Most farmers do not recognize the need to efficiently manage their farms as they have no commercial awareness.

(3) Poor Access to Agricultural Markets

There are few farmers in the Study Area with a farming spirit and depending entirely on agriculture or commercial farms. There is no farmer's organization such as a cooperative, producers' association, water-use association, or marketing association in the Study Area. Farm owners have no opportunity to access the market for information on prices or demand. They have no choice but to sell their products to wholesalers at prices lower than the production costs. Due to lack of market information, many farmers produce similar crops at the same time.

(4) Low Competitivity against Imported Agricultural Products

Because of the open-market and duty-free policies on agricultural products upheld by the government, an abundance of high-quality vegetables and fruit flows into UAE markets from all over the world. In most cases the prices of imported products are lower than domestic production costs, and are of better quality. Occasionally, domestic agricultural products are expelled from the market and abandoned or fed to animals.

(5) Insufficient Technical Extension Service

Many farmers in the Study Area are eager to acquire guidance on crop cultivation, post-harvest techniques and market information. The present agricultural extension services are concentrated on distribution of the government subsidy in providing seeds, fertilizers, seedlings and agricultural chemicals to the farmers. It is possible to say that the technical extension services are insufficient. In parallel with the extension services, experimental research at MAF Research Stations cannot said to be coping fully with the farmers' demands.

5.1.2. Basic Strategy

(1) General

As already stated in the previous section, the annual groundwater use in the Study Area is estimated at about 54 MCM/a which is far in excess of the sustainable development potential of the groundwater, which is estimated to be about 22 MCM/a. This over-extraction has been ongoing since the 1970s, and has resulted in deterioration of groundwater, such as depletion of the groundwater table by nearly 40 m and degradation of groundwater quality in the Study Area. According to the simulation results, the groundwater table in the Study Area will drop more than

100 m after 20 years (in 2015) and be dried up within 45 years (by 2040). In this case, an alternative water source (possibly desalinated water) will need to be imported for the continuation of agricultural production in the Study Area.

Currently, the sustainable development of natural water resources is no more than common sense to everybody. The policy or guidelines of UAE on this subject, however, are not clear.

Given these conditions, the basic strategy of the Study in agriculture and water development is set forth in two (2) policy options as stated below:

Option -1 : Agricultural development plan within the sustainable development potential of groundwater in the Study Area;

Option-2 : Agricultural development plan on the present scale supported through the introduction of an alternative water source.

The agricultural development plans in both options intend for a type of agriculture that is sustainable, water-saving, high-income and market-oriented. Feasibility would take into account not only economic but also sociological and environmental factors. In consideration of a shift in agricultural scale or new water resources, both short- and long-term measures should be taken into account, for either option.

(2) Target Year

The Study aims to solve the degradation of regional agriculture caused by deterioration of quality, quantity and water table of the groundwater, and in addition, if possible, to develop agriculture more fully.

According to the Well Inventory Survey, the average depth of submersible pumps in the well varies from 74 m in Mileiha to 206m in Dhaid. It can be said that their average depth is about 140m. Generally, the limitation for normal lift of prototype submersible pumps with a capacity of 5 to 15 lit./sec is 100 m. Hence, it is necessary to take action to stop the groundwater deterioration before present pumps cease to supply water.

The results of groundwater balance analysis by mathematical simulation show that the groundwater head in the Study Area will go down to 100 m below ground by 2015 if the present pumping rate continues.

Consequently, the target year of the Study is set at 2015, about 20 years from the present.

(3) Basic Strategy of Water Development

a) Groundwater Development

The amount of potential groundwater for development in the Study Area is said to be 21.5 MCM/a, adding the expected amount of groundwater augmented by recharge dams and recharge trenches of 2.0 MCM/a to the sustainable yield which is currently 19.5 MCM/a.

b) Alternative Water Source

A supplemental water source to the sustainable groundwater source for agricultural development in Option-2 is desalinated water. The desalinated sea water produced in Sharjah City would be transported to the Study Area by pipeline.

(4) Basic Strategy for Agricultural Development

The most important issues concerning UAE agriculture are to implement a manageable, stabilized, sustainable agriculture and an efficient utilization of limited groundwater resources. The main issue in agricultural development for the present Study is to formulate a master plan for a sustainable water-saving, high income and market oriented agriculture. In order to achieve these aims the following problems must be addressed:

i) Grasp of the most effective use of water and restriction of Irrigated Area,
ii) Effective utilization of irrigation water,
iii) Development of a high-income agriculture,
iv) Access to markets and production of commercial-quality products; and
v) Socio-economic considerations.

