THE HASHEMITE KINGDOM OF JORDAN
MINISTRY OF MUNICIPAL AND RURAL AFFAIRS
AND THE ENVIRONMENT

THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK-TAFILA DEVELOPMEHT REGION

VOLUME 3 MAIN REPORT
PART 2
PREPARATORY STUDIES OF PRIORITY PROJECTS

March 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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FOR THE KARAK - TAFILA DEVELOPMENT REGION

FINAL REPORT

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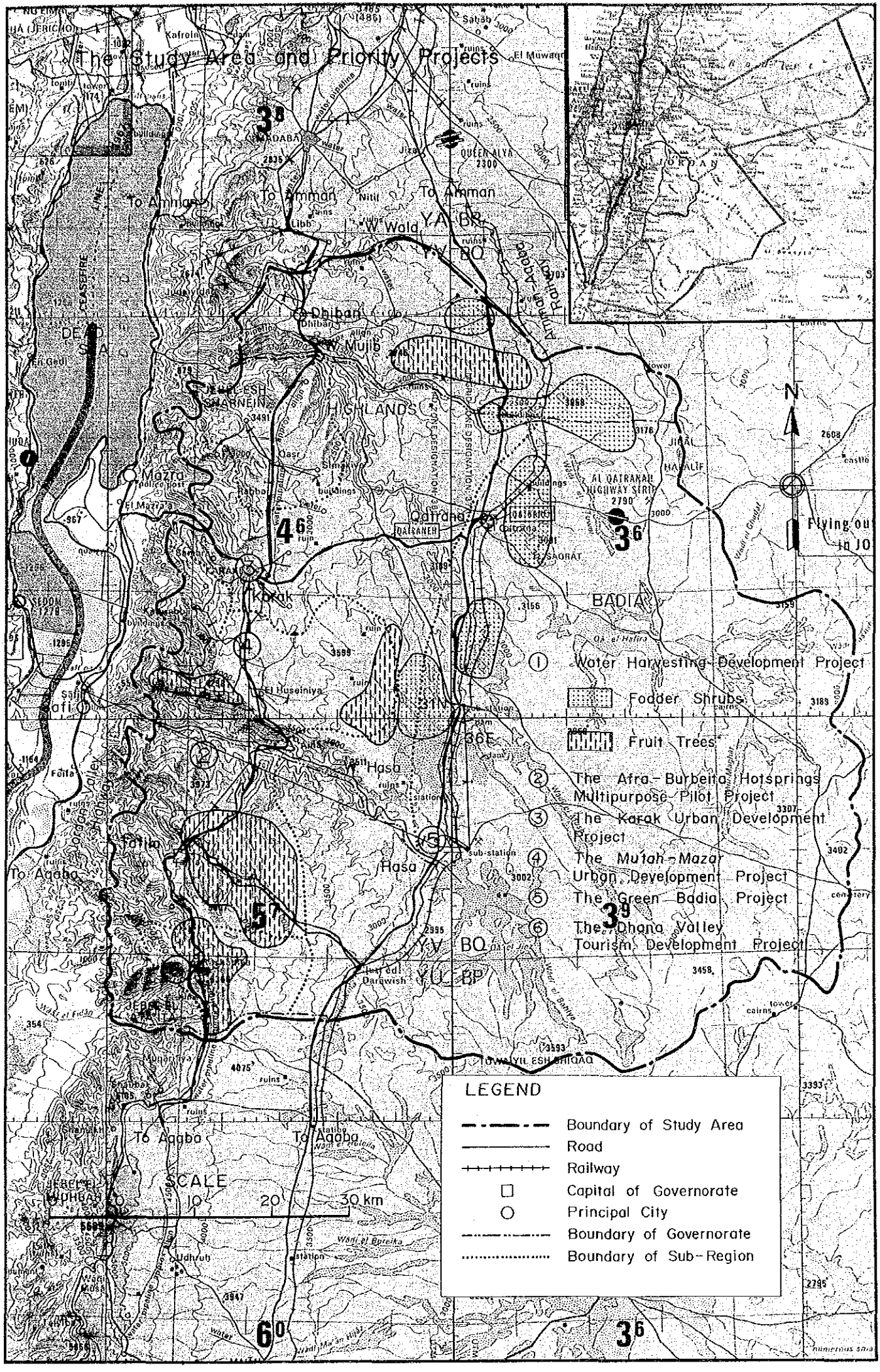
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THE STUDY ON
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ABBREVIATIONS

(1) International/Foreign Organizations

JICA	Japan International Cooperation Agency
UNRWA	United Nations Relief and Works Agency
USAID	United States Agency for International Development
WHO	World Health Organization

(2) Jordanian Governmental Organizations

MOA	Ministry of Agriculture
MOC	Ministry of Communications
MOE	Ministry of Education
MEMR	Ministry of Energy and Mineral Resources
MOHE	Ministry of Higher Education
MOIT	Ministry of Industry and Trade
MOL	Ministry of Labour
MOP	Ministry of Planning
MPW	Ministry of Public Works
MMRAE	Ministry of Municipal and Rural Affairs and the Environment
MOT	Ministry of Transport
MCTA	Ministry of Culture, Tourism and Antiquities
CBJ	Central Bank of Jordan
CVDB	Cities and Villages Development Bank
DOS	Department of Statistics
IDB	Industrial Development Bank
JEA	Jordan Electricity Authority
JIEC	Jordan Industrial Estate Corporation
JNGC	Jordan National Geographic Centre
JVA	Jordan Valley Authority
NPC	National Planning Council
NRA	Natural Resources Authority
RSS	Royal Scientific Society
WAJ	Water Authority of Jordan

