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SHORT REPORT ON COST OF IRRIGATION WATER AND IRRIGATION WATER CHARGES IN SOME ARAB COUNTRIES

by

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1. INTRODUCTION

At present the Arab Countries import more than 50% of its food requirements and the rate of increase in demand for food exceeds the rate of increase in agricultural production. On the other hand aridity is the major constraint for increaed food production, and, hence irrigtion development is considered a prime way of raising agricultural production, which is a prerequisite for attaining the goal toward food security. This is confirmed by the fact that at present only 30% of the cultivated areas in the Arab Countries is irrigated but its production amounts to some 75% of the total agricultural production.

A rapid irrigation development in the Arab Countries only started in 1950's and gained full momentum during 1960's. In all large river basins, major surface storage reservoirs have been built or are under construction (Nile, Euphrates and Tigris). In other parts of the Arab World, (Jordan, Lebanon, Saudi Arabia, Yemen Arab Republic and Countries of North Africa) smaller dams are in different stages of planning or execution. Saudi Arabia, Yemen Arab Republic and People's Democratic Republic of Yemen are planning to convert the traditional spate irrigation to perennial irrigation by better control of flood water of these seasonal wadis and the use of the groundwater reservoirs in the alluvial plains of these wadis. The large groundwater basins known so far (Egypt, Sudan, Libya, Tunisa, Algeria, Saudi Arabia and the Gulf States) are being developed.

This process of rapid agricultural development under irrigation was accompanied by the process of desertification as marked by increasing micro-aridity and declining productivity. In many Arab Countries (Egypt, Iraq, Syria, etc.) manifestations of waterlogging and salinity on irrigated lands are major problems due to poor management of irrigation water in the conveyance system as well as in the field. Also increasing salinity of underground water and falling level of water tables due to overpumping is another serious problem in nearly all Arab Countries. In Saudi Arabia and the Gulf States, for example, the artesian flow of springs and wells is decreasing, the water quality is deteriorating the water level is falling due to increased extraction and perhaps decreased recharge; thus causing salt water intrusion.

From the above it becomes evident that in most Arab Countries the easily accessible conventional water resources, such as river

flows and shallow groundwater of good quality have been almost entirely committed. In the allocation of water between the sector, priority normally is given to the domestic sector for which quality requirements are stringent. Agriculture on the other hand, requires relatively large quantities of water, but this sector can accept low quality water. As indicated above in most Arab Countries, the easily accessible good quality water supplies for agriculture are diminishing and it is therefore inevitable that there will be a tendency, in the future to look for agriculture as a potential user of marginal quality water, including the utilization of effluent water from domestic as well as for industrial waste, this will not only alleviate the water shortage situation, but it will also solve the problem of wastewater disposal.

Hence the scarcity of water supplies, which is badly needed to meet the increasing needs of population growth and rapid development in agriculture as well as in industry has given cause for concern in formulating of national development plans in the Arab Countries. It is gratifying to report that decision makers are being increasingly involved in divising ways to optimise the use of available supplies as well as augmenting the available water resources by non-conventional means and the development of costly and deep underground water. The non-conventional resources programme includes two programmes, one is for increasing domestic water supply through desalination of saline water (sea water and underground water) and the other is for the treatment of the sewage effluent and its use for different purposes.

In this regard it may be pointed out that in arid areas, as is the case with the Arab Countries, recycling of water may have a greater impact on future usable water supply than any of the technologies aimed for increasing water supply such as, water harvesting, weather modification (artificiala rain) desalting of saline water, etc. Treated sewage water can be used for irrigation, industry, rercharge groundwater and in special cases, properly treated wastewater could be used for municipal supply. With careful planning various industrial and agricultural demands may be met, by purified water, there-by freeing freshwater for municipal use. Several Arab Countries, particulary, Jordan and the Gulf States, have already initiated ambitious programmes in this field.

2. COST OF UNDERGROUND WATER IN SOME ARAB COUNTRIES

The following discussion is based on the available information on ground-water costs from FAO files and project reports and the documentation centre of FAO. The cost of groundwater from wells depends on the cost of the well and pumping equipment plus the cost of operation and maintenance. It also depends on the discharge of the well and the number of pumping hours per annum. The well cost depends primarily on the geological formation, the depth, the well design and the type of screen to be used. Well cost is sensitive to the location, both in terms of access to site and availability of drilling equipment (existence of a Government Drilling Department, for instance). Well cost increases markedly if equipment and material have to be imported

from outside the country, especially by a Contractor. The cost of groundwater as related to depth of wells is summarized in Table 1, while Graph 1 shows the relationship between the depth of wells and their total cost in different countries. On the other hand Table No. 2 indicates the cost of water taking all related factors into consideration.

