4.4.2. Selection of New Extension Farm Land Area

The following two farm land areas in the downstream of the Wadi Jizzi basin have been proposed for agricultural development as mentioned in Paragraph 3.7.1. The Site-1 is an area adjacent to the Oman Sun Farm and Site-2 is an area located on the right bank of the Wadi Suq near Amq. Of these two, Site-1 has been selected for the proposed extension farm land, (see Figure 4-5), taking into account the following;

i) Site-1 is topographically very flat as compared with Site-2, and it is considered that the construction of farm at Site-1 is easier than at Site-2.

ii) Groundwater potential at Site-2 is expected to be less than that of the Site-1 because impervious formations upheave closely by to the ground surface.

iii) Site-2 is located on the area close to Majis where the port facilities for shipment of copper products are under construction. It is considered that the area will be affected by industrialization under the mining project.

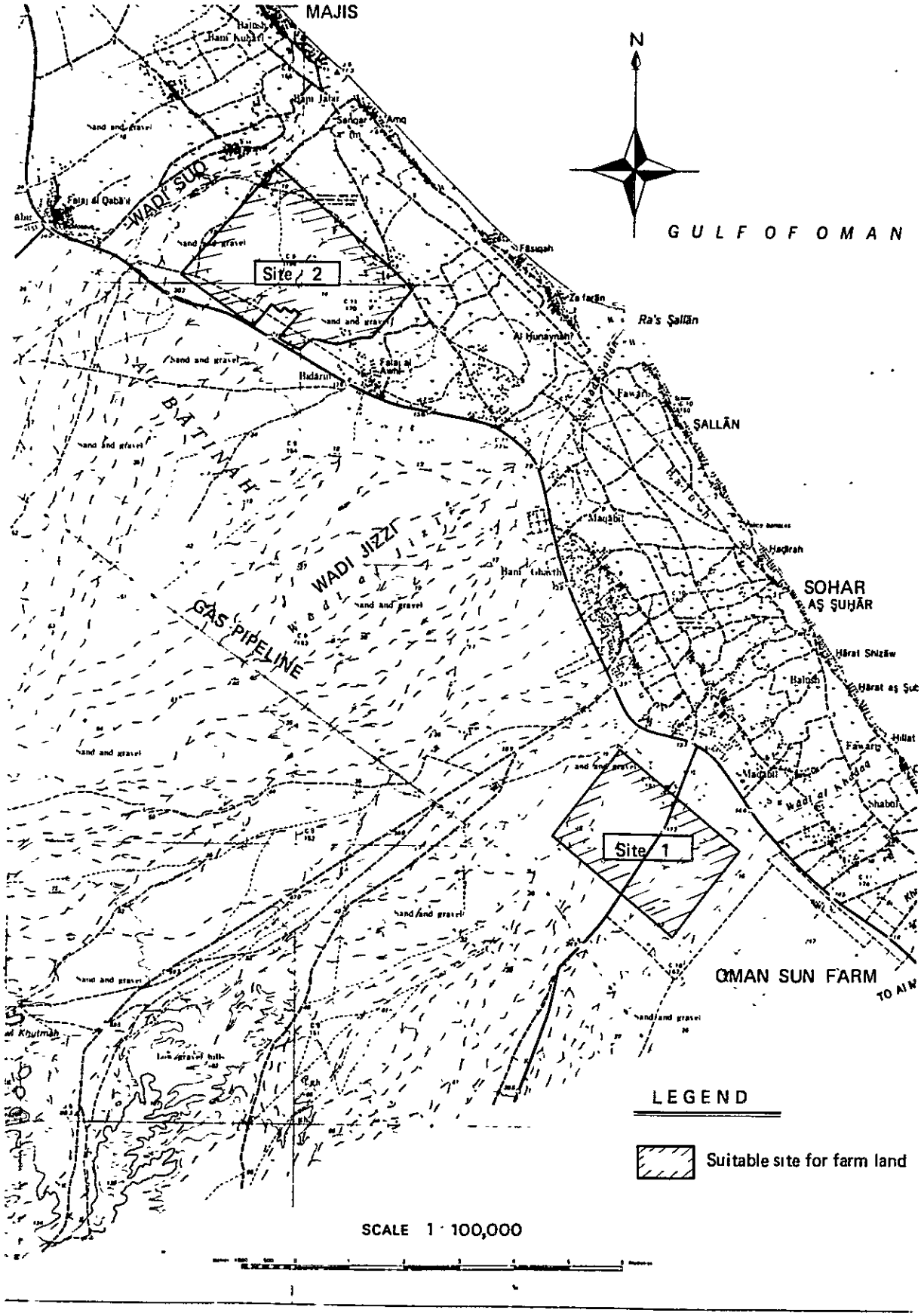
iv) The soil at both of the farm land sites lacks organic matters which are indispensable for agriculture. Being adjacent to the Oman Sun Farm, Site-1 is very conveniently located to obtain such organic matters.

4.5. Agricultural Development Plan

4.5.1. Alternative Study on Farm Organization

The main strategy for agricultural development in the Project is as follows:

FIGURE 4-5 LOCATION OF SUITABLE SITE FOR FARM LAND



- to augment agricultural production through cultivation of additional land;

- to construct a modern farm with the irrigation system aiming at the effective use of limited water resources for the largest area possible;

- to encourage farmers to practise the timely production and marketing to meet the requirements of consumers; and,

- to increase the number of successful private farmers through the allocation of the optimum scale of new lands.

Alternative study on farm organization was carried out on the following five items.

The first is the farming type. Three alternative farming types are considered for the management of the new extension farm of 100 ha; the family farm, big commercial farm, and government farm.

In Wilaya Sohar, a production farm is already under the control of the Sohar Extension Center. Also the Royal Farm has been successfully operated. It will be not desirable to establish more governmental farms in Wilaya Sohar.

The Oman Sun Farm located adjacent to the proposed farm land in the Project is the most famous and largest commercial dairy farm in the country with feed grass lands of 400 ha cultivated for raising about 150 head of cattle. A dairy farming commonly requires a large size of lands and water resources for its successful operation and management.

This farm once had a plan to expand its land area into the Project Area, and if such an expansion plan had been realized, the water sources for the dairy farming could not be sufficiently secured

as illustrated in this report. The Project under discussion will supply the irrigation water available only for about 85 ha of the farm lands and not be able to meet the water requirements by the large-scaled daily farming with a wide land area for raising cattle.

Investment in the Project must be meant to raise the income of inhabitants in Wilaya Sohar and to promote the welfare of people. Consequently, the family farm is proposed to be created.

The second study item is the farm size to be allotted. The optimum farm size should be determined for successful operation and management of the farms. The current farm income from the typical land of 1.24 ha was estimated at 1,070 R.O. as detailed in Paragraph 3.6.7, Farm Economy, and the said value was employed in the alternative study of the farm economy by farm size. The study was made on the assumption that a family consists of seven members and that the living cost required, cropping pattern, productivity per hectare, and production cost per hectare all take the same values for each alternative study. The optimum land area per family is proposed to be five hectares (12 Feddans) in terms of the Omani family labor availabe, living cost to be incurred in future, and repayment capacity for the credit loaned by the Bank for Agriculture and Fisheries.

The third item is the selection policy of the new settlers, who should be chosen along with the Government's policy. However, the first priority for settlement should be given to local farmers in Sohar.

The fourth item is the marketing type. The three types of marketing are taken into consideration; individual marketing, marketing through networks provided by the Agricultural Marketing Corporation, and marketing through the agricultural cooperative movement.

The individual marketing refers to the present method where each farmer forwards the farm products to the markets by his own truck. The second type, as described in Paragraph 3.6.8, refers to the networks being planned by the Corporation under the control of the Public Authority for Marketing Agriculture Produce, and in future this network will be used by the new settlers in this Project. The third type is an cooperative marketing method by which small farmers replace middlemen and can gain profits. This activity requires an investment in the marketing facilities to be managed by the Cooperative. As mentioned in Paragraph 3.6.8, the credit regulation for the agricultural cooperative has not been enforced yet. In this report, the second type would be considered. The marketing of produce from the twenty farmers projected would be taken care by the Public Authority for Marketing Agriculture Produce.

The fifth is the alternative study on the layout of the proposed farm houses and storages. Two ideas are taken up; one is that each building shall be located in their farm yard, and the other is that buildings are gathered at one place. In terms of the living infrastructures and communication facilities, the study recommends the latter idea as more suitable plan.

This plan, however, will raise two problems. One is the fair allotment of new farm lands to each farmer in considering the distance from his residence to the farm land; the farthest farm plot will be located about 1.2 km distant from the proposed housing lots. One of the fair methods will be to place some differences in the government's selling prices of the lands in consideration of such difference in distances, etc.

The other problem is the ownership of the allotted lands. One farm size to be allotted is five hectare, of which 4.25 ha is the arable land, 0.1 ha is the house lot, and the remainder of 0.65 ha is used for road and canal. The arable lands and housing lots are for the private use, while the remainder for the public use. Though the legal matters and practices on land ownership for the in Oman are not

a subject in this study, the site of road and canal will be considered to be the common holdings.

4.5.2. Agricultural Production

a) Proposed Land Use

The proposed new extension farm provides 100 ha of the total lands consisting of 85 ha for the farm lands and 15 ha for residential lots, roads, windbreakes, and farm ponds, etc. The proposed 85 ha farm lands include 50 ha for orchards, 15 ha for upland fields, and 20 ha for feed crop fields. One housing lot will be 0.1 ha and 20 houses will be constructed in the Area. The main road in the Area will be constructed with width of 5.0 m, and the farm roads with width of 4.0 m. Each farm block will face these farm roads at least on one side of the lot. The windbreakes will be provided in the Project Area at an interval of 200 m and the circumference of the respective farms will be totally surrounded by the wind-breakes with 5.0 m width. The pipeline networks will convey the water from the farm ponds to each farming lot. The farmers will be given the farm land of 4.25 ha each, which includes 2.5 ha for orchards, 0.75 ha for upland fields (0.25 ha by three plots), and 1.0 ha for feed crop field.

b) Proposed Crops and Cropping Pattern

The proposed crops for the Project are three tree-crops of date palms, limes and bananas, and five vegetables of tomatoes, cabbages, watermelons, eggplants and red peppers, and one feed crop of alfalfa. All of these crops are of commercial values and have long been grown in the Project Area with considerably stable yields.

The farm lands of 4.25 ha will be allocated to one farm household in the Project, of which 1.0 ha for dates palm trees, 1.0

ha for limes, 0.5 ha for bananas, 1.0 ha for alfalfa and 1.35 for vegetables.

Vegetables are grown in the inter cropping system in 0.3 ha of the date palm and lime orchards as well as mainly grown in the upland fields of 0.75 ha. Commonly, the vegetables are grown in a single winter cropping a year except for watermelons which have been grown in both the winter and summer seasons. The five-year rotational cropping system in principle will be employed for the vegetable growing in the Area as illustrated in the following table. The renewal of alfalfa will be made in the Project at the interval of five to eight years.

The crop-wise cropping acreages are shown in the following table, and the cropping intensity was estimated at 120 percent.

For expediting the cost recovery, the inter cropping acreages in the date plam and lime orchards shall be taken in each 0.6 ha for five years until the date plams start to be harvested (refer to Table H-17 to H-21, in Appendix H).

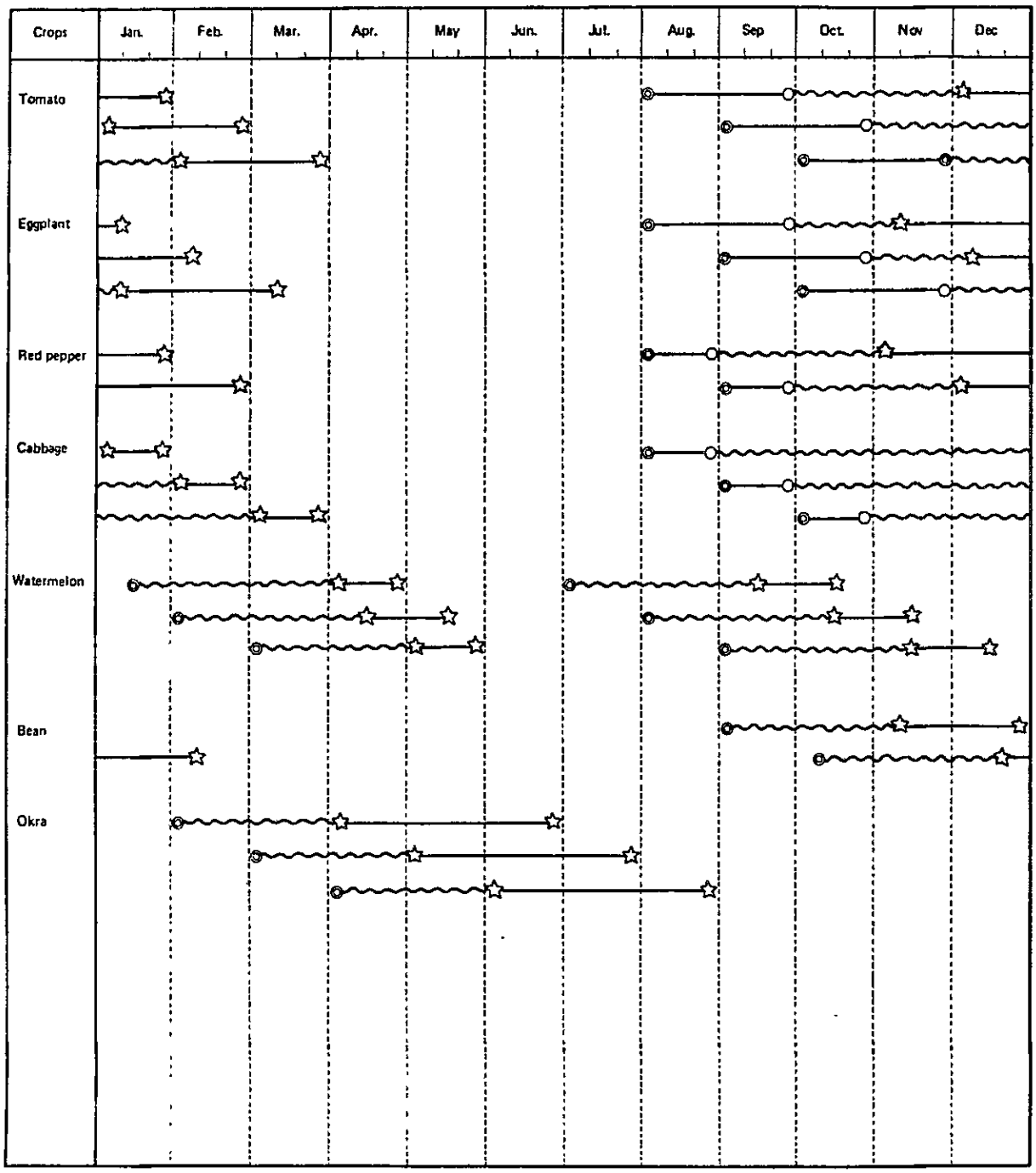
5-Year Rotation

Item	Area (ha)	1st year	2nd year	3rd year	4th year	5th year
Vegetable	0.25	To(WM)	Ca	WM	Eg	Re
Field	0.25	Ca	WM	Eg	Re	To(WM)
	0.25	WM	Eg	Re	To (WM)	Ca
Dates	0.30	Eg	Re	To(WM)	Ca	WM
Lime	0.30	Re	To(WM)	Ca	WM	Eg

To.... Tomato WM.... Watermelon Ca .... Cabbage

Eg.... Eggplant Re.... Redpepper ( ) .... Summer crop

FIGURE 4-6 PROPOSED CROPPING PATTERN



Note Details are given in Table H - 1, Appendix H - 1

Area by Crops

Tree-crops (ha)		Vegetables (ha)		Feed Crops (ha)	
Dates	20	Tomatoes	5	Alfalfa	20
Limes	20	Winter Watermelon	5	Sub-total	20
Bananas	10	Summer Watermelon	5		
Sub-total	50	Cabbages	5		
		Eggplants	6		
		Redpeppers	6		
		Sub-total	32	Grand Total	102 ha

The vegetables will be cropped in staggering with early-matured varieties, mid-matured varieties, and late-matured varieties so as to ease the demand peak labor and provide a high marketability of these farm products. Figure 4-6 illustrates the proposed cropping pattern for the Project.

Beans and okras are added in the cropping calendar to the representative five vegetables for references.

c) Agricultural Inputs

The successful achievement of the target yields will inevitably requires the timely application of the following agricultural inputs according to the Standard of Cultivation (see Table 3-16). The total requirements of the respective items are shown below.

Items	Quantity Required	Remarks
Organic Fertilizers	1,380 ton	
Compound Fertilizers	73.2 ton	
Seeds	787 kg	
Seedlings	23,860 p'ces	First year only
Agri-chemicals	2,031 kg	
Supporting Rods	41,000 p'ces	First year only
Pots	240,000 p'ces	"
Gasoline for fuel	11,580 littles	
Light oil	206 littles	

Note: Details are described in Table 4-4 and 4-5.

d) Agricultural Production

The crop-wise target yields were estimated based on the results of the consultative discussion with the Ministry of Agriculture and Fisheries and the Agricultural Experimental Farms concerned because there have been no statistics available on the agricultural production in the country.

The gestation period required for achieving the target yields of the respective crops was estimated at 11 years for dates and limes, and three years for bananas and vegetables (see Table 4-6).

Since the date production in the coastal area will be able to keep the current level or higher with the protection of the sea water intrusion after construction of the proposed dam, the benefits to be created therefore have been adopted (refer to Appendix H-4).

