveness of water allocation is the level of transaction costs incurred in the allocation process. Transactions costs are the costs that arise from obtaining information, forging agreements or making contracts, and monitoring and enforcing those contracts. They occur in any water-allocation process, particularly when water is reallocated between individuals and sectors, and include (a) the costs of identifying beneficial opportunities for transferring water; (b) the costs of negotiating water transfer, or the costs to administration of deciding on the same; (c) the costs of monitoring possible third-party effects and other externalities; (d) the infrastructure costs of actually conveying the water and monitoring transfers; (e) the infrastructure and institutional costs of mitigating, or eliminating possible third-party effects and externalities; and (f) resolution of conflicts that arise during water reallocation.

6. *Experiences from various countries*

The allocation mechanisms described above have been applied, in whole or in part, to different sectors and in different locations. The case reviews below provide lessons that could usefully be considered when implementing allocation mechanisms in future.

(a) *Marginal cost pricing*

France. In the southern part of the country, an irrigation scheme is in place that relies on marginal cost pricing. This pricing recognizes the need to take long-term costs into account if farmers are to make 'correct' investment decisions in respect of land, cultivation, crops, irrigation equipment and storage (and, indeed, if the scheme itself is to take the correct path in respect of work on new water resources). To set up the tariff, a peak period lasting for five months from mid-May to mid-September was identified, and in setting the tariff the following rules were applied: (i) during the peak period, the price was set as the long-term marginal capital cost, augmented by the operating costs, of supplying the water consumed; (ii) during the off-peak period, the price was set as the operating cost only of supplying the water consumed; and (iii) fees were applied to reduce polluting discharges. The development costs of the infrastructure that brings the water from source to field (which in theory should likewise fall during peak periods in line with irrigators' demands) is in fact merged with operating costs in order to establish a single year-round volumetric charge. This system resulted from an examination of the way in which water was consumed, its distribution between peak and off-peak periods being well known. The advantage of the system is that it simplifies pricing and facilitates the use of a single meter reading. In other sectors (urban, industrial), the price was again set as only the operating cost of supplying the water consumed. Off-peak demand thus has no role in determining responsibility for capital-cost recovery, as the economic theory of peak demand dictates.

(b) *Public water allocation*

United States. At the turn of the twentieth century, there was a strong feeling that the large western rivers should be brought under control to a certain extent. The Bureau of Reclamation was created and it undertook the building, operation and maintenance of dams, reservoirs and canals to support irrigation expansion in the west of the country. The Bureau has authority to allocate water for irrigation, for nearby towns and cities, and for hydroelectric power, but it has no rights to the water itself. Rather, it has control and management authority of the water-distribution and storage systems and sets the charges (although these charges cannot amount to more than the capital and operation and maintenance costs). After it was proposed that there should be federal assistance in settling the arid west of the country, a fund to subsidize reclamation was set up; this was a revolving fund to which costs could be repaid within ten years. It has since evolved into a programme that provides major subsidies to irrigation water users—sometimes more than 90 per cent of construction costs. The programme has resulted in more irrigation in the west, but at a cost. While many private investments in irrigation in the west failed, the government continued to subsidize irrigation and averted farm failures by extending repayment periods, deferring repayment, and sometimes waiving repayment altogether. These subsidies have led to the inefficient use of land and water resources (as well as capital, labour and materials), and the costs of many subsidy-supported project sites have far exceeded the benefits.

(c) *Water markets*

Chile. The water code of 1981 established a system of water rights that are transferable and independent of land use and ownership. Water rights are defined as permanent (from unexhausted sources) or contingent (from surplus water), and as consumptive or non-consumptive. The most frequent transaction in Chile's water market is the 'renting' of water between neighbouring farmers with different water requirements. This is also termed a 'spot market', in which an owner sells a portion of his or her water, usually over a brief period of time (perhaps even hours), sometimes without fulfilling formal, legal requirements. Although the volume of sales may not be metered, the buyer and seller have good information on the amount exchanged. Compensation may be in kind, or in some other form of monetary or non-monetary benefits. The formal buying and selling of water rights requires legal sanction and registration, but prices for such rights are left to buyers and sellers.

United States. A water bank is an institution that offers to buy and sell water in a given service area under a specific set of rules regarding prices and quantities. Water banks can mark up water prices to cover transaction costs and to compensate the water's area of origin. A water bank that could facilitate the transfer of water rights with a minimum of environmental degradation was set up in California, with the aim of transferring water from the agricultural sector in northern California to the urban, municipal and agricultural sectors in southern California. The water bank ensured that (i) all transfers were voluntary; (ii) fish and wildlife were protected; (iii) groundwater basins were protected; (iv) water was used efficiently in the receiving areas; and (v) the rights of present water-rights holders were protected. The direct and indirect effects of the water bank were analysed. Positive effects include increased income in receiving areas, but negative indirect effects were noted on soils and wetlands, and there were third-party effects in the form of unemployment in the selling areas.

(d) *Mixed allocation systems*

United States. In Southern California, pragmatic, diverse, decentralized, and to a large extent successful approaches to groundwater management have evolved over time, as water users and local governments have responded to the depletion of groundwater resources and degradation of the environment. Four principles govern groundwater rights in California: (1) owners of the land lying over groundwater have rights to the reasonable use of that groundwater; (2) these landowners have correlative rights to water and share proportionately in reductions in water supply in the event of shortages; (3) appropriators (those pumping groundwater who do not own the land lying over it) all occupy a position in a seniority system, with reductions in water use imposed first on junior rights holders; and (4) owners of the land lying over the groundwater have a superior right, compared with that of appropriators, to water that may be deemed for their reasonable use, and appropriators have a right to the surplus remaining, if any. Solutions for groundwater management are not imposed, or even considered, unless a management problem exists, thus preventing interventions that can derail efficient utilization of the groundwater. The negative effect of this is that the move toward solutions often does not begin until significant damage to the groundwater resource has been done, in large part because of the difficulty in obtaining information about the status of the aquifer.

Jordan and Yemen are maintaining the safe yield of groundwater aquifers by setting up regulatory and financial measures to control and reduce overextraction.

(e) *User-based allocation*

Indonesia. The irrigation associations of the Subaks of Bali are one of the best examples of user-based allocation (Dinar, Rosegrant and Meinzen-Dick 1997). Discovery of the sophistication of their systems provided the basis for some of the early challenges to assumptions that State management of irrigation was necessary. The irrigation associations have developed and constructed their own irrigation systems with very little external assistance. The systems have been sustained over time by elaborate management rules and practices that specify the obligations of each association member in terms of labour and cash towards operation and maintenance, including periodic rehabilitation. A key feature of these associations is the *tektek* principle, which is the proportional allocation of water to each individual member. The *tektek* share is based on a proportion of flow through diversion structures. There is a strong emphasis on equity, and the allocation takes into account the role of individual farmers in the association, distance from the intake, initial investment, soil conditions, and transfers of water rights among members. The system exhibits also a high degree of flexibility and responsiveness to negotiations among members.

Egypt. At the town of Balaktar in the Beheira governorate, a user-based association has been set up among the farmers to manage a new water-channelling system, which is equipped with control gates. The farmers of the user association allocate among themselves without wastage the amount of water needed by every farm. This is an excellent example of user-based allocation that engenders in everyone concerned a sense of belonging (الملامح الرئيسية للسياسة المائية نحو عام 2000).

Portugal. The practical application of water rights in day-to-day distribution is a sensitive matter: efficient and fair allocation can result in inefficient and unjust distribution. Rules developed in Vila Cova—an agricultural communal village—in Portugal form the basis of distribution of water among users. Issues such as the beginning and end of the irrigation period, losses in canals, the time it takes water to travel, user sequence and the night rota, are addressed with various arrangements that involve the community priest and other community institutions. For example, once it has been decided which user will start the summer irrigation, a clock is put in the window of the priest's house to show the length of time over which irrigation should take place, and when the flow should be diverted from one user to another (Dinar, Rosegrant and Meinzen-Dick 1997).

B. SUPPORTING POLICIES AND MEASURES

Decisions on allocation and investment tend to be made with only limited reference to economic analysis and assessment of the alternatives. They tend to be administrative in nature and are made on an *ad hoc* basis, rather than through a comprehensive planning process involving the relevant stakeholders. Allocation mechanisms, where they exist, are usually inadequate to satisfy pressing needs for water when they arise, without adversely affecting existing users and the environment. Allocations of water to various sectors are largely circumscribed by history, and reallocations are increasingly being made according to a prescribed order that prioritizes certain uses. The criteria used to make such allocations have rarely included consideration of the relative value of water in its various uses or sectors. Reallocations of water, typically from agriculture to domestic or industrial consumers, are achieved through compulsory acquisition and usually without compensation. The critical constraint to success in this area is the lack of a comprehensive analytical framework or decision-support system that encompasses all water-using sectors and facilitates appropriate pricing and allocation decisions in line with considered development objectives. Better integration of social and economic considerations in water allocation and management will thus require complementary development of institutions, planning and analytical capabilities.

1. *Economic, social, institutional and regulatory measures*

Most water-allocation systems avail themselves of a combination of water-allocation mechanisms, since each individual mechanism has its advantages and disadvantages. Efficiency is an important goal, but an allocation mechanism that is considered efficient is often hard to implement and requires supporting institutions and infrastructure, as well as expensive monitoring and enforcement systems. Water allocation that pursues economic efficiency therefore requires commitment at the highest levels, and the expense of monitoring and enforcement systems justifies such commitment. However, this expense is actually a social cost, and when the expense is too great, it may not be economically efficient to pursue what would otherwise be deemed economically efficient allocation methods.

In the ESCWA region water is becoming scarce in quantity and inadequate in quality, mainly owing to ever-increasing demands that persistently exceed available supplies. Some of the challenges that are facing the ESCWA region are common to many other regions in the world; others are region-specific. All have to be addressed and assessed correctly for water-resource allocation to be planned properly. Although agricultural activities are the dominant consumer of water resources in the ESCWA region, the global average for agricultural consumption during the twenty-first century is anticipated to maintain a level that does not exceed 65 per cent.

A number of countries are already trying to develop much needed allocation-oriented policies and mechanisms. Intersectoral allocation priorities have been established either by law or by declared policies in all countries advancing towards this objective. High-level intersectoral and inter-ministry mechanisms (e.g., water-resource councils) have been formed to bring about an integrated water-sector perspective and to resolve allocation conflicts. The most successful countries either have or are developing national water plans that provide the necessary technical framework for fine-tuning intersectoral and interregional water allocation patterns.

Worldwide, most countries, even those with tradable private water-use rights, have asserted the overall regulatory and allocable rights of the State. Some countries, however, have explicitly recognized private water-use rights, and several are already in the process of establishing transferable rights. Countries have begun to recognize the functional distinction between the centralized mechanisms needed for coordination and enforcement and the decentralized arrangements needed for user participation and local-level solutions. The key feature of the ongoing process of decentralization is the increasing importance attached to river-basin organizations at the sectoral level, to turn-over programmes in the irrigation subsector, and to utility-type bodies in the urban water subsector. The main mode of decentralization in the irrigation subsector is irrigation management transfer, under which managerial responsibilities, including cost recovery and system maintenance, are transferred to legally registered water-user associations. Decentralization in the urban water subsector manifests itself in autonomous organizations responsible for water provision that are financially self-dependent and similar to utilities.

Privatization is linked to the decentralization of the urban water subsector just as user participation is linked to the decentralization of the irrigation subsector. However, given the role of the private sector in financing the water sector and technological development, as well as the necessity of user participation in water planning and allocation, privatization and user participation can together transcend sectoral boundaries (Saleth and Dinar 1999). The role of the private sector in investment in, operation of and maintenance of the water supply is being increased in the countries of the Gulf Cooperation Council and Yemen; in Bahrain, Egypt, Jordan, Lebanon and Yemen, the private sector is being enrolled in the management of water utilities.

Implementing water-sector reforms must take into account the fact that water is a public good and is important as a basic need for all segments of the population. Most fundamental is the provision at affordable rates of at least the necessary minimum quantities of safe and reliable drinking water to rural and urban consumers, particularly the poor. The pricing structure should reflect this, and various mechanisms to achieve this exist, including multi-tiered pricing based on income and subsidies directed to consumers or suppliers. Unfortunately, in developing countries, this approach has often been misdirected towards providing subsidies to wealthy citizens. Wealthier urban consumers often pay less for water than the extremely poor, who have no access to running water and are compelled to buy from private vendors at a much higher unit cost. For the general consumer—farmers, urban and rural households, industries, etc.—the prices currently set for water are insignificant relative to the value of the benefits derived from its use.

2. *Licencing and permits enforcement*

Licences and permits are control mechanisms that grant the water user the right to withdraw a certain quantity of water usually at a fixed annual rate of extraction. They may contain other specific restrictions and particular stipulations to optimize extraction rates. (Problems of overextraction often occur because users have no incentive to optimize their long-term rate of extraction, as leftover water can be taken by other users or potential future users.) These instruments are used to encourage reduction in consumption and wastage (including water-transmission losses) so as to improve water availability, raise efficiency and generate savings, especially in urban water service and delivery, and household and industrial water use.

The concept of the tradable permit, both in the form of water-pollution allowances and water-abstraction rights, has been used in water-resource management in a number of countries, especially in regions suffering from water stress. Tradable permits are an efficient tool for allocating water among competing demands and a cost-effective way of reducing water pollution. Key lessons that emerge from experience include the following:

(a) Trading permits can be put in place when water is decoupled from land ownership;

(b) Temporary or seasonal trades are more frequent than permanent trades;

(c) The potential for trades in pollution allowances between point sources and non-point sources (e.g., agricultural run-offs) need to be explored further;

(d) Water cannot be defined purely as a private good, and its treatment as a homogeneous tradable commodity can face social resistance;

(e) Trading schemes need to be adapted to existing local institutional frameworks for water management.

Permits and licences have been used in the ESCWA region, but mostly in connection with groundwater-resource management. Most countries provide licences and/or permits specifying the amounts of water to be withdrawn, but very few are able to use them as an effective tool to control the quantity of water withdrawn. In Yemen, as well as water being transferred away from agricultural use, regulation has been introduced into the water market.

3. *Fiscal, investment and other policies*

Other instruments being used in the water-reform process include fiscal, investment and other policies aimed at encouraging better efficiency of water use. The possibility of restructuring domestic and irrigation water tariffs to cover at least operation and maintenance costs is being investigated in Bahrain, Egypt, Jordan, Lebanon, Palestine, the Syrian Arab Republic and Yemen.

(a) *Subsidies*. One of the easiest ways to improve the efficiency of water use is to stop providing subsidies to the water sector (e.g., by not subsidizing the prices of water-intensive crops). Previously, there were various restrictions on imported commodities in several countries, but faced with the necessity of implementing trade reforms as part of a wider implementation of stabilization and structural adjustment programmes (including the reduction of the level of protection afforded to water-intensive crops), governments effectively provided incentives for water conservation without ever mentioning water or lower water prices. In Yemen, increases in diesel fuel prices (which the government raised from US$ 0.02 to US$ 0.10 and then to US$ 0.16 per litre), combined with the end of credit subsidies and the lifting of import bans on fruits and vegetables, have generated significant decreases in the quantity of water utilized in agriculture. Other incentives that were provided also encouraged better water conservation and more efficient use of water in agriculture.

(b) *Agricultural pricing and marketing policies*. Various distortions in the system result from agricultural pricing and marketing policies, and these policies need to be adjusted. Artificial barriers to international and intraregional trade need to be dismantled to enable less distorted prices and market signals to determine cropping patterns, regional specialization and (indirectly) modes of water-use behaviour that are more consistent with natural comparative advantage. Thus, bodies that set water prices should include as part of their mandate a review of subsidies and marketing policies that indirectly affect water-intensive agricultural outputs and inputs.