TABLE 1

SUMMARY OF GROUNDWATER COST AS RELATED TO DEPTH OF WELLS AND ADJUSTED FOR 3 600 H OF PUMPING

Country	Year	Depth of Well m	Cost in US $ Per 1000^3 m
Jordan	1984	200	92
Libya	1972	500	113
	1982	200	185
Egypt	1977	500	30
	1981	200	60
Tunisia	1982	400	205
Syria	1975	500	83
Saudi Arabia	1979	500	27
	1979	400	20
	1979	200	12

Irrigation projects based on groundwater derived from wells (especially deep wells) are expensive and normally fall in the category of high expensive irrigation projects. In addition to the high cost of water the costs of the water distribution system as well as the land development have to be added. Higher capital costs (above $ 4 000/ha) plus operation and maintenance costs ($100 to 300/ha/year) always require higher valued crops and higher cropping intensities so as to be justified on an economic basis. Table No. 3 summarises the cost of irrigation projects related to the depth of groundwater.

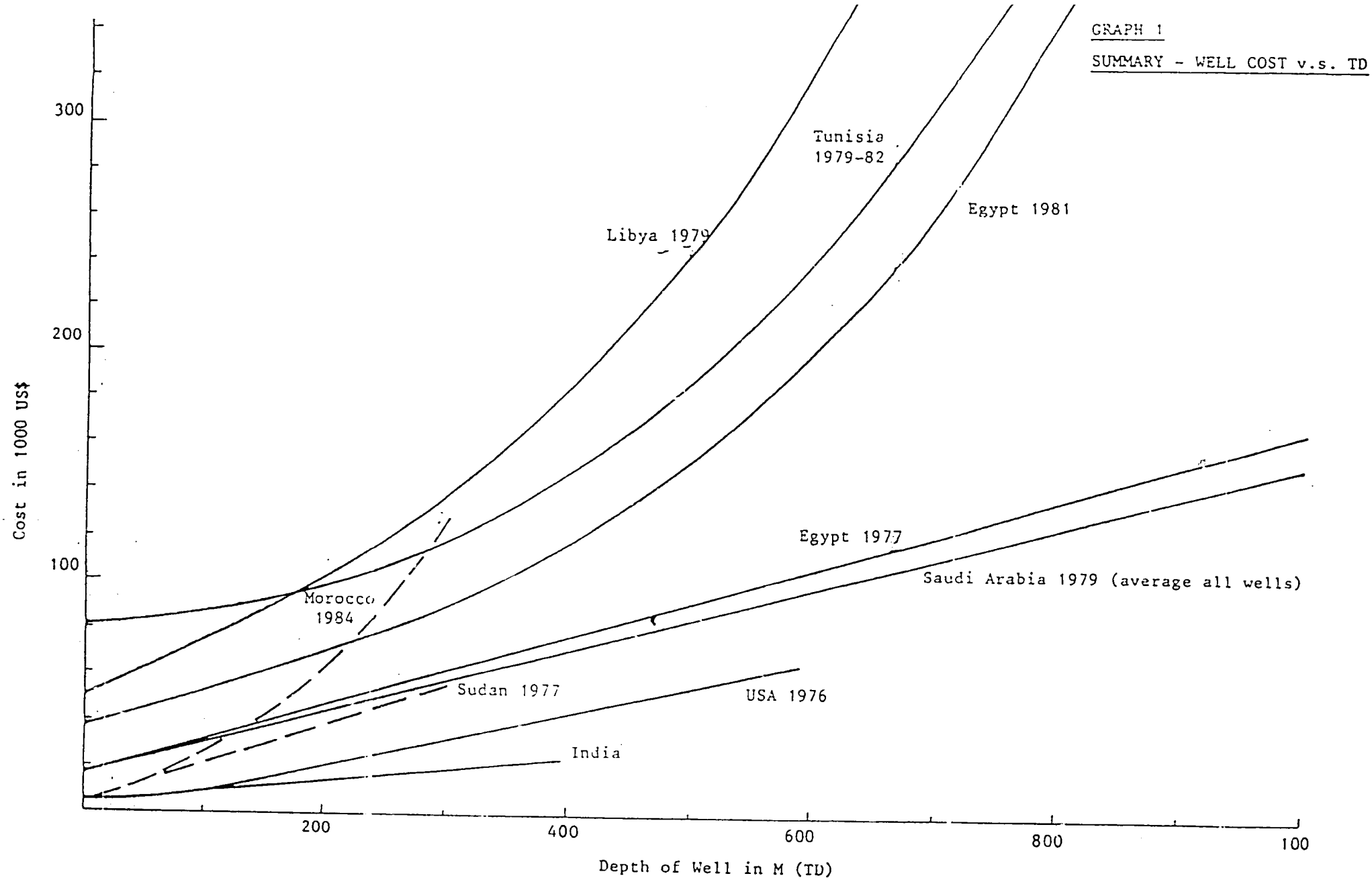
GRAPH 1
SUMMARY - WELL COST v.s. TD
Cost in 1000 US$
300
200
100
Libya 1979
Tunisia 1979-82
Egypt 1981
Egypt 1977
Saudi Arabia 1979 (average all wells)
Morocco 1984
Sudan 1977
USA 1976
India
200
400
600
800
100
Depth of Well in M (TD)

