THE HASHEMITE KINGDOM OF JORDAN

MINISTRY OF PLANNING

FEASIBILITY STUDY ON AGRICULTURAL DEVELOPMENT FOR THE KARAK-TAFILA DEVELOPMENT REGION

MAIN REPORT

OCTOBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

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LIST OF REPORTS

I. Main Report

II. Annex

A: Meteo-hydrology
B: Socio-economy
C: Land Use Plan
D: Agriculture
E: Facilities Development Plan
F: Organization and Management
G: Project Evaluation

PREFACE

In response to a request from the Government of the Hashemite Kingdom of Jordan, the Japanese Government decided to conduct a Feasibility Study on Agricultural Development Project for the Karak-Tafila Development Region and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Jordan a study team headed by Mr. Takayoshi Yamazaki, Nippon Koei Co., Ltd. from October 1989 to March 1990.

The team held discussions with the officials concerned of Jordan and conducted field surveys in the Development Region. After the team returned to Japan, further studies were made and the present report was prepared.

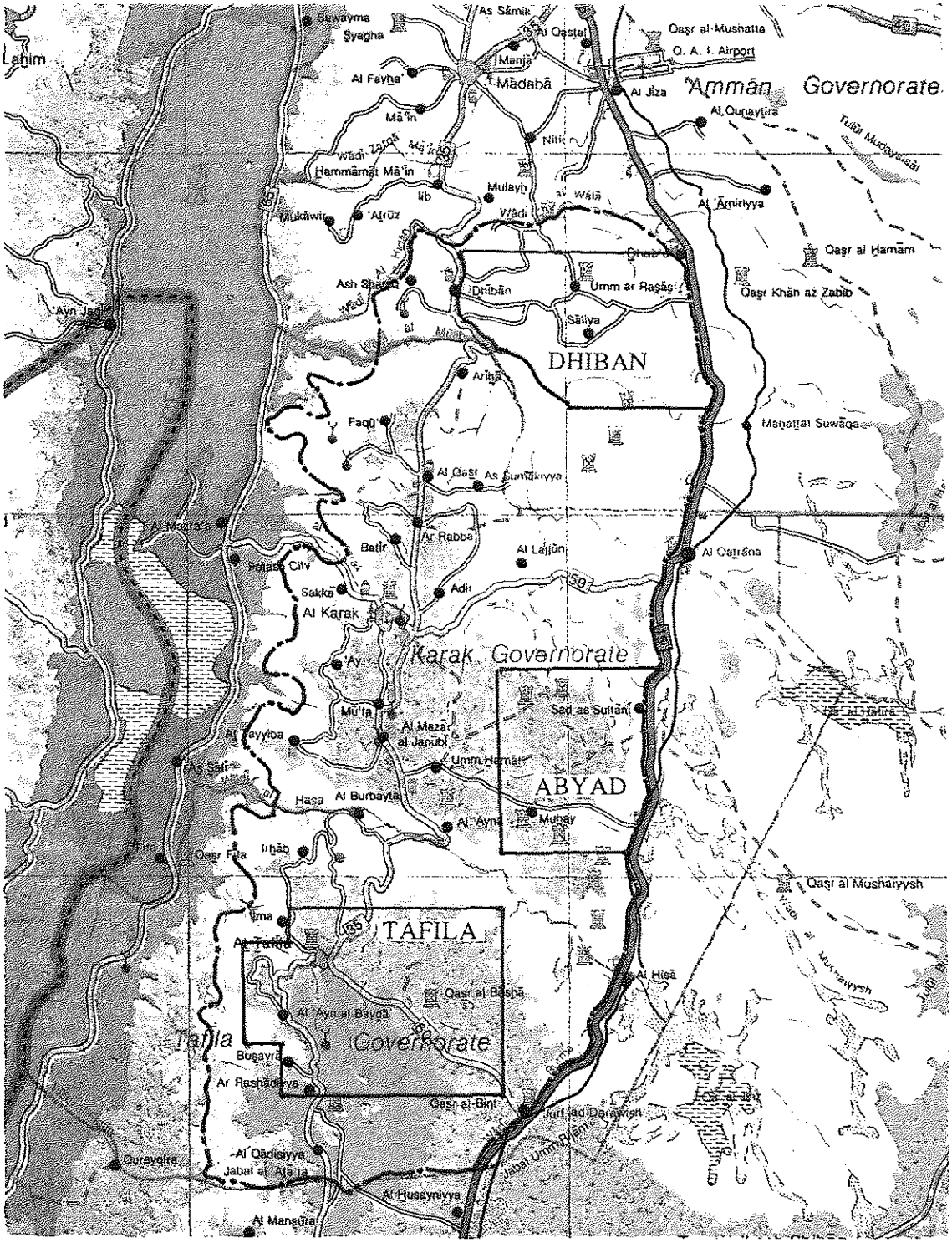
I hope that this report will contribute to the development of the Project and to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Hashemite Kingdom of Jordan for their close cooperation extended to the team.

October 1990

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency



LEGEND

Boundary of Study Area

Boundary of Priority Study Area

25 km

LOCATION MAP

THE HASHEMITE KINGDOM OF JORDAN

FEASIBILITY STUDY ON AGRICULTURAL DEVELOPMENT FOR THE KARAK - TAFILA DEVELOPMENT REGION

JAPAN INTERNATIONAL COOPERATION AGENCY

SUMMARY

Authority

This is the Feasibility Study Report on the Agricultural Development Project for the Karak-Tafila Development Region (the Project) prepared in accordance with the Scope of Work agreed upon between the Ministry of Planning of the Hashemite Kingdom of Jordan and the Japan International Cooperation Agency (JICA) on April 11, 1989.

The objectives of the Study were to formulate an agricultural development plan by applying water harvesting techniques for the Karak-Tafila Development Region and to justify the technical and economic feasibility of the Project.

Background of the Project

Even befor the most recent developments, the economic boom in the Gulf countries had ceased as a result of over-supply of petroleum in the world markets. Jordan's economy, which is much dependent upon the Gulf economy through export of labor and commodities, has been experiencing a severe economic recession since the late 1980s. Creation of job opportunities for returning labor as well as for the young are urgent issues to be solved. Improvement of the trade balance and financial deficit is another crucial issue for the nation.

The study area extends to the west of the Desert Highway with a total area of approximately 4,000 km^2 of the Karak-Tafila Development Region. Its population was estimated at 166,800 in 1990 growing at the rate of 2.6% per annum. There are 194 villages in the study area. The number of households was estimated at 20,600 giving the average family size of 8.1 persons per household.

Karak and Tafila governorates are less developed areas than other regions of the country. The average annual household income in both governorates combined was JD 2,188 in 1986/87, which was equivalent to 63% of the national average and to 48% of that in Amman in the said year. The regional economy is dependent mainly on the service sector which shared 37 % of GRDP in 1985, while agricultural sector occupied only 10% of GRDP.

Among the constraints that the local farmers are facing, low crop productivity due to limited and erratic rainfall is predominant. The mean annual rainfall ranges between 350 mm in and around Karak and less than 100 mm in the desert area giving an average rainfall of

approximately 200 mm, which does not allow reliable rainfed crop production. Although irrigation development is expected to directly improve crop productivity, Government of Jordan (GOJ) regulates water use for agriculture purposes by giving the priority to the municipal water supply and industry. In fact, new irrigation development is strictly controlled, and further exploitation of groundwater or wadi water for irrigation purposes is virtually prohibited.

In addition, sufficient extension services are crucial for the regional agriculture, yet there are only 17 staff and no vehicles for extension services in Karak and Tafila governorates. No leaflets to convey the technical message from the Government and other agencies are available for local farmers who seek improved farming techniques and marketing information.

Taking into consideration the facts that (i) a substantial number of inhabitants earn most of their income from agriculture and (ii) vast areas of land are still left under-utilized, the necessity as well as potentials for agricultural development are much larger than in other sectors.

Objectives of the Project

Under the GOJ's regulation of water use control, intensive use of rainfall is envisaged. Rain water lost by evaporation is as high as 70% to 80% of total rainfall leaving for 35% to 15% for groundwater recharge and 5% for river run-off. This fact implies that there is much room for exploitation of rain water. Crops can thrive even under meager rainfall, say 100 mm/year, when rainfall is properly trapped, collected and supplied by applying water harvesting measures. The applicability of such measures has been successfully demonstrated in many arid countries. In Jordan, water harvesting measures have also been studied by the researchers of both Jordan University and the Ministry of Agriculture (MOA). Besides, some progressive farmers in Jordan have already introduced this technique commercially and get satisfactory returns.

Encouraged by such performance, the idea of developing water harvesting measures was launched for the Region in which farmers suffer most severely from limited rainfall. The proposed measures are expected to improve unit yields of fruit trees and forage crops of the Region. Among the various measures developed in various counties, microcatchments, contour furrows and contour bunds were selected for the proposed crops, topographic conditions and availability of materials. In addition, check dams and winter irrigation techniques were also proposed.

Taking the development constraints and opportunities into account, the following objectives of the project were formulated.

(1) To increase agricultural production, productivity and income, making full use of under-utilized natural resources such as rainfall and land.
(2) To conserve basic agricultural resources such as soils and water.
(3) To generate new job opportunities in the rural areas through promotion of agricultural development.

The development strategies were set as follows:

(1) Application of water harvesting measures, such as microcatchments, contour furrows, contour bunds, and winter irrigation (runoff farming) to agricultural production.
(2) Introduction of deep rooted crops such as fruit trees and fodder shrubs to the water harvesting projects.
(3) Encouragement of farmers to participate in the water harvesting development projects through the provision of enough agricultural support services by theGOJ.
(4) Promotion of fodder shrub plantation with water harvesting measures under the initiative of the MOA.

In order to establish the appropriate development plan, some intensive study areas were selected for the purpose of in-depth study through which development constraints and potentials were verified at detail. The selected three priority areas, namely Dhiban, Abyad and Tafila, are characterized by representative features of the study area. The priority areas have a total extent of 120,000 ha, of which 39,900 ha are currently used for rainfed farming for wheat, barley and tree crops. The total population of the priority areas was estimated at 39,580 in 1990.

The Project

The following guidelines were proposed for water harvesting measures in connection with rationalized land use plan.

Slope (%)	Soil Depth (cm)	Annual Rainfall (mm) 300-200	200-100
0-8	50-100	-	microcatchments (fodder shrub)
	100<	-	microcatchments (fruit trees)
8-12	50-100	stone wall/ contour furrows (field crops)	stone wall/ contour furrows (fodder shrub)
	100<	stone wall/ earth banks (fruit trees)	stone wall/ contour furrows (fodder shrub)
12-30	50-100	stone wall/ contour furrows (barley, forage legume, shrub)	
	100<	stone wall/ earth bank (fruit trees)	

Water harvesting measures are to be introduced to the expansion areas, which are defined as land currently not used with higher suitability for crop production with flatter slopes (30% >) and deeper soil depth (50 cm <) under rainfall of over 100 mm per year. The expansion areas are classified as follows:

(unit: ha)

Slopes (%)	Soil Depth (cm)	Annual Rainfall (mm) 300-200	200-100	Total
0-8	50-100	61	3,956	4,017
	100<	407	9,079	9,486
8-12	50-100	846	2,178	3,024
	100<	282	1,328	1,610
12-30	50-100	3,645	0	364
	100<	321	0	321
Total		5,562	16,541	22,103 (13,260)/1

Remark: /1: Area to be planted, 13,260 ha, is estimated at 60% of the expansion area excluding area for villages, roads and other infrastructures.

The other development measures will consist of winter irrigation and check dam development. The target development area for winter irrigation was estimated at 33.9 ha based on the topography, present land use and water balance studies, while that for check dam development was estimated at 93 ha in total based on the prevailing catchment area v.s.

planted area ratio i.e. 0.3 ha/300 ha, in which the catchment areas should have an annual rainfall of more than 100 mm and a land slope of less than 30 %.

Expected annual additional crop production at the full development stage of the Project was estimated as follows.

Crops	Water Harvesting	Winter Irrigation	Check Dam	Rainfed Wheat	Total
Wheat					
Area(ha)	-	33.9	-	270	303.9
Yield (t/ha)	-	3.5	-	1.8	-
Production (t)	-	119	-	486	605
Olives					
Area(ha)	2,387	11.3	31	-	2,879.3
Yield (kg/ha)	104	5,949	5,949	-	-
Production (t)	295	67	184	-	546
Grapes					
Area(ha)	2,837	11.3	31	-	2,879.3
Yield(kg/ha)	207	11,750	11,750	-	-
Production (t)	587	133	364	-	1,084
Apricot					
Area(ha)	2,837	11.3	31	-	2,879.3
Yield(kg/ha)	97	9,266	9,266	-	-
Production (t)	275	105	287	-	667
Atriplex					
Area(ha)	4,480	-	-	-	4,480
Yield(kg/ha)	650	-	-	-	-
Production (t)	2,912	2,912	-	-	-
Total area(ha)	12,990	33.9	93	270	13,386.9

Remark: - not applicable

The annual net benefit at the full development stage of the schemes was estimated as follows:

(JD/ha)

Crops	Water Harvesting	Winter or Check Irrigation Dam	Irrigated Wheat	Rainfed Wheat
Wheat	-	340	340	162
Olives	22.0	1,222	-	-
Grapes	80.0	4,954	-	-
Apricot	27.0	2,453	-	-
Atriplex	13.0	-	-	-

Remark: - not applicable to the project

Wheat and fodder shrubs will be consumed locally. Fruit will be marketed to wholesale markets in large cities such as Amman by farmers themselves or middlemen.

The MOA will be the executing agency of the Agricultural Development Project for the Karak-Tafila Development Region. The crop production scheme will be executed through the agricultural extension system of MOA. Accordingly construction and management will be done directly by the private sector with technical assistance and guidance from MOA. As for the fodder shrub production scheme, there are several on-going projects which have been executed by MOA. This scheme would be executed in parallel with these on-going projects.

The MOA will coordinates all activities of the relevant government agencies and the regional administrative organizations in connection with project implementation. The agricultural offices in Amman, Karak and Tafila governorates under MOA will have direct responsibility for project implementation.

The Project will be implemented in accordance with the following schedules:

(1) Crop Production Scheme

Phase-I (5 Years):

i. Trial farming in the field, and continuation of existing research and experimental works for water harvesting measures
ii. Extension of the tentative water harvesting measures to the existing fields
iii. Training of extension agents related to the scheme
iv. Improvement and strengthening of agricultural supporting services
v. Preparation of design criteria for detailed design and construction
vi. Implementation of winter irrigation
vii. Preparation of extension schedul

Phase-II (5 Years):

i. Development in the potential areas with over 200 mm of annual rainfall
ii. Continuation of research and experimental works for further improvement of water harvesting measures

Phase-III (5 Years):

i. Development in the area with below 200 mm of annual rainfall

(2) Fodder Shrub Production Scheme

Phase-I Stage (5 Years):

i. Trial grazing in the existing project areas

ii. Detailed design and preparation of operation and management plan

Phase-II Stage (10 Years):

iii. Construction and management

The total construction costs were estimated as summarized below.

(Unit: JD 1,000)

Scheme	Economic Cost
Crop Production Scheme	2,608.3
1) Water Harvesting Measures	1,438.6
2) Check Dam	970.3
3) Winter Irrigation	199.4
Fodder Shrub Production Scheme	385.2

Project Evaluation

The EIRR and B/C were estimated as follows. The highest EIRR was 36.6% of the water harvesting development, and -1.4% of fodder shrub production was the lowest. The EIRR of the check dam development was modest. These results indicate that the development for water harvesting and winter irrigation would be economically viable, but fodder shrub production scheme would be unfeasible from an economic view point.

Scheme	EIRR (%)	B/C
Crop Production Scheme	20.2	2.45
1) Water Harvesting Measures	36.6	3.98
2) Check Dam	7.3	0.70
3) Winter Irrigation	13.1	1.41
Fodder Shrub Production Scheme	-1.4	-2.50

Although the fodder shrub production scheme will have low economic efficiency but it should nevertheless be implemented with government subsidies for the following reasons:

a. The project areas are more disadvantaged than other areas in Jordan by the poor natural resources.

b. The fodder shrub production scheme will be environmentally beneficial in that it will conserve soils and water effects of which are very difficult to justify in monetary terms.

c. The fodder shrub is a kind of food reserve or security.

