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# THE ECONOMICS OF IRRIGATION IN THE JORDAN VALLEY

THIS valley is famous for the River Jordan which flows through it from Lake Tiberias (Sea of Galilee) to the Dead Sea. The river, small though it is, has acquired an importance far in excess of its flow, owing mainly to the political division of Palestine and the aridity of the climate in its valley.

The Jordanian portion of the valley covers an area of 943 square kilometres of which some 513 are irrigable. Only a small fraction of this potential is used at present. A 1953 survey showed that 3,825 farms provided some employment for 108,000 persons, and afforded an average net farm income of U.S. \$190, or a total net farm income of \$725,000 for the whole valley. The reasons for such low returns are numerous, but reliance mainly on rainfall ranks high on the list.

The valley is in general highly fertile and is free from frost throughout the year (giving it an advantage over the uplands around it). Furthermore, it has an abundance of water in the Iordan River and its tributaries in relation to land that could be irrigated. There is a total flow of 1.2 billion cubic metres annually, or some 60 inches of water, for the irrigable area. Capital, however, is a limiting factor in a country as poor as Jordan where the population of 630 persons to each irrigated square kilometre or its equivalent is increasing at the annual rate of 2.9 per cent. To accentuate this condition, an influx of 929,000 Palestinians raised the census figure from 400,000 in 1948 to 1,329,000 in 1952, while the gross area changed from 90,000 to 95,200 square kilometres, and the cultivated area from 4,000 to 7,000.2 Half a million refugees now live in camps and represent a pool of employable labour estimated at some 250,000 men. Thus the addition of 513 square kilometres of irrigated land to the currently productive resources is highly desirable. Jordanians would give it the first priority if they had the necessary capital. Their hope, supported by field studies and detailed plans, is that more efficient use of the land and water resources of the Jordan Valley for irrigation would contribute

<sup>&</sup>lt;sup>1</sup> Master Plan Report (see bibliography (2)), pp. 16-27.

<sup>&</sup>lt;sup>2</sup> Ibid., vol. ii, pp. 58-60.

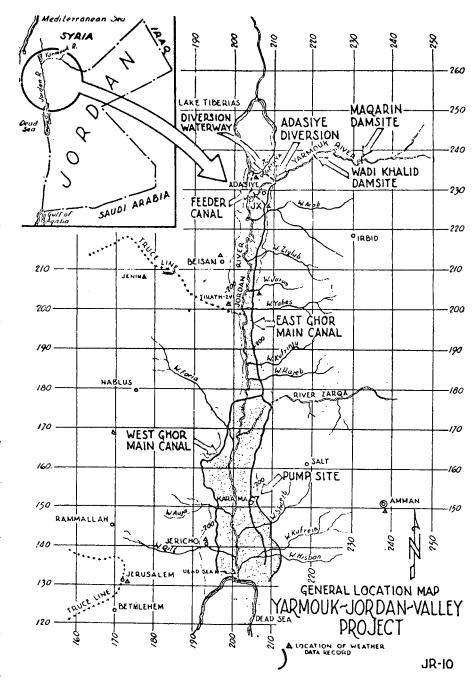


Fig. 1. From Baker and Harza, Master Plan.

significantly to an improvement in incomes as well as raise the morale of a population too long confined to camp life.

Jordan, however, is not the only claimant to the waters of the Jordan River system. Syria contributes water from a drainage area of some 5,000 square kilometres to the Yarmouk River. In 1953 some 2,500 hectares of land were irrigated in the Mzeirib Plateau, and the International Bank Mission recommended the irrigation of an additional 2,900 hectares in the same area, where peanuts, cotton and citrus are reportedly adapted.<sup>2</sup> The cost per hectare of these irrigation facilities would be around 1,500 Syrian pounds. The Syrian Seven-Year Plan provides 7,000,000 Syrian pounds for this project, reported to be in an advanced stage of completion.3 The government of Jordan, in recognition of the Syrian claim, signed a Treaty for the Utilization of the Yarmouk River with the Syrian Government in Damascus (4 June 1953). In this treaty Syria reserved its priority rights to waters arising in its territory as well as to 75 per cent. of any power generated in the Yarmouk as against a 5 per cent. contribution to the costs of development.