TABLE 2: COMPONENT OF WATER COST FROM DIFFERENT DEPTHS OF WELLS - SYNTHESIS OF WELL DATA

TD (m)	Q (m^3/h)	Pump Lift L (m)	Q x TD (10^3/hxm)	Equip. cost (10^3US$)	Total Well cost (10^3US$)	Energy cost* diesel ($/h)	Energy cost* elect. ($/h)	Average annual energy cost (10^3 $) h. of pumping 2880	3600	4200	Capital & Replacement costs (10^3 $) Well**	Pump***	Total Incl. 4% mainten.	GW cost (US$/$10^3 m^3$) h. of pumping 2880	3600	4200
100	50	80	5	5.5	44.5	0.64	0.69	1.93	2.41	2.81	5.67	3.75	9.79	81	68	60
200	100	150	20	12.6	61.5	4.66	5.00	13.83	17.28	19.57	7.10	8.59	16.31	105	93	85
300	150	200	45	20.4	91.7	9.33	10.00	27.65	34.56	40.32	10.36	13.90	25.23	122	111	104
400	200	300	80	28.7	132.6	18.66	20.00	55.58	69.12	81.06	15.10	19.57	36.05	159	146	139
500	250	400	125	37.4	185.0	31.12	33.30	92.16	115.2	134.4	21.44	25.83	48.78	196	182	174
600	300	500	180	46.5	250.0	46.67	50.00	138.24	172.8	201.6	37.14	31.07	70.93	242	226	216
800	400	600	320	56.1	416.0	74.60	79.90	221.8	277.2	323.4	64.80	61.60	131.50	114	91	78
1000	500	700	500	65.4	628.7	108.80	116.60	322.6	403.2	470.4	95.00	103.30	206.20	143	115	98

* Energy cost calculated on the basis of: overall pump eff. = 0.7; overall pump eff. x motor eff. = 0.6, diesel oil cost: $0.26/Lt.; electricity: $0.08/kwh

** Capital cost I = 5; N = 20. Replacement cost I = 10; N = 20

*** Capital cost I = 5; N = 20: Replacement cost I = 10; N = 7.

TD = total depth
Q = well discharge
GW = groundwater

TABLE 3

UNDERGROUND PROJECTS - UNIT COST PER HECTARE (IN US DOLLARS)

Items	Shallow wells Tunisia[a]	Deep Tubewells			
		100 m-deep Bangladesh	100 m-deep Turkey	330 m-deep Egypt (New Valley)	400 m deep Tunisia
Well	1 900	500	390	2 100[b]	1 600
Pump set	700	220	1 050[c]	700	400
Water distribution system	400	-	640	4 500	5 000
On farm development	-	-	320		
Total	3 000	720	2 400	7 300	7 000

a Masonry well 17 m deep and 4.5 m diameter
b Stainless steel screen
c Including power line