AGRICULTURAL DEVELOPMENT PROJECT
FOR
THE KARAK-TAFILA DEVELOPMENT REGION

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

TERMINOLOGY

The terminologies used in this report on water harvesting, runoff cultivation, check-dams and water-spreading follow those in the book entitled "Water Resources and Agricultural Development in the Tropics" by Chris Barrow, in 1987 as follows:

a) Water harvesting is the collection and concentration of rainwater for irrigation or water supply to livestock or to domestic needs, and includes microcatchments and catchment improvement.

b) Runoff cultivation is a cultivation method which delays and retains runoff to increase moisture infiltration and reduce soil erosion. Contour farming (furrow) and terraces are included in this method.

c) Check-dams and water-spreading is the use of seasonal and ephemeral streams and flows by spreading water over the ground to moisten it and by trapping wet silt for cultivation.

ABBREVIATIONS AND MEASURES

Weight

kg	:	kilo gram
ton or t	:	metric ton

Volume

l or lit	:	liter
m^3	:	cubic meter
MCM	:	million cubic meters

Length

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer

Area

cm^2	:	square centimeter
m^2	:	square meter
km^2	:	square kilometer
ha	:	hectare
dunum	:	0.1 ha

Time

s or sec	:	second
min	:	minute
hr	:	hour

Other

%	:	per cent
^oC	:	degree centigrade
EC	:	electrical conductivity
El.	:	elevation
AD	:	Aqaba datum

Derived Measure

l/s or lit/sec	:	liter per second
mS/cm or mmho/cm	:	milli-Siemen per centimeter
ton/hour	:	ton per hour
cum/sec	:	cubic meter per second

Money

JD	:	Jordan Dinar
Fil	:	1/1000 JD
US$	:	U.S. dollar

(US$ 1.00 = JD 0.680 as of November 1989)

Organizations

MOP	:	Ministry of Planning
MOA	:	Ministry of Agriculture
MOS	:	Ministry of Supply
DOS	:	Department of Statistics
WAJ	:	Water Authority of Jordan
JVA	:	Jordan Valley Authority
ACC	:	Agricultural Credit Corporation
JCO	:	Jordan Cooperative Organization
JVFA	:	Jordan Valley Farmers' Association
AMO	:	Agricultural Marketing Organization
AMPCO	:	Agricultural Marketing and Processing Company
APC	:	Arab Potash Company
NRA	:	National Resources Authority
FAO	:	Food and Agricultural Organization of the United State
JICA	:	Japan International Cooperation Agency

Others

GDP	:	Gross Domestic Products
RGDP	:	Gross Regional Domestic Products
GNP	:	Gross National Products
ETo	:	Potential Evaporation
CUW	:	Consumptive Use of Water
kc	:	Crop Coefficient
TDS	:	Total Dissolved Solids

CHAPTER 1 INTRODUCTION

1.1 Background

1.1.1 Authority

This Report was prepared in accordance with the Scope of Work for the feasibility study on the Agricultural Development Project for the Karak-Tafila Development Region (the Project) agreed upon between the Ministry of Planning of the Hashemite Kingdom of Jordan and the Japan International Cooperation Agency (JICA) in April, 1989. The report presents the results of the phase-I and -II studies including the agricultural development plan.

1.1.2 Background of the Project

The Government of Jordan is now implementing the Third Five Year Development Plan (1986-1990), in which high priority is given to agricultural development with the objectives of improving the food security and of improving the regional economic imbalance.

People in the study area obtain much of their income from agriculture, growing wheat and barley etc. under rainfed conditions. Crop production however is decreasing year by year. Productivity is rather low and the cultivated acreage and yields of wheat and barley fluctuate heavily due to extreme fluctuation of rainfall both between and within different years. The study area is characterized as one of the least developed regions in Jordan and agricultural development was given high priority in the Integrated Regional Development Master Plan for the Karak-Tafila Development Region, conducted by the Japan International Cooperation Agency (JICA) during 1986-88.

In October, 1988, the Government of Jordan requested the Government of Japan to provide technical assistance for a feasibility study of the agricultural development in the Karak-Tafila Development Region. In response to this request, JICA dispatched a preliminary survey team to Jordan, and concluded the Scope of Work for the study with the Ministry of Planning on behalf of the Government of the Hashemite Kingdom of Jordan.

1.1.3 Objectives of the Study

The objectives of the study were to formulate an agricultural development project for the Karak-Tafila Development Region and to verify the technical and economic feasibility of the project.

1.1.4 Study Area

The study area extends to the west of the Desert Highway with a total coverage of approximately 4,000 km^2 with a total coverage of approximately 4,000 km^2 in the Karak-Tafila Development Region as shown in Location Map. Intensive study areas were located in the east of Dhiban, the west of Abyad and the east of Tafila.

1.1.5 Scope of the Study

The study was carried out both in Jordan and in Japan during the 11 months from October 1989 to August 1990. The study was carried out in two phases; Phase-I from October to December-1989 and Phase-II from January to August 1990 (see Fig.1.2).

(1) Phase-I Study

Field Work

Various data and information relevant to the project were collected through surveys and investigations of natural, agricultural and socio-economical conditions of the project area. Past studies on the development were reviewed.

Based upon the above work, potentialities and constraints of the development were identified and priority areas for the development were selected. Then the basic concept of the agricultural development in the study area as well as in the priority areas were studied.

(2) Phase-II Study

Field Work

Supplemental data collection and detailed field surveys in the priority areas identified in Phase-I study were carried out preliminary agricultural development plans were formulated after discussion of the development concept with the Government of Jordan.

Home Office Work

The feasibility of the agriculture development was studied on the following study items.

1) Agricultural development plans including the land use plan and water harvesting scheme,
2) Plan of winter irrigation scheme,
3) Preliminary design and cost estimation of the main facilities,
4) The project implementation plan
5) Benefit-cost analysis
6) Project evaluation
7) Recommendations

1.2 Activities during the Phase-I and Phase-II

1.2.1 Phase-I Study

The activities during the Phase-I period may be summarized as follows:

(l) Hydrological, Meteorological and Geological Surveys

The purpose of the hydrological study was two-fold. In order to plan the winter irrigation scheme and the water harvesting scheme, data collection on hydrology, meteorology and geology as well as field reconnaissance of hydrology and geology were carried out. Based on the data collected, hydrological and meteorological analyses were also conducted.

(2) Runoff Survey

Runoff observations were carried out from October 1989 to February 1990 in the following way:

- Construction of a small scale weir
- Installation of a rain gauge
- Topo surveys of the reservoir of the small scale weir
- Analysis of the relationship between rainfall and runoff

Observations were continued till the end of February, 1990.

(3) Land Use Study

Present land use analysis was carried out to clarify prevailing constraints against rational land use and to make a land evaluation for its agricultural development potential. A survey on the land tenure system was also conducted.

(4) Studies for the Winter Irrigation Scheme

The following four (4) weir sites were selected for the winter irrigation scheme. These weir sites are shown in Fig.1.3.

1) E-1, at Wadi Zabda
2) D-2, at Wadi Laban
3) J-1, at Wadi Khaur
4) Abyad, at Wadi Abyad

Topographical surveys and mapping were done for each weir site.

(5) Agricultural Survey

Data on the present conditions of farming, agro-economy and socio-economy were collected and analyzed. Aside from data collection, field reconnaissance and farm interview surveys were conducted so as to confirm the collected data with more practical information.

(6) Surveys of Farmer's Opinions

Surveys of Farmer's Opinion were conducted in order to reflect farmer's opinions in the development plan. A contract was made between Mu'tah University and JICA study team for implementation of the farm survey. The main objectives of the survey were to identify the problems of farmers, to involve farmers in the planning for the smooth implementation of the project and to establish the basic concepts of the project. One hundred eighty farmers were interviewed.

1.2.2 Phase-II Study

(1) Hydrological Survey

Daily rainfall data of station No. DB-2 (Prince Hasan Nursery, Abur) were collected for the years 1967/68 - 1988/89. Frequency curves of rainfall intensity-duration were collected from WAJ to estimate the peak discharges of the proposed weirs for design. The rainfall stations for the Frequency Curves were selected in the vicinity of each proposed weir site basin: namely, Mazar, Hasa El-Tannour, Tafila and Rashadiya.

(2) Runoff Observations

Runoff observations commenced on the Wadi Sukur in Muhai on December 13, 1989. The rainfall observed so far are as follows:

Date	Rainfall (mm)	Date	Rainfall (mm)
Dec. 13-31	None	Jan. 26	4.0
Jan. 4	24.0	Jan. 27	0.5
Jan. 16	2.5	Feb. 1	4.5
Jan. 17	1.0	Feb. 7	0.5

Runoff coefficients were estimated in the home office work on the basis of the data obtained including the data of the above mentioned observations.

(3) Topographical Surveys

Topographical surveys and mapping work for the winter irrigation scheme were carried out by a local contractor and completed in the middle of February, 1990.

(4) Land Use Planning

The land use planning study has clarified present land use conditions in the study area by focusing on the relationship between the extent of farmland and other ancillary land elements governing present land use. It was confirmed that there was a significant relationship between the present land use in the study area and its rainfall distribution as well as slope gradient.

From January to February, 1990, land classification and land use planning were carried out. In response to the technical comments arising from the meeting on the progress report, soil conditions have been more emphasized in land classification. In January, a soil survey was made in order to collect more detailed information on (i) soil depth and (ii) rockiness. Soil maps were prepared at a scale of 1:25,000 on which the said land characteristics can be seen. On the basis of the soil maps thus prepared, land capability was evaluated and classified to indicate the possible land use alternatives of the study area in the future.

In association with the Agronomist and the Agro-economist, the proposed guidelines for land use planning were prepared with a particular attention to introduction of water harvesting measures. The future land use plan was worked out to reflect the land development potential.

(5) Socio and Agro-Economic Survey

Activities of agricultural and agro-economic surveys covered were the followings.

1) Analysis of the farm interview surveys
2) Socio and agro-economic surveys relating to the following items:
   - Crop production
   - Animal husbandry conditions
   - Production costs
   - Market and farmgate prices
   - Marketing in the study area
   - Farm machinery services
   - Research and extension systems
   - The agricultural credit system
   - Agricultural cooperatives
3) Demand and supply forecast for agricultural products in Jordan and a study of marketability for agricultural products
4) Analyses of crop and farm budgets
5) Studies of implementing procedures
6) Studies of agricultural support services and systems
7) Economic and financial evaluations of the project

CHAPTER 2 NATIONAL SOCIO-ECONOMY

2.1 Geography and Population

2.1.1 Geography

The Hashemite Kingdom of Jordan, comprising the East and West Banks of the Jordan Valley, has a land area of 97,740 km^2. The East Bank extends over an area of 89,200 km^2, of which about 90% is desert or semidesert. The East Bank area is divided into three distinct physiographic regions by their topography and climate; i.e. (i) the Jordan Rift Valley Region, (ii) the Highlands Region and (iii) the Desert Region.

The Highlands Region extends from the Irbid plateau in the north to the Shaubak ridge in the south. The approximate area of the region is 7,900 km^2. The northern highlands enjoys a mediterranean semi-arid climate and is the major cereal and fruit producing region. The southern highlands receives less annual rainfall than the northern highlands indicating a lower agricultural potential.

2.1.2 Population and Labour Force

In 1988, the total population on the East Bank was estimated at about 3 million with an annual growth rate of 4% during the period from 1982 to 1988. About 60% inhabit the Great Amman area. Rural population percentage to the total has been declining from 41% in 1979 to 30% in 1988.

The Jordanian active labour force was estimated at 522,000 in 1988. The structure by major economic activity comprised 48.1% for social and public administrative services, 10.3% for mining and manufacturing, 10.0% for construction, 7.6% for agriculture, etc.

2.2 National Economy

The Jordanian economy has two features: one is heavily service-oriented with only modest productive sectors such as mining and agriculture; the other substantially depends on its trade earnings on the remittances by skilled workers employed abroad.

In 1987, the gross domestic product (GDP) in Jordan was JD 1.69 billion at current market prices or the equivalent of US$ 5.0 billion, as shown in Table 2.1. In the same year, per-capita GDP was about JD 577 or US$ 1,700. During the previous six (6) years from 1982 to 1987, GDP in real terms increased at a rate of 2.6% per annum. Of the GDP in 1987, 18.4% was derived from government services, followed by 16.7% from the wholesale and retail trade, restaurants and hotels. The agricultural sector only accounts for 7.3%.

With real GDP peaking in 1985, the growth rate seems to be on the decrease: there is increasing unemployment; the balance of trade is also deteriorating. The decline in economic growth is due mainly to the external events. Jordan depends on the oil-producing Gulf States as an export market for both commodities and skilled labor. The decline in oil prices has reduced the economic activities of these states which has reduced the size of the export market as well as the resource transfer to Jordan.

2.3 Agriculture

2.3.1 Land Use and Agricultural Production

The total area of the East Bank is 8.92 million ha of which 0.4 million ha (4.6%) is agricultural land. The cultivated area fluctuates widely from one year to another due mainly to variations in climatic conditions. Of the total cultivated area, only 16% is completely or partially irrigated.

The main crop products in the country are wheat, barley, olives, citrus and tomatoes (see Tables 2.2 and 2.3). In 1988, their productions were estimated at about 79,000, 45,000, 71,000, 101,000 and 219,000 tons respectively. During the past 15 years from 1974 to 1988, the production of olives, citrus and tomatoes has tended to increase, whereas wheat and barley were stagnant. The production of crops is concentrated in the governorates of Amman, Mafraq, Irbid and Al Ghouar in the northern part of Jordan. In 1988, more than 60% of the total cultivated area and production was located in these governorates (see Table 2.4).

Table 2.5 shows the number of livestock and animal products in the Kingdom. The annual production head of cattle and goats has decreased gradually, while poultry has increased rapidly from 1981 to 1987. The production of broilers has increased along with an increase in breeding stock to about 63,000 tons in 1987, up from 28,000 tons in 1981.

2.3.2 Trade in Agricultural Products

During the period from 1983 to 1988, imports of agricultural commodities including food, live animals and vegetable oil amounted to about JD 181 million or 18% of the total import value. As shown in Tables 2.6 and 2.7, wheat and flour amounted to about JD 28 million or 16% of the total imports of agri-cultural commodities, followed by meat (15%), fruits, vegetables and nuts (13%).

Agricultural exports, comprised primarily of horticultural crops, contribute a modest 9-10% of the merchandise export trade. Tomatoes, eggplants, cucumbers and citrus are the main export crops of the Kingdom.

2.3.3 Food Balance

Jordan is far from being agriculturally self-sufficient. Jordan has been importing staple foods, such as wheat and barley to meet 80-90% of the total domestic demand, and there has been no significant change in this situation during the past 5 years from 1984 to 1988. Following wheat and barley, the main crops consumed in the country are rice, tomatoes, eggplants, cucumber, citrus and apples. With regard to rice, all of its domestic demand has been imported. Other crops are self-supporting except for apples.

Of the agricultural products, per capita consumptions of barley, chick-peas, rice, cucumber, onion and red meat have upward trends, while citrus has been decreasing gradually. The remainder is more or less stable. Further details were given in Table 2.8.

2.4 Agricultural Support System

2.4.1 Research and Extension

There are now two formal institutions mainly involved in the implementation of research and extension in Jordan; the National Center for Agricultural Research and Technology Transfer of the Ministry of Agriculture (MOA) and the Faculty of Agriculture of the University of Jordan. Although some organizations and educational institutions, such as Yarmouk University and Jordan Cooperative Organization (JCO), are also engaged in agricultural research and extension, their achievements are still limited.

(1) National Center for Agricultural Research and Technology Transfer (NCARTT)

The organizational structure of MOA and NCARTT was shown in Fig. 2.1 and 2.2, respectively. NCARTT has 56 staffs, of which PhD and BSc are 12 and 16, respectively. NCARTT has its headquarters at Al Baqa'a and has eight research stations. However, the eight outlying stations are now proposed to be reduced to five regional agricultural service centers (RASC) to conduct and coordinate applied research applicable to the regional environment.

There are two main categories of research activity: firstly, major commodity-oriented research programmes funded jointly by the Jordan government and foreign assistance; secondly individual, mostly uni-disciplinary research projects which have up to now been heavily cereal-biased, especially wheat, with low priorities given to livestock, range, improvement tree crops and water management.