Israel is the next claimant, being a riparian area contributing some 23 per cent. of the total 1,440 million cubic metres of water that finds its way annually to the river basin. Plans based on various assumptions have been made, namely the Hays Unified Development, Seven-Year and Ten-Year Plans and the Cotton Scheme. Some 3,000 hectares of peat soil have now been drained in the Huleh basin and the conveyance system for the water to be diverted is reported to be completed. The main diversion works have been postponed repeatedly for politico-strategic reasons. These structures would take the waters out of the Jordan Valley into southern Palestine.

The various plans formulated are listed in the bibliography below. Only the *Master Plan Report* is based on detailed field work involving all the aspects of the scheme—economic, engineering, agricultural and human. It has been chosen as the main source of information for the present article.

Recently the Board of Development of Jordan invited civil engineering firms to offer tenders for the construction of an irrigation scheme designed to irrigate about 12,000 hectares of land in the East Ghor—

<sup>1</sup> I hectare is equivalent to 10 dunums, the unit of land in the Jordan Valley.

<sup>&</sup>lt;sup>2</sup> International Bank of Reconstruction and Development, The Economic Development of Syria, 1955, pp. 41 and 335.

<sup>&</sup>lt;sup>3</sup> U.N.R.W.A., Quarterly Bulletin of Economic Development, No. 15, Beirut, March 1958 (mimeo).

that section of the valley on the right of the River Jordan. This project is based on the *Master Plan Report* prepared in 1955. This plan provided for the irrigation of 51,300 hectares and the production of 160 million kilowatt-hours of energy per year. Moreover, security, storage and flood control measures were included.

The Jordan Valley is a rift valley lying for most of its length below sea-level. It is an arid area. Rainfall is not only limited in amount, especially in the more southerly parts, but is also very erratic, variations between years amounting to as much as 75 per cent. Rainfall is confined to a short winter season. Thus irrigation would seem to be the main source of water for agriculture. Underground water resources were thought to be important on the basis of the expectations of Chas. T. Main, Inc., responsible as they were for the Unified Development Plant (better known as the Johnson Scheme). Field investigations reported in the Master Plan show underground waters to be essentially unreliable. Thus only surface water is available, coming from the Jordan and Yarmouk Rivers together with the wadi flows. These represent a total flow of 1,200 million cubic metres annually. The total diversion requirement of the irrigable area in the Jordan Valley is about 760 million cubic metres. It is thought that this figure represents an underestimate of some 15 per cent. Thus the total requirement is of the order of 900 cubic metres annually. Enough would therefore remain for both Syria and the recognized needs of Israel within the watershed area (especially since the drainage of Huleh Lake) as 60 cubic metres previously lost to evaporation are now preserved.

Land classification surveys have provided a firm basis for agricultural planning. Table 1 shows 34,753 hectares to be irrigable, and

TABLE 11

Land class	Area in hectares	Percentage of total		
Irrigable (1)	14,309			
(2) (3)	13,847 6,597	14·7 7·0		
(1+2+3) Reclaimable (4)	34,753 17,231	36·9 18·3		
Arable land Non-arable (6)	51,984 42,300	55 <sup>2</sup> 44 <sup>8</sup>		
	94,284	100.0		

<sup>&</sup>lt;sup>1</sup> Master Plan, vol. ii, pp. 44 et seq.

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17,231 hectares to be class 4 and reclaimable into land classes 1, 2 or 3. The non-arable area is equal to 44.8 per cent. Only 51,320 hectares are within the project area, including 950 hectares at present under irrigation.

The costs of clearing, levelling, and land planing by classes, together with the cost of reclamation of class 4 land, are as follows (1953 prices):1

#### TABLE 2

Land class	Approximate cost per hectare \$
I	100.00
2	111.70-137.50
3	180.00-300.00
Reclamation and development	
of class 4 land into lands of	
class 1	170.00
2	240.00
3	280.00

The Master Plan<sup>2</sup> provides for a multi-purpose dam on the Yarmouk River not far above its junction with the Jordan, and also a diversion structure on the Yarmouk to divert water into either an East Ghor Canal or into a feeder canal leading to Lake Tiberias, where flood waters would be stored. It also provides for lateral and secondary canals to the farms, for farm development and drainage, and also for power generation.

The storage-dam site was selected at the Magarin station. A 71-metre dam would have a gross storage capacity of 47 million cubic metres, considered sufficient for irrigation purposes. For electric-power generation, a dam 147 metres high would be required to store the necessary 460 million cubic metres. The construction of the dam would take some two or three years and cost \$36,000,000 (1953 prices), of which \$11,350,000 would be the allocated cost for irrigation storage.