(3) Other Public Organizations

ACC	Agricultural Credit Corporation
ALIA	Royal Jordanian Airline
APC	Arab Potash Company
ARC	Aqaba Railway Corporation
HC	Housing Corporation
HJR	Hejaz Jordan Railway
IDECO	Irbid District Electricity Company
JCFC	Jordan Cement Factories Company
JCO	Jordan Cooperative Organization
JETT	Jordan Express Tourist Transport
JPMC	Jordan Phosphate Mines Company
TCC	Telecommunications Corporation
UDD	Urban Development Department of MMRAE

(4) Technical Terms

AMSL	above mean sea level
SS	suspended solids
TDS	total dissolved solids
EC	electric conductivity

(5) Economic Terms

JD	Jordanian Dinars
GNP	Gross National Product
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
ICOR	Incremental Capital Output Ratio

(6) Measurement

mm	millimetre	cm^2	square centimetre
cm	centimetre	m^2	square metre
m	metre	ha	hectare
km	kilometer	km^2	square kilometer
cm^3	cubic centimetre	mg	milligramme
1, lit	liter	g	gramme
m^3	cubic metre	kg	kilogramme
MCM	million cubic metre	ton	metric ton
bbl	barrel	t.o.e.	tons of oil equivalent
s, sec	second	^{o}	degree
min	minute	'	minute
h, hr	hour	"	second
y, yr	year	^oC	degree Celsius
V	Volt	m^3/s	cubic metre per second
A	Ampere	lcd	liter per capita per day
W	Watt		
kW	kiloWatt	kWh	kiloWatt-hour
MW	megaWatt	MWh	megaWatt-hour
GW	gigaWatt	GWh	gigaWatt-hour
10^3	thousand	10^6	million
ppm	parts per million	ppt	parts per thousand
ø	diameter in mm		

(7) Exchange rate

US$ 1.00 = JD 0.34 (the prevailing rate in mid 1987)

CHAPTER 1 SELECTION OF PRIORITY PROJECTS

1. SELECTION OF PRIORITY PROJECTS

1.1 Introduction

40 Master Plan Projects including ongoing projects under the Third Five-Year Plan have been identified and formulated in the Master Plan, which is presented in Volume 2: Main Report - Part 1. Implementation of all these projects by the year 2005 is needed to achieve the socio-economic frameworks set in the Master Plan. In this chapter the selection procedure is described together with the priority projects which require preparatory studies immediately.

1.2 Selection Criteria

(1) First selection: Of the 40 Master Plan Projects, those projects that did not meet all the following three conditions were excluded:

(A) New projects; not ongoing under the Third Five-Year Plan
(B) Projects directly beneficial to the region's development
(C) Short-term projects which should be implemented before 1995

In Table 1-1, the above three conditions are examined for each project. As a result eleven projects were selected for the second stage selection.

(2) Second selection: The priority projects were finally selected from consideration of the following qualitative criteria:

(A) Small to medium scale projects, or projects which can be divided into small components for staged implementation
(B) At least one project from each of the three Development Sub-areas
(C) Productive projects which would contribute to improvement of income levels and to creation of new job opportunities
(D) Contribution to realization of a balanced spatial structure of the socio-economy in the Study Area, or to development of the least developed sub-regions
(E) Pioneer or innovative projects
(F) Contribution to environmental conservation or rehabilitation

1.3 Selected Priority Projects

Five priority projects were originally selected according to the above criteria in the Interim Report submitted in March 1987. People in Tafila Governorate and Tafila Municipality, however, desired the early implementation of the Dhana Valley Tourism Development Project and urged that this project be taken up as one of the priority projects. Accordingly, six priority projects were eventually selected and they are briefly described below:

(1) The Water Harvesting Development Project is an innovative project for development of agriculture in the Highlands utilizing flood flow and rainwater as well as land resources. The project would increase and stabilize the agricultural production substantially. Benefits of the project would be reaped almost immediately because of the remarkable effect that water has on crop production in a semiarid climate. Moreover, constructions of microcatchments, contour furrows and small dams and weirs will contribute to reduction of the sediment flow into wadis.

(2) The Afra-Burbeita Hot Springs Multipurpose Pilot Project is a pioneer project for development of geothermal energy in Jordan. Various development schemes such as greenhouse horticulture, aquaculture and a health resort could be planned to achieve optimum utilization of the geothermal energy. The benefits would be realized quite soon and with little risk owing to the abundant hot water and the base flow available at the project site. The successful development of this project will have a great impact on the utilization of other hot springs in the region as well as in the Kingdom.

(3) The Karak Urban Development Project: Karak City has the highest potential, among the municipalities in the Study Area, for fast growth and to provide diversified urban services as the regional centre. The project aims at the complete renewal of the City. Old Karak needs renovation of its historical and cultural assets, while New Karak needs to expand with new functions such as public administration and residential zones.

(4) The Mu'tah-Mazar Urban Development Project is a key project for realization of the proposed Techno-Highland development. It provides for development of an academic conglomeration (Technopolis) which will integrate functions of academy, business and urbanization. Mu'tah University is already a going concern in the project area and is scheduled to have a new civilian campus. The project requires a coordinated master plan, which will provide proper guidance to prospective industrial investors.

(5) The Green Badia Project is the first step in the overall Green Badia Plan, which is planned to continue towards the 21st century. It will contribute to rehabilitation of the Badia through tourism development with the proposed artificial oasis park, and to realize a balanced spatial structure within the Region. Early implementation of this project is required for improvement of the environment with greenery for today's human settlement as well as for the tourism promotion and as an industrial location in the future. The well arranged environment will attract investors from Greater Amman and foreign countries.

(6) The Dhana Valley Tourism Development Project is proposed as a further core project to stimulate economic development of Tafila Governorate. Old Dhana and its surrounding plateau, at an altitude of about 1,400 m AMSL, has a famous view including natural forests and cool fresh air. Old Dhana still has a row of old Arab stone houses. These tourism resources have a high potential to attract long-stay tourists for a summer vacation. This project will also complement the tourism axis along the King's Highway from Amman to Aqaba. Early implementation of this project will contribute to expansion of the local and regional economy.