3. The cost of water from wells of more than 200 meters deep is expected to be at least 10 US cents per cubic meter and can go up to 25 US cents per cubic meter, depending on the depth and location of wells as well as on the country concerned. In the early 1970s and before the steep rise in the cost of energy it was projected that by 1990 the cost of desalted water from the sea will drop to 5 US cents per cubic meter from desalination plants with a capacity of more than 4 million m^3/day. However, due to the rise of oil prices after 1974, this projection is no longer valid. At present the cost of desalted water from brackish water of 3 000 to 10 000 ppm using the reverse osmosis process (which is the most suitable) is just above $1.0/$m^3$. While the desalted water from the sea using multi-stage-flash (the most suitable) costs about $1.5/$m^3$. Hence groundwater from deep wells and which is suitable for domestic supply is still competitive with the desalted water from either brackish or seawater.

4. When using expensive water for irrigation, as is the case with groundwater from deep wells, maximizing the efficient use of this water is imperative, hence the advent of improved irrigation systems such as drip irrigation and more recently the minisprinklers and

bubbler systems opend up another potential factor of two in the efficiency of water use by crops. This is not to mention the role of protected horticulture and the use of controlled environment in maximizing the production per unit of water as well as per unit of land. For continued intensive use, these methods should have very high priority and optimum use of other inputs, which can justify relatively high expensive water.

5. It must be pointed out that irrigated agriculture of 15 years from now, when it will be optimized for expensive water, such as groundwater from deep wells and desalted water from sea or brackish water, will be a much different enterprise than that of today. The control of plant enzymes is developing rapidly and the techniques of breeding in specific characteristics are increasing in strength and precision. Even without special breeding programmes, one can look forward to seeing farms where only 200 litres of fresh water per day can grow one person's food needs at a cost of 5 cents US/day for the water, if the cost of water is as high as 25 cents per cubic meter. This should be kept in mind when talking about the cost of groundwater from deep wells and its potential use for irrigation purposes.

6. Lastly, it must be recognized that while water supply is a social and economic necessity to the community as a whole, the amount consumed varies widely with different activities. Thus the practice is to support part of the cost of water by general taxes and part by revenues from users. Farming (the highest consumer of water) in particular has always been favoured in receiving water at low cost because of the important super structure of business and commerce which derives from the agricultural structure, but which consumes little water itself.

3. WATER CHARGES AND COSTS

In principal, the total cost of irrigation water is the summation of Capital Investment and the operation and maintenance costs of the irrigation system. In the case of multipurpose structures, such as large dams only a part of the cost of such structures should be allocated to irrigation, while allocating another part to other uses, as the case may be, such as power generation, navigation and flood control. In the countries under review, i.e., Egypt, Jordan and Morocco, irrigation water is either provided free or heavily subsidized.

3.1. Egypt

Economic feasibility studies of land reclamation programs in Egypt indicate that the minimal cost for irrigation water is 0.005 LE/m³ (0.4 U.S. cent/m³). This covers the operation, maintenance and modernization of the irrigation system in Egypt. It does not cover investment cost of irrigation structures neither the cost of pumping water. For newly reclaimed areas, there are additional investments in construction and maintenance of new main canals. Furthermore, the additional supply of water needed for major reclamation activities requies investments in the upper Nile basin or through treatment of

water for re-use in irrigation. This increases the cost substantially above the minimal cost. In fact, it is estimated that the cost will be in the range of 0.01 to 0.02 LE/m³ (0.8 to 1.6 U.S. Cent/m³) in the 1990's. Moreover, the water that may be supplied through the Jonglei canal in Sudan was estimated to cost 0.065 LE/m³ (5 U.S. Cent/m³), with actual cost expected to be much higher. The cost of irrigation water from underground source, such as the New Valley is estimated to be about U.S. Cent 3 to 6 per cubic meter.