(5) Groundwater Monitoring and Database Plan

In order to achieve sustainable groundwater development in the Study Area, it is necessary to monitor groundwater and to establish databases for these observation data. The project is to include the formulation of a monitoring system and establishment of a database.

5.2. Water Resources Development

5.2.1. Groundwater Resources

(1) Sustained Yield

The groundwater resource in the Study Area has been sustained by three aquifers; namely, Upper, Lower and Fissure Aquifers. The Upper Aquifer, which is comprised of Pleistocene to Holocene sediments, has been widely exploited for irrigation since historical times. The water in this area, however, trickles along the mountainside due to its low yield, which results in overdrafting, especially in the center of Dhaid.

The rapid development from the lower aquifer has progressed in the last decade to cause serious drawdown in the groundwater head. Furthermore, the fissure water suffers from very limited distribution in spite of its high yield. In the Study Area, the its sources are found at only three localities, such as the faulting zone running along Jabal Mileiha, the structural zone extended from the west of Diba zone, and the thrust-faulting zone running in the W-E trend in the boundary area of the Oman Mountains and Bahada Plain as well. The resource of Fissure Water is considered to be essentially provided from the Upper and Lower Aquifer, mainly by the Upper Aquifer. Consequently, the Fissure Water itself has no potential reserves. In addition, the existence of a deeper aquifer below 600 m in depth is not considered to be practical for development according to the observation data collected in the Study. Moreover, the salinity of the water tends to be higher compared with the shallower horizon.

Taking all the above conditions into account, all the groundwater to be developed in the Study Area originates from only two aquifers, the Upper and the Lower Aquifers. Furthermore, the restricted part in the Lower Aquifer in the undeveloped area has some potential for groundwater development.

The forecast analysis (refer to the simulation result of Case 1) was made on a case that the groundwater extraction at the current level is maintained till the groundwater head dropped to 300 m depth. The drying-up, regarded as a pumping level of below 300 m, begins in 2003 at the Upper Aquifer, and this extends to whole aquifer by 2010. The drying-up of the Lower Aquifer commences in 2023 and covers the entire aquifer by 2040. Thus, all groundwater resources to be pumped economically in the Study Area may continue to be mined up to 2040.

This evaluation was made based on the concept of "mining yield", which is expressed by total quantity of non-renewable groundwater in the groundwater basin and by the extent of economical and practical pumpage.

As a definite countermeasure to be enforced to the future, the concept of "sustained yield" is to be introduced instead of the undesirable situation of the simulated result. To formulate the groundwater development plan in consideration with various phenomena in the Study Area, the following basic course was mapped out:

- the groundwater draft is set out by a renewable yield or sustained yield,
- the gradual shifting of pumpage is to be planned from the present yield to the sustained yield,
- the groundwater head is to be controlled to a realistic level of 100 m depth,
- the pumping level within the control head is to be maintained during/after the shifting period of pumping,
- prevent the saline water intrusion from the lower reach,
- prevent pumping in areas affected by saline water.

Simulation Case 2 made under above basic courses indicated a sustained yield of 19.5 MCM/a, which is one-third of the present draft (54 MCM/a). A smooth transition of the groundwater draft to 19.5 MCM/a is to be made within 20 years (refer to Figure 5.2.1.). If the period is postponed more than 20 years, the groundwater head may drop beyond the control head in some places in the Study Area. The appropriate yield for each year is given below:

Year	1995	1997	1999	2001	2003	2005	2007	2017
Groundwater Draft (MCM)	54	51	45	36	34	27	22	19.5

(2) Groundwater Augmentation

Two plans, composed of (1) Recharge Trench and (2) The combination of Recharge Trench and Detention Dam, are proposed as groundwater augmentation schemes. The effect of these plans was examined given the hypothesis that they are located along Wadis Siji, Khuderah and Shoukah. The effectiveness of each respective plan is given in the following table:

Groundwater Augmentation Facility	Basic Items for Facility	Effectiveness for Groundwater Recharge
Groundwater Recharge Trench	3 Sites (Wadi Siji, Wadi Khadrah, Wadi Shoukah) Depth; 6 m, Length; 1 km	Total 0.3 MCM/a
Groundwater Recharge Trench + Detention Dam	3 Sites (Wadi Siji, Wadi Khadrah, Wadi Shoukah) Reservoir Capacity 2.46 MCM/a (W. Siji) 2.46 MCM/a (W. Khadrah) 3.28 MCM/a (W. Shoukah)	Total 1.97 MCM/a

A maximum effect as large as 1.97 MCM/a was obtained based on the results of the combination plan. If this amount was added to the 19.5 MCM/a of the sustainable yield, the total amount of 21.5 MCM/a would be the available groundwater resource to be utilized in the Groundwater Development Plan in the Study.

(3) Water Costs

The raw water costs yielded by various facilities were evaluated under the two conditions of natural and artificial yields. The natural yield means the sustained yield maintained by the groundwater recharge from the surface. Consequently, extraction from this resource can be made from the Upper Aquifer. The pumping would be made by tubewell only, deepened to 150 m, and with a submersible pump at an intake level of 100 m depth.

On the other hand, the cost related to the artificial yield was evaluated by both costs of facilities as well as pumpage cost. The respective raw water costs are given as follows:

Type of Facility	Water Cost (Dhs/m^3)	Components of Applied Facility
Water Well and Pump for withdrawal		
(Depth:75m)	1.5	Well Depth=100m, Pump Cap.=7900m^3/a, H=76m, KW=1.1
(Depth:100m)	2.0	Well Depth=150m, Pump Cap.= 7900m^3/a, H=148m, KW=2.2
(Depth:200m)	3.0	Well Depth=250m, Pump Cap.= 7900m^3/a, H=214m, KW=3.7
(Depth:300m)	7.9	Well Depth=350m, Pump Cap.= 7900m^3/a, H=328m, KW=7.5
Groundwater Trench	7.8	Wadi Siji, Wadi Khadrah, Wadi Shoukah (3 sites @ 1km= 3km)
Groundwater Trench + Detention Dam	10.7	Groundwater Trench: Wadi Siji, Wadi Khadrah, Wadi Shoukah (3 sites @ 1km= 3km) Detention Dam: Wadi Siji, Wadi Khadrah, Wadi Shoukah (3 sites)
Pipeline for Desalinated Water	10.0	Pipeline: Sharjah-Dhaid, Desalinated Water: 1.25$/$m^3$

5.2.2. Alternative Water Source

There are few surface water resources adjacent to the Study Area. Intermittent floods followed by heavy rain flow down the mountain wadis only 20 days a year on average. A small amount of perennial base flow in the mountain wadis is available throughout the year, but this is hardly considered to be a water resource due to the small size of the amount. For this reason, the natural water resources in the Study Area depends only on groundwater. If another source is required, then desalinated water is to be considered as an alternative. The amount required for the alternative water source is set in Option 2 as below:

Case	Groundwater Resources	Alternative Water Source
Case required by Option 1	21.5 MCM/a (sustained yield + development yield by artificial facility)	-not required -
Case required by Option 2	21.5 MCM/a (ditto)	33.9 MCM/a (water demand-sustained yield-development yield by artificial facility)

Desalinated water is produced in the plant in Sharjah City and delivered to the Study Area by a pipeline system. The raw water cost at the Study Area consists of the production and delivery costs.

The pipeline system consists of the delivery line which extends from the plant at Sharjah Port to the hill located on the west end of Al Dhaid City, and the distribution pipeline system which includes branch A to Falaj Al Mualla, branch B to Dhaid I, the branch to Dhaid II and branch C' to Fili.

The delivery pipeline is scheduled to be installed along the Sharjah-Dhaid highway. This route is considered to be the shortest way because this highway crosses the desert area in a straight line. On the way to Al Dhaid, three pumping stations are planned to boost the water to the top of hill, an elevation of 120 m. The pipe l is made of steel and has a diameter of 1,000 mm and is 58 km in length.

The distribution pipeline is made of steel and has a diameter of 600 mm or 700 mm, while the extension is 46 km. Basically, water flows by gravity in this system. Only branch C' to Fili has a pumping station because it has to pass through three wadis by pipe siphon and send water to the southern-most part of the Study Area.