Extension services are provided through the Technology Transfer Department, which has only three of the 56 NCARTT staff. However, many of the research staff spend time on extension activities. In 1989, 84 extension agents were positioned in RASCs. Most of these were young graduates holding BSc degrees, but with little or no experience nor special training in extension. The organization of extension was presented in Fig. 2.3.

(2) Faculty of Agriculture (University of Jordan)

The overall objective of the FOA is to raise the level of agricultural productivity and production. Towards that end, the FOA directs an integrated program consisting of teaching, training, research, and extension. The FOA has 63 PhD researchers. However, the FOA's primary function is teaching and the proportion of staff time allocated to research is relatively small. Much of the FOA's research is undertaken in collaboration with MOA/NCARTT staff.

The FOA's main facilities are a headquarters building, research laboratories, glass houses for teaching and research, and the University Farm located in the Jordan Valley. In the field of extension, FOA has tried to avoid duplication with the MOA/NCARTT. Its extension activities reinforce and strengthen the extension efforts of MOA, in the areas of preparation of information materials in the form of extension bulletins.

(3) Others

The Agricultural Credit Corporation (ACC) and JCO also have important roles in extension activities. Both institutions have a number of qualified agricultural engineers. In the process of borrowing/lending for agricultural investments, the staff of these institutions evaluate, supervise and discuss the investment, technology, and production processes, and provide a forum for information transfer.

2.4.2 Agricultural Credit

Institutional agricultural credit agencies in Jordan are commercial banks and two institutions; the Agricultural Credit Corporation (ACC) and the Jordan Cooperative Organization (JCO). Commercial bank lending to the agricultural sector is considerable. However, agriculture is not very important to the commercial banks due to its minor share of the banks' outstanding credits.

(1) Agricultural Credit Corporation (ACC)

ACC was established by law in 1959 as a wholly government owned institution which provides loans to farmers at reasonable costs to finance agricultural projects which contribute to agricultural development in accordance with national development plans. ACC operates through its head office in Amman and its 14 branch offices. ACC is the major source of medium to long-term loans, which comprise 75% of its loan portfolio, and offers the following three types of loans:

1) Short/seasonal loans repaid in less than one year and limited to the purchase of farm inputs such as fertilizers, seeds and feed for livestock, and payment of labor costs. The interest rate is 8%, plus 1% as a penalty for default. Early payments are encouraged by a refund of 1%.

2) Medium-term loans repaid within 1 to 10 years. These loans are issued for purchase of farm machinery; establishment of orchards, fruit-tree farms, livestock farms, and poultry industry; construction of minor irrigation projects; reclamation and physical improvement of agricultural land; and the construction of farm stores. The interest rate on long- and medium-term loans is 7%, unless the loan is for dryland farming with an amount of less than JD5,000, when the rate drops to 6%.

3) Long-term loans repaid in 10-15 years. Such loans are offered to support major irrigation schemes shared by five or more farmers, agricultural industrial projects, land reclamation for orchard establishment in rain fed areas and the purchase of land to consolidate holdings and prevent fragmentation.

The main financial problem of ACC is the low repayment of loans in recent years due mainly to the collapse in vegetable prices. Debt forgiveness and rescheduling by the government also corrupted the credit discipline among borrowers and discouraged the collection efforts of the credit institutions.

(2) Jordan Cooperative Organization (JCO)

JCO is responsible for cooperative development and provides loans to farmers through agricultural cooperatives. In contrast to ACC, the JCO's clientele are primarily small to intermediate scale farmers and the cooperative societies to which they belong. Current rates charged by JCO range between 5% and 7%.

JCO has recently concentrated its financing more on short-term or seasonal loans, and has faced a longstanding problem of declining repayment. The decline in farm production and prices is cited as the cause of the decline in the JCO's performance, and its financial condition was deteriorating prior to the onset of production and pricing problems. The recovery rate for all loans was 29% in 1984 but declined even further to 14% in 1986. In 1989 JCO stopped lending and there is no lending by JCO.

2.4.3 Cooperatives

JCO is a semi-government organization, in which the Government currently holds the majority of the share capital. The Director General is appointed by the Cabinet. The JCO's services are not confined to agriculture, however, provision of services to rural and agricultural communities represents a major target of JCO. JCO's functions include the supply of inputs and the implementation of specialized government programmes, such as the crop seed multiplication scheme and the agricultural machinery scheme. It also operates the agricultural credit schemes. But JCO does not engage in agricultural product marketing. Out of a total number of 453 cooperatives in 1986, agricultural cooperatives accounted for 198 with a membership of 17,839.

2.4.4 Subsidies

Wheat and barley are subsidized both for seed and food/ feed uses. The Government contracts for seed wheat and barley through JCO. The certified seed is sold to the Government at a premium and is resold to farmers at a modest subsidized prices. In order to achieve more cereal self-sufficiency, domestic wheat and barley procurement prices were determined substantially the import parity price. In addition, the Government of Jordan takes following measures:

1) In order to support the promotion of agricultural production, all agricultural inputs (except for spare parts and a few other minor items) used in agricultural production are exempt from customs duties.

2) MOA provides seedlings of olives, grapes, citrus and some fruits at prices lower than those in the private sector.

3) All income generated by individuals through agricultural production activities is exempt from income tax.

The low barley prices subsidized discourage the alternative feed stuff development and increase the livestock number beyond the holding capacity of the natural ranges.

2.5 Prices and Marketing System of Agricultural Products and Inputs

2.5.1 Marketing

Trade in agricultural products is controlled by the government. The Ministry of Agriculture controls the amount of import and export of agricultural products through licensing, and the Ministry of Supply (MOS) controls the domestic prices of staple food, animal products, horticultural products. MOS is the monopoly importer and distributor of red meat. Livestock export has been sometimes prohibited by the government to stable the domestic prices.

The Agricultural Marketing Organization (AMO) was established as an independent government organization to be responsible for organizing external and internal trade in agricultural products, commercial operations, and such support functions such as market research and regulatory activities.

The Agricultural Marketing and Processing Company (AMPCO) was established by the government as the private company to trade and to provide all consumption requirements for local markets of potatoes, onions and garlic either from local and/or outside sources. It is an important function among the AMPCO's objectives to directly purchase some of the surplus products like tomatoes from producers on the request of the Government at subsidized prices to reduce heavy losses incurred on such farmers. AMPCO is virtually a sole agent permitted by the government to import horticultural products.

In Jordan domestic food production is much lower than demand. Food imports have to fill these gaps in type and quantity. All domestic production of food is in the hands of the private sector, while imports are shared between the private sector and MOS.

The objective of MOS is to provide consumers with food at the lowest possible profit margin. Virtually all basic food-stuffs such as sugar, rice, wheat, wheat bran, barely, maize, lentils, olive oil and red meat are imported by MOS under quantitative restriction. Furthermore, in order to protect the domestic producers and encourage self-sufficiency, the import of fruits and vegetables is controlled through prohibition and licensing.

Farmers get farm inputs such as fertilizers, agro-chemicals, on farm facilities for irrigation and mulching through farmers' associations, cooperatives and/or private dealers.

2.5.2 Prices

(1) Producer Price

MOS supports the producer prices of some commodities such as wheat, barley, chick peas and lentils, potatoes, onions, and processing tomatoes. The support price objective varies with the crop. However, these are broadly divided into two categories: (i) floor prices for wheat, onion and potatoes are provided as a mean to stimulate production, and (ii) minimum priee for processing tomatoes is to support a minimum return to growers. The most important price support is for wheat; the market farm gate price generally fluctuates around the support price, but on average, tend to be equal to or greater than the support price.

(2) Agriculture Input Prices

The prices for most agricultural inputs are determined through market mechanism except a few cases: Rates for machinery hire from cooperatives are at cost recovery levels,

and the prices of fruit tree seedlings distributed by MOA are nominally prices resulting in a 50 per cent subsidy.

2.5.3 Production Control

The Government operates a Cropping Pattern Program with the main objectives being to avoid problems in marketing of some vegetables such as tomatoes, cucumbers, eggplants and squash and to promote production of some deficit crops such as onions, potatoes, garlic and grains etc. MOA regulates the area to be planted of each selected crop under irrigation through issuing licenses to farmers both in the Jordan Valley and Highlands with advised dates of cropping. This was also to promote other crop production by utilizing the saved fields and irrigation water. The Programme has now been reduced and only the growing of tomatoes and eggplants in Jordan Valley is controlled through the Programme.

2.6 Five Year Development Plan

The Government of Jordan determined the third Five-Year Development Plan for economic and social development, in the fiscal years from 1986 to 1990. The Plan sought to achieve its aims through the following policies:

1) Creation of new employment possibilities for increasing numbers of graduates and job-seekers,

2) Improving the balance of payments and reduce the deficit in the trade balance,

3) Stimulating economic and social activity through regional development programs aimed at achieving a geographic balance in the distribution of economic gains,

4) Promoting the welfare state, and

5) Expanding the linkage with other Arab economies and promoting cooperation with all friendly countries.

To implementing these policies, a total of JD 3,116 million was to be spent during the period 1986-1990, of which 60.2% was to be devoted to the infrastructure sectors and productive sectors. The Third Development Plan envisaged attaining the following three goals in the agriculture sector:

1) To increase the average net income from agriculture at constant 1985 prices from JD 97 million during the period 1981-1985 to JD 138.1 million during 1986-90, a total increase of 45.6% at an annual growth rate of approximately 7.8%, through increasing agricultural production.

2) To conserve basic agricultural resources and protect the natural environment by halting their deterioration and utilizing them to best economic advantage, and

3) To increase the return on agricultural investment and improve the incomes of farmers and labors in order to promote investment in agriculture and encourage farmers to remain on their farms and in their village.

These goals were to be attained by increasing the area of irrigated land in the Jordan Valley region, embarking on highlands development projects, developing agricultural systems and enhancing the productivity of irrigated and rainfed areas by introducing advanced agricultural and irrigation techniques.

To implementing these policies, JD 574.2 million was to be devoted to the agricultural sector including water and irrigation during the period 1986-1990. However, due to the economic and financial crisis in 1989, the 3rd Five-Year Development Plan was suspended. The government plans to prepare an annually rolling development plan in place of the 5-year development plans.

CHAPTER 3 PRESENT CONDITIONS OF THE STUDY AREA

3.1 Location and Population

The study area covers about 4,000 km^2 extending to the west of the Desert Highway and includes the highlands of the Karak governorate excluding Safi sub-region, Tafila governorate, and a southern part of Amman governorate. There are the following 17 development units in the study area.

Governorate	Sub-governorate	Development Unit
Amman	Madaba	Aljeezeh Ummleih Jmail Dhiban
Karak	Karak	Karak Abdalia Zahum
	El-Qasr	El-Qasr Faqu'a Jada
	Mazal Jandbi	Mazal Jandbi Taybeh Hosaynia
	Ayy	Ayy
	Qatraneh	Qatraneh
Tafila	Tafila	Tafila
	Bosarah	Bosarah

According to the 1984 National Village Survey, population in the study area was estimated at about 166,800 in 1990, comprising 109,300 in Karak Governorate (except for Safi Sub-region), 42,500 of Tafila Governorate and 15,000 in the area belong to Madaba Sub-region of Amman Governorate (see Table 3.1). The average annual growth rate of Karak and Tafila Governorates was 2.6%. There are 194 villages in the study area. The number of households was estimated at about 20,600 which corresponds to 8.1 family members/household.

In 1985, employment in the study area was estimated at 28,800 which was 5.7% of national employment. Of this total, public and other service sectors accounted for 61%, followed by 17% in the agricultural sector, and 12% in the mining and manufacturing sector (see Table 3.2).

In 1980, the total population in the priority areas was only 30,000, concentrated in the Tafila area as shown below.

Priority Areas	Actual 1980	Projected 1985	Projected 1990
Dhiban	5,670	6,560	7,340
Abyad	1,150	1,290	1,450
Tafila	23,520	26,940	30,790
Total	30,340	34,790	39,580

Source: National Village Survey 1984.

3.2 Natural Condition

3.2.1 Climate

(1) General

The climatic characteristics of the study area are divided into two well defined seasons: a hot, dry summer and a relatively wet, cold winter. As for atmospheric conditions, Mediterranean depressions known as Cyprus lows are formed repeatedly during the winter season mainly from October to April. Most annual rainfall occurs within this season due to active cold fronts stretching from the depressions. On the other hand, in spring mainly from the middle of March to the middle of May Khamsinic depressions spread rapidly from the west causing heavy showers for short period of coming time. During the rest of the year high pressures prevail throughout the country, which accounts for the absence of rainfall practically from June to September.

The mean annual rainfall in the study area ranges from 350 mm in a restricted area around Karak, to less than 100 mm in the desert area along the Desert Highway. The average rainfall of the study area is approximately 200 mm. The mean daily temperatures range from 22 oC in the west along Jordan Valley, to 16 oC in the south of Tafila. Most of the study area falls between 16-18 oC.

(2) Rainfall

The rainfall distribution of long term average is shown in Fig. 3.1. Areas with an annual rainfall larger than 300 mm/y are found around Karak and Qasr, and areas with comparatively higher rainfall along King's Highway. Rainfall decreases rapidly westwards to the Jordan Valley, and gently eastwards to the Desert Highway. Rainfall along large Wadi

courses trending east-west and opening their mouths to the valley is markedly lower than in the surrounding high-lands.

The annual rainfall of the seven stations in the three priority areas are illustrated in Fig. 3.2. Dhiban and Tafila areas show the larger precipitation although they exhibit marked change annually. On the other hand the other five stations show the less precipitation and variation.

3.2.2 Physiography and Soils

The study area is situated on the plateau extending to the east of the Dead Sea Rift. The plateau varies in elevation from El. 600 m along the fringes of the escarpment facing the Dead Sea to El. 1,400 m immediately adjacent to the west side of the Kings Highway. The Lands basically slope eastwards down to the Desert Highway passing from elevations ranging from El. 700 m to 800 m on the borders of the study area.

The soils of the study area are broadly classified into Orthids derived from Quaternary sediments as well as limestones and such alternations as marls and cherts, which are characterized by reddish color and medium to coarse texture with less developed structures.

The land capability classification was made on the priority areas according to (i) topography, (iii) rock outcrops coverage under each annual rainfall class on basis of the physiography. The results are presented in Table 3.3 to 3.5. The tables show the total area, farmland, non-farmland, and expansible area falling in each land class. The extent of non-farmland was simply obtained by deducting the extent of farmland from the total area. Total expandable area was calculated at 61,300 ha by deducting rock covered area from non-farmland. In view of the potential assessment of land development, the total area and expandable area excluding shallow soils (< 50 cm deep) are summarized below.

(Unit:1000 ha)

Rainfall (mm)		Slope (%)			
		0-8	8-12	12-30	Total
Dhiban					
300-200	Total	3.2	0.9	0.6	4.7
	Expandable by	0.1	0.2	0.3	0.7
200-100	Total	16.2	3.1	-	19.3
	Expandable by	5.9	1.4	-	7.3
Abyad					
300-200	Total	0.3	0.1	0.0	0.4
	Expandable by	0.1	0.1	0.0	0.2
200-100	Total	11.4	2.2	-	13.6
	Expandable by	7.0	1.8	-	8.8
Tafila					
300-200	Total	1.6	3.4	9.4	14.3
	Expandable by	0.2	0.8	3.7	4.7
200-100	Total	0.6	0.8	-	1.4
	Expandable by	0.1	0.3	-	0.4
Total (expanded)					22.1

It is apparent that most of flatter land in the 300-200 mm rainfall class is already used for the agriculture. Although 5,400 ha in the 300-200 mm rainfall class of Tafila are expandable, some 80% occurs on sloping land with over 12% gradient. As a whole, the expandable area in this rainfall class is limited. Below 200 mm of rainfall, a considerable amount of flat land is left in Dhiban and Abyad. The distribution pattern of land classes is illustrated in Fig. 3.3 to 3.5.

3.2.3 Hydrology

Running water in a wadi is dependent on capricious storms over its drainage basin. Flash floods flow directly down to the Jordan Valley for a few days after a storm, leave a small amount of base flow only after a good amount of rainfall and flood flow during winter.