Table 1-1 FIRST SELECTION OF PRIORITY PROJECTS (1/2)

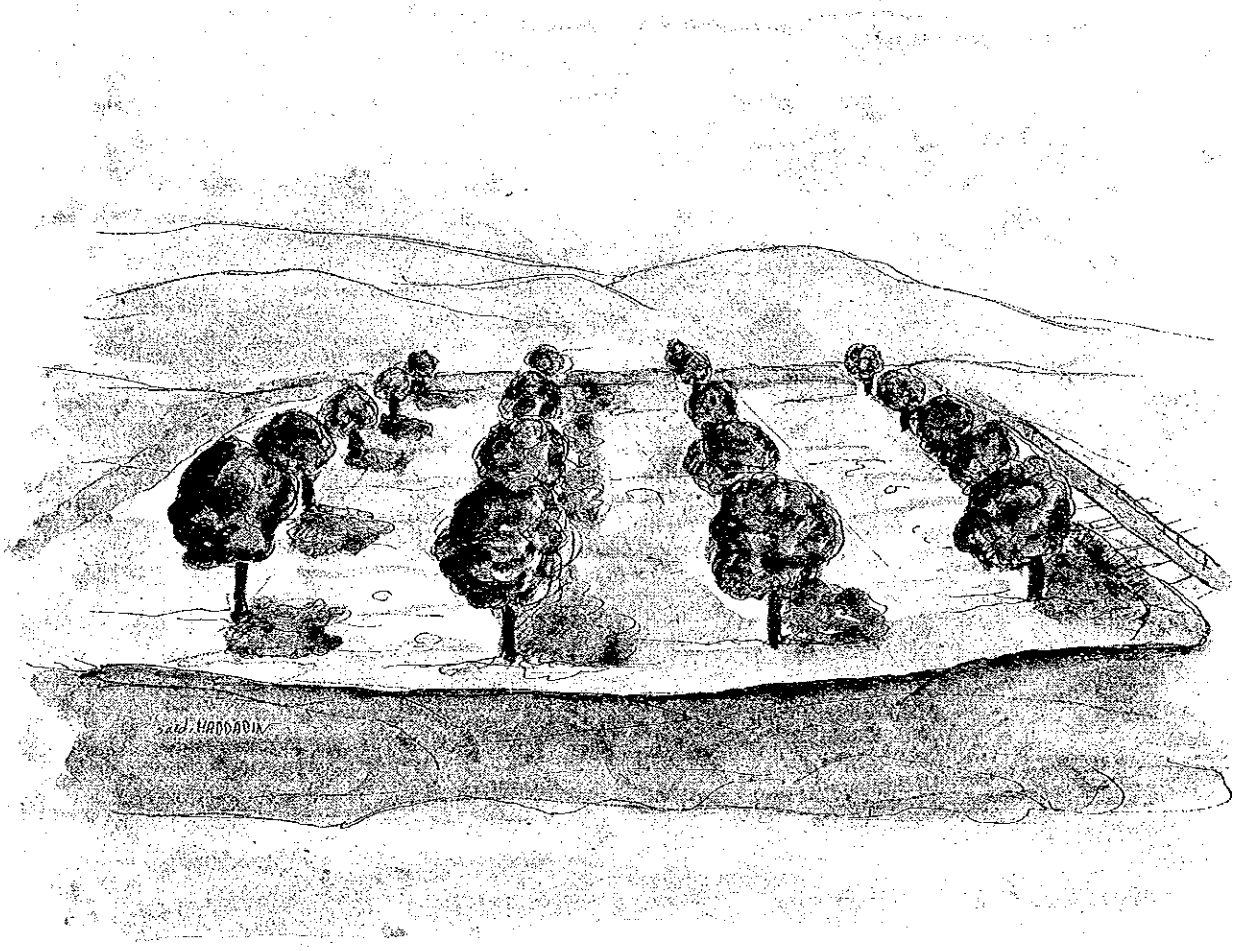
No.	Project	New Project	For Regional Development	For Early Stage
Rural Development Plan				
<u>Projects related to the rural life</u>				
RDP-1	New Village Project	Y	Y	M
RDP-2	School Bus Project	Y	Y	Y
RDP-3	Village Clinic Project	N	Y	Y
RDP-4	Home Garden Project	Y	Y	M
RDP-5	Darawish-Tafila Pipeline Project	Y	Y	N
RDP-6	Lajjun-Karak Pipeline Project	Y	Y	N
<u>Projects related to the production sector</u>				
RDP-7	Lamb Fattening Centre Project	N	Y	Y
RDP-8	Rangeland Reservation Project	N	Y	Y
RDP-9	Fodder Shrubs Planting Project	N	Y	Y
RDP-10	Introducing Forage Crops into Farming Cycle Project	N	Y	Y
RDP-11	Introducing Legumes into Farming Cycle Project	N	Y	Y
RDP-12	Veterinary Clinics Project	N	Y	Y
RDP-13	Development of Farming in the Highlands Project	N	Y	Y
RDP-14	Production of Certified Seeds Project	N	Y	Y
RDP-15	Mechanized Agricultural Services Project	N	Y	Y
RDP-16	Fruit Tree Seedling Production Project	N	Y	Y
RDP-17	Soil Conservation and Fruit Tree Planting Project	N	Y	Y
RDP-18	Water Harvesting Development Project	Y	Y	Y
RDP-19	Spring Irrigation Improvement Project	Y	Y	Y
RDP-20	Cottage Industry Development Project	Y	Y	Y
RDP-21	El Lajjun Oil Shale Retorting Project	Y	M	N
RDP-22	Unused Minerals Utilization Development Project	Y	Y	Y

Table 1-1 FIRST SELECTION OF PRIORITY PROJECTS (2/2)