Table 4-4 Agricultural Input Material

Crops	Area (ha)	Manure (t)	Fertilizer (t)	Seed (kg)	Dimethoate (ℓ)	Diathane (kg)	Kafil (ℓ)	Pirimor (ℓ)	Omit (ℓ)
Tomato	5	75	3.6	3	6	45	10	-	-
Watermelon (Winter S.)	5	75	3.6	18	-	-	-	-	-
Watermelon (Summer S.)	5	75	3.6	18	-	-	-	7	10
Cabbage	5	75	2.4	18	-	-	15	4	-
Eggplant	6	90	4.32	5	24	-	12	-	-
Redpepper	6	90	4.32	5	24	-	-	-	-
Dates	20	300	14.4	(2,960) unit[1/]	-	-	-	-	-
Lime	20	300	14.4	(4,900) unit	144	-	-	-	-
Banana	10	-	13.0	(16,000) unit	-	-	-	-	-
Alfalfa[2/]	20	300	9.52	720 kg	576	-	-	-	-
Sub-total[3/]	102	1,380	73.16	-	774	45	37	11	10
Cauliflower	6	90	2.9	11	-	-	18	5	-
Onion	6	90	3.0	60	-	-	-	-	-
Sub-total	12	180	5.9	-	-	-	18	5	-
Total[4/]	114	1,560	79.06	-	774	45	55	16	10

Note: 1/ Only fast year 2/ Lift time 6 years 3/ At full development stage
4/ Pre-full development stage (for 5 years)

Table 4-5 Agricultural Input Material

Crops	Area	Furadan (kg)	Nogos (ℓ)	Nemacur (kg)	Pot (unit)	Support (unit)	Gasoline (ℓ)	Light Oil (ℓ)
Tomato	5	-	-	-	111,000	21,000	35,542	380
Watermelon (Winter S.)	5	-	-	-	-	-	11,180	130
Watermelon (Summer S.)	5	-	-	-	-	-	14,053	123
Cabbage	5	-	-	-	-	-	21,600	221
Eggplant	6	-	-	-	129,000	20,000	30,566	405
Redpepper	6	-	-	-	-	-	16,552	257
Dates	20	-	74	-	-	-	53,040	129
Lime	20	-	-	-	-	-	72,852	-
Banana	10	400	-	680	-	-	88,946	-
Alfalfa	20	-	-	-	-	-	125,415	-
Sub-total[1/]	102	400	74	680	240,000	41,000	469,746	1,645
Cauliflower	6	-	-	-	-	-	25,920	265
Onion	6	-	-	-	-	-	30,566	405
Sub-total	12	-	-	-	-	-	56,486	670
Total[2/]	114	400	74	680	240,000	41,000	526,232	2,315

Note: 1/ At full development stage 2/ Pre-full development stage (for 5 years)

Table 4-6 Crop Production

Crops	Area (ha)	Yield	1st Year	2nd Year	3rd Year	3 - 5 Year	6 - 10 Year	11 - 20 Year	21 - Year
Dates	20	t/ha	0	0	0	0	4	6	6
		p.t[1/]	0	0	0	0	80	120	120
Lime	20	t/ha	0	0	0	4	10	20	20
		p.t	0	0	0	80	200	400	400
Banana	10	t/ha	0	10	13	13	13	-	-
		p.t	0	100	130	130	130	-	-
Tomato	5	t/ha	20	30	40	40	40	40	40
		p.t	100	150	200	200	200	200	200
Cabbage	5	t/ha	13	19	25	25	25	25	25
		p.t	65	95	125	125	125	125	125
W.Watermelon	5	t/ha	8	12	15	15	15	15	15
		p.t	40	60	75	75	75	75	75
S.Watermelon	5	t/ha	5	8	10	10	10	10	10
		p.t	25	40	50	50	50	50	50
Eggplant	6	t/ha	13	19	25	25	25	25	25
		p.t	78	114	150	150	150	150	150
Redpepper	6	t/ha	8	12	15	15	15	15	15
		p.t	48	72	90	90	90	90	90
Alfalfa	20	t/ha	30	45	60	60	60	-	-
		p.t	600	900	1,200	1,200	1,200	-	-
Cauliflower	6	t/ha	10	15	18	18	-	-	-
		p.t	60	90	108	108	-	-	-
Onion	6	t/ha	8	12	15	15	-	-	-
		p.t	48	72	90	90	-	-	-

Note: 1/ p.t; Production (ton)

Crop-wise Production and Production Value

Crops	Target Yield (t/ha)	Production (t)	Production Value ('000 R.O.)
Dates	6.0	120.0	60.0
Limes	20.0	400.0	240.0
Bananas	25.0	250.0	37.5
Tomatos	40.0	200.0	40.0
Cabbages	25.0	125.0	31.3
Watermelons (Winter)	15.0	75.0	15.0
Watermelons (Summer)	10.0	50.0	10.0
Eggplants	25.0	150.0	15.0
Redpeppers	15.0	90.0	22.5
Alfalfas	60.0	1,200.0	84.0
Total			555.3

4.5.3. Irrigation

a) Irrigation Water Requirements

1) Potential Evapo-transpiration

The reference crop potential evapo-transpiration (ETPc), which is generally recognized as fairly reliable index for calculating consumptive use, can be determined by a number of methods, such as the evaporation measurement with evaporation pan and the application of empirical formula based on the climatological data. In the Project, the monthly evapo-transpiration was estimated on the monthly basis, by applying the both methods of modified Penman method and modified Blaney-Cridle method, based on the climatological data observed at Sohar and Rustaq meteorological stations, and the arithmetic mean of the both estimated values are adopted as the ETPc in the Project as shown below:

Potential Evapo-transpiration (ETPc)

(Unit: mm/month)

Month	Penman Method	B - C Method	Average
Jan.	74.4	97.0	85.7
Feb.	89.6	98.7	94.2
Mar.	120.9	138.6	130.0
Apr.	147.0	179.7	163.4
May	176.7	242.1	209.4
Jun.	189.0	260.0	224.5
Jul.	186.0	267.4	226.7
Aug.	170.5	243.8	207.2
Sep.	153.0	197.4	175.2
Oct.	127.1	171.9	149.5
Nov.	81.0	124.0	102.5
Dec.	74.4	110.3	92.4
Total	1,589.6	2,130.9	1,860.7

Note: Detailed estimates of the above ETPc values are given in Appendix G-3.

2) Crop Water Supply Requirements

(a) Crop Evapo-transpiration

Crop evapo-transpiration (ETc) (consumptive use of crops) of each crop[1/] has been estimated by multiplying the estimated ETPc values by crop coefficients which express the relationship between the reference crop potential and the actual evapo-transpiration during the vegetative stage of the crops. The crop evapo-transpiration (ETc) of each crop was estimated based upon the above procedures and is shown in Tables G-24 to G-31 in Appendix G-4.

(b) Water Supply Requirements

For the estimation of water supply requirement for each crop, the following equation has been applied:

$$V = \frac{10}{EP} \left[\frac{A\ (ETc - RE)}{1 - LR} \right]$$

where;
- A : area (ha)
- ETc : crop evapo-transpiration (mm)
- RE : effective rainfall (mm)
- EP : project irrigation efficiency
- LR : leaching requirement

In the estimation, effective rainfall, irrigation efficiency, and leaching requirements have been accounted, based upon the following bases.

Effective Rainfall

The effective rainfall for crops was estimated on the monthly basis by applying the FAO criteria[2/].

Project Irrigation Efficiency

The following two types of irrigation efficiency were adopted in the Project in accordance with the two irrigation methods of drip and sprinkler irrigation. The details are discussed in the subsequent paragraph.

1/: Proposed cropping pattern in irrigation unit (net irrigation area of 4.25 ha) is given in Figure G-3, in Appendix G-4.

2/: FAO Irrigation and Drainage Paper, NO 24, Table 34 "Average Monthly Effective Rainfall as Related to Average Monthly ETPc and Mean Monthly Rainfall" (see Tables G-22 and G-23 and Figure G-4 in Appendix G-4).

	Drip Irrigation	Sprinkler Irrigation
Conveyance efficiency	0.95	0.95
Farm application efficiency	0.85	0.70
Project irrigation efficiency	0.81	0.67

Leaching Requirements

As mentioned in the previous paragraph of Water Quality, the groundwater in the Wadi Jizzi Plain, which is the water sources of irrigation for the Project, has been found to need some countermeasure for salinity control such as leaching. The leaching requirements are the minimum amount of irrigation water that must be supplied and drained through the root zone to keep the soil salinity at a specific level. For sandy loam soils with good drainage and in the areas where rainfall is small, the leaching requirements can be obtained from the following equation.

Leaching requirement (LR) for drip and high frequency sprinkler;

$$LR = \frac{EC(W)}{2MAX.\ EC(E)} \cdot \frac{1}{LE}$$

where, EC(W) : electric conductivity of irrigation water, 0.56 mmhos/cm (average of five water samples) (see Table G-9, Appendix G-2)

Max.EC(E) : maximum tolerable electrical conductivity of the soil saturation extract for crops, derived from FAO Irrigation and Drainage Paper No.24, Table 36 (see Tables G-24 to G-31, in Appendix G-4)

LE : leaching efficiency, 0.8 (sandy loan)

The leaching requirements were estimated at 1.1 percent for dates and 4.4 percent for growing limes and bananas (see Table 4-7).

Water supply requirements for each crop have been calculated by applying the above-mentioned procedures as shown in Tables G-24 to G-31 in Appendix G-4, and the results are summarized in Table and Tables 4-7 and 4-8.

(c) Total Water Demand

Taking into account the cropping intensity, the annual water requirements per hectare were estimated at about 15,700 cu.m/ha/annum as shown in Table 4-9. These considerations reveal that the area of 100 ha (net irrigable area 85 ha) could be developed as a new extension farm lands by using the developed groundwater resources developed, and that total water demand for the area will be 1.34 MCM/annum.

b) Proposed Irrigation System in Irrigation Unit

The proposed farm land area of 100 ha was divided into four irrigation blocks with an area of 25 ha each as shown in Drawing No.F-1010, taking into account the most suitable pipeline systems as well as location of wells for irrigation, of which studies will be made subsequently. Furthermore, one irrigation block will be subdivided into five irrigation units with an area of five hectares each which correspond to one farming unit of the farmers.

The followings are the descriptions of the irrigation networks in an irrigation unit.

Table 4-7 Monthly Water Supply Requirement by Crops per Hectare

(unit: cu.m/ha)

Month	Tomato				Cabbage				Water Melon (Summer)				Water Melon (Winter)		
	Early Variety	Medium Variety	Late Variety	Average	Early Variety	Medium Variety	Late Variety	Average	Early Variety	Medium Variety	Late Variety	Average	Early Variety	Late Variety	Average
Jan.	784.5	989.8	673.7	816.0	526.5	749.0	765.8	680.4	-	-	-	-	151.8	-	75.9
Feb.	-	646.9	851.1	499.3	-	362.9	601.7	321.5	-	-	-	-	433.5	-	216.8
Mar.	-	-	1,289.0	429.7	-	-	878.7	292.9	-	-	-	-	1,283.2	982.5	1,132.9
Apr.	-	-	-	-	-	-	-	-	-	-	-	-	1,354.2	1,544.0	1,449.1
May	-	-	-	-	-	-	-	-	-	-	-	-	-	1,928.8	964.4
Jun.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jul.	-	-	-	-	-	-	-	-	1,508.1	-	-	502.7	-	-	-
Aug.	262.9	-	-	87.6	263.5	-	-	87.8	2,067.6	1,378.4	-	1,148.7	-	-	-
Sep.	222.3	222.3	-	148.2	891.2	222.8	-	371.3	1,748.3	1,748.3	1,165.5	1,554.0	-	-	-
Oct.	872.5	189.7	189.7	417.3	1,330.8	760.5	190.1	760.5	669.9	1,491.8	1,491.8	1,217.8	-	-	-
Nov.	936.3	598.2	130.0	554.8	1,055.8	912.4	521.4	829.9	-	456.7	1,022.8	493.2	-	-	-
Dec.	1,108.2	755.2	461.9	775.1	839.2	862.7	733.5	871.8	-	-	337.0	112.3	-	-	-
Total	4,186.7	3,402.1	3,595.4	3,728.0	4,907.0	3,870.7	3,691.2	4,156.1	5,993.6	5,075.2	4,017.1	5,028.7	3,222.7	4,455.3	3,839.1

Month	Eggplant				Red pepper						
	Early Variety	Medium Variety	Late Variety	Average	Early Variety	Late Variety	Average	Date	Lime	Banana	Alfalfa
Jan.	423.1	724.9	765.1	637.7	531.9	756.6	644.3	641.5	447.3	874.4	969.6
Feb.	-	252.0	572.8	274.9	-	366.6	183.3	489.8	278.9	729.2	797.6
Mar.	-	-	733.5	244.5	-	-	-	1,057.2	769.5	1,429.2	1,590.0
Apr.	-	-	-	-	-	-	-	1,280.4	911.5	1,739.8	1,933.2
May	-	-	-	-	-	-	-	1,829.6	1,351.7	2,433.1	2,716.0
Jun.	-	-	-	-	-	-	-	1,961.6	1,449.2	2,608.6	2,911.8
Jul.	-	-	-	-	-	-	-	1,980.8	1,463.4	2,634.1	2,940.4
Aug.	266.2	-	-	88.7	266.2	-	133.1	1,810.4	1,337.5	2,407.6	2,687.4
Sep.	225.0	225.0	-	150.0	900.2	225.0	562.6	1,530.8	1,131.0	2,035.7	2,272.4
Oct.	921.8	192.0	192.0	435.3	1,344.3	768.1	1,056.2	1,306.3	965.1	1,737.1	1,939.1
Nov.	1,053.3	632.0	131.7	605.7	1,066.5	921.6	994.1	895.6	661.7	1,191.0	1,329.5
Dec.	812.1	859.6	481.1	717.6	847.7	871.4	859.6	723.7	517.7	984.6	1,093.2
Total	3,701.5	2,885.5	2,876.2	3,154.4	4,956.8	3,909.3	4,433.2	15,507.7	11,284.5	20,804.4	23,180.2

Table 4-8 Annual Water Supply Requirement per Hectare

Item	Tomato	Cabbage	Water Melon Summer	Water Melon Winter	Egg-plant	Red-pepper	Date	Lime	Banana	Alfalfa
Evapo-transpiration, ET crop (mm)	618.2	522.0	395.1	347.5	584.2	545.8	1,302.6	930.6	1,674.9	1,581.5
Effective Rainfall, RE (mm)	36.6	35.6	0.0	69.2	34.9	28.6	58.1	56.3	63.2	62.5
Project Irrigation Efficiency, EP (%)	81.0	81.0	81.0	81.0	81.0	81.0	81.0	81.0	81.0	67.0
Leaching Requirement, LR (%)	2.7	2.9	3.5	3.5	3.9	3.9	1.1	4.4	4.4	2.2
Leaching Efficiency, LE (%)	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Water Supply Requirement, V (cu.m)	3,728.0	4,156.1	5,028.7	3,839.1	3,154.4	4,433.2	15,507.7	11,284.5	20,804.4	23,180.2

Note: Water Supply Requirement, V

$$V = \frac{10}{EP}\left[\frac{A\ (ET\ crop - RE)}{1 - LR}\right]$$

A: area (ha)
ETcrop: evapo-transpiration (mm)
RE: effective rainfall (mm)
EP: project irrigation efficiency, drip irrigation: 0.81, sprinkler irrigation: 0.67
LR: leaching requirement

$$LR = \frac{EC\ (W)}{2\ Max\ EC(E)} \cdot \frac{1}{LE}$$

EC (W): electric conductivity of irrigation water (mmhos/cm), EC(W) = 0.56
MaxEC(E): maximum tolerable electrical conductivity of soil saturation extract(mmhos/cm)
LE: leaching efficiency, LE = 0.80 (sandy loam)

Table 4-9 Average Monthly Water Supply Requirement per Hectare

(Unit : cu.m/ha)

Month	Vegetable						Fruit Crop			Feed Crop	Average 1/
			Water melon			Red					
	Tomato (5.88%)	Cabbage (5.88%)	Summer (5.88%)	Winter (5.88%)	Eggplant (7.06%)	pepper (7.06%)	Dates (23.53%)	Lime (23.53%)	Banana (11.75%)	Alfalfa (23.53%)	(120.0%)
Jan.	816.0	680.4	-	75.9	637.7	644.3	641.5	447.3	874.4	969.6	770.0
Feb.	499.3	321.5	-	216.8	274.9	183.3	489.8	278.9	729.2	797.6	547.6
Mar.	429.7	292.9	-	1,132.9	244.5	-	1,057.2	769.5	1,429.2	1,590.0	1,098.2
Apr.	-	-	-	1,449.1	-	-	1,280.4	911.5	1,739.8	1,933.2	1,260.3
May	-	-	-	964.4	-	-	1,829.6	1,351.7	2,433.1	2,716.0	1,730.2
Jun.	-	-	-	-	-	-	1,961.6	1,449.2	2,608.6	2,911.8	1,794.2
Jul.	-	-	502.7	-	-	-	1,980.8	1,463.4	2,634.1	2,940.4	1,841.4
Aug.	87.6	87.8	1,148.7	-	88.7	133.1	1.810.4	1,337.5	2,407.6	2,687.4	1,749.5
Sep.	148.2	371.3	1,554.0	-	150.0	562.6	1,530.8	1,131.0	2,035.7	2,272.4	1,572.4
Oct.	417.3	760.5	1,217.8	-	435.3	1,056.2	1,306.3	965.1	1,737.1	1,939.1	1,441.0
Nov.	554.8	829.9	493.2	-	605.7	994.1	895.6	661.7	1,191.0	1,329.5	1,042.6
Dec.	775.1	811.8	112.3	-	717.6	859.6	723.7	517.7	984.6	1,093.2	876.3
Total	3,728.0	4,156.1	5,028.7	3,839.1	3,154.4	4,433.2	15,507.7	11,284.5	20,804.4	23,180.2	15,723.7

Note : 1/: Average monthly water requirements are estimated basing on the monthly water requirements and cropping intensity.

1) Irrigation Networks and Irrigation Methods

For the effective use of water resources to be developed the Project, pipeline irrigation systems by dripping and sprinkling have been proposed in the Project. The former method will be adopted in the irrigation for vegetables and fruit crops, and the latter method in the irrigation for feed crops.

Figure 4-7 shows the typical layout of terminal irrigation systems in an irrigation unit of five hectares.

2) Design Discharge for Terminal Irrigation Systems

For designing the terminal irrigation systems (manifolds and laterals), the maximum design modulus of pipe capacity for each crop was calculated on the daily basis as below;

Maximum Water Supply Requirements 1/

(Unit: mm/day)

Vegetable		Fruit Crop		Feed Crops	
Tomato	4.42	Dates	6.54	Alfalfa	9.71
Cabbage	4.22	Lime	4.83		
Watermelon(s)	6.67	Banana	8.70		
Watermelon(w)	6.22				
Eggplant	3.51				
Redpepper	4.34				

1/: Loss is included and the detailed figures are shown in Table G-32, Appendix G-5.