(c) *Environmental incentives*. Each country should undertake a review of its environmental pricing for water and introduce a revised set of incentives and disincentives that provides substantial impetus for industries and towns to introduce and sustain environmentally friendly technologies. These could be introduced through a system of subsidies and tax breaks on investments in water-conservation technologies (or water-recycling technologies where there is no water). Particular attention should be paid to introducing a system of significant and punitive variable costs for polluting, based on the ‘polluter pays principle’ (widely discussed at the United Nations Rio de Janeiro conference in June 1992). Countries that already have such systems in place need to explore ways and means of enhancing them to make them more effective; this could include fines and major adjustments and increases in existing pollution taxes, so that the systems provide meaningful incentives for controlling pollution. In addition, revised water charges and the introduction or expansion of other incentives for water recycling and conservation are needed to encourage industries to adopt more environmentally friendly technologies and production processes. Industrialized countries have already experienced industrial pollution on a grand scale, and measures to deal with this and best practices from which the ESCWA region could benefit should be found. There has in fact been a remarkable turnaround to a clean water environment.

(d) *Accompanying improvements in irrigated agriculture and productivity*. These could be achieved through the improvement of the performance of irrigation systems, including the rehabilitation and modernization of irrigation infrastructures, coupled with intensification of agricultural extension programmes.

(e) *Accompanying public awareness campaign*. The above measures should be preceded and accompanied by a process of consensus-building between the political establishment and the rest of society, followed by a major outreach programme to farmers. Policy reform will be accepted far more easily if decisions are thoroughly discussed and explained and, in particular, if the benefits from more productive irrigated agriculture are understood.

(f) *Switching to volumetric charging*. Those countries that have not already done so should implement a change from area/crop-based charging to volumetric charging. Volumetric charging will be particularly important as opportunities for different levels of water use develop, from the diversification of cropping patterns and agricultural technology, to new irrigation-delivery systems such as dynamic control systems and, at the micro-level, drip and sprinkler irrigation. Volumetric charging would probably be implemented as demand for it arises, since it needs to be accompanied by the introduction of (or improvements to) a water-delivery system, the installation of measuring devices, and arrangements for bulk sales to water-user associations. Water-user associations agreeing to bulk sales could have preferential rates over other farmers, and charges for collection of water by water-user associations could be rewarded with a discount.

(g) *Creating a decision-making and price-regulation apparatus*. It may be desirable to establish a decision-making apparatus, such as a special committee, so analyses can be undertaken and recommendations presented to the government. The mandate of these committees should include not only setting charges for farmers but also for other water services, such as bulk water supply to urban and industrial users and drainage and flood control. A broader mandate would also include water rates in other sectors, such as urban, rural and industrial water supply.

4. *Water-user rights and market allocation*

(a) *The role of the water market in improving the efficiency of water allocation between competitive uses*

As a supporting measure, water users may be given the right to withdraw a specified quantity of water, at a specific location and for a specified use. However, they do not own the water they use: ownership remains in the hands of the government. Market-based allocation is considered economically efficient from the individual and social points of view, because water resources are transferred from low-value uses to high-value uses. Such a system involves the creation of appropriate conditions that can support a compensation system for transferring water from one use to another. Water-market exchanges are increasingly being used to adjust water allocations. As agriculture is the dominant water user, it is expected that most transfers will entail the transfer of water away from agriculture to urban, industrial and other uses, especially since modern agricultural technologies allow supplies of irrigation water to be very stable.

Water markets have been advocated as a means of improving water-resource management by increasing the efficiency of water use and allocation within and between sectors. The implementation of water markets requires both government involvement and active water-user participation. The difference between implementing an administrative system and a market system may not be as large as expected. The principal differences may be defined as follows:

(a) *Defined and transferable water rights*. Reallocation through trade entails compensation, unlike administrative reallocation, where right holders may not receive any compensation when water is reallocated to a different use. In water markets, right holders will not only consider what the water can produce for them, but also the opportunity cost of the water (such as the value added by using the water in car manufacturing). If the highest value of water use is taken into account, an incentive is provided for more efficient use of water and reallocation of water to uses with higher values;

(b) *Internal institutional market arrangements*. Buyers and sellers need to find each other and to have confidence in the characteristics of the goods they want to exchange. A properly functioning water market will measure the water available for trading, develop a simple mechanism to find prospective buyers and sellers, and carrying out the transfers. If official transfer is difficult, then informal trading will probably occur anyway. The disadvantage of informal trading is that water use is hard to track;

(c) *A physical delivery system*. Traded water is likely to move from one user to another. Depending on the hydrological conditions or previously constructed infrastructure, the cost of adequate infrastructure may be too high and outweigh the benefits from transfers, pushing the water price so high that no buyers can be found. The government may absorb the cost, but thorough analyses are needed to establish whether the introduction of a trading system will produce sufficient societal benefits to warrant large investments.

The most challenging institutional feature of a water market may be the definition and registration of water rights, together with the making available of adequate information and the implementation of transaction mechanisms that provide equal opportunity for all water users to participate in the market. These mechanisms would have to include access to price information, and the registration, enforcement and monitoring of rights. Developing countries characteristically suffer from weak institutional frameworks, such as slow judicial systems, ill-defined land rights, strong concentrations of land ownership, and unenforced laws and environmental regulations. Before the introduction of water markets, the necessary legal and institutional requirements in each site should be compared with what already exists. A review should be undertaken to determine whether the laws and institutions could be changed in order to minimize the political and social costs of introducing a properly functioning water market.

Socioeconomic asymmetries need to be considered, because water users will vary in educational background, culture and economic power. A phased approach to water trading may be the most appropriate, starting with the introduction of water rights, monitoring and enforcement, and followed at a later stage by tradability. This would give water users, especially those in the more vulnerable segments of society, the time to realize the value of their new rights. Another important issue is the impact of water reallocation on uses with higher values, and the consequent impact on regional economies and the environment.

(b) *The effect of water user-rights and market allocation*

The market mechanism, if operated under appropriate conditions, has the potential to secure water supply for high-value uses in various sectors without the need to develop new, costly water resources. Also, by allowing compensation for water sold by low-value uses, water markets provide an incentive for more efficient water use. The seller has an opportunity under certain conditions to increase profitability (unless all water resources are sold and the seller ceases economic activity), and the buyer benefits, because a water market encourages increasing water availability. Tradable water rights allow the price of water to reflect the value of its alternative uses, which creates the incentive to put it to the most productive use. In addition, those who buy water rights are likely to conserve water more efficiently.

The securing of a water supply for higher-value uses through tradable water rights is cheaper than other alternatives (such as building an expensive new hydraulic infrastructure). Although an infrastructure to transfer traded water must be built if it is not already in place, the cost of building may be less than that of generating new water rights. Secure water rights are particularly beneficial for smaller farmers, who have been most vulnerable historically to reductions in their water allocation and who have few other sources of collateral.

Secure water rights give potential investors in new hydraulic projects the confidence that, once they obtain the rights to the water generated by their investment (e.g., storage reservoirs or water conveyance infrastructure), the rights will be theirs to keep or sell on to others (farmers, industry, hydropower and water companies). As a result, ongoing State-owned projects could be privatized by selling the hydraulic infrastructure and unallocated water and land rights associated with the project, on the condition that buyers respect existing land and water rights. A comprehensive regulatory framework, as is prepared for the sale for public utilities, would assist in such a privatization.

5. *Optimum utilization of existing water resources*

In Bahrain, Egypt, the United Arab Emirates and Yemen, changes are being made to cropping patterns, and certain crops are beginning to be irrigated with brackish water. Different sorts of water rationing can be used, such as increasing water efficiency through minimizing losses in the domestic and agricultural sectors, encouraging rain-fed agriculture (as implemented in the Syrian Arab Republic and Yemen), and providing incentives for the use of water-saving devices in the domestic and industrial sectors (as implemented in Jordan and Saudi Arabia).

V. ANALYSIS OF WATER ALLOCATION

Different types of mathematical models can be used to determine the optimal allocation of water resources to satisfy demand. Some models use an optimization approach to achieve specific objective functions dependent on the maximization of the net return of particular agricultural sector activities, or the minimization of the total investment required in construction, transport, and operation and maintenance costs. Other models analyse the geographic distribution of both water sources and demands to maximize returns and minimize costs. The availability of water and its sustainability over time are the main constraints in determining the amount of water that can be allocated from each source of water supply (surface water, groundwater, desalinated water, etc.) to each demand.

The agro-economic model is an optimization model, allowing the optimal crop pattern to be determined, subject to water, land and labour constraints. It projects the production, consumption, export, import and livestock use of the main crops produced. The model takes into account all cropping activities and the geographical distribution of the agricultural land to simulate agricultural-sector performance, maximizing the consumers' and producers' surplus in the process.

A. Review of selected models used for water allocation

Doppler, Salman, Karablieh and Wolff (2002) discuss the optimal water allocation and cropping patterns for the Jordan Valley, taking rising water prices and variations in income expected from agricultural production into consideration. The calculations are based on information available on water supplies, areas under irrigation and market conditions, and use linear programming models to determine solutions that maximize gross margins and minimize potential variations in these margins. The results indicate that optimizing cropping patterns and the allocation of irrigation water has a substantial potential to increase the financial return to agriculture. Optimal solutions that consider the risk from varying gross margins react quite elastically, as far as demand for irrigation water is concerned, to rising water prices. This factors changing market supply into discussions about managing water consumption between sectors through pricing mechanisms.

Salman et al. (2001) introduced a linear programming optimization model for analysing inter-seasonal allocation of irrigation water in terms of both quantity and quality, and its impact on agricultural production and income. Their inter-seasonal agricultural water allocation system (SAWAS) model is a developed version of an agricultural sub-model, and the research highlights water-scarcity issues as a problem arising when water is not found in the right quantities and of the right quality at the appropriate place and time. The SAWAS model generates an optimal mix of water-using activities that maximizes the net agricultural income of the area and calculates water demands at various water prices. It also provides the planner with tools to carry out 'what-if' experiments and to generate optimal water-demand curves. An important feature of the SAWAS model is the fact that it considers water demand and the benefits derived from water together with costs and optimization within the agricultural sector in order to specify the optimal usage of different qualities of water. Although Salman et al. apply the SAWAS model to the Jordan Valley, the model is designed to serve as a decision-making tool for planners of agricultural production at both the district and the regional level, bridging the gap between limited water resources and increased agricultural production in areas that suffer from severe water scarcity.

However, the models most usually used to assess water management and allocation issues are integrated hydrologic-economic ones. Such models include (i) depiction of the entire system (at the basin or the country level); (ii) integration of hydrologic and economic relationships in an endogenous system; (iii) incorporation of water demands from all water-using sectors; and (iv) the possibility of evaluating the economic benefits and costs of each of these demands (Ringler 2001; Rodgers and Zaafrano 2002; Rosegrant, Ringler, McKinney, Cai, Keller and Donoso 2000). Several models have been developed using this framework. One is the integrated hydrologic-economic model developed for the Mekong River Basin, which optimizes water allocation based on an objective function and its accompanying constraints (Ringler 2001). The model includes hydrologic, agronomic, economic and institutional components, but focuses particularly on the economic component. It is highly aggregated, factoring in country-level and regional-level water supply and demand, as well as economic-benefit functions, and provides a solution for optimal water allocation at the basin level, subject to a series of physical, system-control and policy constraints. The optimal allocation of water across water-using sectors is determined on the basis of the economic value of water in its various uses. A second model was developed by Wichelns (2002) to evaluate the trade-offs involved when Nile River water was allocated between competing regions and projects in Egypt. The goal of the model was to maximize the net social benefits generated with limited water resources. Other types of analysis have also been used; these include input-output models, which allow changes in the economy as a result of droughts or the reallocation of water away from agriculture to be analysed (Wolfenden, Gill and van der Lee 2001).

Although comprehensive, the models outlined in Ringler (2001) and Wichelns (2002) are fairly complex and time-consuming, requiring substantial amounts of data for proper analysis to be conducted and advanced statistical programmes to run the analysis. In fact, most of these models are usually run on selected hypothetical situations. For example, Wichelns limited his analysis to a small-scale (10 hectares) simulated scenario of three regions and one crop. Given these complexities, and the data and time requirements of these models, the approach adopted in this study will be a cost-benefit analysis, which can be used to assess regulatory actions or policies. Some of the issues underlying the broader use of this method in this study are outlined below.

B. Background information on cost-benefit analysis

According to the literature (Moore 1995, Ward and Deren 1995, Pagiola 1994, Gittinger 1982), cost-benefit analysis is a technique for assessing the comparative costs and benefits of an activity or project over an appropriate time period. The objective of the analysis is to determine what action should be taken, and the level at which the action achieves the greatest net economic benefit or economic efficiency. The technique has its origins in economic feasibility studies of public infrastructure projects such as dams, and its use has mirrored the increase in laws and regulations to protect health, safety and environmental values since the 1970s. The use of the cost-benefit analysis to evaluate the merits of public actions requires that positive and negative effects be translated to a common denominator, most often a monetary one.

Proponents of cost-benefit analysis argue that the method and assumptions needed to measure positive and negative effects and to translate these effects into monetary terms can make cost-benefit analysis a complex undertaking. It is also argued that cost-benefit analysis can be expensive and difficult to explain, because indirect methods are usually employed to estimate the approximate monetary values of public actions. These indirect estimation methods are sometimes necessary because many public services and benefits have no private-sector equivalents, and as a result, no market prices can be associated with them. Professionals sometimes disagree on the methods used to obtain the estimates, and this can lead to some important cost-benefit categories being ignored.

Despite these negative arguments, cost-benefit analysis has gained wide acceptance over the years as a way of dealing with failures in the market that affect many sectors, such as health and the environment. Not long ago, private markets were not concerned about the social cost of their productive or consumptive activities and were letting those costs be borne by affected individuals or society at large. With the gradual changes there have been in lifestyle and economic development, these adverse effects have increasingly been recognized as costly and objectionable to various segments of society, especially to those who cannot be compensated. Governments have therefore tried to put tighter regulations in place and to force private markets to internalize more of these associated costs (health protection, environmental conservation, etc.). However, increases in regulation raise concerns that an undue burden is being placed on private persons and markets, and even governments themselves and society at large. This explains why interest in assessing the cost versus the benefits of particular regulations has grown over time.

Whether dealing with a public-sector project or a proposed policy, cost-benefit analysis attempts to estimate if the activities involved achieve an improvement in the allocation of resources, that is, whether society is better off in economic terms as a result of proposed changes. This efficiency criterion can apply either to a project that will add to economic output (net domestic product), or to actions that are not directly measurable in terms of GDP, but which have the potential to increase national economic well-being by creating more collective benefits than costs (usually estimated in monetary terms). Cost-benefit analysis therefore offers a simple yet powerful approach to the analysis of water-allocation issues that is relatively easy to implement. The method is particularly suited to the applied analysis of specific practical situations.

C. Cost-benefit analysis formulation

Cost-benefit analysis can be applied in different settings. It has usually been associated with analysis at an aggregate level, as it will be here, but it can also be applied at the economic-unit level (e.g., farms). Cost-benefit analysis at the aggregate level was chosen as the analytical tool for the present study, since water allocation among different and often competing sectors is best analysed over large areas; aggregate-level analysis provides a truer reflection of reality than is possible with economic-unit level analysis. Moreover, the recommendations given here are intended for policy and decision makers who must decide on the proper course of action in the light of their countries' development plans, production possibilities and the constraints they face in allocating such scarce water resources as are available to the State; cost-benefit analysis is the most appropriate model to analyse which action could maximize benefits for the largest portion of the population. Carrying out the analysis at the aggregate level will therefore increase the likelihood that the appropriate course of action is recommended based on the real constraints faced by policy and decision makers; it will also allow attention to be focused on the distribution of benefits among different sectors as a result of water allocation.

Cost-benefit analysis can be carried out from either a private or a social perspective. When analysis is made from the private perspective, only the costs and benefits that actually accrue in a particular resource-use scenario are considered, and these costs and benefits are valued at existing prices, with no adjustments made for distortions that may result from government policy or market failure. This approach is most appropriate when dealing with the incentives offered to different economic agents or sectors that are, for example, utilizing, developing or investing in scarce resources. When analysis is made from the social perspective, all costs and benefits for a given activity are considered. For example, if subsidy leads to wastage of water, this represents a real cost to society that should be taken into consideration, together with the value of the output obtained and any other associated effects. In order to measure the true opportunity cost, the valuation of the resource used and the output obtained from production utilizing the water should be adjusted for any distortions resulting from policy intervention or market failure. However, obtaining the necessary data to conduct a proper social analysis is time-consuming and difficult, so the present analysis will be limited to the estimation of private returns on water allocation to different sectors.

