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LAND AND WATER POLICIES IN THE NEAR EAST REGION

Case-studies on Egypt, Jordan and Pakistan

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PART ONE

REGIONAL OVERVIEW*

Introduction

Water in the Near East is scarce in many of its countries, and rain-fed cultivation is almost limited to Turkey, the Fertile Crescent, northern portions of the Islamic Republic of Iran and Pakistan, the south-west corner of the Arabian Peninsula, and the north-west corner of Africa.[1] Cultivation elsewhere in the region is possible only through irrigated agriculture.

The strategic importance of water is evident in its indispensability for life and for development activities in practically all social and economic sectors. Shortages of municipal water have adverse impacts on public health and the environment, with high financial costs, and shortages of irrigation water have adverse economic, social and environmental impacts.

Irrigation accounts for about 80% of the water used region-wide, and the demand for municipal and industrial water already accounts for substantial percentages of the overall renewable water resources, and will further increase with time as the population levels escalate and the quality of life improves. Diversion of irrigation water to municipal uses has been customary in many countries of the region, especially when such waters are close to urban areas. Inter-basin transfers of water have also become customary, and high pumping heads in excess of 1,200 metres are not unusual. The cost of supplying municipal water to many urban areas has been rising, especially the energy component of such costs.

Major water resources in the region are shared between two countries or more. About 62% of the water resources of Arab countries flow from non-Arab countries. The most significant river basins are those of the Tigris, the Euphrates, the Orontes, the Jordan and the Nile, all of which have been the subject of contentious riparian issues. Agreements were made between Iraq and the Syrian Arab Republic (1990) on the Euphrates to share the flow of the river crossing the Syrian borders with Turkey. Agreements were also made between Jordan and the Syrian Arab Republic (1987) on the Yarmouk, a tributary of the Jordan River, but excluding the third riparian, Israel. Agreements were also made between Egypt and the Sudan (1957) on the Nile, but not including other riparians on the river. Large aquifers underlie the Middle East and North Africa, the majority of which store fossil water, and no agreements have been made to regulate water sharing and environmental protection of these aquifers.

Where water has been relatively abundant, individual sectors have developed and used surface and groundwater with little regard for impacts elsewhere. As demands increased, competition among the user sectors emerged and water quality deteriorated and affected other users and the environment.[2]

With the exception of Turkey, none of the countries of the region has been able to balance its exports and imports of food commodities, and they all ran agricultural trade deficits that ranged in 1989 between US$ 10.00 per capita for the Syrian Arab Republic to $757.00 per capita for the United Arab Emirates, with

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* The regional overview was prepared by Munther Haddadin, President of the Regional Office for Integrated Development, Amman. Mr. Haddadin was also responsible for the overall preparation of the present study. The views expressed in this study are those of the author and do not necessarily reflect the views of the United Nations Secretariat.

[1] For the purposes of this study, the term Near East includes Algeria, Bahrain, Egypt, Iraq, Islamic Republic of Iran, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Mauritania, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, Turkey, United Arab Emirates and Yemen.

[2] See *A Strategy for Managing Water in the Middle East and North Africa* (World Bank, 20 September 1993).

a region-wide average of $241.00. Irrigated agriculture accounts for a high percentage of the value of production.

Waterlogging and soil salinity have emerged as problems for the sustainability of irrigated agriculture, and have been caused by various factors. Land fragmentation, very small holdings, soil erosion, sloping terrains and overgrazing of natural pastures are problems contributing to the decrease in agricultural production and to the increase in the cost thereof.

The above regional overview suggests that the region will soon have to cope with difficult water and land issues dealing with supply management, demand management, conservation, protection and sustainability, and institutional, legal and riparian issues.

A. Land resources

The area of the Near East countries is about 16.2 million square kilometres, equivalent to 12.1% of the total area of the world's countries; the area had a population of about 448.5 million people in 1991, or about 8.7% of the world's population. The area of the Arab countries in the Near East is larger than Europe (138%), Australia (177%) or the United States of America (145%).

The vast majority of the lands in the region (93.1%) are arid deserts or *badia*, and a relatively small percentage (6.9% or 1.088 million square kilometres) of this is arable. This translates into an average per capita share of 0.2426 hectares (ha). More than half of the arable lands (55.1%) are located in three countries (Islamic Republic of Iran, Pakistan and Turkey), and the rest are located in 18 countries of the region. There are seven countries in the region where the ratio of arable lands to total area is less than 2%. This ratio is between 2% and 5% in five countries, between 5% and 9% in two countries, from 10% to 20% in three countries, 20% to 30% in three countries and is above 30% in only one country (Turkey).

Among all the countries of the region, there are only four with land areas under permanent cultivation exceeding 100,000 square kilometres (sq km) or 10 million ha. These countries are: Turkey (22.73 million ha), Pakistan (20.9 million ha), the Islamic Republic of Iran (14.84 million ha) and the Sudan (12.5 million ha) with a total of 70.97 million ha under permanent cultivation. This translates into respective per capita shares of 0.3967 ha, 0.1805 ha, 0.2572 ha, and 0.4826 in the four countries.

Horizontal expansion in agricultural production in the region has to come from irrigated agriculture, and there is room for improvement in agricultural yields from both rain-fed and irrigated agriculture.

The total irrigated land area in the Near East region is about 397,000 sq km or 39.7 million ha. This constitutes 2.54% of the total land area of the countries of the region. This percentage is slightly higher than the percentage in all developing countries (2.18%) and higher than the percentage in other country groups. This percentage is 1.22% in the Organization for Economic Cooperation and Development (OECD) member countries, 1.16% in all industrial countries, and 1.75% in all the countries in the world. The average percentage of irrigated land in the arable land in the region is 36.5%, which is high compared with the average of 20.63% for all developing countries, the average of the OECD countries which is 10.24%, the average for all industrial countries which is 9.40%, or the world average which is 15.5%. This shows the aridity of the countries of the region relative to the other country groups in the world.

Forest land in the Near East countries forms 7.45% of the total land area; this is slightly larger than the arable land area and is three times the irrigated land area. Three countries possess 73.7% of the forest

area in the region. These are: the Islamic Republic of Iran with 15.5%, the Sudan with 40.9% and Turkey with 17.3%.

Agricultural land resources per capita of the countries in the region are shown in table 1 below.

TABLE 1. AGRICULTURAL LAND RESOURCES, 1991
(in ha/capita)

Country	*Population*	*Irrigated*	*Rain-fed*	*Pastures*	*Sum*
Algeria	25.7	0.0134	0.2800	1.1829	0.3202
Bahrain	0.5	0.0020	0.0020	0.0080	0.0080
Egypt	53.6	0.0587	---	--	0.1761
Iraq	18.7	0.1357	0.1980	0.2139	0.6051
Islamic Republic of Iran	57.7	0.0997	0.1447	0.7626	0.4438
Jordan	4.1	0.0146	0.0920	0.1929	0.1358
Kuwait	2.1	0.0005	0.0014	0.0638	0.0029
Lebanon	2.8	0.0307	0.0764	0.0036	0.1685
Libyan Arab Jamahiriya	4.7	0.0502	0.3828	2.8298	0.5334
Mauritania	2.1	0.0057	0.0890	18.690	0.1061
Morocco	25.7	0.0486	0.2806	0.8132	0.4264
Oman	1.6	0.0256	0.0038	0.6250	0.0806
Pakistan	115.8	0.1354	0.0414	0.0432	0.4476
Qatar	0.4	-	0.0100	0.1250	0.0100
Saudi Arabia	15.4	0.0649	0.0494	5.5195	0.2441
Sudan	25.9	0.0718	0.4100	2.1622	0.6254
Syrian Arab Republic	12.5	0.056	0.4000	0.6585	0.5680
Tunisia	8.2	0.0317	0.5410	0.3720	0.6361
Turkey	57.3	0.0436	0.4423	0.1501	0.5731
United Arab Emirates	1.6	0.0013	0.0088	0.1250	0.0127
Yemen	12.5	0.0248	0.0970	1.2852	0.1714
TOTAL	448.9				

Source: FAO Production Yearbook, 1989; and World Development Report (World Bank, 1993).

Land policies

The underpinnings of land and water policies in a country are closely related to the Government's objectives in agricultural development. Increasing food security, reducing food import dependency, increasing foreign exchange earnings through increasing the exports of tradeable agricultural commodities, and raising rural incomes have all been important objectives in countries of the Arab region. Land and water policies have directly or indirectly revolved around these, often conflicting, objectives.

In the past, the *de facto* land policy in the Arab region was considered to be primarily commensurate with agrarian reform, complemented in a few countries by land reclamation and soil conservation. Water policies, at the same time, were synonymous with the expansion of irrigated areas, irrigation investment and construction of drainage networks.

Government interventions in the form of land reforms were implemented in many of the Arab countries in the past three decades. In many cases, lands appropriated by the Governments were redistributed to landless or small farmers. In others, Governments retained large tracts of land for agricultural production as State farms, as in Algeria, Egypt, Iraq and Yemen. Ceilings on ownership were fixed. In the Syrian Arab Republic, the Agrarian Reform of 1958 fixed the maximum size of ownership, which was reduced further in 1980. Tenurial arrangements were revised in some of the countries such as Egypt, the Syrian Arab Republic, Tunisia and Yemen, while in others cropping patterns were fixed, as in Egypt where it was compulsory under the law to devote 33% of the area to cotton and another 33% to wheat.[3]

Land tenure has an impact on the use of land through changes in the operational size of holdings. Tenancy in the region varies from 4% of landholdings in Oman to 25-30% in Jordan and Egypt.[4] Tenurial arrangements in Egypt for a long time gave the heirs of the tenant the right to inherit the tenancy on land where rents remained fixed and at below market prices.

Evolution of such practices after land reforms led to a reduction in the values of land, decreasing incentives for landowners to invest and suboptimal returns. The supply response of both producers and landowners to administered rent and crop prices in Egypt led to a reduction in the leased-out area.[5]

Whereas landless peasants, tenants and sharecroppers benefited from the distribution of land, in general, the efficacy of land policies in the region remained circumscribed owing to less than optimal implementation of land reforms, substantial State intervention in the land market thorough fixing of rent controls and cropping patterns, and social and cultural traditions governing land tenurial arrangements and management rights.

Land concentrations remained high. In Egypt, despite successive land reforms, only 14% of total agricultural households benefited from the reform, which distributed about 12% of the total cultivated area.[6]

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[3] M. R. El-Ghonemy, "The Egyptian State and agricultural land market 1810-1986", *Journal of Agricultural Economics*, vol. 43, No. 2, May 1992, p. 179.

[4] International Fund for Agricultural Development, *The State of World Rural Poverty, 1993*, p. 120.

[5] M. R. El-Ghonemy, "The Egyptian State and agricultural land market 1810-1986", p. 189.

[6] *The State of World Rural Poverty, 1993*, p. 114.

Whereas the land reforms were successful in reducing the inequity in land distribution, they also contributed to a process of polarization and fragmentation of landholdings over a period of time. The boom of the 1970s in the region artificially raised the prices of land, forcing many subsistence farmers to sell off their parcels and leading to polarization. In addition, inheritance laws and the regulatory framework governing ownership resulted in fragmentation of land. In the mid-1980s in the Sudan more than 25% of the landholdings were on cropped areas of less than 2.5 feddans (1 feddan equals 1.038 acres), and 73% of the holdings were less than 5 feddans.[7] The agricultural census of 1981 in the former Yemen Arab Republic indicated a similar trend. More than two thirds of the landholdings comprised less than 1 ha of land.[8]

Fragmentation of land became a serious constraint on modern agriculture in the region. In Tunisia about 50% of landholdings consisted of 6-10 plots with an average size of 1.8 ha. [9] In the Syrian Arab Republic, the total number of agricultural holdings in 1970 was 396,282, comprising 1.8 million plots of land.[10] Reductions in landholdings per capita served to reduce household income and consumption. An offshoot of low farm incomes was a lack of investment in—and management of—land. Despite the provision made in the 1952 land reform and laws later for private investment in the reclamation of land in Egypt, private investment ranged between 4-12% of total agricultural investment between 1960-1980.[11]

In the face of the rapid increases in population, survival for many farmers depended on encroachment of marginal lands and intensive exploitation of available parcels. Migration from rural to urban areas also caused a shift of fertile arable land to commercial use.

Soil conservation policy, at the same time, focused on erosion control. Rates of soil loss were given attention through conservation measures aimed at reducing these to acceptable levels. Extension services focused on erosion control in isolation from other agricultural improvements. Declines in soil fertility due to physical, biological and chemical soil degradation were not considered in an integrated manner.

Despite the fact that large-scale land reclamation projects were undertaken, these fell short of the desired objectives owing to lack of adequate planning, inadequate knowledge of soils and weak post-project extension services. In Egypt, conversion of fertile areas to non-agricultural uses at rates higher than the rate of reclamation of additional lands decreased the irrigated arable area by 2% between 1960-1985.[12] The construction boom between 1975-1977 led to a loss of 250,000 feddans of highly fertile agricultural land in Egypt.[13] In the Syrian Arab Republic and Tunisia there has been no net increase in cultivated land since 1975.[14]

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[7] ESCWA, *Problems of Fragmentation of Agricultural Holdings in the Near East* (E/ESCWA/AGR/WG.18/4), 1985, p. 3.

[8] Ibid.

[9] Ibid.

[10] Ibid, p. 5.

[11] M. R. El-Ghonemy, "The Egyptian State and agricultural land market 1810-1986", p. 181.

[12] M. R. El-Ghonemy, *Land Reform and Rural Poverty in the Near East and North Africa*, IFAD Working Paper No. 22, 1990, p. 13.

[13] M. R. El-Ghonemy, "The Egyptian State and agricultural land market 1810-1986", p. 181.

[14] The World Bank and the European Investment Bank, *The Environment Program for the Mediterranean, 1990*, p. 29.

Together, all these factors contributed to an intensive use and degradation of land resources.

B. Water resources

Annual renewable water resources in the Near East region average about 850.5 billion cubic metres (BCM).[15] The average per capita share in 1991 was about 1,895 cubic metres (m^3) per year and will drop to 1,018 m^3 per year in the year 2025. These "comfortable" averages mask the discrepancies in the distribution of the renewable water resources over the countries of the region. Table 2 below shows these water resources per country in 1991, and what they will be in the year 2025 when a country like Jordan, for example, will have a per capita share of 66 m^3, hardly enough for municipal consumption. Six other countries in the region will have a per capita share of less than 100 m^3, the amount required for municipal and industrial consumption.

1. Shortages in land and irrigation water resources

Shortages in land resources are calculated and parallel shortages in irrigation water are computed based on a water duty of 14,000 m^3 per hectare per year. The results are shown in table 2 below. In terms of the 1991 irrigation water need per capita, the results were as follows: Kuwait (1,020 m^3/capita), Qatar (1,015), Bahrain (1,008), United Arab Emirates (998), Oman (840), Mauritania (793), Jordan (710), Lebanon (635), Yemen (626), Egypt (616), Saudi Arabia (456), Algeria (280), and Morocco (31). Not included in the need for irrigation water are the quantities already pumped in excess of the safe yields of aquifers. These are believed to be substantial in Saudi Arabia, which uses no less than 14 BCM (909 m^3 per capita) of fossil water for irrigation. In Jordan, for example, groundwater aquifers are being overpumped at a rate of 200 million cubic metres (MCM)/year, and fossil water is being used at the rate of 65 MCM per year. This translates into about 65 m^3/capita of water needed to ensure the sustainability of irrigated agriculture there. The same can be said about Yemen, the Libyan Arab Jamahiriya, the Gulf States, some regions of the Syrian Arab Republic (Barada and Awaj basin) and others.

Countries without deficits/shortages in 1991 (seven) will eventually develop such deficits/shortages in the future as their populations increase. Other reasons for development of shortages would be loss of part of the agricultural resource base due to soil erosion, waterlogging, desertification, or groundwater depletion, increased salinity, or water quality degradation.

It is important to remember the bases and assumptions on which the above shortages have been computed, and to recall that half of the deficits in agricultural trade are to be offset by increments in yields of agricultural lands, and the other half by horizontal expansion in irrigated agriculture. Even with those assumptions, the additional irrigation water needed is beyond the potential of the renewable water resources of the above countries with the exception of Mauritania.

The above regional analysis of land and water resources indicates that countries of the region have to deal with water management and planning issues and with institutional issues sooner than most of them anticipate.

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[15] *World Resources 1992—93*, a report by the World Resources Institute in collaboration with the United Nations Environment Programme and the United Nations Development Programme (New York-Oxford, 1992).

2. *Water policies*

In the Near East region, water policies are inextricably linked to land policies and issues of food security. In the past, water policies have focused on the supply-side management of water resources. Water policy has been synonymous with irrigation policy with the objective of expansion of irrigated areas through investments in irrigation and drainage systems. Water development projects included the construction of dams, reservoirs, well fields, canal or pipe networks. In some countries government policy has encouraged the digging of wells through subsidizing the costs thereof. The Syrian Arab Republic in the last 10 years has devoted 60-70% of its entire agricultural budget to irrigation. Eighty per cent of the new land since 1987 has been irrigated through drilling wells supported by government fuel subsidies for the operating pumps.[16]

TABLE 2. SHORTAGES IN LAND AND IRRIGATION WATER RESOURCES, 1991

Country	*Population Million*	*Current irrigated land equivalent*	*Irrigated land shortage ha/cap*	*Additional irrigated land thousands ha*	*Additional irrigated water MCM*
Algeria	25.7	0.1067	0.02	514	7 196
Bahrain	0.5	0.0026	.072	36	504
Egypt	53.6	0.0587	.044	2358	33 012
Iraq	18.7	0.2170	-	-	-
Islamic Republic of Iran	57.7	0.1480	-	-	-
Jordan	4.1	0.0452	.0506	208	2 912
Kuwait	2.1	0.001	.0728	153	2 142
Lebanon	2.8	0.0562	.0452	127	1 778
Libyan Arab Jamahiriya	4.7	0.1778	-	-	-
Mauritania	2.1	0.0354	0.0566	119	1 666
Morocco	25.7	0.1421	0.0022	57	798
Oman	1.6	0.0268	.0598	96	1 344
Pakistan	115.8	0.1492	-	-	-
Qatar	0.4	0.0033	0.0716	29	406
Saudi Arabia	15.4	0.0813	0.0326	502	7 028
Sudan	25.9	0.2084	-	-	-
Syrian Arab Republic	12.5	0.1893	-	-	-
Tunisia	8.2	0.2120	-	-	-
Turkey	57.3	0.1910	-	-	-
United Arab Emirates	1.6	0.0042	0.0712	114	1 596
Yemen	12.5	0.0571	.0447	559	7 826

Source: Consultant's calculations.

[16] Food and Agriculture Organization of the United Nations, *The State of Food and Agriculture, 1993*, p. 254.

In many countries, externalities in water sector activities resulted when large irrigation investments were undertaken in the past without controlling for drainage; this resulted in waterlogging and salinity in sloping and downstream areas. Improper irrigation practices were the cause of an unsustainable rise in the water table in Egypt, which went from a depth of 15-20 metres to 2-3 metres per year.[17] In the Syrian Arab Republic, critical contents of gypsum cover 21% of the total area and 50% of the fertile Euphrates basin.[18] The middle and lower Euphrates terraces and adjoining areas are composed of soils with more than 70% gypsum.[19]

In Pakistan, government policies in the past have contributed to misuse of groundwater resources, inequitable water distribution and a consequent detrimental effect on environment. The annual recharge added to the groundwater is the single most important variable that contributes to the waterlogging problem in Pakistan. Development of canal systems without due consideration of drainage has resulted in a serious problem of waterlogging and salinity, and the situation is deteriorating at a distressing rate. In the saline areas, the water table has risen to levels that render land uncultivable and pose serious environmental challenges. In some areas past policies have also contributed to lowering of the water table to more than the desired level and to making pumping uneconomical (negative recharge). Inappropriate design, cheap credits, water charges far below the economic or even the financial prices and an electricity subsidy are some of the policies that might have contributed to overextraction of underground water.

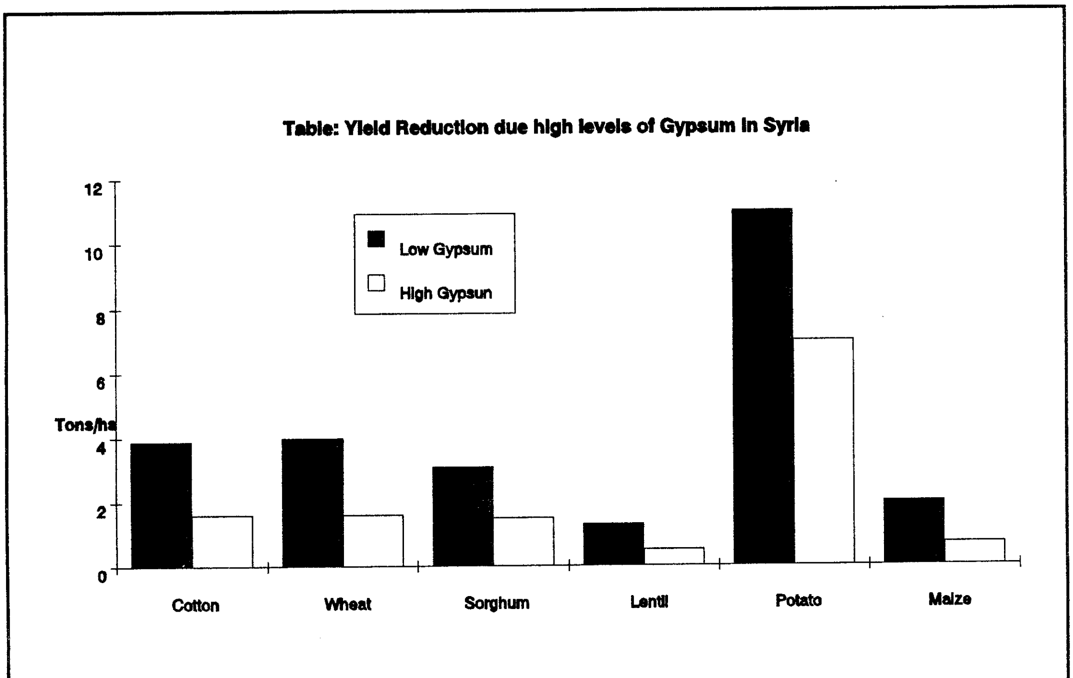

Figure I. Yield reduction due to high levels of gypsum in the Syrian Arab Republic

Whereas the expansion in the network of canals and watercourses contributed to a rapid rise in agricultural production and yields initially, insufficient maintenance led to leakages and a gradual rise in the

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[17] Dina L. Umali, *Irrigation-induced Salinity*, World Bank Technical Paper No. 215, 1993, p. 32.

[18] FAO/UNDP, *Syrian Arab Republic, Irrigation Sub-sector Review, Mission Report*, February, 1993, p. 11.

[19] Ibid.

water table which, in turn, adversely affected yields in the long run. Figure I indicates that the increase of gypsum from "low" to "high" has reduced the yield of cotton from 3.9 tons/ha to 1.6 tons/ha and in the case of wheat from 4.0 tons/ha to 1.6 tons/ha in the Raqqah area in the Syrian Arab Republic.

Demand management of water resources was not explicitly included in water policies in the past in most of the Arab region partly because the focus, initially, was on expanding the supply and partly because socio-culturally water was believed to be a free good.

Lack of demand management practices in the past also contributed to a low efficiency of water use and consequent waste. In addition, improvements in the availability of water due to the introduction of high technology in the past diverted attention from demand management and reduced emphasis on low cost alternatives such as improving efficiency, conservation and reduction of waste through maintenance.[20]

Water charges in the agricultural sector, which uses about 80% of the water in the Arab countries, have been kept low in a bid to offset the price controls on agricultural produce. The price of water is so low that in many countries it does not cover the operation and maintenance costs. With increasing water scarcity leading to rising marginal costs of an additional unit of water in the region, such a policy has not been sustainable in the long run.

Irrigated water charges were (and still are) typically well below full recovery levels. Subsidies on water are provided as a means of offsetting low farm incomes brought about by controlled producer prices and often overvaluation of the exchange rate. As such, pricing policies in agriculture, especially of water, are self-defeating inasmuch as they conflict with the stated objectives of enhancing food security and maximizing agricultural exports.

C. WATER MANAGEMENT AND PLANNING

Water quantity and water quality are inseparable since all water uses require that water quality fall within a range specific to that use. Water management and planning must therefore deal with the two aspects in an integrated way.