Based upon the above maximum water supply requirements, hydraulic calculations in cases of the drip irrigation and the sprinkler irrigations were made (see Appendix G-5) and the maximum capacity of manifolds was estimated at 8.16 lit/sec with total head of 39.85 m and 6.58 lit/sec with 24.84 m of head, respectively, as shown in Figure 4-7.

FIGURE 4-7 TYPICAL LAYOUT OF IRRIGATION UNIT AND TERMINAL IRRIGATION SYSTEM

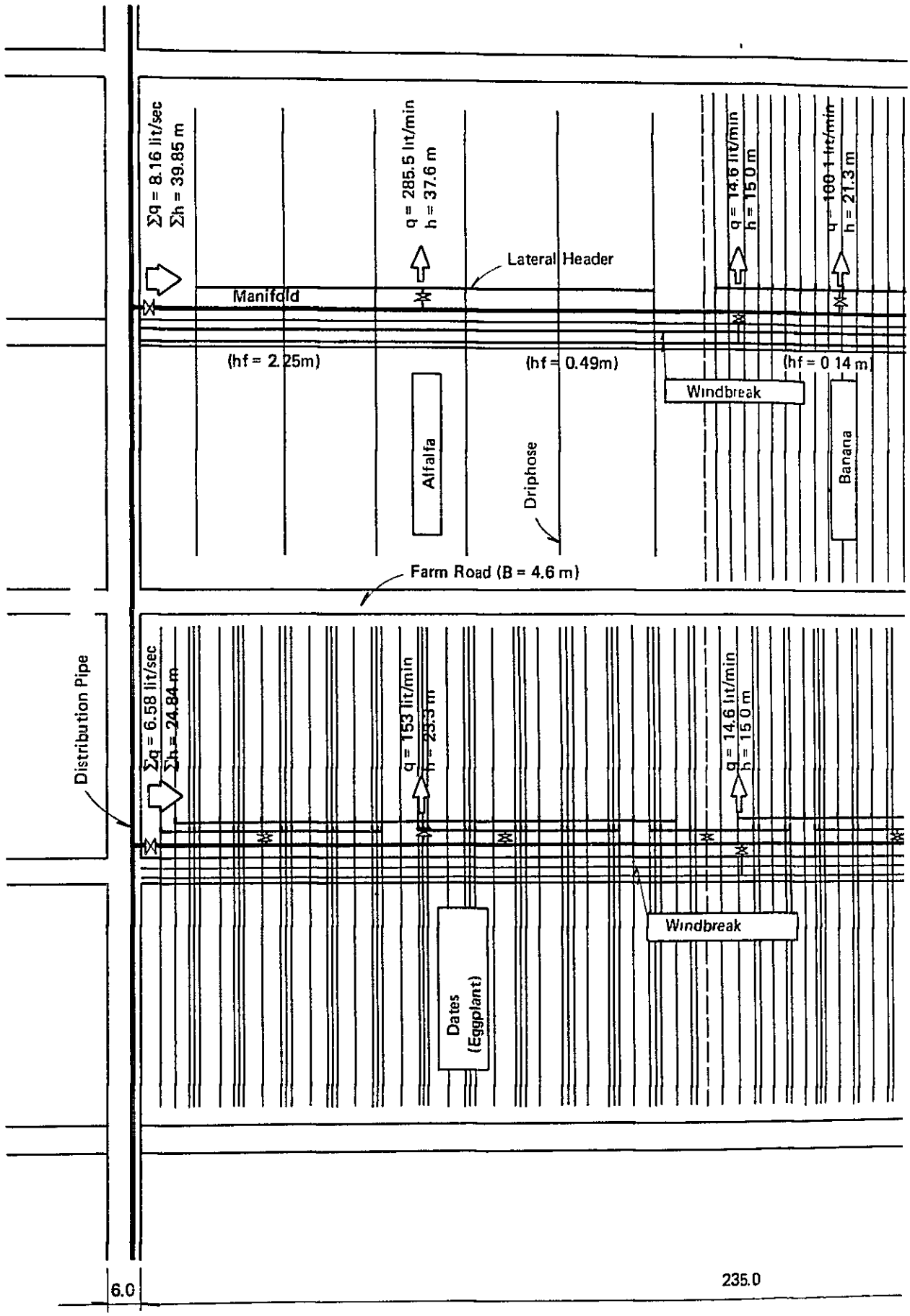
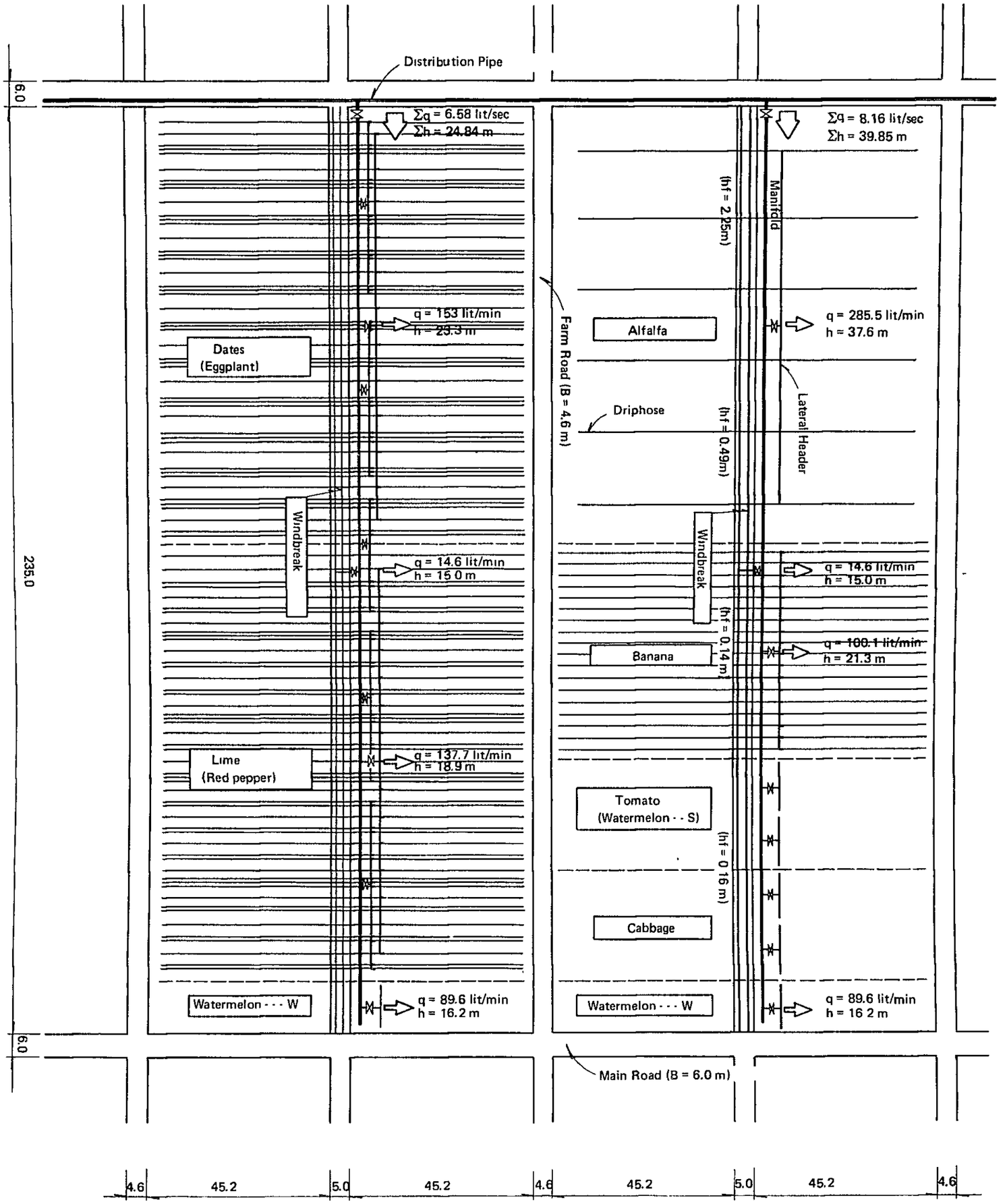


FIGURE 4-7 TYPICAL LAYOUT OF IRRIGATION UNIT AND TERMINAL IRRIGATION SYSTEM



LEGEND

q = Distribution capacity
h = Required distrivution head
Irrigation Unit = 4.25 ha

c) Water Supply for Crop

In order to find out an adequate irrigation method in the Project, intake rate measurements were made at four sites in and around the proposed new farm land area.

In parallel with the intake rate measurements, soil sampling for the analysis of physical properties of the soils in the field was also made. Rumais Agricultural Research Station was requested to carry out the soil analyses such as specific gravity, porosity, field capacity and wilting point. Appendix G-6 shows the results of the intake rate tests and soil analyses.

The basic intake rate observed in the study ranged from 43.3 mm/hr to 128.5 mm/hr. Taking it into consideration, it would be concluded that the drip and sprinkler irrigation are the most adequate methods for the Project as follows;

- Vegetable and fruit crop : Drip irrigation
- Feed crop (Alfalfa) : Sprinkler irrigation

Vegetables

Vegetables would be grown by level planting, and dripping hoses should be placed close to the plants in the field so as to effectively deliver water to their root zone. The dripping hoses should be provided along each ridge, accordingly. The nozzles will be put at a regular interval of 30 cm in order to avoid troublesome works to change the hoses for respective vegetable, although it is desirable to put the nozzles at the same interval as that of the plants. However, the nozzle intervals for watermelon cropping only should be kept 70 cm.

Fruit Crops

Irrigation for the fruit-crops like dates, limes, and bananas will be practised by pipeline systems with long trickle arms attached to the emitters on the laterals which are branched off from the manifolds. And for young seedlings, the water is supplied through a single trickle arm and the number of long trickle arms will be gradually increased to five to six arms to cover the expanding plant root areas as the trees grow bigger.

Feed Crop (Alfalfa)

For irrigating alfalfa which is seeded by broadcasting method, the sprinklers should be placed at the regular intervals, and the sprinklers used for the purpose should be of portable type.

d) Operation System of Water Supply

1) Water Use Plan

The principles for the water use plan in the proposed farm are summarized as follows:

i) Scarce water must be utilized as efficiently as much as possible,

ii) Taking into account the principle in item i) and the current practices of water use in the Project Area, the rotational irrigation method will be employed; and,

iii) Automatic water supply system will be introduced for the farm to be optimally irrigated with a scarce labor.

Based on these principles, the proposed irrigation networks for this Project will adopt the link pipeline system inclusive of farm pond. Vegetables and fruit will be irrigated by the drip irrigation whereas alfalfa by the sprinkler irrigation method.

2) Water Supply Facilities and Operation

Water supply facilities to lift groundwater for irrigation comprise three deep wells and lifting pumps.

The farm pond will be located where the water supply facilities and the water conveyance pipeline meet each other and will adjust the shortage or the excess of water caused by the difference in water supplied from water sources and required for the farm irrigation.

The operation devices provided at water supply facilities will recognize the water requirement by making use of the hydraulic information on the water level change obtained from the farm pond and the lifting pumps will be operated automatically in response to the the water level in farm pond.

The water lifted from Wells No.1 and No.2 will be conveyed to the farm pond (A) and the water from Well No.3 to the farm pond (B). Each lifting pump starts and ceases to operate depending upon the water level of each farm pond.

Figure 4-8 shows the diagram of proposed operation systems for water supply.

3) Irrigation Facilities in Farm Land

Delivery pumps to be installed at the farm ponds will supply, through pipelines, water having an appropriate pressure for irrigation. The delivery pumps will automatically be operated by the use of the water tank and its water pressure control devices.

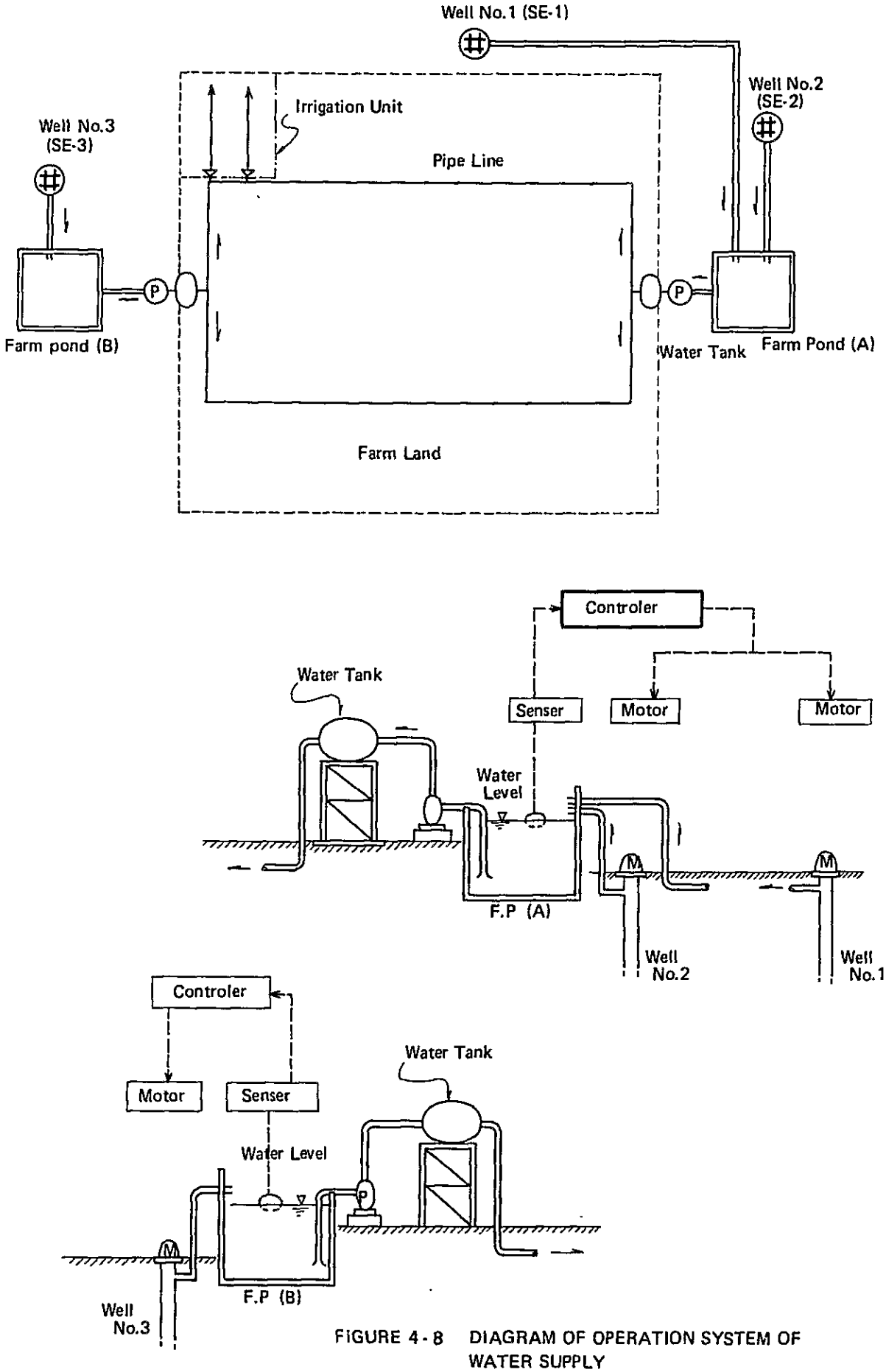


FIGURE 4-8 DIAGRAM OF OPERATION SYSTEM OF WATER SUPPLY

The irrigation in the irrigation unit of five hectares will be made through the manual operation of two valves in each unit.

4.5.4. Farm Management

a) Farm Mechanization and Labors

In the new extension farm land, plowing works will be made with tractors (65 ps) and disk-plows (26" x 4) owned by the Office of North Batinah, Ministry of Agriculture and Fisheries. The field acreages for such services will cover about 32 ha in total for vegetable cropping. The annual plant protection works will cover about 354 ha for fruit-crops, vegetables, and feed crops. Each one unit of the tractor and disk-plow will be provided at the office for the services, while five sprayers will be required considering the fact that one sprayer takes five days for plant protection of the new extension farm land.

Farming works others than the above should be done by each farm with its own tillers, equipment and tools.

The equipment and tools that each farm should purchase are as follows.

Machine/Equipment to be Procured by One Farm

Machinery	Capacity	Unit
Tiller	7 ps	1
Redger	3 row	1
Cultivator	5 teeth	1
Hand mower	1.7 ps	1
Sprayer	1.5 ps	1
Trailer	0.9 m x 1.8 m	1
Pick-up	1.5 t	1
Total		7

The annual working hours in the farms were estimated at 6,503 hours, which are equivalent to 929 man-days. The peak labor hours are 660 hours (equivalent to 94 man-days) for the two months of July and December, and every farm plans to provide four working members of family and/or hired labor so as to cover the whole farming works. The other operation and maintenance works for the windbreakes, farm roads, etc., will be conducted by the surplus labors in each farm. The crop-wise monthly labor requirements per hectare, the monthly labor requirements per farm and the total labor requirements by all farms are shown in Table H-2 and H-13, and Appendix H-2, respectively.

The operation schedule of plows and sprayers is shown in Figure H-1, Appendix H-3.

b) Farm Management

The basic idea for the farm management of the 20 settler farmers is to encourage private enterprises. These farmers will be given guidance and orientation for successful private farm management on crop growing and irrigation by the extension agents of Sohar Office of the Agricultural Department, North Batinah. The collective works, however, will be required for operation and maintenance services of the equipment to pump up the water from the proposed farm ponds and pipelines, and for collection of the water charges.

Such common practices will be performed in the close cooperation with the Sohar Office of the Directorate of Water Resources.

The Public Authority of Marketing of Agriculture Produce will supervise the marketing of farm products by 20 settler farmers.