Total construction cost is US$ 240 million or Dh. 876 million and the O&M cost is US$ 1.8 million or Dh. 6.6 million per year. The water cost is US$ 2.76/m^3 or Dh. 10.1/m^3, which consists of both the transportation and production costs. This cost of desalinated water is 7% cheaper than the water costs of the recharge facility.

5.3. Agricultural Development Plan

5.3.1. Introduction

As stated in previous sections, the basic strategy of agricultural development in the Study is to achieve sustainable and highly profitable agriculture. To achieve these targets, the following plan has been formulated:

- Estimate an appropriate size of area for cultivation,
- Efficient water use (irrigation) plan,
- Most profitable cropping plan,
- Selection of market oriented cash crops; and
- Review of socio-economic and institutional systems with regard to agriculture.

5.3.2. Land Use and Water Sources

It has been confirmed by groundwater balance analysis that the origin of deterioration of both quantity and quality in the groundwater is caused by the over-development of farm land and then over-extraction of groundwater for irrigation in the Study Area. Recently, the developed farm lands have been located on the outskirts of the fertile lands, and cultivated since ancient times in the Dhaid area. The land is basically gravelly, and consequently the surface is covered to a certain depth by transported silty sand for cultivation, although it cannot improve irrigation efficiency.

In the Option One Plan, it is planned to reduce the cultivation area to meet the irrigation water requirements up to the sustainable yield of groundwater, after maximization of the recharge capacity. How to reduce the area of cultivation or close existing farms is too difficult to define because of social background, and it is not proposed in this Study. In the case of closing a farm, those farms which practice inefficient irrigation, such as farms in gravelly areas, are to be selected.

In the Option Two Plan, the entire cultivation area as of 1994 will be supplied with irrigation water from the available groundwater and then supplemented with desalinated water.

In both options, new farm development or the expansion of existing cultivation is not proposed.

5.3.3. Farming Plan

In order to achieve the basic strategy of agricultural development which the Study proposes, a development plan is to be formulated covering sustainable and highly profitable agriculture, scrutinization of appropriate crops, period of cultivation, methods of cultivation, area of cultivation, irrigation water requirements and expected net income.

(1) Appropriate Crops and Cultivation Method

In order to select appropriate crops for the Study Area, the indicator of the net income per unit water consumption (NI/WC) has been introduced. The NI/WC for each crop is obtained from the data obtained through the farm survey, MAF statistics and the results of experiments in cultivation conducted in UAE. From this, the crops with a high NI/WC indicator are selected.

According to the NI/WC indicator estimated by the Inventory Survey, Jew's mallow, cucumber, carrot, tomato, okra, green pepper, cauliflower show a NI/WC greater than Dh. 10/m^3 (Table 4.2.2.). Based on MAF statistical data, crops with a NI/WC ratio greater than Dh. 10/m^3 are cucumber, turnip (laft), Jew's mallow, green bean, eggplant, potato, cabbage, bean and squash, as shown in Table 4.8.2. The basis of estimation between the Farm Inventory Survey and MAF statistical data differ in yields, unit prices, production costs, amounts of water consumption (80% of estimated net irrigation water requirement using FAO methods of estimation and the actual period of cultivation). Even though they cannot be compared directly, it is possible to say that cucumber and Jew's mallow show high NI/WC indicators in both cases.

On the other hand, the results of the supplemental farm survey in greenhouse vegetable cultivation conducted by the Study Team and the experimental cultivation results in open field and greenhouse published by UNDP/FAO in 1987-88 are analyzed using the same method. In analysing the UNDP/FAO results, the production costs applied as same as MAF Statistics, but a groundwater extraction cost of 100 m head at Dh. 0.54 /m^3 is added, and unit prices applied are average wholesale prices during the production period at Dubai Market in 1993 (Tables 4.8.3. and 4.8.4.). Crop water consumption was also applied in the same manner. In this case, NI/WC indicators show high on cabbage, cauliflower, carrot, musk melon, watermelon, tomato and spinach for open field crops, and all crops such as musk melon, cucumber, sweet melon, dwarf bean, sweet pepper, and Jew's mallow for greenhouse cultivation. The only low-yielding crop here is tomato.