Water management falls within two main categories: supply management activities required to locate, identify, develop and manage new resources; and demand management mechanisms to promote more desirable levels and patterns of water use. Planning integrates both with environmental concerns, and provides the analytical basis for choosing between them. Water planning should reflect the unique characteristics of water, notably its variable and unitary nature, and the issues that require government intervention in management. The meaning of "planning" in this context must be understood: it does not mean that Governments should control each and every aspect of resource management; it is better to decentralize many important activities to autonomous, local, private or user entities. Nor does it mean that Government alone should be responsible for setting objectives and priorities. On the contrary, stakeholder participation in decision-making not only promotes accountability and transparency but also leads to solutions that are often more efficient.[21]

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[20] Hasan K. Qasahu, "Partnerships in regional water resources developments: the technology-innovation imperative in the Middle East", Proceedings of the International Symposium on Water Resources in the Middle East: Policy and Institutional Aspects, University of Illinois, 24-27 October 1993, p. 48.

[21] *A Strategy for Managing Water in the Middle East and North Africa*, (World Bank, 20 September 1993).

1. Supply management

Water development projects include the construction of dams, reservoirs, well fields and canal or pipe networks. As accessibility to new surface sources decreases and projects become more expensive, other sources including groundwater take on greater significance. Ultimately, as renewable freshwater becomes fully utilized, non-conventional sources such as treated wastewater, desalinated water and water imports may become the only sources of new supplies.

(a) Augmentation of irrigation water resources

(i) Urban wastewater reuse

One way of augmenting irrigation water resources is the reuse of treated urban wastewater, a practice already followed in water-short countries of the region such as Jordan, Kuwait, Saudi Arabia, Tunisia, Yemen and others. Treated wastewater is being used in irrigation with or without blending it with fresher water. More reuse of treated affluent will be made in the countries of the Near East. Associated with such reuse are issues of public health and environmental, technical, institutional, socio-cultural and sustainability issues that have to be adequately addressed. The treated urban wastewater is expected to account for a good percentage of the irrigation water in many of the Near East countries, and its reuse would in many cases allow the diversion of irrigation water for municipal and industrial purposes which could use treated wastewater.

If the urban population by the end of this century comprises 70% of the total population in the majority of the countries of the region, and the average urban water consumption is around 80 m^3 per capita on the average, it is reasonable to suggest that 60% of the urban water consumption can be recovered and treated for reuse. This translates into a renewable irrigation water resource of 33.6 $^{m}3$ per capita of the population of the country. The treated effluent of a city of 3 million people would be sufficient to irrigate about 10,000 ha.

(ii) Use of brackish water

Experimental research on the use of brackish water for irrigation of certain seasonal and perennial crops has advanced, especially in sandy soils. Extensive fossil waters of marginal quality underlie the territories of several of the countries of the region, and can be used for a long period in irrigation. Renewable brackish aquifers also underlie some territories and discharge in wadis through springs. Likewise these can be used in irrigation and the production of certain crops.

Tunisia provides good examples of the use of brackish water for irrigation of seasonal crops and perennial trees, especially in the south of the country. Salinities of up to 4,000 parts per million (ppm) of total dissolved solids are not unusual there.

Issues of sustainability parallel the use of brackish water, especially soil salinity. Careful control of water application has to be exercised, and the choice of the salt-tolerant varieties of crops would ensure better results.

(b) Augmentation of municipal and industrial supplies

(i) Desalination of brackish and sea water

Desalination of sea water is now common practice in the six countries of the Gulf Cooperation Council (GCC). There are 29 desalination plants in Saudi Arabia alone that produce a total of 795 MCM per year and account for 30% of all desalinated water in the world. The six GCC countries of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates have over 55% of the world's desalination capacity. Desalinated water is usually blended with brackish water to produce water with acceptable salinity for domestic uses.

Desalination of brackish groundwater is also practised in Saudi Arabia using reverse osmosis techniques, and the produced water is blended with raw water; the blend is pumped for domestic uses.

Associated with such options are economic/financial issues related to the cost of desalination as compared with the average share per capita of the gross national product (GNP), especially in countries not endowed with cheap energy resources, and environmental issues related to the safe disposal of the brine produced, especially in offshore plants. Manpower training and technology transfer are other issues to be dealt with under these options.

TABLE 3. DESALINATED WATER RESOURCES IN GCC MEMBER COUNTRIES IN 1992

Country	*Desalinated water, MCM/yr*
Bahrain	34
Kuwait	165
Oman	67
Qatar	65
Saudi Arabia	795
United Arab Emirates	163

(ii) Interbasin transfers: water imports

This is another option that has received attention in recent years. A study was conducted for Jordan (1984) to import 160 MCM per year from the Euphrates River in Iraq where it crossed the Iraqi borders with the Syrian Arab Republic. The high cost of water transfer to Amman compared with what Jordanians can afford to pay was prohibitive, and the scheme was not implemented. Another study was conducted to transfer water from the Ceyhan and Seyhan rivers near Adana in south-west Turkey to the water-short countries of the Middle East, a project often referred to as the "Peace Pipeline". The cost of such a scheme is equally prohibitive when compared with income of consumers and their ability to pay the full cost. Other schemes for importing water were suggested but were not scrutinized properly for technical, economic and financial feasibility.

Projects to augment water resources for municipal and industrial uses are both capital- and energy-intensive, and require that middle income and low income economies of the region be further developed to

boost their gross domestic product (GDP) and improve income distribution patterns in order that consumers of the expensive water can afford to pay the cost of supply.

(c) Improved management of supplies

Improved management of currently available supplies can often be a partial alternative to investment in new supply. Plans for operation and maintenance of water systems are prerequisites for planning at both basin and project levels. For a variety of reasons, however, planning for operation and maintenance has often been deficient, at least when it comes to implementation of such plans. Improved management of supplies often provides a cost-effective means of increasing freshwater supplies. Examples are conjunctive use in real time of surface water and groundwater and integrated basin-wide management.

(d) Reallocation of supplies

Very few countries have been willing to consider reallocation of water from irrigation to municipal and industrial uses. Irrigation accounts for about 80% of water use region-wide, and it is argued that a small percentage of that water diverted to municipal uses could resolve the municipal shortages. In Morocco, for example, a 5% diversion from irrigation could double the supplies available for municipal uses, while in Jordan a 5% diversion would contribute 15% to the supplies now available for municipal and industrial uses.

There are reasons for the reluctance of Governments to commit themselves to reallocation of water resources despite certain attractions. Diversion of water away from irrigation in arid areas destroys the viability of agriculture and invites desertification with its immense adverse environmental impacts. Not only are the multiplier effects and costs to third parties substantial, but Governments are also very reluctant to accept depopulation of rural areas and migration to urban areas that are already under extreme stress. Unemployment among farmers would rise and their skills to perform non-agricultural jobs are limited. Moreover, it is significantly less expensive to create jobs in the agricultural sector than it is to create an equal number of jobs in such sectors as industry, transportation, mining and others.

When a reallocation of supply is being considered, a full equilibrium analysis of the regional economy and its relation to the national economy should be made. This may show whether the reallocation is economically justified. A social impact assessment and an environmental impact assessment should also be made. In some cases the spread of urban areas on to irrigated land will itself release irrigation water for other uses. The Ghuta of Damascus is a case in point, as were the springs around Amman.

2. Demand management

Demand management can take the form of direct measures to control the use of water and indirect measures that affect voluntary behavior (public awareness, market mechanisms, financial incentives). Price and market distortions often magnify both scarcity and water quality problems. Low water charges have many disadvantages, ranging from encouraging wasteful, extravagant habits to putting pressures on budgets of operation and maintenance. Input pricing distortions can pose a threat to industrial pollution. Inefficiently low fertilizer prices similarly lead to increased fertilizer consumption that results in degradation of the quality of water supplies.

Demand management measures aim at increasing water use efficiency, and possibly equity.[22] Efficiency is, however, a relative concept and must reflect all the interactions in the water cycle. For

[22] Ramesh Bhatia, Rita Cesti and James Winpenny: "Policies for Water Conservation and Reallocation: Good Practice Cases in Improving Efficiency and Equity", draft, 5 October 1992.

instance, irrigation efficiencies at the farm or scheme level may be relatively low but, if water losses recharge groundwater or are reused via the drainage system, basin efficiency can be much higher. Scheme level efficiencies in Egypt are, for instance, notoriously low by the standards of some other countries in the region, but annual average efficiency in the Nile basin between the Aswan High Dam and the sea is estimated at 65%, comparable to the efficiency of modern concrete-lined canals with land levelling elsewhere.

(a) Public awareness

Frameworks designed to invite stakeholders' participation in decision-making promote transparency and accountability, and can secure public support and commitment to water policies and programmes. Appeals to the public through public education programmes and similar initiatives can lead to significant changes in human behaviour related to conservation and use. These are in large part almost costless compared with the investments in the water sector, and should be encouraged and supported in the countries of the Near East.

(b) Water efficiency improvements

Reduction in water losses is important in any demand management programme. Unaccounted for water has reached 56% in urban delivery systems of some of the countries in the region. While some of the losses can be recycled, loss reduction should always have first priority. Leak detection and repair programmes, replacement of old networks, identification of illegal connections, gauging of defective water meters, and reduction in system pressures can all play a part in resolving this problem. Many low water use devices and technologies have been introduced on the market and can be promoted for use in the countries of the region.

Technical interventions to reduce water losses have particular potential in irrigation. Canal lining and improved conveyance technologies can save water by up to 10-30%. At the farm level, surface irrigation can be improved through land levelling and the introduction of advanced on-farm irrigation techniques. Micro-irrigation in particular has potential for major savings. These can be up to 30-50% compared with surface methods. Micro-irrigation techniques can also improve the agricultural output from a unit area of land per unit flow of water. Drip methods have been introduced and are now widely used in Jordan, and sprinkler and drip methods are being widely used in the reclamation of lands in Egypt.

3. Regulatory measures

The most direct regulation is to mandate water use. Rationing or rational deliveries can achieve comparable effect and are commonly adopted in drought years, or where demand exceeds the delivery capacity of the system. Such measures can maximize the return from scarce water resources. Direct control of cropping patterns is another option which in principle could reduce water consumption at the farm level. However, mandated cropping patterns constrain farmers' ability to respond to market signals and may thus have adverse effects on the net farm income and on agricultural value added.

The regulation of groundwater exploitation is a universal but often intractable problem. Uncontrolled overdrafts from groundwater aquifers are not uncommon in the countries of the region. Administrative capacities for proper controls are not sufficient and should be reinforced and equipped with modern technological means of surveillance. Overdrafts have reached dangerous proportions in some of the countries of the region (Jordan, the Libyan Arab Jamahiriya and Yemen, and in some basins in the Syrian Arab Republic and other countries) and should be curtailed.

Regulation of water quality standards has been widely adopted and overambitious targets have sometimes been set. Costs incurred to meet the quality standards often induce non-compliance if they are high. Non-point source pollution, notably from fertilizers and pesticides, has proved more intractable not only in the region but also worldwide. This poses a direct threat to the groundwater aquifers when intensive irrigated agriculture is practised in the recharge areas of the aquifers.

(a) Water pricing

Financial interventions should be made in accordance with two accepted principles: the user-pays-principle and the polluter-pays-principle. These two principles are viewed as fair and also result more often in efficient water use.

Several approaches have been suggested to structure the financial interventions. One defends the idea of fully financing the operation and maintenance cost of water supply to the users, another advocates pricing at levels equal to the marginal cost of water. In practice, water charges are normally well below levels needed to recover financial costs let alone to keep pace with rising marginal costs, as they are set at levels that do not approach the real value of the water. In Algeria the long-run marginal cost of water to urban consumers, including both raw water supply and distribution, is about US\$ 0.52/m^3 compared with the average water charge of \$0.12/m^3. The contrast is more striking in irrigation: current water charges average US\$ 0.02/m^3 compared with an average marginal water cost of US\$ 0.32/m^3. In Jordan, irrigation water charges in public irrigation systems currently approximate half of the operation and maintenance costs. In Egypt the combined cost of raw water supply and distribution ranges from US \$0.03 for rural areas to US\$ 0.25 in major urban areas, compared with average water charges for domestic consumers of no more than US\$ 0.03/m^3. To the above costs should be added the cost of collecting and treating wastewater; these costs range from an estimated average of US\$ 0.12/m^3 in Morocco to US\$ 0.37/m^3 in Jordan (for wastewater reuse in irrigation), and US\$ 0.40/m^3 in the Gulf States. The public is therefore unaware of the economic value of water and at low levels of water charges has no incentive to conserve water; therefore the public cannot be expected to take responsibility for water protection and conservation.[23]

Most Governments have the objectives of setting water charges that will cover the operation and maintenance costs of urban utilities and in many cases also a portion of the capital costs. But in practice, they are often unwilling to implement their own policies, and revenues fall short of those needed to recover these costs. Even in Jordan, where urban water charges approach the long-run marginal cost of new supplies, unaccounted for losses and other deficiencies require government subsidies. Water supply services are usually publicly owned and run, and some hold the view that a certain level of water and wastewater services should be provided at a cost affordable to all to maintain public health standards. Although this view has merit, services above basic requirements should be charged at the true cost.

Irrigation water charges are typically well below even the inadequate levels of the municipal sector and many Governments are unwilling to accept the principle of irrigation cost recovery. Irrigation water charges are kept below full recovery levels as a means of offsetting low farm incomes controlled to keep down food prices in the cities, to maintain agricultural jobs and their related externalities, and to curtail the costly migration from rural to urban areas. However, free irrigation water sends the wrong signal to farmers, and increased irrigation water charges should be an important element in the considerations to eliminate price distortions and to "get the prices right".

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[23] *A Strategy for Managing Water in the Middle East and North Africa* (World Bank, 20 September 1993).

Few countries in the region have recognized the need to charge "adequately" for irrigation supplies. In Morocco the water law requires that all water consumption be subject to the payment of fees on a common basis even if, in practice, rates in irrigation continue to be well below those in urban areas, and as in most countries, irrigation continues to be subsidized. In Egypt and Yemen, surface water supplies for irrigation are provided free with the water agencies financed from taxes and other public revenues.

Any meaningful increase in water charges would encourage economies in water use, by, for instance, encouraging farmers to install water-saving irrigation systems and to adjust their cropping patterns for optimum net returns.

Pricing of water, however, has been receiving increased attention in much of the region, in Egypt, Jordan, Palestine, the Syrian Arab Republic and elsewhere. Whereas many countries now, in principle, accept the need to increase water charges the debatable issue is: by how much?

Several concepts are being studied to determine how best to determine water charges. Under perfect market conditions, the economic price of water represents its marginal or opportunity cost. One approach is to price water to cover the operation and maintenance cost of supplying water to the user. Another would include a portion of the capital investment as well. A third approach is to price water at its opportunity cost or the cost in the next best use in the short run, assuming capacity is fixed. Another view, especially in the face of rising costs of an additional unit of water, is to price it at its long-run marginal cost (LRMC) which, by definition, would include the environmental damage or resource depletion costs in the long run.

The objective of the pricing policy could be one or a combination of the following:[24]

(a) To allocate resources efficiently between sectors within the economy and within the sector itself;
(b) To satisfy considerations of equity or the ability to pay of consumers, especially the poor;
(c) To raise revenues to meet the financial requirements of providing the service;
(d) To subsidize special areas to encourage rapid development;
(e) To take into account political considerations for a special area or subsector of the population.

Some of the objectives are conflicting. For most countries satisfying these multiple objectives would involve a trade-off.

Pricing of water at its LRMC would include the operation and maintenance cost, capital cost, and the cost of resource depletion and environmental damage. This would imply valuing water at its social-efficient price to the community, and is different from pricing of water, assuming that future costs of supplying the additional unit would remain unchanged. Under such a pricing mechanism, if demand is increasing (owing to changing patterns of consumption or increases in population as is the case in many of the Arab countries) water supply costs will increase. In practice, it would imply a different structure of prices for different consumers, supply times (peak vs. non-peak time), quality of water supplied and geographical areas.

When prices are set according to the LRMC under conditions where marginal costs of producing an additional unit of water are increasing, as in many of the Arab countries, a financial surplus may be generated. This could be diverted for subsidizing special groups such as the poor, or those in underdeveloped areas.

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[24] This section is based on Mohan Munasinghe, *Water Supply and Environmental Management: Developing World Applications*, Studies in Water Policy and Management (Westview Press, 1992).

In the face of the water scarcity in the Arab region, considerations of sustainable development dictate that pricing of water reflect as closely as possible its long-run marginal cost. As a first step, water charges should be levied: (a) to recover operation and maintenance costs plus a portion of the investment costs; and (b) as a tool to improve efficient use of the resource.

Groundwater resources, in many countries of the Arab region, are being depleted at an alarming rate. The market failure corresponds to the case of a common property resource that is being depleted. To check continuous depletion, Governments can resort to measures such as taxation, assigning water rights or outright control (see figure II below).

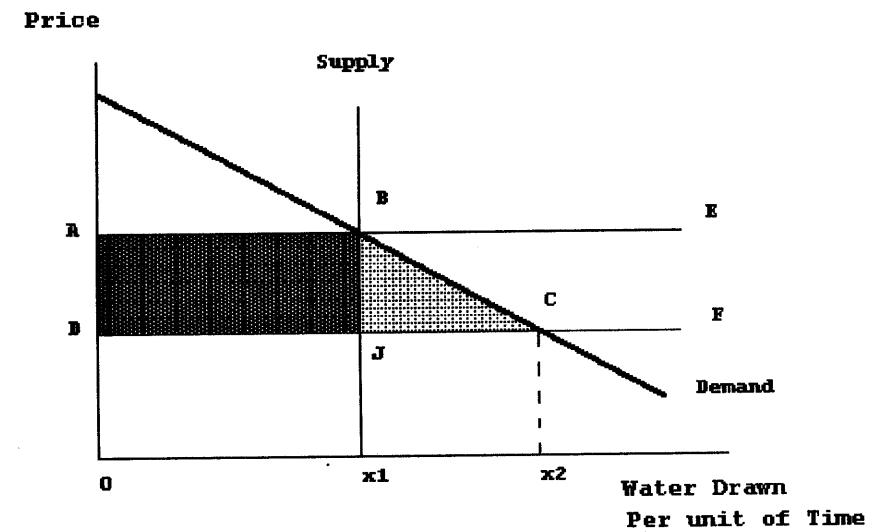

Figure II. Quantity of water drawn from ground per unit of time

Policies which underprice the natural resource send wrong economic signals to the farmers. The consequence, in terms of the amount of income lost to the society, is phenomenal. Figure II presents an illustrative example depicting the cost of overpumping for the "open access" case. The demand curve represents the farmer's willingness to pay for an additional unit of water. The natural recharge rate allows a maximum supply of X_1. OD represents the initial per unit cost of obtaining the water by pumping. At this price, in the absence of control, X_2 units of water will be pumped. As water is pumped more than the sustainable level of X_1 (pumping greater than recharge), the water level in the basin starts to fall (as is the case in many countries of the region) leading to higher costs to pump the same amount of water.

Under the new equilibrium, less water would be pumped (X_1) at a higher cost. The farmer is paying a price that does not take into account the user cost (or the intergenerational cost of water use). The user enjoyed an initial period of extra benefits obtained by an off-take of water, X_2 as shown by the white dotted area in the figure, but which cannot be sustained because the situation leads to extra cost, as shown by the dark dotted area. In economic terms, the discounted benefits generated in the early period would be less than the discounted cost due to a free access policy.

The sustainable least cost solution in the above figure can be achieved by imposing a fee equal to the amount of AD (in the figure) on each unit of water drawn from the groundwater or creating a market for

rights to draw water up to the sustainable levels of X_1. In many countries of the region, free access to groundwater is making pumping uneconomical and is also adding to the problem of resource degradation and in many cases leading to desertification.

An appropriate price policy would require that in the long run one should ascertain the intergenerational value of groundwater depletion which is reflected in the following relation in marginal terms.

MOC_I = $MC_I + MUC_I + MEC_{IJ}$
MOC_I = marginal net opportunity cost of using up the water resource
MC_I = marginal direct cost of extracting or developing water
MUC_I = marginal user cost of using up the water resource (intergenerational consideration)
MEC_{IJ} = marginal intersectoral cost imposed on sector (resource) j by using up resource i

(b) Legislation and institutional issues

Legislation provides the basis for government regulation and operations, and establishes the context for action by non-governmental entities and individuals. Indeed "recognition of water resource planning in legislation is perhaps the single most significant mechanism for sound decision-making in the management of water resources in the long run."[25]

The provisions of Islamic law are visible in the codification of water rights and uses throughout the Moslem countries, but the influence of the former Mandatory Powers in the region (Britain and France) is visible in the legislation related to water (and other subjects) in the countries that were under their influence. Islamic law was fully observed under the Ottoman Empire and codifications can be found in the *Majallah*, the official gazette of the Ottoman Empire.

State permits are generally required for private exploitation of water resources, and State supervision is usually built-in for such permits.[26] Protection of water resources against pollution or overuse is organized by legislation under which the State assumes authority and responsibility to ensure protection. Implementation of such legislation has not been up to the level of expectations.

Regulatory functions comprise the monitoring and enforcement of effective laws, agreements, rules and standards. Many other regulatory functions have an impact on water, as on other areas of the economy, including those governing civil service administration, procurement, markets, finance and audits, employment and private enterprise. Regulatory functions are often weakly and inconsistently developed in the countries of the region. These weaknesses may be a reflection of factors that go well beyond the water area so that, in the real world, water resources may often have to accept—and respond to—second-best conditions.[27]

Under conditions of increasing scarcity of water resources, and the increasing marginal costs of water supply, the regulatory functions of government in the water sector have to be improved and reinforced. Government administration of the water sector needs to be reformed with better efficiency as the primary

[25] S. Burchi, "Current development and trends in water resources legislation and administration", Third Conference of International Association for Water Law (AIDA), Alicante, Spain, 11-14 December 1989.

[26] Legislation is still pending in some countries of the region: the Republic of Yemen is one such example.

[27] *A Strategy for Managing Water in the Middle East and North Africa* (World Bank, September 1993).

objective. Such reform would have an impact on the institutional set-up for management of water resources, and would ensure a clearer definition of the role of the private sector. One may expect that the reallocation of water resources will take on increasing importance, especially in water-poor countries with middle income and low income economies. Wastewater treatment and reuse will also take on more importance. These and other compelling factors will impose institutional and legislative reforms to cope with the regulatory and other functions that the new water situations will bring about.

4. International waters

Many water issues in the Near East are international in nature. They span issues arising from the sharing of water resources, surface and groundwater, to the environmental issues resulting from water uses upstream as they affect downstream users. However, out of the 286 international water treaties worldwide, only one comprehensive treaty involves a country of the region, namely Pakistan, the signatory party with India to the Indus River Treaty. Other treaties have been concluded in the region but none of them includes all the riparians to an international river. The Nile treaty of 1957 between Egypt and the Sudan does not include any of the other seven riparians, notably Ethiopia, where about 70% of the total Nile flow originates. The 1987 treaty between Jordan and the Syrian Arab Republic to utilize the Yarmouk river waters does not include Israel, a riparian on the river. The 1990 agreement between Iraq and the Syrian Arab Republic to share the Euphrates flow that crosses the Turkish-Syrian borders does not include Turkey, the uppermost riparian on the river. The arrangements on the Senegal river that affect a country in the region, Mauritania, appear to be working satisfactorily thus far. No treaties or comprehensive agreements exist on the Jordan River, the Tigris, the Shatt al-Arab (navigational), or the Orontes.

More can be said about the status of international agreements on the shared groundwater resources in the region. Several important aquifers underlie the territories of more than one country in the region. Some are renewable groundwater resources (Jordan and the Syrian Arab Republic; Palestine and Israel; Lebanon and Israel; the Syrian Arab Republic and Turkey; and other cases), and others are non-renewable, mostly fossil waters. The water quality of the fossil aquifer varies with location, and is fresh in some locations (the Saq formations underlying Jordan and Saudi Arabia), and with salinities that can be used in plant production in some other areas. No agreements have as yet been concluded to share the groundwater among the riparians nor are understandings worked out to protect the quality of the shared aquifers.

Under the conditions of water scarcity which today prevail in several countries of the region, the conclusion of treaties or agreements among all the riparians of each water basin is even more important. In the Middle East peace process, Jordan and Israel recognized the importance of concluding an agreement on the shared water resources, the surface resources in the Jordan River basin and the groundwater resources, mostly fossil waters, underlying their respective territories in Wadi Araba. The issue has been listed under item B.3 of their common agenda initialled by the two parties on 14 September 1993. The outcome of negotiations should pave the way to a comprehensive water treaty among all the riparians of the Jordan River basin. Attempts are still being made by the three riparians on the Euphrates and the Tigris (Iraq, the Syrian Arab Republic and Turkey) to reach a comprehensive agreement. A temporary understanding was reached in 1987 between the Syrian Arab Republic and Turkey to ensure a minimum flow of 500 m^3 per second to cross the Syrian borders from Turkey. A bilateral agreement was concluded between Iraq and the Syrian Arab Republic to share the flow coming into the Syrian Arab Republic with a share of 58% for Iraq and 42% for the Syrian Arab Republic. However, these arrangements are far from conforming to the objective of a comprehensive treaty among the parties. Agreements are also needed on the Orontes between Lebanon, the Syrian Arab Republic and Turkey.