No.	Project	New Project	For Regional Development	For Early Stage
Projects related to the environment protection and tourism				
RDP-23	Afforestation Project	N	Y	Y
RDP-24	Greenbelt Project	N	Y	Y
RDP-25	Afra-Burbeita Hot Springs Multipurpose Pilot Project	Y	Y	Y
RDP-26	Dhana Valley Tourism Development Project	Y	Y	Y
RDP-27	Environmental Assessment of El Lajjun Oil Shale Project	Y	Y	N
Urban Development Plan				
UDP-1	Karak Urban Development Project	Y	Y	Y
UDP-2	Mu'tah-Mazar Urban Development Project	Y	Y	Y
UDP-3	Mu'tah University Related Project	Y	Y	N
UDP-4	Tafila Urban Development Project	Y	Y	M
Green Badia Plan				
GBP-1	Sustaining the Production Level of Existing Phosphate Mines	N	M	Y
GBP-2	Local Materials Utilizing Project	Y	Y	Y
GBP-3	Green Badia Project	Y	Y	Y
GBP-4	Desert Dam Project	M	Y	Y
GBP-5	Infrastructure and Housing Project (Phase 2)	Y	Y	N
GBP-6	Hasa Industrial Estate Project	Y	Y	N
GBP-7	Traffic Terminal Project	Y	Y	N
GBP-8	Sultani Oil Shale Power Plant Project	Y	M	N
GBP-9	Environmental Assessment of Sultani Oil Shale Power Plant Project	Y	Y	N

Note: Y: Yes N: No M: Medium
Y in bold face shows the priority in the first selection, as it meets all the three criteria.

CHAPTER 2 WATER HARVESTING DEVELOPMENT PROJECT



2. WATER HARVESTING DEVELOPMENT PROJECT

2.1 Introduction

The Water Harvesting Development Project is proposed in the Master Plan to develop under-utilized land and water resources for promotion of Highlands agriculture. The Project consists of two schemes; the Water Harvesting Scheme, and the Winter Irrigation Scheme. Details of the Water Harvesting Scheme are presented in Annex-B.

2.2 Project Background

Present agricultural landuse in the Study Area is summarized in Table 2-1. Highlands agriculture produced about 10 per cent of the GRDP in the Study Area in 1985. In terms of employment, agriculture is important providing about 17 per cent of total employment in the Study Area.

Agricultural population and farm size: According to the Statistical Year Book 1985, the rural population is 80 per cent of the total in Karak, and 61 per cent in Tafila. The average family size per farm household is 8.1 both in Karak and Tafila Governorates (Agricultural Census, 1983). In the Study Area, farm population is about 106,000, and the number of farm household is about 13,000. The average farm size in terms of arable land, cultivated area and number of livestock is shown in Table 2-2.

Rainfed agriculture: The main crops in the Study Area are wheat and barley. The area cultivated to wheat is about 16,000 ha, and to barley about 6,000 ha. During the past 10 years, however, the area under crop cultivation varied widely from 11,400 ha in 1984 to 44,100 ha in 1978.

Crop production also fluctuates widely from year to year. Average unit yields of field crops are low; during the period 1981-1985 0.67 t/ha for wheat, 0.52 t/ha for barley, 0.64 t/ha for lentils.

Livestock farming: Animal production is more popular in the Highlands than cereal production. The most important livestock are sheep and goats. According to the Agricultural Census in 1983, the total number of chicken farms in Karak and Tafila was 77, of which 64 were broiler farms and 13 were egg-laying farms. Most of these were newly established and were capital intensive based on a combination of imported feed and locally raised stock and compounded feed.

2.3 Plan Formulation

2.3.1 Development Objectives

The Water Harvesting Project aims:

(1) to increase agricultural production, productivity and income for enhancing rural life in the Highlands

(2) to increase food security by substituting domestic produce for imported food as well as to promote agricultural exports

(3) to generate new job opportunities in the Highlands

2.3.2 Basic Concepts

In this Water Harvesting Project, *flood flow* is defined as the rainwater that has reached wadis and is flowing down a wadi course, while *rainwater* is defined as rainwater that remains on farmland or a hill slope and has not reached the wadis. The Water Harvesting Scheme is proposed to achieve more efficient utilization of rainwater on farmland, while the Winter Irrigation Scheme is proposed to exploit the flood flow in the Highlands during the winter season.

The basic concepts of the proposed two schemes are as described below:

(1) The Water Harvesting Scheme aims to collect rainfall from natural or artificial watersheds by the following methods:

(A) Runoff farming: Areas unsuitable for cropping such as highways and rock outcrops will be used as the catchment. Rainfall on the catchment will be collected in a small cropped area for the crop growing (see Fig. 2-1).

(B) Microcatchments: The principle of microcatchments is the same as for runoff farming but on a smaller scale. It will be applied to areas which are flatter than areas for runoff farming. A tree or a shrub may be provided with its own catchment area (see Fig. 2-2).

(C) Contour furrows: In hilly areas, small ridges will be made at a certain interval and along contours to hold water as well as to prevent soil erosion. Trees are grown along the contours (see Fig. 2-3).

Microcatchments are the most promising of the options available, for their simple structure and low construction costs. Their economic viability has already been demonstrated in experiments at Sapha, 30 km east of Mafraq, under annual rainfall of about 150 mm and at an altitude of about 600 m AMSL. Sites for the microcatchments need to be free from foreign drainage and to have deep soils.

Check-dam cum terraced land (a kind of the runoff farming) is also promising. Pioneering works of check-dam cum terraced land are found in a wadi 17 km south of the Roman Pond near Jiza along the Desert Highway. These were built by a Bedou in about 1965. Olive trees and grape vines are growing well without irrigation and yield well. Wadi bottoms with deep soils and free from large floods are the most suitable for the construction of check-dam cum terraced land, but such areas are limited.

With the Water Harvesting methods above, the presently unutilized land can be planted with fruit trees and fodder shrubs.