The Yarmouk Diversion near the village of Adasiye is a dam 17 metres high intended to divert the waters released from the Magarin dam into the East Ghor Canal. Pending a political settlement, the Tiberias features are impracticable.

The Main Canal would convey water from the headworks to the various sections of the scheme, namely, East Ghor North, East Ghor South and West Ghor, where 16,950 hectares, 18,360 hectares and 15,110 hectares respectively are irrigable. The total canal length

<sup>&</sup>lt;sup>1</sup> Master Plan, vol. vii, appendix B, pp. 125-35.

<sup>&</sup>lt;sup>2</sup> Ibid., Presentation Letter (bound with vol. i).

would be 159 kilometres. The section now tendered for is the East Ghor (North), 65.7 kilometres long, which is expected to irrigate about 12,000 hectares by gravity flow.

From the main canal, lateral and secondary canals would take water to the high points of the farm units. The areas not irrigable by gravity would be served by a network of nine pumping stations and lateral canals arising from them. Wadis, or streams, would provide irrigation water to 2,184 hectares through a system of wadi laterals supplying water by gravity flow. Drainage is provided for in the *Master Plan*, to a depth of 1.50 metres.

Farm unit development, which would include land development and assistance to settlers, was thought to be best done at the project level in order to insure an optimum productivity of land under continuous irrigation, at an average cost of \$295.60 per hectare (1953 prices).

Thus construction costs would amount to U.S. \$108,719,600, inclusive of a contingency reserve and overhead costs. Table 3 gives an itemized breakdown of cost by areas.

Table 3. Cost of construction of Jordan Valley Irrigation Project (in thousands of dollars, 1953 prices)<sup>1</sup>

Features	East Ghor North	East Ghor South	West Ghor	Total
Yarmouk Dam*	. 3,257.4	4,437.9	3,654.7	11,350.0
Adasiye Division*	. 331.5	451.6	371.9	1,155.0
East Ghor (North)* Main Canal.	. 2,556.8	3,483.3	2,868.5	8,908.6
Laterals	. 5,526.5	6,466∙1	4,099.2	16,091.8
Pump laterals and Wadi Extension	. 5,507.9	4,250.4	8,007.8	17,766.1
Drains	. 3,773.8	3,172.3	2,185.8	9,131.9
Farm Unit Development	4,165.0	5,799.0	4,943.0	14,907.0
East Ghor (South) Main Canal .	.	5,210.0		5,210.0
West Ghor Main Canal	.		9,377.2	9,377.2
General property†	. 521.8	710.8	585.4	1,818.0
Railroad relocation	. 287.0	391.0	322.0	1,000.0
Tiberias features	3,445 1	4,693.5	3,865.3	12,003.9
Total cost (\$1,000)	. 29,372.8	39,065.9	40,280.8	108,719.5

<sup>\*</sup> Allocated by sections. † Includes garages, yards, offices, &c.

The yearly costs incurred in the operation and maintenance of the scheme are shown in Table 4. The interest rate is taken as  $2\frac{1}{2}$  per cent. per annum for 6 years and the amortization factor was based on the sinking-fund method at  $2\frac{1}{2}$  per cent. per annum for 100 years,

<sup>&</sup>lt;sup>1</sup> Ibid., vol. viii, pp. 68-69.

450 THE ECONOMICS OF WATER SUPPLY AND CONTROL following the practice of the U.S. Bureau of Reclamation. All estimates are based on 1953 prices.

Table 4. Cost per hectare for supplying irrigation water (in thousands of dollars, 1953 prices)<sup>1</sup>

Costs	East Ghor North	East Ghor South	West Ghor	Total
Estimated construction cost	29,372.8	39,066.0	40,280.8	108,719.6
per section at 2½ per cent.)	2,203.0	2,930.0	3,021.1	8,154-1
Total investment	31,575.8	41,996·o	43,301.9	116,873.7
Amortization factor	0.02731	0.02731	0.02731	0.02731
Annual amortization cost	862.3	1,146.9	1,182.6	3,191.8
ment	315.9	342.2	281.6	939.7
Total annual costs	1,178.2	1,489.1	1,464.2	4,131.5
Area in hectares	16,950 \$69·70	18,360 \$82.00	15,110 \$98·00	50,420 \$82.00

East Ghor North, being nearer to the headwaters, costs least on a per hectare basis, while the West Ghor is the most expensive, the figures being \$69.70 and \$98.00 per hectare respectively.