While negotiated agreements are the most durable and form the highest levels of commitments on the part of the signing parties, international rules and practices are definitely helpful in assisting the parties to

conclude the desired agreements. The work of the International Law Association and of the International Law Commission of the United Nations can serve as a guide to the negotiating partners.

The conditions of water use and management within a given riparian country, although seemingly an internal matter that relates to the sovereignty of that country over its territories and resources, are reflected in the concepts normally adopted in negotiating water sharing among riparians. The institutional set-up for management of shared water resources may be a happy outcome of successful negotiations among the riparians, and examples can be set in the region that may be helpful to other countries, especially those located in the arid and semi-arid zones of the world.

PART TWO

CASE-STUDIES

EGYPT, JORDAN AND PAKISTAN

I. LAND AND WATER POLICIES IN EGYPT*

Introduction

Egypt is a country with a high rate of population growth and limited water resources. Water has been and still is a constraining factor on the horizontal expansion of irrigated agriculture. With the Nile as the major source of water, there is uncertainty regarding the future flows of the Nile water since that depends on development plans of the Nile riparians.

The main characteristic of the resource/population indicators is the decline in per capita cultivated and cropped land and per capita share of water supply. With productivity constant or slowly increasing, the food security situation, as measured by self-sufficiency indicators, is deteriorating. Along with that there is a deterioration in the environment stemming from the discharge of untreated wastewater into the water system.

Agriculture is the largest user of water, with its share exceeding 80% of the total demand for water. Consequently, most land and water policies are directly related to agriculture. Sustainable development requires the formulation and implementation of appropriate policies regarding land reclamation, land productivity, land tenure, agricultural price policies, wastewater treatment and reuse, environmental policies, water prices, policies addressing the future flows of the Nile water, and policies dealing with the institutional set-up for the implementation of land and water programmes and policies.

This study focuses on some of these major issues.

A. POPULATION, LAND AND WATER RESOURCES

1. Population

In 1990 Egypt's population was 5.5 times its size at the beginning of the century. It increased from 10 million in 1900 to about 55 million in 1990 with a long-run average growth rate of 1.9% per annum. However, during the last three decades the annual average growth rate was about 2.6%.

The rural population still constitutes more than 55% of Egypt's population despite rapid urbanization. This represents a substantial decline in the weight of the rural population, from 84% of total population in 1900 to about 56% in 1990. However, it is worth noting that the rural/urban population ratio remained almost constant during the period 1976-1986. This indicates not only the freezing of rural-urban migration but may also refer to a reverse migration from urban to rural areas. Factors behind this phenomenon are: the improvement of the quality of life in the rural areas, rising unemployment and the high cost of housing in the urban areas.[1]

2. Land

Egypt has a total land area of about 1 million square kilometres. It is a very arid country and water is a limiting factor for agricultural production. Agricultural land area in the past century, from 4 million

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* This case-study was prepared by Ahmad Abu-Shaikha, Director, Al Quds Open University, Amman Office. The views expressed in the case-study are those of the author and do not necessarily reflect the views of the United Nations Secretariat.

[1] M. Al-Deeb, "Labor force in Egyptian agriculture" in Analysis of Agricultural Policies in Egypt (FAO and Egyptian Ministry of Agriculture and Land Reform, 1992) (in Arabic).

feddans in the year 1800, increased to 4.7 million feddans in 1880. A century later, it increased to 5.87 million feddans, a mere 25% increase over a century. No single current figure is given for the area of cultivated agricultural land. Official data indicate that the cultivated area has been around 6 million feddans since 1960 (table 4).

3. *Water resources*

The River Nile is the main source of surface water in Egypt. According to the 1959 agreement between Egypt and the Sudan, Egypt's share was put at 55.5 BCM out of the 74 BCM of annual average usable water in Lake Nasser. Groundwater resources, which come mainly from the deep percolation of irrigation water diverted from the Nile, are estimated at 500 BCM. These utilizable resources are distributed between the Nile Valley aquifer (200 BCM with an average salinity of 800 parts per million [ppm]) and the Delta region (300 BCM). In addition, non-renewable groundwater resources are present at varying depths in the Western Desert and are estimated at 40,000 BCM with salinity ranging from 220 to 700 ppm.

B. POPULATION AND RESOURCE AVAILABILITY AND USE

Egypt represents a case where the balance of resources to population is continuously deteriorating. This stems mainly from the rapid population increase against a stagnant or slowly increasing resource base, mainly land and water.

1. *Land/population*

Per capita cultivated land has declined over time. From 0.51 feddans per capita in 1897 it declined to 0.23 feddans in 1960 and to 0.11 feddans in 1988. Meanwhile, there was a corresponding decline in per capita cropped area from 0.4 feddans in 1960 to 0.22 feddans in 1988 (table 4).

TABLE 4. POPULATION AND AGRICULTURAL LAND RESOURCES IN EGYPT

Year	Population in millions	Cultivated Land: Total million feddans	Cultivated Land: Per capita feddans	Cropped total million feddans	Area per capita feddans
1960	25.9	5.88	0.23	10.37	0.40
1965	29.4	6.02	0.20	10.26	0.34
1970	33.3	6.00	0.18	10.75	0.32
1975	37.2	5.79	0.16	11.16	0.30
1980	42.3	5.87	0.14	11.13	0.26
1985	48.5	6.00	0.12	11.22	0.26
1988	52.9	5.97	0.11	11.49	0.22

Source: A. Yamani and Samir Adli, "Some issues on land and water use policies in Egypt" in *Analysis of Agricultural Policies in Egypt* (FAO and the Ministry of Agriculture and Land Reclamation, 1992) (in Arabic).

At present, landholdings are estimated at about 7.5 million feddans of which 7.3 million feddans are cultivated. Most of the cultivated land (5.4 million feddans) consists of the "old" land which consists of the historical Nile lands. The remaining land (1.9 million feddans) makes up the "new" lands.

Historically, the increase in total cultivated area was the result of land reclamation over a very long period of time. Through this process 3 million feddans were reclaimed during the nineteenth century. After the 1952 revolution, Egypt adopted a land reform programme with the major objectives of equitable redistribution of agricultural land and the horizontal expansion of land through reclamation.

During the 1950s about 80,000 feddans were reclaimed out of a targeted 1 million feddans. However, the construction of the High Aswan Dam made it possible to pursue an expansionary reclamation policy in the 1960s. About 912,000 feddans were reclaimed during the period 1960-1971, the bulk of which was in the West Delta. Reclamation slowed considerably during the 1970s but was resumed vigorously in 1978, and about 75,000 feddans were reclaimed during the period 1978-1989.

In sum, the gross reclaimed land amounted to 1.067 million feddans between 1950 and 1988. The corresponding increase in population was about 32.4 million persons, indicating incremental per capita cultivated land of 0.033 feddans. This is substantially lower than per capita cultivated land of 0.3 feddans in 1950. Furthermore, the reported reclaimed area is given in gross terms. Net agricultural land is estimated at 75%—85% of gross cultivated area.[2]

With continuously declining per capita cultivated land and no compensating increase in agricultural productivity, deterioration of the food security situation is inevitable.

TABLE 5. WATER AVAILABLE PER CAPITA

Year	Population (million)	Regulated flow (BCM)	Per capita (m^3)
1966/67	30.9	58.6	6981
1970/71	34.8	55.5	5951
1971/72	35.6	56.0	3751
1976/77	38.8	56.1	6441
1977/78	39.8	61.8	3551
1981/82	44.6	59.0	3231
1985	48.5	55.9	3511
1986	49.9	55.2	6011
1987	51.3	54.7	6601
1988	52.9	52.1	985
1989	53.9	53.2	987
1990	55.0	54.0	982

Source: A. Yamani and Samir Adli, "Some issues on land and water use policies in Egypt" in *Analysis of Agricultural Policies in Egypt* (FAO and Ministry of Agriculture and Land Reclamation, 1992) (in Arabic).

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[2] A.K. Biswas, "Land and water management for sustainable agricultural development in Egypt: opportunities and constraints" in *Analysis of Agricultural Policies in Egypt* (FAO and Egyptian Ministry of Agriculture and Land Reform, 1992).

2. *Water and population*

The construction of the High Dam made it possible to provide a live storage capacity of 130 BCM. This exceeds the average annual flow of the Nile at Aswan of 84 BCM. With this average flow, Egypt is assured of an annual regulated flow of 55.5 BCM under the Nile Water Agreement of 1959. In some years, Egypt exceeded the 55.5 BCM mark. Despite that, the per capita share of the Nile water was decreasing over time.

The problem of the decreasing per capita share of the Nile water is aggravated by prolonged periods of drought in African countries to the south of Egypt. This is translated into lower Nile flow into Lake Nasser.

In addition to the Nile water, other sources of water consist of the following:

1. Groundwater which is abstracted at an annual rate of 3.1 BCM and used for agricultural, municipal and industrial purposes;

2. Non-conventional water resources which consists of 4.7 BCM currently used for irrigation in addition to some 200 MCM of treated sewage effluent.

Thus the total supply of water for all purposes amounts to 63.5 BCM which indicates a per capita share of water from all sources of about 1,144 m^3 in 1990.

On the demand side, agriculture is the largest consumer of water, using 49.7 BCM or 84% of total demand for water: the municipal demand is around 3.1 BCM or $56m^3$ per capita. The remaining demand is for industrial purposes, 4.6 BCM, and navigation requires 1.8 BCM per annum.

Thus total demand was around 59.2 BCM in 1990, indicating a surplus of about 4.3 BCM.

TABLE 6. SOURCES AND USES OF WATER (1990)

Sources	BCM	Uses	BCM
River Nile	55.5	Irrigation	49.7
Groundwater		Municipal	3.1
- Valley + Delta	2.6	Industrial	4.6
- Desert	0.5	Navigation	1.8
Agricultural drainage water	4.7		
Treated sewage effluent	0.2		
Total	63.5		59.2

Source: Country and subregional action programmes, Egypt.

C. Other major constraints and problems

Population pressure on land and water resources has already created a Malthusian situation. However, the declining per capita share of land and water resources is not the only problem. It is aggravated by a set of economic, technical, social, managerial and even political constraints.

1. Land and water productivity

Productivity of resources is a central development indicator. In fact, development is frequently reviewed and defined as "the increase of productivity". This increase comes as the result of the interaction of several factors including: physical input factors, policies and measures, organizations and development institutions and technology. In analysing productivity one can take the total productivity as well as partial productivity approach. The measurement could also be in physical terms such as output per unit of land and in monetary terms.

Agriculture has been practised in Egypt since ancient times, and its productivity is high by world standards. In 1980, the yields of all crops, except sugar cane, were higher than those reported for 1952. The highest increase was for maize and cotton and the lowest was for peanuts. However, in 1990 the yields for barley and cotton were lower than those of 1980. In examining the productivity trend, two sets of factors, working in opposite directions, should be dealt with.

The first is productivity-enhancing factors. Among these is the construction of the High Dam, which made it possible to double the cropping intensity, thus increasing output per unit of land. Other factors include the use of yield-increasing inputs such as fertilizers, pesticides and insecticides, improved seed varieties and improved cultural practices. The adoption of new capital-intensive technologies including plasticulture and drip irrigation are factors contributing to higher yields.

Table 7. Average yields of main crops
(Ton/hectare)

Crop	1952	1980	1985	1990	Annual % change 1952-1980	Annual % change 1980-1990
Barley	2.05	2.67	2.78	2.42	1.1	-0.9
Beans	1.67	2.07	2.52	2.95	0.9	4.2
Raw cotton	1.57	2.69	2.54	1.95	2.5	-2.7
Maize	2.10	4.03	4.60	5.80	3.3	4.4
Millet	2.87	3.73	3.83	4.73	1.1	2.7
Peanuts	1.81	2.14	1.96	2.13	0.6	0.0
Rice	3.29	5.83	5.85	6.77	2.8	1.6
Sesame	0.80	0.98	0.99	1.20	0.8	2.3
Soybeans	-	2.62	2.81	2.57	-	-0.2
Sugar cane	84.11	81.43	89.53	96,69	-0.1	1.9
Wheat	1.85	3.21	3.76	5.20	2.6	6.2

Source: World Bank calculations.

The second set of factors works in the opposite direction, i.e. reducing land productivity. The major factor here is the deterioration of soil fertility in many areas. This is the result of excessive water application through the widespread use of pumps. This, in turn, leads to high water tables, salinity and waterlogging. The reuse of drainage water and untreated wastewater and the lack of proper maintenance of the drainage network are important factors contributing to the deterioration of soil quality and fertility.

Productivity figures of land and water in monetary terms calculated from farm budget studies indicate that net farm revenue ranged from 342 Egyptian pounds (LE) per feddan for short berseem to LE 2,465 per feddan for tomatoes. The figures also indicate that economic net returns were substantially lower than financial net returns for all crops except cotton. The value added per feddan ranged from LE 295 for short berseem to a high of LE 2,665 per feddan for tomatoes.

TABLE 8. RETURNS FROM LAND
(LE/feddan)

Crop	Net farm revenue	Financial net return	Economic net return	Value added	Water m^3/feddan	Return on water LE/m^3
Sugar beet	487	230	138	954	2 700	0.35
Long berseem	873	803	182	777	1 640	0.47
Short berseem	342	293	-47	295	1 058	0.28
Wheat	783	684	526	1 289	1 590	0.81
Maize	640	490	216	1 034	2 700	0.38
Rice	724	609	35	1 363	8 800	0.15
Cotton	850	737	740	2 073	3 180	0.65
Sugar cane	1838	1 836	-636	1 552	12 000	0.13
Beans	736	628	134	903	1 350	0.67
Tomatoes	2465	2 141	1 480	2 665	3 260	0.82
Oranges	1237	1 237	604	1 433	3 100	0.46
Potatoes	1181	924	362	1 177	2 700	0.44
Sunflower	616	616	199	831	1 000	0.83

Source: World Bank calculations.

The return on water is measured by value added per feddan. This ranges from a low of LE 0.13 per m^3 for sugar cane and LE 0.15 per m^3 for rice to a high of more than LE 0.8 per m^3 for wheat, tomatoes and sunflowers (table 8).

Another way of evaluating the productivity of land and water is to compare the share of each crop in the total value added with its share in the consumption of irrigation water and occupation of agricultural land. For example, sugar cane occupies 4% of total land area, consumes 9% of total irrigation water but contributes only 3% of total value added.

The percentage of land and water needed for tomatoes is 3% for both land and water, but the percentage of total value added is 7%.

The largest consumers of irrigation water are rice, maize, sugar cane, wheat and berseem. However, the main crops occupying agricultural land are wheat, berseem, maize and cotton. Crops with high value added and relatively low use of land and water resources are cotton, wheat and vegetables (table 9).

TABLE 9. ECONOMIC CONTRIBUTION OF MAJOR CROPS

Crop	% of land	% of water	% of value added
Sugar cane	4	9	3
Orchards	10	6	7
Vegetables	4	5	7
Tomatoes	3	3	7
Wheat	17	9	17
Long berseem	13	8	10
Short berseem	4	3	2
Beans	2	1	2
Maize	15	15	14
Rice	8	26	10
Cotton	11	9	14
Potatoes	1	2	2
Other crops	8	4	6
Total	100	100	100

Source: World Bank calculations.

Given the set of costs, prices and policies, Egypt has a strong comparative advantage in vegetables, fruits, cotton and wheat, a moderate comparative advantage in maize, beans, potatoes, long berseem and oil seeds, and a comparative disadvantage in rice and sugar cane, which are water-intensive crops. Clearly, through the application of suitable policies, there is room to introduce changes in the cropping pattern of crops with high returns and low-water requirements, which will increase the value added in the agricultural sector.

2. *Land tenure*

Land tenure is the keystone of agriculture because the form under which land is held has a bearing on the efficiency of farming, investment in agriculture and the mode of land utilization. Furthermore, in

countries where agriculture is predominant, land tenure determines, to a certain extent, the distribution of income and wealth among the population.

In its broadest sense, land tenure means the patterns of land rights. These range from full ownership of land to the right to use land without owning it, and any form of holdings between these two extremes.

In most Middle Eastern countries, land tenure systems are based on the Ottonam Land Code of 1858, which relied heavily on Islamic concepts related to landholding. In these countries historic, economic and political factors were behind the prevalence of several forms of land ownership, such as State land, private land, *waqf* and corporate land and several forms of tenancy including a fixed-rent system and sharecropping.

One of the major components of land policy in the region was land reform and horizontal expansion of agricultural land through reclamation and settlement. In Egypt, land reform was carried out following the 1952 revolution with the objectives of breaking up feudal power and redistribution of land, the main form of wealth in rural areas, in favour of the State and landless farmers. Later, faced with a deteriorating food security situation and a trend towards liberalization of the economy, agricultural policy in Egypt shifted towards emphasizing the growth of agricultural production. Privatization of State farms and allocation of land to private companies and agricultural engineers in the newly reclaimed areas became major elements in the newly adopted land policies. Among the major issues regarding land tenure in Egypt were the size of holdings, land fragmentation and land rents.

The agrarian structure in Egypt is characterized by the predominance of small holdings. According to the 1981/82 Agricultural Census, the number of holdings was 2.47 million and the total area of the holdings 6.6 million feddans. This indicates an average landholding of 2.7 feddans per holder. The distribution of holdings indicates that about 90% of holders are small holders with holdings of less than 5 feddans each. The skewed nature of the distribution of landholdings is manifested by the fact that 58% of the holders have holdings of less than 2 feddans each and the total area of their landholding is less than 18% of the total area. Holders with more than 5 feddans each constitute 10% of the total number of holders but they hold 48% of the total area.

TABLE 10. DISTRIBUTION OF AGRICULTURAL HOLDINGS

Size group (feddans)	Number of holders (in thousands)	% of holders	Area of holdings (in thousands of feddans)	% of the area
Less than 1	796.4	32.3	339.4	5.1
1-2	623.9	25.3	830.1	12.5
2-3	473.0	19.2	1073.1	16.2
3-4	223.2	9.0	722.4	10.9
4-5	107.4	4.3	458.6	6.9
More than 5	244.5	9.9	3 208.9	48.4
Total	2 468.4	100.0	6 632.5	100.0

Source: A. Yamani and Samir Adli, "Some issues on land and water use policies in Egypt", in *Analysis of agricultural policies in Egypt* (FAO and the Egyptian Ministry of Agriculture and Land Reclamation, 1992) (in Arabic).

Land fragmentation is another weakness in the agrarian structure of Egypt. Over time, there have been excessive fragmentation and subdivision of agricultural land. The result was not only smaller holdings but also many holdings composed of several scattered pieces of land. Land fragmentation is associated with various losses and inefficiencies. Among these are the loss of land through allocating parts of it for passages, fences, and irrigation canals. There is also a loss of time in travelling between plots and difficulties in using machinery and other technologies in such an optimal way as to realize economies of scale.

The main cause for land fragmentation is inheritance laws which allow the subdivision of land between heirs. Law No. 178 of 1952, which prevented the subdivision of land below 5 feddans, was practically ineffective in the prevention of fragmentation.

A key issue related to land tenure is tenancy arrangements. Studies on the relations between landowners and tenants showed a wide gap between the amount of land rent obtained by landowners according to the law and the amount determined by the supply of and demand for agricultural land. Substantial areas were rented in the parallel market, i.e., outside the legal system, and rents were much higher than the legal rent. Prior to 1992 land rent was fixed at seven times the land tax. The landowner had virtually no control over rented land since the tenancy contract was passed automatically from tenants to their heirs.

Law No. 96 of 1992 fixed land rent at 22 times the land tax during a transitional period ending in 1996/97.

The law favoured the landowners in the sense that it gave them the right to buy back the contract and for rents after the transitional period to be determined by market forces. This could be viewed as a step forward to realizing more equity, security and efficiency in the holding and utilizing of agricultural land.

Land tenure is the foundation of agriculture. An adequate land tenure system is a prerequisite for agricultural development. In Egypt the majority of farmers have small farms and are illiterate; many of them are under the poverty line. Laws governing land fragmentation and rent control seem to be ineffective in the face of the rapid increase in population and the resulting increase in the demand for agricultural land. An appropriate land tenure policy should concentrate on a comprehensive land consolidation programme in the old lands. This necessitates a massive job-creation programme outside the agricultural sector to absorb the surplus labour stemming from land consolidation.

3. *Environmental issues*

Protection, preservation and development of the main natural resources, water and land, are prerequisites for sustainable development.

The intensification of agriculture and rapid urban development have resulted in serious environmental problems affecting water quality and soil structure and fertility. Since 1960 there has been a fourfold increase in the use of nitrogen, phosphate and potash fertilizers. There has also been a significant increase in the use of pesticides. These chemicals ultimately leach into the water system and affect both surface water and groundwater.

Untreated wastewater discharged in the Nile, irrigation canals and drainage is another cause of water pollution. It is claimed that 90% of wastewater is untreated.[3]

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[3] Biswas, op. cit.

Despite the existence of a law controlling water pollution, its implementation is hampered by the inadequacy of institutional arrangements, availability of adequate funds, trained manpower and sophisticated laboratories for analysis, monitoring, inspection and enforcement requirements.

4. *Risks and uncertainties related to water availability*

There are two major risks and uncertainties associated with the future availability of the Nile Water.

The first is the natural flow régime of the Nile. Given the proposed land reclamation programme (1.4 million feddans) and three possible future climate cycles: typical, drought and extreme drought conditions, water shortages may range between 2%-27% of total water requirements.[4]

The second relates to the international character of the Nile, where nine countries share the Nile basin. Development planning in these countries, especially the Sudan and Ethiopia, is going to have a direct effect on water availability for Egypt in the long run.

5. *Food security*

Food security is a national strategic objective for many countries of the world. However, its precise definition differs from one country to another. It is viewed by some as producing domestically the quantities of certain crops, considered to be strategic, to meet the domestic demand of these crops. By others, it is viewed in a broader context as the ability of the country to secure supplies from domestic as well as external sources to satisfy domestic demand. According to the first view, the main concentration would be on the production of subsistence crops. The second view would entail more reliance on the interaction of free market forces and would result in growing the crops with the highest comparative advantage that would use the scarce resources of the country, especially water, in an optimal way and generate a surplus to pay for the importation of crops in whose cultivation the country does not have a comparative advantage.

During the 1980s there was an increase in the cropped area, from 11.1 million feddans in 1980 to about 12.1 million feddans in 1990, an 8.6% increase. The largest increase was in the area of orchards (83%) followed by winter crops (13.5%) while there was a decline of 1.5% of the Nile crops area. Correspondingly, there was a significant increase in the production of cereals, beans, sugar cane and fruits. There was a drastic 42% decline in the production of cotton. In 1993 there were further increases in the production of most major crops (table 11).

This trend in agricultural production was the result of the reduction of the implicit tax on major crops from LE 5.5 billion in 1985 to about LE 1 billion in 1991 with cotton and sugar cane remaining as the two major crops under price controls and area allotment.

Egypt is a net importer of cereals, wheat and maize. Net imports of these items have increased substantially during the past decade (table 12). At the same time Egypt is a net exporter of rice, vegetables and fruits. The major agricultural exports of Egypt are cotton, oranges and potatoes which account for about 90% of total agricultural exports.

In general, high population growth and the increase in per capita income led to an increase in the demand for food that outstripped domestic supply. Consequently, the agricultural trade balance shifted from

[4] World Bank calculations.

a surplus of US$ 255 million in 1960 to a deficit in the early 1970s which increased to US$ 1,565 million in 1987.

TABLE 11. AREA HARVESTED AND PRODUCTION OF MAIN CROPS

	Area (Thousands of hectares)			Production (Thousands of metric tons)		
	1980	**1990**	**1993**	**1980**	**1990**	**1993**
Cereals	1978	2302	2426	8100	13011	14657
Wheat	587	644	879	1736	4266	4786
Rice	439	413	511	2382	3167	3800
Barley	45	50	104	107	148	119
Maize	792	842	826	3231	4799	5300
Vegetables	na	na	na	7184	8713	9418
Fruits	na	na	na	2371	4131	4750

Source: FAO, AGROSTAT.