(2) Selection of Suitable Crops and Cultivation

There are three sources of crop production data, 1) the Farm Inventory Survey results from 1995, 2) MAF statistical data for 1994 and 3) experimental cultivation conducted by UNDP/FAO in 1987-88. This data is analyzed using the same criteria, as described below:

- Unit price : average whole sale price during harvest period at Dubai Market,
- Production cost : based on costs applied in MAF statistics with water costs added; and
- Crop water consumption : data estimated using FAO method for each crop growing period.

A comparison of each crop based on the same assumptions is shown in Tables 5.3.1. and 5.3.2. in order of NI/WC value. It is possible to say that crops with estimated higher NI/WC indicators also show high values of net income per unit area.

With reference to the unit cost of desalinated water, crops which show a NI/WC indicator greater than Dh. 10/m^3 are recommended as suitable crops for the Study. In the case that there is more than one crop in the same growing period with high NI/WC, only the crop with the highest NI/WC is selected. In the case that two crops show high NI/WC but have different growing periods, they are selected together.

Tree and forage crops show lower NI/WC, less than Dh. 10/m^3, and they are not recommended for cultivation in the Study Area based on this criteria. Considering the importance of dates, which is a traditional national staple food, however, it has been selected for cultivation. For this selection, an increase in market price by introducing a high-quality and high-yield variety is necessary (present unit price is Dh. 3.5/kg, and expected price is Dh. 7.0/kg). It was considered that the NI/WC ratio of dates will be able to be increased to the expected value by intensive introduction of the variety called Barhi, which is a high-quality and high-yield variety of dates, in addition to improvement in cultivation and post-harvest techniques.

Alfalfa, which is one of main forage crops for traditional livestock breeding, is considered as an important crop next to vegetables and dates for the following reasons:

1) It is a perennial income crop that can be harvested thirteen times a year,
2) It is in high demand and the market is stable;
3) It can be used as a rotation crop with vegetables; and
4) It contributes to fertilization of the land (nitrogen fixation).

Consequently, alfalfa is also recommended as a suitable crop for the project.

The selected crops and their cultivation practices are shown in Figure 5.3.1. The highest profitable water-saving crops are musk melon when grown in a greenhouse (October 15 to February 5), sweet melon grown in open field (January 16 to April 15), cucumber in a greenhouse (November 18 to February 12), spinach in open field (November 1 to April 15), pimento in a greenhouse (November 16 to June 11) and cabbage in open field (October 27 to December 28).

(3) Sustainable Agricultural Development

In the proposed two options in the master plan, the cultivation areas and required amounts and sources of irrigation water were determined in the following manner:

Option One Plan: the proposed cultivation area is to be reduced to meet the sustainable yield of groundwater, namely 21.5 MCM/a; and

Option Two Plan: the cultivation area is to be maintained as its current size, 4,584 ha, and the required additional irrigation water is to be secured by use of the sustainable groundwater yield and a supplemented alternative source, namely desalinated water.

(4) Cultivation Area (Option One Plan)

The proposed cultivation area of vegetables was determined based on the their productivity. The total required production of vegetables at harvesting period was estimated on the assumption of a unit consumption of 300 g/capita/day for one million consumers. Total demand for vegetables at 300 g/capita/day was given as 307 g in Japan in 1980, and 307 g in Europe in 1992, according to FAO. The Plan is expected to yield a total vegetable production of 67,600.

The cultivation area of dates was determined based on the extent needed to maintain the present total net profit of tree crops.

The cultivation area of alfalfa was determined based on the extent of available water resources remaining after the requirements of vegetables and dates have been met.

(5) Cultivation Plan (Option One Plan)

Given the above-mentioned conditions, a sustainable, highly profitable crop production plan for Option One was formulated, as shown in Table 5.3.3. and Figure 5.3.1.

a) Area of Cultivation

A total cultivation area of 2,548 ha is planned, with 1,713 ha given over to vegetables (67% of total cultivation area), 272 ha to dates (11%) and 564 ha to alfalfa (22%). Compared with the present cultivation area, these areas are equivalent to an increase of 148% for vegetables, but reductions of 15% for dates and 35% for alfalfa, and 56 % of the total cultivation area (Table 5.3.4.). The cultivation area of each vegetable, its cultivation period, method of cultivation (in open field or greenhouse, seeding period, direct seeding or transplanting, harvesting period) are shown in Table 5.3.6. and Fig. 5.3.1.