The principle of the analysis is simple: it involves calculating the difference in the flows of costs and benefits between what would happen if the current water allocation continued and what would happen if a specified amount of water was reallocated from one sector to the other. This is not the same as a before and after analysis, and the results estimate the return on the specific water allocation being examined, not on water allocation *per se*. Thus, a finding that a particular water allocation is not profitable does not imply that all water allocations are unprofitable. Details are provided in annex I.

D. Data and assumptions

The data to be used in the analysis include the quantity of water used in each sector, the costs involved in supplying the said water quantity to a particular sector, the revenues or consumer surplus generated using the allocated water (for agriculture and industry, the value of the output; for the domestic sector, the consumer surplus). Average prices were obtained from secondary sources. The discount rate used is derived by trial and error.

Table 5 provides the data used to estimate costs and benefits in this analysis. The economies of the countries in our selected case studies are assumed to grow at the historical annual-rate levels for the ESCWA region of between 2.5 per cent (without water reallocation) and 3 per cent (with water reallocation), and the costs and benefits in the agricultural, domestic and industrial sectors are then projected over a 20-year period. The 2001 agricultural and industrial value added (as provided in *World Development Indicators 2003*) were used as the initial values (World Bank 2003), while the net consumer benefit for domestic water was calculated using the formulae provided in annex I. The remaining data were drawn from secondary sources and are also given in table 5.

TABLE 5. DATA FOR THE ESTIMATION OF COSTS AND BENEFITS

	Egypt		Jordan	
	Per capita	Total (million)	Per capita	Total (million)
Water consumption and requirement (m^3)				
Domestic demand				
- Current consumption	42.7	2 950	76.8	388
- Requirement[a/]	227.3	15 702	227.3	1 148
Industrial demand				
- Current consumption	77.4	5 350	12.5	63
- Requirement[a/]	30.0	1 575	30.0	115
Agricultural demand				
- Current consumption	867.1	59 900	156.6	791
- Requirement[a/]	511.0	87 386	511.0	6 390
Total demand				
- Current consumption	987.3	68 200	245.9	1 242
- Requirement[a/]	1515.1	104 663	1 515.1	7 653
Total supply	1004.3	69 377	232.9	1 177
Quantity of water reallocated (m^3)[b/]				
- Agriculture	-52.7	(-2/3)	-56.6	
- Domestic	72.7		37.7	(+2/3)
- Industry	-20.0	(-1/3)	18.9	(+1/3)
Water supply cost ($/$m^3$)				
- Domestic and industry	0.295		0.706	
- Agriculture	0.006		0.025	
Maximum water tariff ($/$m^3$)				
- Domestic	0.088		1.031	
- Industry	0.590		0.350	
- Agriculture			0.0042	
Water projects development ($/$m^3$)				
- Capital	0.2842		0.2842	
- Operation and maintenance	0.1194		0.1194	
- Total	0.4036		0.4036	
Modern irrigation equipment ($/$m^3$)				
- Capital	0.006		0.006	
- Operation and maintenance	0.004		0.004	
Value added (GDP)				
- Agriculture	242	16 741	52	265
- Industry	470	32 497	437	2 207
Discount rate (%)	5–15	13.3[b/]	15	10.9[c/]

Sources: ESCWA, 2001, *Implications of Groundwater Rehabilitation on Water Resources Protection and Conservation: Artificial Recharge and Water Quality Improvement in the ESCWA Region*, E/ESCWA/ENR/2001/12, New York; ESCWA, 2001, *Progress Achieved in the Implementation of Chapter 18 of Agenda 21, with Emphasis on Water for Sustainable Agricultural Production: Case Studies*, New York (E/ESCWA/ENR/1999/22); Haddadin, M.J., 2002, 'Water issues in the Middle East: challenges and opportunities', *Water Policy*, 4, pp. 204–222, Elsevier; IMF, 2002, *International Financial Statistics Yearbook*, vol. LIV, International Monetary Fund, Washington, DC; Paetz, R.J. and Maloney, S. 2002, 'Demonstrated Economics of Managed Irrigation for CBM-Produced Water', paper presented at the meeting Making Water Produced During Oil and Gas Operations: a Managed Resource for Beneficial Uses, 16–17 October 2002, Ground Water Protection Council, Oklahoma City, Oklahoma (http://www.gwpc.org/Meetings/PW2002/Papers/ Steel_Maloney2_PWC2002.pdf); and World Bank, 2003, *World Development Indicators 2003*, World Bank, Washington, DC.

a/ Water required at level of income, which is that of low-middle-income countries.

b/ Negative = quantity taken, positive = quantity added.

c/ Official lending rate in 2001.

The quantity of water to be reallocated was derived from the current level of water consumption in each sector compared with that which could be achieved at the income for Egypt and Jordan, which is that of low-middle-income countries. However, given the water-scarcity level in both countries, the water-consumption levels adopted for the agricultural and industrial sectors were those of high-income countries, as provided by Haddadin (2002). Consequently, in Egypt, water will be reallocated partly from the agricultural and industrial sectors to the domestic sector, while in Jordan, water will be reallocated from the agricultural to the domestic and industrial sectors.

E. Application of cost-benefit analysis to selected countries

The estimated relationships (annex I) were used to project revenues and net benefits, with and without water allocation, over a 20-year period. The results of this economic analysis are shown in tables 6, 7 and 8, the calculations for which were as follows.

TABLE 6. ANALYSIS OF RETURNS ON WATER ALLOCATION: AGRICULTURE ($/m^3)

Country	Egypt (discount rate 5%)				Jordan (discount rate 15%)			
Year	1	5	10	20	1	5	10	20
Without water allocation								
Revenues (GDP)	242.0	246.9	253.1	266.1	52.0	53.0	54.4	57.2
Water costs[a/]	0	0	0	0	0.7	0.7	0.7	0.7
Returns (R)	242.0	246.9	253.1	266.1	51.3	52.4	52.4	56.5
PV[b/] R	242.0	203.1	163.2	105.3	51.3	30.0	30.0	4.0
With water allocation								
Revenues (GDP)	217.8	245.1	284.2	298.7	46.8	52.7	61.1	64.2
Water costs[a/]	0	0	0	0	0.4	0.4	0.4	0.4
Allocation cost[c/]	4.9	4.9	4.9	4.9	0.6	0.4	0.4	0.4
Returns (R)	212.9	240.2	279.3	293.8	45.8	51.9	60.2	63.4
PV[b/] R	212.9	197.7	180.0	116.3	45.8	29.6	17.1	4.5
Return on water allocation								
Net benefits (NB)	-29.1	-6.6	26.2	27.8	-5.6	-0.5	6.5	6.9
PV[b/] NB	-29.1	-5.5	16.9	11.0	-5.6	-0.3	1.9	0.5
Cumulative PV[b/] NB	-29.1	-84.6	-42.0	92.4	-5.6	-13.0	-6.9	2.6
NPV[d/] 20 years	92.4				2.6			
IRR[e/] (%)	5.8				15.3			
Years to break even	13				16			

Source: ESCWA calculations.

a/ This is the water cost as charged to the user.

b/ PV is the present value.

c/ Cost incurred as a result of the water reallocation: investment in water-saving irrigation technologies.

d/ NPV is the net present value.

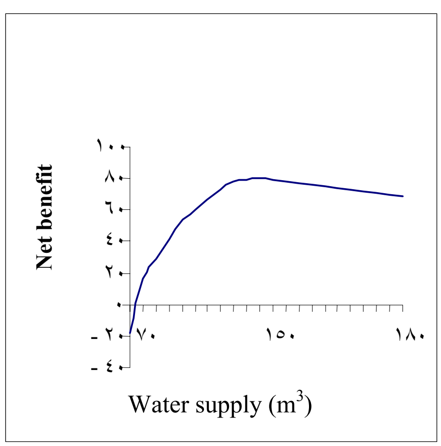
e/ IRR is the internal rate of return.

Without water allocation, water costs (water quantity multiplied by the water tariff) are subtracted from revenues (which is the value added for the agricultural and industrial sectors, and consumer surplus for the domestic sector) to obtain the returns (R). The returns are then discounted to obtain the present value (PV) of returns for different years within a 20-year period. With water allocation, in addition to the above, allocation costs are also subtracted. In the first year, allocation costs are equal to the water quantity multiplied by the cost of irrigation equipment or the cost of water-development projects (for the domestic and industrial sectors). In the following years, there are no allocation costs for the domestic and industrial sectors, as the operation and maintenance costs are included in the water tariff, while for agriculture the allocation cost is equal to the water quantity multiplied by the operation and maintenance cost of the irrigation equipment, as these costs are not included in the water tariff. The net benefit (NB) of water allocation is computed by subtracting the without-water allocation return from the with-water allocation return. The present value (PV) of net benefits obtained by discounting the NB are then totalled for the period under consideration to obtain the cumulative or net present value (NPV) for the period. The break-even year (the year in which the NPV is zero) and the internal rate of return (IRR, which compares two discount rates at the break-even year of the lower rate) are then derived.

For Jordan in the first year, reallocating water away from the agricultural sector will cause revenues to drop, as farmers will be both coping with a reduction in water supply and investing in new technologies. From year 2, revenues will grow again at an accelerated rate, reaching their peak during year 10, at which point new technology will no longer contribute to increased growth in output beyond normal, if other inputs are kept at the same level. Under these conditions, water reallocation will still be profitable to the agricultural sector, as can be seen from the net present value, which amounts to US$ 2.6 per cubic metre of water by year 20, at a discount rate of 15 per cent.[1] The internal rate of return is 15.3 per cent, and all investments incurred are recovered by year 16. However, if water reallocation is implemented, the net returns to agriculture would be negative until year 5 as a result of the reduction in output and the initial investment in water-saving technologies required to maintain output levels. For Egypt, the water cost is zero, as irrigation water is provided free of charge to farmers. This results in a net present value (NPV) of US$ 92.4 per cubic metre after year 20, at a discount rate of 5 per cent. The internal rate of return is only 5.8 per cent, and the break-even point for investments is year 13. Thus the agricultural sector in Egypt is a low-value producer compared with that in Jordan, most probably because production is focused mainly on relatively low-value crops such as wheat and others, while Jordan has a substantially greater irrigated sector oriented towards the production of high-value crops such as vegetables.

For Jordan, reallocating water to domestic consumption will benefit domestic consumers, as illustrated in figure V. Reallocated water will increase the overall benefit up to a per capita consumption level of about 150 cubic metres under present conditions. Beyond that level, the level of benefits to consumers will start to decrease, albeit slowly. The reallocation of water will benefit domestic consumers from the first year of reallocation, although the costs associated with delivering the reallocated water will keep returns low in the first year. Thereafter, benefits are assumed to follow the general pattern of the economy. Water reallocation results in a high consumer surplus for domestic consumption. The net present value of the surplus by the end of year 20 would amount to US$ 69 per cubic metre of water, at a discount rate of 15 per cent, while the internal rate of return would be as high as 19.3 per cent. The break-even year would be year 7, and negative consumer benefits would only be recorded in year 1, as the result of the investment required to develop and supply the additional quantities of water. For Egypt, water is reallocated away from both the agricultural and industrial sectors to the domestic sector, as the agricultural and industrial sectors are currently getting larger proportions of water compared with similar sectors in high-income countries. However, given the low water charges, the net present value of the consumer benefit is negative, meaning that consumers are not viewing water as a scarce commodity.

Figure V. Municipal net-benefit function



[1] The official lending rate was 10.9 per cent in 2001 in Jordan, and 13.3 per cent in Egypt (IMF 2002).

For Jordan, reallocating water away from the agricultural sector to the industrial sector would be highly profitable, given the current levels of industrial production in the country. The reallocation will not decrease the output of the industrial sector, even though some investments will be required to develop and supply the reallocated water. Overall evolution is assumed to follow that of the economy overall. The net present value by the end of year 20 would be US$ 53 per cubic metre of water, at a discount rate of 15 per cent, and the return on capital would be 17.5 per cent; all capitals would be repaid by the end of year 10. Negative returns would be recorded only in year 1, as a result of investments required to develop and supply the additional quantities of water. For Egypt, given the large share of water already consumed by this sector, it is assumed that a small amount will be diverted to meet domestic demands. In the first few years this reallocation will negatively affect industrial output. The net present value of benefits will equal US$ 1 per cubic metre by year 20, with an internal rate of return of 15.2 per cent; investments will break even in year 20.

TABLE 7. ANALYSIS OF RETURNS ON WATER ALLOCATION: DOMESTIC CONSUMPTION ($/m^3)

Country	Egypt (discount rate at 15%)				Jordan (discount rate at 15%)			
Year	1	2	3	4	1	5	10	20
Without water allocation								
Consumer Benefit	24	26	29	38	248	274	310	397
Water costs[a/]	13	13	13	13	54	54	54	54
Returns (R)	11	13	17	25	194	220	256	343
PV[b/] R	11	8	5	2	194	126	73	24
With water allocation								
Consumer Benefit	27	31	35	48	273	308	357	479
Water costs[a/]	34	34	34	34	81	81	81	81
Allocation cost[c/]	29	0	0	0	15	0	0	0
Returns (R)	-36	-3	1		177	227	276	398
PV[b/] R	-36	-2	0	1	177	130	78	28
Return on water allocation								
Net benefits (NB)	-47	-17	-15	-11	-17	7	20	56
PV[b/] NB	-47	-10	-4	-1	-17	4	6	4
Cumulative PV[b/] NB	-47	-96	-127	-147	-17	-7	20	69
NPV[d/] 20 years	--				69			
IRR[e/] (%)	--				19.3			
Years to break even	--				7			

Source: ESCWA calculations.

a/ Water cost is the actual cost to supply the water.
b/ PV is the present value.
c/ Cost incurred as a result of the water reallocation: investment in water development and supply.
d/ NPV is the net present value.
e/ IRR is the internal rate of return.

The above results for Jordan show that water used in the industrial and domestic sectors has a much higher value than water used in agriculture. Based on these results, it would be advisable to reallocate water resources away from agriculture to the industrial and domestic sectors. Unfortunately, other, non-financial considerations would also have to be taken into account, such as the number of people who would be affected by this reallocation and the impact on other areas (agriculture, environment, transport, hydroelectricity, etc.). As seen above, an economically more efficient, and more complex, solution would be to allocate water resources to those sectors generating the greatest value for the economy, which would be charged an economic price for the water, and to redistribute this value in the form of relief or supportive action for those adversely affected by the reallocation. However, this assumes that there would be sufficient capacity to monitor, design and implement such programmes. Cooperative action in the allocation of water will be necessary to enable all water-using sectors to move closer to realizing the greatest potential system values of the available water resources.

TABLE 8. ANALYSIS OF RETURNS ON WATER ALLOCATION: INDUSTRIAL PRODUCTION ($/m^3)

Country	Egypt (discount rate at 15%)				Jordan (discount rate at 15%)			
Year	1	5	10	20	1	5	10	20
Without water allocation								
Revenues (GDP)	470	519	587	751	437	482	546	699
Water costs[a/]	46	46	46	46	4	4	4	4
Returns (R)	424	473	541	706	433	478	541	694
PV[b/] R	424	271	154	50	433	273	154	49
With water reallocation								
Revenues (GDP)	447	503	583	783	437	492	570	766
Water costs[a/]	34	34	34	34	11	11	11	11
Allocation cost[c/]	0	0	0	0	8	0	0	0
Returns (R)	413	469	549	749	418	481	559	755
PV[b/] R	413	268	156	53	418	275	159	53
Return on water allocation								
Net benefits (NB)	-12	-4	7	43	-14	3	18	61
PV[b/] NB	-12	-3	2	3	-14	2	5	4
Cumulative PV[b/] NB	-12	-33	-30	1	-14	-18	3	53
NPV[d/] 20 years	1				53			
IRR[e/] (%)	15.2				17.5			
Years to break even	20				10			

Source: ESCWA calculations.

a/ Water cost is the actual cost to supply the water.
b/ PV is the present value.
c/ Cost incurred as a result of the water reallocation: investment in water development and supply.
d/ NPV is the net present value.
e/ IRR is the internal rate of return.

For Egypt, on the other hand, it appears that endeavours have been geared more towards achieving equity rather than efficiency. This is negatively affecting overall economic performance, and urgent reforms are needed in order to achieve greater efficiency.