TABLE 12. IMPORTS AND EXPORTS OF MAJOR CROPS
(Thousands of metric tons)

	Imports		Exports		Balance	
	1980	**1990**	**1980**	**1990**	**1980**	**1990**
Cereals	5907	8478	112	96	(5795)	(8382)
Wheat	5302	6513	0	4	(5302)	(6509)
Rice	0	4	112	93	112	89
Barley	9	0	0	0	(9)	0
Maize	596	1960	0	0	(596)	(1960)
Vegetables	46	45	93	111	47	66
Fruits	33	3	130	196	97	193

Source: FAO, AGROSTAT.

For most major crops self-sufficiency has, in general, declined over time (table 13).

6. Some economic aspects of land and water

Egypt has invested heavily in land development and irrigation and drainage networks.

(a) Land cost

It is estimated that over LE 3,000 million have been spent on land reclamation since 1952. In successive development plans, the land reclamation share was 40% of the planned investments for the agricultural sector.

The cost of land reclamation ranged from LE 3,000 to LE 7,000 per feddan with an average cost of LE 5,000 per feddan. Annual running cost ranges from LE 200 to LE 400, excluding on-farm cost.

TABLE 13. AGRICULTURAL TRADE BALANCE AND SELF-SUFFICIENCY

	1960	1974	1983	1987
Agricultural trade balance (US$ million) self-sufficiency (%)	225	188	1920	1545
- Wheat	70	37	34	28
- Rice	144	111	101	150
- Sugar	114	96	50	50
- Pulses	92	81	73	78
- Cotton	400	232	170	151
Population Index (1960=100)	100	138	180	195

Source: FAO, AGROSTAT.

(b) Cost of irrigation water

Data on the cost of irrigation water vary according to the individual studies on the subject. Some studies estimated the cost at LE 1.92 per 1,000 m^3. In 1984 the cost of irrigation water in Upper and Middle Egypt was estimated at LE 9.46-18.8 per 1,000 m^3. A later study indicated that the cost ranged from LE 10-20 per 1,000 m^3, the equivalent of LE 80-160 per feddan.[5]

These studies do not indicate the cost components, i.e., whether they include the sum of capital and operation and maintenance costs or just the operation and maintenance costs.

An indication of the marginal cost of water comes from estimates of the cost of water from new water projects and the non-conventional sources of water. The lowest annual cost (which could be interpreted as capital recovery cost) is for the reuse of drainage water for irrigation and rationalization of the use of irrigation water.

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[5] Biswas, op. cit.

The highest is the cost of desalination of water which is 260 times the cost of the lowest priced alternative (table 14).

Cost recovery

Traditionally, irrigation water has been provided free for farmers. The Ministry of Public Works and Water Resources (MPWWR) is responsible for the operation, maintenance and rehabilitation of Egypt's system of irrigation and drainage. Under the old system, (the "old land"), farmers were responsible only for their own *mesqas*, while under the new system (the "new land") tertiary level operation and maintenance costs would be recovered from farmers. Farmers will also contribute to the capital cost of on-farm work. For equity purposes, the contribution of farmers will vary according to their holding status: small holders, graduates and private investors. In addition, farmers are paying for the cost of installing tile drainage, but payments are interest free for 20 years.

TABLE 14. ANNUAL COST PER 1,000 M³ IN 1984 PRICES

Source	**LE**
Upper Nile	7.5
Reuse of drainage water	4.6
Groundwater	19.0
Treated wastewater	32.0
Treated industrial water	45.0
Desalination of water	1200.0

Source: A. Yamani and Samir Adli, "Some issues on land and water use policies in Egypt", in *Analysis of Agricultural Policies in Egypt* (FAO and the Egyptian Ministry of Agriculture and Land Reclamation, 1992) (in Arabic).

It is argued that irrigation water was not exactly a free commodity since agriculture was implicitly taxed through the price mechanism. It is estimated that implicit taxation amounted to LE 5.5 billion in 1985 but was reduced to LE 1 billion in 1991 with price liberalization and cotton as the remaining principal taxed crop.

Although there are political, social and cultural constraints that should be seriously considered before introducing a system of cost recovery and water changes, there is a consensus that such a system is necessary to achieve the following objectives:

(a) Conservation and rational use of land and water resources;
(b) Adoption of optimum cropping patterns;
(c) Generation of revenues for the operation and maintenance of the irrigation and drainage system;
(d) Equitable income distribution;
(e) Protection of the environment.

A comprehensive study on water cost recovery to determine irrigation water cost was carried out in 1992.[6] The objective of the study was to determine the net operation, maintenance and rehabilitation cost of the main irrigation and water supply system in Egypt, as it is currently supported, and what those costs might be under an enhanced or "acceptable" budget allocation. The analysis was limited to the costs of the main system: defined as the Nile River structures and the main and secondary canals but excluding the on-farm portions.

As a methodology, the study provided four scenarios:

1. The current water supply system, which delivers water to old and new lands. This scenario is confined to current budget expenditure on OM & R (operation, maintenance and research).

2. This scenario involves an OM & R policy upgraded to an "adequate" level for long-run sustainability.

3. This is the same as scenario 1 but extended to incorporate new lands.

4. This scenario extends scenario 2 to the new lands.

For each scenario two stages were involved:

1. Estimation of system-wide OM & R costs for all water use sectors. These were obtained from official government expenditures on personnel, recurrent maintenance costs and durable capital investments for the last five years.

2. Cost allocation among water using sectors: irrigation, rural water supply, navigation, hydropower, ground transportation, recreation and tourism, fishery and flood control.

The "Separable Cost-Remaining Benefit" (SCRB) method was used for allocation of costs among sectors. In estimating the benefits for cost allocation, two approaches were used: the incremental net income (with and without project) which was used for crops, and the alternative cost method which was applied to hydropower, water supply and navigation.

The study adopted the following assumptions:

1. A 12% interest rate in real terms was selected.

2. All prices were December 1991 constant prices.

3. Sunk capital investments such as the High Aswan Dam were excluded.

4. The lifetime for durables was 30 years.

5. Economic externalities such as pollution cost were ignored.

The result of the study showed the allocation of annual OM & R costs among the beneficiary sectors for the four scenarios (table 15).

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[6] USAID, Irrigation Water Cost Recovery in Egypt, Determination of Irrigation Water Costs (November 1992).

The study proposed a charging mechanism for irrigation water that involved two instruments: land area (charge per feddan) and volumetric charge (charge per 1,000 m^3).

According to the first approach, the annual cost per feddan ranged from LE 73 to LE 109. This is translated into LE 10 to LE 15 per 1,000 m^3.

TABLE 15. ALLOCATION OF ANNUAL OM & R JOINT COSTS AMONG SECTORS
(In millions of LE and percentages)

Sector	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	LE	%	LE	%	LE	%	LE	%
Old agriculture	461.3	83.1	624.0	78.8	444.8	80.1	595.2	75.2
New agriculture	0.0	0.0	0.0	0.0	37.8	6.8	68.6	8.7
Rural water supply	1.2	0.2	1.3	0.2	1.1	0.2	1.2	0.2
Navigation	27.0	4.9	36.6	4.6	21.3	3.8	28.8	3.6
Hydropower	9.9	1.8	28.8	3.6	7.8	1.4	22.5	2.8
Ground transport	8.7	1.6	11.3	1.4	6.5	1.2	9.3	1.1
River tourism	41.9	7.6	81.4	10.3	31.7	5.7	60.6	7.7
Fishery	1.2	0.2	2.0	0.2	0.9	0.2	1.5	0.2
Flood control	3.8	0.7	6.4	0.8	3.0	0.5	5.0	0.6
Total	555.0	100.0	791.7	100.0	555.0	100.0	791.7	100.0

Source: USAID, Irrigation water cost recovery in Egypt, Determination of irrigation water costs (November 1992).

D. FUTURE POSSIBILITIES AND PRIORITIES

The main issues concerning land and water resources in Egypt can be summarized as follows:

1. A continuous decline in the per capita share of agricultural land and water. This is attributed to the rapid increase in population, and the slowly increasing land and water resources. Along with the horizontal expansion of agricultural land through land reclamation, land is lost through urbanization and excessive application of irrigation water.

2. Deterioration of the environment as indicated by the degradation of water quality. The widespread use of chemicals in the water system and the flow of untreated wastewater into the water system are factors behind water pollution.

3. For sustainable agricultural and economic development and the alleviation of pressure on urban areas, the following should be considered:

(a) **Horizontal expansion of cultivated land** should be carried out through land reclamation and the adoption of an integrated development approach in the new lands.

Detailed studies[7] on land resources in Egypt indicated that total land which can be reclaimed is around 3.45 million feddans subject to the availability of irrigation water. This consists of 2.88 million feddans that can be reclaimed using the Nile waters and 570.000 feddans by using groundwater in Sinai and the New Valley.

On the basis of technical as well as economic considerations, about 1.61 million feddans, mostly the Delta region, should receive priority in the land reclamation programme and this should be completed in the year 2000.

(b) **In the year 2000, it is projected that the demand for water will be around 69.4 BCM**, a 17% increase over 1990. The demand for irrigation water will be around 60 BCM, a 21% increase over 1990, and the demand for municipal water will be around 3.1 BCM, the same as in 1990, but the distribution loss will be reduced from 50% in 1990 to 20% in 2000. The demand for industrial water will be around 6.1 BCM, a 33% increase over 1990 while the demand for navigation water will be reduced to 0.3 BCM, from 1.8 BCM in 1990.

The supply of water is projected to increase to 74 BCM in the year 2000, a 16.5% increase over 1990. The sources of additional water supplies are:

- 2 BCM on completion of the first phase of the Jonglei Canal in the Sudan;
- 2.3 BCM from the reuse of drainage water;
- 2.3 BCM from groundwater in the Delta and Valley aquifers and 2 BCM from deep aquifers in the eastern desert saved.
- 1 BCM from improved management of water in the conveyance and distribution systems (table 16).

(c) **Introduction of efficiency-enhancing measures and technologies** should be carried out.

(d) **A comprehensive system of cost recovery and water charges** consistent with the long-run objective of growth with efficiency and equity should be introduced.

(e) **A system of environmental impact assessment** should be introduced as an integral component of each project.

(f) **Future water supply from the Nile should be secured** through negotiating agreements with the nine riparian countries.

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[7] Biswas, op. cit.

TABLE 16. SUPPLY AND DEMAND FOR WATER IN 2000

Supply	BCM	Demand	BCM
River Nile	57.5	Irrigation	59.9
Groundwater valley	4.9	Municipal	3.1
Desert	2.5	Industrial	6.1
Agricultural drainage water	7.0	Navigation	0.3
Treated sewage effluent	1.1		
Improved water management	1.0		
Total	74.0		69.4

II. DEVELOPMENT OF LAND AND WATER RESOURCES IN JORDAN*

A. BACKGROUND

Jordan is a small country classified by the World Bank as a lower-middle-income economy, covering an area of 9.25 million ha situated near the south-eastern coast of the Mediterranean. The population is approximately 4.1 million (1992), with a 3.4% annual growth rate.[1] Water resources availability influenced the population distribution and settlement patterns of the country. Currently, around 90% of the population live in the north-west quadrant of the country where most of the rainfall and water resources are located.

The country can be divided into three physiographic regions, each with a distinct climate. First, there are the Highlands which comprise mountainous and hilly areas that run from north to south. Their altitude varies from 600 to 1,600 metres above sea level, and the climate is generally wet and cool. Fruit trees, vegetable and cereals are planted in the highlands. Secondly, the Jordan Valley, which, as part of the Great Rift, runs down the entire length of the country. The Jordan River Valley lies between 200 - 400 metres below mean sea level and stretches 104 km from the Yarmouk river in the north to the Dead Sea in the south. With a favourable climate, the Valley serves as a greenhouse that makes agricultural production possible almost all year round. The Jordan River Valley has fertile soil and is relatively rich in water resources. Thirdly,the Desert region in the east, an extension of the Arabian Desert, forms nearly two thirds of the country.

B. DEVELOPMENT OF LAND AND WATER RESOURCES

Securing a reliable supply of water resources, adequate in quantity and quality, is the most challenging issue in Jordan. The past two decades have witnessed a dramatic increase in the attention given by government policy makers and planners to the issue of sustainable development of the land and water resources. Not only is the present supply of cultivable land limited, but so also is its potential expansion. Today, most lands with suitable soil and sufficient precipitation have been utilized. The Government initiated a programme to expand the cultivation of hilly areas in order to increase agricultural land and to prevent soil erosion. The programme provides farmers with soft loans and expertise.

Population growth is the main driving force behind water and land resources development. From 1948 to 1992 Jordan's population increased from less than 1 million to more than 4 million because of natural growth and forced migration from Palestine. The country became more urbanized over the same period. This rapid rate of population growth and urbanization, along with substantial improvements in the standard of living, imposed tremendous pressures on the scarce water resources. Encroachment on the limited cultivable land by urban areas further reduced the per capita share of productive land resources. Loss of a substantial portion of the country's shares in the Jordan and the Yarmouk rivers contributed to a state of water stress. In 1948, for example, the per capita share of agricultural land was slightly in excess of 0.4 ha, mostly rain-fed, but that share dropped to about 0.1 ha in 1992. Because of variability in rainfall intensity and timing, about half of the rain-fed lands are cultivated each year. The per capita share of renewable water resources was in excess of 3,400 m^3 in 1948, but dropped to less than 205 m^3 in 1992.

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* This case-study was prepared by Ali Ghanzawi, Economist with the Royal Scientific Society, Amman. The views expressed in the case-study are those of the author and do not necessarily reflect the views of the United Nations Secretariat.

[1] Department of Statistics, *Annual Statistical Yearbook, Hashemite Kingdom of Jordan* (Amman, 1992).

During the period 1973-1992, Jordan's total investment in the water sector exceeded 650 million Jordanian dinars (JD): 58% was devoted to the comprehensive development of the Jordan Valley and Southern Ghor,[2] and more than 45% of that was allocated to the development of water resources and the expansion of the irrigation and municipal water systems. The institutional set-up has been the creation of the Jordan Valley Authority (1977) and its predecessor the Jordan Valley Commission. The Jordan Valley Development Law was enacted in 1977 and modified in 1988 when a Ministry of Water and Irrigation was established.

Indeed, the most accessible and lowest cost sources of water in Jordan have already been used. For example, it used to cost JD 570 to develop one hectare of irrigated land in the Jordan Valley in the mid-1960s. However, this increased to about JD 1,800 per hectare in the late 1980s. The operation and maintenance costs for irrigation projects have also risen steadily over the past 30 years.

1. Land resources

About 249,700 ha of the total area of Jordan is utilized annually for cultivation, of which 75% is rain-fed and the remaining 25% is irrigated.[3] Presently there are 34,480 ha developed for irrigated agriculture in the Jordan River Valley and the Ghor south of the Dead Sea (Southern Ghor), and the remaining irrigated areas have been developed in the Highlands. However, as a result of water shortages brought about by upstream diversions of the Yarmouk river water, about one sixth (6,000 ha) of the land developed for irrigation in the Jordan River Valley is partially utilized for winter cropping.

Unfortunately, only 86% of the area's cultivable land was utilized in 1991 (61% with fields crops, 25% with fruit trees, and 14% with vegetables [see table 17]). This underutilization of the cultivable land was due to water shortages for the irrigated land and inadequate rainfall for the rain-fed land. In addition, the high cost of agricultural inputs and unstable markets discouraged some farmers from the full utilization of the cultivable land.

Two other major factors (in addition to the availability of irrigation water resources) are influencing the development of land resources in Jordan: land fragmentation and urbanization. The partitioning of lands through inheritance is causing severe fragmentation of the holdings in the Highlands. In the Jordan Valley farms, however, fragmentation has been constrained by the law. Urbanization, however, is regarded as a twin of desertification as more good cultivable land with more than 300 millimetres (mm) annual rainfall is lost to it. Construction of buildings, roads and parking lots not only took out of agricultural production good fertile lands, but also hampered the natural recharge rates of valuable groundwater aquifers. Presently, 32% of the population live within the Greater Amman area. Rapid urban expansion has also raised land prices and rendered cultivation an undesirable option for land use. According to the records of the Ministry of Municipalities, Rural Affairs and the Environment, the Irbid Governorate, the second in population in the Kingdom, lost more than 30,000 hectares of its agricultural land in the past three decades to the Greater Irbid expansion.

In view of the special importance of the Jordan Valley in terms of its development potential for expanding and diversifying agricultural production, the Government of Jordan decided to develop this region on an integrated basis (see box 1). Modern planning for the development of water resources of the Jordan Valley started at the turn of the century. Several technical and economic feasibility studies, which were

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[2] Based on information supplied by the Jordan Ministry of Water and Irrigation.

[3] Ibid.

conducted starting in 1952, proved the viability of developing water resources available in the Jordan Valley basin and their harnessing for irrigation purposes. A total of 36,400 ha were found arable in the East Jordan Valley, as were about 16,000 ha in the West Jordan Valley.

Box 1. **Jordan Valley Development Law**

An Authority known as the Jordan Valley Authority shall be established and shall undertake the following:

1. The development of the water resources of the Valley and utilizing them for purposes of irrigated farming, domestic and municipal uses, industry, generating hydroelectric power and other beneficial uses; also their protection and conservation and the carrying out of all the works related to the development, utilization, protection and conservation of these resources.

2. Develop and improve the environment and living conditions in the valley and carry out related works.

3. Planning, design and construction of road networks including highways and village and farm roads.

4. Development of tourism in the Valley, delineation of areas having special features which can be developed for touristic and recreational purposes and the development of these areas and the construction of touristic and recreational facilities on these areas.

5. Development of the social status of the Valley's inhabitants including the establishment of private local institutions in order to help them actually contribute to the development of the Valley.

Source: Ministry of Water and Irrigation Law No. 19 of 1988, Jordan Valley Development Law.

On the basis of these studies, a master plan for the development of the Jordan Valley was prepared in 1955.[4] Until 1973 development focused on water resources and irrigation as compared with other sectors. Since then, a social and economic development approach has been adopted, resulting in immense gains.[5]

(a) Agricultural production

Jordan's agricultural sector plays a significant role in the economy, representing about 8% of GDP and 15% of the country's exports earnings, and employs a little more than 10 % of its labour force.[6] Agricultural output has grown rapidly in Jordan during the past two decades. This is attributable to the expansion in irrigation systems, using more fertilizer and other modern inputs. In 1991 the country's total

[4] Early work for the development of the Jordan Valley was done by a joint venture between the United States-based firms Harza Engineering Co. and Michael Baker Inc.

[5] "The Jordan Valley, 1973-1987, A Dynamic Transformation", a study conducted for the United States Agency for International Development, 1987.

[6] Central Bank of Jordan, *Monthly Statistical Bulletin*, vol.28, No.12, December 1992.

agricultural production was estimated at 695,168 tons of vegetables, 284,484 tons of fruit and 119,616 tons of field crops. Although the Jordan Valley represents a rather modest share (15%) of the cultivated area of the country, its contribution to agricultural GDP, value added off-farm, and agricultural exports is much greater. In 1991, its share in total production amounted to 70% of vegetables, 66% of fruits, and 11% of field crops. This was mainly due to the natural greenhouse conditions prevailing in the Jordan Valley and a high productivity per hectare. As shown in table 18, the Jordan Valley's average fruit production was five times greater than the Kingdom's average, and three times greater than the average vegetable production.

TABLE 17. JORDAN'S CULTIVATED LAND AREA, 1988-1991 (ha)

Region	Fruit trees	Field crops	Vegetables	Total	%
1988 Kingdom Jordan Valley and Southern Ghor	 54 091 7 184	 140 650 5 064	 28 000 19 202	 222 739 31 452	 14.1
1989 Kingdom Jordan Valley and Southern Ghor	 54 358 7 399	 103 356 2 846	 22 358 15 624	 180 073 25 869	 14.4
1990 Kingdom Jordan Valley and Southern Ghor	 54 547 7 523	 128 901 4 417	 28 841 20 339	 212 288 32 404	 15.3
1991 Kingdom Jordan Valley and Southern Ghor	 54 914 7 638	 131 405 4 724	 28 969 20 501	 215 287 32 863	 15.2

Source: Department of Statistics, Annual Agricultural Statistics, 1988-1991, Amman.

TABLE 18. AGRICULTURAL PRODUCTIVITY IN JORDAN, 1991 (ton/ha)

Crops	Kingdom	Jordan Valley and Southern Ghor	Jordan Valley and Southern Ghor production as % of Kingdom
Fruit trees	4.55	24.5	65.7
Field crops	0.88	2.72	10.8
Vegetables	14.05	23.7	69.9

Source: Department of Statistics, Annual Agricultural Statistics, 1991 (Amman).

Despite the substantial development of the land and water resources of Jordan, the goal of self-sufficiency was only partially met. Owing to the rapid population growth, the per capita share of cultivable rain-fed areas decreased from 0.35 ha in the early 1960s to less than 0.1 ha in 1992, which induced increasing dependency on food imports.

In turn, the average per capita food production growth rate index registered a negative 1.2 (1979-1981 = 100).[7] A good portion (40%) of Jordan's net food imports is composed of cereals. At the same time, Jordan's imports of cereals increased sharply and reached 1,539 metric tons, representing an increase of about 300% within only one decade.[8] Furthermore, food aid in cereals was 14% of Jordan's 1980 cereals imports bill and gradually increased to about 30% in 1991. Between 1988 and 1990, Jordan achieved only 9.4% and 16.2% self-sufficiency in cereals and wheat production respectively. In 1991, Jordan's total imports exceeded $2,507 million, of which 26% was the share of food imports: this meant an average of $146 per capita food imports compared with $107 for the whole Arab region that year. This means Jordanians paid 14% of their GNP in 1991 to import the necessary food requirements. Additionally the Kingdom's average food imports dependency ratio (ratio of food imports to consumption) is the highest in the Arab region. The ratio reached 87.2% during the period 1980—1990, in comparison with 61% between 1969 and 1971.[9]

(b) Precipitation

The annual average rainfall in the country is about 8.5 billion m^3, and it ranges from a minimum 6 billion m^3 in dry years to over 12 billion m^3 in wet years.[10] More than 85% of the rainfall is lost to evaporation and only 5% recharges underground aquifers. Annual precipitation ranges from less than 100 mm per year in the desert region to over 500 mm per year in the north-west tip of the country.[11] Table 19 shows that only 8.6% of Jordan's territory receives an average precipitation in excess of 200 mm/yr and some 91.4% of the country receives less than 200 mm of rainfall annually, insufficient for most rain-fed agriculture.

Rainfall is a crucial factor in determining the size of the land in the country that can be cultivated annually. Over the last 10 years, annual rainfall varied from year to year. Such variations have significant implications for planning and management of the land and water resources. Rainfall fluctuation is also a key factor for farmers in planning their forthcoming agricultural season. Rain shortfalls reduce the rain-fed agricultural yields, reduce the supply of irrigation water, and also reduce cultivated areas by making it necessary to leave land fallow during the summer season planting and in some cases during the winter cultivation period. Furthermore, restraints are imposed upon farmers with regard to the type of crops to be grown in irrigated areas and the cropping intensity therein. Agricultural experts in Jordan started working on the assumption of two dry years in every four years in order to balance development with the realities of a dry climate.

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[7] The World Bank, *World Development Report 1993.*

[8] Ibid.

[9] Ibid.

[10] Jordanian Ministry of Water and Irrigation, unpublished report (Amman).

[11] National Geographic Center, Amman, Jordan.

TABLE 19. CLASSIFICATION OF JORDAN'S LAND

Region	Average rainfall	% of the total area
Arid-desert	Less than 100	81.0
Desert	100 - 200	10.4
Marginal	200 - 300	5.7
Semi-arid	300 - 500	1.8
Semi-wet	More than 500	1.1
Total		100

Source: Jordanian Ministry of Water and Irrigation, unpublished files.

2. *Water resources*

Jordan has been witnessing a substantial imbalance in the population-water resources equation. Not only have deficits in the foreign trade of agricultural commodities been chronic over the past three decades, but also the ability to supply urban water has been impaired. This imbalance in the population-resource equation has triggered a chain of adverse impacts. The per capita share of water has been decreasing in parallel with the rapidly increasing population. Consequently, rationing of water supplies has been the general practice for many years. In many groundwater aquifers, the water extraction rate considerably exceeded the replenishment rate of these aquifers. Expensive interbasin transfers of water have been customary since the late 1970s to cope with the rapidly escalating municipal and industrial demand. Water reallocation has been carried out, and irrigation water was diverted for municipal and industrial purposes and was only partially replaced with treated municipal wastewater.

In 1992, the total water supply for various uses of surface, ground and wastewater resources was about 950 MCM.[12] It is worth mentioning here that 1991/1992 was an unusually wet year, and water use then was above average. Usually, the available water resources are not sufficient to meet the demand. In order to meet the increased demand, the country had to exceed the groundwater safe yield by 172 MCM in order to compensate for shortages.