The duration of floods ranges from less than a day to several days. Most of them last a few days. The longest of them was one that lasted from January 14 to January 25 in 1974. The largest flood occurred from December 6 to 8 in 1979, its total volume amounting to 22.62 MCM.

Running volume frequently occurring varies from 0.02 to 2 MCM. Annual total runoff volume is within a range of 0.75 MCM to 38.46 MCM, its average is 8.53 MCM. The peak discharge varies from 0.2 m^3/sec to 420 m^3/sec.

(1) Runoff Coefficient

Analyses were conducted for estimating the annual runoff coefficient applicable to the proposed weir sites. Annual runoff coefficient of the Wadi Hasa Tannour Sub-basin was calculated at 7.9%. The annual runoff coefficient of 7.9% is applied to estimating the annual runoff in the proposed weir sites.

(2) Annual Rainfall of a Weir Site Basin

For the purpose of determinating the annual runoff volume at the weir site, five (5) stations were selected among fifty one (51) rainfall stations located in and around the study area.

Annual rainfall data of these stations is shown in Table 4.13. Annual mean rainfall of the each weir site were calculated by the Thiessen polygon method.

The calculated annual mean rainfall in the each weir site basin may be summarized as follows

Weir	Wadi	Place	Catchment area (km^2)	Annual rainfall (mm/yr)	Runoff coefficient (%)
E-1	W.Zabda	Tafila	9.5	227	7.9
D-2	W.Laban	Tafila	34.8	219	7.9
J-1	W.Sallam	Qadisiyya	16.7	204	7.9
Abyad	W.Abyad	Muhai	116.5	172	7.9

(3) Annual Runoff at the Hasa Tannour Gauging Station(G.S)

Based on the annual runoff volume for 19 years at the Hasa Tannour G.S. the annual runoff volumes of various return periods were obtained by a probabilitic method Log-Pearson type III. The results by Log-Pearson type III may be summarized as follows:

Return Period (years)	Runoff Volume (MCM/yr)
1.01	0.16
1.25	1.56
2	4.64
5	11.88
10	18.36
25	28.03
50	36.06

(4) Annual Runoff at the Proposed Weir Site

The annual runoff volume at weir sites was estimated using the annual runoff of various return period at the Hasa Tannour G.S., their annual rainfall and runoff coefficients, and by the following equation:

$$Dw = Dt \times (Rw/Rt) \times (Cw/Ct)$$

Where;

Dw: Runoff depth at a weir site (mm)
Dt: Runoff depth at Hasa Tannour (mm)
Rw: Annual mean rainfall at a weir site (mm)
Rt: Annual mean rainfall at Hasa Tannour (mm)
Cw: Mean runoff coefficient at a weir site
Ct: Mean runoff coefficient at Hasa Tannour

The result of the estimation may be summarized as follows:

Annual Runoff Volume at Weir Sites

(unit: MCM/yr)

Weir	Wadi	Catchment (km^2)	Return Period (year)						
			1.01	1.25	2	5	10	2	50
E-1	Zabda	9.5	0.004	0.03	0.10	0.24	0.37	0.57	0.74
D-2	Laban	34.8	0.020	0.12	0.34	0.86	1.36	2.03	2.61
J-1	Sallam	16.7	0.007	0.05	0.10	0.38	0.59	0.91	1.17
Abyad	Abyad	116.5	0.040	0.31	0.90	2.26	3.47	5.34	6.86

3.3 Economy in the Study Area

Regional production is much dependent on mining and service sectors, however the mining sector contributes little to the livelihood of local people.

The Gross Regional Domestic Product (GRDP) of the study area was estimated at JD 98 million in 1985, which accounted for 6.1% of the whole Kingdom (see Table 3.2). The per capita GRDP of the Study area was JD 687, but excluding part of the mining sector it was only JD 381. Among the productive sectors, mining sector accounted for 47% of total GRDP, followed by 10% of the agriculture sector. The manufacturing sector accounted for only 0.7%. Service sectors accounted for 36%, consisting of 15% by private service sector and 21% by public service sector.

The household income of the area is very low. According to the Household Expenditure and Income Survey in 1986/87 an average annual household income of the Karak/Tafila governorates was JD2,188, which was equal to 63% of the national average and to 48% of the Amman.

3.4 Social Infrastructure

(1) Electricity

Electricity in the study area is supplied by 132 kV and 33 kV transmission lines which are connected to the Interconnected System at the Qatrana Substation. In addition, there are one gas turbine (18 MW) and three diesel generators (3 x 1.5 MW) in Karak City. The number of consumers in the study area was 23,000 in 1985, which has grown at 22.6% per annum since 1980 (8,300). The increase is mainly by immigrant from the West Bank.

(2) Transportation

In the study area, the Desert Highway and the King's Highway run in parallel from north to south, to connect the capital city Amman and Aqaba seaport. The former has four lanes in the section between Qatrana and Ma'an, and the later has two lanes. These two trunk roads are connected to each other by several lateral roads in the area. In addition to road transportation, there is a railway along side the Desert Highway. The railway is mainly for the transport of phosphate rock.

(3) Water Supply

Most of the water supplied for regional consumption is groundwater and spring water. Due to the high altitude of about 800 m AMSL or more in most parts of the study area, utilization of base flow and flood flow in deep wadis is limited to areas along wadi beds with a low elevation of some 400 m AMSL or less.

There are four types for water consumption in the area, i.e. i) municipal water, ii) irrigation water, iii) mining and large scale industrial water and iv) water transfer.

The municipal water supply was estimated at 3.5 MCM in 1985. The irrigation water is supplied from springs by 7.5 MCM/year and from deep wells by 3 MCM/year. At present, about 10 MCM/year of groundwater are extracted for the two phosphate mines in the study area. Groundwater from the Mujib basin is transmitted to Greater Amman at about 15 MCM/year. The base flow of Wadi Hasa and adjacent small wadis is supplied to the Southern Ghor Irrigation Project, and its supplying volume was about 39 MCM/year.

3.5 Present Land Use

(1) Present Land Use in the Study Area

Rainfed farming is the mainstay of the regional economy. Due to the limited and erratic rainfall, however, cropping intensity as well as crop productivity is lower than in the northern highland regions. The present land use conditions of the study area with 400,000 ha are estimated below.

Land Use Category	Area (ha)	Proportion (%)
Field crops	24,400	6.1
Irrigated vegetables	900	0.2
Tree crops	3,600	0.9
Fallow	75,800	19.0
Forest	17,800	4.5
Sparse grasses/brush	275,600	68.8
Build-up areas	1,900	0.5
Total	400,000	100.0

Almost 70% of the study area is non-arable land sparsely covered by low natural vegetation, e.g. Artemisia brush. The extent of fallow land is outstanding. Under the well-scheduled nationwide afforestation programme, some 18,000 ha is covered by afforestation.

Actively used agricultural land amounts to 28,900 ha in total. Among several crops, wheat leads the crops in both planted area and production although they have fluctuated year by year. Where flat topography allows to introduce the farm mechanization, large scale cereal production is extensively managed during wet winter from October to April. Animal husbandry is also prevailing. Herdsmen force flocks of sheep and goats to wadi floors covered by drought resistant grass species. To make up low carrying capacity of natural vegetation, cereals and their plant residues provide supplemental feed source to local animals. Apart from cereals and stock raising, fruit trees are important income sources for the farmers in the study area. By selecting small parcels on gentle and lower topographic position favorable for collection of runoff water, olive trees are planted. In some plots, water harvesting measures, e.g. contour stone walls, are applied. Irrigation farming has been introduced to a limited extent. Reflecting better price setting of tree crops in recent years, farmers have the intention to introduce irrigation techniques to tree crops even though considerable investment would be borne by farmers themselves.

(2) Present Land Use in the Priority Areas

On the basis of the recently prepared 1:25,000 topographic maps and panchromatic aerial photography taken in June to July 1984, the present land use conditions were investigated for 120,000 ha of the priority areas located in 36,300 ha of Dhiban, 35,700 ha of Abyad and 48,000 ha of Tafila. The extent and spatial distribution of farmland is illustrated in Plate-1 for Dhiban, Plate-2 for Abyad and Plate-3 for Tafila. The extent of land use categories is summarized below:

(Unit: ha)

Land Use Category	Dhiban	Abyad	Tafila	Total
Field Crops	18,500	5,450	15,200	39,200
Tree Crops	100	50	500	600
Forest	0	0	800	800
Grasses and brush	17,200	30,150	30,850	78,200
Villages	500	50	650	1,200
Total	36,300	35,700	48,000	120,000

More than 80% of the flat land with 0-8% slope under 200 mm of rainfall has already been utilized for agriculture. Dry land with below 100 mm of rainfall and steeper land with 30% slope has not been utilized for agriculture, in most cases.

3.6 Land Tenure and Land Holding Size

3.6.1 Current Situation of Land Registration

Land adjudication and registration are still in progress. The large portions of the Karak-Tafila Development Region are not settled yet in terms of land ownership. The following figures show the progress of land registration in the Region (Fig.3.6).

Governorate	Total Land (ha)	Registered Land	
		Area (ha)	Proportion (%)
Karak	400,985.2	170,088.9	42.4
Tafila	220,168.9	85,705.1	38.9

According to the Land and Survey Department (LSC) about 60 to 70% of the land in the Karak Region is owned by the Government. However, large portions of the government land are used for grazing purposes by nomads.

3.6.2 Specific Features of Land Tenure System in Jordan

The average minimum size of land category, i.e. parcel size, in Jordan tends to become smaller and smaller. Land is generally inherited from a holder by his or her bereaved family as shared heritage. Such land owned by several persons is called "Mussha". About 10 to 20% of the private land of GAM is categorized as Mussha. For utilization of the Mussha land, the decision making process tends to be complicated and time consuming.

3.6.3 Land Holding Size in the Study Area

At LSD, the data inputs and arrangements have not been completed for the Karak-Tafila Development Region. The National Village Survey 1983 investigated (i) the land holding size of the average farmer and (ii) the proportion of freeholders and leaseholders in the Karak old Governorate.

There were 7,519 land holders in Karak old Governorate who had 53,600 ha in total giving 7.1 ha as the overall average land holding size as presented in Table 3.6. Some 60% of holders are classified into land size groups of less than 5 ha although their lands occupy only 15% of the total area. As LSD pointed out, subdivision of parcels will be a constraint. About 20% of the farmers are sustained by farmland of less than 1.0 ha, which is evaluated to be the minimum farmland area which can sustain an average farm family in Jordan according to MOA. Table 3.6 shows the proportion of freeholders and leaseholders. In Karak, there were very few leaseholders, indeed less than 1% in number.

3.7 Agriculture

3.7.1 Cropping Pattern and Crop Production

(1) Cropping Pattern

Main crops grown in the study area are wheat and barley. They cover 84% of the total agricultural areas including fallow areas (the 1988 master plan), while fruit trees covers about 12%. Irrigated vegetables occupy only 3%. Olives and grapes are the main fruit trees and tomatoes are the main vegetable crop.

The present cropping pattern in and around the priority areas is illustrated in Fig.3.7. In general, most of the field crops such as wheat and barley are sown from November to January and are harvested from June to July. With the exception of olives, a mixed culture of fruit tree crops is common practice in the study area.

(2) Farming Practices

Field Crops

In Jordan hard wheat (Triticum durum L) is mainly grown. The main varieties are traditional Hourani Nawari, F-8 and Hourani 27. Quality seed distribution has been improved by the JCO certified seed distribution project. According to information from spot surveys, about 50% of the seeds are annually replaced by farmers. Mixtures of local varieties are commonly used for barley growing. Beside these, Deir Alla 106 and ACSAD 176 are mainly used as the identified varieties.

Plowing is done normally by disc plow drawn by tractor. In hilly areas, animal plowing is practiced. Sowing is carried out by hand broad-casting. Weeding after sowing is rarely done. Plowing consists of deep plowing and shallow plowing (soil covering of seed). The period of deep plowing has been taken wide range from just after harvesting to just before seeding, while shallow plowing is done at the beginning of the rainfall season. According to the farm interview survey, the peak requirement of plowing occurs at this shallow plowing period in November and December, and the farmers cannot sow at the right time due to insufficient mechanical power.

Combine harvesting is practiced in flat areas, while in steep areas, manual harvesting is practiced. Custom services of plowing and harvesting are undertaken by JCO and private companies but their availability is not always sufficient, particularly at the peak season.

Fruit Tree Crops

There are no large fruit gardens more than 100 ha other than gardens in Aina, Tafila City and Ain Sara, which have been developed based on the large springs. Old fruit gardens are mostly developed by using spring water. Some new gardens have been expanding under drip irrigation using deep wells. Old fruit gardens are operated extensively with a few farm inputs.

Weeding is done by hand hoes and only around the fruit trees. Mechanized plowing is found only in large gardens. Fertilization is carried out mostly using animal manure. Training and pruning of the trees are seldom carried out except for some regenerative pruning for old trees and staking for young trees. Wind breaks are rarely observed except in government gardens. Plant protection is rarely carried out for olives and grapes. Fungal diseases such as Monilia and mildew are rarely observed.

(3) Crop Production

Crop production and yields in Amman, Karak and Tafila Governorates are shown in Table 3.8 to 3.10. Wheat and barley yields show wide annual fluctuations. The average yield of wheat per ha for the period 1981-1987 was 760 kg for Amman, 630 kg for Karak and 600 kg for Tafila governorate. The wheat yield is generally higher than barley yield. Growing of wheat and barley is risky industry and the farmers don't apply fertilizers and chemical to them in most cases.

Olive and grape yields also fluctuated annually. The average yields of these crops were higher in Tafila governorate than the other two governorate. Generally the yields of most vegetable crops have been increasing during 1981-1987 especially tomato and water melon. There are no major yield differences among 3 governorates (see Tables 3.8 and 3.10).

3.7.2 Livestock Production

Animal husbandry is more important economically than crop husbandry in the study area. The main livestock are sheep and goats (see Table 3.11). Chickens are also important. According to the 1983 National Village Survey, the livestock population per farm household in Karak Old Governorate was estimated at 14 for sheep, 12 for goats, 242 for chicken. Sheep and goats are grazed on natural range or field crop areas after harvest using crop residues.

The rangelands are often plowed even on steep slopes and barley is sown to increase fodder production resulting in acceleration of soil erosion and decrease in soil fertility. Due to insufficient grass production from rangelands concentrates such as barley, bran and sorghum are given supplementarily. When annual rainfall exceeds 400 mm, farmers feed their animals for more than 6 months on public rangelands. But if the rainfall falls below 200 mm/year, farmers can feed their animals for only 3 to 4 months on the public rangelands.

In general, the average liveweight of a sheep is about 50 kg. The mating season is normally June to July. The average birth rate of a ewe is about 56%/year. Lambs are sold at 3 to 4 months old with a liveweight of 20 to 25 kg.

Goat meat is mostly consumed locally. The Shami goat is characterized by its high milk production and is mostly kept in village compounds and fed supplemented feeds.

The veterinary service of the Agricultural Directorates is insufficient in manpower and facilities including transport means. Lambs are sold alive at farms. Sheep/goat milk is generally consumed by the farmers themselves.

On the basis of a farm interview survey, the livestock production per flock (100 head) of sheep and goats is estimated as follows.

Mortality		9%
Delivering rate		56%
- Selling of live sheep and goats	(heads)	13
- Selling of lambs and kids	(heads)	47
- Wool	(kg)	85
- Milk	(kg)	1,850

Remark: Lactating period: 3 months

3.7.3 Agricultural Support Services

The agricultural governorate of the Ministry of Agriculture is the formal organization for agricultural extension in the study area. There are 3 agricultural governorates in the study area.

Their organizational structures, staffing and equipment are shown in Tables 3.12 and 3.13.

Agricultural extension services for farmers are insufficient in terms of manpower, facilities (vehicles) and messages (technical, marketing, management). There are only 17 extension workers in Karak/Tafila governorate. Extension workers do not have specified vehicles for the extension services. Twenty seven cars (sedan, pick-up) are jointly used by 291 personnel of the agricultural offices in both governorates. There are no leaflets on crop or animal husbandry for the distribution to farmers in the agricultural offices.