Table 4-10 Labor Requirement per Farm

(Unit: hr)

Crops & Area (ha)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Tomato	0.25	54	36	15	3	-	-	13	21	32	100	114	126	514
Watermelon														
Winter	0.25	10	30	42	67	33	16	-	-	-	-	-	-	198
Summer	0.25	-	-	-	-	-	2	12	28	50	57	40	16	205
Cabbage	0.25	43	35	29	2	-	-	1	14	50	60	56	27	317
Eggplant	0.30	59	28	7	-	-	-	13	21	30	85	106	120	469
Redpepper	0.30	26	14	3	-	-	-	38	64	76	66	31	29	347
Dates	1.00	112	136	92	60	92	160	162	192	60	62	90	92	1,310
Lime	1.00	137	86	152	140	72	290	262	62	105	77	60	97	1,540
Banana	0.50	65	28	53	57	43	42	73	44	42	59	43	65	614
Alfalfa	1.00	85	80	88	83	85	86	85	85	86	85	83	88	1,019
Sub-total[1/]	5.10	591	473	481	412	325	596	659	531	531	651	623	660	6,533
Onion	0.30	64	77	49	8	-	-	-	1	77	122	68	26	492
Cauliflower	0.30	50	43	19	-	-	-	1	11	72	102	56	34	388
Sub-total	0.60	114	120	68	8	-	-	1	12	149	224	124	60	880
Total[2/]	5.70	705	593	549	420	325	596	660	543	680	875	747	720	7,413

Note: 1/ At full development stage 2/ Pre-full development stage (for 5 years)

Table 4-11 Labor Requirement

(Unit: hr)

Crops	Area (ha)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Tomato	5	1,080	720	300	60	-	-	260	420	640	2,000	2,280	2,520	10,280
Watermelon														
Winter	5	200	600	840	1,340	660	320	-	-	-	-	-	-	3,960
Summer	5	-	-	-	-	-	40	240	560	1,000	1,140	800	320	4,100
Cabbage	5	860	700	580	40	-	-	20	280	1,000	1,200	1,120	540	6,340
Eggplant	6	1,180	560	140	-	-	-	260	420	600	1,700	2,120	2,400	9,380
Redpepper	6	520	280	60	-	-	-	760	1,280	1,520	1,320	620	580	6,940
Dates	20	2,240	2,720	1,840	1,200	1,840	3,200	3,240	3,840	1,200	2,240	1,800	1,840	26,200
Lime	20	2,740	1,720	3,040	2,800	1,440	5,800	5,240	1,240	2,100	1,540	1,200	1,940	30,800
Banana	10	1,300	560	1,060	1,140	860	840	1,460	880	840	1,180	860	1,300	12,280
Sub-total[1/]	102	11,820	9,460	9,620	8,240	6,500	11,920	13,180	10,620	10,620	13,020	12,460	13,200	130,660
Onion	6	1,280	1,540	980	160	-	-	-	20	1,540	2,440	1,360	520	9,840
Cauliflower	6	1,000	860	380	-	-	-	20	220	1,440	2,040	1,120	680	7,760
Sub-total	12	2,280	2,400	1,360	160	-	-	20	240	2,980	4,480	2,480	1,200	17,600
Total[2/]	114	14,100	11,860	10,980	8,400	6,500	11,920	13,200	10,860	13,600	17,500	14,940	14,400	148,260

Note: 1/ At full development stage 2/ Pre-full development stage (for 5 years)

4.5.5. Farm Economy

An arable land of 4.25 ha will be allocated to each farm household which will settle in the new extension farm land. The farmers will commence the farm management from 1986. The cropping intensity in the Project was computed at 120 percent based on the proposed cropping pattern. It has been planned that the agricultural production will increase from 47.8 tons in 1986 to 119 tons in 1995. Of the whole farm production, alfalfa will occupy about 60 percent in 1986 and 50 percent in 1995.

The farm economy of each household in the new extension farm land was assessed, and the results are shown in Table 4-12. The prices of output and input materials are estimated by using the financial prices. The production costs cover those of seeds, fertilizers, pesticides, machinery, and labor. The labor will be secured from the farm families and by employment. The machinery to be used was described in the previous paragraph. The cost items other than the above were estimated on the presumption that these will be subsidized by the Government.

The net farm income of 2,140 R.O. in 1986 will increase to 14,420 R.O. in 1995. Each farm household has to invest the capital cost of about 90,000 R.O. in the initial stage, which consists of the costs for farm land, house, irrigation facilities, farm facilities, farm machinery, etc. The initial capital will be expected to be loaned by the Bank for Agriculture and Fisheries. In this study, the terms and conditions for loan under the present regulations are tentatively used for analysis. The irrigation charge covers the operation and maintenance cost. This cost is deducted from the net farm income. Thus, the estimate results in the surplus income.

A balance in the farm economy in the beginning year will be negative. Therefore, the farm households to settle in the new extension farm land have to prepare an amount of fund of more than about 2,200 R.O.

Table 4-12. Settler's Farm Economy

	1986 (1st Yr.)	1990 (5th Yr.)	1995 (10th Yr.)
Arable Land (ha)	4.25	4.25	4.25
Cropping Area (ha)	5.1	5.1	5.1
Fruit	2.5 (0)	2.5 (1.5)	2.5 (2.5)
Vegetable	1.6	1.6	1.6
Alfalfa	1.0	1.0	1.0
Cropping Intensity (%)	120	120	120
Total Production ton)	47.8	105	119
Fruit	-	10.5	24.5
Vegetable	17.8	34.5	34.5
Alfalfa	30	60	60
Gross Income (R.O.)	5,550	14,260	19,860
Fruit	-	3,380	8,980
Vegetable	3,450	6,680	6,680
Alfalfa	2,100	4,200	4,200
Production Cost (R.O.)	3,410	5,080	5,440
Fertilizer	270	530	530
Machine	1,240	2,950	2,950
Labor	1,380	1,590	1,587
Net Farm Income (R.O.)	2,140	9,180	14,420
Interest and Instalment of Fixed Capital (R.O.)	3,160	7,430	7,430
Irrigation Fee (R.O.)	1,182	1,182	1,182
Surplus Income (R.O.)	-2,202	568	5,808

Note:
1. Figures in the parenthesis show the acreage of fruit-tree cropping.
2. Production cost is presently subsidized by regulation.
3. Irrigation fee per ha is 278 R.O.
4. Surplus income during 2nd Year to 4th Year is positive.
5. Fixed Capital is 90,000 R.O., which 35,000 R.O. for farm land, 24,000 R.O., for housinsing 21,000 R.O. for irrigation facilities, 6,900 R.O. for farm facilities and 3,100 R.O. for farming machinery, respectively. Interest ranges three to five percent. Terms of repayment are 20 years including grace period of four years.

4.5.6. Agricultural Supporting Services

a) Improvement of Existing Agriculture

To upgrade the present agriculture in the Project Area, the following works would be required to be executed.

i) Introduction of high quality seeds

ii) Increase in dosing amount of fertilizers and improvement of fertilizing methods

iii) Growing eggplants, tomatoes, etc. with plant-supports

iv) Improvement of the irrigation methods
Determining reasonable water requirements, providing ridges with reasonable width, and increasing the planting density.

v) Increasing the number of the necessary machines and operators

vi) Establishment of a plant protection system from diseases and harmful insects

vii) Enforcement of extension services by increasing the number of extension agents and vehicles for their service use.

b) Agricultural Credit

The Bank for Agriculture and Fisheries is expected to satisfy the loan requirement of the settlers in the execution of the Project. The required funds will be as follows;

Loan for twenty farmers: (Unit: '000 R.D.)	
Farm land	700
House building	480
Irrigation facilities	420
Farm facilities	138
Farm machine	62
Sub-total	1,800

4.6. Preliminary Design of Facilities

4.6.1. Recharging Structures

In general, for water resources development in the arid countries, the recharging facilities are mainly composed of detention dam and dispersion facilities. The roles of these facilities are to store temporarily the flood discharge that appears once or twice a year and to recharge groundwater through infiltration in the water routes into aquifers.

a) Detention Dam

1) Dam Site and Dam Axis

Based on a comparative study of five potential dam sites, the downstream dam site (D-2), which is located about 23 km upstream of the mouth of the Wadi Jizzi, has been proposed as the detention dam site in the Project. The dam will be constructed across a comparatively wide wadi carved in the terrace plain.

The bottom elevation of the wadi bed at the detention dam site is about 152 m and the reservoir will mainly extend to east-west directions along the above-mentioned wadi developed in dendrite.

In determining the dam axis, a form with combined axis of line and curve has been selected based on the results of comparative studies (see to Appendix I-1.1).

2) Dam Site Topography

The Wadi Jizzi basin is roughly divided into three topographical classifications; lowlying area consisting of fan land and gravel plains, hill area consisting of river terrace, talus and the foot of the mountain, and central mountain mass consisting of ophiolite. The proposed dam site is located on the middle stream of the Wadi Jizzi and has the river bed of 650 m wide and terrace rising steeply therefrom.

The topographical features of the dam site are described hereunder in the order of the left bank, right bank and river beds.

The left and the right banks are the river terraces consisting of sand and gravel, and rise on the dam axis with slope of about 20 degrees from the river bed. The crests, however, present flat at an elevation ranging from EL 165 m to EL 170 m and have been widely spread. On the flats lie many deep gullies which are being developed vigorously.

The recent river bed of the Wadi Jizzi, formed with flood plain deposits, grows abruptly wider at the confluence with the Wadi Awhin - the proposed dam site, and reaches about 10 km wide or more in the coastal area. In the upperstream portion, the river bed width varies with bulges of the mountain. Four flow courses can be clearly observed at the Wadi Jizzi around the dam site including the Wadi Awhin. The river bed slope does not show a large fluctuation in the areas where the wadi deposits are recognized, and the slope is about 1/120 in the mid-stream area including the dam site, while about 1/160 in the downstream area.

3) Dam Site Geology

The Wadi Jizzi basin is geologically mainly composed of the Hawasina group of the sedimentary rocks, the metamorphic rocks, the Semail ophiolite of the igneous rocks, and the Quaternary deposits. The stratigraphy and facies of the dam site area within these members are shown in the following table.

The river-bed and the both abutments of the proposed dam site are composed of river terrace deposits belonging to the Quaternary. The facies observed at the both banks are continuous in the river-bed portion under the younger deposits. The geological profile covering the dam axis indicates that the bed rocks can be traced 10 to 30 m deep under the formation.

The geological map and profile obtained from the investigations are shown in Drawing D-1002 and the detailed descriptions of the geological investigations are given in Appendix D-1.

Strategraphy and Facies of Members around Dam Site

Age		Formations	Rock Facies, Lithology
Quaternary	Alluvium	Talus deposit	Gravel with silt, silt with gravel Gravels angular to subangular. Distributed in the deep gully, cliff of the terrace.
		Recent Wadi deposit	Gravel and sand Nonconsolidated. Gravels subrounded to angular. Widely distributed in the recent wadi bed.
	Diluvium	Middle terrace deposit	Gravel and sand Having variety facies. Gravels round to subround, maximum diameter about 50 cm.
		Upper terrace	Gravel and sand Well consolidated except upper 1 - 2 m. Gravels round to subround, maximum diameter about 50 cm. Permeability coefficients 10^{-1} - 10^{-2} cm/sec order.
Cretaceous		Hawasina group	Limestone, chert Bed rock of the dam site area. Distributed about 20 m below the recent wadi bed.

The both abutments are mainly composed of rounded gravel and sand, and they have facies with a variety of horizons prevailing in well-sorted sand and pelitic materials. The sand and gravel have been well developed in conglomeration; particularly, the conglomerates with calcareous matrix can be found in the lower part of this horizon. The gravels mainly consist of basic rocks, however, some rocks of diabase and gabbro are very fragile due to weathering.

The Quaternary deposits consisting of the river bed can be classified into the recent wadi deposits and higher terrace deposits. The recent wadi deposits are formed with unconglomerated layers containing many rounded gravels and subangular gravels, and these layers are developed evidently independent of the conglomerated

lower formation which abounds with calcareous matrix. The geological profile of the dam axis indicates the thickness of these layers, tending to grow large toward the right bank. The layers are about five meters in maximum thickness.

Like horizons of the both abutments, the higher terrace deposits below the recent wadi deposits composed mainly of the round to angular gravels having facies with a variety of the horizons prevailing in well-sorted sand and pelitic materials. The permeability test conducted within an extent of the horizon shows rather high values ranging from n x 10^{-1} to n x 10^{-2} cm/sec. The horizons have been well developed in conglomeration in the whole extent.

The bed rocks, as mentioned previously, are observed 10 to 30 m below the younger deposits. The deepest point is around the center of the river bed, becoming more shallow near the both abutments. The facies seem to be composed of limestone and chert of Hawasina group. These rocks are hard and siliceous, and have many cracks; however, the shear zone and faults are not expected around the dam site. (see to Appendix I-1.2)

4) Construction Materials and Dam Type

Terrace deposits are widely distributed around the dam site and can be gained easily from any place. According to the results of soil survey and tests, the terrace deposits at the spillway site mainly consist of sand and gravel materials which belong to GW-GM type under the Unified Soil Classification System and can be utilized for semi-pervious materials of the dam body.

Talus deposits originated siliceous limestone obtained at the quarry site, which is located about 2.0 km away from the dam site, might be hauled as the embankment materials of rock and riprap fill.

As to the materials to be used for the filter zone and concrete aggregates, the river-bed deposits of sand and gravel materials will be utilized with the arrangement in gradation distribution by screening plants to be located around the dam site.

At the detention dam, a zone-type fill dam has been proposed as the most suitable dam type taking into account the purpose of dam construction, topographical and geological conditions, and the distribution of embankment materials around the dam site (see Appendices I-1.3 and I-1.4).

5) Dam Design and Foundation Treatment

The dam crest elevation is determined by adding a height of wave due to the wind, which is decided in the detailed study, to the maximum water surface level in a reservoir, and determined to be 168.0 m above the mean sea level. Therefore, the height of detention dam is about 17.0 m from the trench base. The distribution of embankment materials around the dam site is an important factor in designing of a fill type dam. Borrow areas for the embankment of semi-pervious zone and rock zone have been determined at the terrace deposits around the spillway site and the talus deposits originated siliceous limestone at the quarry site, respectively. However, it is desirable that the utilization of talus deposits (rock zone and riprap materials) should be limited from the economic point of view.

The design values of embankment materials as derived from the soil tests and data are summarized below:

Zone	Density		Shearing Strength		Permeability Coefficient
	γt [1] (t/cu.m)	γsat [2] (t/cu.m)	ϕ [3] (° - ')	C [4] (t/sq.m)	(cm/sec)
Semi-pervious	2.11	2.32	35°-00'	0	1×10^{-4}
Rock	1.96	2.22	37°-00'	0	-
Filter	2.11	2.32	35°-00'	0	-

where, 1/ t: wet density, 2/ γsat: saturated density
3/ ϕ: angle of internal friction, 4/ C: cohesion

Stability analysis of the dam body has been carried out from the structural and hydraulic viewpoints. The structural analysis against sliding failure was made by slip circle method taking into account the pore pressure and earthquake acceleration. And also, hydraulic analysis was carried out on the seepage through dam body and piping in dam body.

From the results of the above-mentioned analyses the dam body, the upstream and downstream slopes of the dam have been determined at 1.0 vertical to 3.0 and 2.5 horizontal, respectively, as shown in Drawing D-1003. The cases considered and the factors of safety obtained in the structural analysis are tabulated below:

Reservoir Condition	K [1]	Slope	S.F. [2]	Pore Pressure
Full water level (F.W.S. EL 163.90 m)	0.10	Upstream Downstream	1.331 1.329	Steady flow
Immediately after completion (empty)	0.05	Upstream Downstream	1.883 1.531	Nil
Middle water level (M.W.S. EL 159.00)	0.10	Upstream	1.343	Steady flow
Rapid drawdown (F.W.S. to L.W.S [3])	0.10	Upstream	1.448	Unsteady flow
Flood water level (EL 167.20 m)	Nil	Upstream Downstream	2.115 1.759	Steady flow

Where, 1/ K : horizontal seismicity, adopted by 0.10 in usual case and 0.05 in special case
2/ S.F : safety factor
3/ L.W.S: low water level, adopted by EL 154.0 m

The ripraps shall be hand-placed on the upstream and downstream slopes in order to prevent the dam body from moving and washing-out wave action and from erosion by rain water.

In the downstream of the sand and gravel zone, the intercepter with horizontal drain is planned to be provided in order to reduce the seepage water pressure and to safely permit seepage water to flow out the zone.

As regards the foundation treatment of the detention dam, a stripping thickness for the entire dam base will reach 0.5 m on average inclusive of removal of all vegetal soils, although a deep excavation of two meters an average will be required for the trench base.

It is desirable that the measurement devices such as surface settlement points and water gauge will be installed on the dam body surface and at the entrance of the emergency outlet, respectively, in order to check the displacement of the dam body and to monitor the water surface level in the reservoir (see Appendices I-1.5, I-1.6 and I-1.7)

6) Spillway

A non-control open-type spillway will be provided on the terrace plain at the right abutment of the dam site in terms of the applicability of topographic feature, dam type, hydraulic characteristics of itself and avoiding risk by gate control.

A 10,000-year probability flood discharge of 1,890 cu.m/sec is adopted for designing the spillway taking into account the lack of hydrological data and precedents in arid countries.

A complete overflow-type broad-crested weir with 169.2 m crest length will be provided at the end of approach channel of the

spillway from which the trapezoidal chute and tailrace will be constructed to connect the existing wadi tributary. At the chute and tailrace, the protection works with gabion should be executed to prevent excessive erosion and scouring.

If it is defined that the ultimate outflow capacity of the spillway is equivalent to the discharge released through the spillway when the reservoir water surface has arrived at the dam crest elevation, the said capacity amounts to about 2,850 cu.m/sec. Judging from the above-mentioned fact, the reservoir formed by the detention dam will play a vital role in flood control (see Appendix I-1.8).

7) Outlet Facilities

The water temporarily stored the detention dam will be released through the outlet facilities and flows into the downstream of wadi course.

A reinforced concrete conduit of the circular shape with 1.4 m inside diameter is installed beneath the dam body.

At the end of outlet conduit, the masonry paving shall be executed in order to prevent excessive erosion and scouring.

For of accidental blockade at the outlet conduit, a tower structure of intake with 1.4 m inside diameter of conveyance conduit is provided as an emergency outlet at the left abutment of the dam site (see Appendix I-1.9).

b) Dispersion Facilities

In order to effectively utilize the excess flood discharge flowing out through the spillway, the dispersion facilities will be provided on the wadi course about 3.3 km downstream the detention dam

site. The facilities consist of an Irish-cross with gabion dike to dam up a stream, outlet conduits located on the main water route, and connecting canals to transfer the excess flood discharge to tributary water routes which form a reticulate shape isolated by small sand bank on the wadi course.