Surface water capacities in Jordan are estimated at 692 MCM per year, of which only 55% were utilized in 1992. Because of aridity in the eastern, south-eastern and southern basins, and because of other economic constraints, about 475 MCM of these water resources can be developed economically. The main sources of surface water in Jordan are:

Flood water: Estimated to be 334 MCM, of which only 110 MCM can be stored annually owing to the above reasons.[13]

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[12] Ministry of Water and Irrigation, unpublished report (Amman).

[13] "Jordan River Basin Management Study", a study conducted for the World Bank by the Regional Office for Integrated Development, December 1993, to be published.

River baseflow and spring water: Estimated at 358 MCM, to which the Yarmouk River contributes an estimated average of 165 MCM.

Groundwater: In 1992, the Kingdom extracted 514 MCM from its groundwater resources generated from the following sources:

Renewable: The safe yield of this source is estimated at 277 MCM/yr. However, in 1992, more than 443 MCM/yr were pumped, with seven aquifers overpumped by an amount of 197 MCM, an overextraction of 180% above their safe yield. The danger inherent in such practices to the sustainability of water resources is not a secret.

Non-renewable: The estimated annual yield of the fresh fossil aquifer is about 143 MCM/yr and can be sustained for 100 years. In 1992, only 71 MCM were pumped from this aquifer. Groundwater pumped from renewable and non-renewable resources comprised 54% of the total flow utilized in 1992.

Irrigation in the highlands depends primarily on groundwater, which is utilized by the private sector under government licence. This explains the high rate of groundwater usage. Jordan's efforts to impound the Yarmouk river floods and to regulate its flow have not been successful because of the complicated riparian issues. Such regulation would have increased the availability of surface water for various uses. The Water Authority of Jordan has initiated a programme to monitor, measure and control the pumping of groundwater.

Treated wastewater: Now considered an important water resource in Jordan's water strategy, treated wastewater is already used to replace a portion of irrigation water that has been diverted to municipal and industrial uses. In 1992, more than 55% of the population of Jordan was served by wastewater collection networks and treatment systems. Fourteen treatment plants have been built and are in operation[14] with over 52 MCM of treated wastewater outflow that conforms more or less to the World Health Organization's guidelines for reuse of treated wastewater for irrigation.[15] The majority of the treated wastewater is being used in irrigated agriculture. This 52 MCM of treated wastewater was equivalent to more than 25% of the municipal water consumed in 1992. The treatment and reuse of this vital resource is well recognized by the water resources planners, and future plans aim at improving the quality and expanding the reuse of treated wastewater. The benefits to public health, the environment and the social and economic benefits of wastewater treatment and reuse all justify the undertaking, given the water scarcity in the country.

C. WATER USES

Several factors influence the consumption of water resources in Jordan. The first factor is population growth: water shortages in Jordan resulted mainly from the imbalance of the population-natural resources equation. Since 1948, the Kingdom hosted three waves of refugees which have resulted in an average growth rate in excess of 7.5%, more than double the natural growth rate of 3.4%. This imposed high pressure on the water resources.

[14] Ibid.

[15] The As-Samra treatment plant serving Amman, Zarqa and environs needs upgrading badly. Designed to treat 68,000 m^3 per day, it is being operated at a flow in excess of 125,000 m^3 per day.

The second factor is economic development: water is an indispensable input in almost all economic activities. Economic and social development over the past three decades, as manifested by expansion in manufacturing, transport, mining, construction, irrigated agriculture and other sectors, contributed to the high rate of increase in water consumption. In 1991, for example, more than 7 million square metres of buildings were under construction as a result of an increasing demand for real estate in the country generated by the returnees from the Gulf.[16]

The third factor is urbanization: high standards of living and the search for higher living standards (migration from the rural areas to urban centres) are conducive to increased water consumption. It is worth noting that, with the exception of the Jordan Valley, the country witnessed a rural migration to its urban centres mainly because of those seeking job opportunities.

Table 20 outlines the water resources and their sectoral distribution in 1992.

TABLE 20. WATER RESOURCES AND CONSUMPTION BY SECTOR, 1992
(in MCM)

Sector	Source			Total	%
	Surface	Ground	Wastewater		
Irrigation	318	332	50	700	73.7
Industrial	3.0	30	2	35	3.7
Municipal	59	147	-	206	21.7
Livestock	4	5	-	9	0.9
Total	384	514	52	950	100

Source: Jordanian Ministry of Water and Irrigation, unpublished files.

1. Municipal uses

More than 97% of the Kingdom's population is served by municipal water networks, and a total of 206 MCM was pumped in the water networks in 1992.[17] This translates into a per capita share of 50 m^3 (136 litres per capita per day [l/c/d]). The percentage of "unaccounted for" water was a high 56% that year, of which an estimated average of 30% was attributed to leakage from the networks. The actual consumption of domestic water per capita was therefore 35 m^3 (96 l/c/d), less than half the recommended average of 73 m^3 per year (200 l/c/d).

The higher cost of municipal water supply averages about JD 0.5/m^3 (from the Jordan Valley to Amman). Compared with an acceptable leakage of 10% from the networks, the estimated leakage of Jordan's networks wasted 41.2 MCM over the accepted average. Although it is argued that this leakage recharges groundwater aquifers, it is definitely a very expensive way of aquifer recharge. The annual cost

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[16] Ministry of Public Works and Housing, Amman, Jordan.

[17] Jordanian Ministry of Water and Irrigation, unpublished report, Amman, Jordan.

of excess leakage is about JD 20 million, enough to finance the replacement of a substantial portion of the old leaking networks.

By the year 2010, it is estimated that the municipal water demand will reach 489 MCM with an average service of 225 l/c/d inclusive of a 20% leakage rate. This requires preparation for a high degree of efficiency in municipal water management, and for increasing the allocation of water to municipal uses at acceptable rates per capita.[18] Plans to develop the water resources for municipal uses must take into consideration such important factors and should focus on wastewater treatment and reuse.

2. Industrial uses

About 4% or 35 MCM of the total amount of water consumed in Jordan was utilized by the industrial sector. The bulk of this quantity was consumed by large-scale industry such as the Jordan Petroleum Refinery, the King Hussein Thermal Power Station, and phosphate and potash mines. By the year 2010, as a result of expansion in this sector, the share of the industrial sector will increase to reach 140 MCM.

3. Livestock uses

Presently there are 23 livestock farms and 345 dairy farms operated in Jordan. Livestock consumed around 9 MCM of water in 1992 to sustain 28,900 cattle, 19,950 goats and 1,523,000 sheep.[19]

4. Irrigation uses

Irrigated agriculture is an important sector in the economy of Jordan. Expansions in public irrigation in the Jordan Valley and private irrigation in the Highlands have been a major achievement in Jordan during the last two decades. Over that period the area under irrigation in Jordan more than quadrupled. In the early 1970s the irrigated area was about 12,000 ha and in 1992 it exceeded 61,700 ha.

Irrigation played a crucial role in the development of the agricultural sector in Jordan. Irrigated agriculture helped compensate for the shrinking per capita share of rain-fed land, and allowed the cultivation of marginal land by using modern irrigation techniques.

Irrigation water requirements in 1992 amounted to 800 MCM, of which 505 MCM were needed to irrigate 36,100 ha in the Jordan Valley and Southern Ghor (see box 2) and 495 MCM to irrigate 27,220 ha in the Highlands. But, in 1992, this sector was supplied with 700 MCM. This amount of water was used to irrigate only 55,700 ha, of which 28,480 ha were in the Jordan Valley and Southern Ghor.[20] This meant that part of the irrigated area was left fallow, that the cropping intensity was reduced and crops were receiving less than the optimum amount of water. It is worth noting that in 1992 only one half of irrigation water for the Jordan Valley and Southern Ghor were billed; the other half was considered as follows:

- 7.6% as total spilled
- 28.6% as normal losses in the system
- 13.1% as unaccounted for water.

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[18] "Jordan River Basin Management Study", conducted for the World Bank by the Regional Office for Integrated Development, December 1993.

[19] Ministry of Agriculture, Amman, Jordan.

[20] Jordanian Department of Statistics, Annual Statistical Yearbook, 1991, Amman.

This situation requires greater management skills with regard to the water resources , improvement of the irrigation networks, and enhancing the water storage capacity to reduce spills.

Box 2. Perennial trees

Perennial trees are considered high value crops in Jordan, and farmers tend to prefer to plant them. This may be attributable to the market stability of fruits and to other social values. In 1991, the perennial trees in the Jordan Valley and Southern Ghor (mainly citrus and banana):

. Occupied 22% of the Valley's irrigated area.
. Consumed 41% of the Valley's irrigation water.
. Contributed 35% of the Valley's irrigated produce value.*

and displayed the following indicators:

. Every thectare cultivated with perennial trees consumed an average 1,279 cubic metres of irrigation water.
. Every cubic metre of irrigation water consumed by irrigated perennial trees yielded 444 fils (gross revenues).
. Every hectare cultivated with perennial trees yielded JD 5,680 (gross).

* About 70% of the Valley's perennial trees were bearing fruit in 1991.

Furthermore, the average irrigation water consumption in the Jordan Valley and Southern Ghor is about 9,445 m^3/ha/yr, which is about half the Highland average consumption of 15,834 m^3/ha/yr. This may be due to the fact that 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 (see table 21).

TABLE 21. AVERAGE IRRIGATION WATER CONSUMPTION BY REGION

	Consumption (MCM)	Area* (ha)	Water (m^3/ha)
Jordan Valley and Southern Ghor	269	28 480	9 445
Highland	431	27 220	15 834
Total	700	55 700	12 567

Source: Department of Statistics, Annual Statistical Yearbook 1991, Amman, Jordan.

* In addition, 6,000 ha were developed in the Jordan Valley but not cultivated because of water shortages.

As a result of acute water shortages in the dry season, especially in the Jordan Valley and Southern Ghor, the cropping intensity had to be reduced. In addition, rigid government restrictions are imposed on the planting of trees and other summer crops to save water for the existing trees.

(a) Organization of irrigation

Irrigation development in Jordan is shared between the Government and the private sector. Through government agencies organized for the purpose, surface water flows are regulated through storage dams and associated hydraulic structures and irrigation networks are built. In areas thus developed for irrigation, legislation on land redistribution regulates the allocation of irrigated farms. The owner of the land prior to the irrigation retains part of his holding, and the remainder is allocated to farmers with small holdings and to landless farmers. Through the Jordan Valley Authority, now a part of the Ministry of Water and Irrigation, the Government developed 22,000 ha of new land and replaced the surface irrigation networks with pressure pipes for about 6,000 ha of land, and will do the same for another 5,000 ha. Dams with an aggregate storage capacity of 110 MCM have been built. The Jordan Valley Authority is responsible for the maintenance, replacement and operation of the irrigation systems up to the farm gate. On-farm responsibilities are borne by the farmers.

The private sector undertook the responsibility of developing irrigation outside the Jordan Valley. With drilling permits issued by the Water Authority of the Ministry of Water and Irrigation, the private farmers bear the cost of well drilling and the installations needed to abstract the groundwater and to distribute it through the on-farm irrigation systems. Each is to abide by the abstraction rate as specified in the drilling permit, and is responsible for the maintenance, replacement and operation of his installations.

(b) Water pricing and cost recovery

Prior to the development of the Jordan Valley, farmers distributed the water among themselves according to tribal water rights and Islamic law with no charge. In 1961 the first irrigation water tariff was introduced in the Jordan Valley at a fixed rate of 1 fils per m^3, and modified in 1966 to 1 fils/m^3 for the first 1,800 m^3 and 2 fils/m^3 above that quantity.[21] The tariff was increased in 1973 to 3 fils/m^3 regardless of the quantity of irrigation water consumed, and in 1989 the price was doubled; it is scheduled for a further increase, probably 10 fils/m^3, under the economic adjustment programme. Table 22 shows the development of the irrigation water tariff.

Several studies conducted on the production cost of the irrigation water in the Jordan Valley concluded that the current tariff charged is not even covering the cost of operation and maintenance. This implies that irrigation water is subsidized and that there is no cross subsidy as there is for the municipal and industrial water tariff, whereby the biggest water consumers subsidize the smallest consumers. In 1992, the Government contributed JD 1.44 million in subsidies to cover the cost of the irrigation water supply. Furthermore, the cost of operation and maintenance was estimated at JD 2.18 million (150 MCM of irrigation water was sold) and only JD 900,000 or 41% of the cost of operation and maintenance was collected from farmers in the same year.[22]

A recent study conducted on the cost of irrigation water in the Jordan Valley concluded that the cost depends on the quantity of irrigation water sold to farmers which also depends on fluctuations in rainfall.

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[21] Ministry of Water and Irrigation, Jordan Valley Authority open files, Amman, Jordan.

[22] Ministry of Water and Irrigation, Jordan Valley Authority, Amman, Jordan.

To estimate the cost of irrigation water, the capital and operation and maintenance costs were incorporated in the calculations. The estimated cost (capital + operation and maintenance) in a dry year, when only 100 MCM/yr of irrigation water was sold, was 59.8 fils/m^3, of which 17.4 fils was for operation and maintenance. In a wet year, when an average 175 MCM were sold, the cost decreased to 37.5 fils/m^3, of which 9.9 fils covered operation and maintenance (see table 23).

TABLE 22. DEVELOPMENT OF IRRIGATION WATER TARIFF

Year	Fils/m^3	Notes
1961	1	Fixed
1966	1	First 1,800 m^3
	2	1801 m^3 and more
1974	3	Fixed
1989	6	Fixed
1994	(10)	Planned

Source: Ministry of Water and Irrigation , Jordan Valley Authority files; and private communications.

TABLE 23. AVERAGE COST OF IRRIGATION WATER IN THE JORDAN VALLEY

Item	Dry years	Wet years
Water sold	100 MCM	175 MCM
Total cost	59.8 fils/m^3	37.5 fils/m^3
Operation and maintenance cost	17.7 fils/m^3	9.9 fils/m_3
Subsidy	53.8 fils/m^3	31.5 fils/m^3

Source: Ministry of Water and Irrigation, 1991, Amman, Jordan.

Jordan invested JD 380 million in the comprehensive development scheme of the Jordan Valley and Southern Ghor, of which JD 127 million was for the development of irrigation projects.[23]

As for the irrigation water in the Highland, water is drawn from the wells at no charge other than the pumping cost. The estimated cost of pumping one cubic metre in the Highland, which includes operation and maintenance, is about 50 fils irrespective of volume.

The combination of the high capital costs of new development of irrigation projects and their running costs is the major problem facing the irrigation sector. Opponents of the irrigation sector have cited the issue of cost recovery (fee structure to cover the cost of providing a service) as an obstacle to the further development of this sector, and have proposed reallocating the water resources of the country by diverting part of this sector's water for municipal and industrial purposes.

[23] J.Price Gitinger, *Economic Analysis of Agricultural Projects* (EDI-The World Bank), p. 223.

The economic and social and environmental costs of such a proposition should be adequately assessed before it is taken into consideration. A water charge sufficient to cover the operation and maintenance cost of delivery should be assessed in the irrigation projects. The capital cost is assumed to be offset by the indirect benefits to the national economy that accrue from irrigated agriculture.

(c) Types of irrigation networks

Irrigation networks in the Jordan Valley primarily off-take from a main carrier, the King Abdallah Canal fed from the Yarmouk River, and from several side wadis, some of which have storage dams. Some areas are irrigated independently from the Canal, especially south of the Dead Sea (4,800 ha), as well as 3,700 ha north of the Dead Sea. Irrigation networks are primarily pressure pipe networks that maintain a pressure of 2 to 3 atmospheres at the farm gate. By 1995, all networks in the Valley, with the exception of the King Abdallah Canal itself, will be pressure pipe networks that maximize water conveyance and distribution efficiency.

Outside the Jordan Valley, piped conveyance of irrigation water has been replacing the surface canals (earth or concrete-lined), and on-farm networks are being integrated with these piped systems, a conversion prompted by the desire of farmers to achieve the highest output from water that their financial capabilities allow.

On-farm irrigation systems range from the surface farrow and basin methods to the more advanced systems of drip irrigation techniques. Since the introduction of drip systems in 1974, they have been widely adopted by farmers in the Valley and outside. Management of on-farm irrigation systems is the farmer's responsibility, and management of the networks is the responsibility of the developer, the Jordan Valley Authority for Government-built projects and the private sector elsewhere. Rationing of irrigation water is frequent, especially in drought years, and is done throughout the dry months in the Jordan Valley with the expansion in perennial cropping.

D. WATERLOGGING AND SOIL SALINITY

Of the total land area currently irrigated, around 1,500 ha located in the Jordan Valley and Southern Ghor are affected by waterlogging. The majority of the problem could be overcome by the construction of subsurface drainage networks to drain the water into natural wadi beds that discharge into the Jordan River and to the Dead Sea.[24] Soil salinity is caused by a combination of poor drainage and high evaporation rates that concentrate salts on irrigated land, especially in arid and semi-arid countries. Salinity existed in some of the Jordan Valley soils, and has been or is being treated by over-application of irrigation water in winter for leaching purposes. During the process, no major problems of waterlogging have been observed.

The major degradation in water quality since 1977 has taken place in the Zarqa River, in the catchment of which more than 30% of the country's population live, and the majority of its manufacturing industries are located.[25] Municipal and industrial wastewater are being treated in a major treatment plant at As-Samra, and the effluent is discharged into the Zarqa River regulated by the King Talal Dam. In 1990, the Government issued a closure order for more than 40 industries because their wastewater was discharged in

[24] Munther J.Haddadin, *Progress in the Implementation of the Mar del Plata Action Plan* (United Nations Department of Technical Cooperation for Development, 1990).

[25] Ibid.

the wastewater collection network and caused pollution of the water in the King Talal Reservoir.[26] On-site treatment facilities for the wastewater had to be installed.

On the one hand, the increased abstraction for municipal and industrial water use from the aquifer that feeds the base flow of the Zarqa River dried up many of its springs, On the other hand, the flow of the wastewater from the Amman - Zarqa populated area and its industries into the River partially replaced the flow of the springs but did not mitigate the environmental consequences. Treatment of wastewater by stabilization ponds did little to eliminate the non-degradable detergents, and local treatment of industrial effluent has not been effective enough to remove all hazardous pollutants.

The Zarqa River pollution problem is monitored carefully, but action is still needed to protect the water quality of this water source, considered pivotal in the development of irrigated agriculture is the Jordan Valley.[27] Salinity of irrigation water in the Jordan Valley increases in the summer months, especially because of the Zarqa River waters that are the sole source of summer irrigation for about 6,000 ha. Winter irrigation from the Yarmouk helps to bring much better quality water, and additional quantities are served to the farms (free of charge) to leach summer salinity.

More recently, funds have been allocated to upgrade the performance of the wastewater treatment plant and to expand it. It is now overloaded, operating at about double its design capacity, and the quality of the effluent leaving the plant is substandard.

The above issues affect the sustainability of irrigated agriculture in the Jordan Valley, and have to be addressed before they get much worse.

E. PRESENT AND FUTURE DEMAND FOR WATER

Jordan's water balance suffers from a chronic deficit as a result of a demand which has been greater than the available resources, and the gap between demand and supply is widening. While demand increases for food production and for municipal and industrial purposes, the availability of water resources decreases. Between 1991 and the year 2005, water demand is projected to increase by 50%. In the same period the deficit is projected to increase by 78%.

Projections for municipal water demand for the year 2000 corresponding to a population of 5.3 million people will be around 350 MCM. Industrial water demand that year will amount to 150 MCM. Municipal and industrial demand thus totals 500 MCM, or 66% of the total renewable water resources that can be economically developed. This projection adopts a per capita share of 65 m^3, which is below the recommended 73 m^3.

As for irrigation uses, the demand is expected to increase from 800 MCM to 1,088 MCM in the year 2000. The irrigation water actual requirements assume the utilization of arable lands in the Jordan Valley and Southern Ghor, and about 2,000 ha in Wadi Araba. This demand has to be reduced by increasing efficiency, and a conjunctive use pattern between surface, ground and treated wastewater resources has to be devised.

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[26] *Jordan Times*, 19 July 1991, Amman.

[27] Ibid.

TABLE 24. JORDAN WATER BALANCE (MCM)

	1991	*1995*	*2000*	*2005*
- Supply	776.5	818.5	973.5	973.5
- Surface	321	400	555	555
- Renewable	277.0	277.0	277.0	277.0
- Non-renewable	143	143	143	143
- Treated wastewater	37	52	66	90
- Demands	1 098	1 449	1 548	1 638
- Agricultural[a]	800	1 088	1 088	1 088
- Industrial	43	61.5	101	124
- Municipal[b]	255	300	359	426
Balance(deficit)	(321.5)	(579)	(508.5)	(574.5)

Source: Ministry of Water and Irrigation, unpublished files.

[a] Assuming the utilization of all the developed irrigated area in the Jordan Valley and Southern Ghor (34,480 ha, 496 MCM) and keeping the level of irrigated land in the highland at current level (28,000 ha, 304 MCM).

[b] Assuming in 1991 180 l/c/d, in 1995 188 l/c/d, in 2000 188 l/c/d, and in 2005 188 l/c/d.

F. FUTURE OPTIONS

Water resources are a key element in the social, political and economic stability of the Kingdom of Jordan and of the entire region. Any national water policy should take these factors into consideration to achieve the set goals of this vital sector. Jordan's policy makers and planners are well aware of the critical and difficult situation the Kingdom is facing as a result of the insufficient supply of water resources to meet present and future demand. Important options were reviewed above. The following are the recommendations and measures proposed to ease water shortages, increase the water supply and improve conservation techniques:

1. The construction of diversion and storage dams wherever feasible in order to store flood water in the winter to be used in the summer;

2. The rehabilitation of the municipal water networks to reduce water leakage, currently estimated at between 30 -35% of the total amount of water pumped. It has been estimated that the cost of one cubic metre captured from leakage is feasible and cheaper than any other resource to develop.

3. Increase irrigation efficiency through the following:

(a) On-farm through the conversion from traditional irrigation methods such as surface irrigation to drip and sprinkler techniques;

(b) Outside the farms through conversion from the open field canals to pressure pipes;

4. The adoption of appropriate irrigation water pricing mechanisms to eliminate waste and allocate water optimally. This mechanism should take into consideration the affordability of the farmers to pay;

5. The conducting of studies on the local environment to determine the actual water requirements per crop and region;

6. The use of brackish water in agriculture, since some desert crops can be grown by using saline water;

7. The strengthening of the agricultural research facilities in the technology of agriculture;

8. The expansion of the reuse of the treated wastewater and agricultural drainage water for irrigation purposes.

III. WATER RESOURCE POLICIES IN PAKISTAN*

Introduction

Pakistan's agricultural sector relies predominantly on irrigation. The country possesses what is probably one of the oldest and largest gravity flow irrigation systems in the world: the Indus Basin Irrigation System. Water has played a key role in contributing to the growth of agriculture in Pakistan. The irrigation system supplies surface water from canals as well as groundwater from tubewells. The total water availability increased at an average annual rate of 1.9% from 1965-1966 to 1988-1989, with the percentage of groundwater continuously increasing. Currently the total water available at the farm gate is about 105 million acre feet (MAF).

The system consists of the Indus River and its tributaries, three major reservoirs, 19 barrages/headwork, 12 link canals and 43 canal commands and 90,000 *chaks* (tertiary irrigation command). The total length of these canals is about 40,000 miles with watercourse, field channels and field ditches running another 1 million miles. Approximately 100 MAF of surface water are diverted annually into the canal system. SCARP (Salinity Control and Reclamation Project) tubewells are another component of the public irrigation system. This includes 14,000 public tubewells supplying another 10.1 MAF of water at the farmgate.

The process of rapid irrigation development, without due consideration of drainage, resulted in waterlogging and salinity, deterioration of water quality and depletion of groundwater. Increasing salinity of soils is one of the major problems of irrigated agriculture in Pakistan. Out of 40.0 MAF of water pumped annually by tubewells, about 50% causes salinity in soils. About 1.3 million ha of cultivated area and 0.9 million ha of uncultivated saline land have drainage problems.

One of the main problems with the irrigation system in Pakistan is that its design does not meet the current water demand. The canal-irrigated system in the subcontinent was designed for low water allowances and targeted at a cropping intensity of 75%. Growth in agriculture with an increasingly commercial orientation, coupled with population growth, demanded increases in cropping intensity and diversification. Unfortunately, the water allowances could not be augmented from the existing canal system. However, the water supply was increased to some extent from groundwater with the installations of tubewells.