The Jordan Cooperative Organization (JCO) also provides agricultural extension services on production inputs, marketing and credit to members of the cooperatives. There were 21 agricultural cooperatives in Karak Governorate and 9 in Tafila Governorate consisting of 1,924, and 291 members, respectively in 1986. JCO has branch offices in both Karak and Tafila.

3.7.4 Marketing and Prices

Most of the crops in the study area are consumed by farmers and the surplus products are sold in local markets in order to get cash income. Some crops are sold to merchants in Amman Central Market. In this case, the products are transported by the farmers themselves. The products which are sold to Amman are mainly vegetables and livestock products. As for

wheat and barley, the study area has no surplus market. Barley in the study area is mainly consumed as animal feeds.

On the basis of the results of a farm interview survey, the farmgate prices of farm inputs and outputs in the study area were estimated as shown in Table 3.14. The farmgate prices of fruits and vegetables fluctuate inversely as marketed quantities. The prices presented in Table 3.14 indicate the average figures in 1989.

3.7.5 Farmers' Economy

(1) Crop Budget

The crop budget analysis for each crop grown in the priority areas was made on the basis of data and information obtained from agricultural offices and the farm interview survey. The results of analyses are presented in Table 3.15.

The net income of wheat and barley are negligible i.e. JD31/ha and JD5/ha, respectively due to extremely low yields, while the fruit trees and vegetables have a good balance for examples, JD 100/ha for olives, JD 680/ha for apples and JD 336/ha for grapes.

As a result of crop budget analysis, it can be said that cultivation of wheat and barley has been carried out in the marginal zone from the financial viewpoint. If the yields decrease more than 0.04 tons/dunum, the balance will be in deficit.

(2) Animal Husbandry

The livestock grazed in and around the priority areas are mainly sheep and goats. The net income for a flock (100 heads of sheep and goats) was estimated at JD 830. The details are shown in Table 3.16.

The feeding of feeds such as sorghum, barley and bran is common among the farmers. The quantities per flock averages 13.9 tons/year in total. The annual income derived from livestock raising is of great significance for the farm economy. Livestock raising plays an important role in protein food supplies for local people.

(3) Farmers' Economy

In order to grasp the economic activities and living standards of farmers in the priority areas, a farm budget analysis was made on the basis of the crop budget analysis and the farm interview survey. The results of the analysis are presented in Table 3.17.

The general characteristics of the farmers' economy may be summarized as follows:

a) Half of the farm income is derived from livestock raising.

b) A considerable amount of the gross income is derived from non-farm income consisting of wages earned from other farms or non-farm works.

c) Food expenses amounting to 48% represent the largest portion of total living expenses.

d) The net reserve is negligibly small. It is indicated that the farmers in the priority area have no re-investment funds for improvement of their farming activities.

3.7.6 Existing Agricultural Projects Related to Water Harvesting

There are the following seven (7) projects related to water harvesting in Jordan.

a) Development of Rangelands and Meat Production Project
b) The Highland Development Project
c) Hamad Basin Development Project
d) Zarqa River Basin Project
e) Range Rehabilitation in the Eastern Low Rainfall Area of Jordan, Lajjun Area of Karak Range (Lajjun Range Rehabilitation Project)
f) Experiment on Water Harvesting by University of Jordan
g) Experiment on Water Harvesting by NCARTT

Out of these projects, the following three (3) projects have been under implementation in the study area.

(1) Development of Rangelands and Meat Production Project

JCO and the Ministry of Agriculture are carrying out this project through agricultural cooperatives and the Department of Forestry and Soil Conservation in Ma'an, Tafila, Karak and Madaba governorate covering about 20,000 ha in total with financial assistance of the World Food Programme (WFP). Atriplex spp is the main shrub planted. In the study area, 3,200 ha of the governmental land will be planted and be managed by grazing cooperatives. By 1987/88, about 2,200 ha had been completed in the study area.

(2) The Highland Development Project

This project has been implemented since 1965 by the Ministry of Agriculture with technical and financial support from FAO through WFP. The project is aimed principally at soil and water conservation by construction of stone walls and by planting fruit (mainly olive) and forest trees in hilly areas which have been severely affected by soil erosion. Farmers with an area of 0.4 ha to 5 ha, a land slope between 8 and 30 degrees, and rainfall at least 250 mm/year can get food materials free of charge after their construction of stone walls, contour furrows, or fences. As at the end of August, 1987, 7,600 ha had been covered with this project with 5,500 farmers and 3000 sites. In Karak/Tafila regions, the following acreage, sites and farmers have been covered.

Governorate	No. of Farmers	No. of Sites	Coverage
Karak	269	109	297 ha
Tafila	108	47	173 ha

The project has been extended several times and between 1990 and 1994, 15,000 ha will be covered benefiting about 7,500 farmers in Jordan

The Government has given considerable subsidies to the farmers. If the farmers construct the structures recommended by the Project, they receive the following subsidies from WFP through Highland Development Project.

a) Stone Walls
- 1 m^3 = 3 man-days
- Subsidy per 1 man-day

Wheat	2.5 kg
Vegetable oil	200 g

Sugar	150 g	
Dry skim milk	100 g	
Dates	200 g	(depending on availability)

b) Digging holes: 10 man-days/dunum for 5 persons of a family

(3) Lajjun Range Rehabilitation Project

This project covers about 5,000 ha of governmental land in Lajjun area in Karak Governorate. The annual rainfall is between 100 and 250 mm. The long-term objective of the project is to establish a model operation project for rehabilitation of degraded rangelands in the low rainfall area. The short-term objectives are:

1) Rehabilitation of rangelands of 5,000 ha through improvement in density and composition of the vegetative cover and through prevention of soil erosion,

2) Increase in marketed output of animal leading to decrease in rural poverty and

3) Promotion of the interest of local people in the rehabilitation effort through membership of mutually equitable societies.

The project has been implemented since 1985 with the assistance of the United Nations Environmental Programme, Arab Gulf Programme for UNDP and USAID.

3.7.7 Problems Recognized by Farmers

Problems pointed out by farmers during the problem census were summarized as follows;

1) Farm land, grazing land, soil and land use

a) Agricultural land has been divided into small parcels by heritage and such land fragmentation inhibits the development of mechanized farming and soil and water conservation measures.
b) Mixed landownership has been increasing and becoming an obstacle to rational land use and management.
c) In spite of various efforts to restore vegetation and to develop fodder shrub plantations, the grazing areas are not enough to supply animals with enough feed

d) Agricultural land with a comparatively high potential has been decreasing rapidly due to urban encroachment and soil erosion.

2) Water resources and supply

a) Insufficient and unpredictable rainfall causes the extreme fluctuations in crop production specially for cereal rainfed crops.
b) The expansion of irrigated agriculture and livestock farming is constrained by the scarcity of surface and ground water resources. Moreover the utilization of such water resources is strictly restricted because priority is given to municipal and industrial water use.
c) Water supplied by WAJ for supplemental irrigation and animals is very costly for farmers to purchase and the water transportation facilities are also limited.

3) Labor force and machinery power

a) Agricultural labour depends mainly on unstable migrant workers because of unavailability and the high wages of Jordanian workers.
b) Agricultural machinery services and machinery maintenance services are generally insufficient at the government stations.
c) Agricultural machinery and their spare parts are too expensive for farmers to purchase and the rental charges for the machinery are also very high.

4) Supply of seeds and seedlings

a) Number of seeds distribution centers is not sufficient and the center does not distribute seeds at the right time.
b) The quality of cereal seeds available both at the distribution centers and in the private shops is usually low.
c) Some kinds of imported vegetable seeds are not available in many cases and these are very costly even if available.
d) Seeds of green fodder are in most cases not available.
e) Some seeds and seedlings are not tested and are not appropriate to the prevailing climate and soil conditions.

5) Supply of fertilizers and agro-chemicals

a) Both fertilizers and pesticides are too expensive for ordinary farmers to purchase.
b) Kinds of pesticides are limited and certain types of pesticide for specified pests are not available in many cases.
c) Because of insufficient extension services, many farmers are not receiving enough information regarding application practices of fertilizers and pesticides.

6) Extension services and credit

a) Since the number of extension agents is limited, farmers are not receiving proper advice on farming practices and appropriate land use.
b) The use of institutional credits is very low for various reasons such as the religion, necessary qualifications, high interest rates and short repayment periods.

7) Marketing and transportation

a) Farmers think that there is unreasonable exploitation by middle men.
b) Marketing and transportation processes are inconvenient for farmers due to an insufficient number of marketing centers.
c) Favouritism plays an important role in every kind of transaction.

8) Post harvest facilities

a) Storage facilities for products are insufficient.
b) There is no processing factory for dairy products in the area.

CHAPTER 4 AGRICULTURAL DEVELOPMENT PLAN

4.1 Basic Concepts of the Agricultural Development

4.1.1 General Background

The study area is characterized as the least developed area in the country due mainly to unfavorable natural conditions, scarcity of population, insufficiency of infrastructures, etc. According to the Household Expenditure and Income survey in 1986/87 the average annual household income in the Karak/Tafila governorates was JD2,188, which was equal to 63% of the national average and to 48% of the Amman.

The regional economy is heavily dependent on the service sector, which accounted for 37% of GRDP in 1985. While the agricultural sector accounted for 10% of GRDP.

Agriculture in the study area is not well endowed with natural resources. However, considering the fact that a substantial number of inhabitants earn most of their income from agriculture including livestock and vast land is still left under-utilized, the potential for agricultural development will be much larger than in other sectors.

4.1.2 Constraints on Agricultural Development

Low agricultural productivity is the fundamental constraint of the agriculture in Jordan resulting in large inflow of agricultural produce from abroad. This trend will be accelerated by the reduction in agricultural subsidies and relaxing of import restrictions on agricultural produce by the government.

The followings are thought to be the main reasons for the low productivity.

(1) Low and unpredictable rainfall

Crops like field crops in the study area dependent on rainfall without irrigation are very susceptible to low and erratic rainfall. Improved capital-intensive technology packages recommended for rainfed field crops by the government have not yet been widely adopted by the farmers due to the high risks involved.

(2) Insufficient agricultural extension services

Agricultural extension services to farmers are insufficient in terms of manpower, facilities (vehicles) and messages (technical, marketing, management). There are only 17 extension workers in Karak/Tafila governorate. Extension workers don't have specific vehicles for the extension services. Twenty seven cars (sedan, pick-up) are jointly used by 291 personnel of the agricultural offices in both governorate. There are no leaflets on crop or animal husbandry for distribution to farmers in the agricultural offices.

(3) Fragmentation of agricultural land, joint ownership and farm absenteeism

Equal inheritance of land among heirs causes land fragmentation into small parcels and joint ownership of the land reduces the efficiency of farm machinery and farm management. Farm absenteeism associated with the land fragmentation and higher income in non-agricultural sectors lessens the motivation of landowners for higher farming productivity. Sustained improvement in soil fertility and long term investment in agriculture such as fruit tree growing which need long non-bearing periods are difficult to be anticipated in tenant farming.

(4) Government restriction on the usage of groundwater/river runoff for irrigation

Due to the scarcity of water resources in the country, the government of Jordan regulates water use giving priority to the municipal water supply and industry. Thus, new irrigation development in the study area is strictly controlled and new large irrigation development using ground water or wadi water is virtually prohibited.

4.1.3 Development Opportunities

(1) Under-utilized Water and Land Resources

The project area (Karak-Talifa Regions) has extensive under-utilized arable land and under-utilized water resources. About 19% of the area i.e. 75,800 ha, has been left abandoned even being arable land due mainly to the existence of more profitable job opportunities in the oil producing countries in Gulf and due to low productivity of agriculture in the project area. In the three priority areas with a total area of 120,000 ha, the following agricultural potential areas were identified through the land use study. The potential area for expansion excluding shallow soils (< 50 cm deep) was assessed as follows:

(Unit: 1,000 ha)

Rainfall (mm)	Slope (%)			
	0-8	8-12	12-30	Total
Dhiban				
300-200	0.1	0.2	0.3	0.7
200-100	5.9	1.4	-	7.3
Abyad				
300-200	0.1	0.1	0.0	0.2
200-100	7.1	1.8	0.7	8.8
Tafila				
300-200	0.2	0.8	3.7	4.7
200-100	0.1	0.3	0.9	0.4
Total				22.1

About 70% to 80% of the rainfall is estimated to be lost by evaporation from soil surface leaving about 5% for river run-off and about 15% to 35% for groundwater recharge. There is much room for utilization of the water presently evaporated for agricultural production.

(2) Water Harvesting Techniques

Crops can thrive even under meager rainfall, say 100 mm/yr, when the meager rainfall is collected sufficiently for growing. This method is called water harvesting and its suitability in an arid climate has been successfully demonstrated in many countries. In Jordan also, the water harvesting has been successfully demonstrated in experiments by Jordan University and by the Ministry of Agriculture. Some progressive farmers in Jordan are adopting this technique commercially and get satisfactory returns.

The water harvesting will increase agricultural production such as of fruit trees, and forage crops making use of extensive under-utilized land and rainfall in the project area. Water harvesting techniques includes microcatchments, contour furrows, check dams and weirs etc.

(3) Superiority of Agriculture in Economic Recession

The economic boom in the gulf countries has ceased due to over-supply of petroleum in the world markets. The Jordan economy which is much dependent on the Gulf economy through export of labor forces and commodities has been experiencing a severe economic recession since late 1980s. Generation of job opportunities for returning labourers as well as

for the young generation are urgent issues to be solved. Improvement of the trade balance and financial deficit are also priority problems for the country.

Agriculture has the characteristic of subsistence in relieving the financial burden of the government and has more capacity to absorb labour forces than other economic sector in Jordan in the present economic conditions using under-utilized land and water resources.

(4) Low Self-sufficiency in Food and Development Priority Given to Agriculture

Apart from the above facts, and since self-sufficiency in staple foods in Jordan is as low as about 20%, and the export of some horticultural crops contributes to foreign currency earnings, the Government has given development priority to the agricultural sector in consecutive national development plans and has devoted a substantial share of the development budget to the agricultural sector.

4.1.4 Development Strategy

(1) Objectives

Taking the development constraints and opportunities into account, the following objectives of the project were formulated:

1) To increase agricultural production, productivity and income making full use of natural under-utilized resources such as rainfall and land.

2) To conserve basic agricultural resources such as soils and water.

3) to generate new job opportunities in the rural areas through increase in agricultural production.

(2) Strategies

The strategies of the agricultural development in the Karak-Tafila region were set as follows:

1) Application of water harvesting measures, such as microcatchments, contour furrows, contour bunds winter irrigation (runoff farming) to agricultural production.

2) Introduction of deep rooted crops such as fruit trees and fodder shrubs to the water harvesting project.

3) Encouragement of farmers to participate in the water harvesting development projects through the provision of enough agricultural support services by the government.

4) Promotion of the fodder shrub plantation with water harvesting measures under the initiative of cooperatives.

4.2 Land Use Planning

4.2.1 Principles of Land Use Plan

Based on the national policies for agricultural and regional development, the basic principles of land use planning were established as follows:

1) Staple crop production will be planned for higher potential flatter land with over 200 mm of annual rainfall.

2) Tree crops will be planted on sloping land covered by deeper soils by introducing water harvesting measures.

3) Land with 200-100 mm of rainfall will be used mainly for fodder shrub development.

4) Dry land with less than 100 mm of annual rainfall is excluded from the land use planning. This will be left as natural grazing land as it is.

5) Land covered by shallow soil of less than 50 cm deep is excluded from agricultural land development regardless of rainfall class. This will be left as it is for natural grazing purposes.

6) Steeper land with over 30% slope is excluded from land use planning and will be defined as afforestation area.

The optimum land use plan has to be justified from the standpoints of (i) land and water development potentials, (ii) agronomic studies for crop selection and farming practices by introducing the water harvesting measures, and (iii) socio-economic analyses for both demand-supply balance of farm products, profitability of crop alternatives, and farm economy. For setting up the land use proposals, guidelines were prepared as presented in Table 4.1

4.2.2 Proposed Land Use Plan

Based on the guidelines in Table 4.1, land capability classes were categorized for crop production and fodder shrub development as presented in Tables 4.2 to 4.4.

The proposed land use plan emphasizes the importance of soil and water conservation. Irresponsible land use is to be controlled so as not to accelerate soil erosion. The existing field crops planted are basically to be retained in the land use planning. For rational land use concept, crop diversification is taken into account to the certain extent. According to the land use guideline in Table 4.1, suitable crops are proposed for each land class as follows. (Table 4.5).