b) Expected Yield

An increase of 67,800 tons (265% of present condition) in vegetable production, and reductions to 5,229 tons (18%) in the production of dates, and to 51,209 tons (37%) in alfalfa production, making a total reduction to 124,238 tons (65%) of the current total annual production are expected (Table 5.3.4.).

c) Expected Net Income

Income from vegetables is expected to increase to Dh. 187 million (841% of present condition), whereas it would stay the same at Dh. 25 million (100%) for dates, and be reduced to Dh. 61 million

(36%) for alfalfa, producing a total net income of Dh. 273 million, without considering the excess cost involved in groundwater augmentation. Total net income would be increased by 26 % (see Table 5.3.4.).

d) Gross Irrigation Water Requirements

The gross irrigation water requirement is estimated to be 6.2 MCM/a (208% of present condition) for vegetables, 2.0 MCM/a (9%) for dates, 13.3 MCM/a (40%) for alfalfa (Table 5.3.4.) This total irrigation water volume is equivalent to that of the sustainable groundwater yield in the Study Area after the groundwater augmenting measures have been implemented.

As mentioned before, because the estimate of the gross irrigation water requirement is based on procedures proposed by FAO, and the proposed area of cultivation will presumably be irrigated more efficiently, there is a possibility of more water being used than the gross irrigation water requirement. It is important to apply effective water use by introducing water-saving systems of irrigation.

Compared to cultivation in open fields, it is relatively easy to make effective use of irrigation water in greenhouses. An area of 420 ha is suggested for vegetable cultivation in greenhouses, this being 0.2 ha/farm given over to greenhouses (equivalent to 6 standard commercial greenhouses). Given the labor force of the farm, such an area of greenhouses is considered to be easily manageable for farm laborers.

e) Proposed Farming at a Typical Farm in the Study Area

The proposed crop production plan for a typical farm in the Study Area is shown in Table 5.3.5. The total cultivation area is 1.26 ha (0.85 ha for open field, 0.21 ha for greenhouse, 0.13 ha for dates, 0.28 ha for alfalfa). A net income of Dh. 135 thousand is anticipated and 11,047 m^3/year of irrigation water will be needed. As several kinds of vegetables are to be cultivated, it is necessary to adjust the cultivation area given over to each vegetable among the farms.

(6) Cultivation Area (Option Two Plan)

The same cultivation area as at present for vegetables, dates and alfalfa is planned, to be applied in the same manner as the Option One Plan. The cultivation areas of each vegetable would be determined based on the same portions of cultivation area for each as in the Option One Plan. Dates and alfalfa would be applied to the same areas as at present.

(7) Proposed Farming (Option Two Plan)

a) Area of Cultivation

A total cultivation area of 4,584 ha is planned. This would be: 1,158 ha for vegetables (25% of total cultivation area), 1,825 ha for dates (40%), and 1,601 ha for alfalfa (35%). Cultivation areas for each vegetable, its period of cultivation, the method of cultivation (open field or greenhouse, seeding period, direct or transport seeding, harvesting period) are shown in Table 5.3.6.

b) Expected Production

An annual production of 45,836 tons (179% of present condition) of vegetables, 35,094 tons (118%) of dates, 145,475 tons (107%) of alfalfa and 226,405 tons (118%) of the current total annual production are anticipated (Table 5.3.7.).

c) Expected Net Income (excluding the cost of desalinated water)

A net income of Dh. 126 million (568% of present condition) generated from vegetables, Dh. 167 million (671%) from dates, Dh. 174 million (103%) from alfalfa and a total net income of Dh. 467 million (217% of the present total net income), without considering the excess costs incurred for groundwater augmentation and desalinated water, are expected (Table 5.3.10.). Inclusive of Dh. 154 million/year for the annual cost of purchasing desalinated water and exclusive of construction and O&M costs for the water distribution facilities, a total net income of Dh. 312 million (145% of present total) is expected.

d) Gross Irrigation Water Requirement

The gross irrigation requirements would be: 4.19 MCM/a (141% of present condition) for vegetables, 13.4 MCM/a (63%) for dates, and 37.8 MCM/a (112%) for alfalfa, making a total gross irrigation requirement of 55.4 MCM/a (107%) (Table 5.3.7.). This total irrigation water requirement is 2.6 times larger than the annual sustainable groundwater yield in the Study Area. It would consequently be necessary to purchase 33.9 MCM/a (average 1.08 m^3/sec, monthly maximum 1.58 m^3/sec, monthly minimum 0.46 m^3/sec) of desalinated water.

e) Proposed Farming at a Typical Farm in the Study Area

The proposed crop production plan for a typical farm in the Study Area is shown in Table 5.3.8. The total cultivation area is 2.27 ha (0.43 ha for open field, 0.14 ha for greenhouse, 0.9 ha for dates, 0.8 ha for alfalfa). An average net income of Dh. 231 thousand could be expected, with irrigation water requirements being 27,456 m^3/year.