Pakistan faces a serious dilemma of natural resource management, as its agricultural production is under increasing pressure to meet the demands of a rapidly growing population on the one hand, and to conserve its resource base for the benefit of future generations on the other hand. The supply-oriented strategy (export drive for cotton and rice and self-sufficiency for wheat) followed in the past has led to expansion of cultivated area, bringing more marginal land under cultivation and reducing the area of land left fallow. All these factors tend to lead to overexploitation of land and water resources, reducing productive capacity and the resource base for the future. The efficient management of natural resources, the most important being land and water, requires some policy decisions to develop agriculture on a sustainable basis.

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* This case-study was prepared by Mahmood Ahmad, Resource Planning Economist with the Joint ESCWA/FAO Agriculture Division. The views expressed in the case-study are those of the author and do not necessarily reflect the views of the United Nations Secretariat.

A. Water as a scarce resource

The development of the Indus Basin was a major undertaking in the water sector. Since the completion of the Tarbela Dam in the mid-1970s, there has been no significant water storage development to expand the supply of water. Surface water availability at the canal head has remained almost constant since the mid-1970s, averaging about 102 MAF at the head and 61.2 at the farmgate (for a detailed breakdown see figure III). Given the seasonal nature of the water flow through the Indus Basin, 85% of the flow occurs during the summer season (*Kharif*) and 15% during the winter season (*Rabi*). The water scarcity occurring during the *Rabi* season is partly offset by two large dams, the Mangla (4.88 MAF) and the Tarbela (8.86 MAF). However, the storage in these two reservoirs meets only a fraction of the *Rabi* demand. Additional sites (Kalabagh and others) exist to augment future supplies (6.1 MAF), but interprovincial water disputes and lack of financial resources are preventing the implementation of these projects.

The situation would have been more discouraging if increases in groundwater supplies had not been developed. Groundwater, which is currently 41.32 MAF, increased from 15% of the water supply in 1965-1966 to around 37% in 1989-1990. However, the growth rate has recently declined, mainly owing to the reduction in public tubewell growth. Opportunities for further developing groundwater are also scarce. Out of 35 million acres of Canal Command Area (CCA) 21 million acres are underlain by fresh groundwater. The lack of regulations to control access to the groundwater has resulted in depletion of the aquifer at an unsustainable rate in the fresh water zones.

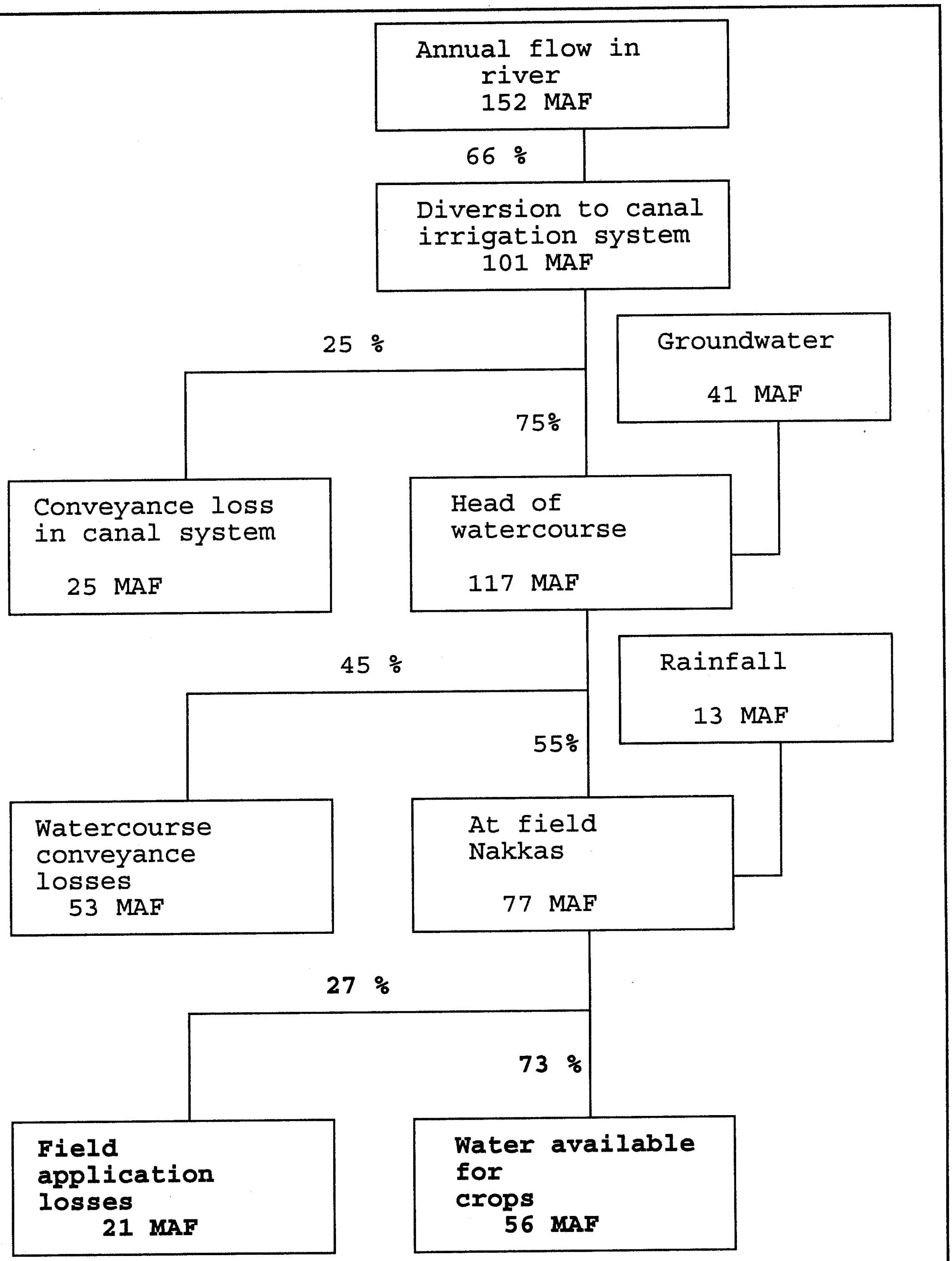
The problem with water scarcity also pertains to two other dimensions. First many areas are receiving canal diversions in amounts greater than their needs while some areas are without water or do not have enough. Secondly, it is often the case that farmers do not have access to water when it is most needed. Crops require water at a critical time of their growth. As water is distributed according to farmer "turns," it is often impossible to schedule water deliveries to coincide with the water needs of the crops. According to one study, the farmers who have access to tubewells show a cropping intensity of 157% as compared with 113% cropping intensity found on farms with access to canal water only. Similarly the farmers with supplementary water register 88% higher yields compared with those having access to canal water.

B. Policy issues in water resource development

1. Efficient use of water resources

One of the main objectives of water resource development in the past has been to maximize economic benefits in terms of increased agricultural production to generate employment and strengthen food security. How successful the water development programmes, projects and policies were in meeting this objective is a question which is drawing increased attention from policy makers.

The performance of the agricultural sector during the last 10 years has been disappointing. During the sixth and seventh five-year plans, growth was either stagnant or declining, except for cotton. Despite significant farmgate water supplies (23%) and irrigated areas (14%), yields were stagnant, keeping production down. The objectives were not realized because on the one hand government macro and price/subsidy policies penalized agriculture and because on the other hand investment policies were biased towards large irrigation projects. However, despite irrigation investments, inefficiency in water management (faulty design, poor maintenance and use) hampered the efficient use of this highly subsidized input in providing returns to the agricultural sector. The end result was that the returns on large irrigation investments were low or negative and contributed to an unsustainable pattern of agricultural development in Pakistan.



Source: Perspective Planning Division, Water and Power Development Authority, Pakistan.

Figure III. Indus Basin water flow chart

Loss of water from surface water, groundwater and rainfall

There is a growing realization on the part of the Government and the donors that past investment in irrigation has not paid the returns expected, mainly owing to suboptimal and often wasteful utilization of existing irrigation facilities. The system is neither efficient nor equitable. The farmers are provided with an unreliable water supply owing to poor operation and maintenance of the irrigation system. The maintenance of this vast irrigation system requires sizeable revenues on a sustainable basis. Irrigation in the public sector is heavily subsidized and has become an enormous fiscal drain on the national exchequer. Currently revenues from water charges do not even cover the expenditures of the provincial irrigation departments. Further, owing to budgetary constraints, the financial outlays for operation and maintenance do not fully support the maintenance of the irrigation system. In addition, low water charges encourage the inefficient use of this natural resource.

One of the major causes of this suboptimal water use of resources and lack of cost recovery is the improper irrigation pricing policy with inadequate attention given to the level and form of water charges, methods and mode of collection and proper allocation of revenues to the most desired programmes and projects.

There is little room to augment supply due to inter-provincial disputes and high costs of new investments; future water policy should be based heavily on demand management promoted through economic pricing of water, development of water markets and non-economic measures such as institutional reforms and enactment of legislation and regulations to develop water rights. Appropriate pricing can be a key element in future policy formulation to manage water resources efficiently in Pakistan. It can play a critical role in determining the level of supply and demand for water. Some of the issues related to operation and maintenance costs, the rate of return on investment and the provision of irrigation services on a sustained basis are directly and indirectly linked to water pricing policy.

2. Water resource use and environmental degradation

Land degradation due to waterlogging and salinity is the single most important challenge to agricultural development in Pakistan. Development of the canal system without consideration given to drainage has resulted in a serious problem of waterlogging and salinity. The situation is deteriorating at an alarming rate. It is estimated that 25% of cultivated land in Pakistan is waterlogged or saline. Currently 30% of the gross commanded area (GCA) is waterlogged, with 13% being highly waterlogged. It is further estimated that 6% of GCA is moderately salt-affected and 8% is severely affected.

The policy makers are faced with a dilemma. In the saline areas the water table has risen to levels that render land uncultivable and pose a serious environmental challenge. Water is needed to flush down the salts, and the extra water is not easy to divert from the given supply owing to the various technical and political dimensions of the problems. In fresh groundwater areas the soil salinity is also building up, but at a lesser rate, and can be controlled by reducing groundwater pumping and providing more surface water to leach the salts.

Two programmes, the lining of canals and on-farm improvement of watercourses, have been undertaken to reduce water losses. The water loss in fresh groundwater areas is not a major concern as it contributes to the recharge of the aquifers. The canal losses in the saline area are harmful as the water lost is not recoverable as fresh water. Furthermore these losses also contribute to the problems of waterlogging and salinity.

Masood and Kutcher (1992) noted that the single most important factor in the waterlogging problem is the annual net recharge to groundwater. A positive net recharge over an extended period means waterlogging and salinity. However, when the recharge is negative, the aquifer has been mined and salinity

has been induced through tubewell operations. Table 25 indicates the net recharge that varies enormously across the Indus Basin both in fresh and saline groundwater areas.

TABLE 25. NET RECHARGE IN FRESH AND SALINE WATER AREA OF THE INDUS BASIN*

	PMW	PCW	PSW	PRW	SCWN	SRWN	SCWS
Fresh water	-.41	-3.94	-1.57	-3.83	.69	.23	-.56
Saline water	.41	2.06	1.34	1.24	.72	1.40	.57

Source: Author's calculations.

* The Indus Basin is divided into the following agroclimatic zones:

NWFP (north-west frontier province);
PMW (Punjab mixed wheat);
PRW (Punjab rice-wheat);
PSW (Punjab sugar cane-wheat);
PCW (Punjab cotton-wheats);
SCWN and SCWS (Sind cotton-wheat north and south);
SRWN and SRWS (Sind rice-wheat north and south).

In the fresh groundwater areas unplanned development of private tubewells has resulted in rapid lowering of the water table and increasing the cost of pumping the water. Overexploitation of water could have negative implications on agricultural growth.

The growing differential in the water table between adjacent fresh and saline groundwater areas is resulting in saline water intrusion and is contaminating the fresh water.

3. Social aspect of water use

Equitable water distribution was one of the main responsibilities of institutions responsible for water delivery. Provincial Irrigation Departments (PIDs) are responsible for delivering water to the farmers. It is increasingly felt that the Canal Act of 1873 and the subsequent amendments are outdated and that there is an urgent need to restructure the PIDs and other institutions responsible for water delivery, in the face of their declining relevance to different needs and challenges. In the rural set-up of Pakistan, informal institutions (caste and family ties) have prevailed over formal institutions, and this has often resulted in suboptimal use of resources.

Furthermore, over time the shifts in cropping patterns have altered the water requirements of different regions. The present *warabandi* (weekly rotational schedule of irrigation deliveries to farmers) system has failed to reflect these changes. At the same time, its rigid seven-day cycle impedes the availability of water when it is required. The water losses are also not taken into consideration. Furthermore, the *warabandi* system does not fully allow the farmers to supplement their canal water supplies with their own tubewell water or to sell the surplus water to neighbouring farmers. This has resulted in underutilization of existing private tubewell capacity.

The above, as well as the location of farms in relation to watercourses, has also resulted in inequitable water distribution and illegal water diversions. To improve social equity, the water markets need to be legalized.

C. SUSTAINABLE WATER DEVELOPMENT: POLICY OPTIONS

According to economic theory, if the competitive conditions are suitable and externalities are absent the market price will represent the social price of water, which is also called efficiency prices. The efficiency aspect of irrigation can be considered under four possible water policy scenarios in Pakistan.

The first policy scenario represents a case, in the very short run, where water can be considered as a scarce resource and the objective is to maximize net benefits to the society. Policy prescriptions would require that the marginal social value of water across different uses (canal, tubewell, commercial use) is the same. If this is not the case, redistribution of water will increase net benefits to the society. In other words, the distribution should be Pareto optimal. Agriculture is usually the prime user of the water and pays less per centimetre (cm) compared with the other sectors competing for water. Tremendous price differentials also exist in different types of irrigation in Pakistan.

A second case is when the Government is expanding the supply from the existing irrigation system. The usual instrument is the yearly investment allocations made by the Annual Development Plan (ADP). The additional funds committed (as variable costs) to enhance supply at margin will not be available for investment elsewhere in the economy, and their allocation would be justified as long as the marginal social benefits from such investment exceed or equal the marginal social cost.

The third case looks at the investment decisions in the medium term, in which the Government is concerned with expanding the supply by investing through irrigation projects and programmes. Five year plans are used for short- and medium-term investment in Pakistan. Again such an investment is justified as long as social benefits exceed social cost of those investments at margin. Capital investment decisions in irrigation projects have been one of the major decisions the Government had to take in each planning horizon. The question is being raised as to the economic, social and environmental rationale of investment decisions in the past.

Finally, there is the case that involves long-term aspects of policy and optimal investment decisions in the irrigation sector. Sectoral plans such as the Revised Action Plan (RAP) and the Water Sector Investment Planning Study (WSIPS) have been prepared in the past. Traditionally, large irrigation projects have been given priority over small irrigation and drainage projects, soil and water conservation projects and efficient use of water at farm level. The past investment portfolio indicates a preference for civil works packages, often poorly conceived and without due emphasis on the institutional and policy aspects of irrigation development in Pakistan.

Future water development would require well-conceived investment plans and appropriate policies that would improve water efficiency, providing more equitable distribution and reducing environmental degradation of resource use. Given the budgetary constraints and the necessity of achieving a sustainable water resource development programme conducive to growth in agriculture, multi-objective criteria would be one possible approach to integrating the economic, social and environmental aspects of water development in Pakistan. This will be reviewed in greater detail below.

1. Economic water pricing policy

A rational water price policy is the key to sustainable water development, given its growing scarcity in Pakistan. As water is becoming a scarce resource, its true value to the society is becoming apparent. The policy makers and donors are increasingly demanding that water be priced on the basis of its true value. The economic price or marginal value of water represents its scarcity value. The marginal value of water

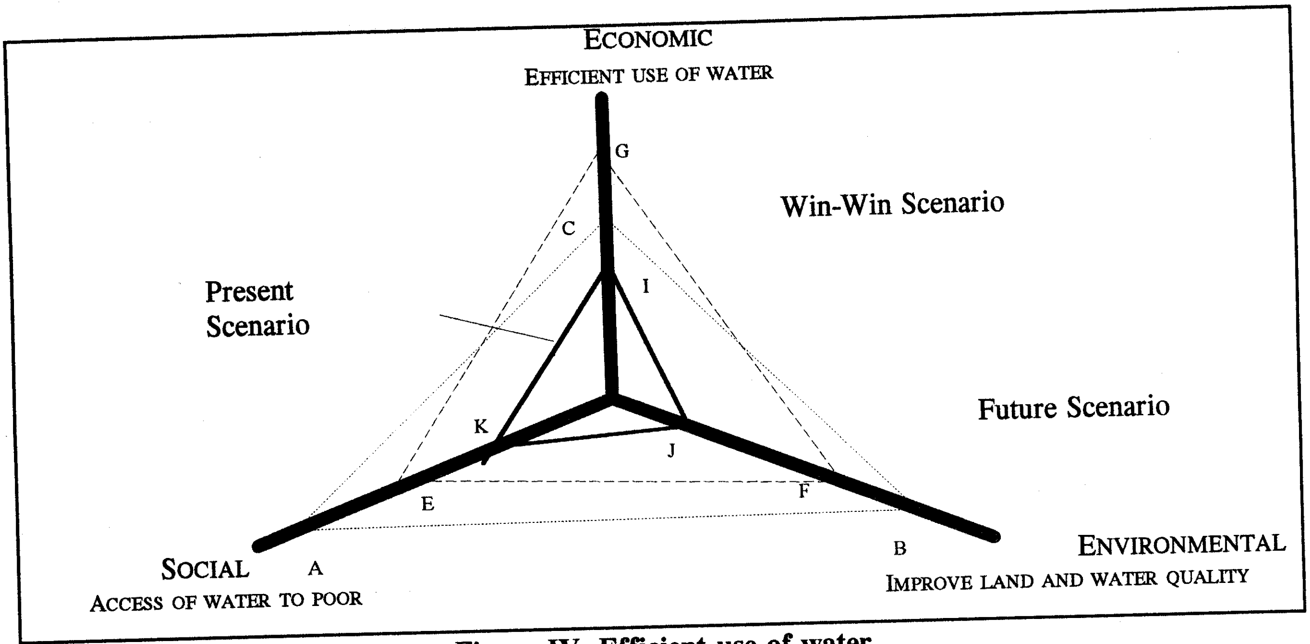


Figure IV. Efficient use of water

is estimated for the economic evaluation of its potential uses and development of water resources. The estimated values help policy makers to ascertain the relative merits in allocating the available water supply among competing uses. Marginal value is also useful in determining the estimated benefits from potential projects that provide additional water supply to the region.

The basis for setting the price of water based on its marginal cost is explained with a simple supply demand curve. Figure V represents the current situation with regard to supply and demand curves. At price P and quantity Q, the total benefits to the consumers are represented by the area under the demand curve or the consumers' willingness to pay.

Benefits (CWP)	= 1+2+3+4
Cost of supply	= 3+4+5
Net benefits	= 1+2-5

In figure V, the cost of supplying water represents the area under the supply curve and is given by the area (3+4+5). Net benefits, that is area (1+2-5), are equal to the benefits (1+2+3+4) minus costs (3+4+5).

The net benefits are maximized (see figure VI) where marginal benefits are equal to the marginal cost or at price P_o and quantity Q_o.

Benefits (CWP)	= 1+2+3
Cost of supply	= 3
Net benefits	= 1+2

2. Estimating the value of water

Before introducing the different procedures involved in estimating water value, it is important to define the distinction between private (financial) and social prices (economic). Private prices are the market prices

observed to calculate the benefits and costs values of a commodity. Private prices often diverge from their true value because of either market failure or externality. By removing these distortions, one can calculate the social or economic prices. For the commodity of water, markets are usually inadequate or absent. The value of water is usually based on financial accounting (usually on average price).

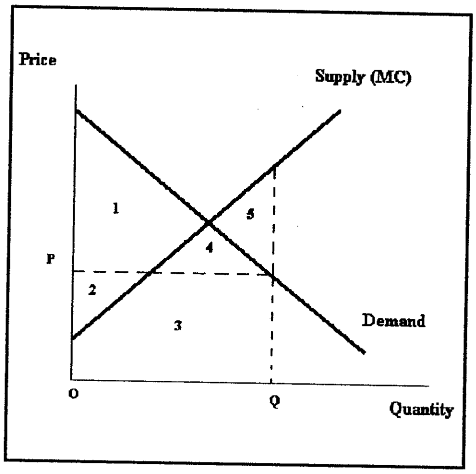


Figure V. Price of water below MVP
(Marginal value product)

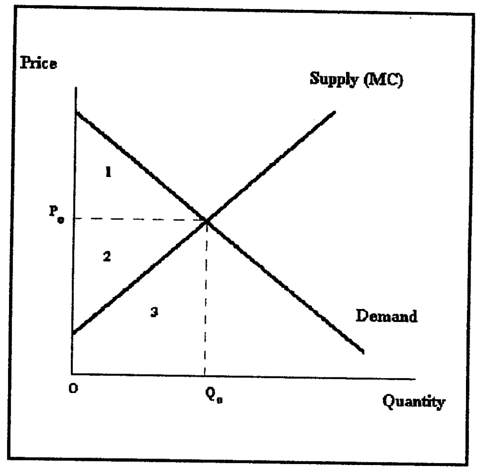


Figure VI. Pricing of water at MVP
(Marginal value product)

3. Production function

The production function technique has been used to derive the marginal value product of the specified inputs. Cross-sectional or time series data are often used for estimating the value of inputs in crop production. In the model presented below, production is explained by the level of irrigation and a host of other explanatory variables. A number of studies in the past have estimated value of water using either the Cob-Douglas or Quadratic Function.

In 1992 the Punjab Economic Research Institute (PERI) used the production function model (based on experimental data or farm management surveys) to calculate the relative contribution of selected inputs to crop production, value of the marginal product of each input and the allocative efficiency of resource use. The marginal value product for water in the SCARP and non-SCARP areas was classified by the size of the farm.

$$Y=a.x_1^{b_1}.x_2^{b_2}.x_3^{b_3}.x_4^{b_4}.x_5^{b_5}.x_6^{b_6}.e^{u}$$

where

y	=	Value of crop produced
X_1	=	Land input measured in terms of acres
X_2	=	Labour input
X_3	=	Value of seed
X_4	=	Fertilizer input, nutrients kgs per farm
X_5	=	Irrigation water measured in acre inches per farm
X_6	=	Value of chemicals
$b_1..b_6$	=	Parameters to be estimated
e^u	=	Error term

The value of the marginal product for irrigation was estimated by multiplying the marginal physical product of the input by the price of output.

$$MVP_{x_i} = \frac{\Delta y}{\Delta x_i} = \frac{\Delta}{\Delta x_i}(a.x_1^{b_1}.x_2^{b_2}.x_3^{b_3}.x_4^{b_4}.x_5^{b_5}.x_6^{b_6})$$

reveals that the marginal value product of water both in the SCARP (37 Pakistan rupees [PRs] per acre inch) and non-SCARP areas (PRs 36) is more than three times its opportunity cost (PRs 10 per acre inch). The opportunity cost is based on the price of water in informal trading or water markets. These estimates reflect the lower estimates of price in water markets which, according to World Bank estimates, range from PRs 10 to PRs 70 per acre foot. Given the lower value of opportunity cost, large farmers can further extract economic rent by enhancing water use, whereas small farmers are using water quite efficiently, as MVP was PRs 10.08, a value close to the opportunity cost. Comparing prices in the water markets (opportunity cost) and MVP indicates that economic gains from water selling are possible. More competitive and legal markets will improve rational and equitable use of water.

4. *Residual imputation*

This method allocates the total value product (TVP) among all resources used in production. If appropriate prices are assigned to all inputs but one, then the residual of the total value of product is imputed to the remaining resources.

A recent study based on crop budgets uses this simple model to estimate the value of land and water for selected crops in Pakistan.

NI_i	$= GI_i - VC_i - FCi$
NI_i	= Per acre net income from farm
GI_i	= Per acre gross income from farm
VC_i	= Per acre variable costs in production of crop i.
FCi	= Per acre fixed costs in production of crop i.

Combining the data on crop water requirements, one can calculate the value of water for crop by

$$\textit{Value of water} \in \textit{crop } i = \frac{\textit{Net income of crop } i}{\textit{Water req. of crop } i}$$

Both private and social returns per thousand cubic metres of water are highest for cotton. Coarse rice brings the lowest private returns and sugar cane the social returns. One can note that divergence is highest in the area growing export crops such as rice and cotton. Clearly sugar cane and sunflowers are subsidized in Pakistan. For wheat, rice and cotton the economic returns on water consumed are high once price distortions at output and input levels are removed. Attempts to bring the water price to its social value would erode the private profitability of the farmers.