(2) The Winter Irrigation Scheme is proposed to develop the flood flow in small basins in the Highlands by constructing small dams and weirs. The Scheme will have the following two types:

(A) Storage Dam Schemes: these will be applied to sites where storage dams can be constructed in terms of topography, geology, hydrology, irrigation and landuse in the reservoir area. A typical scheme will consist of a storage dam and irrigation ditch (see Fig. 2-4). Storage dams would be combined where possible with check dams located at the upstream end of the reservoir for maintaining the

planned storage capacity and/or protecting intake facilities from sedimentation as well as reducing sediment transport to downstream reaches.

If infiltration through a reservoir bed is expected to be high and could be utilized in downstream reaches, the scheme would be designed for recharge of groundwater. If the stored water cannot be transmitted to farmlands by gravity flow, the Scheme will need a pumping system.

(B) Diversion Weir Schemes: these will be applied to those sites where a Storage Dam Scheme cannot be applied. A typical scheme will consist of a diversion weir, irrigation ditches, a cistern for storing flood water beside farmland, and terracing works (see Fig. 2-5). Where a base flow is available during the winter season, a pumping scheme is also conceivable (like Ain Sara in Wadi Karak).

Even with a Storage Dam, most of the flood water stored in the reservoir will have to be distributed to farmlands within a few months to minimize evaporation and infiltration losses. In principle, therefore, the water will be stored in the soil of farmland.

With the Weir Scheme, flood water could be abstracted only during flood time, which may be only of the order of several hours. It would therefore, need a relatively large capacity of intake and waterway. The annual number of floods is 2 to 8 times in general. In rich water years the irrigable area will expand, but in poor years the irrigable area will decrease. To store the diverted flood water temporarily in farmland until it infiltrates into soils, terracing works will be required. Also, cistern storage will be required for supplemental irrigation during the summer season.

2.3.3 Agricultural Development by Water Harvesting

Fruit trees and fodder shrubs were selected as target crops of the project because: (1) they have long root systems, which is essential for survival without irrigation under arid conditions; and (2) they offer possibilities of import substitution because large volumes of fruit and meat, e.g. about 38,000 tons of apples and about 50,000 tons of meat are

imported every year.

Recommendable fruit trees and fodder shrubs for the Water Harvesting are:

Fruit Trees	Fodder Shrubs
Apple	Atriplex halimus
Peach	Atriplex dimor
Apricot	Atriplex nummularia
Pomegranate	Salsola foetida
Olive	Ziziphus nummularia
Grape	Prosopis cineraria

Apple, among recommended fruit trees, is thought to be most promising for its high demand, short supply, and high durability in storage. The expected yield of apples is 20 kg/tree/yr. The following varieties of apple are available in Government nurseries:

- Jonathan
- Starking
- Golden Delicious
- Super Starking Delicious
- Summer Champion
- Fuji
- Granny Smith
- Spartan
- Top Red
- Super Red Delicious
- Spurs Red
- Tsugaru

Atriplex halimus (North African Salt Bush) is the most recommendable fodder shrub for its high adaptability to the desert or semidesert environment, its notable productivity even in the dry season, its self-seeding characteristic and its high palatability to sheep and goats. If deep soil is available and some irrigation is provided after transplanting, Atriplex halimus should produce 650 kg/ha/yr of fresh fodder, which can support 0.3 head of ewe, even under an annual rainfall of 100 mm.

2.3.4 Water Harvesting Scheme

The project area has been selected by the criterion of land slope: land with a slope of 0-12 per cent for microcatchments; and land with a slope of more than 12 per cent for contour furrows. The Water Harvesting Scheme as a whole would cover about 45,200 ha gross for fruit pro-

duction, and about 22,200 ha gross for fodder shrub production as broken down in Table 2-3 and as shown in the figure at the beginning of this report.

Sites for microcatchments need to be free from foreign drainage and to have deep soils. The basic plot size for a unit microcatchment is assumed to be 500 m^2 (22.3 x 22.3 m), and its water collecting basin size 4.0 x 4.0 x 0.15 m. The height of the bund around a plot is 15 cm, and the length of its base is 30 cm. The height of the bund around a collecting basin is 30 cm and the base length is 60 cm. Construction of plots and ploughing of basins can be done by a disc plough drawn by a tractor. Shaping of the basin will be done manually.

The contour furrows would be applied to slightly steeper slopes, which have deep soils and long uniform slopes and are free from foreign drainage. Construction of the contour furrows will have to be done manually or by animals due to the steep slopes of the land. The depth and width of the U-shaped furrows are assumed to be 30 cm and 36 cm respectively. Assuming the interval between furrows to be 6.0 m, the length of furrows per hectare would be 1,666 m.

2.3.5 Winter Irrigation Scheme

Selection of promising dam and weir sites: In this Study, 37 potential small dam or weir sites were selected from topographic maps at a scale of 1/50,000. Then through field reconnaissance, 14 promising sites were selected out of the 37 from considerations of topography, geology and irrigation (Table 2-4 and Fig. 2-9).

Outline of Storage Dam and Diversion Weir Schemes: A preliminary study was made based on the profiles of 9 promising storage damsites and topographic maps at a scale of 1/25,000 or 1/50,000 as available. Inflow is estimated on the basis of annual basin rainfall and runoff coefficient given in Fig. 2-12. The gross reservoir capacity was chosen to be enough to store an annual flood volume of 5-year in occurrence probability. With this gross capacity and a check dam, the dam should, in general, have an ultimate effective storage that is enough to store a

2-year probable flood after 50 years' operation.

The results of the preliminary study on the Winter Irrigation Scheme are presented in Tables 2-4 to 2-6 and Figs. 2-10 and 2-11. Site characteristics of each dam and weir scheme are presented in Fig. 2-13.

Six dam schemes and five diversion weir schemes are judged to be adequate at this stage used for irrigation of farmland nearby as shown in Fig. 2-10 and listed in Table 2-6. The weir scheme A-4 is, however, an alternative scheme for the dam scheme A-2 provided that the base flow of Wadi Karak may be allocated to the farmland to the north of El Ifranji.