In Egypt farmers pay no charge for irrigation water, but they are responsible for the maintenance of the last common irrigation canal (Mesqas) and their field ditches. Hence the financial cost of irrigation water to farmer is much less than the economic cost. In other words, there is a substantial amount of subsidy provided to farmers concerning irrigation water. This, should be considered in the light of studies by the Water Research Institute indicating the marginal value product (MVP) of water used in cotton cultivation in Abyuto and El-Minya at 0.06 LE/M³ (4.62 Cent/m³). For maize cultivation the marginal value product of irrigation water was 0.039 LE/m³ (3.00 Cents/m³). Water charges, however, should be considered within the overall system of taxes, subsidies and net transfers into the agricultural sector. A joint study by the Ministry of Agriculture and the U.S.A. Agency for International Development indicated the following:

In 1975 the Egyptian consumer received a net subsidy from the agricultural sector of LE 600 million (US $ 460 million). This was effected through lower prices received by farmers. It is estimated that Government paid prices ranging from 50% to 20% below those prevailing on the free market. Agriculture also subsidised the rest of the economy through capturing the difference between world and farmgate prices, minus subsidies provided to farmers on inputs such as water energy, fertilizers, seeds and pesticides. This implicit tax revenue amounted to LE 600 million in 1975. The rest of the economy provided LE 400 million to consumers in the for of lower prices for food and fiber. Thus the agricultural sector is a net subsidizer to the rest of the economy although it is not charged for irrigation water.

3.2 Jordan

Jordan Valley Irrigation Project:

In the East Ghore Canal Irrigation Project farmers were charged 1 fils (1000 fils equal 1 Jordanian Dinar, (JD)); 1 JD= $2.85 US) per cubic meter of water for the first 1500 mm of irrigation depth and 2 fils per cubic meter for the amount that exceeded 1500 mm. The irrigation water was supplied on demand and was measured by a constant head orifice. The irrigation network is a lined gravity system and each farm unit (3 to 5 ha size) was provided with this water measuring device. The above policy was based on the assumption that under the project soil, climatic and cropping pattern and intensity, and with a reasonable water management the depth of 1500 mm should be sufficient. Any amount exceeding this was supposed to be mainly due to poor water management and farmers should pay double for this unnecessary waste.

In the year 1973, a revision of water charges in the Jordan Valley was made and a new set of water charges were approved by the Government. Water charges were set at JD 0.003/m³ (0.90 cent/m³) and were immediately imposed. They were to be increased annually according to an approved schedule. Such a decision was made in view of the following considerations:

- Farmers are the main beneficiaries of irrigation water and they have to pay for at least the operation and maintenance cost of the irrigation system.

- Farmers ability to pay is limited in the early stages of farming, but increases as they become more experienced. This is the idea behind setting water charges at low levels in the early stages and higher levels subsequently.

However, water charges were frozen at the 1973 level. The current water charge is 3 fils per cubic meter. This is not a trivial charge; it is a moderate charge relative to typical agricultural water charge. For example, it is equivalent to 30 JD per hectare/meter, $86 US per hectare/meter, $10.5 US per acre/foot, or $0.03 US per 1000 US gallons.

Unfortunately, this current water charge falls short of covering the O&M cost of the Jordan Valley irrigation systems; the 3 fils do not even cover the cost of billing the farmers. The actual O&M cost is 7 to 10 times higher, i.e., 21 to 30 fils per cubic meter. The Jordan Valley Authority (JVA) intends to increase water charges over a period of time until they covered the O&M costs, but this is politically difficult and, while a charge of perhaps 25 fils per cubic meter may not be a problem for producers of high value fresh market vegetable and fruit crops, it may be an almost overwhelming burden to producers of lower value processed vegetables and ordinary field crops.

An important reason why O&M charges are high per unit of water delivered is because the system only accounts for the delivery of about 500 mm of water over the approximately 240,000 dunums (du) (24,000 ha) served. Competition for water is high at critical times during the year and the system has to be operated continuously throughout the year. Furthermore, in order to assure a reasonable degree of equity throughout the system, the JVA provides delivery services to the headgates of each farm unit. In addition, the project serves a long, narrow and complicated irrigated area.

Water is very valuable in the Jordan Valley. In comparison with wells, the capital plus operating cost of pumped water from private tubewells in the region is estimated to be more than 30 fils per cubic meter. For the most part, private tubewells are only used to irrigate high value crops. Furthermore, farmers with their own wells have complete control of their water supply so tend to pay a premium for this security. At any rate, this gives evidence that farmers are willing (and can) pay more for their water.

Operation and Maintenance

The Operation and Maintenance Department in the Jordan Valley has kept the water distribution systems sufficiently maintained to deliver water for more than 20 year without major problems or interruptions of service. Furthermore, the system boasts of having an 87 percent conveyance efficiency at normal flow, disregarding spillage losses and unbilled deliveries. During low flows the conveyance efficiency averages from 70 to 80 percent. From the available records it was estimated that in normal years only about two-thirds of the salable water is billed.