VI. SECTORAL WATER ALLOCATION IN SELECTED ESCWA MEMBER COUNTRIES

Water-allocation policies differ from one country to another, because physiographic features, social standards, and legal and administrative structures vary. Politics and the economy also play major roles. The following sections introduce some of the water-allocation policies implemented in selected ESCWA member countries.

A. EGYPT

Egypt has about 40 per cent of the total population of the ESCWA region. In 2000, it had about 8 million feddans[2] of agricultural land, most of which is irrigated. Water resources in Egypt are becoming scarce: surface-water resources are now fully exploited, while groundwater sources are nearly so (Attia 2002). The population is currently increasing by more than 1 million per annum and is expected to reach some 86 million by 2025, having been approximately 65 million in 2000. A large proportion of this population is employed in agriculture (table 9), although the proportion is declining. Reallocating water away from agriculture will thus have major social implications, unless alternative employment can be generated in the receiving sectors (industry and others).

TABLE 9. THE AGRICULTURE LABOUR FORCE AND ITS SHARE IN THE NATIONAL LABOUR FORCE

	Labour force in thousands		
Year	National	Agriculture	Percentage
1985	11 838	4 258	35.9
1986	11 980	4 295	35.8
1987	12 256	4 447	36.3
1988	12 351	4 381	35.5
1989	12 715	4 432	34.8
1990	13 489	4 483	33.2
1991	13 900	4 535	32.6
1992	14 256	4 588	32.2
1993	14 335	4 649	32.4
1994	14 436	4 682	31.8
1995	14 893	4 745	30.8
1996	15 693	4 815	30.7
1997	16 318	4 916	30.1
1998	16 468	4 978	30.0
1999	16 618	4 987	30.0
2000	16 768	4 998	29.8

Source: Ministry of Agriculture and Land Reclamation, statistical reports.

Newly developed water-resource management strategies are more integrated, in that they consider water scarcity from all angles, looking at the technical, institutional, managerial, legal and operational activities required to plan, develop, operate and manage the water-resource system on both national and local levels, while considering all the sectors of the economy that are dependent on water.

Egyptian water-allocation policies always prioritize domestic water requirements over other sectors. However, while agricultural water use currently accounts for the largest percentage of water use in Egypt (approximately 56 billion cubic metres), domestic and industrial activities in 2000 used about 4.5 billion and 7 billion cubic metres of water respectively. No additional discharges are currently required to satisfy navigational needs in the main river owing to the recent abolition of the winter closure period (during which water was released from the High Aswan Dam (HAD) for navigational purposes only). Water requirements

[2] 1 feddan = 1.038 acres = 0.42 hectares.

for hydropower generation are fully met by day-to-day releases into the irrigation system, since additional releases for power generation were prohibited to counteract drought conditions.

Future demands for all uses will definitely increase on account of rapidly increasing population and land-reclamation and industrialization policies (see below). The rate of increase will vary from one sector to another. For example, in the year 2017, the rate of increase in demand will be 23 per cent in agriculture, 50 per cent in the domestic sector, 42 per cent in industry, and 2 per cent in navigation. Reallocation of available water resources will be needed to meet these demands. Current government policy is designed to control the cultivation of water-consuming crops (rice and sugar-cane) and expand the reclamation of desert lands to relieve the high population density in the Nile valley and delta. Measures for improving water efficiency in agriculture include the application of water-saving technologies that are both practicable and economically feasible. The introduction of water fees is also under consideration.

The cost of irrigation water is an important issue in water-resource planning and management. Although considerable work has been done on water pricing in general, little rigorous work has been done on the cost of delivery and collection of irrigation water, despite the substantial liberalization of prices in Egyptian agriculture since 1986. Irrigation water is still free and constitutes a source of price distortion. In 1983, the average cost to the nation of irrigation water was estimated as 1.92 Egyptian pounds (LE) per 1000 cubic metres; this included the full cost of multi-purpose structures operated and supervised by the Ministry of Water Resources and Irrigation (MWRI), but serving purposes other than irrigation (navigation, hydropower, flood control, etc.).

Municipal water-supply tariffs in Egypt were previously set according to a life-line system, with a flat rate per cubic metre consumed. The Ministry of Housing and New Communities recently established a new system of municipal water tariffs and applied it in new communities to distinguish between high-income areas and areas occupied by those on low incomes and the newly graduated, providing subsidized water only to those in the latter areas. There is also a higher tariff for water allocated to tourist villages and resorts.

Apart from the small amount of scattered seasonal rainfall on the Mediterranean coastal strip, Egypt relies on the Nile as its major source of freshwater. There are deep reserves of groundwater in large aquifers in the western desert, but utilization of this water is limited because it is very costly to pump from such great depths, and the aquifers are generally considered to be non-renewable. Low flow in the Nile threatens Egypt's water security and affects the government's ability to implement development plans, and the construction of the HAD and Lake Nasser reservoir helped to control releases of water downstream and store excess water during years of high flow, in order to meet part of the demand during years of low flow.

1. *Drought*

Because the 1979-1987 drought was so prolonged, many studies were carried out to help decision makers and water-resource planners maximize the use of the limited volumes of water available to meet the various demands from all sectors and avoid a water-shortage crisis. Optimization models were used to study the effects of changing releases downstream from the HAD and to examine the effect of alternative cropping-pattern policies on Lake Nasser at the end of the water year under different inflow volumes (Al-Turbak 1999). Municipal and industrial demands were given priority, the burden of water shortage being borne by agriculture, and the optimum cropping pattern that would maximize the consumers' and producers' surplus was calculated. As a result of these studies, the MWRI took different decisions to mitigate the effects of the drought.

(a) No releases of water were allowed from the HAD for the sole purpose of power generation. The Ministry of Electricity developed a national plan to expand the use of thermal power plants to make up any shortfalls in hydropower generation. The Ministry of Electricity maintained the maximum hydropower generated from all water structures and made up the shortfall with thermal power plants;

(b) The New Esna Barrage and the new Nag-Hammadi Lock were constructed to allow improved water control;

(c) Changes were made in the timing and duration of winter closure periods (which were reduced from 28 to 21 days, during which time releases from the HAD were minimized);

(d) Releases of freshwater to the sea through the Rosetta branch were minimized;

(e) The national Irrigation Improvement Project was launched (see section 3(b) below).

2. *Land reclamation*

The Ministry of Agriculture together with the MWRI has developed a land-reclamation plan calling for the reclamation of:

(a) 1.7 million feddans to be irrigated with water saved through more efficient use of surface water;

(b) 200,000 feddans to be irrigated with water provided by sewage-treatment projects;

(c) 300,000 feddans to be irrigated with non-renewable groundwater in the New Valley (Western Desert) and Sinai.

Land reclamation in Egypt

The South Valley development project in Egypt (often known as Toshka or the New Valley) was inaugurated in January 1997. The plan aims to create an alternative delta, parallel to the Nile valley, involving large-scale land reclamation linked to industrial, tourist and mining projects, and the creation of new urban communities to relieve congestion in the Nile valley. When completed, the project will use 5 billion cubic metres of water per annum from the Nile River. It is intended to settle some 6 million people, to cultivate between 800,000 and 2.2 million feddans (336,000–924,000 hectares), and to increase the inhabited land area of Egypt from 4 per cent to 25 per cent.

However, in response to financing constraints, the Toshka project has been scaled down to focus initially on reclaiming 540,000 feddans of desert land. Under the initial plan, a pumping station at Toshka on the western shore of Lake Nasser would have lifted 25 million cubic metres of water into the main canal per day. In the first phase, the canal will extend 30 kilometres into the Western Desert, and a further 350 kilometres under the second phase, to the Paris oasis.

The South Valley scheme is part of the much larger National Land Reclamation Project, scheduled to cover 3.4 million feddans by 2017. The programme includes 150,000 rain-fed feddans on the north-west coast, as well as areas along the Nile (including ones that border with Sudan) and others that are fed by groundwater, such as East Oweinat in the Western Desert. The El-Salam canal, inaugurated in October 1997, will carry Nile water from near Dumyat under the Suez Canal to south of El-Arish in Northern Sinai, irrigating 620,000 feddans of desert land on the way and enabling 1.5 million people to settle in a currently uninhabited area (EIU 2002).

The implementation of this ambitious plan faces several obstacles, such as resistance at coastal lakes to water conservation during the winter closure period (owing to the adverse impact on fisheries and the environment) and constraints in the reuse of drainage water (owing to the increasing pollution in drains). Moreover, the salt balance in the Delta requires that at least 8 billion cubic metres of drainage water per annum be flushed into the sea; this could limit future increases in drainage water reuse. On account of these obstacles, horizontal expansion could be limited. In order for the plan to reach its targets, the following measures have to be taken:

1. Implementation of a strict scheme for protecting waterways from pollution (there is good cooperation between the Ministry of Public Works and Water Resources and the Environmental Affairs Agency).

2. Reduction of the areas planted with rice.

3. Modification of the current cropping pattern to incorporate fewer water-consuming crops (replacement of sugar-cane with sugar-beet).

4. Modification of the winter closure period to make it more flexible, and conservation of freshwater otherwise lost to the sea.

5. More accurate calculation of crop water requirements at field level by using new methods for computing evapo-transpiration losses and aerial photogrammetry or satellite imaging techniques to obtain actual cropping patterns.

6. Eradication of aquatic weeds to reduce evapo-transpiration losses from canals and lakes.

7. Maximum reuse of drainage water in order to minimize the spillage of drainage water to the sea beyond the amount needed to maintain the salt balance.

3. *Optimal water allocation*

Optimal use of all available water resources can be achieved through an integrated plan working at both the national and local levels. This plan should translate the overall policy targets into long-term programmes and enable their impacts on socio-economic development to be examined and reviewed. Not all available resources can be used for all purposes, as there are many interrelated factors that define the optimal resource for a specific use, the principal ones being environmental conditions, period of availability and geographic distribution. On the demand side, the main controlling factor is the socio-economic impact resulting from the utilization of such resources by different users. For example, municipal water demand must take a higher priority when water is allocated for different uses, and its share must come from freshwater of good quality. The following is the set of strategies proposed to achieve optimal use of all the available water resources.

(a) *Minimize water losses*

The main strategies proposed for minimizing water losses are:

(a) The use of pipelines to transfer water in newly reclaimed land, especially at locations of high-porosity soil;

(b) The gradual expansion of groundwater wells for use as a secondary source of water at the farm level, to reduce conveyance losses in third-order canals;

(c) The replacement of level-based water-distribution systems with flow-based water-distribution systems through the calibration of control structures;

(d) The introduction of new technologies for canal maintenance and weed resistance;

(e) The improvement of the Nile navigation path and facilities to reduce, or eliminate, the amount of water released for that purpose during the winter closure period.

(b) *Irrigation Improvement Project (IIP)*

The main objective of the IIP in the old lands is to improve the efficiency of the water use at mesqa (small channels) and farm levels. It also initiates user participation in the operation, maintenance and management of the irrigation system. The IIP comprises the rehabilitation and improvement in control structures, modern methods of land levelling/tillage, on-farm development, and the rehabilitation of main and branch canals and of most mesqas, the use of one-point collective pumping from canals to mesqas, and the redesign of field irrigation systems. These measures promote equity of water distribution and, through the formation of water-user associations (WUAs), facilitate cooperation between the irrigation directorate and farmers. WUAs were recently institutionalized in the Egyptian parliament, through legislation in which they were defined as private organizations owned and operated by their members. WUA membership is composed of those who use the watercourse for their own benefit and those who work in the area of water use and distribution (and all related organizational activities) towards raising agricultural productivity. The MWRI established a special fund to finance mesqa improvements in future, additional to the contributions already made by the farmers themselves; the fund is to be built up from budgetary transfers, foreign grants and loans.

(c) *Cost recovery*

Increasing demands for water by all users will require continuous improvement and rehabilitation of the water system, which adds more burdens to the government budget. It is therefore essential to set up a cost-recovery system in which water users pay for the services of water distribution and network maintenance. Cost allocation and cost recovery are highly sensitive issues. The first step should be to initiate a public awareness programme to highlight the importance of water and encourage the setting up of water-user associations.

One approach to cost recovery that should be structured in Egypt has emphasized the mesqa as the service-delivery point and its function in cost recovery. The approach identifies six main components, which include suggestions for making the improvements that should feature in any irrigation-management programme. It also attempts to integrate into Egyptian irrigation the experience of introducing cost recovery in Indonesia and highlights the advantage in water management of creating single-point mesqas. The model suggests the introduction of a mesqa operational fee, as the WUAs' contribution to the operation and maintenance costs of the main system, and identifies the institutional and administrative changes that need to be made (Abu-Zeid 1997, Attia 1999).

(d) *Shifts in cropping patterns*

Economic analyses have shown that there are substantial differences in the total economic returns to different crops grown in Egypt. It was seen that water productivity in some regions is low, since their crops consume great amounts of water and have low value added. The following policies are proposed to reduce agricultural water consumption:

(a) The gradual replacement of sugar-cane with sugar-beet, especially in Upper Egypt (taking the lifespan of existing sugar factories, which were designed to process sugar-cane, into account);

(b) The reduction of the area cultivated with rice to about 900,000–1 million feddans, which would be sufficient to satisfy national demand, provide some potential for export, and salinity levels in soil rising and intrusion by sea water;

(c) The replacement of the varieties of rice currently used with the new varieties with shorter lifespans, higher rates of productivity and smaller water requirements;

(d) The development of new crop varieties using genetic engineering that have higher productivity and smaller water requirements;

(e) The narrowing of the gap between net revenues of similar seasonal crops to enable the Ministry of Public Works and Water Resources to encourage the cultivation of crops that consume less water;

(f) The design of an indicative cropping pattern for each region in the country based on climatological conditions, soil characteristics and the availability of water resources (in terms of both quantity and quality); farmers should be advised to follow the indicative cropping pattern or pay for excess water if they deviate.

(e) *Groundwater development strategies*

Groundwater policy aims to encourage agricultural development in desert areas. These areas will be the basis for new communities that can absorb part of the highly concentrated population in the Nile valley and delta.

The groundwater in the Nile valley and delta region cannot be considered an independent resource, as it is recharged only from seepage losses from the Nile, canal and drainage networks, and from deep percolation losses of irrigated lands. Groundwater strategy depends on the conjunctive use of Nile surface water and groundwater through:

(a) The utilization of the aquifer as a storage reservoir to supplement surface-water supply during peak periods—the aquifer is then recharged during periods of minimum demand;

(b) The use of modern irrigation methods in newly reclaimed lands (sprinkler or trickle methods) that make use of groundwater as the water source—this prevents waterlogging and keeps the water table far from the root zone;

(c) The use of the vertical wells drainage system in Upper Egypt—this prevents the water table from reaching the root zone and thus avoids waterlogging and increases productivity;

(d) The use of groundwater as a water source for fish aquaculture—groundwater has a consistent and steady temperature and is of a good quality;

(e) An increase in canal water supply by pumping groundwater from low-capacity private wells at the tail ends of long mesqas where water shortage is experienced.

Groundwater in the Western Desert and Sinai is only found at great depths and needs large investments to be utilized. Future strategies for groundwater utilization therefore include the following:

(a) Modern technologies to determine the main characteristics of each aquifer, its maximum capacity and safe yield should be employed. This data should constitute the basic criteria for selecting the most suitable projects that could use such aquifers as a sustainable source of water;

(b) New small communities (2,000–5,000 feddans) in desert areas should be designed to utilize all available natural resources through integrated planning;

(c) Non-conventional energy sources (solar and wind energy) should be used to minimize the costs of pumping;

(d) Use should be made of new technologies for farm irrigation in desert areas to minimize field losses, especially those resulting from percolation due to the high soil porosity.

(f) *Reuse of agricultural drainage water*

The reuse of drainage water increases the overall efficiency of the water system, but it must be regulated to prevent adverse environmental impact in the future. Future strategies for drainage water reuse include the following:

(a) Increasing the amount of drainage water reuse. This could be achieved through implementing several projects to expand reuse capacity in different areas. The main projects proposed include the El-Salam canal project, the El-Omoom drain project, and the El-Batts drain project;

(b) Improving the quality of drainage water, especially in the main drains that are included in the Ministry’s plan for drainage water reuse. It is recommended that a series of small treatment plants on secondary drains or at the locations of reuse pump stations be set up;

(c) There should be separate systems for the collection of sewage and industrial wastewater from the drainage system;

(d) About 50 per cent of the total drainage water generated in the delta should be drained to the sea to prevent the intrusion of sea water and to maintain the salt balance of the system;

(e) After updating and upgrading, an integrated information system should be implemented for monitoring water quality in drains, using existing data collection networks;

(f) There should be continuous monitoring and evaluation of the environmental impact of the implementation of the drainage-water reuse policy, particularly the impact on soil characteristics, cultivated crops and public health.