Table 5.2 Estimated net income of the farm units budgeted for the fordan Valley Irrigation Project

U.S. \$           Gross farm income           Cereals         .					0		
Cereals         57         72           Vegetables         541         439           Fruit         267         390           Other crops         180         228           Livestock         116         430           Total farm income         1,161         1,559           Farm expenses         Taxes, depreciation and repairs         98         105           Seeds and fertilizers         149         187           Other crop expenses         63         110           Charges for irrigation water         123         213           Other farm expenses         333         627           Total farm expenses         766         1,242						U.S. \$	U.S. \$
Vegetables         541         439           Fruit         267         390           Other crops         180         228           Livestock         116         430           Total farm income         1,161         1,559           Farm expenses         7         149         187           Other crop expenses         63         110           Charges for irrigation water         123         213           Other farm expenses         333         627           Total farm expenses         766         1,242	Gross farm ince	ome					
Vegetables         541         439           Fruit         267         390           Other crops         180         228           Livestock         116         430           Total farm income         1,161         1,559           Farm expenses         7         149         187           Other crop expenses         63         110           Charges for irrigation water         123         213           Other farm expenses         333         627           Total farm expenses         766         1,242	Cereals				.	57	72
Fruit         267         390           Other crops         180         228           Livestock         116         430           Total farm income         1,161         1,559           Farm expenses           Taxes, depreciation and repairs         98         105           Seeds and fertilizers         149         187           Other crop expenses         63         110           Charges for irrigation water         123         213           Other farm expenses         333         627           Total farm expenses         766         1,242	Vegetables				.		430
Other crops         180         228           Livestock         116         430           Total farm income         1,161         1,559           Farm expenses           Taxes, depreciation and repairs         98         105           Seeds and fertilizers         149         187           Other crop expenses         63         110           Charges for irrigation water         123         213           Other farm expenses         333         627           Total farm expenses         766         1,242	Fruit .		,		.	- :	
Livestock         116         430           Total farm income         1,161         1,559           Farm expenses         1,161         1,559           Taxes, depreciation and repairs Seeds and fertilizers         98         105           Other crop expenses         63         110           Charges for irrigation water         123         213           Other farm expenses         333         627           Total farm expenses         766         1,242	Other crops				.	•	
Farm expenses       98       105         Taxes, depreciation and repairs       98       187         Seeds and fertilizers       149       187         Other crop expenses       63       110         Charges for irrigation water       123       213         Other farm expenses       333       627         Total farm expenses       766       1,242						116	430
Taxes, depreciation and repairs       98       105         Seeds and fertilizers       149       187         Other crop expenses       63       110         Charges for irrigation water       123       213         Other farm expenses       333       627         Total farm expenses       766       1,242	Total farm	n inco	me			1,161	1,559
Seeds and fertilizers	Farm expenses						
Other crop expenses         63         110           Charges for irrigation water         123         213           Other farm expenses         333         627           Total farm expenses         766         1,242				d repa	irs	98	105
Charges for irrigation water         . 123         213           Other farm expenses         . 333         627           Total farm expenses         . 766         1,242	Seeds and fe	ertilize	ers			149	187
Other farm expenses						63	110
Total farm expenses 766 1,242				vater		123	213
Net forms in a second	Other farm	expen	ses			333	627
Net farm income 395 317	Total farm	n exp	enses			766	1,242
	Net farm	incom	ne			395	317

<sup>&</sup>lt;sup>1</sup> Master Plan, vol. viii, pp. 70 et seq.

<sup>&</sup>lt;sup>2</sup> Adapted from ibid., pp. 44-45.

The planners of the project estimated that a farm of 1.5 hectares of classes 1 and 2 land (irrigated) or 2.6 hectares of class 3 land (irrigated) would produce the minimum disposable income deemed sufficient for the living of an average family of 5.3 persons at a reasonable subsistence level. Farms of these sizes would require roughly 535 mandays of work a year with a supply of 600 man-days available from family members.

The budgeted income and expenses for the two typical farms of the sizes mentioned above are given in Table 5.