Implementation of the project will be phased. In Phase-I the higher potential land with favourable climate will be developed. In the Phase-II pass the lower potential land will be developed.

The basic features of the phased land use plan are as follows:

(1) Dhiban

Phase-I 300-200 mm

1) Field crops expansion to 140 ha on 0-8% slopes
2) Tree crops expansion to 250 ha on 8-12% and 320 ha on 12-30% slopes by introducing earth banks and stone walls

Phase-II 200-1000 mm

1) Expansion of tree crops to 5,900 ha of deep soils on 0-8% slopes
2) Expansion of fodder crops to 1,400 ha of deep to moderately deep soils on 8-12% slopes

(2) Abyad

Phase-I 300-200 mm

1) Expansion of field crops to 190 ha on 0-12% slopes

Phase-II 200-100 mm

1) Expansion of fruit trees to 3,200 ha of deep soils on 0-8% slopes
2) Expansion of fodder shrubs to 3,900 ha on 0-8% and 1,800 ha on 8-12%

(3) Tafila

Phase-I 300-200 mm

1) Expansion of field crops to 990 ha on 0-12% slopes
2) Expansion of fruit trees with 30 ha
3) Expansion of fodder shrubs with 3,600 ha on 12-30%

Phase-II 200-100 mm

1) Expansion of fruit trees with 70 ha
2) Expansion of fodder shrubs with 300 ha on 12-30%

The future land use plan of the 3 priority areas were presented in Plates 1 to 3.

4.3 Crop Production Plan

4.3.1 Development Area

Based on the land use guidelines proposed in chapter 4.2 and the basic concept of the development, target expandable development areas by rainfed farming such as water harvesting are 1,314 ha for wheat/barley, 9,682 ha for fruit trees, 7,462 ha for fodder shrubs and 3,645 ha for mixtures of barley, forage legume and fodder shrubs as shown in the next table.

The plantable area excluding area for roads and residents was estimated at about 60% of the above figures.

Development Area by Rainfed Farming

(Unit: ha)

Area	Wheat/barley	Fruit trees	Fodder shrub	Mixture(*)
Dhiban	141	6,430	1,424	0
Abyad	192	3,151	5,689	0
Tafila	981	101	362	3,645
Total	1,314	9,682	7,462	3,645

Remark (*): barley, forage legume, fodder shrub. (22,103)

The development area by winter irrigation was estimated at 33.9 ha in total based on land suitability and water balance studies of the 7 alternative sites. Check dams will be constructed in areas with annual rainfalls of more than 100 mm and with land slopes of less than 30%. The total development area by check dams was estimated at 93 ha applying the existing ratio of a plantable area to a catchment area i.e. 0.3 ha/300 ha.

4.3.2 Proposed Crops

(1) Fruit Trees

The main technology proposed in the present project for crop cultivation is water harvesting using microcatchments. The prerequisite characteristics of crops suitable to water harvesting techniques is deep rooting, which can make use of stored water in the soil even in summer. Fruit trees and fodder shrubs are appropriate crops for the water harvesting project having deep rooting systems. Some field crops have showed good results in water harvesting experiments in other countries but the practical application of the water harvesting techniques to field crops in Jordan needs some actual trials and assurance.

The definite kinds of crops finally proposed were selected based on crop performances shown in experiments in Muwaqar by Jordan University, NCARTT experiments in Balama, experiments in Sapha by Ministry of Agriculture and others in Negev, Arizona, Mexico etc.

The following fruit trees showed good performances and seem to be suitable among others for the water harvesting project.

- Olives
- Apricots
- Pistachio
- Grapes
- Apples
- Almonds

Olives are the most recommendable crop for its high drought resistance and good marketability in the future, followed by grapes and apricots.

As shown in Table 4.6, figs, plums and pomegranates, which have shown good performance in water harvesting experiments in other countries would present problems in marketing in the future.

(2) Field Crops

Field crop development was proposed for winter irrigation and the common rainfed cropping. Winter irrigation utilizing weirs and check-dams needs rather heavy investments and thereby needs intensive cultivation to recover the investments and also needs winter growing crops to make use of the winter rainfall as much as possible.

Wheat was selected as the most suitable crop for winter irrigation and for the common rainfed cropping because wheat:

a) is grown in winter, in which most parts of the rainfall concentrates,
b) is assured of a marketing outlet and a price by the government, and
c) is the main source of the staple food for the local population as well as urban population.

Lentils, vetch and chickpeas are harvested by hand and their harvesting is drudgery abhorred by labourers resulting in low productivity. There are no suitable harvesting machines for these crops. Without mechanized harvesting and government protection against imports, growing lentil, vetch and chickpeas will not be attractive for farmers.

4.3.3 Cropping Pattern and Farming Practices

No specific cultivation method will be applied to the projects. The usual common cultivation methods recommended by the government will basically be applied to the projects.

(1) Fruit Trees

Olives, grapes and apricots were selected as the representative fruit trees.

Seedling

Seedlings of the fruit trees are available at government nurseries. There are 6 government nurseries producing seedlings including budded and grafted ones. Another 5 government nurseries also produce both fruit seedlings and forestry seedlings.

Planting density

The planting density for fruit trees was determined based on the water balance study. i.e. crop water requirements. vs. rainfall. The crop water requirements were estimated based on the recommended modified Penman method. Planting density is estimated as follows. Detailed calculations are shown in Table 4.7.

	Planting Density (plants/ha)		
Annual Rainfall	Olives	Grapes	Apricots
100 - 150 (mm)	5	44	3
150 - 200 (mm)	6	61	5
200 - 250 (mm)	8	79	6

Considering the good performance in experiments in Balama and Sapha, microcatchments might be best suitable for fruit growing. Definite suitable methods of water harvesting should be decided based on experiments.

Varieties

The following varieties might be recommendable.

a) Olive: Nabali, Rasseii, Carotin, Mansonella
b) Grapes: Adjlouni, Salti, Halwani, Hamburg-Muscat
c) Apricots:

Self-sterility is the common characteristic of apricots. Mixed planting of different varieties is necessary. Hamawi (Syria) and Angrska (French) varieties are recommendable.

Pruning

Pruning should be started form the 3rd year after planting to get good aeration, to let sunshine reach inside branches and leaves and to facilitate crop husbandry. A pyramidal shape of crown will be suitable for olives and apricots. Pruning to control water consumption by the plants might be necessary. Pruning will be done from November to December.

Fertilization

Fertilizations were determined by reference to Jordanian or Japanese standards as follows.

Fertilization at Full Development Stage (kg/plant)

Fertilizer	Olives	Grapes	Apricots
N	0.53	0.16	0.63
P_2O_5	0.45	0.14	0.38
K_2O	0.75	0.28	0.50

Chemical fertilizers will be applied from December to January.

Plant protection

There are no serious insect pests and diseases against olives favored by dry and harsh climate in the project areas. Regular spraying of chemicals might not be necessary for olives. For grapes and apricots, regular spraying of chemicals will be necessary against vine mildew, grape worms, fruit fly, and wood borers. Cu compound and malathion should be applied. Spraying should done from June to July.

Harvesting

Manual harvesting will be adopted. Olive fruits will be packed in jute bags. Grapes and apricots will be packed in styrofoam boxes. Olive will be harvested from mid October to mid December. Grapes and apricots will be harvested from July to September. Most of the harvested fruits will be marketed to the central market of Jordan.

(2) Field Crops

Wheat will be grown for the common rainfed cropping and for the winter irrigation project.

Land preparation

The first plowing should be done by chisel plows with a plowing depth of about 15 cm 2-4 weeks after harvest. The 2nd plowing would be done also chisel plows during September and October before sowing.

Sowing

Seed should be drilled with fertilizers at a rate of about 80 kg seed/ha together with 420 kg DAP/ha for the winter irrigation and 80 kg seed/ha together with 90 kg DAP/ha for the common rainfed cropping in November. Sowing depth will be 6 to 8 cm. Hourani 2, Hourani Nawawa, ACSAD 65 varieties might be suitable.

Weed control

Weeds should be controlled basically by tillage practices such as plowing and surviving weeds should be controlled by chemicals such as 2.4-D. 2.4-D which should be applied after emergence of weeds.

Harvesting

Harvesting can be undertaken by JCO machinery service centers or by private custom services. In hilly areas, harvesting will be done by hand. Most of the harvested wheat will be consumed locally.

4.3.4 Crop Yields and Crop Budgets

Wheat yield by the common rainfed cropping was estimated at 1.8 ton/ha based on the JCO seed project record. Expected yields of fruit trees by the water harvesting methods were estimated by referring to the yields under the Highland Development Projects (renamed as Development of the Highland Agricultural Regions by WFP). Expected yields of crops are given in the following table:

Expected Yields

(kg/plant, ton/ha)

Crop	Years after planting 1-3	4	5	6	7	8	9	10	11	12	13-15
Olives	0	0	0	2.3	3.1	6.5	8.5	12.2	13.0	18.0	20.8
Grapes	0	1.1	2.1	3.1	3.5	3.7	3.8	4.0	4.3	4.6	4.7
Apricots	0	0	6.8	11.9	15.2	18.6	22.3	26.2	29.2	31.5	32.4
Wheat,irr.	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Wheat,rain	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8

The expected economic lives of the fruit trees and the fodder shrubs are 70 years for olives, 15 years for grapes, 20 years for apricots and 30 years for Atriplex.

The additional crop production expected in the project was given in the following table.

Expected Annual Additional Crop Production at the Full Development Stage of the Project

Crops	Water Harvesting	Winter Irrigation	Check Dam	Rainfed Wheat	Total
Wheat					
Area(ha)	-	33.9	-	270	303.9
Yield(t/ha)	-	3.5	-	1.8	
Production (t)	-	119	-	486	605
Olives					
Area(ha)	2,387	11.3	31	-	2,879.3
Yield(kg/ha)	104	5,949	5,949	-	
Production (t)	295	67	184	-	546
Grapes					
Area(ha)	2,837	11.3	31	-	2,879.3
Yield(kg/ha)	207	11,750	11,750	-	
Production (t)	587	133	364	-	1,084
Apricot					
Area(ha)	2,837	11.3	31	-	2,879.3
Yield(kg/ha)	97	9,266	9,266	-	
Production (t)	275	105	287	-	667
Atriplex					
Area(ha)	4,480	-	-	-	4,480
Yield(kg/ha)	650	-	-	-	
Production (t)	2,912	-	-	-	2,912
Total area(ha)	12,990	33.9	93	270	13,386.9

Remark:- not applicable

The crop budgets estimated for the agricultural development are given in Tables 4.8 to 15. The followings are the net benefits expected in the respective schemes:

Annual Net Benefit at the Full Development Stage of the Schemes

(JD/ha)

Crops	Water Harvesting	Winter or Check Irrigation Dam	Wheat Irrigated	Wheat Rainfed
Wheat	-	340	340	162
Olives	22.0	1,222	-	-
Grapes	80.0	4,954	-	-
Apricot	27.0	2,453	-	-
Atriplex	13.0	-	-	-

Remark:Asterisk(*) means non- application in the project

4.4 Livestock Development Plan

4.4.1 Development Area

Existing rangelands can be classified into the following two areas:

a) Unproductive areas with shallow soils of less than 50 cm deep, not suitable to growing field crops or fruit trees, even endorsed with an annual rainfall of more than 200 mm.

b) Unproductive areas with an annual rainfall between 100 mm and 200 mm.

Fodder shrub development by water harvesting will implemented in areas with an annual rainfall of 100-200 mm, a land slope of less than 12% and a soil depth of 50-100 cm.

The areas meeting the above conditions in the priority areas are:

Dhiban	:	1,424 ha
Abiad	:	5,689 ha
Tafila	:	349 ha
Total		7,462 ha

4.4.2 Proposed Fodder Crops

Atriplex halimus (north African salt bush) and Atriplex nummularia (old man salt bush) will be grown by water harvesting or by runoff farming. Atriplex halimus is a native fodder shrub grown in the project areas and is an important feed source for sheep and goats. It has a self-seeding characteristic and can be expanded by sowing. The feed value of 4 kg of Atriplex species when fresh is equal to 1 feed unit, which is equivalent to 1 kg of barley.

Atriplex numularia is of Australian origin and is more palatable to animals, than A. halimus, but is not self-seeding under local conditions. Once completely grazed, it can't regenerate.

4.4.3 Husbandry of Fodder Shrubs

Land Preparation

Microcatchments with an individual plot size of $32m^2$ together with a retaining pit of $1.5m^2$ x 0.1m will be constructed. The land preparation should be done in summer or autumn.

Planting

Seedlings can be obtained from the government nurseries. Planting should be done when the pits have enough moisture. The planting time might be from December to February. Too big seedlings should be shortened to about 35 cm to save water consumption.

Browsing

Browsing should be started 3 years after planting and be done in summer or autumn to save grazing pressure on the existing grazing land, because the main purpose of the growing of fodder shrubs is to reserve grazing resources for drought months. Atriplex could be browsed twice a year with a 3.5 month interval. Every 9 years, Atriplex should be renewed by cutting to a height of 30 cm in winter.

4.4.4 Proposed Feeding and Management Methods

Rangelands developments normally cover a large acreage, of which management is normally done by government organizations or farmers' cooperatives. Permanent

management of the rangelands by government organizations are thought to be unsuitable from the viewpoint of productivity. But during the initial development stage, when various risks are involved, the management should be done by the Ministry of Agriculture or Jordan Cooperative Organization. After stabilization of management, farmers' cooperative societies should take over the management. Browsing of the fodder shrubs should be allowed to farmers or Bedous in summer or autumn when animal feed is most deficient.

4.5 Afforestation Development Plan

Afforestation will consist of the forest development and windbreak tree development.

4.5.1 Development Area

According to the land classification by slope in the study area, more than 60% of the area is subject to soil erosion having slopes of greater than 8%. The farmer's opinion survey also showed that soil erosion was one of the serious causes of land degradation. Soil erosion is thus one of the major constraints against agricultural development in the study area.

Based on the proposed guidelines for land use planning, steeper land with over 30% slopes was defined as suitable for afforestation and natural pasture. Areas with a soil depth of more than 50 cm and under 200 - 300 mm of annual rainfall and areas with a soil depth of more than 100 cm and under 100 - 200 mm of rainfall were proposed for afforestation areas. The rest of the areas with over 30% slopes were proposed for natural pasture. According to the land development potential in each area, expandable development areas for forest will be 34 ha and 683 ha in Dhiban and Tafila respectively. These areas will be covered by forest for the effective conservation of soil and water.

Windbreaks around farm land would be one of the most promising techniques for evapotranspiration control and for soil conservation by providing mild microclimate conditions within fields for better plant growth and also by maintaining the fertile soil against erosion loss.

At present, windbreaks are mostly used around the big farms, the government facilities and other industrial establishments. But in the future windbreaks will be established by ordinary farmers starting from the perimeter of farm land.

4.5.2 Proposed Trees

(1) Forest Trees

Forest gradoni will be applied to areas with slopes between 5 and 50% and with rock outcrop of 0 - 75% not only as a soil and water conservation measure but also as a water harvesting measure. Forest gradoni is widely used for existing afforestation areas and also for the forage shrub plantation. Forest trees suitable for forest gradoni under annual rainfall of 100 - 300 mm may be as follows.

Scientific name	Arabic name
Acacia cyanophylla	Acacia cyanophylla
Cupressus sempervirens	Saraw (Ofoqi, Amodi)
Pinus halepensis	Snobur (Halabi)

(2) Windbreak Trees

Plantating of windbreaks is increasing especially in the Jordan valley by cooperatives under Jordan Valley Authority and in irrigated areas. Single lined and mono-variety windbreaks are common in Jordan, though there are some disadvantages. In some cases trees fall by diseases or other reasons in single lined windbreaks. A slit is then formed and the wind then blows through this slit very strongly. This harms the windbreak itself and also harms plants grown inside the windbreaks. Furthermore, if plant diseases invade mono-variety windbreaks, all the trees will be affected. Multi lined mixed windbreaks are therefore recommended. Combination and selection of varieties are also important for the best functioning of windbreaks. In the case of 3 lines for example, bush types, middle height trees with broad leaves and tall coniferous trees will be distributed respectively at the outside, center and inside of the belt.