The equity of distribution is quite good because the JVA has placed a high priority on assuring that each farm unit receives its fair share of water. Upon a system of farmer-initiated requets, during critical (low) flow periods in the main crop season, each farm unit probably receives approximately 70 percent or more of its fair share of the delivered water (part of the variation is due to variations along the length of main canal).

Achieving this has been costly since the JVA services and maintains the distribution system up to the turnout of each farm and provides water distributors (ditchriders) to control and monitor the quantity of water deliverd to each farm unit. Hence there may be room for savings in distribution and maintenance cost of the small laterals by turning some of this responsibility over to the farmers. Further savings could be achieved by more efficient deployment of and better transport for the JVA ditchriders.

In the upland the cost of irrigation water pumped from wells ranges from JD 0.015 to 0.030/m³ (4.3 to 8.6 cent/m³) depending on the characteristics of the geological formation and depth of groundwater (see table 4).

From the figures in table 4 it could be noted that it is a deliberate Government policy to subsidize heavily irrigation water in the Jordan Valley. This subsidy however is much less in case of irrigation settlement project in the upland. In case of Qaa' Ed Disi, this project has no settled farmers, and water is being used by the Ministry of Agriculture for commercial irrigation projects and by the Authority of Aqaba for municipal water supply. In this case the water is being sold at prices, a bit higher than the actual cost, thus leaving a small margin of profit.

Table 4

Cost of Irrigation Water in Jordan and Prices charged to the Farmers (1 $ = JD 0.350)

Project	Depth of GW M	Actual Cost US Cent/m³	Price of Water to the Farmers US Cent/m³	% of Charged Price to Actual Cost
1.Jordan Valley	Surface	8.57	0.86	10.0
2.El Jafir	15-20	4.29	1.14	26.6
3.Katranah & Wadi El-Abyadh	30-50	4.86	1.71	35.2
4.El-Arja	30-50	5.14	2.00	38.9
5.Qaa' Ed Disi	150	8.57	11.43	133.4

3.3. Morocco

In Morocco irrigation water charges range from Dm 0.22-0.27/m³ with an average of DM 0.25/m³. Out of this, the cost of energy ranges from DM 0.05-0.20/m³ while the operation and maintenance ranges from DM 0.80-0.10/m³. (DM = $ US 0.113)

Some case studies indicated that actual water charges are about 38% of the production and dlivery cost of each cubic meter. because of the relatively cheap and subsidized irrigation water, farmers benefiting from irrigation projects tend to play it safe and apply more than recommended amounts of water. It is estimated that in the lower Moulouya Irrigation Project, actual water use was 48% higher than the recommended use.

The Government of Morocco intervenes in the price of some inputs and agricultural outputs. Subsidies are provided to maintain low retail prices for flour, bread, sugar, edible oil and milk, as well as for agricultural inputs such as fertilizers, seeds, machinery, livestock and credit. The beneficiaries of land reform projects pay 40% of the total cost of land and irrigation development over a 20 year period. The interest rate charged is 4% compared to the current interest rate of 14% charged by commercial banks.

In this connection it may be mentioned that in Iraq, that the annual water charges were set in 1983 as one Iraqi Dinar (ID=2.7 US$) for every donum (donum=2500m²) of reclaimed land which is irrigated by irrigation network owned by the Government and half a dinar for every donum of reclaimed land or orchard that is irrigated by non-government means.

4. CONCLUSIONS

4.1 In principles, the total cost of irrigation water is the summation of capital investment and the operation and maintenance costs of the irrigation system. In the case of multipurpose structures, such as large dams, only a part of the cost of such structures should be allocated to irrigation, while allocating another part to other uses, as the case may be such as power generation, navigation and flood control.

4.2 It is recognised that while water supply is a social and economic necessity to the community as a whole, the amount consumed varies widely with different activities. Thus the practice is to support part of the cost of water by general taxes and part by revenues from users. Farming (the highest consumer of water) in particular has always been favoured in receiving water at low cost because of the important super structure of business and commerce which derives from the agricultural strucutre, but which consumes little water itself. Hence in the countries under review irrigation water is either provided free or heavily subsidised.

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