Table 6. Farm economy in the Jordan Valley (1953); 3,825 farms (primarily dry land farming)<sup>1</sup>

					Total (\$)	Per farm (\$)
Income						
Cereals					1,458,800	381
Vegetables					947,000	247
Fruit .					305,000	80
Livestock					149,400	39
Other .					17,300	. 5
Total inco	ome		•		2,877,500	752
Expenses						
Taxes .					46,900	12
Depreciation	n and r	epai	irs		122,000	32
Seeds and fe	ertilizei	rs			557,500	146
Hired labou	г				596,500	156
Other .	•		•		829,600	216
Total farr	n expe	nses		•	2,152,500	562
Net farm	income	2		•	725,000	190

The net farm income of roughly \$350 a year per family settled on land in the Jordan Valley irrigated by the Yarmouk River water shows a marked increase over the net farm income of \$190 found in 1953 when 3,825 farms on the west side of the Jordan Valley were surveyed. The latter afforded full-time employment for 12,000 persons and part-time work for 36,000 others. These farms generally furnished subsistence through production of a variety of crops and the keeping of a few animals on each. Field crops were generally grown in the northern section of the valley where the yield depends on rainfall.

The direct benefits of the Yarmouk-Jordan irrigation project are quite apparent in the larger net farm income of roughly \$350 compared with \$190 in 1953. In that earlier year an estimated 60,000

persons were indirectly supported by the farmers who employed their services and traded in their shops.

The Master Plan estimated that following completion of the project the Jordan Valley would provide a modest living for about 224,000 persons, or roughly double the number in 1953. At the assumed levels of family living, living expenses of the 30,700 farm families on irrigated plots would amount to \$4,200,000 annually and the grand total of farm business expenses would amount to \$21,284,000. In the East Ghor North alone, the 10,600 farms to be supplied with irrigation water would earn a gross income of \$12,704,600 per year. Total business expenditures would amount to \$7,201,800. These flows of money would support some 64,000 in secondary employment excluding such processing industries as cotton ginning, oil extraction and sugar manufacture.

Under the projected plan of development it is expected that the expanded food production would effect a net reduction in imports of about \$6,000,000 at 1950-3 price levels. This is important for the economy of the country. Since 1948 Jordan's balance of trade has shown an increasing deficit. A sizable proportion has consisted of various staple food items such as sugar, rice, wheat and livestock products, in addition to cotton goods. Varying parts of these requirements can be produced in the Jordan Valley with irrigation water. With the expanded area under irrigation, production of vegetables and fruits during the winter months will be greatly increased. Jordan exports these farm products to the neighbouring countries of Syria, Saudi Arabia and Lebanon. This trade is expected to continue to be profitable in view of the expanding population and rising incomes in these countries.

The crops and rotations considered for the irrigated farms were planned to provide for diversified agriculture in order to support the families and to demonstrate that a wide variety of crops could be adopted and grown successfully. These products would help to correct the imbalance of trade by reducing food imports. Since the Jordan Valley is well adapted climatically to the production of vegetables, bananas and oranges, the growing of these products can be increased as the market outlets for them expand. A United Nations survey in 1953 estimated a good market for these products in neighbouring

<sup>&</sup>lt;sup>1</sup> United Nations Relief & Works Agency for Palestine Refugees, 'Reconnaissance Survey of the Marketing of Fruits and Vegetables in the Arab Middle East', *Quart. Bull. Econ. Deve.*, No. 12, Beirut, Lebanon, 1956 (mimeo).

countries. The moves towards an Arab Common Market are encouraging and suggest that exports to other Arab countries will increase in the future. This will enable the farmers in the Jordan Valley to increase the proportion of their lands devoted to the production of higher-value products with a corresponding increase in income. Thus the prospects suggest increasing benefit in the future from the irrigation programme.

The Master Plan calculated the annual net benefits from the irrigation scheme at \$13,512,000, of which the East Ghor North would contribute \$4,399,100. Benefits were calculated to be the total gross revenues of the farms supplied with irrigation water less the total farm production expenses other than water charges (because annual costs of furnishing the water are included in the annual expenses for operating the project). The ratio of benefits to the annual operating expenses together with the amortizing of the costs of construction and development of the farm units would be 2.58 for the whole valley and 2.95 for the East Ghor North sector. These prospective benefits have led to plans to start construction of the East Ghor North part of the project in the summer of 1959. In fact 6 kilometres of canals have already been excavated in anticipation that water will become available in the not too distant future.

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