The location of Irish-cross and connecting canals, and structural dimensions of these facilities are shown in Drawing D-1009.

4.6.2. Water Supply Facilities

The water supply facilities consist of three wells to be used as irrigation water resources, lifting pumps, and conveyance pipelines extending from the pumps to the farm ponds to be constructed in the farm. The optimum pipeline irrigation networks inclusive of the water supply facilities have been studied in view of technology and economy (refer to subsequent paragraph of 4.6.3. "Irrigation and Farm Land Facilities"). As a result, a link pipeline system, which is one of pipeline formations in distribution networks, has been revealed to be most optimum as the pipeline system in the Project.

According to the proposed plan, the water lifted from the wells SE-1 and SE-2 is planned to be conveyed to the farm pond (A) through independent conveyance pipe, while the waters from the well SE-3 will be conveyed to the farm pond (B).

a) Wells

The major dimensions of the proposed three wells[1/] are tabulated as below;

1/ The proposed wells were referred to in the previous paragraph, 4.2.2. "Development Plan" shall be made.

Well	Potential Yield (cu.m/hr)	Diameter of Well (mm)	Depth of Well (m)
SE-1	134.0	260	56
SE-2	47.0	260	50
SE-3	106.0	260	55
Total	287.0		

b) Production Pumps

Peak Discharge and Allocation of Design Pump Discharge

The peak discharge for the net irrigable area of 85 ha was estimated at 285.9 lit/sec[1/] based upon the peak manifold capacity in the terminal facilities. The capacity of the pump, which will be installed at each well, was allocated in proportion to the respective wells' potential yield, which is 141.1 lit/sec[2/] for No.1 pump at the well SE-1, 49.5 lit/sec for No.2 pump at the well SE-2 and 95.3 lit/sec for No.3 pump at the well SE-3.

The water will be delivered for six hours a day to meet the requirements in the peak time through distribution pipeline networks, whereas the pump operation is planned to be operated for 23 hours a day. In this case, the wells can meet the required discharge in their potential yield as shown below;

Wells		Lifting Pump		
Well No.	Well Yield (A) (lit/sec)	Pump No.	Pump Capacity (B) (lit/sec)	Comparison
SE-1	37.2	No.1	36.8	(A) > (B)
SE-2	13.1	No.2	12.9	(A) > (B)
SE-3	29.4	No.3	24.9	(A) > (B)

1/ 6.6 lit/sec x 20 plots = 132.0 lit/sec
8.1 lit/sec x 19 plots = 153.9 lit/sec
Total 285.9 lit/sec

2/ 285.9 lit/sec x 2/3 x 134/181 = 141.1 lit/sec
285.9 lit/sec x 2/3 x 47/181 = 49.5 lit/sec
285.9 lit/sec x 1/3 = 95.3 lit/sec

Design of Pump

The proposed pumps to be installed are designed based upon the peak discharge and the total head as shown in Table 4-13.

c) Conveyance Pipeline

Vinyl chloride pipes (VP) will be used for the conveyance pipelines, which function to transport the water lifted by pump. The major specific features of the conveyance pipelines are as follows:

Well	Pump	Conveyance Pipeline Diameter (mm)	Length (m)	Type
SE-1	No.1	ϕ 200	730	VP
SE-2	No.2	ϕ 150	240	VP
SE-3	No.3	ϕ 200	120	VP

The layout of the water supply facilities are shown in the attached Drawing No. F-1010.

4.6.3. Irrigation and Farm Land Facilities

a) Irrigation Facilities

1) Irrigation Networks in New Extension Farm Land

Alternative Study on Irrigation Networks

To determine the most optimum pipeline irrigation networks in the new extention farm land, the following two alternative studies have been made based on the topographic conditions as well as the location and the capacity of the proposed three wells.

Case-1. (Link System) : All the pipelines are connected with link facilities and the water is delivered by pumps at two sites.

Table 4-13 Calculation for Required Pump Head (H_T)

Item	SE-1	SE-2	SE-3
1. Site Altitude, E (mamsl)	EL 20.0	EL 18.6	EL 18.4
2. Lowest Water Level, W (mamsl)	2.4	2.2	2.2
3. Peak Discharge, Q (cu.m/hr)	132.48	46.44	89.64
4. Specific Capacity, S.C (cu.m/hr/m)	67	25	56
5. Drawdown, S_1 = (Q) / (S.C) (m)	1.98	1.86	1.60
6. Interferenced Drawdown, I[1] (m)	0.03	0.04	0.04
7. Interference with Well Losses[2], S_2 (m) S_2 = (I) / 0.75	0.04	0.06	0.06
8. Total Drawdown, S_3 = (S_1) + (S_2) (m)	2.02	1.92	1.66
9. Operating Water Level, W_2 = (W_1) - (S_3) (mamsl)	EL 0.38	EL 0.28	EL 0.54
10. Actual Head, H_1 = (E) - (W_2) (m)	19.62	18.32	17.86
11. Friction Loss in Conveyance Pipe, L_f (m)	8.3[1]	2.6	2.2
12. Pump Loss, L_p (m)	2.0	2.0	2.0
13. Total Head, ΣH = (H_1) + (L_f) + (L_p) (m)	29.92	22.92	22.06
]4. Design of Pump			
Peak Discharge, Q (cu.m/min)	2.208	0.774	1.494
Pump Diameter, D (mm)	125	100	125
Pump Type	Vertical turbine pump		
Motor Capacity, P (kw)	18.5	7.5	7.5
Water Rising Pipe, L (m)	35 (ø 125) SGP	35 (ø 100) SGP	35 (ø 125) SGP

1/: estimated by the following formula;

$$L_f = 10.666 \times C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L \text{ (m)}$$

C : Velocity coefficient, 100 (SGP), 140 (VP)
D : Diameter of pipe (m)
Q : Discharge (cu.m/sec)
L : Length of pipe (m)

Case-2. (Open System) : Pipeline systems having the delivery pump used exclusively are independent of each other.

The comparison of the costs and the operation method of facilities between the two cases was made and the results are summarized in Table 4-14.

Proposed Irrigation Networks

As seen in Table 4-14, the annual operation cost in the Case of the Link System was estimated at 36,690 R.O., while in the Case of the Open System at 37,510 R.O., and furthermore, the Case-1 has a merit of allowing an adequate countermeasure to be taken in case of accidents. It was found that the former would be considered more recommendable than the latter from the viewpoints of costs and operation of the facilities. Consequently, the Link System has been selected as the proposed plan in the Project.

2) Terminal Irrigation Facilities

The drip irrigation system with manifolds and driphoses and the sprinkler system will be employed as the terminal irrigation facilities in the Project, the former will be used for irrigation for cropping the vegetables and fruit-crops, while the latter for the feed crop (alfalfa). The dimensions of these terminal irrigation facilities are summarized below;

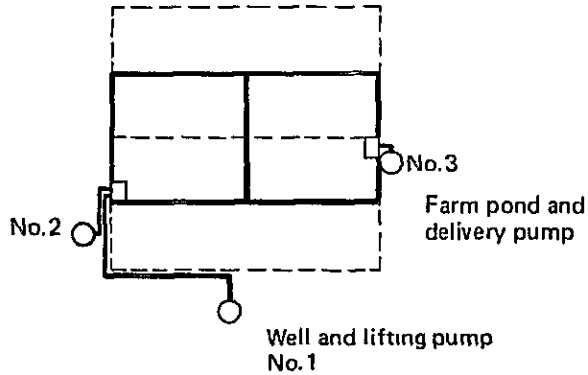
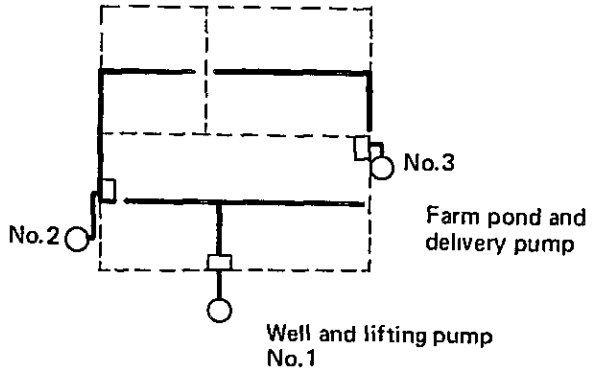
Drip Irrigation

Manifold:

Capacity: q = 8.16 lit/sec (head h= 39.85 m)
q = 6.58 lit/sec (head h= 24.84 m)

Pipe : L = 235 m (vinyl chloride pipe)

Table 4-14 Alternatives of Irrigation Networks

Item	Case-1 (Link System)	Case-2 (Open System)
1. Diagram of Irrigation Networks		
2. Dimension of Facilities Pipeline Pump	ℓ = 3,470 m, D = 75 - 300 mm (VP) P = 45 KW x 4 units + 45 KW x 2 units Holizontal volute pump	ℓ = 2,780 m, D = 75 - 350 mm (VP, Dip) P = 45 KW x 3 units + 45 KW x 1 unit + 45 KW x 2 units Horizontal volute pump
3. Cost; Construction cost 1/ Annual cost	169.5 10^3R.O. 36,690 R.O. (100)	174.6 10^3R.O. 37,510 R.O. (102)
4. Merit and Demerit	° Easy for correspondence to accident ° Easy to obtain constant water pressure	° Difficult for correspondence to accident ° Easy to control water distribution

1/ Consisting of the costs for distribution pipeline systems and delivery and lifting pumps
Detailed descriptions on alternative study are shown in Appendix I-2.

Driphose

Emitter capacity:

Vegetable	:	3.98 lit/hr at 15.1 m head
Date	:	76.5 lit/hr at 14.5 m head
Lime	:	38.3 lit/hr at 14.5 m head
Banana	:	9.27 lit/hr at 18.9 m head
Windbreak	:	5.61 lit/hr at 13.6 m head

Pipe : L = 45 m (Polyethylene pipe)

Sprinkler Irrigation

Sprinkler capacity : 35.7 lit/min at 28 m head

The detailed descriptions are given in Appendix G-5.

3) Pipelines

The distribution pipes in the selected irrigation networks were estimated at 3,470 m in total length and planned to be of the vinyl chloride pipe with the diameter of 75 mm to 300 mm, taking into account the required water pressure, which ranges from about 40 m to 45 m. (see Table I-2, Appendix I-2) These pipes are to be provided in the ground along the roads.

Figure 4-9 indicates the proposed irrigation networks in the farm.

4) Delivery Pumps

Two delivery pumps will be provided in an almost symmetrical position in the proposed irrigation networks, taking into account the location of existing wells to be utilized in the Project. The type of pumps adopted is horizontal volute pump and the design of these pumps are tabulated as shown below:

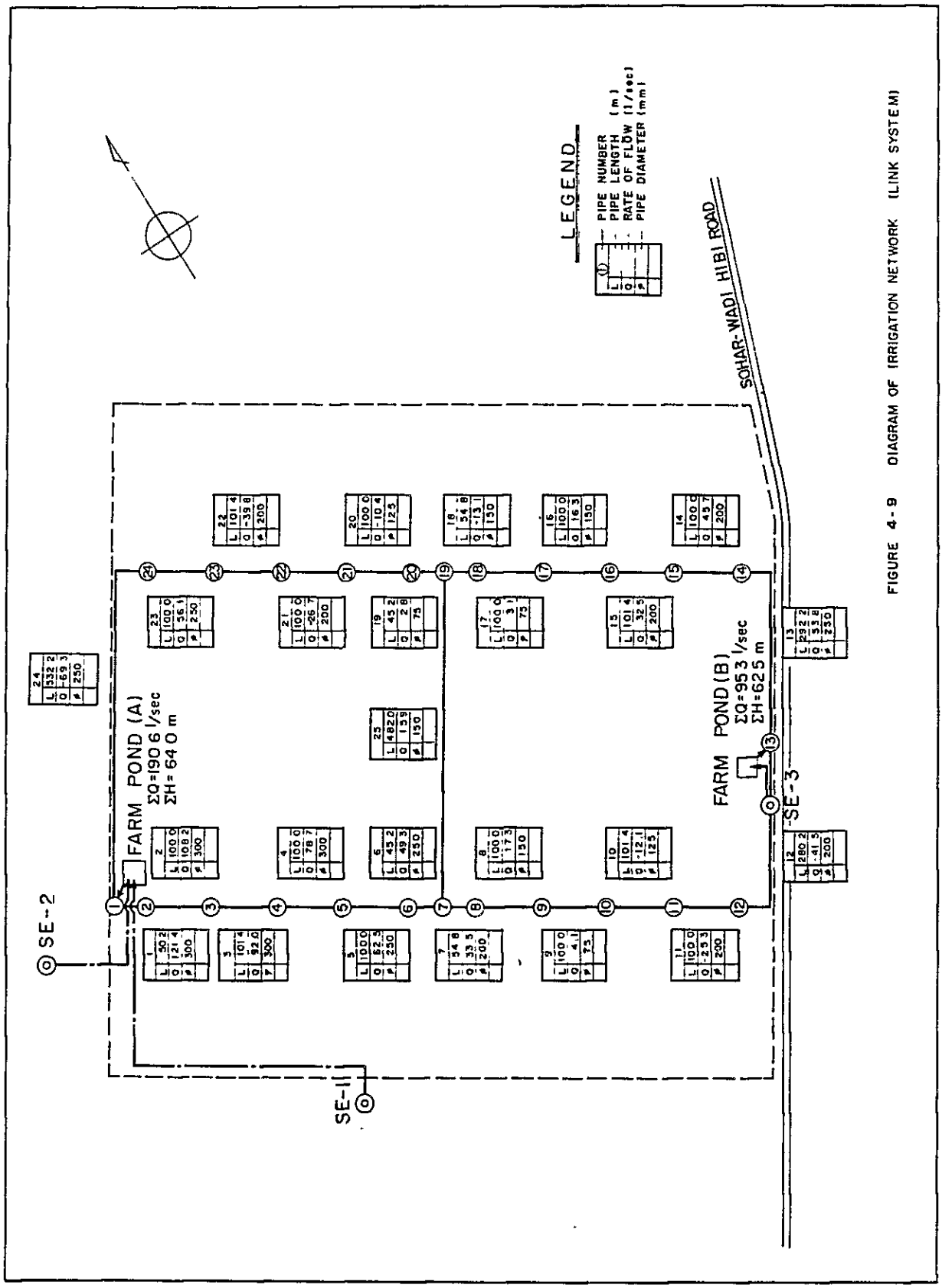


FIGURE 4-9 DIAGRAM OF IRRIGATION NETWORK (LINK SYSTEM)

Major Features of Delivery Pumps

Item	Pump No.1	Pump No.2
Suction Water Level (m)	EL. 15.5	EL. 15.5
Delivery Water Level (m)	EL. 64.0	EL. 62.5
Actual Head (m)	48.5	47.0
Total Head (m)	50.5	49.0
Peak Discharge (lit/sec)	190.6	95.3
Peak Discharge per Unit (cu.m/min)	2.859	2.859
Pump Diameter (mm)	150.0	150.0
Motor Capacity (kw)	45	45
Pump Units	4	2
Pump Type	Horizontal Volute Pump[1/]	

5) Farm Ponds

Two farm ponds with the delivery pumps provided have been planned to be constructed in the farm land. The capacity of the farm ponds was determined to be 3,100[2/] cu.m for Farm Pond (A) and 1,600[3/] cu.m for Farm Pond (B), taking into consideration the that operation hours of water supply through distribution pipe, and those of lifting pumps are six hours and 23 hours, respectively, during the peak discharge.

As described previously, the lifting pumps No.1 and No.2 will be connected with the Farm Pond (A) by conveyance pipe, while the pump No.3 with the Farm Pond (B).

The designs and the structures of the irrigation facilities are shown in the attached Drawings No. F-1010 and F-1011.

1/ A kind of centrifugal pump which does not provide the guide vane is called volute pump.

2/ (36.8 lit/sec + 12.9 lit/sec) x 3.6 x 17 hr = 3,100 cu.m

3/ 24.9 lit/sec x 3.6 x 17 hr = 1,600 cu.m

b) Farm Land Facilities

1) Layout of Farm Land Facilities

The layout of the farm land facilities have been made on the topographic map of 1:2,000 in scale, based upon the following conditions;

° Total area to be developed	:	100 ha
° Net cultivation area	:	85 ha
° Total number of settlers	:	20 households
° Size of one plot	:	1.062 ha (45.2 m x 235.0 m)
° Irrigation unit (farming unit)	:	4 plot (4.25 ha)
° Irrigation blocks	:	5 irrigation units (21.25 ha)

Drawing No. F-1010 shows the layout of the farm land.

2) Farm Land Facilities

The farm land facilities consist of roads, windbreaks, and flood protection works.

Roads

Main roads of five-meter wide and farm roads of four-meter wide will be provided for the transportation of products and operation and maintenance of the facilities. The main roads are planned to be of 10-cm thick gravel paving.

Windbreak

Two rows of windbreaks will be provided at an interval of 200 m in the direction of northeast to southwest in the farm and in the

surrounding of the farm, in order to protect the crops from harsh climate and to make the farm livable and comfortable, eucalypti or casuarina equestifolia will be planted.

Flood Protection Works

The flood protection works consisting of drainage canals and flood protection dike around the farm will be provided.

The typical layout of the farm land facilities are shown in the attached Drawing No. F-1010.

4.6.4. Farm and Related Facilities

Within the farm area, 20 houses for settlers and one sorting and packing center of the farm products will be constructed, and every house of the settlers should be provided with a storage for farming equipment/tools and agri-input materials. The base floor area per farm house is designed to be 150 sq.m and that of the sorting and packing center 200 sq.m. Water supply will be made to individual houses with the water pumped up in the newly-dug well.

a) Location

Farm related facilities will be located in the central part of eastern farm land alongside Sohar-Wadi Hibi road. The site will be chosen across the main road by allocating 2.20 ha for settler's houses and 0.50 ha for sorting and packing center. The area of sorting and packing center of 0.50 ha will include the farm pond and the pump stations.

The elevation of the site is 18.50 m, but will be raised to 18.80 m with embankment equaling to the height of the proposed farm road.

b) Buildings

The following are the buildings to be constructed in the site.