The most suitable species of bushes and trees for the windbreaks may be as follows.

Scientific name	Arabic Name
Bushes	
Atriplex spp.	Qataf
Haloxylon spp.	Ghadha
Middle height trees	
Acacia cyanophylla	Acacia cyanophylla
Tamarix articulata	Athil
Tall trees	
Casuarina equisetifolia	Casuarina
Cupressus sempervirens	Saraw (Ofoqi, Amodi)
Eucalyptus camaldulensis	Kina
Pinus halepensis	Snobur (Halabi)

4.5.3 Afforestation procedure

No new specific tree plantation method will be applied to the projects. Common tree plantation methods recommended by the Department of Forest and Soil Conservation will basically be applied to the project.

(1) Preparation of seedlings

Most of the tree seedlings are available at the nursery of each directorate and are distributed upon requests. The most suitable time for seed collection and sowing for each species will be as follows;

Species	Collection of seed	Sowing	Treatment of seed
Acacia cyanophylla	Summer	Feb/Mar	Soak in water 48 hr
Casuarina equisetifolia	Late summer	Apr/May	
Cupressus sempervirens	Late summer to autumn	Dec/Jan	
Eucalyptus camaldulensis	Spring to Autumn	May	
Pinus halepensis	Summer to early autumn	Feb/Mar	

(2) Land preparation

Forest Gradoni will be used in afforestation area. The spacing for forest trees will vary from 4 m to 10 m with predominant spacing at 5 m. Forest Gradoni have been made manually. Since this is expensive and time consuming, the mechanized construction will be adopted for Forest Gradoni by introducing the "Mouflon" which is a multipurpose agricultural

machine developed by CINAM, Montpellier, France. This machine can make gradoni on slopes up to 40%. Supportable walls and small dams will also be prepared as a protective work against erosion and effective conservation of rain water. Estimated cost for the construction of forest gradoni by using the "Mouflon" are as follows;

Activities	Executor	Unit	Units/ha	Price per unit (JD)	Cost (JD)
Contour survey	Surveyor+laborers	day	1	1x4 + 2x3	10
Gradoni making	Mouflon	day	0.125	12.3	1.54
Manual finish	Manpower	day	4	3	12
Total					23.54

(3) Tree plantation

A seedling should be deep-planted in the middle of a pit prepared on Gradoni to concentrate most of the rainfall around its roots. Organic matter such as sewage sludge, if available, should be applied to a pit to improve the physical and chemical properties of the soil. Planting should be carried out in the rainy season to secure fast and deep root penetration. At the end of the winter and early spring, the soils around seedlings should be hoed to clear all weeds to mitigate competition for soil moisture. In drought years or when rainfall distribution is uneven, watering should be carried out during the first summer to ensure survival.

4.5.4 Benefits of afforestation development

Although under the present conditions afforestation is hardly an economic proposition, trees fulfil many protective functions which are difficult to express in terms of money. Production of timber is insufficient to recover heavy investments required. But, tree planting in these area will have the following intangible benefits.

1) To provide greenery and shade for man and his herds.
2) To provide windbreaks to protect agricultural crops and settlements from wind and dust storms.
3) To protect soils against water and wind erosion.
4) To provide recreational grounds to meet the increasing demands for outdoor recreation.

4.6 Proposed Facilities for Agricultural Development

4.6.1 Soil and Water Conservation Measures

(1) Existing Soil and Water Conservation Measures

Jordan has been promoting soil and water conservation projects since the 1960s such as Soil Conservation and Fruit Tree Planting Project, Highlands Development Project and Zarqa River Basin Project and has accumulated substantial experiences in the soil and water conservation measures. The Highland Development Project renamed "Development of Highland Agricultural Regions" has been implemented since 1965 by the Ministry of Agriculture with technical and financial support from FAO through the World Food Programme (WFP). This project is the most informative for its long experiences on the soil and water conservation measures. The objectives were:

a) To control soil erosion;
b) To ensure better utilization of the limited water resources;
c) To stabilize agricultural output at higher levels; and
d) To bring about a shift in production from cereals to olive and other fruit trees in hilly areas with shallow soils.

The following practices were used by several of the soil conservation projects carried out in Jordan.

a) Earth Banks
b) Bench Terraces
c) Contour Stone Terraces
d) Stone and Reinforced Concrete Structures
e) Micro-Catchments
f) Check Dams

Detailed descriptions of the above structures were given in Chapter 1 of ANNEX-E.

(2) Water Harvesting

The following 5 measures have been adopted in the existing project.

i. Stone contour terraces (stone walls)

ii. Absorption earth banks (earth banks)
iii. Bench terraces
iv. Check dams

According to the farm survey by the present study team on farmer's intentions on soil conservation and water harvesting measures, the terraces were the choice of only 3% of the fruit farmers among several alternatives i.e. pond, contour furrows check dams, water tanks (like cistern), terraces, and stone walls, as shown in the following table.

Farmers' Choices of Soil/Water Conservation Measures

Measures		Farmers		
		Livestock	Cereal	Fruit Trees
No. of farmers answered		20	13	25
a. pond	(%)	50	40	14
b. contour furrows	(%)	0	0	6
c. check-dams	(%)	18	5	14
d. water tanks	(%)	29	30	47
e. terrace	(%)	0	5	3
f. stone walls	(%)	3	15	17
g. others	(%)	0	5	0

Source: Survey by the present study team

Terraces are no so supported by farmers due mainly their high costs. Water tanks are wanted by many farmers but can only be constructed with the help of existing government supports such as credits. Ponds cannot be recommended because there is not enough water to be stored and no suitable sites for them.

In conclusion the following measures are recommended to be adopted in the project.

- Stone walls
- Earth banks
- Tied contour furrows
- Microcatchments
- Check dams

The Highland Development Project has been developing suitable design criteria for water harvesting structures since 1965.

The following application criteria were made primarily based on the existing criteria applied in the Highland Development Project. Stone walls have been the typical soil and water conservation measures in Jordan since the Roman era and are very effective in retaining runoff in soils with low initial and maintenance costs. They are 60 cm to 100 cm high, about 50 cm wide and installed at 25 m to 100 m intervals. In areas with insufficient stones earth banks are applied in place of stone walls. Earth bank are about 50 cm high and about 50 cm wide. Microcatchments originated in North Africa and were improved in the Negev. They are diamond-shaped with a side of 5 m to 50 m long and planted with fruit trees etc. in the lowest point where runoff accumulates. Check dams have been utilized for crop production since before Christ being constructed in wadi bottoms with catchment areas of 100 ha to 500 ha. A check dam retains runoff water in the soils of the reservoir, in which crops are grown(Figs. 4.2 to 4.4).

Application Criteria

Slopes (%)	Soil Depth (cm)	Annual Rainfall (mm)	
		300-200	200-100
0-8	50-100	-	microcatchments (fodder shrub)
	100<	-	microcatchments (fruit trees)
8-12	50-100	stone wall/ contour furrows	stone wall/ contour furrows
		(field crops)	(fodder shrub)
	100<	stone wall/ earth banks (fruit trees)	stone wall/ contour furrows (fodder shrub)
12-30	50-100	stone wall/ contour furrows (barley, forage legume, shrub)	
	100<	stone wall/ earth bank (fruit trees)	

The guidelines for construction of the proposal facilities such as Contour Stone Walls (CSW), Absorption Earth Banks, Micro-Catchments and Check Dams, are given in Chapter 2 of ANNEX-E.

(3) Construction Costs for Water Harvesting

The details of the cost estimate are presented in Table 4.16. The followings is a summary of the cost estimates for the water harvesting scheme.

1) Contour stone wall (spacing 100 m) JD 131.6/ha
2) Contour stone wall (spacing 25 m) JD 506.3/ha
3) Absorption earth bank (spacing 100 m) JD 107.4/ha
4) Absorption earth bank (spacing 25 m) JD 384.9/ha
5) Microcatchments JD 55.9/ha
6) Check dam JD 3,120/site

4.6.2 Proposed Facilities for the Winter Irrigation Scheme

(1) Selected Weir Sites

For the winter irrigation scheme, the following weir sites were selected. Location map of each weir site is shown in Fig.1.3 to 1.6.

1) Wadi Laban (D-2) site with a catchment area of 34.8 km^2 is located on the Wadi Laban in Tafila about 700 m northern from the existing trunk road between Tafila and Jurf al Darawish.

2) Khashake (E-1) site with a catchment area of 9.5 km^2 is located on the Wadi Zabda in Tafila about 8 km northeast from the proposed D-2 weir site.

3) Karbat Shade (J-1) site with a catchment area of 16.7 km^2 is located on the Wadi Sallam in Al Qadisiyya.

4) Abyad site with a catchment area of 117 km^2 is located on the Wadi Mujib basin about 25 km southeast of Karak.

(2) Design of Facilities

1) Design Criteria

It was found that the four (4) weir sites of D-2, E-1, J-1 and Abyad were technically feasible in terms of annual runoff at the weir site.

The design of the facilities for the winter irrigation scheme are divided into the following 3 components:

a. Diversion weir

b. Intake
c. Irrigation canal

The study was based on surveyed topo maps at 1/500 scale, profiles and cross-sections at the storage area of the proposed weir sites.

The maximum flood discharge at the proposed weir sites was estimated by using the rainfall intensity, collected from Water Authority of Jordan (WAJ), and the rational formula for each weir site.

a) Diversion Weir

As for the type of weir, the following weirs are considered.

- Homogeneous earthfill
- Wet masonry
- Concrete gravity

Typical sections for the above 3 types of weir are shown in Fig.4.5.

Spillways with non-gated overflow weirs were adopted due for safety and ease of flood control, the normal water level (NWL El.) corresponding to the crest elevation of a spillway overflow weir.

In order to design the spillway of the weir. The maximum flood discharge of a 10-year return flood is adopted.

b) Intake

The intake facility is designed in a way to make the intake water depth at least 1 m below the NWL in order to make use of the meager runoff to the full extent.

Sand flush gates at intakse were adopted to prevent sedimentation in the reservoir.

c) Irrigation canal

The capacity of the canal is supposed to take the mean daily rainfall into account.

The supposed maximum discharge of water intake for the capacity of canal are as follows:

Weir Site	Water Intake
D-2	1.2 m^3/s
D-1	0.3
J-1	0.6
Abyad	4.1

2) Comparative Study

A comparative study was carried out by the following procedure at the each proposed weir site.

- To determine the intake water level corresponding to the normal water level (NWL E1.) based on the topo surveyed map and the relevant topo data.
- To select the three weir sites including their center lines on the topo survey maps based on the NWL as above mentioned.
- To decide the weir type such as earthfill, wet masonry and concrete gravity type.
- To estimate the construction cost include the irrigation canal by the preliminary design.
- To determine the weir site and type at the each weir site by the comparative construction costs.

a) D-2 weir site

This weir site will have an the intake water level elevation of E1. 1,194 m taking the topographic conditions into consideration. Weir sites were selected 150 m and 250 m upstream from the center line of the topo survey (See Fig.4.6).

b) E-1 weir site

The intake water level of E-1 weir site was determined as E1. 1020.5 m. The weir sites compared were on the center line of the topo survey and 25 m downstream, and designed only as wet masonry type due to the comparatively narrow space between the banks (see Fig.4.7).

c) J-1 weir site

The intake water level of J-1 weir site was adopted as E1. 1,394 m. The weir sites compared were 200 m and 300 m upstream from the center line of the topo survey (see Fig.4.8).

d) Abyad weir site

The intake water level of Abyad weir site was adopted as E1. 884 m. The weir sites were selected as 300 m and 500 m upstream from the center line of the topo survey (see Fig.4.9).

3) Facilities

As a result of the comparative studies, the principal features of the four weir sites for the winter irrigation scheme are as follows:

a) D-2 weir (see Figs.4.6 and 4.7)

- Catchment area;	34.8 km^2
- Frequent annual runoff (2-year return);	0.34 MCM
- Weir type;	wet masonry
- Crest level;	E1. 1,195.5 m
- Weir height;	4.5 m
- Weir length in total;	45.0 m
- Weir volume;	220 m^3
- Spillway type;	non-gated type
- Design flood;	42.8 m^3/s
- Overflow crest level (NWL)	E1. 1,194.0 m
- Overflow crest length	12.0 m
- Discharge of water intake	1.2 m^3/s

b) E-1 weir (See Figs.4.8 and 4.9)

- Catchment area;	9.6 km^2
- Frequent annual runoff (2-year return);	0.10 MCM
- Weir type;	wet masonry
- Crest level;	E1. 1,021.5 m

- Weir height; 4.0 m
- Weir length in total; 23.0 m
- Weir volume; 194 m^3
- Spillway type; non-gated type
- Design flood; 8.4 m^3/s
- Overflow crest level (NWL) El. 1,010.5 m
- Overflow crest length 10.0 m
- Discharge of water intake 0.3 m^3/s

c) J-1 weir (see Figs.4.10 and 4.11)

- Catchment area; 16.7 km^2
- Frequent annual runoff (2-year return); 0.15 MCM
- Weir type; Homogeneous earthfill type
- Crest level; El. 1,395.5 m
- Weir height; 2.5 m
- Weir length in total; 70.0 m
- Weir volume; 830 m^3
- Spillway type: non-gated and U-shaped type
- Design flood; 28.6 m^3
- Overflow crest level (NWL) El. 1,394.0 m
- Overflow crest length 19.0 m
- Discharge of water intake 0.6 m^3/s

d) Abyad weir (see Figs.4.12 and 4.13)

- Catchment area; 116.5 km^2
- Frequent annual runoff (2-year return); 0.9 MCM
- Weir type; wet masonry
- Crest level; El. 885.5 m
- Weir height; 4.3 m
- Weir length in total; 65.0 m
- Weir volume; 480 m^3
- Spillway type non-gated type
- Design flood; 112.6 m^3/s
- Overflow crest level (NWL) El. 884.0 m
- Overflow crest length 25.0 m
- Discharge of water intake 4.1 m^3/s

(4) Cost Estimate

Winter Irrigation Scheme

The costs of the construction work were estimated by work items. The estimated costs of each work item are the accumulated amount of all the necessary costs to perform each work at the each weir site. The work volumes of each work item were estimated basing on the design drawings.

In estimating the unit price of each work item, unit prices collected from the WAJ were adjusted updated to 1989 price level. The breakdown of the each weir site cost is shown in Table 4.16.

The annual operation and maintenance cost of the facilities of a weir site was calculated cost about JD 20.0 (4 man-day x JD 5.0/day) covering canal cleaning cost on the basis of 1989 prices.

4.7 Organization and Management Plan

4.7.1 General

The Agricultural Development Project for the Karak-Tafila Development Region consists of two schemes; one is the crop production by introducing water harvesting measures and the other is the fodder shrub production. It is proposed that these schemes be implemented by the private sector for crop production and by farmers' cooperatives or the Government for fodder shrub production, taking the following points into consideration.

1) Crop production scheme (field crops and tree crops)
   - Most of proposed area for the crop production is located in the private land.
   - The Government has encouraged the development by means of private sector.

2) Fodder shrub production scheme
   - The fodder shrub production area is located mainly on government land.
   - The main purpose of this scheme is to improve the living standards of the nomads, and the scheme will be implemented as a social project under conditions of non-profit.

4.7.2 Executing Agency

The Ministry of Agriculture (MOA) would be the executing agency of the Agricultural Development Project for the Karak-Tafila Development Region. In MOP, there is the Department of Projects under the Steering Committee (see Fig 2.1). The Project belongs in this department, and would be executed under the supervise of the Steering Committee. It will be proposed that MOP and WAJ related to the execution of the Project are included in this Steering Committee. In addition, it is recommended that a system of government subsidy for the development of water harvesting measures and check dam is established in MOA, because the repayment capability of these developments is lower than the other projects.

The crop production scheme would be executed through the agricultural extension system of MOA. Accordingly construction and management would be done directly by the private sector with technical assistance and guidance from MOA. As for the fodder shrub production scheme, there are several on-going projects which have been executed by MOA. This scheme would be executed in parallel with these on-going projects.

The MOA coordinates all activities of the relevant Government agencies and regional administrative organizations in connection with the project implementation. The agricultural offices in Amman, Karak and Tafila governorates under MOA have direct responsibility for project implementation.