The variation between crops and regions cannot be explained by differences in delivery and transport costs alone. The marginal value of water estimated by other methods also indicates a wide variation in different regions and among crops. The trading price of water in the informal markets also ranges from PRs 100 to PRs 700 per acre foot. The monopoly power enjoyed by tubewell owners and varying energy charges can explain to some extent the price variations.

TABLE 26. AVERAGE NET RETURNS ON IRRIGATION WATER BY CROP
(PRs per 1,000 cubic metres)

Crops	Private prices	Social prices
Wheat (Punjab)	1014	1853
Rice (Punjab)	583	1828
Sugar cane (Mardan)	250	-381
Cotton	1486	4499
Sunflower	1418	-89

Source: Longmire, *Agriculture and Comparative Advantage in Pakistan*, 1993.

5. *Value of water by linear programming model*

The linear programming technique is well suited to estimate the marginal value of water. The model determines the crop mix or farming system required to maximize income under a typical farm operating under different water supplies. One way to value a resource at margin is to consider the farm at short run optimum and measure how increasing or decreasing the water supply by the desired amount affects revenues (see figure VII).

The marginal value of water, calculated as a change in net farm income from canal water supply to canal plus tubewell divided by change in water supply from canal to canal plus tubewell, indicates that net benefits to per acre inch of water increased from PRs 1,006 under the initial water supply situation to PRS 1,560 per acre inch when additional water was made available from private tubewells. The difference in net benefits under two water supply levels can be defined as incremental net benefit to irrigation water or the marginal value of water.

6. *Water value and cost of tubewell water*

The value of water is often estimated using the cost of producing water from tubewells. A farmer operating under a canal supply system is often constrained by limited water availability. It is argued that farmers with access to tubewells will pump water to the point where the marginal value of water is equal to its cost of production. In other words, the marginal value of water is represented by its cost of production. This is the underlying assumption by which the cost of tubewell water is used to represent the true value of canal deliveries.

It is clear that the economic cost of producing water is higher in a Diesel tubewell (high speed diesel [HSD]) as compared with the electric tubewell. The cost of tubewell water in the study ranges from as low as PRs 193 per acre feet (electric, flat rate) to PRs 369 (Diesel, HSD and 10% utilization). Water rates based on these marginal values of water would amount to almost commercial rates and farmers would not be in a position to pay these rates unless implicit taxation on agricultural outputs is removed (see below).

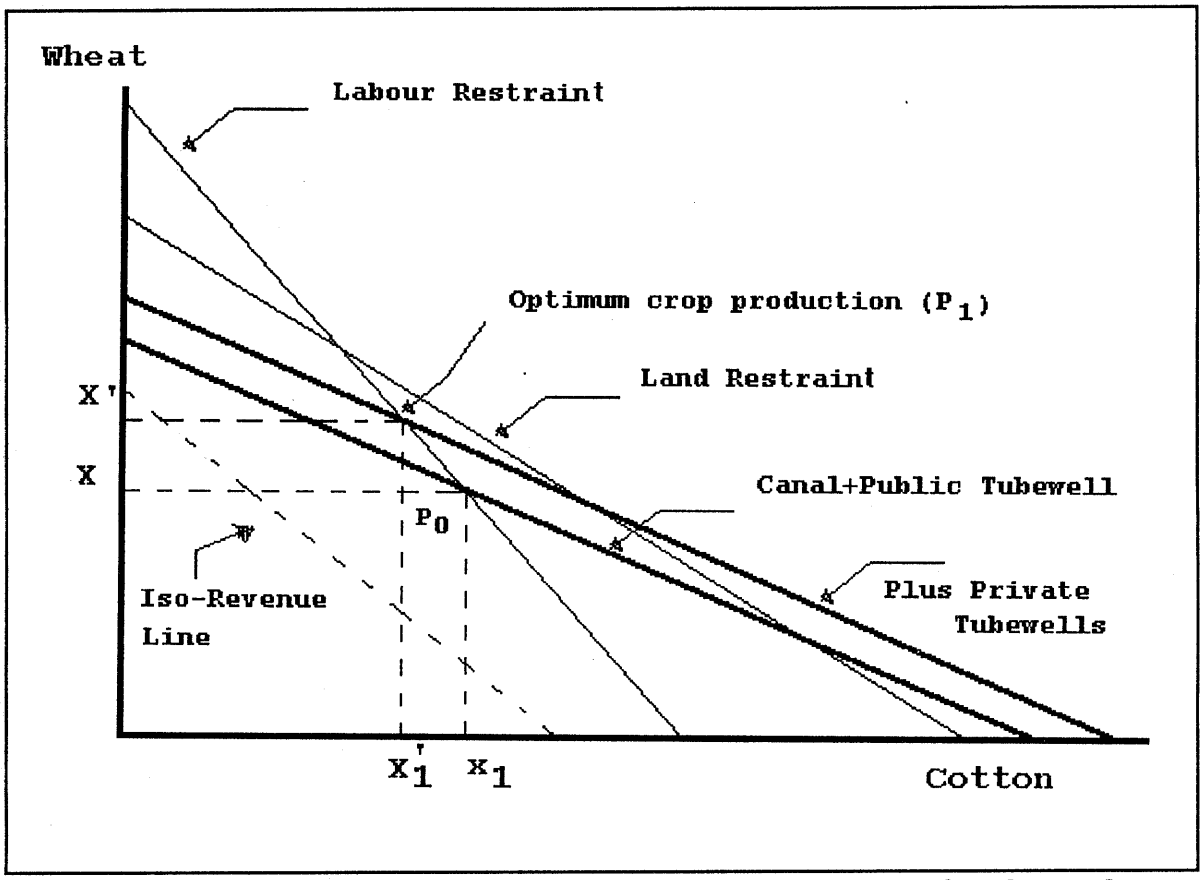


Figure VII. **A two-crop farm model showing the optimum crop acreage for wheat and cotton with two levels of water supply and with land and labour constant**

TABLE 27. ECONOMIC COST OF TUBEWELLS (PER ACRE FOOT)

Utilization	Electric	Diesel	
		HSD[a]	LSD[b]
10	293	369	308
15	238	277	226
20	210	231	184
25	193	203	159

Source: Water Sector Investment Planning Study, APOA, 1990.

[a] High speed diesel.
[b] Low speed diesel.

Using the cost of tubewell water as a proxy for canal water value has its own limitations. Tubewell water is in most cases used to supplement and not to substitute for canal irrigation. The high cost of tubewell water reported above cannot serve as a benchmark in setting a price for the canal water.

7. Farmers payment capacity and water charges

Another option is to review the water charges based on the farmers' ability to pay additional charges. The capacity of the farmers to pay additional water charges depends on the net income of the farmers. The data in table 28 indicate that water charges constitute only 2.6% of the net income obtained from cotton and 2.8% from wheat. In comparison, a high rate of 13.2% was estimated for sugar cane.

The above analysis reveals that the present level and structure of water charges do not encourage farmers to use water efficiently. There is a tremendous divergence between current water charges and the private and social prices as calculated by the different techniques mentioned above. As farmer are only paying one third of the marginal value of water or are paying only 2 to 8% of net income, it is argued that given a relative high economic value of water, the farmers can absorb the enhancement of the current level of water charges to some extent. These decisions have to take into account equity issues. The present water charges are so low that even small farmers can also afford to pay; however, a steep rise in water charges can have negative distributional effects depending on the size of farms and their location relative to sources of distribution.

TABLE 28. FARMERS' PAYMENT CAPACITY

Crops	Water charges Financial	Net income PRs/acre	Percentage
Wheat (Punjab)	29	1014	2.8
Rice (Punjab)	32	583	5.4
Sugar cane (Mardan)	33	250	13.2
Cotton	40	1486	2.6
Sunflower	53	1418	3.7

Source: Longmire, *Agriculture and Comparative Advantage in Pakistan*, 1993.

Note: The social price of water is estimated at PRs 237 for all crops.

8. Reasons against water price increase

It is true as analysed above that water is heavily subsidized in Pakistan. It is argued that water charges should not be increased until a policy review on output price increase is considered.[1] Historically, Pakistan's agriculture (wheat, cotton, rice and sugar cane) has been heavily taxed.

[1] As the case-study was being completed, the Government of Pakistan (provincial government) decided to increase water charges by 15%.

Recent studies on agricultural price policies in Pakistan show that traded crops such as cotton, rice and wheat, an import substitution crop, are taxed through direct (sectoral) and indirect (exchange rate and trade policies) interventions. Table 29 provides a summary of the results of two World Bank studies covering the period 1972 to 1985 and more recently a 1993 study covering the period 1986-1992.

TABLE 29. DIRECT AND INDIRECT TAX ON SELECTED CROPS

	1972-1985			1991-1992
Crops	Direct	Indirect	Total	Total
Wheat	- 3	- 9	- 12	- 14
Cotton	- 20	- 24	- 44	- 40
Rice	- 23	- 9	- 32	- 33
Sugar cane	26	- 30	- 04	91

Source: Navid, Ijaz and Anjum, two studies published by the World Bank in 1990; and Longmire, *Agriculture and Comparative Advntage in Pakistan*, 1993.

The table calculates the direct nominal protection coefficients as defined by the percentage by which domestic producers prices deviate from the border price (adjusted for marketing cost) measured at the official exchange rate. The indirect effect takes into account trade and macroeconomic policies as they affect the estimation of equilibrium exchange rate. The studies indicate that all crops under consideration were significantly taxed at indirect levels. Sugar cane is subsidized through government price policy at the sector level. Total effect entails a taxation on all crops. The analysis clearly indicates a discrimination against the agricultural sector. The situation has not changed much according to the latest study in 1991-1992. Given the heavy direct and indirect taxation in agriculture, it is understandable that farmers in Pakistan are resisting any increase in the water charges. Any increase in world prices has to take into account the input and output price structure facing farmers in Pakistan. As long as farmers are taxed, water price increases will worsen the sectorial terms of trade against the agricultural sector and erode farmers' income to invest in resource conservation.

In summary, the above analysis indicates a number of problems in adopting the approaches outlined above.

1. Prices of water differ by types of crops, size of holding, time of crop growth and source of water supply.

2. The marginal or average prices determined by production function, residual methods and linear programming techniques are beyond the repayment capacity of the farmers.

3. The prices based on "willingness to pay criteria" as reflected by the price in water markets or using cost of tubewell water as a proxy for canal water are not appropriate; the former is the additional and not a substitute supply of water.

Future increases in water charges should at least take into account that (1) overall price adjustments are needed to remove both direct and indirect price interventions; that (2) in the short run water rates should be increased to mobilize sufficient financial resources which are badly needed to develop an efficient operation and maintenance irrigation system; and that (3) in the long run the intergenerational value of water, which is reflected in the following relation in marginal terms, should be ascertained.

MOC_I = $MC_I + MUC_I + MEC_{IJ}$
MOC_I = marginal net opportunity cost of using up the water resource
MC_I = marginal direct cost of extracting or developing water
MUC_I = marginal user cost of using up the water resource (inter-generational consideration)
MEC_{IJ} = marginal intersectoral cost imposed on sector (resource) j by using up resource i

9. Water charges and cost of operation and maintenance

The very low water charges in Pakistan have restricted the Government in mobilizing funds required for efficient operation and management. In the early 1970s, farmers were paying at least the operation and maintenance costs and generating revenues from water charges. The situation changed, and subsidies that amounted to PRs 578 million were given in 1980-1981; the amount of the subsidy had grown to PRs 1,720 million by 1990-1991. The subsidy on water is the direct result of low water prices that have contributed to inefficient use of the resource and poor maintenance of the infrastructure. A major part of the subsidy goes to operation and maintenance of the public tubewells. As noted above, a rational price policy should at least meet the financial requirements if the economic criteria cannot be met in the short run.

As efficient use of water is a critical input to any future agricultural growth, increasing expenditures on operation and maintenance can provide good returns on the investment (box 3). Inadequate maintenance of the irrigation system results in frequent breaches and consequent interruption of water supplies. This can (1) decrease crop yields; (2) affect the cultivated area; (3) result in a shift to low-value crops; and (4) diminish on-farm investment. In view of this, water charges should be increased at least to the level where they can cover the operation and maintenance cost of irrigation infrastructure but also to generate financial resources to rehabilitate it.

D. FUTURE POLICY OPTIONS

1. In the short run (2-3 years) water charges should be based on recovering the operation and maintenance costs of the irrigation infrastructure. In the short run equalization of marginal return of water to its price is not feasible, given the underdeveloped water markets and economy-wide price distortion generally biased against the agricultural sector.

2. The current operation and maintenance recover 70% of their cost. The farmers are paying only 5% of the cost of production on farm income. The price of water should be increased to recover the entire operation and maintenance costs.

3. The larger divergence in the returns on water and the actual cost indicates that substantial gains can be realized if prices are rationalized in the long run. Water distribution along commercial lines through public utilities can be one possibility. To ensure financial viability, prices have to be based on either MVP or on acceptable returns on investments as a fraction of net assets and working capital. In the long run this would be the rational choice.

4. The proposed increase in water charges should be linked to agricultural price policy in Pakistan. Historically the farmers have faced direct and indirect taxes on some on the strategic crops in Pakistan. Removal of distortions in input prices should also accompany output prices.

5. Prices in the water markets in Pakistan show a wide range of divergence. Potential gains can be made by legalizing water markets, developing water rights and regulatory frameworks to acquire and use scarce water resources.

Box 3. **Benefits and costs of operation and maintenance expenditure in Pakistan**

Findings

- A 10 per cent increase in operation and maintenance expenditures on canals in one year would increase agricultural productivity by 30 per cent.

- Marginal Value Product (MVP) of investment in operation and maintenance spending was PRs 19 in six years. The present value of MVP was estimated to be PRs 13 at 10 per cent discount.

- The agricultural output was estimated to increase at an average rate of 8.39 per cent in response to a 6 per cent annual increase in operation and maintenance spending in real terms and moderate growth in demand (3 per cent).

- Operation and maintenance investments yield substantial gains to producers and consumers as the output is increased and prices are depressed.

Policy implications

- Estimates of marginal benefits to past and prospective future operation and maintenance investments suggest the need to allocate more funds for operation and maintenance of the canal system.

- In addition to producers who are the direct beneficiaries of operation and maintenance services, consumers should also be taxed to generate part of the funds required for operation and maintenance activities.

- The support programmes targeted to favour producers would provide an opportunity to finance operation and maintenance through enhanced water charges. Higher water charges would help to bridge the income distribution gap between irrigated and non-irrigated farmers.

6. Research indicates that operation and maintenance yields high rates of return on investments and therefore should be given high priority. The operation and maintenance costs should linked to water charges.

1. Sustainable water resource management and environmental considerations

(a) The problem areas

The most common environmental issues facing water resource development include:

1. Waterlogging and salinity
2. Groundwater overdraft
3. Sedimentation
4. Disposal of saline drainage effluent
5. Riverain areas

6. Intrusion of water in the river delta

(i) Waterlogging and salinity

The annual recharge to the groundwater is the single most important variable that contributes to the waterlogging problem in Pakistan. As mentioned above (section B), development of the canal system without due consideration of drainage has resulted in waterlogging and salinity, and the situation is deteriorating at a distressing rate. It presents Pakistani planners with a policy dilemma. In the saline areas, the water-table has risen to levels that render the land uncultivable and this poses a serious environmental challenge. One needs water to flush down the salts, and the extra water is not easy to divert from the supply owing to the various technical and political dimensions of the problem. In areas with fresh groundwater the soil salinity is also building up but at a less alarming rate and can be controlled by reducing groundwater pumping and providing more surface water to leach the salts.

Two programmes, the lining of the canal and on-farm improvement of watercourses, are being undertaken to reduce water losses in the canal and water courses. The water loss in fresh groundwater areas is not a major concern as it contributes to the recharge of the aquifers. The canal losses in the saline area are harmful as the water lost is not recoverable as fresh water. Furthermore this also contributes to the problems of waterlogging and salinity.

The total area affected by waterlogging is increasing at an alarming rate. The SCARP tubewells and private tubewells have improved the situation in some areas. The problem is more acute where drainage for the irrigation system is not available or is very poor. Poor sub-surface drainage is emerging as a leading cause of stagnant or declining agricultural production and at the same time a factor in environmental degradation in many parts of the country.

The drainage needs of the region depend on the water supply which in turn determines the level of the water-table. To achieve optimal yield, the water-table needs to stay within a certain range. The drainage problem begins when water levels start rising to the point of diminishing returns. The relation is presented through four graphs (figure VIII) showing the relation of the water-table to sustainable agricultural production.

As water supplies increase, cropping intensity also increases but at a decreasing rate as farms use more water per unit of area. This additional supply eventually results in the rise of the water-table, primarily owing to lack of drainage facilities available to farmers. As the water-table rises to more than the critical level, the crop yields start to decline. Waterlogging tends to reduce the production potential of farms. Lack of a proper drainage system means that extra water yields less and less benefits and this eventually results in production losses. This is represented by a quadratic function which indicates a diminishing return as more water is applied. If proper drainage was provided, the growth would increase but eventually at a decreasing rate.

Investments in drainage provide a high rate of return, close to 20%. Priority should be given to seriously affected areas (0-5 ft water table) in saline groundwater zones.

(ii) Groundwater overdraft

Government policy has been to encourage private tubewells without giving due weight to the fact that it can lead to resource depletion or pumping the water at high cost in the future. This is a case of a common property resource that is being depleted. The question to be raised by policy analysts is what alternative might be used to increase the groundwater recharge in the areas where the water-table is declining or what

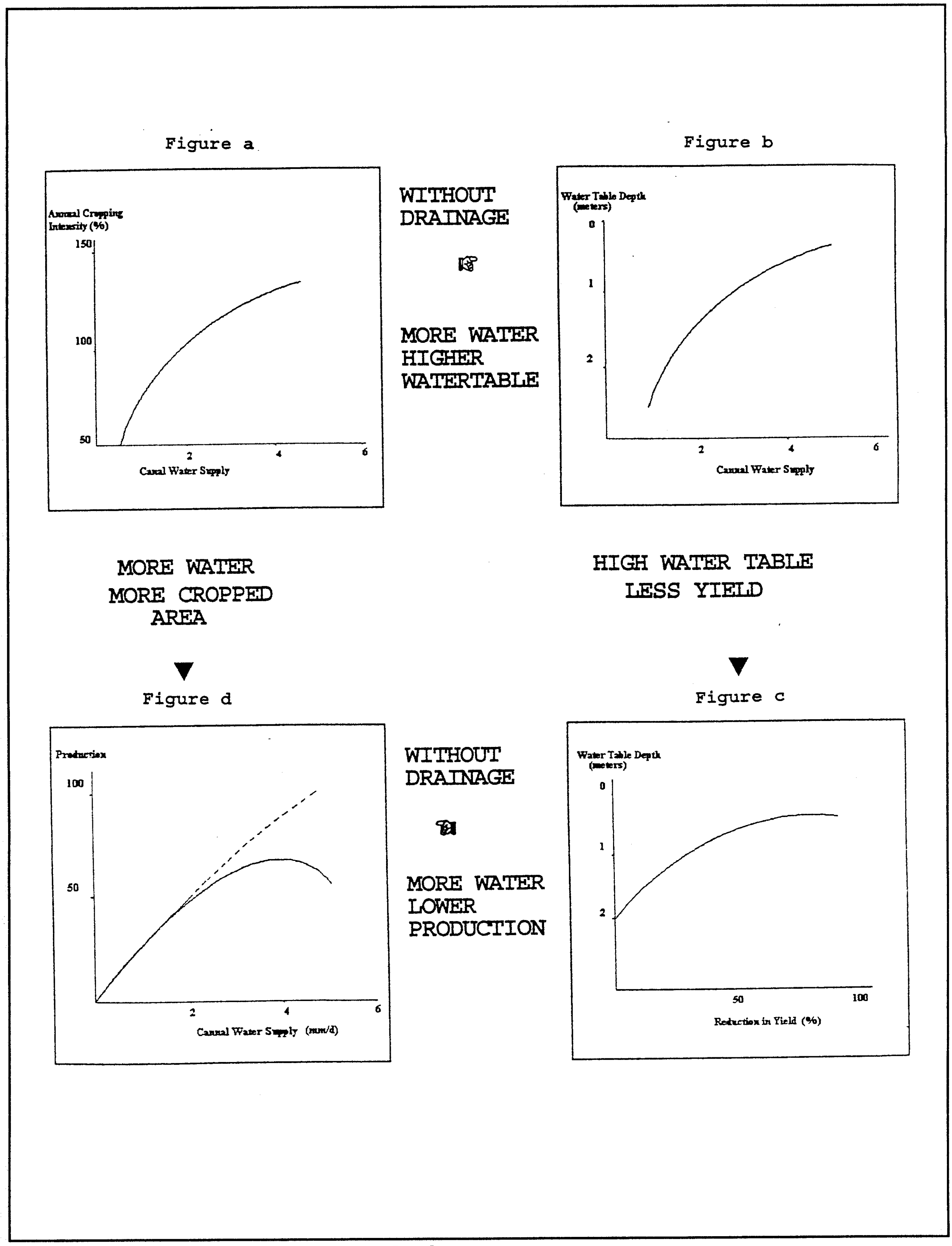


Figure VIII. Sustainable groundwater development

alternatives are possible for regulating the pumping and installation of new wells. In most cases the policy options open to the Government include taxes, assigning water rights or outright control.

Government policies in the past have also contributed to misuse of groundwater resources, inequitable water distribution and have had a detrimental effect on the environment. The policies have contributed to lowering the water-table to more than the desired level and making pumping uneconomical (negative recharge; see table 30). Inappropriate design, cheap credits, water charges far below the economic or even the financial prices and subsidies for electricity are some of the policies that might have contributed to overextraction of underground water.

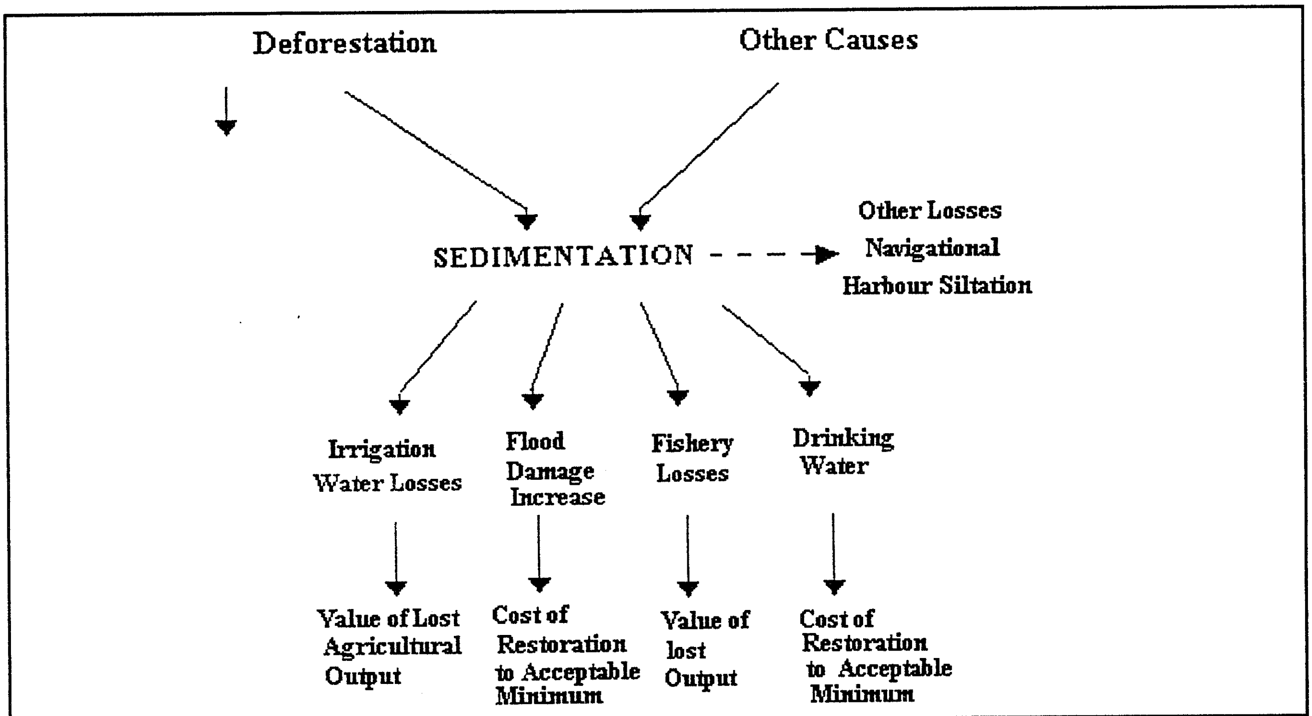


Figure IX. The cost of natural resource depletion in developing countries *(D. Pearce and A. Markandya, World Bank, 1985)*

Such policies reduce the pumping costs and send farmers the wrong economic signals. The amount of income lost to the society can be phenomenal. In cases where lowering of the water-table cannot be stopped or slowed down short of the point where marginal pumping cost (MPC) equals the marginal value product (MVP) of irrigation water. The important question is how farmers adjust to this situation. It would be interesting to study the impact of future declines of the water-table on cropping patterns, areas of irrigation and the net income of the farms.