(g) *Reuse of sewage water*

Future policy for the utilization of this resource can be summarized as follows:

(a) An increase in the amount of secondarily treated wastewater;

(b) A limit on the use of treated wastewater to cultivate non-food crops such as cotton, flax and trees;

(c) The separation of industrial wastewater from domestic sewage, so that it is easier to treat domestic sewage (which can be done at minor cost), and avoid the intensive chemical treatment needed for industrial wastewater.

The best course of action is determined economically in accordance with the attributed opportunity costs (the marginal benefits of water in its next-best use). From this viewpoint, increased irrigation is unlikely to generate benefits, because farmers already over-irrigate, on account of the heavy clay soils, which require extensive irrigation for leaching purposes. On the other hand, the marginal benefits resulting from the changes in cropping patterns that become possible with increased water supply are reckoned to yield short-term opportunity costs. Marginal benefits would be at their maximum, representing long-term opportunity costs, if changes in cropping patterns were combined with land-reclamation projects (see above). However, since cropping patterns can be changed from year to year, land reclamation is preferred for its potential to yield coherent water opportunity costs in the long run. Moreover, due to growing population pressures in Egypt, land reclamation has additional advantages over cropping pattern changes, including relieving overcrowding in the Nile valley and delta, increasing the overall level of investment, mitigating urban encroachment on productive land in the vicinity of the Nile, creating job opportunities, etc. Finally, in the light of current rates of food exports in Egypt (which are 50 per cent, 30 per cent and 80 per cent of the national consumption of grain, sugar and oil respectively), land reclamation is expected to bridge the gap between population growth and food production. Annex II gives additional basic data on water and the agricultural sector in Egypt.

B. JORDAN

Water-allocation policies in Jordan combine both equity and economic efficiency principles. Each household is entitled to 15 cubic metres of water per month at subsidized prices (equity principle); this guarantees water for basic needs and sanitation purposes. When consumption exceeds this amount, allocation is based on economic efficiency principles, including marginal cost pricing.

All discussions of water scarcity in Jordan call for improved sectoral water allocation, as agriculture is the largest consumer of water (more that 80 per cent), while its contribution to the GDP is between 3 per cent and 5 per cent. A small reallocation of water away from agriculture could be translated into a very high increase of water availability in other sectors. Reallocation of a mere 5 per cent of water used by agriculture could nearly double the total amount of water available in another sector (for example, the domestic sector, whose share in available water would increase to 15 per cent).

1. *Explicit policies*

Jordan has developed a water strategy that stresses the need for improved water-resource management, with particular emphasis on the sustainability of present and future uses and the care needed to protect Jordan's water resources against pollution, quality degradation and depletion. The strategy states also that government agencies must continually aim to achieve maximum practicable efficiency in the conveyance, distribution, application and use of water resources. It also recommends that public agencies adopt a dual approach of demand management and supply management, using appropriate technology to enhance their resource-management capabilities.

The strategy defines the long-term goals that Jordan is seeking to achieve in the water sector, and recommends that appropriate governmental institutions should formulate policies to help achieve these goals. So far, the following four policies have been enacted: (i) a groundwater management policy; (ii) an irrigation-water policy; (iii) a wastewater-management policy; and (iv) water-utility policies. The irrigation-water policy, formulated in 1998, addresses issues such as sustainable agriculture, resource management, technology transfer, water quality and efficiency. Among its most important elements are:

(a) The promotion of the sustainable irrigated agriculture by protecting groundwater resources (among other methods);

(b) The development of new sources of water, such as wastewater and rainfall;

(c) The use of modern technology, such as genetically engineered plant varieties to enhance agricultural yield, and advanced irrigation technologies (e.g., cloud seeding for increased rainfall);

(d) The enhancement of water management at the farm level by promoting (for example) the application of irrigation water by night, the automation of farm irrigation networks, the monitoring of soil moisture, and examining crop water requirements for micro-climate zones;

(e) The monitoring of the quality of irrigation water at the source and during conveyance, and of the distribution network, as well as improvement in the quality of wastewater (allowing unrestricted irrigation) and the testing of soil salinity;

(f) Improvement in management and administration through better operation and maintenance of irrigation facilities from sources (e.g., reservoirs, rivers or springs) to farm gate, the use of piped irrigation networks, the metering of water at the farm, and participatory irrigation management;

(g) The introduction of better water pricing, so that prices can be differentiated according to water quality, and irrigation water managed as an economic commodity, with prices covering at least operation and maintenance costs, and, where possible, capital costs;

(h) The introduction of regulation and controls to discourage crops with high water needs through economic and market forces.

2. *Implicit policies*

Until the mid-1980s, Jordan witnessed strong economic growth. However, real income growth had slowed by that time, and the economy actually contracted during the 1988 crisis. In 1989, the country was unable to meet its external obligations: debt was extremely burdensome (more than 200 per cent of the GDP), and foreign exchange reserves were very low. Since then, the government of Jordan has embarked on a phase of broad economic reform, by implementing a long-term structural adjustment process that has been supported by multilateral and bilateral donors. As a result, many substantial and far-reaching changes have been made in overall economic and sectoral policies. Among other things, general government policy aims at:

(a) The containment of external and internal debt;
(b) Fiscal reform, by introducing a VAT system and tax reform;
(c) Improved budget management to reduce the deficit;
(d) Structural reform through privatization.

The long-term structural adjustment process and the policies related to its implementation have brought about many substantial changes in the policies of different sectors, including agriculture, food security and water. The agricultural sector was the first candidate to be reformed, because it was a traditional recipient of subsidies and was the largest contributor to the government's subsidy expenditures. In addition, policy reform, particularly in the agricultural and water sectors, continues apace.

Studies are also recommending that Jordan orient its cropping patterns towards exporting crops of high value that consume less water (like strawberries, winter vegetables, cut flowers and others), while importing crops that have high water consumption (like rice, bananas and livestock fodder). It is felt that a water-scarce country such as Jordan should not export virtual water to water-rich countries in the form of crops that have high water demands.

Irrigation in Jordan

Irrigation has played a crucial role in the development of the agricultural sector in Jordan. Irrigated agriculture has helped compensate for the shrinking per capita share of rain-fed land and allowed the cultivation of marginal land through modern irrigation techniques. It is worth noting that in 1992 cropping intensity was reduced, and crops received less than the optimum amount of water. This resulted in roughly one half of irrigated water for the Jordan Valley and Southern Ghor being billed; the break-down for the other half was as follows:

- 7.6 per cent spilled;
- 28.6 per cent normal system losses;
- 13.1 per cent unaccounted for.

This situation requires greater water-resource management skills, improvement in irrigation networks, and the enhancement of water-storage capacity to reduce spills. Perennial trees are considered high-value crops in Jordan, and farmers tend to prefer them.

The water supply in the Jordan Valley and Southern Ghor is controlled and rationed by the Jordan Valley Authority. The volume of water supplied by the Authority to farmers is allocated according to the crop grown and the availability of irrigation water. In the highlands, irrigation water is mostly groundwater, pumped by the farmer with virtually no supervision.

3. *Optimal cropping pattern and water demand*

Agriculture, especially in the Jordan Valley, requires water for irrigation and competes for that water with the household and industrial sectors. There are substantial differences in the characteristics of water consumption between the various sectors. For example, compared with agriculture, water demands by households are not price sensitive, at least for the high-priority uses necessary for human life. On the other hand, agriculture can utilize low-quality water (recycled, brackish or untreated surface water), while the household sector and some of the industrial sector can only use freshwater. Another significant difference is that water supply to households and industry must be extremely reliable, whereas the reliance of the agricultural sector on a dependable supply of water may not be as important, especially when water is to be used for low-value field crops. While agriculture is subjected to considerable uncertainty as to water supply, it also has considerable flexibility with regard to water, since in the same area a large variety of crops can be grown and other water-consuming activities undertaken.

A linear programming model is being formulated for the Jordan Valley. Its objectives function is the net agricultural income of the district, which is maximized by selecting the optimal mix of water-consuming activities. In this procedure, the decision variable consists of the areas of land where the activities are undertaken. Each activity is characterized by its water requirements per dunum[3] (by type of water, soil class, production technology [whether drip, open field or plastic]) for each district of the Jordan Valley. However, each activity can, in principle, use one or more types of water. Four water-quality types (freshwater

[3] 1 dunum = 0.1 hectares.

[groundwater], surface water, brackish water and recycled wastewater), combined with two production seasons (autumn and spring) in the three districts of the Jordan Valley produce 24 season/water-quality combinations. The model can be formulated to support up to 12 different water prices based on season/water-quality combinations.

4. *Tools and institutions used for implementation*

Water-policy development in Jordan is initiated by a water-policy committee of the Ministry of Water and Irrigation (MWI). The committee reviews all relevant documents (including previous policies from other government agencies) and all literature (including water-policy review papers from the World Bank, the FAO, other institutions and other countries). The committee has grouped all policies into six major categories: water resources and supply management; demand management; allocating priorities; water quality; investment in the water sector; and institutional and legal aspects. Brief policy profiles were established for each one of these categories.

The irrigation water policy of the MWI and the irrigated-agriculture policy of the Ministry of Agriculture are in agreement in terms of sustainable use of water resources, irrigation-water management and irrigation-water quality. Prices and cost-recovery policy for irrigation water are set only by the Jordan Valley Authority, because it is responsible for delivery and collection of monies. In fact, the role of the Ministry of Agriculture in irrigation-water policy is limited to public awareness and research, and it has no power in policy implementation.

Public institutions play a decisive role in the provision of water for irrigation facilities. The price of irrigation water in Jordan is far lower than that charged to households and the industrial sector and reflects only a fraction of the true cost of supply. The MWI sets the price of irrigation water and justifies its cheapness on account of risks at the farm level (e.g., crop failure from disease) and the political demand for rapidly increasing agricultural production and/or income. The financial deficit that results from this low-price policy has to be compensated for by the rest of the agricultural sector and by other parts of society. Efforts are being made by the MWI to set up a tariff system that ensures partial recovery of all operational and maintenance costs and encourages the efficient use of water.

C. THE WATER SITUATION IN SELECTED OTHER ESCWA MEMBER COUNTRIES

The following sections describe briefly the water availability, the reduction in the agricultural water share, and the contributions made towards improved water-resource management and irrigation methods in three countries of the ESCWA region.

1. *The Syrian Arab Republic*

Surface-water and groundwater resources are used for agriculture in the Syrian Arab Republic; the domestic and industrial sectors receive water from groundwater resources. However, because of population expansion and economic growth, competition between the agricultural, industrial and municipal sectors for the limited water supplies is increasing rapidly. Syrian water development has been designed to irrigate about 650,000 hectares, even though the area currently irrigated is much less, owing to salinity, waterlogging and reduced river flows. At present, agriculture accounts for around 85 per cent of the country’s water consumption. Domestic water production reached 951.6 million cubic metres in 1995, and current projections suggest that domestic water requirements will increase by between twofold and threefold by 2010. During the 1980s, industrial water demand rose by nearly 900 per cent, and as industrial capacity continues to grow, current distortions in sectoral water allocation will become more and more apparent.

Irrigation is undertaken primarily on relatively large projects, particularly those in the Euphrates River basin, where water is provided to private farms, State farms and tenant farmers on State lands. The private irrigation sector includes farmers who drill wells to extract groundwater and pump water from lakes, rivers and springs. While the increase in the area irrigated is making important short-term contributions to economic growth, the current rate of uncontrolled groundwater exploitation is likely to have long-term social, economic and environmental consequences and will act as a major destabilizing force to the current precarious water-sharing situation between different sectors. Significant drops in groundwater levels have already been documented in the Damascus, Aassi and Aleppo basins (among others), and this diminishing supply, coupled with growing competition from industrial and domestic water users, is making better water allocation an urgent concern.

Designing and implementing policies, programmes, projects and techniques to improve water-use efficiency in all sectors coupled with more effective control of surface-water and groundwater exploitation in agriculture should be the two most important and urgent concerns for Syrian policy makers. Growing water scarcity is likely to have important short- and long-term implications for the country's overall social and economic development. However, the government is currently addressing a few important water-related issues, which include among others: better public-sector management of irrigation systems; the introduction of water-conservation techniques at system and farm levels; the implementation of water-reuse techniques and water harvesting systems; and the reduction of losses in water-supply networks in towns. These will improve the overall efficiency of the water sector and should allow greater conservation of water resources, making the present water-allocation structures more sustainable (Hadeed 1999).

2. *Saudi Arabia*

The Saudi Arabian government has taken several measures to conserve non-renewable groundwater resources and to ensure a better balance of water use between agriculture and other sectors by refocusing its strategy on food security rather then food self-sufficiency. However, there are still critical issues related to water-resource management in the kingdom: measures for controlling water consumption must be enhanced to prevent wastage and ensure rational consumption; regulations for conserving water must be reviewed and strictly enforced; a mechanism for reducing water consumption in agriculture must be developed through (for example) the expanded use of water-saving technologies; and national standards and specifications for all water facilities must be prepared. Water consumption and extraction from all sources should be monitored through effective metering, modernization of water transmission and distribution networks for domestic purposes, and the adoption of effective measures to improve the collection system. Similar attention should be given to promoting public awareness through all types of media about the importance of rationalizing water consumption. All this is expected to lead to greater savings in the quantity of water consumed and, if coupled with better sectoral water allocation, would allow the net social benefit to be maximized.

The private sector has participated in various water-related activities, such as the drilling of wells, the construction and maintenance of dams, the provision of drinking water with tankers, the operation and maintenance of drinking-water distribution networks, the implementation of projects for the reuse of reclaimed wastewater for agricultural purposes, as well as the supply and installation of pumps and equipment for water projects. The private sector is expected to play a greater role in the future, not only in the areas of implementation, operation and maintenance, but also in the domains of finance and management, thereby helping to improve economic efficiency in its broadest sense (investment, production and organization). In order to support these initiatives, the government will have to design appropriate policies that will encourage and enhance sectoral water allocation, such as the development of water markets and tradable water rights.

In order to save water that could be reallocated to other sectors, the government is implementing a series of measures. For example, the increasing demand for water for agricultural purposes is being addressed by reducing the area cultivated with crops with high water requirements (such as livestock fodder and alfalfa), by suspending the distribution of fallow lands (except in areas with renewable water resources), by expanding the cultivation of agricultural products with lower water requirements, and by adopting a wide range of measures to rationalize other water consumption for agricultural purposes. Such measures include the adoption of advanced irrigation techniques, the determination of water requirements for agricultural products, monitoring water consumption through the installation of meters on wells, setting tariffs for water used in excess of the specified water requirement for a particular crop, utilization of the natural comparative advantages of the various regions to redistribute agricultural products, and the intensification of agricultural extension programmes to ensure that farmers are aware of the significance of water conservation (Kingdom of Saudi Arabia, Ministry of Economy and Planning, 2000–2004).

3. *Yemen*

Water demands in Yemen are growing because of the high rate of population growth, expansion in the area irrigated, and rapid industrial growth. The supply-demand gap is widening alarmingly and cannot really be bridged without rationalizing water use through appropriate water-management and development policy. The major source of concern is water use in agriculture, as the sector not only accounts for more than 90 per cent of the total water use in the country, but also has extremely low rates of efficiency of water use, owing to inefficient water-management practices. Competition among water users for the limited supplies available is becoming intense and leading to conflict. The government recognizes the problem of depleting water resources, over-use and mismanagement and has designed a programme that aims to address these issues. It has outlined the following major objectives for the water sector:

(a) The protection of water resources from over-exploitation, quality degradation, and irreversible damage;

(b) The allocation of water resources between different sectors to sustain economic growth with equitable distribution of benefits and balanced demographic distribution;

(c) Satisfaction of society's need for water, food and ecological stability by meeting drinking-water requirements, by providing for safe disposal of wastewater and solid waste, by increasing productivity per unit of land and water, and by maintaining an ecological balance.