4.7.3 Implementing Procedure

The executing agency will promote crop production by water harvesting measures, check dam and winter irrigation to the farmers in the priority areas, and already supplies the grazing yard to the livestock raising farmers in and around the priority areas. The overall implementing procedures of both schemes are presented in Figs. 4.14 and 4.15. The details are described hereinafter.

(1) Crop Production Scheme

1) Preparation of Design Criteria for Detailed Design and Construction

The researches and experiments for the water harvesting measures such as micro-catchments, contour furrows, earth banks, etc. will be continued by MOA during the implementation period of the Project. Based on these results and the design

criteria prepared in this feasibility study, MOA prepares more detailed design criteria for the detailed design and construction.

2) Extension and Construction

a) Advertisement and Recommendation

The extension offices in Amman, Karak and Tafila governorate will advertise the water harvesting scheme and will make recommendations to the farmers through their extension activities.

b) Screening, Field Reconnaissance and Technical Evaluation

The farmers who will request the scheme will be screened by the extension officers. The fields located in the proposed area will be selected for inclusion in the scheme, and in the case of land held by a group (family), their approval will be checked.

The extension agents will make a reconnaissance survey of the fields requested by the farmers. The main investigation points are i) area ii) slope, iii) soil depth, iv) soil texture and v) availability of materials (stone). On the basis of these results, the extension agents will evaluate the technical possibility of water harvesting, and propose optimum water harvesting measures to the farmers.

c) Design and Farming Plan

With reference to the design criteria, the extension offices will design the structures for water harvesting and will make a proposed farming plan. Then, economic evaluation will be done by the extension offices in order to clear the financial feasibility of the proposed scheme. If this scheme is financially marginal, the government subsidy to the farmers is arranged by the extension office.

d) Farmers' Review and Construction

The extension offices will submit the results of design, farming plan and economic evaluation to the farmers. The farmers will review these results and make final decision for implementation of water harvesting. The construction cost will be

born by the farmers themselves. The construction will be done directly by the farmers or contractor under the technical assistance from the extension offices.

3) Farm Management

After completion of construction, farm management will be immediately conducted by the farmers. In order to improve farming practices and solve the technical problems which will occur during the management stage, the extension office will make monitoring surveys of the water harvesting farmers.

(2) Fodder Shrub Production Scheme

The construction and management of the fodder shrub production scheme are done directly by the Government, and the agricultural offices in Amman, Karak and Tafila Governorates have its direct responsibility under the technical and administrative assistance from the Head Office.

As shown in Fig. 4.15, the operation plan for grazing is prepared by the agricultural office, which includes the annual grazing head, grazing area per one farmer, grazing period, grazing rotation, etc. The Office make contracts with the farmers under the provisions of the plan. The contract will be renewed at about five-year intervals. Then the operation plan is revised and all contract farmers will be re-screened.

4.7.4 Agricultural Support Services

For successful implementation of the schemes, especially of the crop production scheme by the introduction of water harvesting measures, it will be necessary to improve and strengthen the organizational structures of agricultural supporting services and their functions. The main improvements and strengthening points are described hereinafter.

(1) Research and Extension Work

Prior to the implementation of the project, the following improvements will be required to the agencies concerned.

a) Strengthening of research and experimental works for water harvesting measures, which have been carried out by MOA and Jordan University.

b) Increase in the extension agents and training of staff related to the project implementation.

(2) Farm Machinery Services

After the implementation of the project, the mechanical power requirement will increase with expansion of the crop area. It is therefore proposed to strengthen the farm machinery services of the private sector or JCO organization.

(3) Agricultural Credits

A considerable amount of initial investment will be necessary for implementation of the scheme. This investment cost will be covered by credits, because the farmers have no investment capacity. It is expected that the agencies will offer some soft loans at lower interest rates with long repayment and grace periods, because the repayment capability of water harvesting project is lower than other projects.

At present, credit institutions have a big problem with agricultural credit, which is the low repayment of loans, as mentioned in 2.4.2. To solve this problem, the following improvement and strengthening activities are proposed to the credit institutions.

- to establish mobile bank services for collecting repayment money,
- to supervise the defaulters for improving their repayment condition, and
- to make promoting campaign for loan repayment.

4.7.5 Implementation Schedule

(1) Crop Production Scheme

In implementation of the water harvesting project which will be invested by the private sector, careful consideration must be paid not only to technical viability but also to financial feasibility. In general, the farmers in the priority areas have little capacity to pay for loans, while considerable amounts of loans will be required for the farmers to implement the scheme. According to the financial analysis, it seems that the development by check dam and water harvesting measures such as micro-catchment and stone walls (fruits cultivation) will inevitably be financially marginal. This means that the farmers will face some financial risk in undertaking these.

Accordingly, phased implementation is recommended for the Project with implementation divided into the following three stages:

Phase-I (5 Years):

1) Trial farming in the actual field, and continuation of existing research and experimental works for water harvesting measures.
2) Extension of the tentative water harvesting measures to the existing fields.
3) Training of extension agents related to the scheme.
4) Improvement and strengthening of agricultural supporting services.
5) Preparation of design criteria for detailed design and construction
6) Implementation of winter irrigation
7) Preparation of extension schedule.

Phase-II (5 Years):

1) Development in the potential areas with over 200 mm of annual rainfall.
2) Continuation of research and experimental works for further improvement of water harvesting measures.

Phase-III (5 Years):

1) Development in the area with below 200 mm of annual rainfall.

Overall implementation schedule is presented in Fig. 4.16. In the Phase-I stage, MOA makes researches and trial farming on the water harvesting measures. In parallel with these trial farming and researches, it is proposed that the tentative water harvesting measures are implemented to the existing fields, which construct the small stone walls or ditches for collecting rainfall water around the tree crops or fodder shrubs. The effects of water harvesting and more practical information will be collected and confirmed through these tentative measures.

The development priority would be given to the development areas with over 200 mm of annual rainfall. After confirmation of the development effects which are implemented in the Phase-II, the Phase-III stage is conducted in the areas with below 200 mm of annual rainfall.

Total development period was assumed to take 15 years including 5 years of the Phase-I stage. The annual development area was estimated at 670 ha/year for the Phase-II stage and 1,090 ha/year for the Phase-III stage, as shown in Table 4.17.

(2) Fodder Shrub Production Scheme

The fodder shrub development scheme would be implemented carefully as well as the crop production scheme. At present, MOA and JCO have been implementing the fodder shrub projects in and around the study area, however these are still in the trial stage. Considering such situations, it is proposed to implement the scheme in stages:

Phase-I Stage (5 Years):

- Trial grazing in the existing project areas.
- Detailed design and preparation of operation and management plan.

Phase-II Stage (10 Years):

- Construction and management.

In the Phase-I stage, all preparatory works required for implementation of the project would be done by MOA. The farming practices such as optimum grazing period, maximum grazing density, planting density of fodder shrub, grazing interval and grazing season will be confirmed through the experiment and trial grazing in the existing projects.

The total development period was assumed at 15 years as with the crop production scheme. The annual development area during the Phase-II stage was estimated at about 450 ha (see Table 4.17).

CHAPTER 5 PROJECT EVALUATION

5.1 General

The objective of the project evaluation is to assess the economic and financial feasibility of the Project. For the economic evaluation, two measures of project worth, namely, economic internal rate of return (EIRR) and benefit-cost ratio (B/C) were examined. The financial evaluation was made by analyzing cash flow statement and profit and loss statement. The indirect benefits and socio-economic impacts were also studied briefly.

5.2 Economic Evaluation

5.2.1 Economic Benefits

The economic benefits of the Project would consist of only crop production. In general, the economic benefit is defined as the difference of the net return between the future with and the future without project conditions. In the Project area, no net return under the future without project condition would be estimated, because crop cultivation without water harvesting measures and check dam and winter irrigation methods is so limited. Therefore, the economic benefit would accrue from the total net return under the future with project condition.

The total net return by each project component under the full production stage is summarized as below.

(Unit: JD 1,000)

Scheme	Year 20th	21st	22nd/2
Crop Production Scheme	982.1	974.7	962.9
1) Water Harvesting Measures	717.1	731.8	746.8
2) Mechanized Farming/1	(58.3)	(58.3)	(58.3)
3) Check Dam	230.3	208.2	181.4
4) Winter Irrigation	34.7	34.7	34.7
Fodder Shrub Production Scheme			
1) Water Harvesting Measures	51.3	51.3	1.3
Whole Project	1,033.4	1,026.0	1,014.2

Note: /1 Mechanized farming was excluded from the evaluation because of no investment.
/2 1st year = Initial year of Phase-I

5.2.2 Economic Costs

The economic costs would consist of initial investment cost and O&M cost, and these economic costs can be obtained by applying the standard conversion factors (SCF) to the financial costs (excluding import, export and service taxes). SCF used to convert financial into economic costs was estimated at 1.0, because most of farm machinery and construction equipment are tax free. The total economic costs are summarized below.

(Unit: JD1,000)

Scheme	Economic Cost
Crop Production Scheme	2,608.3
1) Water Harvesting Measures	1,438.6
2) Check Dam	970.3
3) Winter Irrigation	199.4
Fodder Shrub Production Scheme	385.2

The implementing period of the water harvesting measures and fodder shrub production scheme is estimated at 10 years. As for the winter irrigation scheme, almost all of the costs for construction would be invested within one year. Therefore, it is assumed that all economic costs would occur in the 4th year in the Phase-I stage. The check dam development would be implemented during the period of 5 years in the Phase-II stage.

5.2.3 EIRR and B/C

In order to compute the EIRR and B/C, the annual economic costs and benefits flow were firstly prepared as shown in Table 5.1 to 5.3. From these tables, the EIRR and B/C were estimated as follows.

Scheme	EIRR (%)	B/C
Crop Production Scheme	20.2	2.45
1) Water Harvesting Measures	36.6	3.98
2) Check Dam	7.3	0.70
3) Winter Irrigation	13.1	1.41
Fodder Shrub Production Scheme	-1.4	-2.50

The highest EIRR was 36.6% of the water harvesting development and -1.4% of fodder shrub production scheme for the lowest. EIRR of the check dam development was modest. These results indicate that the developments for water harvesting and winter irrigation would be economically viable. It is proposed that these two developments are implemented in the project area.

As for the check dam development and fodder shrub production scheme, it is recommended that they would also be implemented in the project area which belongs the semi-arid zone, though they do not prove high economic viability of the project.

In Jordan, a semi-arid country, water is so precious that the surface water resources in the country have to be used thoroughly. For the fullest use of scarce water, such schemes would have a big significance to Jordan situated in the semi-arid zone. In addition, the fodder shrub development would be expected to contribute to the stabilization of nomads' living standard. The livestock raising of the nomads in and around the project area is an important income source in their livelihood. One of the problems of their livestock raising is the grazing. Namely, the grazing of livestock have been carried out mainly in the dry land with below 300 mm of annual rainfall, and the availability of pasture is very limited and unstable. After completion of the fodder shrub production scheme, a grazing area of 4,480 ha would be provided stably to the nomads, thereby it is expected to increase their income from livestock raising and to secure a sure means of their living.

5.3 Financial Evaluation

5.3.1 Cash Flow Analysis

In order to analyze the repayment capability of the project, the cash flow statements of each project component were prepared as shown in Table 5.4 to 5.7.

The farm management of crop production scheme was done by private sector. In the analysis of repayment capability, farm size of each development measure were assumed as follows:

1) Water Harvesting: 10 ha (100 dunum)
2) Check Dam: 0.3 ha (area of one site)
3) Winter Irrigation (fruits and irrigated wheat): 33.9 ha
   - Site: J1 3.4 ha
   - Site: D2 7.7 ha
   - Site: E1 2.3 ha
   - Site: Abyad 20.5 ha

As for the fodder shrub production, all area which was estimated at 4,480 ha would be managed by the Government. But in this study, its size was assumed at 10 ha (100 dunum), in order to make cooperative study with the crop production scheme.

In addition, it is assumed that all initial investment costs and running costs would be generated by the investor from the private markets or the Government agencies (ACC and JCO). In case of the fodder shrub production scheme to be implemented by the Government, initial investment costs including construction, seedling, hired labour, etc. would be invested from the government budget under the condition of no interest and no repayment. The loan conditions assumed comprehensively would be as follows:

Interest:	8%/year
Repayment period:	6 years
Grace period:	1 years

As a result of analysis, the farm managements for micro-catchment and stone walls (fruits) have a difficulty for loan repayment because of a poor income in their cash flow. In order to promote these schemes in the project area, it is necessary that initial investment costs for facilities and fence are subsidized by the Government. The cash flow statement with the government subsidy is presented in Table 5.12.

5.3.2 Profit and Loss Analysis

Based on the cash flow statement as described above, the profit and loss statement of each scheme was prepared as shown in Table 5.8 to 5.11. An annual surplus of micro-catchment and stone walls (fruits) would accrue from the 12th year from the start of operation (after the planting), but debt would continue until 14th year. In case of check dam and winter irrigation, an annual surplus would accrue from 5th to 6th year, and debt would turn to surplus in the 9th to 11th year. The farm management by stone walls (fruits + field crops) and winter irrigation has a good balance.

As the results of profit and loss analysis, the farm management by winter irrigation has the highest profitability in the Project, followed by the stone walls (field crops + fruits). These two development measures are financially feasible. The other project components are financially marginal, but it is recommended that they are implemented in the project area. From the stand point of the fullest use of the scarce water, the implementation of such projects will has a big significance on the national needs, as mentioned earlier.

In addition to the above analysis, the profit and loss statement with the Government subsidy are prepared as shown in Table 5.13. If the initial investment costs for facilities and fence are subsidized by the Government, the farm managements of the crop production schemes will improve drastically.

5.4 Indirect Benefits and Social Impacts

Various indirect benefits and socio-economic impacts are expected from the implementation of the project. They are summarized as follows.

(1) Fruits Supply

The project area would produce a substantial quantities of fruit crops which are estimated at 400 tons of olives (green), 870 tons of grapes and 570 tons of apricots. Since demand for these crops in the country will continue to increase with population growth, the project area will have to be a fruits supply base to the country.

(2) Employment Opportunity

The project would increase the employment opportunities in Amman, Karak and Tafila governorates. The labor requirement for farm management was estimated to be 17,800 man-days/year, and the farmers would employ these laborers in the three governorates. Furthermore, about JD 71,200 of labor wages would annually flow in this region.

(3) Marketing of Farm Inputs and Outputs

Further marketing in the area is likely expand as compared with the present condition. With anticipated agricultural production, more farm inputs and outputs could be marketed by the farmers and the proportion of sales would also increase relative to consumption. The agricultural cooperatives and merchants would have a large turnover which could increase their income.

(4) Contribution to National Economy

With completion of the project, the production of wheat, olives and grapes would reduce the annual amount of those imported crops. If the import of these crops continues in future, the saving of annual foreign exchange would amounts to JD 762,000.

(5) Ecological Improvement

Soil degradation such as soil erosion by strong wind and rainfall will be mitigated by the project through stone walls, check dams, afforestation, microcatchments etc. This is very important for the sustained development.

CHAPTER 6 RECOMMENDATIONS

(1) Early Implementation of the Schemes

The schemes except the fodder shrub development were verified herewith to be technical sound financially feasible. It is highly recommended that the necessary arrangements for early implementation of the schemes be taken as soon as possible.

(2) Strengthening of Trials on the Water Harvesting Techniques

There have been a few experiments in water harvesting in Jordan, though, more information is required on the following subjects as the result of experiments.

- Crop suitability especially regarding drought resistance and water logging resistance,
- Hydrological characteristics of small basins such as runoff coefficients and hydrograph,
- Soil water balance(crop water requirements, percolation, evapotranspiration, water holding capacity etc.)
- Groundwater recharging effects of the water harvesting and possibility of the recycle of recharged water by pump.
- Possibility of the combination of pitcher irrigation with water harvesting.

Existing information on the water harvesting should be utilized to fullest extent by the concerned people. Exchange and sharing of the existing information on water harvesting in Jordan is very limited. Seminars and a society for the development of water harvesting should be organized. Study tours of relevant persons to existing experiments and schemes in Jordan might be an effective means for extension of the information. Financial supports should only be given to experiments which have an obligation to publish experimental results within a reasonable period.