Structures	Floor Area (sq.m)	No.	Total Area (sq.m)	
Settler's House	150	20	3,000	
Sorting & Packing Center	200	1	200	(including office)
Pump Station (A)	96	1	96	
Pump Station (B)	63	1	63	
Total			3,359	

i) Settler's House (designed for a family of 7 persons)

Floor Area	:	150 sq.m
Type	:	One-story house
Structure	:	Concrete block
Facilities	:	Water supply and electricity
Exterior Finishing	:	Roof; Cement tile Wall; No finishing
Interior Finishing	:	Plaster

ii) Sorting and Packing Center

Floor Area	:	200 sq.m
Type	:	One-story building
Structure	:	Reinforced rod with reinforced concrete foundation
Facilities	:	Water supply, air cooling facilities, and electricity
Exterior Finishing	:	Wave shaped asbestos concrete
Interior Finishing	:	Plaster and plastic paint (for office only)

iii) Pump Stations

Floor Area	:	Station (A); 96 sq.m Station (B); 63 sq.m
Type	:	One-story station
Structure	:	Reinforced rod with reinforced concrete foundation
Facilities	:	Electricity
Exterior Finishing	:	Wave shaped asbestos concrete

c) Water Supply and Electricity

i) Water Supply (supplied by wells)

Facilities	Persons	Consumption (lit/capita/day)	No.	Total Demand (lit/day)
Settler's House	7	250	20	35,000
Sorting & Packing House	7	250	1	1,750
Total				36,750
				= 37,000

Assuming 12 hours of consumption per day, the hourly average is estimated to be 3,085 lit/hr and the hourly maximum 6,200 lit/hr.

Elevated Water Tank: Volume; F.R.P. made 7,000 lit
Height; Steel made 20 m

Lifting Pump : Volume; 350 lit/min.
(full in 20 min.)
Total Head; 50 m
Diameter; 65 mm
Capacity; 11 kw
No. of Pumps; 2 (one in reserve)

Well Pump : Volume; 360 lit/min.
Diameter; 65 mm
Head; 20 m
Capacity; 3.7 kw
No. of Pumps; 1

Settling Basin : Volume; 7,000 lit.

Piping Works : Vinyl coating steel pipe
(average diameter 50 mm)

ii) Electricity (to use the existing service facilities)

Voltage	:	220 V	
Volume	:	Settler's House;	120 KVA (6 KVA x 20)
		Sorting & Packing Center;	7 KVA
		Pump;	15 KVA
		Total;	142 KVA

Layout of the above farm related facilities are attached in the Drawings No. F-1012 to No. F-1013.

4.7. Cost Estimates

The total investment cost, allowing for the price escalation during the construction period, was estimated at 10.0 million R.O. (US$29.2 million) of which 8.5 million R.O. (US$24.8 million) will be a foreign currency component and 1.5 million R.O. (US$4.4 million) will be a equivalent local component.

Table 4-15 shows the breakdown of the investment costs by major items, and their detailed estimate is given in Appendix J. As for reference, the investment cost of the water resources development scheme is shown in Table 4-16. The annual disbursement schedule for the investment cost is shown below.

Year	Foreign Currency ('000 R.O.)	Local Currency ('000 R.O.)	Total ('000 R.O.)
1983	580	140	720
1984	2,710	560	3,270
1985	5,180	820	6,000
Total	8,470	1,520	9,990

Note: Details are given in Table J-4, Appendix J-3.

The cost estimate of the project was made in the following manner;

Table 4-15 Investment Cost of the Project

Description	Total		Foreign Currency		Local Currency	
	R.O.'000	(US$ '000)	R.O.'000	(US$ '000)	R.O.'000	(US$ '000)
1. Construction Works						
1-1. Preparation	505	1,477	420	1,228	85	249
1-2. Dam	3,159	9,237	2,744	8,024	415	1,213
1-3. Water Supply Facilities	67	196	62	181	5	15
1-4. Farm & Related Facilities	1,383	4,044	1,183	3,459	200	585
1-5. Overhead	1,023	2,991	882	2,579	141	412
Sub-total	6,137	17,945	5,291	15,471	846	2,474
2. Pre-engineering Works	146	427	125	365	21	62
3. Administration Cost	26	76	0	0	26	76
4. Consulting Services	910	2,661	725	2,120	185	541
Sub-total (1-4)	7,219	21,109	6,141	17,956	1,078	3,153
5. Contingency	1,083	3,166	921	2,693	162	473
Sub-total (1-5)	8,302	24,275	7,062	20,649	1,240	3,626
6. Price Escalation	1,688	4,936	1,406	4,111	282	825
Total (1-6)	9,900	29,211	8,468	24,760	1,522	4,451

Table 4-16 Investment Cost of the Water Resources Development Scheme

Description	Total		Forign Currency		Local Currency	
	R.O.'000	(US$ '000)	R.O.'000	US$ '000)	R.O.'000	(US$ '000)
1. Construction Works						
1-1. Preparation	745	2,178	604	1,766	141	412
1-2. Dam	3,159	9,237	2,744	8,024	415	1,213
1-3. Overhead	781	2,283	670	1,958	111	325
Sub-total	4,685	13,698	4,018	11,748	667	1,950
2. Pre-engineering Works	126	368	108	316	18	53
3. Administration Cost	21	61	0	0	21	61
4. Consulting Services	670	1,959	534	1,561	136	398
Sub-total (1-4)	5,502	16,086	4,660	13,625	842	2,462
5. Contingency	825	2,414	699	2,044	126	368
Sub-total (1-5)	6,327	18,500	5,359	15,669	968	2,830
6. Price Escalation	1,278	3,737	1,058	3,094	220	644
Total (1-6)	7,605	22,237	6,417	18,763	1,188	3,474

1) Construction Works

Preparation: to include the cost of necessary preparation works, office building, access road, survey works, and etc.

Dam: to include the cost of dam body, spillway, conduit, emergency outlet, and dispersion facilities.

Water Supply Facilities: to include the cost of lifting pumps and water conveyance pipelines.

Farm and Related Facilities: to include the cost of farm facilities such as irrigation facilities, roads, windbreaker and buildings with water and electric supply facilities.

Overhead: to include 20 percent of the required cost of construction works.

2) Pre-engineering Works

Pre-engineering works include the survey works for major facilities such as dam, dispersion facilities and farm land, and geological investigation.

3) Administration Cost

Three percent of the required local currency in the items of 1) and 2) is allotted as administration cost, in order to evaluate the overhead charge for government staff who engage in the newly organized project office.

4) Consulting Services

Engineering fee for consulting services covers the implementation of i) preparation for pre-engineering works, ii) final detailed design, iii) tendering, iv) supervision of the project and v) operation and maintenance of facilities.

5) Contingency

Contingencies are included in the total base to allow for minor differences in actual and estimated quantities, unforeseeable difficulties in construction, possible changes in the plan because of site conditions or uncertainties regarding the foundation. The percentage of contingencies on civil work adopted for the Project is 15 percent.

6) Price Escalation

Price escalation was estimated using the following international price index of Asian Development Bank (ADB) and the rate reported by the Oman Government.

Price Escalation Index

(Unit: %)

	1982	1983	1984	1985
Foreign content 1/	8.0	8.0	7.5	7.0
Local content 2/	9.0	9.0	9.0	9.0

1/ : derived from Asian Development Bank, Updated IBRD Commodity Price Forecasts, memographed, July 1981.

2/ : derived from Sultanate of Oman the Second Five-Year Development Plan (1981 - 1985).

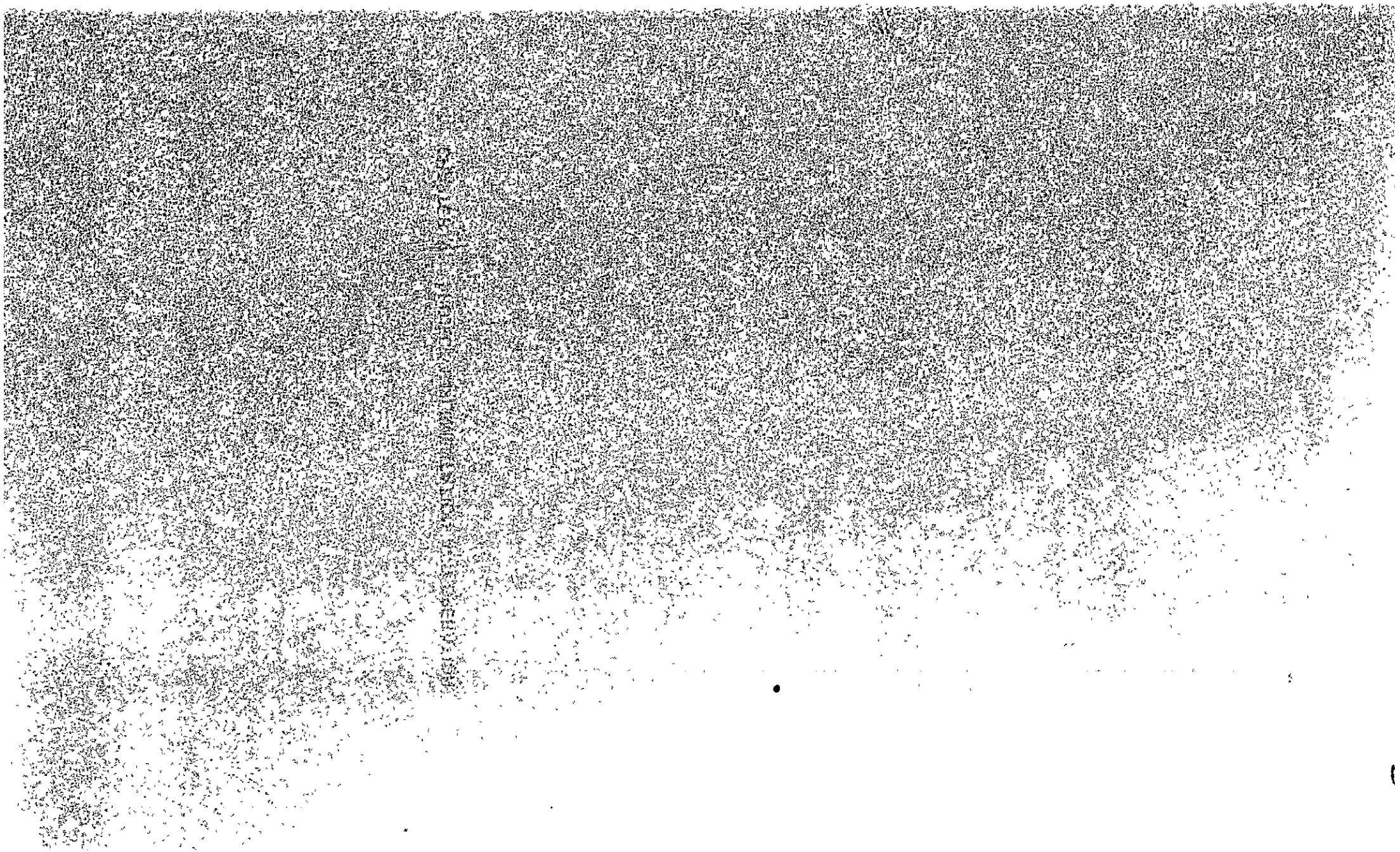
7) Unit Cost

The cost of construction materials to be used in the project was estimated on the basis of the prevailing price as of January, 1982, prepared by the Oman Government. The labor cost is estimated on the basis of the wage rate of labor for every type of job.

8) Foreign and Local Procurement of Materials

Item	Foreign Procurement (%)	Local Procurement (%)
Skilled labor	90	10
Unskilled labor	80	20
Cement	50	50
Steel bar	100	0
Fuel and oil (Refined)	20	80
Sand and gravel & water	0	100
Construction equipment	100	0

CHAPTER V. PROJECT IMPLEMENTATION AND OPERATION



CHAPTER V. PROJECT IMPLEMENTATION AND OPERATION

5.1. Project Organization

5.1.1. Executing Agency

Since the major works involved in the Project are dam construction and farm land reclamation, the Directorate General of Water Resources and Irrigation, Ministry of Agriculture and Fisheries will be an executing agency for the implementation of the Project under the assistance and cooperation of the Directorate General of Agriculture in their respective fields. The Director General of Water Resources and Irrigation will be appointed as Project Director, who will be fully responsible for overall administration of the Project, and will direct to give the Project Manager full responsibility for all the works in the job site.

5.1.2. Project Office

A Project Office will be established in Sohar by reorganizing the existing Branch Office of the Water Resources, the Department of Water Resources and Irrigation. A fully qualified and experienced higher ranking technical official in the Department of Water Resources and Irrigation will be appointed as fulltime Project Manager, and the Project Office will be adequately staffed for efficient project implementation. The Project Manager will also have the responsibility for ensuring timely preparation of specifications, calling for a meeting of tender evaluation and negotiation, and execution of contracts with the assistance of the Consultants.

Figure 5-1 illustrates a proposed organization of the Project Office for implementation.

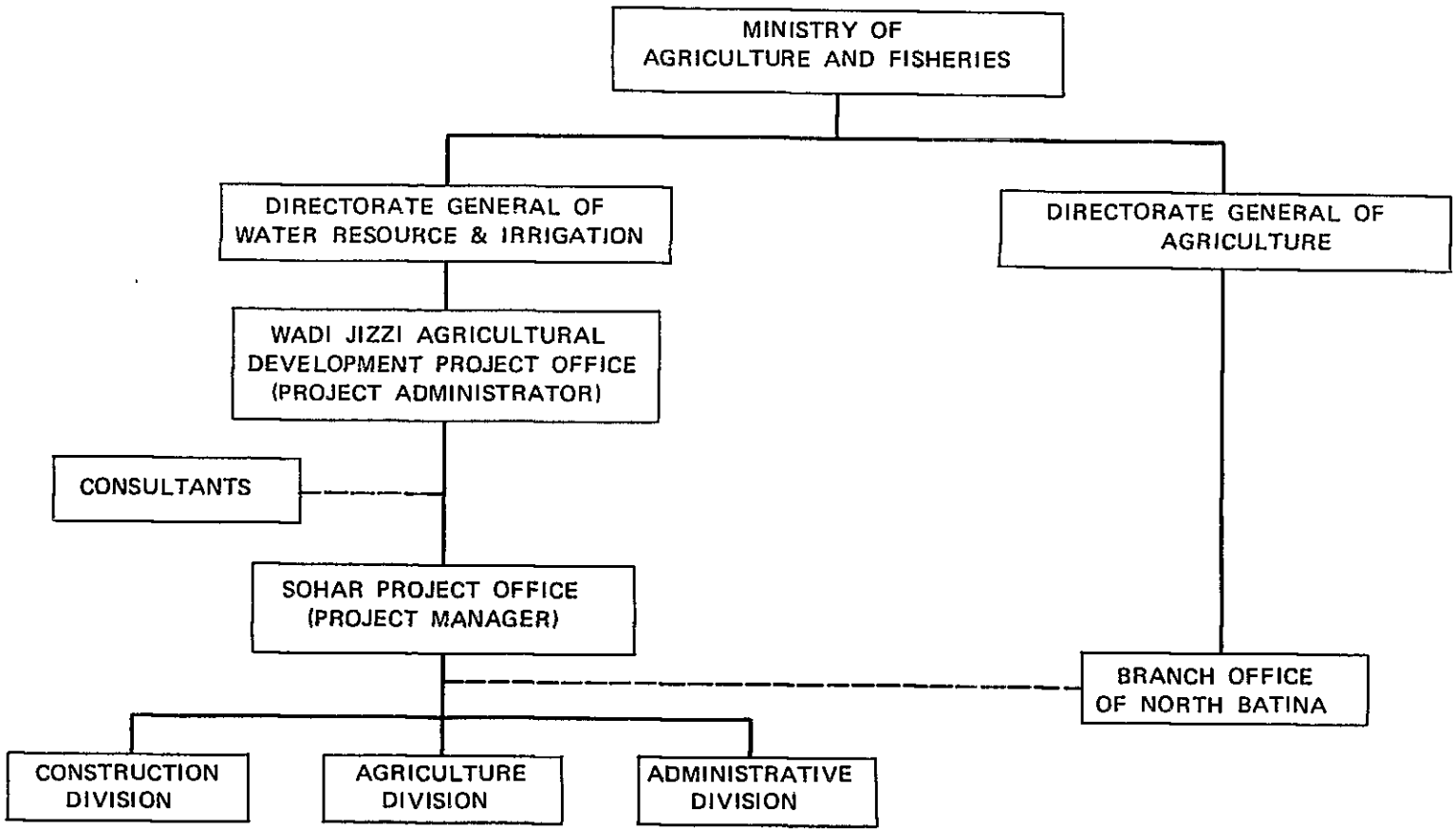


FIGURE 5 – 1. PROPOSED ORGANIZATION CHART FOR PROJECT IMPLEMENTATION

5.2. Construction Method and Schedule

5.2.1. Construction Method

The Wadi Jizzi Project includes various kinds of civil works such as construction of dam, water supply facilities, and farm. There are two ways in implementing such civil works; one is on the force account basis and the other on the contract basis.

The construction of the project has been planned to be undertaken by contract basis, after due consideration of present construction systems for the various fields such as petroleum, mining, road, and water resources in the Sultanate of Oman.