2.4 Pilot Scheme

The technical soundness and economic viability of the Water Harvesting Project should be tested and proved through a pilot scheme, which aims:

(1) to identify the most suitable methods of the Water Harvesting in relation to slopes, soil and rainfall conditions
(2) to confirm the economic viability of agricultural development by the Water Harvesting Scheme
(3) to demonstrate the economic merits of the Water Harvesting Project to farmers
(4) to train agricultural extension workers in design and construction of the Water Harvesting measures as well as in farming

The proposed site for the Pilot Scheme is situated about 6 km west of the Desert Highway and along the El Huseiniya-Abiad road as shown in Fig. 2-6 (refer to Annex-B for site conditions). A preliminary layout of the pilot scheme is shown in Figs. 2-7 and 2-8.

Cultivable areas for respective Water Harvesting methods are preliminarily proposed as:

- 56 ha for Winter Irrigation with water conveyed by gravity flow from a diversion weir
- 82 ha for microcatchments

Of the 56 ha for the Winter Irrigation, about 15 ha could be planted with perennial crops, and the remaining 41 ha with annual crops when rainfall is abundant.

Three kinds of experiments would be carried out as described below:

(1) Water harvesting method tests:

(A) Microcatchments for different slopes, sizes, soil, covers and soil depths

(B) runoff farming

(C) contour furrows for different slopes, soil depths and soil covers

(D) pitcher irrigation

(2) Crop suitability tests using the following crops under the Water Harvesting:

(A) Wheat, barley, alfalfa, sunflower, peas, hardy grass

(B) Olives, grapes, apples, pistachio nuts, beans, peaches, figs, almonds, apricots, pomegranates

(C) Atriplex halimus, Atriplex dimor, Atriplex nummularia, Prosopis cineraria

(D) Onions, Artichokes, Asparagus

(3) Fertilizer application tests to find the optimum amount of fertilizers under the Water Harvesting

In these tests, meteorological conditions, crop water consumption and salt movement will be monitored together with crop production. In the course of these experiments, in-service training of agricultural extension workers will be carried out.

2.5 Costs

(1) Pilot Scheme: The construction cost is estimated as follows:

- Direct construction cost of the winter irrigation system	JD	181,000
- Direct construction cost of the microcatchments ...		1,000
- Engineering & administrative costs (10% of the above)		18,000
- Contingency (10% of the above)		20,000
Total	JD	220,000

(2) Water Harvesting Scheme: The same design criteria and unit costs as for the Pilot Scheme have been applied to the microcatchments in the main Scheme. The direct construction cost of the Water Harvesting Scheme is estimated at about JD 13 million. With engineering, administrative and contingency costs, the total construction cost of the Water Harvesting Scheme is estimated at about JD 15.6 million (refer to Annex-B for details).

(3) Winter Irrigation Scheme: A preliminary estimate of construction costs has been made with reference to the unit costs given in the JICA Mujib Report and others. Results are summarized in Table 2-4, which also present the unit water cost at the dam, including details of dams proposed by the previous studies for comparison. The total construction cost of the Scheme, excluding the dam scheme A-2 but including its alternative weir scheme A-4, is estimated at about JD 5.16 million, consisting of JD 4.33 million for civil works, JD 0.24 million for farm development, and JD 0.59 million for pipeline and pumping systems.

Unit water costs at the farm including costs of irrigation facilities are presented in Table 2-6. As shown in the table, the unit cost of the water would be of the order of 105 to 627 fils/m^3. Of the six dam schemes, four would have relatively high unit water costs at around 600 fils/m^3. Unit water costs of the other seven dam and weir schemes will be between 105 and 228 fils/m^3. Instead of the dam scheme A-2, its alternative weir scheme A-4 will be much cheaper, showing the high cost required for the flood flow development while the base flow can be

developed at a lower cost even with some pumping.

2.6 Implementation Schedule and Project Management

A preliminary implementation schedule for this Project is presented in Fig. 2-14. Phased development is proposed to mitigate risk and to lessen the financial burden of the Project. The Project should start with a pilot scheme to collect basic technical and economic data on the Water Harvesting under conditions prevailing in the Study Area.

The Jordan Cooperative Organization (JCO) is recommended to be the executing organization of the Project for the following reason:

(1) JCO is an independent corporate body with administrative and financial autonomy, which is essential for taking strong leadership in the project management.
(2) JCO is thought to have strong support from farmers.
(3) JCO is run by a Board of Directors, on which are represented MOA, MOP and CBJ as well as the cooperative societies. Coordinating functions will be assured in this Board.

A special project section in the Cooperative & Project Department of JCO would be in charge of the project.

2.7 Conclusions and Recommendations

(1) Conclusions: Under the Water Harvesting Development Project, two schemes are proposed for promoting Highlands agriculture in the Study Area; the Water Harvesting Scheme covering about 67,400 ha gross, and the Winter Irrigation Scheme tentatively covering about 300 ha net.

As Water Harvesting measures for effective use of rainwater, micro-catchments are proposed to cover about 45,200 ha gross with slopes less than 12 per cent, while contour furrows would cover about 22,200 ha with slopes steeper than 12 per cent. As crops under the Water Harvesting Scheme, fruit trees and fodder shrubs are proposed for their long root systems and the domestic demand. Planting of about 900,000 fruit trees is proposed on about 44,400 ha to yield fruits of about 18,000 t/yr. Planting of fodder shrubs is proposed on about 17,500 ha to produce

fresh fodder amounting to about 11,000 t/yr, which could support about 5,000 sheep or goats.