The strategy takes into account the specific nature of the natural water-resource systems in Yemen, the institutional setting, prevailing socio-economic constraints, guiding principles resulting from local custom and experience, and experience gained elsewhere under similar conditions. It also calls for a halt to groundwater mining. The strategy consists of a series of general and specific measures that provide the necessary basis for sustainable economic and social development through the implementation of a comprehensive water-resource management programme at the national and regional levels. This would involve, among other things, the planning and implementation of efficient water-resource management policies in relevant sectors, as well as integrating the management of several water-consuming subsectors at different levels and improving the current sectoral water allocation. An important element of the strategy is the proposal to enact legislation to meet national water-management objectives (Essam 1999, Elmahdi 2002).

VII. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Water allocation between various uses is an essential mechanism—maybe the most essential—for adapting to the constraints on water distribution. Agriculture consumes around 80 per cent of the total water in the ESCWA region, and therefore reallocation of even a small amount of water away from agriculture could be translated into a very high increase of water available to other sectors. In some countries of the region, a 5 per cent water reallocation from agriculture could nearly double the total amount of water available to other sectors, particularly the domestic sector. In Jordan, for example, a 5 per cent transfer of water from agriculture could translate into the domestic sector's share in water almost doubling to 15 per cent (Berkoff 1994).

Efficient sectoral water allocation cannot occur if prices fail to reflect the true costs of water provision and the scarcity value of water itself. Getting the price right at the subsectoral level is fundamental to achieving optimal water use not only within, but between sectors. There are many instances where water pricing in one sector has had a negative impact on water availability or quality in another sector. For instance, insufficient charges for electricity have been made in pricing groundwater pumping, and this has resulted in indiscriminate agricultural use and, consequently, the drying up and contamination of domestic rural drinking-water supplies. Conflicts over water between hydropower and irrigation can also largely be attributed to the subsidization of water in the agricultural sector. As well as revising the pricing regime, reforms must also target allocation mechanisms themselves. Key areas are: (i) improvement of the administrative allocation of water by incorporating economic or value-based criteria into decision-making; (ii) development of administrative brokering of compensated trades; and (iii) development of formal water markets, including the establishment of institutional, legal, regulatory and technological frameworks. Reform in these three areas is based on a common rationale: sectoral water allocation should incorporate an economic dimension, whether it occurs through negotiation or through 'automatic' market exchanges. The suitability of one allocation mechanism over the other will depend on circumstances, but the end result should be one of mutual benefit to the parties involved.

The current annual water resources available within the ESCWA region are about 197.61 billion cubic metres, while the total requirements to satisfy various human activities are estimated at 170.17 billion cubic metres. If we take the water poverty/scarcity line to be 1,000 cubic metres per capita per annum, it is expected that most ESCWA member countries will face severe water shortages by the year 2025. The situation will become critical as the population increases, based on current population projections for 2025 and assuming no changes occur in the availability of water. By 2010, only two ESCWA member countries (Iraq and the Syrian Arab Republic) will be above the water poverty/scarcity line, and only Iraq will stay above this line in 2025 (although the water quality in Iraq has been affected by the war there). The situation is alarming in the extremely water-poor countries such as Jordan, Palestine and Yemen, as is the deterioration in water quality. The current and future water-scarcity situations need action on both sides of the water balance equation, either by increasing supply or managing demand better. Most of the available water (92.53 per cent) is located in only four ESCWA member countries: Iraq (37.38 per cent), Egypt (34.65 per cent), the Syrian Arab Republic (11.60 per cent) and Saudi Arabia (8.90 per cent). These countries also have the highest population densities and, as their populations increase, their water wealth will be invaluable.

Water allocation is about sharing the available water between the economic development and environmental considerations of the present and the future. It is also about social equity, not only sharing between current and future generations, but also about sharing between sectors (public water supplies, industry, agriculture and recreational use). Several possible allocation mechanisms and policies have been outlined above. Water allocation policies vary from country to country, with each adopting their own mechanisms that are dependent on natural conditions, social and economic structures, and political influence.

Water-resource policies should always be evaluated in terms of their effects on the environment, as well as their economic and socio-political aspects. Some ESCWA member countries already have serious water-deficit problems arising from insufficient resources for increased populations; other ESCWA member countries will soon have these problems. It is almost impossible to develop more resources within the

ESCWA region. Nevertheless, some countries have already started programmes to manage demand by improving water-use efficiency and maintaining water quality.

Expected droughts will allow the hydro-political agenda to be renegotiated. Such renegotiations usually involve the introduction of notions of sustainability, linked to a demand-management strategy. Enforcing water charges may help in water conservation, but it is not of itself enough to achieve an effective water allocation policy. The solution to the worldwide water shortage is to make the use of water among sectors efficient, using allocation policies that take the two principles of economic efficiency and equity into consideration. These two principles together make decision-making compatible with social objectives.

This study has outlined several criteria used to compare appropriate means of resource allocation used to achieve optimal allocation. Cost-benefit analysis is the most common method for evaluating different alternatives for a project. The model also can serve as a decision-support device, suggesting to planners (for example) what crop pattern is likely to prove optimal under different policies. Recently, mathematical models based on operational research and developed from systems engineering have been used in water allocation to solve the economic functions, which are non-linear in nature. These models also serve as decision-support tools, suggesting to planners what crop patterns are likely to prove optimal under particular policies.

All types of allocation policies are found in ESCWA member countries, including marginal cost pricing, public allocation, user-based and market allocation. The application of each is subject to certain conditions, but no single type is best for all conditions. Although user-based allocation is more flexible than public allocation, its application in the region remains in its early stages, limited to small-scale projects in Jordan, Egypt and Tunisia. So far, user organizations have not been able to provide services to users in a sustainable manner.

Only a few member countries in the ESCWA region apply market allocation principles, in spite of the advantages of the incentives they provide for users to seek the highest-value application of water resources. Water-market allocation is applied in Jordan on a small scale to all sectors: to the agricultural sector, where the cost of water is governed by economic efficiency; to the domestic sector, where the price is based on the cost of water; and to the industrial sector, where the price includes a cost-recovery element. Water market allocation principles are practised under conditions of scarcity and during crises. Few cases of tradable water rights can be found, apart from in the Southern Ghor of Jordan, where farmers prefer to sell their rights to industry. The practices outlined are not regulated, so government should be committed to developing and supporting water-market and tradable water-rights legislation.

In general for the ESCWA region, the following can be concluded.

1. The role of governments in water allocation has been successful, as they take economic-efficiency and equity principles into consideration.

2. Agriculture is the last and residual claimer of water, which means that water allocation to agriculture can be viewed as State policy.

3. The implementation of a water-pricing policy as an incentive for improving on-farm irrigation efficiency and water productivity has been very successful.

4. The involvement of the private sector in water distribution (by way of management contracts) has improved system performance and reduced unaccounted for losses at an annual rate of 5–7 per cent (in Jordan for example).

5. Appropriate pricing and market-mechanism policy have encouraged farmers to grow crops with high net returns per cubic metre of water that are in demand in the domestic and export markets.

6. Formulation of the National Strategy for Agricultural Development as a tool for agricultural policy implementation has been successful and is considered to be a first step toward implementation. The main

reason for its success is the involvement of target groups, individual farmers and decision makers in the process of strategy formulation.

6. Agricultural reform policy brought a slackening of the economy and investment in the short term (1994–2000), but the economy has picked up since 2000.

7. The policy of limiting the role of the government to regulation, control and support, such as extension and research, has been translated in the new agriculture law.

B. Recommendations

A national policy whose aim is access to water for all should be designed in such a manner that irrigation does not result in long-term harm to soil health and that social equity is ensured in the sharing of available water. Participatory management of irrigation water resources, including systems of rotational distribution of water, will help to foster the equitable and efficient use of water. Pricing policies should take the inter-generational equity aspects of water use into account. The basic objectives of a successful water policy should be:

(a) To allocate and use available surface water and groundwater in a sustainable manner;
(b) To express allocated water as a volume of water that may be taken and used;
(c) To use water resources efficiently;
(d) To maintain water quality;
(e) To maintain ecosystems dependent on groundwater;
(f) To maintain aquifers.

Based on the review of water-allocation policies in this study, it is recommended that:

1. Irrigated areas be reduced if there are low returns from the agricultural sector;

2. The saved water be reallocated to the industrial sector, where its return is the highest of all the economic sectors (this will help create more jobs and will have a social and economic impact as a result);

3. Provision of water for domestic use should not be jeopardized;

4. Agricultural policies should be focused among other things on reducing the amount of irrigation water, improving efficiency, changing crop patterns, applying deficit irrigation methods, and using modern irrigation techniques and drip irrigation.

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Annex I

COST-BENEFIT ANALYSIS SPECIFICATION

For the consumption of water in agriculture and industry, if y_{1t} is defined as the production generated in year t with a specific water allocation, and $c_1(y_{1t})$ as the cost associated with utilizing that water in production, then the gross returns obtained in year t with the specified water allocation are given by

$$R_{1t} = p_t y_{1t} - c_1(y_{1t})$$

Similarly, if y_{2t} is the production generated in year t with a new water allocation, the returns in year t would be given by

$$R_{2t} = p_t y_{2t} - c_2(y_{2t}) - c_{2t}$$

where $c_2(y_{2t})$ is the cost associated with utilizing the water in agricultural or industrial production, and c_{2t} the cost of reallocating the water (additional investments, if any; maintenance costs of bringing water to a new location, etc.). The net benefit obtained by adopting a new water allocation in any given period would therefore be given by

$$NB = R_{2t} - R_{1t}$$

where t = 1,2…T.

Variations in agricultural output as a result of a change in water allocation will be calculated approximately using an FAO (1979) formula, as follows:

$$Y_A = (1-K_Y).Y_P$$

Y_A and Y_P are respectively the actual and potential output, and K_Y a yield response coefficient (for the major crop produced). K_Y describes the fractional reduction in yield relative to its potential at full water supply (Y_P) and has been determined by the FAO for several crops (FAO 1979). To facilitate this analysis, the rate of evapotranspiration is considered to be zero.

For domestic water consumption, if w_{1t} is defined as actual water consumption, $c_1(w_{1t})$ as the cost associated with the supply of that water, w_o as the potential water consumption for a given level of income, p_o as the maximum tariff of water charged at full use, and e as the price elasticity of water demand, then the returns on water use for domestic purposes in year t with a specific water allocation are given by

$$R_{1t} = w_o \cdot p_o/(1+e^{-1})[(w_{1t}/w_o)^{1/e} + 2/e+1] - w_{1t} \cdot c_1(w_{1t})$$

Similarly, if w_{2t} is the production generated in year t with a new water allocation, the returns in year t would be given by

$$R_{2t} = w_o \cdot p_o/(1+e^{-1})[(w_{2t}/w_o)^{1/e} + (0.743 - 1/(1+e^{-1}))] - w_{2t} \cdot c_2(w_{2t}) - c_{2t}$$

where w_{2t} is the new level of water consumption, $c_2(w_{2t})$ the cost associated with the supply of that new level of water, and c_{2t} the cost of reallocating the water (additional investments, if any; maintenance costs of bringing the water to a new location, etc.). As for the industrial and agricultural sectors, the net benefit obtained by adopting a new water allocation in any given period would be given by

$$NB = R_{2t} - R_{1t}$$

where t = 1,2…T.

Another way to measure the different productive uses of water is to calculate water's value added in each sector (Bakker 1999). This value added is also known as the productivity factor of water and is defined as

$$VA_{1t} = R_{1t}/w_{1t}$$

where w_{1t} is the volume of water. Losses and benefits in different periods are discounted back to the current period and set against each other. If r is the discount rate, then the net benefit, in present-value terms, of reallocating water to an alternative use is given by

$$\text{NPV} = \sum_{t=0}^{T} \frac{(R_{2t} - R_{1t})}{(1+r)^t}$$

Implementing a new water allocation will be profitable if NPV > 0. If new investments are required to implement the new water allocation, the net benefit is likely to be negative for the period in which the investment is made. Several years could pass before the new water allocation becomes more profitable than the previous one. In that case, additional time would be required before the cumulative benefits of the new water allocation are sufficiently high to pay back the initial investment. If the investment required is quite substantial, repayment of the investment might not occur, and implementing the new water allocation would thus be economically profitable for a particular country or area.

The NPV is the criterion most commonly used to judge the profitability of alternative investments, but other criteria can also provide good insights. For example, the internal rate of return (IRR) is the discount rate under which the NPV is equal to zero or (in other words) the discount rate is such that:

$$\sum_{t=0}^{T} \frac{(R_{2t} - R_{1t})}{(1+i)^t} = 0$$

This measure is most useful when the discount rate to be used cannot be established easily (as is commonly the case).

It is also often useful to know the number of years before the initial investment is repaid, that is, the smallest number of years such that

$$\sum_{t=0}^{T} \frac{(R_{2t} - R_{1t})}{(1+i)^t} \geq 0$$

This measure is particularly useful when the planning horizon of policy or decision makers is restricted or uncertain.

Cost-benefit analysis does not usually provide any optimization, and because options are usually considered in pairs, there is no guarantee that other unexamined options may not be preferable to both options examined. However, the method's usefulness lies in the fact that it facilitates comparison of numerous alternative water allocations, so that the most profitable alternative may be chosen. Furthermore, because cost-benefit analysis is a widely used technique, the results of calculations are simple to communicate to policy makers. The calculations are easily carried out in a spreadsheet programme, which has the added advantage of allowing a sensitivity analysis.

For cost-benefit analysis to take place, the consequences of alternative water allocations on the outputs and quantities of water consumed in different sectors must be quantified. Water use is sensitive to economic factors such as prices and incomes (in the case of domestic water demand), and to prices and output levels (in the cases of commercial, industrial and agricultural water demand) (Renzetti 2000). To analyse water allocation in the agricultural and industrial sectors, the data required will be aggregate production values; the quantities of water consumed by sector; and costs, which can be obtained from World Bank and ESCWA data. Other data, such as the price elasticity of water demand, can be put together from secondary sources (Ringler 2001, FWR 2001, Manwaring 1998).

Annex II

ADDITIONAL DATA RELATING TO WATER AND THE AGRICULTURAL SECTOR IN EGYPT

TABLE 1. PROPOSED CROPPING PATTERN

Crop	Area (in thousand feddans)		
	2007	2012	2017
Long berseem	1 750	1 900	2 000
Short berseem	875	875	900
Wheat	2 700	2 850	3 500
Barley	350	400	400
Beans	380	420	450
Lentils	35	60	75
Fenugreek	50	60	75
Chickpeas and lupins	50	60	75
Flax	50	60	75
Onions	90	125	150
Garlic	50	60	70
Sugar-beet	100	125	300
Vegetables	550	650	800
Medicinal plants	90	160	200
Others	15	20	25
Winter total	7 135	7 825	9 095
Cotton	1 000	1 000	1 000
Maize (S+N)	2 400	2 750	3 150
Sorghum (S+N)	420	450	500
Rice (S+N)	1 000	1 000	1 000
Groundnuts	200	250	300
Sesame	150	200	300
Soya beans	150	200	300
Sunflower	150	200	300
Yellow maize (S+N)	200	250	300
Green fodder (S+N)	550	650	850
Vegetables (S+N)	1 300	1 600	2 500
Others (S+N)	225	250	300
Summer total	7 745	8 800	10 800
Sugar-cane	290	290	290
Fruit	1 250	1 400	1 650
Alfalfa	55	60	65
Total perennial crops	1 595	1 750	2 005
Total cultivated area	8 855	9 700	11 200
Total cropped area	16 475	18 375	21 900
Cropping intensity	1.86	1.89	1.96

TABLE 2. SHARE OF AGRICULTURE IN EGYPT'S ECONOMY

	1980	1985	1990	1998	1999
Share of agriculture in GDP (%)	25.4	19.3	19.9	17.0	16.2
Share of agriculture in export (%)	22.5	17.7	20.3	12.0	***
Share of agriculture in employment (%)	37.9	37.5	34.2	30.0	30.0

Source: Ministry for Agriculture and Land Reclamation, statistical report.