5.2.2. Construction Schedule

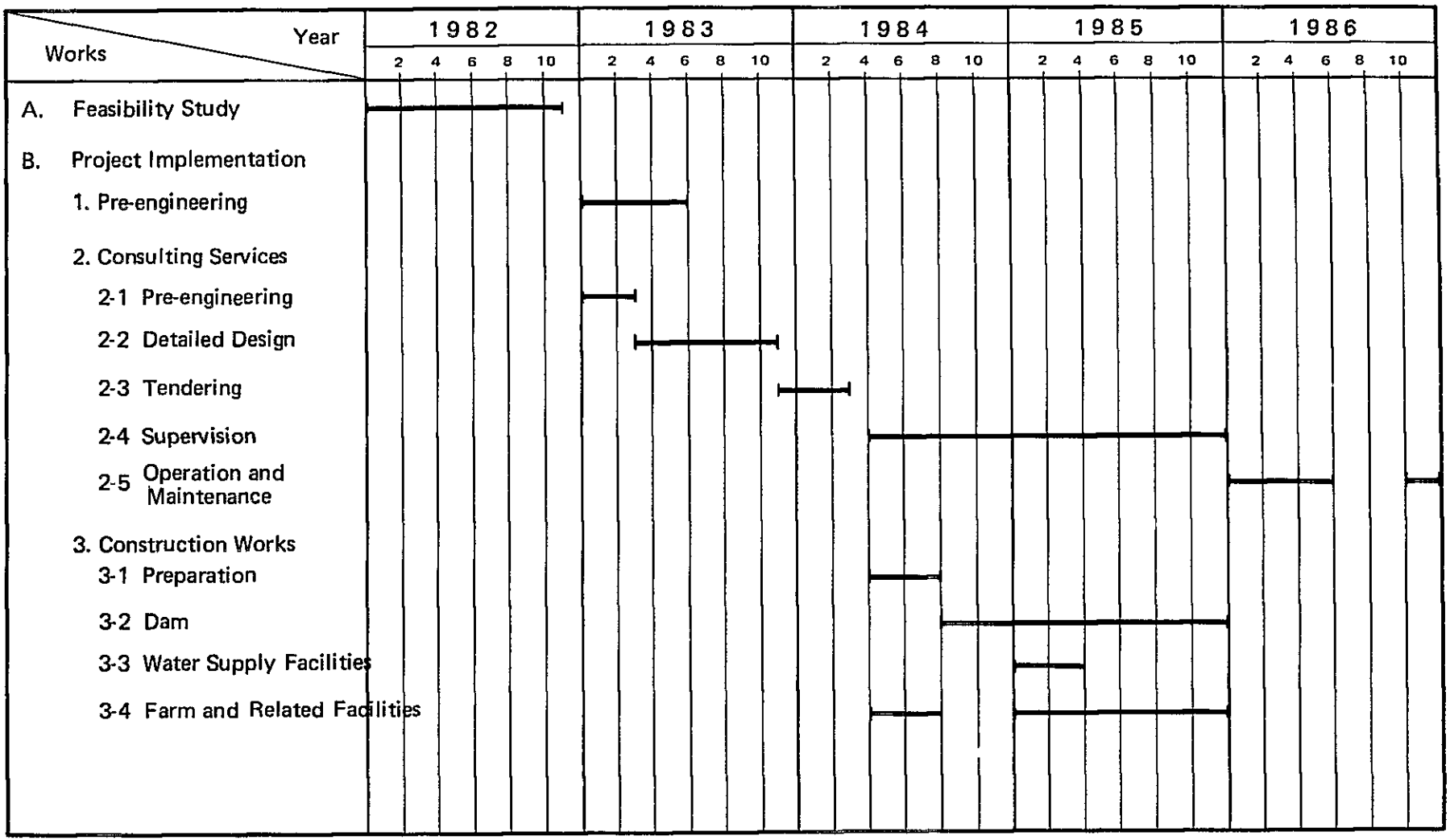
The study on construction schedule was carefully made considering the work volume, workable days, and budget, and as a result, three years from FY-1983 to FY-1985 has been scheduled as construction period, including the periods of detailed design and tendering, as shown in Figure 5-2. As an operation period of the constructed facilities, one year in 1986 has been scheduled.

The construction plan of the major civil works is given in Appendix K-1. In order to complete the Project by FY-1985, due consideration shall be given to the following items.

i) Surveying and geological investigations at the sites of major facilities should be completed before the commencement of detailed design. The description of required items are given in Appendix K-2.

ii) Detailed design for the Project should be completed within FY-1983 and tendering should be completed by March, 1984.

FIGURE 5 – 2 IMPLEMENTATION SCHEDULE OF THE PROJECT



5.3. Operation and Maintenance of the Project

5.3.1. Organization of Operation and Maintenance

a) Establishment of Water Utilization Committee (WUC)

Completion of the Wadi Jizzi Agricultural Development Project, involving the water resources development by groundwater recharge as a major component, will essentially require the Omani authorities concerned to perform the operation and maintenance of those facilities for recharging groundwater, pumping, rainfall observation, water level observation in the related wadis, and well groundwater table observation. Currently, the water resources development projects and agricultural development projects in the Sultanate of Oman have been administered by the Ministry of Agriculture and Fisheries (MAF), while the domestic water supply project in Sohar by the Ministry of Electricity and Water (MEW), and the industrial water supply for Oman Mining by the Ministry of Petroleum and Minerals (MPM).

Consequently, the operation of the projects in the Wadi Jizzi basin will have to be under the control of the said Ministries. In this connection, it is proposed to establish a committee in charge of administering water utilization, which is temporarily named Water Utilization Committee (WUC) and will consist of the members to be assigned by the Ministries of MAF, MEW and MPM, and shall be responsible for controlling the water utilization in the whole basin for the most effective and efficient water use.

b) Organization for Operation and Maintenance of Project

The operation and maintenance office (O & M Office) will be provided in the existing branch office of Water Resources and Irrigation in Sohar, which will function as the Project Office during the implementation, and will take over the responsibility for

operation and maintenance of facilities, water management and agricultural extension services with the staff to be reinforced as shown in Figure 5-3. Operation and maintenance of the main facilities such as detension dam, dispersion facilities, wells and lifting pumps, etc. will be undertaken by the O & M Section under the direct control of the MAF. However, the priorities in water use and comprehensive operation will be made by Water Management Section based on the decision of the WUC. On the other hand, operation and maintenance of the new extension farm land inclusive of the farm ponds, delivery pumps, and irrigation systems will be carried out by farmers themselves. Crop water management and agricultural extension services in the new extension farm land will be conducted under the guidance of North Batinah Agricultural Office, Department of Agriculture.

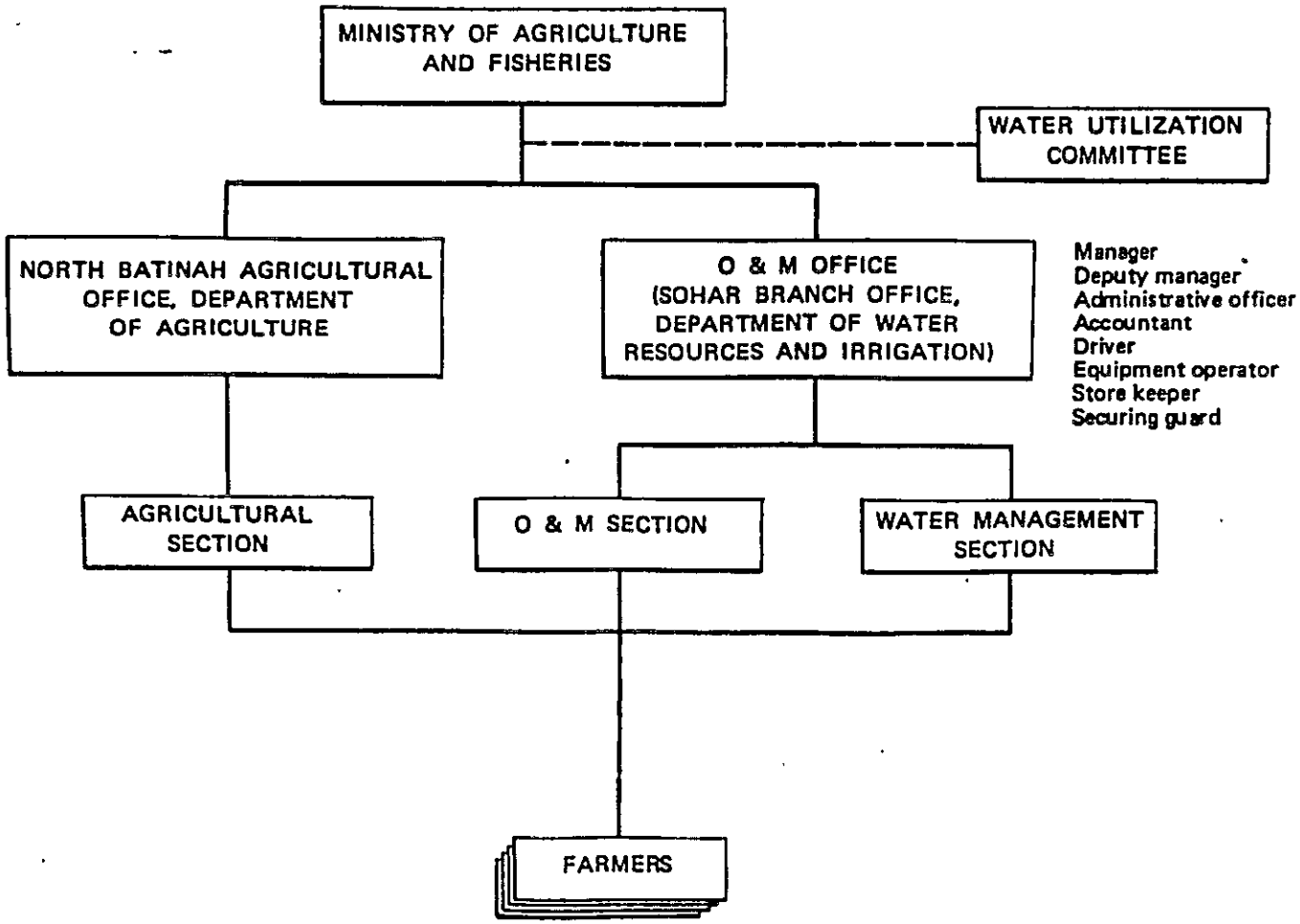
The Wadi Jizzi detention dam requires no operation staff, but such regular maintenance will be necessary as removal of accumulated sediment deposits in the reservoir area and repair of damaged structures. The annual sediment deposits in the reservoir are presumed to be 81,200 cu.m with the catchment area of 812 sq.km.

5.3.2. Operation and Maintenance Cost

The effective operation and maintenance services of the facilities and equipment are inevitably required as the Project service is provided through detension dam, dispersion facilities, intake facilities, new extension farm land and various observation equipment.

The operation and maintenance will be carried out in the method mentioned above, and the necessary O & M cost was estimated at 141,240 R.O. on the annual basis as shown below:

FIGURE 5-3 ORGANIZATION CHART FOR OPERATION AND MAINTENANCE



Operation and Maintenance Cost[1/]

(Unit: R.O.)

Item	Government[2/] Expenditure	Farmer's[3/] Expenditure	Total
1. Salaries and Wages	25,500	-	25,500
2. Equipment Operations	1,500	4,640	6,140
3. Materials and Supplies	81,200	24,570	105,770
4. Administration and General Expenditure	3,830	-	3,830
Total	112,030	29,210	141,240

Note: 1/ Detailed estimation is shown in Appendix K-3.

2/ The cost will be borne by the Government, and will be recovered by the beneficiaries of the present cultivated areas of 2,640 ha as well as the new extension farm land of 85 ha. Cost per hectare was estimated as:

112,030 R.O./2,725 = 41 R.O./ha

3/ The cost will be borne by the farmers in the new extension farm and will be recovered by themselves. Cost per hectare is estimated as:

Irrigation fee: 29,210 R.O./85 ha = 343 R.O./ha

O & M cost: 41 R.O. + 343 R.O. = 384 R.O./ha

5.4. Consulting Services

In the implementation of the Project, the Consultant's services would be necessary for final design, supervision, and operation and maintenance of the Project.

The Consultant's services required will be rendered in the following five stages, the proposed schedule of which is illustrated in Figure 5-4.

Description \ Year	1983	1984	1985	1986	Man-Month	
	4 8	4 8	4 8	4 8	Oman	Foreign
I. Pre-Engineering Stage						
1. Project Engineer (Leader)					1- 1 3	
2. Geologist					1- 2 1	
3. Design Engineer					1- 3 2	
Sub-total					6	
II. Detailed Design Stage						
1. Project Engineer (Leader)					2- 1 1	7
2. Hydrologist					2- 2 1	1
3. Geologist					2- 3 1	2
4. Hydrogeologist					2- 4 1	4
5. Soil Mechanical Engineer					2- 5 1	1
6. Irrigation Engineer					2- 6 1	3
7. Agronomist					2- 7 1	2
8. Design Engineer (Dam)					2- 8 1	7
9. Design Engineer (Pump & Pipeline)					2- 9 1	4
10. Design Engineer (Farm & Irrigation System)					2-10 1	7
11. Design Engineer (Housing)					2-11 1	5
12. Mechanical Engineer					2-12 1	2
13. Electric Engineer					2-13 1	2
14. Construction Planner					2-14 1	2
15. Cost Estimator					2-15 1	2
16. Surveyor (A)					2-16 5	
17. Surveyor (B)					2-17 5	
18. Specification Writer					2-18	2
19. Specialist for Tender Documents					2-19	2

Description \ Year	1983 (4 8)	1984 (4 8)	1985 (4 8)	1986 (4 8)	Man-Month Oman	Man-Month Foreign
I. Pre-Engineering Stage						
1. Project Engineer (Leader)					1- 1 3	
2. Geologist					1- 2 1	
3. Design Engineer					1- 3 2	
Sub-total					6	
II. Detailed Design Stage						
1. Project Engineer (Leader)					2- 1 1	7
2. Hydrologist					2- 2 1	1
3. Geologist					2- 3 1	2
4. Hydrogeologist					2- 4 1	4
5. Soil Mechanical Engineer					2- 5 1	1
6. Irrigation Engineer					2- 6 1	3
7. Agronomist					2- 7 1	2
8. Design Engineer (Dam)					2- 8 1	7
9. Design Engineer (Pump & Pipeline)					2- 9 1	4
10. Design Engineer (Farm & Irrigation System)					2-10 1	7
11. Design Engineer (Housing)					2-11 1	5
12. Mechanical Engineer					2-12 1	2
13. Electric Engineer					2-13 1	2
14. Construction Planner					2-14 1	2
15. Cost Estimator					2-15 1	2
16. Surveyor (A)					2-16 5	
17. Surveyor (B)					2-17 5	
18. Specification Writer					2-18	2
19. Specialist for Tender Documents					2-19	2
Sub-total					25	55
III Tendering Stage						
1. Project Engineer (Leader)					3- 1 3	1
2. Mechanical Engineer					3- 2 1	
3. Cost Estimator					3- 3 1	
Sub-total					5	1
IV. Construction Supervisor						
1. Project Engineer					4- 1 10	
2. Project Engineer (Site Manager)					4- 2 20	
3. Civil Engineer					4- 3 4	
4. Mechanic for Pump and Pipeline					4- 4 11	
5. Mechanic for Irrigation System					4- 5 11	
6. Geologist					4- 6 8	
7. Hydrogeologist					4- 7 4	
8. Site Laboratory Engineer					4- 8 15	
9. Housing Engineer					4- 9 4	
10. Electric Engineer					4-10 4	
Sub-total					91	
V. Operation and Maintenance						
1. Project Engineer (Site Manager)					5- 1 8	
Sub-total					8	
Total					135	56

FIGURE 5-4 PROPOSED SHCEDULE FOR CONSULTING SERVICES

i) Pre-engineering Stage

Additional survey and investigation will be carried out prior to the commencement of the final design. This stage will require the Consultant's services of six man-months starting from January, 1983. The following highly qualified experts will be mobilized for the preparation works in such surveys and investigations in Oman.

- Project Engineer
- Geologist
- Design Engineer

ii) Final Design Stage

The final design will require the Consultant's services of 80 man-months, 25 man-months in Oman and 55 man-months in home country. The services will start from April, 1983.

The following well-qualified experts will be employed;

- Project Engineer (Leader)
- Hydrologist
- Geologist
- Hydrogeologist
- Soil Mechanical Engineer
- Irrigation Engineer
- Agronomist
- Design Engineer (Dam)
- -do- (Pump & Pipeline)
- -do- (Farm & Irrigation System)
- -do- (Housing)
- Mechanical Engineer

- Electrical Engineer
- Construction Planner
- Cost Estimator
- Specification Writer
- Specialist for Tender Documents
- Surveyor (A)
- -do- (B)

iii) Tendering Stage

The stage of tendering will require the Consultant's services of six man-months, five man-months in Oman and one man-month in home country from December, 1983 to March, 1984. The following experts will be assigned to the services in this stage.

- Project Engineer (Leader)
- Mechanical Engineer
- Cost Estimator

iv) Construction Supervision Stage

The construction supervision will require the Consultant's services of 91 man-months from May, 1984 to December, 1985. The experts required in this stage are as follows;

- Project Engineer (Leader)
- -do- (Site Manager)
- Civil Engineer
- Mechanic for Pump & Pipeline
- Mechanic for Irrigation System
- Geologist
- Hydrogeologist

- Site Laboratory Engineer
- Housing Engineer
- Electric Engineer

v) Operation and Maintenance Stage

After implementation of construction works, one Project Engineer (Site Manager) will assist the Government in the operation and maintenance of the facilities. The consulting service requires eight man-months in total; six months from January, 1986 to June, 1986 and another two months from November, 1986 to December, 1986.

The Terms of Reference for the consulting services are shown in Appendix K-4.

CHAPTER VI. PROJECT JUSTIFICATION

CHAPTER VI. PROJECT JUSTIFICATION

6.1. General

The Development Council has adopted a resolution for the economic development strategy in Oman, which presents a broad outline of the long-term targets and policies. In particular, a high priority was given to the natural water resources development as a vital requisite for everlasting economic activities and growth of the nation.

The Project is proposed to meet the requirements of the second five-year plan involving a construction scheme of small recharging dams so as to store flood discharge temporarily by means of cutting the peak of floods, which flow down uselessly into the sea in a short time, for recharging groundwater through infiltration into aquifers.

The benefits of the Project are expected from all the sectors. The recharging structures, water supply facilities, new farm lands, and irrigation facilities will directly bring about the agricultural benefits as incremental crop production after the completion of the Project.

A part of the date gardens developing along the coast has been suffering from salt damages resulting from intrustion of the sea water into the groundwater. So far as over-extracting of the groundwater continues in future, the said dates garden areas to be injured will be expanded.

The rainfall from 12 through 14 February, 1982, was the largest precipitation that the Area has ever observed by the rain gauge at Sohar Office of the Department of Water Resources since 1974. The various properties in the Project Area were damaged by heavy flood flushing over the Wadi Jizzi basin.

Such damages by the salt and the flooding as above could be reduced by providing the dam under the Project. The reduction in damages could be evaluated to a certain degree into the project benefits of the salt and the flooding prevention.