(iii) Policy options to apportion water

There are a number of options available to develop the conjunctive use of groundwater and surface water. Masood and Kutcher estimated annual surface water flows, seepage, net recharge and implied changes in water-table depth for the base year 1988, classified by agroclimatic zones and groundwater. Table 30 outlined the net recharge according to this classification. The present study outlines two possible policy options below to develop groundwater on a sustainable basis in the basin.

a. Changes in canal diversion

The total water diversion needed to obtain sustainable water yields is as follows. In the fresh water zone a total of 21.61 MAF (21.61 to Punjab and -2.53 from Sind) would be required to bring the water balance in line. On the other hand a total of -16.69 MAF would need to be pumped out to attain a zero recharge. On balance the Indus Basin would need an additional 2.4 MAF to ensure overall sustainable water levels.

b. Reducing tubewell withdrawal

Table 30 indicates how much reduction in tubewell withdrawal would be required to attain water balance in the Indus Basin.

Table 30 indicates that the achievement of a steady state of equilibrium would require a reduction of tubewell withdrawal ranging from 57 to 91% in the fresh groundwater area. In the northern Sind area, such a policy would require increasing water pumping to some extent. A reduction of 27.5 MAF would be required in the fresh water zone to bring the water recharge in balance. Given the agricultural importance of these areas, such a reduction would result in a substantial decrease in agricultural production, which is already on the decline. It would be prudent policy, as outlined in the present study, to combine the policies of increasing canal diversion and reducing water withdrawals. In the future, the agricultural sector will be required to use the available water supplies more efficiently to increase production.

The recent water apportioning accord provides the following distribution of canal water to each province in the seasons of *Kharif* and *Rabi.*

TABLE 30. REDUCTION IN TUBEWELL WITHDRAWAL TO ACHIEVE GROUNDWATER BALANCE

	PMW	PCW	PSW	PRW	SCWN	SRWN	SCWS
Net recharge	-1.43	-8.3	-3.69	-5.59	.14	.11	-1.01
Tubewell withdrawals	3.13	19.2	7.43	8.62	1.80	.48	1.60
Seepage from	1.01	4.4	2.12	2.11	.55	.12	.45
Net withdrawal	2.11	14.7	5.31	6.51	1.25	.37	1.15
Required withdrawal	2.11	10.92	5.17	7.87	-.20	-.15	1.41
Percentage change	-67.5	-56.8	-69.5	-91.3	11.0	31.1	-88.2

Source: Masood and Kutcher, *Irrigation Planning with Environmental Consideration*, World Bank Technical Paper 166, 1992.

Notes: PMW (Punjab mixed wheat); PCW (Punjab cotton-wheats); PSW (Punjab sugar cane wheat); PRW (Punjab rice-wheat); SCWN (Sind cotton-wheat north); SRWN (Sind rice-wheat north); and SCWS (Sind cotton-wheat south).

The above distribution patterns were calculated on the basis of accepted water principles; it is not clear what weight was given to environmental considerations.

TABLE 31. WATER APPORTIONING ACCORD: DISTRIBUTION OF WATER

Province	Kharif	Rabi	Total
Punjab	37.07	18.87	55.94
Sind	33.94	14.82	48.76
North-West Frontier Province	5.28	2.30	38.78
Baluchistan	2.95	3.50	3.87
Total	77.34	37.01	114.35

Source: Muhammad Afzal, "Water sector development, present and future", *Indus*, January-March 1993.

(iv) Sedimentation

The silt load of the Indus Basin poses a serious problem along with waterlogging and salinity in terms of economic and environmental damage costs of sizeable magnitude. The annual silt load of the Indus is estimated at 440 million tons, capable of reducing live storage of the Tarbela Dam by 4.25 MAF over a 25-year period. These two issues can dominate agricultural development in Pakistan because of the need to correct the damage done. The efforts can be very costly and most probably will pre-empt investment needed in the rain-fed areas, and in forest development and improving rangelands.

Proper watershed management practices in the catchment areas of the rivers have very high pay-off through the significant reduction in sediment flow to the river. The reduction in sediment flow also contributes to agricultural production and environmental improvements such as:

1. Providing more water owing to reduction in siltation of irrigation channels that results in higher agricultural production;

2. Improving the fish catch as water quality improves with a reduction in siltation;

3. Reducing flood damage which in turn reduces environment damage and crop destruction;

4. Increasing drinking water supply and quantity.

(v) Disposal of saline drainage effluent

The environmental concerns in the disposal of salinity are as follows:

1. Disposal of saline effluent into or through existing wetland causes an increase in water levels and deterioration of its quality.

2. Disposal of salinity into evaporation ponds or back into the canals or rivers is a great environmental concern. Deliveries to the ponds are generally hazardous, especially when they overflow owing to excessive rain or storm water causing seepage and land degradation in other areas. Disposal in the canals or rivers presents a typical case of externalities for the downstream users. The disposal of drainage effluent into canals

and rivers is not environmentally safe and would require an outlet to the sea with link drains from the rest of the basin.

(vi) Riverain areas

With the construction of dams and barrages, the river régime often changes and affects the riverain areas. Farms in these areas depend on discharge from escapes and drains that flood water to their lands. As water releases are controlled, more supply now flows in relative terms during the *Rabi* season than during *Kharif*. This has upset the traditional cropping pattern followed in the riverain areas. The change in water régime also has a damaging effect on fisheries, wildlife and other agricultural activities along the river banks. Furthermore, there is strong evidence that the productivity of riverain forests is on the decline.

(vii) Salt intrusion of sea water

Salt intrusion from the sea into river and coastal lands is a serious problem which is manifested in low river water flow owing to the construction of dams and barrages. The adverse effects take the form of:

1. Increased intrusion of sea water;

2. Effects on the mangrove ecosystem, especially with the construction of the Kotri Barrage. The mangrove requires a transitional ecosystem between land and water. As the volume of water flowing to the sea is reduced, more salt water from the sea moves upstream into the river creeks and mangrove vegetation areas. As a result both fisheries and mangroves are declining in these areas.

3. The adverse effect of the construction of dams and barrages on migratory fisheries.

E. Strategies

1. Effective and productive utilization of surface and groundwater resources should be maintained to optimize agricultural production.

2. Provision of drainage is one of the key investment areas for developing sustainable agriculture in the future. Drainage investments provide a very high rate of return close to 20%. Priority is to be given to critically affected areas (0-5 ft water-table) in saline groundwater zones.

3. Groundwater rights allocations. A detailed analysis is needed to assess the optimal extraction in each command area. The provincial water apportioning accord should assess in both the fresh and saline areas the importance of sustainable yield from the aquifers.

4. Water quality. To ensure environmental protection of the land and water resources of the country, water quality standards must be established. Agricultural productivity is closely linked to guaranteeing a minimum safe quality of water.

5. Interprovincial water markets can promote water efficiency and reduce regional water equity issues.

Box 4. **Sustainable development of natural resources**

If the resources of the region, such as land, water, forestry and fisheries are to be sustainable, they must be treated as capital assets in the national accounts. The government pricing policy must reflect the true value of a natural resource, including the full cost of developing, extracting, regenerating and managing the resource in question. In many countries of the region the natural resources are being depleted at a rate which can have serious implications for providing food on a sustainable basis. As has been seen in the case of groundwater depletion in fresh water zones of Pakistan, it is evident that the groundwater extraction rate is greater than the water recharge, resulting in depletion of storage. The resource has to be used at a maximum sustainable yield.

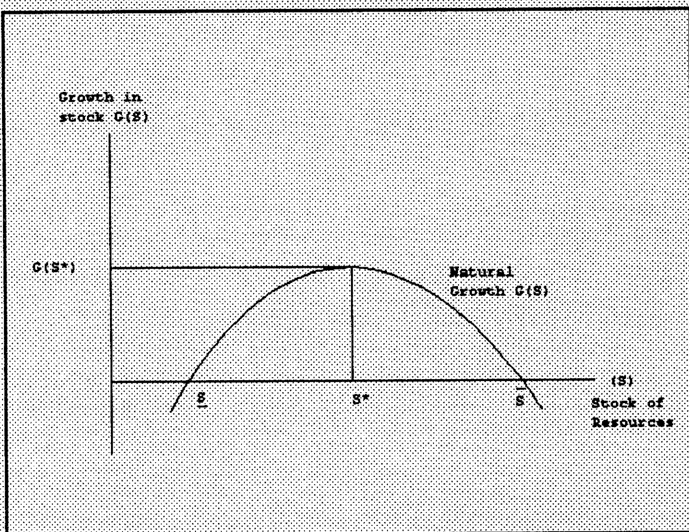


Figure X. Natural growth curve of groundwater

Most of the services of a natural resource are bought and sold in the market in the economy, just as are the other commodities. For agriculture-related natural resource commodities, which are renewable (replenishable), the question one may raise concerning the price system and renewable resources is: What is the optimal rate of resource use that maintains the stock of the resource at the desired level (water recharge balance)? The efficiency of the price system in conserving a natural resource depends significantly on appropriability and externality.

A resource is completely appropriable if the owner of the property can exclude anyone else from access to the services thereon (forestry in some cases). The other extreme is inappropriable on what is often referred to as common property resources, in which case the access to the resource use is free and without any restriction (fishery and groundwater in some cases). The problem with common property resources is easy to identify. So long as the services of the assets are appropriable, the owner has an inerest in developing and maintaining the resource with a view to long-term profit potential. In the case of common property, everyone uses the resource without paying any user cost, with the result that resource use is abused to the point where the marginal benefit from using the last unit of the resource is zero. The waterlogging salinity in Pakistan, depletion of groundwater in many Gulf countries, and the dumping of industrial waste in many countries are classical examples.

F. Social policy in water management

1. Irrigation institutions in Pakistan

Provincial Irrigation Departments (PIDs) are mainly responsible for irrigation management. PIDs undertake some construction work but primarily attend to the operation and maintenance of the irrigation infrastructure. On the other side of the spectrum is the Water and Power Development Authority (WAPDA), linked with the Federal Ministry of Water and Power, an autonomous agency created in 1985 to supervise the construction of the Indus Basin projects and now responsible for water resource development of the country including installation of tubewells under SCARP.

The four PIDs for each province employ a total of 80,000, out of which Punjab alone employs more 50,000 persons. There has been significant growth during recent years in the expenditure on administration, which points to the fact that PIDs tend to get the most out of budgets and staff which are often not related to performance of the departments. The low and fixed salaries that are not related to performance outcome create conditions often leading to corrupt practices.

Irrigation performance in Pakistan has generally remained poor, with huge capital investment (Indus Basin and SCARP projects), extensive training and attempts to elicit farmer participation; the system has been operating at low water efficiency. There has been no consideration of the dynamics, adequacy, or consequences of the present organization of the irrigation system.

On the equity issue, the Green Revolution which was mainly thought of as the spur for development of private tubewells, had a far-reaching impact on income geneneration in Pakistan. Empirical evidence shows that irrigation technology has increased agricultural productivity and employment, but the benefits to the rich have occurred more disproportionately and more rapidly than the benefits to the poor. For the sake of equity, feasible policies and institutional approaches must be identified to improve the access of the poor to irrigation.

Institutional issues are at the centre of water policy issues in Pakistan. One aspect of these issues is the legal access to groundwater and other aspects include social and organizational concerns.

2. *Institutional rigidities*

Pakistan's irrigation management institutions are governed by formal and informal laws and regulations. The formal laws and regulations stem from the prevailing legislation, the Canal and Drainage Act of 1873. There were a number of amendments, subsidiary legislation and new laws relating to other aspects such as land reforms, reclamation and water user's associations, but this act remained the main legal instrument during decades of irrigation development in Pakistan.

It is increasingly felt that the Canal Act of 1873 and its subsequent changes are outdated and that there is an urgent need to restructure the PIDs owing to their declining relevance to different needs and challenges. The provincial and central water and power authorities have failed to take into account the growth of the population and fragmentation of the landholdings and the changes in cropping patterns. There has been a considerable shift toward cash crops or traded commodities that generally require higher water rates and expanded area. This requires a demand-based water delivery system.

The supply driven system is based on *warabandi*, a water distribution system that allocates canal water to farmers on a rotational basis. As noted above, the rigid seven day cycle impedes the availability of water when it is required. The water losses are also not taken into consideration. Further, the *warabandi* system does not fully allow the farmers to either supplement their canal water supplies with their own tubewell water or to sell the surplus water to neighbouring farmers. This has resulted in under-utilization of existing private tubewell capacity.

As excess demand for water continued to increase, its value as a scarce resource resulted in high rental value for the irrigated area. For equitable distribution of water and to ensure that the outlets drew their allocated supply, it was necessary to monitor the distribution system constantly. Over the years as water has become more scarce, the staff of the Irrigation Department have become more prominent in terms of distribution of water. The formal institutional arrangement gave way to informal behaviour on the part of both irrigation staff (corruption at all levels, from *patwari* to higher-level staff) and water users (water breaches, head users versus tail-end users, large farmers versus small farmers and the *biradary* system).

There is very little coordination between the Ministry of Agriculture and the Ministry of Irrigation. In order to maximize the social benefits from the groundwater and surface water management programmes, agricultural extension should include programmes to educate farmers about various water practices and aspects of tubewell technology, and efficient operation and maintenance procedures. Rural institutions should be strengthened to ensure efficient management of groundwater at the local level. Equitable water distribution

was one of the main responsibilities of the institutions responsible for water delivery. A determination of how successful they were requires a review of the analytical data which are presented below

3. Water distribution

(a) Reliability

Problems with reliability of the water supply concern turns missed by the farmers owing to unexpected closure of the Canal and cases when farmers receive less than their due share. A recent study by PERI in 1993 showed that reliability of the irrigation water supply was 70% at the head and 36.3% at the tail in the project area of the study. It indicates the degree of inefficiency of water distribution in Pakistan.

(b) Equity

The present system of water distribution is inequitable in the sense that the farmers at the head or closer to the canal outlet receive better service than the farmers at the tail. Table 32 clearly points out that the farms at the head of the watercourse obtained much higher yields than the farms at the tail. It is clear that the present system of distribution penalizes the latter in terms of low returns on the service charges that they pay.

It is interesting to note how location affects irrigation efficiency. A look at the delivery and application efficiency for the same farmer finds that the farmers at the tail-end are using water more efficiently than those at the middle or at the head of the watercourse. The water is certainly more scarce and valuable to farmers at the tail-end of the system, and they tend to use it more efficiently (table 32).

4. Water users associations

To involve farmers at the grass-roots level, water management programmes have been implemented since 1971 under USAID and later World Bank pilot projects. The OFWM-I project (on-farm water management) requires two conditions: (1) that each province establish a legal ordinance providing for organizing registration of water user associations (WUAs) at the *chak* level; and (2) that project-assisted watercourse improvements cannot begin until farmers on a watercourse organize themselves into a registered water users association. Figure XI provides the number of such associations registered since 1981 under the USAID OFWM project, the World Bank-financed projects OFWM I and II and the Asian Development Bank project. Figure XI shows the distribution of water users associations in three provinces. Of the total, 85% are registered in Punjab.

Byrnes (1992) reports that physical improvement, when accompanied by improved irrigation management, leads to improved irrigation efficiency, changes in farming practices and increased economic benefits. His study, based on interviews with representatives of water users associations, provides a preliminary evaluation of the performance of these associations. Results indicate that the farmers are responding well to on-farm water management projects in terms of meeting physical targets, which ranged from 90% to 180%, and are committed to paying a sizeable amount as cost recovery.

5. Sustainability of water users associations

The success of the OFWM programme cannot be assessed on the evaluation of individual cases as reported above. In the absence of detailed studies, the evidence is inconclusive. A recent World Bank study reported that the programme did not work very well as the water users associations were perceived by the

farmers as simply a means of obtaining financial assistance and the farmers' interest declined once financial support was obtained. There were three problem areas:

(a) Asymmetry of incentives to organize because of different locations of users on watercourses;
(b) Insecurity of land tenure;
(c) Inadequate institutional developments.

The study noted that there were exceptions to this conclusion, but that the programme in its current form was not sustainable, as users organizations were insufficiently developed in Pakistan.

Box 5. **Water markets in Pakistan**

In much of the recent literature, the term "water market"is used to describe the localized, village-level informal sale of water to other farmers. It provides one of the most promising institutional arrangements for increasing access to groundwater irrigation, particularly for small farmers who cannot afford to invest in tubewells. The water markets are developing in all provinces of Pakistan, but water markets are more abundant and developed in Punjab.

The main advantage of groundwater markets can be summarized as follows:

1. Improved utilization of tubewell capacity. Given the small size of landholdings in Pakistan, it is not a prudent policy to expand the number of private and public tubewells when existing capacity is underutilized.

2. Canal water often does not meet the water requirements of crops, especially at critical times, and a water market provides an excellent cushion to protect the small farmers and those at the tail-end of the watercourse against this uncertainty.

3. As water markets develop, the gap between effective price and the average pumping cost narrows.

4. A water market improves equity of access to water which is often beyond the economic reach of small and poor farmers.

A 1993 study examined the performance of the water market in terms of its contribution to agricultural productivity and factors affecting the reliability of water purchased from private tubewells. He found that the increase in productivity (yield per acre) was higher on farms using groundwater in comparison with canal users, and higher on farms where the farmers owned tubewells as compared with the farms purchasing water. The control of water, when and how much needed, was the determining factor in higher productivity on farms with tubewells. The study further noted that policy measures required to improve access to water included: increasing the density of tubewells; lining water delivery channels; and providing a more reliable power supply to rural areas.

In Pakistan trading of water is not legal, though a WAPDA study indicated that 70% of all watercourses traded water. There is an urgent need to legalize water sales and develop water property rights. Future work can address some of the most important aspects of water markets, such as: Is the sale price different from region to region? What are the factors that cause the price differential? What is the role of monopolies in setting water prices?

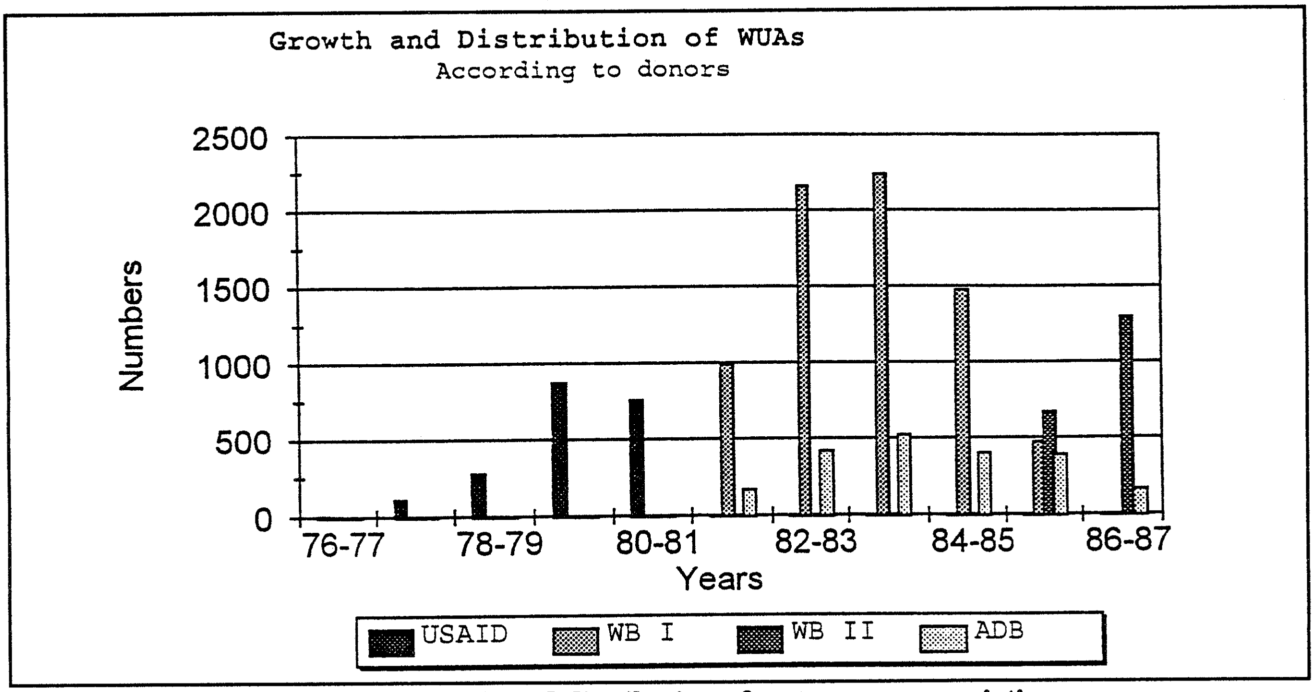


Figure XI. Growth and distribution of water users associations

TABLE 32. AVERAGE YIELD IN MUANDS PER ACRE OF MAJOR CROPS AT DIFFERENT LOCATIONS OF WATERCOURSES

Crops	Head	Middle	Tail
Wheat	54	33	30
Rice	23	16	16
Cotton	10	7	6
Sugar cane	456	271	288

Source: Muhammad Chaudry and Malik Muhammad Asharf. *An Economic Analysis of Level and Structure of Irrigation Water Charges*, 1981.

To conclude, the institutions responsible for water distribution and maintenance are not delivering the water efficiently and equitably. The irrigation performance has been at best poor on the basis of some of the standard criteria such as adequacy, dependability, equity and sustainability, as noted above. Institutional reform seems a precondition for any future investment in water development and sustainable growth of agriculture. There are a number of options, ranging from the Government fiscal model to public utilities. The strategy outlined below looks at some of the options under debate in Pakistan.

6. Institutional reforms: options

There are a number of options recommended for institutional reforms in Pakistan. The Water Sector Investment Study focuses less on changes to the existing "fiscal model" and more on the investment priorities

in the coming years. The World Bank study on irrigation and drainage issues in Pakistan proposes a public utility model, which calls for a major structural change in institutional reforms.

The institutional reforms proposed are:

- Separation of the institutional relations involved in delivery and disposal from those involved in support and advisory services;

- Strengthening of the institutions involved in delivery and disposal (i.e., the PIDs) so that they are able to appreciate the agricultural constraints and objectives of their function;

- Overcoming what has been described elsewhere as the fixation of water management on problems below the *mogha* (small canal) level, and addressing water management at all levels in the watercourse (drain, outfall);

- Strengthening of the institutions involved in the provision of support and advisory services to the farming communities (i.e., the PADs [provincial agricultural departments]) to enable them to see the opportunities for improved management of surface and sub-surface water and react more effectively with the PIDs concerning the provision of water deliveries and drainage;

- Retention and strengthening of organizations like the WUAs and village organizations to encourage greater communal participation and cooperation in development.

The World Bank suggests that the best option for the Government of Pakistan is to develop an autonomous, commercially oriented public utilities service on the basis of a canal command that would be financially independent and would have commercial interests. At farm level (*mogha* level), fully functioning farmers organizations are proposed, with a continuous role in the distribution of water and responsibility for operation and maintenance and collection of user charges. The federal agency WAPDA would continue to be responsible for overall assessment, coordination and development of water resources.

The PIDs should be restructured to develop an administratively autonomous provincial water authority (PWA) that would be responsible for coordinating and planning of water resources of the provinces. A provincial regulatory commission (PRC) would oversee the financial affairs of public utilities, register water rights and settle local water distribution disputes.

The provincial governments are asked to provide their own suggestions for institutional reforms and propose a structure that takes into consideration both the informal and formal institutions in Pakistan. The Planning Department of WAPDA is proposing a structure involving traditional rural institutions such as districts and union councils. They argue that these institutions are in place and represent the only established viable alternative. These institutions do have experience in this field and all that is needed is to train and build up a new base. This option has to evaluated with the idea of strengthening the WUAs under a water management programme.

The World Bank proposal would be difficult to implement in the short run. It will require strong commitment and political motivation on the part of the Government to commercialize irrigation delivery in Pakistan. The idea is sound and perhaps the only option in the long run for developing sustainable agriculture in Pakistan. The transaction cost and feasibility of such a system working through strong informal institutions has to be evaluated carefully before any decision is taken.

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