The Winter Irrigation Scheme is formulated to irrigate farmland during the winter with flood water. This would be stored in small scale Highlands dams or be diverted from intake weirs. The flood water when diverted to the farmland would be stored in the soil. Six potential dam schemes and five potential weir schemes have been identified around Karak and to the east of Tafila (Karak and Tafila Highlands Dam Schemes), where the hydrometeorological conditions are most favourable in the Study Area. The expected water yield is estimated at 2.3 MCM/yr in total. The unit water cost at the farm is estimated at about 250 fils/m^3 on a weighted average, ranging from 105 to 627 fils/m^3. The Winter Irrigation Scheme can be expanded to surrounding areas after the completion of the proposed Karak and Tafila Highlands Dam Schemes.

Before implementing the Project, construction of a Pilot Scheme is proposed to examine the technical soundness and economic viability of Water Harvesting as well as to obtain basic data for design and operation of the two schemes proposed. The Pilot Scheme will extend over 56 ha and 82 ha for experimentation on the Winter Irrigation and the Micro-catchments Schemes respectively.

The construction cost of the Pilot Scheme is estimated at about JD 0.22 million (equivalent to US$ 0.6 million). The construction cost of the Water Harvesting Development Project is estimated at JD 20.98 million (US$ 61.7 million), consisting of JD 15.60 million (US$ 45.9 million) for the Water Harvesting Scheme, and JD 5.16 million (US$ 15.2 million) for the Winter Irrigation Scheme.

(2) Recommendations: A Pilot Scheme is recommended for immediate implementation together with a feasibility study on the main project components: the Water Harvesting Scheme, and the Karak and Tafila Highlands Dam Schemes including an inventory study to identify other potential sites for the Winter Irrigation Scheme to identify other potential sites for the Winter Irrigation Scheme.

In order to fund the Project in its initial investment, establishment of a Watershed Development Fund is proposed (see Section 6.2 of Annex-A: Water for details). In addition, provision of soft loans to farmers, who wish to grow crops by Water Harvesting, should also be considered for construction of necessary structures.

Table 2-1 PRESENT AGRICULTURAL LANDUSE

(Year 1985)

Landuse Category	Area (ha)	(%)
Fallow	75,800	9.3
Field crops	24,400	3.0
Irrigated vegetables	900	0.1
Fruit trees	3,600	0.4
Forest	17,800	2.2
Built-up area	1,900	0.2
Mineral reserve/quarry	71,500	8.8
Grazing/unarable area	616,300	75.9
Total	812,200	100.0

Source: Aerial photgraphic interpretation by the Study Team and National Village Survey, 1984, MOP

Table 2-2 AVERAGE FARM SIZE

	Arable Land (ha)	Cultivated Area (ha)				Sheep (head)	Goats (head)
		Field Crops	Vegetables	Fruits	Total		
The Study Area	62,500	24,420	980	3,600	29,000	185,000	158,000
Per farm household	4.76	1.86	0.07	0.27	2.21	14.0	12.0

Source: Agricultural Census, 1983, MOP

Table 2-3 LAND FOR WATER HARVESTING SCHEME

Crops	Slope (%)	Water Harvesting Method	Gross Land Area (ha)
Fruit trees	0-12	Microcatchments	28,400
	12-	Contour furrows	16,800
Fodder Shrub	0-12	Microcatchments	20,700
	12-	Contour furrows	1,500
Total			67,400

Source: The Study Team

Table 2-4 PRINCIPAL FEATURES OF DAM AND WEIR SCHEMES

Dam No.	Dam Name	Catchment Area (km^2)	Mean Basin Rainfall (mm/yr)	Mean Runoff Volume (MCM/yr)	2-yr Volume (MCM/yr)	5-yr Volume (MCM/yr)	Type of Dam 1/	Dam Height (m)	Dam Volume ($10^3 m^3$)	Reservoir Capacity ($10^3 m^3$)	Expected Yield (MCM/yr)	Direct Construction Cost ($JD10^3$)	Total Construction Cost ($JD10^3$) 2/	Unit Cost of Water (JD/m^3) 3/
1. This Study														
A-2	Kaminna	41.8	340	1.06	0.66	1.72	C	50.0	78.7	1.75	0.86	-	5,150	0.60
C-1	Ghuweir	30.4	237	0.37	0.23	0.60	F	21.0	26.0	0.60	0.30	-	1,700	0.57
C-2	Midden	51.8	237	0.63	0.39	1.03	C	22.0	14.3	1.04	0.52	-	940	0.18
C-6	Dabba	1462.0	165	9.90	6.30	16.20	C	50.0	122.5	16.50	8.13	-	8,010	0.10
X-1	Lajjun	55.8	251	0.76	0.47	1.24	C	32.0	35.2	1.30	0.62	-	2,300	0.37
D-1	Rumeil	18.3	201	0.17	0.10	0.27	C	20.0	11.9	0.32	0.14	-	780	0.56
D-3	Muheila	26.9	201	0.25	0.26	0.67	C	18.0	8.3	0.74	0.34	-	580	0.17
E-1	Nusra-niya	9.0	151	0.55	0.03	0.09	C	12.0	3.7	0.10	0.04	-	240	0.60
M-1	Hasa	1435.0	88	2.29	1.44	3.73	C	25.0	50.5	4.20	1.85	-	3,300	0.18
A-4	Ain Sara	89.1	340	2.26	1.41	3.66	W	2.0	0.24	-	-	-	11.4	-
D-2	Tafila	26.9	201	0.75	0.15	0.40	W	2.0	0.54	-	-	-	25.4	-
I-1	Sidd	10.2	275	0.17	0.10	0.27	W	2.0	0.27	-	-	-	12.7	-
J-1	Shada	19.8	275	0.32	0.20	0.52	W	3.0	0.95	-	-	-	23.2	-
L-1	Bahlut	15.9	201	0.15	0.09	0.29	W	2.0	0.32	-	-	-	15.2	-
2. Mujib Study														
	Wala	1770	-	-	19.31	-	R	65.0	920	28.95	10.8 4/	8,080	12,420	0.12
	Harmam	340	-	-	1.91	-	R or F	16.0	680	2.25	0.8	4,180	6,430	0.80
	Siwaqa	440	-	-	1.10	-	R or C	16.5	28	1.65	0.6	250	380	0.06
	Khabra	290	-	-	6.12	-	R	29.5	290	9.18	2.2 4/	2,550	3,920	0.18
	Nukheila	3560	-	-	20.75	-	R or C	67.0	940	31.20	8.8	8,260	12,690	0.14
	Qatrana	1490	-	-	1.78	-	R	-	-	6.0	2.0 4/	-	-	-
	Sultani	950	-	-	2.02	-	R	-	-	1.2	0.3 4/	-	-	-
3. Tannour														
	Hasa 4/	2,052	106	6.52	4.01	-	R	58.0	683	12.15	5.3	6,000	9,220	0.17