*** not available.

خلاصة تنفيذية

مقدمة

ازداد استهلاك المياه في العالم عشرة أضعاف خلال القرن المنصرم، ويستعمل حالياً ٣٥ في المائة من الموارد المائية، مقابل ٥ في المائة فقط في أوائل القرن المذكور. ويتزامن تزايد الطلب مع نقص هائل في المياه، وخاصة في المناطق الجافة، أدى إلى تفاقم الخلافات بين المنتفعين ولا سيما في الاستعمالات الرئيسية الثلاثة: الزراعية والصناعية والمنزلية. فقطاع الزراعة هو المستهلك الأكبر للموارد المائية في العالم حيث يبلغ استهلاكه ٧٠ في المائة من المياه المتوفرة للفرد، والقطاع الصناعي يستهلك نحو ١٩ في المائة والاستهلاك المنزلي نحو ٩ في المائة فقط.

وليست ندرة المياه وحدها سبب هذه الخلافات، بل عدم قدرة المجتمعات على التوصل إلى توزيع متوازن وكفوء للمياه بين مختلف القطاعات، لا سيما وان قطاع الزراعة، المستهلك الأكبر للمياه، ذو قيمة اقتصادية متدنية إذا قورن بالقطاعين الصناعي والمنزلي.

ألف- الأسباب الموجبة للدراسة

تضمّ منطقة الإسكوا موارد مائية مشتركة مع العديد من الدول، ولذلك كان لا بد من العمل على إيجاد حلول للخلافات التي قد تنشب حول هذه الموارد. فعدد السكان في المنطقة يتزايد باطراد، ويتوقع أن تبلغ نسبة التزايد ٤٠ إلى ٥٠ في المائة في العقدين المقبلين؛ ومكونات الطلب على المياه تشهد تغيّرات سببها تسارع النزوح نحو المدن وارتفاع مستوى المعيشة ونمو الصناعة. وسيؤدي ذلك إلى تفاقم الخلافات الإقليمية حول الأحقية في المياه، فضلاً عن الخلافات بين القطاعات حول الحصص المتاحة لكل منها.

وإضافة إلى ما سبق، يحتم الاستهلاك المتزايد للمياه وشحها وتردّي نوعيتها تغييراً جذرياً في نظرة المعنيين إلى كيفية توزيع المياه والتخطيط لها وإدارتها ووضع سياسات لتنظيمها وتدبيرها وتوزيعها بطريقة متكاملة بغية تحقيق الفائدة القصوى للمجتمع بأسره.

باء- الأهداف والمنهجية المعتمدة

تستهدف هذه الدراسة عرض المبادئ المتعلقة بتحصيص المياه بين مختلف القطاعات مع التركيز على منطقة الإسكوا، وتوفير مفاهيم لدعم صانعي القرار في إدارة التناقص في الموارد واتخاذ التدابير اللازمة لإعادة تحصيص المياه بين مختلف القطاعات.

وتحقيقاً لهذه الغاية، تتوخى الدراسة تقدير الآثار الاقتصادية والاجتماعية للجفاف وبالتالي تحليل الفوائد الاقتصادية لإعادة توزيع المياه بين القطاعات، وذلك ببحث الطرق واقتراح الاستراتيجيات لإعادة تحصيص المياه المتضائلة على القطاعات المتنافسة، بحيث تخفض الكميات المخصّصة للزراعة وتخصّص لغيرها من القطاعات، وهذا يستوجب زيادة الكفاءة في الزراعة باعتماد الأساليب الحديثة والزراعات البديلة. وتتضمن الدراسة عرضاً لسياسات الإدارة المائية وتحليلاً لأوضاع توزيع المياه بين القطاعات الثلاثة على المستوى الإقليمي، كما تتضمن دراسات حالة لبلدان مختارة من منطقة الإسكوا.

وتقع الدراسة في خمسة فصول إضافة إلى مقدمة تعرض الأسباب الموجبة للدراسة وأهدافها؛ والفصل الأول يتضمن صورة عامة عن أوضاع المياه في منطقة الإسكوا ومبادئ تحصيصها بين القطاعات وتأثير ذلك على النواحي الاقتصادية والاجتماعية؛ والفصل الثاني يتناول آليات توزيع المياه بين القطاعات الثلاثة والتدابير المقترحة لتحسينها؛ والفصل الثالث يتضمن أمثلة عن نماذج عددية استعملت في تحليل عملية توزيع المياه ودراسة نسبة الربح إلى الكلفة؛ والفصل الرابع يتناول سياسات توزيع المياه على القطاعات في بعض بلدان الإسكوا، ولا سيما تجربتي مصر والأردن؛ والفصل الخامس يتضمن توصيات بشأن كيفية إيجاد البيئة المناسبة للتطبيق العملي والتحليل الاقتصادي تحقيقاً للاستفادة المثلى من المياه في عالم أفضل.

أولاً- أوضاع المياه في منطقة الإسكوا

كميات المياه العذبة محدودة في العالم، وشحيحة جداً في منطقة الإسكوا، حيث الطبيعة تتراوح بين جافة وشبه جافة، ولا تتجاوز حصة الفرد السنوية من المياه في بعض البلدان ٢٠٠م[٣]. ويتزامن تزايد الشح في المياه مع تزايد في الطلب عليها. فبينما تضم بلدان الشمال من المنطقة مياه متجددة في الينابيع والأنهار بسبب الأمطار الغزيرة نسبياً، تشهد بلدان الجنوب شحاً وبيئة صحراوية، لا أنهار فيها ولا ينابيع، وتعتمد على حصاد الأمطار والمياه الجوفية، وخاصة الأحفورية منها، وكذلك على تحلية مياه البحر.

والقطاع الزراعي هو المستهلك الأكبر للمياه في منطقة الإسكوا حيث يستهلك ٨٣ في المائة من المياه المتجددة بينما تبلغ حصة القطاع الصناعي ٩ في المائة والقطاع المنزلي ٨ في المائة. ومن المرتقب أن تنخفض حصة الزراعة من المياه بسبب الشح وضرورة تحويلها لسد حاجات القطاعات الأخرى الآخذة بالتزايد. ففي عام ٢٠٢٥ يرتقب أن تبلغ حصة القطاع المنزلي ١٢ في المائة، وحصة القطاع الصناعي ١٠ في المائة، ومعنى ذلك أن فروق هذه الكميات ستستقطع من حصة القطاع الزراعي.

وفي عام ٢٠٠٣، بلغ مجموع سكان منطقة الإسكوا ١٨٠ مليون نسمة، بمعدل نمو قدره ٢,٦ في المائة بين عامي ١٩٩٠ و٢٠٠٠، مقارنة بـ ١,٤ في المائة في العالم. ومعدل النمو تراوح بين ٤,٣ في المائة في اليمن و ١,٨ في المائة في مصر، وبحلول عام ٢٠٢٥ سيصل عدد السكان في المنطقة إلى ٢٩٠ مليون نسمة.

وسيترتب على النمو السكاني ضغط على الموارد المائية الضئيلة سيشتد مع تحسن ظروف المعيشة. وبسبب هذا التزايد السكاني في العقود المقبلة، والنزوح نحو المدن، ونمو المدن، والنمو الصناعي، سيزداد الطلب على الموارد المائية لسد حاجات القطاع المنزلي. وفي هذا السياق، ستشكل المنافسة على المياه بين القطاعين المنزلي والزراعي التحدي الأكبر الذي يستلزم تعزيز فعالية الآليات التنظيمية والتشغيلية لإعادة توزيع المياه بين مختلف القطاعات مع الحفاظ على نوعيتها ومعالجتها إذا لزم الأمر. ولذلك من الضروري تحقيق التكامل بين مختلف أوجه الاستخدامات داخل كل قطاع على حدة وبين القطاعات المختلفة.

ثانياً- توزيع المياه بين القطاعات المختلفة وتأثيراتها

ألف- أهمية توزيع المياه بين القطاعات المختلفة

يساعد الاستعمال الأمثل للموارد المائية في الحفاظ عليها، وذلك عن طريق تخفيف الهدر في الاستعمال المنزلي والزراعي، أو تشجيع الزراعة التي تعتمد على الأمطار أو المزروعات الأقل نهماً للمياه،

أو الريّ بالمياه المالحة، أو باستعمال التجهيزات المائية المنزلية التي تقتصد في المياه. وسيساعد اعتماد سوق لتخصيص المياه وتوزيعها بين الاستعمالات المتنافسة على تحسين الأوضاع. وهذه السوق تتيح تحويل المياه من الاستعمالات ذات القيمة المتدنية إلى الاستعمالات ذات القيمة المرتفعة، وكذلك بتحويل استعمال أو ملكية المياه. وهكذا تتيح آلية السوق تأمين المياه للاستعمالات ذات القيمة المرتفعة، دون الحاجة إلى موارد جديدة ومكلفة، بل إلى إطار قانوني وتنظيمي مناسب للتطبيق.

باء- سياسات توزيع المياه بين القطاعات

تستهدف صياغة سياسات توزيع المياه بين القطاعات تنظيم التنافس على الطلب بين الحاجات الزراعية والصناعية والمنزلية. ويطرح خفض مخصصات القطاع الزراعي مشكلة تحسين الإنتاج وتخفيض كمية المياه اللازمة إلى الحد الأدنى مع الآلية التي يتطلبها ذلك. وتحدّد سياسات التوزيع كيفية تحصيص المياه بين الحاجات المتنافسة، والتي يمكن تعديلها لتتناسب مع فترات الغزارة وفترات الشح. فمن الضروري أن تعتمد الدول التي تعاني من الجفاف استراتيجيات تتضمن طرائق لتحسين إدارة المياه واعتماد زراعات لا تتأثر كثيراً بتفاوت كميات المياه، وتستهدف إنماء قطاعات لا تتأثر كثيراً بالمياه، واتخاذ تدابير لتخزين المياه وحصاد الأمطار حينما يتسنى ذلك. وينبغي أن تتماشى هذه الاستراتيجيات مع الأطر التنظيمية والقانونية وتراعي أوضاع البنى الأساسية. ويمكن اتباع إحدى سياستين، إما سياسة تأمين الموارد وإما سياسة إدارة الطلب مع اتخاذ تدابير المراقبة، وفي أكثر الأحيان تكون الموازنة بين السياستين هي الحل الأمثل.

وترتكز سياسة توزيع المياه بين القطاعات على مبدأين أساسيين هما الكفاءة الاقتصادية من جهة والعدالة الاجتماعية من جهة أخرى. فمن الضروري أن تدخل الدولة سياسات وآليات توزيع مناسبة تعتمد على اللامركزية والتشجيع على الخصخصة، والإدارة، والحث على استعمال عدادات المياه مع تأمين المياه للمستهلكين. والسياسة الضريبية والاستثمارات تستهدف تحقيق الفعاليّة في الاستعمال، ويصار إلى إعادة تنظيم هيكل التعريفة في عدد من بلدان الإسكوا. فمنح الدعم الحكومي يساهم في تخفيف كميات المياه المستهلكة، وخاصة في الريّ، وتطبيق الحوافز البيئية، وذلك بدعم من يحافظ على المياه ويستعمل تقنيات إعادة الاستعمال، وتغريم من يلوثها.

جيم- آليات توزيع المياه بين القطاعات المختلفة

من الضروري استعمال الوسائل التي تؤدي إلى التوزيع الأمثل للمياه بين مختلف القطاعات، وخاصة في حال ندرة المياه. وهذه الوسائل يجب أن تتمتع بالمرونة لتعديل الاستعمال عند الحاجة، وأن تضمن الأمان والعدالة الاجتماعية، وأن تكون مقبولة سياسيا وشعبياً.

وتحديد أسعار المياه أو التعريفات من الوسائل التي تؤدي إلى التوزيع الأمثل للمياه بين القطاعات، فضلاً عن تشجيع الاستعمال الأجدى. وطريقة تحديد الأسعار تكون في فرض تعريفة حسب الكمية المستهلكة، سواء أكان في القطاع الزراعي أم الصناعي أم المنزلي أم عند استعمال المياه الجوفية.

ولكل آلية من آليات التوزيع حسناتها وسيئاتها: فالإنتاجية هدف مهمّ، لكن آلية تحقيقها صعبة التطبيق، وتتطلب أنظمة مكلفة للمراقبة والتنفيذ. ولذلك يستحسن حلّ قضايا الحقوق على المياه واللامركزية في الاستفادة من المياه بواسطة مؤسسات مستقلة للمياه المنزلية، وجمعيات المزارعين المستهلكين. فإدارة المزارعين لمنظومة الري تعتبر خير مثال على توزيع العائد للمستهلك، وتتطلب تعاونا وتنسيقا بين مؤسسات

أو جمعيات المستهلكين والإدارة لاتخاذ القرارات. وهذه الجمعيات قادرة على المطالبة بزيادة كميات الميـاه لتوزيعها بين المستهلكين.

وكلفة الحصول على المعلومات، وتحضير الاتفاقات والعقود وإجراء المراقبة، ووضع العقـود قيـد التنفيذ آلية تعتمد في أي عملية توزيع للمياه بين القطاعات المختلفة، بحيث تستعمل الأذونـات والتـراخيص لمراقبة الكميات المسحوبة من المياه، وتغريم من يعمد إلى تلويثها. وهذه الأذونات والتراخيص استُعملت في منطقة الإسكوا في حالة المياه الجوفية.

وطبقت آليات توزيع المياه بين مختلف القطاعات كليا أو جزئياً في مناطق عدة وقطاعـات مختلفـة على مستوى العالم. ومن الأمثلة على ذلك:

(أ) التوزيع عن طريق الإدارة العامة الذي طُبق في الولايات المتحدة الأمريكية واحتاج في بعض الأحيان إلى الدعم؛

(ب) سوق المياه طبقت في تشيلي حيث اعتبرت الحقوق على المياه مستقلة عـن الأرض وبالتـالي يمكن تأجيرها، وفي الولايات المتحدة الأمريكية حيث نقلت المياه من القطاع الزراعي في شمال كاليفورنيـا إلى القطاع المنزلي والزراعي في جنوب كاليفورنيا مع استيفاء بعض الشروط البيئية. وكان لـذلك تـأثير اقتصادي جيد على المناطق التي أخذت المياه، وأضرار، منها مشكلة البطالة، على المناطق التي تنازلت عن مياهها؛

(ج) أنظمة توزيع مختلطة طبقت في الأردن واليمن لمعالجة انخفـاض مسـتوى الميـاه الجوفيـة واستنزافها؛

(د) التوزيع القائم على الاستهلاك طبق في إندونيسيا والبرتغال ومصر في مجـال الـريّ بهـدف تحقيق التوزيع العادل بين المزارعين.

ثالثاً- الطرق التحليلية لتوزيع المياه بين القطاعات

ألف- عرض لبعض النماذج المعتمدة لتوزيع المياه بين القطاعات

تعتمد نماذج عديدة رياضية لتحديد الطريقة المثلى لتوزيع الموارد المائية بحيث تسد الحاجات، ومـن هذه النماذج: نموذج يؤدي إلى إنجاز عمليات معينة هدفها الحصول على المردود الأعلى في القطاع الزراعي وتخفيف الاستثمارات اللازمة في المنشآت والنقل وكلفة التشغيل والصيانة، ونموذج زراعي اقتصادي يحـدد افضل الزراعات لترشيد استخدام المياه.

وبعض هذه النماذج خطية تحدّد سلسلة من الأنشطة التي تؤدي إلى الربح الأكبر ويمكن تنفيذها ضمن مجموعة من القيود وبتحليل نسبة الربح إلى الكلفة؛ وبعضها اقتصادية هيدرولوجية متكاملـة تشـمل مسـحاً للنظام بأكمله ودمجاً للأوضاع الاقتصادية والهيدرولوجية، وجمع الطلبات من كافة القطاعات المستعملة للمياه وإمكانية تقدير الأرباح والكلفة لكل من الاستعمالات. وهذه نماذج معقدة وتتطلب الكثيـر مـن المعلومـات والبرامج الإحصائية المعقدة، وتستغرق الكثير من الوقت.