There are water supply projects contemplated for urban areas and mining industries. The proposed dam capacity was estimated including the water requirements of these water supply projects. Since the proposed dam functions to contribute to steady water supply, the Project will be quite beneficent in terms of the water supply projects as well.

6.2. Economic Evaluation

6.2.1. Method of Economic Evaluation

The measurable economic benefits and costs are expressed in monetary terms and the both streams of benefits and costs on the annual basis over the evaluation period are converted into the respective present worth values. The internal economic rate of return (IERR) is used as the main indicator of the economic justification of the Project.

The Project was evaluated on the basis of the difference between incremental benefits and the required costs for the cases of "With Project" and "Without Project".

6.2.2. Economic Evaluation of Commodities and Labor Prices

The values of traded goods are measured in border prices and are expressed in terms of local currency. The values of nontraded goods which are measured in domestic prices are converted into border prices using conversion factor evaluated by the Consultants.

The standard conversion factor is a reciprocal value of the shadow exchange rate. The shadow exchange rate was calculated by using the trade statistics in Statistical Year Book, the nineth edition, 1980, and the custom duties in Facts and Figures, 1980, Development Council, Technical Secretariat, Directorate General of National Statistics. The shadow exchange rate was estimated at 0.346 R.O. per US$ which is almost the same as the official exchange rate of 0.342 R.O. per US$. This means that the domestic price of traded goods is only about 1.2 percent higher than the international price. The standard conversion factor is estimated at 0.988.

a) Marketing Prospect

In future a considerable volume of vegetables, fruits and fodder products will be supplied from the Project farms to the market in Sohar, the Capital area, and Dubai or Abu Dabi in the UAE.

At first, the vegetables produced in the Project farms will be supplied to the Sohar market. The demand for and supply of vegetables in the Project Area was for recasted for the period of 1978 to 1995. The population will increase from 16,000 in 1978 to 26,400 in 1995. The amount of the consumption and the supply of vegetables in the Project Area are estimated based on some assumptions. If the Project could not be implemented, the present shortage in supply would be furthered in future. Sohar in future will be promising as the vegetable market in view of the supply from the Project Area, and the surplus in Sohar market should be transported to the Capital area.

The dates will be sold to the markets in Sohar and the Capital areas. The market for limes will be available through the present marketing channel, because Saham is the main centre in the North Batinah as well as in the Sultanate for marketing of dry limes.

It is reported that there is no basic reason for Oman to set out on course aimed at achieving complete self-sufficiency. But some products, like meat and meat products, milk and dairy products should be produced in sufficient quantities to meet all the anticipated domestic needs.

The farmers in Sohar Willayat raise goats of 15,300 head, sheep of 12,200, cattle of 2,500, and poultry of 17,000. The number of sheep and poultry occupy more than 20 percent of the total in Oman. This means that Sohar is an important animal raising area in Oman. In order to promote this livestock production, the fodder grass produced in the Project farms should be marketed in Sohar at first, and then in the Capital area and the UAE.

b) Crop Prices

The financial farm gate prices of vegetables and fodder crops are estimated in using the prices of the products sold by the farmers at the Sohar market and the transportation cost from farm house to market. The economic farm gate prices are calculated by multiplying the standard conversion factor by the financial farm gate prices. The prices of dates and limes are based on those purchased from farmers by the Production Farms, Sohar. The economic farm gate prices of crops are as follows. These prices are used in the economic evaluation.

Economic Farm Gate Prices of Farm Products

(Unit: R.O./ton)

Crops	Financial price	Economic price
Tomatoes	200	197
Water-melons	200	197
Cabbages	250	247
Eggplants	100	98
Red peppers	250	247
Dates	500	494
Limes	400	395
Bananas	150	148
Alfalfa	70	69

c) Input Material Price

The fertilizers are traded goods in Oman. The economic prices of these goods have to be forecasted since the international prices fluctuate in future. The economic prices of fertilizers used in the economic evaluation are those based on the commodity price and projected prices in 1980 constant dollars, by the World Bank.

Economic Prices of Fertilizer in 1982 Constant Price

Item	1982		1985		1990	
	Finan.	Econo.	Finan.	Econo.	Finan.	Econo.
Urea, FOB, Europe						
US$/ton	218	218	262	262	276	276
N: O.R./kg	0.27	0.27	0.31	0.31	0.32	0.32
TSP, FOB, US Gulf						
US$/ton	199	199	244	244	254	254
P: O.R./kg	0.3	0.3	0.35	0.35	0.36	0.36
Murait of Potash						
FOB, Vancouver	103	103	94	94	99	99
K: O.R./kg	0.17	0.17	0.16	0.16	0.17	0.16

Note: Finan. ... Financial cost
Econo. ... Economic cost

The kinds of fertilizers that are employed in the economic evaluation are not those recommended by the Omani authorities concerned but those taken up by the World Bank for the price forecasting in 1990.

The agricultural chemicals are also traded goods. The economic prices were estimated based on the prices of chemicals purchased by farm. Manure is imported in dry form from the UAE at present. The new farmers in the Project would purchase the cattle manure from the Oman Sun Farm. Then, the economic price of cattle manure was estimated based on the present prices sold by the Oman Sun Farm.

d) Farm Labor

The annual labor hours required to grow fruits, vegetables, and fodder crops in the areas of about 2,600 ha are about 3.4 million hours at present. According to the First Agriculture Census, 1978 - 1979, the agricultural labor sources in Sohar Wilayat are family labor and hired labor. In the Project Area the former was estimated at 2,100 persons or 60 percent of total labor and the latter 1,280 persons or 40 percent. These labors are classified into three types of full time, part time and casual labors. Monthly actual labor inputs will be estimated on such assumptions that the labor hours per day are eight hours except the summer season when the labor hours are shortened to five hours. The actual annual labor hours are totaled to about 4.6 million hours of family labor and 2.33 million hours of hired labor.

On the other hand, the available yearly maximum hired labor is expected at about 3.69 million hours. The monthly average salary for the hired labor in the Project Area is about 60 R.O., without meals.

This market wage will be paid to the hired labor of 2.33 million hours. On the assumption that the remainders of 1.36 million hours are under unemployment, the marginal productivity of labor was estimated at monthly salary 38 R.O. (60 R.O. x 2.33/3.69 = 38 R.O.)

6.2.3. Evaluation of Benefit

a) Benefit from Incremental Agricultural Production

Vegetables, fodder crops and fruits projected in the cropping pattern study will be grown in the farm land of 85 ha equipped with the modern irrigation system. As these farm lands are reclaimed from the wasteland, the production without the project was evaluated to be zero. The expected production of these crops will be increased from 956 tons in the first year to 2,540 tons in the eleventh year when

the full benefit is realized. The total gross crop income is expected to be increased from 133,000 R.O. to 532,000 R.O. during the same period. The net production value in each year is shown in Table 6-1.

The production cost consists of those seeds, fertilizer, agricultural chemical, machinery operation, irrigation fee and labor. The irrigation fee was calculated listed O & M cost flow.

Table 6-1. Net Production Value

(Unit: '000 R.O.)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Gross Production	133	213	276	324	324	394	394	394	394	394	532
Production Cost	90	83	99	112	112	103	103	103	103	103	103
Net Production	43	130	177	212	212	291	291	291	291	291	429

Net production values are obtained by deducting production cost from gross production. The annual increase of net production value would reach to 429,000 R.O. in the fully-benefited year of 1996 as clearly shown in the above table.

b) Damage Prevention Benefit

(1) Prevention of flood damage

Flood damage will result from the following several causes.

i) A large flood inundates the Irish-crossing point on the national highway and is discharged into the sea. During flooding, the traffic is interrupted. But after a completion of the projected dam the damages to be caused by precipitation below the five year probability could be controlled by the dam. Then, the interruption of traffic in the Project Area will be diminished. However, this

effect will be of a limited extent, so far as the adjacent wadi basins are still flooded. From the viewpoint of the national economy, this limited effect will not be negligible.

ii) The field investigation by the consultants revealed that about 600 ha of the farm lands were inundated by the flood of February 12 through 14, 1982. These damaged lands comprised the cropped fields, fallow lands, and the sites for buildings, farming facilities, roads, etc. In general, vegetables are vulnerable to floods, and tomatoes, eggplants, redpeppers, cabbages, etc. were in harvesting season at the time of flooding in February, 1982, while water melons for winter cropping were in their seedling stage. Under the situation, crops in the stages of harvesting, nursery-bedding, young plants, etc. were damaged by the flooding because the flushing water eroded ridges and washed plant roots out of the earth. The farmers had to repair the ridges eroded with many labourers thrown into the works, accordingly. The loss caused from these crop damages and repair works of the fields can be estimated in monetary terms with an assumption.

iii) On February 14, two passenger cars which attempted to cross the flooded stream were washed away. The relevant damage can be estimated.

iv) The several wadi pass through the farms adjoining along the national highway. One side of these farm's boundary is located along the natural bank of wadis. As the flush stream erode these banks, farmers must repair the bank. This cost will be estimated with an assumption.

v) The buildings in above farms were flooded below the floor level. These damages can be evaluated on some assumption.

The damages in the Project Area caused by February, 14 to 15, 1982 flood are estimated as follows.

Production loss	137,000 R.O.
Repair cost for ridges eroded	3,800 R.O.
Car loss	6,000 R.O.
Damage below the floor level	200 R.O.
Repair cost of bank of wadi	8,300 R.O.
Others	3,000 R.O.
Total	158,300 R.O.

As the frequency of flood occurrence of the above scale is considered to be once for five years and the annual average damage value was estimated at 32,000 R.O. This value will be counted, in turn, as the damage prevention benefit.

(2) Protection of salt damage

According to the results of the groundwater quality check, the date gardens of about 300 ha located along the coast are irrigated by groundwater with chloride content of 1,000 m.g. per liter or more. If an invasion of the sea water into groundwater continues from now on, these date palms would be damaged in the near future unless the proper irrigation are carried out. In the inland part of the above area, about 800 ha of date garden irrigated by groundwater with quality between 700 and 1,000 m.g. per liter is found in the ISO-EC Map.

The field investigation has not allowed the JICA Survey Team to obtain the data that the date plams have been dieing or seriously damaged by sea water intrusion into the groundwater.

After the completion of the Project works, however, the invasion of sea water will be controlled. As a result, the damages that can be avoided by the Project are considered as the benefit.

The dates production in the 1,100 ha totalized by both areas mentioned above would be expected to increase to a certain extent after the completion of the dam. This incremental benefit was estimated at 109,000 R.O. with some assumption. This is conservatively estimated into the IERR for project evaluation.

It will be one of the major subject for well-maintaining the environment of the existing farm lands in Sohar that the benefits of the salinity control can be taken into account as the benefits by the development investment.

c) Water Supply Benefit

There are two water supply projects, water sources of which depending upon the groundwater found around the Wadi Jizzi Basin. Full-scale operation of these two projects, however, would result in accelerating a heavy decline of the water table, and this cause salt and drought damages as well as an irrigation cost increase due to the provision of deeper tube wells to pump up the water.

Under the conditions, the proposed dam in this Project for agricultural development should provide storage capacity to cover the water demands of about 1.26 MCM for these two projects by 1987. In this connection, the groundwater balance study revealed that the estimated shortage in the groundwater ranged from 0.2 to 1.0 MCM if the proposed recharging dam would not be constructed.

Consequently, the new groundwater resources to be created by this Project will contribute to a steady development of the water supply projects in this area. It is considered that the project dam also has a supplementary function to prevent the above damages.

Construction of the proposed dam could increase the benefit to be generated from the Project, which will be equivalent to the value of the damages to be prevented by recharging the groundwater through

the Project operation. Since these damages cannot be estimated readily in monetary terms, the marginal cost of water was employed for computing the benefit to be created from the groundwater recharging of 1.26 MCM.

The annual cost of the water per cubic meter supplied from the existing Ghubrah Desalination Plan is used as the marginal cost of water for estimating the water supply benefit. The data of the variable cost are available in the feasibility report on the Wadi Al-Khawd and through the information supplied by the Ministry of Electricity and Water. The said report quotes it at 330 Baizas per cubic meter, whereas the Ministry's information at 503 Baizas per cubic meter. This study adopted the former cost of 330 Baizas in considering it more reasonable than the latter 503 Baizas.

The fixed cost consists of depreciation costs and interests. The construction costs of the Ghubrah extension desalination plant was treated as the up-to-date capital cost. The capital cost per cubic meter is 1.0 R.O. The annual fixed cost was estimated at 117 Baiza assuming the interest rate of 10 percent and the economic life of the facilities of 20 years. The total water costs per cubic meter using the above two kinds of the variable costs were computed by 447 Baizas and 620 Baizas, respectively.

The water supply benefit was eventually estimated at 563,000 R.O. based on the unit cost by 447 Baizas per cubic meter.

d) Total Benefit

The annual benefits of the respective sectors are totaled as shown in Table 6-2.

Table 6-2. Annual Benefit

(Unit: '000 R.O.)

Project Year	Agriculture (85 ha)	Flood Prevention	Salt Prevention	Water Supply	Total
1. (1983)	-	-	-	-	-
2. (1984)	-	-	-	-	-
3. (1985)	-	-	-	-	-
4. (1986)	43	32	109	563	747
5. (1987)	130	32	109	563	834
6. (1988)	177	32	109	563	881
7. (1989)	212	32	109	563	916
8. (1990)	212	32	109	563	916
9. (1991)	291	32	109	563	995
10. (1992)	291	32	109	563	995
11. (1993)	291	32	109	563	995
12. (1994)	291	32	109	563	995
13. (1995)	429	32	109	563	995
14. (1996)	438	32	374	563	1,133
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
50. (2032)	429	32	109	563	1,133

6.2.4. Evaluation of Construction Cost

The direct costs employed for estimating the internal rate of return consist of those of engineering design, property, and construction of the Project, but exclude the interest to be incurred during the construction period.

Both interest and taxes are considered as transfer payments, therefore, they are not included in the economic costs. The cost of this Project includes a depreciation cost of the construction equipment.

The local currency costs are converted into the border prices by using the standard conversion factor. Unskilled labor cost is re-estimated using shadow prices.

The financial project cost excluding the escalation factor was estimated at 8.302 million R.O. and is shown in Table 6-3. The economic cost used for evaluating the internal rate of return was estimated at 6.786 million R.O. as shown in following table. The annual operation and maintenance cost is used at 140,000 R.O. based on Chapter 5.3.2. Replacement cost consists of those six set pumps, drip and sprinkler equipment.

Economic Cost

(Unit: '000 R.O.)

	Project Year	Project Cost	O & M Cost	Replacement Cost	Total Cost
1	(1983)	691	-	-	691
2	(1984)	1,840	-	-	1,840
3	(1985)	4,255	-	-	4,255
4	(1986)	-	140	-	140
5	(1987)	-	140	-	140
"		-	140	-	140
"		-	140	-	140
13	(1995)	-	140	244	384
"		-	140	-	140
"		-	140	-	140
23	(2005)	-	140	244	384
"		-	140	-	140
"		-	140	-	140
33	(2015)	-	140	244	384
"		-	140	-	140
43	(2025)	-	140	244	384
"		-	140	-	140
50	(2032)	-	140	-	140

6.2.5. Internal Economic Rate of Return

The internal economic rate of return was computed by using the linear interpolation method. The incremental benefit was estimated by subtracting the project cost from the benefits for each project year. The project cost consists of an initial capital and an operation and maintenance cost. The Project economic life was taken to be 50 years.

Table 6-3 Economic Project Cost

(Unit: '000 R.O.)

Description	Total			1983			1984			1985		
	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.
1. Financial Project Cost excluding price escalation	8,302	7,062	1,240	693	561	132	2,809	2,335	474	4,800	4,166	634
2. Resident building cost	689	550	139	-	-	-	689	550	139	-	-	-
3. Financial Project cost used in economic evaluation	7,613	6,512	1,101	693	561	132	2,120	1,785	335	4,800	4,166	634
4. Project cost revised on tax, interest and unskilled cost	6,799	5,816	982	693	561	132	1,844	1,555	289	4,262	3,701	561
5. Standard conversion factor	-	-	0.988	-	-	0.988	-	-	0.988	-	-	0.988
6. Economic Project Cost	6,785	5,816	969	691	561	130	1,840	1,555	285	4,255	3,701	554

The internal rate of return was computed to be 11.5 percent. This percent corresponds to an interest of commercial bank in Oman. It will be considered that this project is barely economically justifiable.

6.3. Sensitivity Analysis

A sensitivity analysis is an effective measures of testing the risk of a project. The analysis for the Project was made for the following cases; In particula, the benefit in a case of water cost of Falaji system shall bring a low IRR.

IERR in Sensitivity Analysis

Items	EIRR %
1. 10% decrease in target yields	11.0
2. 20% decrease in target yields	10.6
3. 10% increase in construction cost	10.5
4. 20% increase in construction cost	9.6
5. One year delay in start of construction	11.4
6. To use unit water cost of 161 Baizer per cubic meter supplied by Falaji system	7.0

6.4. Other Socio-Economic Impact

The project economy should be also evaluated by adopting the indirect benefits. Besides the direct benefits mentioned above, the project will create the indirect benefit and give the socio-economic impacts on both the farm economy in the vicinity of Project Area and the regional and national economy.

From the viewpoint of farm economy, the following impacts can be considered:

i) The recovery of groundwater table will contribute to saving the irrigation cost and to protect the crops from drought damages. This effect will not only reach the present

cropped land of 2,640 ha but the undeveloped arable lands. As a result, the yields of crops will rise and the fallow land or abandoned land will be converted to the cropping lands.

Such yield increase will result in an increase in farm cash income and an expansion of animal husbandry. It is difficult to estimate these benefits in the monetary terms, because the beneficiaries are unspecified.
The indirect benefits will result in an improvement of the standard of living and in an improvement of the regional welfare.

ii) Establishment of the new farms with 20 households will help improve the agricultural techniques and develop a common marketing for the traditional farmers in the Project Area. Such development should be carried out through the extension activities by the Government.

From a viewpoint of the national or regional economy, the following items are enumerated.

- Flood control will contribute to the stabilization of the regional welfare

- The Project will contribute to self-sufficiency in national food supply. This means that foreign currency can be saved to some extent.

- The Project will serve as a model of the water resources development strategy in the Second Five-Year Plan.

- Income of the local people will increase through an employment by this Project during the construction period. Labor income will be roughly expected at over 100,000 R.O. during the construction period.