Note: 1/: C means concrete gravity dam, F means fill dam, R means rock fill dam, and W means diversion weir.
2/: Unit construction costs are assumed at 13.5 JD/m^3 for fill dam and at 65.4 JD/m^3 for concrete gravity dam, including all the relevant costs.
3/: Unit water cost at the dam/weir site. The Capital Recovery Factor is assumed at 10 per cent.
4/: Modified with data provided by WAJ and of this study.

Source: The Study Team and JICA Mujib study

Table 2-5 SUMMARY OF WINTER IRRIGATION SCHEMES

Dam or Weir No.	Place	Name of Wadi	Type of Scheme	Expected Yield (MCM/yr)	Water Demand Irrigation (m^3/yr/ha)	Irrigable Area (ha)	Pump Station	Distribution Facility (Capacity (m^3/s) Type		Crop	Irrigation Method
A-2	Kaminna	W. Karak	S. dam	0.86	6,924	124.2	-------	0.132	Pipeline ø400mmx3700m	Open Field Winter vegetables	Surface
C-1	East Ghuweir	W. Khabra	S. dam	0.3	8,308	36.1	-------	0.038	Pipeline ø200mmx1500m		
C-2	Ghuweir	W. Khabra	S. dam	0.52	6,924	75.1	-------	0.08	Pipeline ø300mmx3600m	--- do ---	--- do ---
D-1	Tafila	W. La'ban	S. dam	0.14	7,548	18.5	ø 80mmx15kWx2sets	0.02	Pipeline ø150mmx600m	--- do ---	--- do ---
D-3	Tafila	W. La'ban	S. dam	0.34	7,548	45	ø125mmx22kWx2sets	0.048	Pipeline ø250mmx1300m	--- do ---	--- do ---
E-1	Tafila	W. Zabda	S. dam	0.04	7,548	5.3	-------	0.006	Pipeline ø100mmx1100m	--- do ---	--- do ---
A-4	Ain Sara	W. Karak	Weir	0.86	6,924	124.2	ø300mmx380kWx2sets	0.132	Pipeline ø400mmx3100m	--- do ---	--- do ---
D-2	Tafila	W. La'ban	Weir	0.030-0.080	9,435	3.2- 7.8	-------	0.556	Open Channel L=1800m	--- do ---	Water Spreading
I-1	Kerbat Shada	W. Sidd	Weir	0.020-0.054	9,435	2.1- 5.7	-------	0.375	Open Channel L=1000m	--- do ---	--- do ---
J-1	Kerbat Shada	W. Khaur	Weir	0.040-0.104	9,435	4.2- 11.2	-------	0.722	Open Channel L=900m	--- do ---	--- do ---
L-1	Bahlut	W. Bureis	Weir	0.018-0.048	9,435	1.9- 5.1	-------	0.333	Open Channel L=1100m	--- do ---	--- do ---

Source: The Study Team

Table 2-6 UNIT WATER COST OF WINTER IRRIGATION SCHEMES

Dam/ Weir No.	(1) Civil Works ($JD10^3$)	(2) Farm Develop. ($JD10^3$)	(3) Pipeline ($JD10^3$)	(4) Pump Station ($JD10^3$)	(5) Electric Charge ($JD10^3$/yr)	(6) O & M ($JD10^3$/yr)	(7) Total Cost ($JD10^3$/yr)	(8) Expected Yield (MCM/yr)	(9) Unit Cost (JD/m^3)
A-2	5,150	90	42	-	-	10.7	539	0.86	0.627
C-1	1,700	26.4	8.4	-	-	3.5	177	0.30	0.590
C-2	940	54	26.4	-	-	2.1	104	0.52	0.200
D-1	780	13.2	10.8	37.2	1.2	1.7	89.4	0.14	0.639
D-3	580	32.4	37.2	44.4	1.7	3.3	77.4	0.34	0.228
E-1	240	3.6	4.8	-	-	0.5	25.4	0.04	0.635
A-4	11.4	90	124.8	240	17	10.4	89.9	0.86	0.105
D-2	25.4	6	21.6	-	-	0.2	5.6	0.03	0.187
I-1	12.7	3.6	12	-	-	0.1	3.0	0.02	0.150
J-1	23.2	8.4	10.8	-	-	0.1	4.4	0.04	0.110
L-1	15.2	3.6	13.2	-	-	0.1	3.4	0.018	0.189

(1) Refer to Table 2-4 of summary of dam and weir scheme
(2) A unit cost for the farm development is estimated at JD 600/ha .
(3) Refer to water pipeline project and JICA Mujib study.
(4) Refer to water pipeline project in Annex-A.
(5) An electricity tariff of 23 files/kWh is adopted.
(6) O & M cost is assumed at 0.2% for (1) and (2); 0.5% for (3); and 4% for (4).
(7) Life time and discount rate are assumed at 50 yr and 10% for (1) and (2); 30 yr and 10.6% for (3); and 10 yr and 16.3% for (4)
(8) A yield for weir scheme is that corresponding to a 2-yr probable annual inflow.
Source: The Study Team