وفي الدراسة الحالية استُخدم التحليل المتكامل باعتباره حلاً لتوزيع المياه بـين مختلـف القطاعـات المتنافسة. فهذا التحليل يعطي صورة أقرب إلى الحقيقة وأنسب لتحديد فائدة أكبر عدد من السكان ولتوزيـع الفوائد المذكورة بين مختلف القطاعات نتيجة لتوزيع المياه فيما بينها، وكذلك يحدد المردود الاقتصادي الناتج من هذا التوزيع. والهدف هو مقارنة قيمة الكلفة بقيمة الأرباح التي ستحقق إذا بقي الوضـع علـى حالـه، وإجراء المقارنة ذاتها إذا أعيد تحصيص كمية من المياه بين القطاعات.

وتستعمل المعطيات في تحليل كمية المياه المستعملة في كل قطاع والكلفة اللازمة لتزويد قطاع معين بالكمية المخصصة له والإيرادات التي يحققها، وذلك باحتساب القيمة الثابتة التي تقدر وفقًا للنسب السائدة في الأسواق المحلية، ويدرس تحليل نسبة الربح إلى الكلفة على مستوى التوريد والطلب للبلد بأسره، ويأتي الحل بالتوزيع الأمثل للمياه ويحدد هذا التوزيع بين القطاعات على ضوء قيمة المياه الاقتصادية فـي اسـتعمالاتها المختلفة.

باء- تحليل نسبة الربح إلى الكلفة في بعض بلدان الإسكوا

لتحليل نسبة الربح إلى الكلفة وضعت تقديرات للإيرادات والأرباح التي تنتج من إعـادة تحصـيص المياه بين القطاعات المختلفة. وافتُرض تثبيت هذه الحصص على مدى ٢٠ عاماً لتقدير مردود التحصـيص المذكور، وافترض أن الإيرادات ستزداد بنسبة ضئيلة بينما يعاد توزيع المياه بين القطاعات، وبعد ذلك يجري تحفيز النمو الاقتصادي من خلال استثمارات جديدة سترفع الإيرادات.

وأسفر عن دراسة الوضع في الأردن ومصر ما يلي:

(أ) في الأردن انخفضت الإيرادات في البدء على أثر انخفاض كمية المياه والتوظيفات المالية فـي قطاع الزراعة. واعتباراً من العام التالي، تسارع ارتفاع العائدات، بحيث قدرت نسـبة المـردود الـداخلي بـ ١٥,٣ في المائة في السنة السادسة عشرة، وفي مصر حيث تكاد كلفة المياه تكون منعدمة، ستكون نسبة المردود الداخلي نحو ٥,٨ في المائة ولن يحصل استرداد الاستثمارات قبل السنة الثالثة عشرة، بسبب الإنتاج الكبير لزراعات متدنية القيمة نسبياً؛

(ب) إعادة تخصيص المياه للاستعمال المنزلي سوف يفيد المستهلكين في الأردن، وستصـل نسـبة المردود الداخلي إلى نحو ١٩,٣ في المائة، ويمكن استرداد التوظيفات في السنة السابعة، بينما في مصر لـن تعطي المياه المعاد توزيعها وتخصيصها لقطاع الشرب بعد أخذها من قطاعي الري والصـناعة أيـة نتـائج لانعدام البدائل؛

(ج) في الأردن يعطي نقل المياه من الزراعة إلى الصناعة نتائج إيجابية، ويمكـن توقـع مـردود بحدود ١٧,٥ في المائة واستعادة رأس المال في نهاية العشر سنوات، وفي مصر سيحدث نقل كميـات ولـو بسيطة من الصناعة إلى القطاع المنزلي آثاراً سلبية في السنوات الأولى على إنتاجية قطاع الصـناعة وفـي السنة العشرين ستستعاد الكلفة مع نسبة مردود داخلي قدره ١٥,٢ في المائة؛

(د) تبين النتائج أن مياه الاستعمال المنزلي والاستعمال الصناعي أعلى قيمة من تلك المستعملة في الزراعة، ولكن من الضروري مراعاة أن القيمة المالية ليست العامل الوحيد بل هناك عوامل أخـرى منهـا: عدد الأفراد الذين يتأثرون بهذا التخصيص والتأثير على غيره من الأنشطة (كالزراعة والبيئة الخ...).

وهناك حل آخر وهو تخصيص المياه للقطاع الأكثر إنتاجية ومن ثم توزيع الأرباح على من تضرروا من ذلك. ولكن هذا يعني اعتماد إدارة ومراقبة شديدتين وتحقيق ربح كافٍ لتوزيعه بين الرابحين والخاسرين.

رابعاً- سياسات توزيع المياه حسب القطاعات في بعض بلدان الإسكوا

تختلف سياسة توزيع المياه بين القطاعات من بلد إلى آخر تبعاً لهيكلها الجغرافي والاجتماعي والسياسي والقانوني. وفيما يلي عرض لبعض سياسات توزيع المياه في بلدان مختارة من منطقة الإسكوا.

ألف- مصر

تشكل مصر ٤٠ في المائة من المساحة الإجمالية لبلدان الإسكوا، ويرتقب أن يصل عدد سكانها إلى ٨٦ مليون نسمة في عام ٢٠٢٥، وتضم مياه سطحية ومياه جوفية. وتعطي استراتيجيات إدارة الموارد المائية الأفضلية للمياه المنزلية ولكن ستحتاج كافة القطاعات إلى مزيد من المياه في المستقبل. ووضعت وزارة الإسكان والبلديات نظام تعريفات جيد للمياه المنزلية يساعد ذوي الدخل المتدني، بينما تفرض تعريفات عالية على قطاع السياحة، وتتجه سياسة الدولة إلى ضبط ري الزراعات التي تحتاج إلى كميات كبيرة من المياه، وزيادة استصلاح الأراضي، واعتماد تقنيات ري أكثر توفيراً للمياه، وتجري حالياً دراسة تعريفات جديدة لمياه الري.

ولما كانت مياه الري تؤدي دوراً هاماً في معرفة جدوى الاستثمارات وفي تحديد سياسة التعريفات، اتخذت الدولة إجراءات مختلفة تتجه نحو إدارة الطلب لتحسين مشاريع الري. ومن هذه الإجراءات التدابير الفنية والإدارية والتعاونية مع جمعيات المزارعين المستهلكين للمياه التي جرى دعمها مالياً من الموازنة العامّة أو من قروض أو منح خارجية. وقد وُضع نموذج رياضي لدراسة استعادة كلفة التشغيل مع تحديد ما يجب تغييره من النواحي الإدارية والتنظيمية.

كما درست الدولة التدابير التي يجب اتباعها في حالات الجفاف علماً بأن بحيرة ناصر خلف السد العالي في أسوان ساهمت في التغلب على سنوات الجفاف باستخدام المخزون المائي. ووضعت الدولة خطة لاستصلاح الأراضي مستفيدة من المياه التي يمكن توفيرها باستخدام تقنيات الري الحديثة وإعادة استعمال المياه العادمة واستعمال المياه الجوفية في الوادي الجديد. وتحث السياسات التي أقرت على اتخاذ بعض التدابير، ومنها تخفيف زراعة الأرزّ، واللجوء إلى زراعات بديلة، وتقدير كمية المياه اللازمة للأنواع الزراعية المختلفة.

والإستراتيجيات المقترحة للتوصل إلى الاستعمال الأمثل للمياه المتوفرة هي: تخفيف الهدر، وتحسين الري، واستعادة الكلفة، وإعداد وتنفيذ خطط لتنمية المياه الجوفية، وتعديل أنواع الزراعات، وإعادة تدوير مياه الصرف الزراعية، وإعادة استعمال مياه الصرف الصحي بعد معالجتها، وقد اتخذت وزارة الموارد المائية والري سلسلة من القرارات لدرء آثار الجفاف.

باء- الأردن

يجمع توزيع المياه في الأردن على قطاعات الاستهلاك المختلفة بين مبدأي الاقتصاد والعدالة الاجتماعية. وعند البحث في ندرة المياه هناك من ينادي دائماً بضرورة تحسين توزيعها بين مختلف القطاعات.

وشددت استراتيجية الدولة على حماية الموارد من التلوث وتردي النوعية والاستنزاف، وركزت على ضرورة العمل على منع الهدر، والتوصل إلى درجات عالية من الفعالية في استعمال المياه، واعتماد طريقة إدارة الموارد بالتوازي مع إدارة الطلب مع ضرورة تغيير أنواع الزراعات واعتماد تلك التي تتمتع بقيمة عالية وقابلية للتصدير. وفي هذا السياق، وضعت الدولة أربع سياسات مائية هي: السياسة المعنية بإدارة المياه الجوفية؛ والسياسة المعنية بالري؛ والسياسة المعنية بإدارة الصرف الصحي؛ والسياسة المعنية بمؤسسات المياه. وكان قطاع الري أول القطاعات التي استفادت من الإصلاح الاقتصادي والخصخصة باعتباره مدعوماً من الدولة.

وقد وضع نموذج برنامج خطي لوادي الأردن حيث العوامل المتغيّرة التي تؤثر على القرارات هي المساحات والأساليب التي تصنف كل نوع من الزراعات حسب كميات المياه التي تحتاج إليها.

وشكلت لجنة السياسة المائية في وزارة المياه والري لتكون أداة تنفيذية، وعُقد اتفاق بين وزارتي المياه والري والزراعة على الاستعمال المستدام للموارد، وعلى إدارة مياه الري ونوعيتها. أما الأسعار والتعريفات واستعادة الكلفة، فهي مسؤولية سلطة وادي الأردن بينما تقتصر مهمة وزارة الزراعة على الترشيد والبحث فقط. وتصنف وزارة المياه والري تعريفات الري بأقل من تعريفات مياه الشرب والمياه الصناعية. وبذلت الوزارة جهداً لإنشاء نظام تعريفة يؤمن جزئيا كلفة التشغيل والصيانة ويشجّع الاستعمال الفعال للمياه، فضلا عن أنه يغطي العجز الناتج من سياسة الأسعار المتدنية لمياه الري من قطاع الري ذاته وغيره من شرائح المجتمع. ومؤخراً عُدلت تركيبة الحكومة بحيث دمجت وزارة المياه والري مع وزارة الزراعة.

جيم- أوضاع المياه في بلدان أخرى أعضاء في الإسكوا

في الأمثلة الثلاثة الآتية تُعرض كيفية العمل على توفير المياه وتقليل حصة الري من تلك المياه، كما يُعرض التحسين الذي أنجزته تلك البلدان في إدارة الموارد المائية ووسائل الري.

١- <u>الجمهورية العربية السورية</u>

تعتمد الزراعة في الجمهورية العربية السورية على المياه السطحية والجوفية على حدّ سواء، ويستقي القطاعان الباقيان مياههما من الطبقات الجوفية. ويشتد التنافس على المياه بين القطاعات، يؤججه التزايد السكاني الكبير.

فالزراعة حالياً تستهلك ٨٥ في المائة من المياه المستهلكة بينما يتوقع أن تزداد الحاجة إلى المياه ثلاثة أضعاف، والطلب على المياه ازداد بنسبة تسعة أضعاف في الثمانينات، فأدّى إلى انخفاض مستوى المياه الجوفية في أكثر من حوض (دمشق والعاصي وحلب).

وإزاء هذا الوضع، وضعت الحكومة برامج محكمة لمراقبة استثمار المياه الجوفية والسطحية، وجعلت في أولوياتها إدارة أكثر فعالية لأنظمة الري، وإدخال تقنيات الحفاظ على المياه في المزارع وفي مشاريعها الكبرى على السواء، وإعادة استعمال مياه الصرف الصحي، وحصاد المياه، وتخفيف الهدر، بما يؤدي إلى استدامة المياه وإعادة توزيعها بين القطاعات المختلفة.

٢- المملكة العربية السعودية

اتخذت المملكة العربية السعودية مجموعة من التدابير للحفاظ على المياه الجوفية غير المتجدّدة، وتأمين التوازن بين استهلاكات مختلف القطاعات، واعتمدت سياسة ركزت على الأمن الغذائي ووضعت تدابير قيد التنفيذ منها تلك التي تعنى بمراقبة الاستهلاك ومنع الهدر وتنظيم حملات إعلامية لترشيد استخدام المياه، وتوعية المواطنين.

وساهم القطاع الخاص في تنفيذ مختلف المشاريع المائية في مجالات التشغيل والصيانة والتمويل والإدارة لتحسين الإنتاجية الاقتصادية. كما خططت الدولة لسياسات تساعد في اعتماد تقنيات حديثة في الري، وتحديد حاجات أنواع الزراعات من المياه، وتوزيع المياه بين القطاعات المختلفة، ومراقبة الاستهلاك ووضع تعريفات، والتوعية بفوائد حماية الموارد المائية والحفاظ عليها.

٣- اليمن

سيزداد الطلب على المياه في اليمن بسبب النمو السكاني الكبير، وتوسيع رقعة الأراضي الزراعية، والنمو الصناعي السريع. وقد بلغ الوضع مستويات مقلقة لا يمكن تجاوزها بدون ترشيد استعمال المياه، واعتماد إدارة سليمة وسياسة إنمائية مدروسة. وتستهلك الزراعة أكثر من ٩٠ في المائة من المياه المستعملة بأساليب ري غير فعالة. وهناك منافسة قوية بين مختلف المستهلكين للمياه تستلزم عملاً على توزيع أفضل للمياه بين القطاعات.

ووضعت الدولة برنامجاً لمعالجة مشاكل الاستنزاف الجائر للمياه والنقص في الإدارة بواسطة تدابير الحماية والتوزيع بين القطاعات. واتخذ القيّمون على البرنامج سلسلة من التدابير العامة والخاصة التي تضمن الإنماء الاقتصادي والاجتماعي، وذلك ضمن برنامج متكامل لإدارة الموارد المائية على الصعيدين الوطني والمحلي.

خامساً- الخلاصة والتوصيات

ستواجه بلدان الإسكوا عجزاً شديداً في مخزونها المائي لعام ٢٠٢٥، يتطلب منها عملاً على زيادة الموارد من جهة وتحسين إدارة الطلب من جهة أخرى. وحسن توزيع المياه بين مختلف القطاعات يعتبر الوسيلة الأساسية لمواجهة الضغوط الناشئة على المياه، ولن يكون هذا التوزيع ممكناً إذا لم تجسد التعريفات والأسعار الكلفة الحقيقية لتأمين المياه.

والهدف من توزيع المياه بين القطاعات هو استعمال المياه بطريقة تتيح الحفاظ على نوعيتها ومراعاة الإنماء الاقتصادي، والظروف البيئية، والعدالة الاجتماعية في كافة استخدامات المياه للشرب والصناعة

والزراعة والسياحة والأنشطة الترفيهية. والواقع يختلف بين بلد وآخر حسب الأوضاع الطبيعية والاجتماعية والاقتصادية والسياسية.

وفي بلدان الإسكوا سياسات مختلفة لإعادة توزيع المياه بين القطاعات، منها الكلفة الحدية، والتوزيع المفروض عن طريق السلطات العامة، أو المستهلكين أو وفقاً لمتطلبات السوق. واقتصرت هذه السياسات على عدد قليل من الدول مع أنها تحفز المستهلك على البحث عن القيمة المثلى لاستعمال المورد المائي.

واستعمل التحليل الذي يعتمد مقارنة الربح بالكلفة بهدف تقييم الحلول المختلفة لمشروع معين، وطبقت نماذج رياضية هندسية لدراسة وتطبيق توزيع المياه بين القطاعات في بعض بلدان منطقة الإسكوا.

وبعد دراسة السياسات المتبعة في تلك البلدان يوصى بما يلي:

(أ) تقليص نسبة المساحات المروية إزاء انخفاض مردود القطاع الزراعي؛

(ب) تحويل الكميات التي لم يعد يستعملها القطاع الزراعي إلى القطاع الصناعي حيث المردود الأعلى بين القطاعات الاقتصادية، وسيساعد على تأمين فرص عمل جديدة، ويحدث بذلك تأثيراً إيجابياً على الصعيدين الاجتماعي والاقتصادي؛

(ج) الحرص على عدم الإضرار بمشاريع مياه الشرب؛

(د) التركيز في تطبيق السياسات الزراعية على تخفيف كمية المياه المخصصة للري، ورفع إنتاجية استعمالها، إضافة إلى تغيير أنواع الزراعات واعتماد التقنيات الحديثة في الري والحد من هدر المياه؛

(ه) الاهتمام بإعادة تدوير مياه الصرف الزراعي وإعادة استعمال مياه الصرف الصحي بعد معالجتها.