5.3.4. Irrigation Plan

(1) Maximization of Water Resources by Water-saving Irrigation

It is necessary to plan for high-profit and sustainable agriculture making maximum use of groundwater and another water source. Also, it is necessary to further promote water-saving irrigation methods and to have MAF provide more support and extension services to farms. The technical extension for transporting irrigation water to the farms economically is also important.

(2) Crop Water Requirements

The crop water requirement is estimated from the potential evapotranspiration and each crop coefficient, considering crop growth stages.

a) Potential Evapotranspiration (Eto)

The potential evapotranspiration (Eto) is estimated by the Penman method. Based on the FAO manual (Irrigation and Drainage Paper No. 24: Crop Water Requirement, 1977), the climate in the Study Area is classified as high temperature, low humidity, arid with moderate winds. Using the Penman method and based on the meteorological data collected at Falaj Al Mualla and Mileiha, Eto was calculated as shown below:

(unit: mm/day)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total*
Falaj Al Mualla	3.00	3.74	4.96	6.60	8.13	8.51	8.62	8.23	7.24	5.69	4.02	2.92	2,184
Mileiha	3.10	3.85	5.22	7.05	8.67	9.12	8.89	8.46	7.44	5.84	4.14	3.03	2,280
Average	3.05	3.80	5.09	6.83	8.40	8.82	8.76	8.35	7.34	5.77	4.08	2.98	2,232

Note * : Unit mm/year

b) Crop Coefficient (Kc)

Based on the FAO manual (Irrigation and Drainage Paper No. 24: Crop Water Requirement, 1977) and field conditions, the crop coefficients are estimated for each crop and each growing stage.

c) Crop Water Requirements

The crop water requirement is calculated using the above-mentioned Eto and Kc.

(3) Irrigation Methods

Considering the results of the infiltration rate test, present water-saving irrigation methods, and intensity of irrigation, the following irrigation methods are planned:

a) Drip Irrigation for Vegetables

Using drip irrigation, frequent irrigation can be carried out using only small amounts of water. It is possible to supply effective irrigation water directly to the root zone of the plant. In the Study Area, traditional furrow irrigation has been applied for vegetables. Recently, the introduction of drip irrigation has been promoted by the Government . From the results of the field test at Hamraniyah conducted by UNDP/FAO, evaporation from the soil at the first growing stage of a crop is restrained by drip irrigation. This shows that a high level of efficiency can be expected. In this field test, the highest application efficiency was found when the drip was placed at a distance of 1.5 to 2.0 m between drip outlet and inter-rows. From the results of the sprinkler test at Hamraniyah, again conducted by UNDP/FAO, potato and onion production was increased by 25% to 75% with sprinkler irrigation, but application efficiency was lower than that of drip irrigation. Considering these results, the drip irrigation method was applied for vegetables in open fields and greenhouses as a water-saving irrigation method.

From the results of the inventory survey, the filter system is used at 80% of the farms who use drip irrigation. An system mixing both drip and sprinkler is installed at 30% of the same farms. The merit of drip irrigation is its effective functioning. Several types of emitter are used with a capacity of 4 liter/hour at one atmospheric pressure and 80-200 cm distance between each drip outlet. These are operated twice a day (around 15 minutes at a time) in the greenhouse.

b) Bubbler Irrigation for Tree Crops

Bubbler irrigation is same type of irrigation method as drip irrigation and is applied to tree crops using a high discharge (330 liter/hour under 1.4 kg/cm^2 of water pressure). From the results of field tests at Hamraniyah and Dibba conducted by UNDP/FAO, it is possible to save 65-70% of irrigation water as compared with basin irrigation. In the drip irrigation field tests, salinization problems were observed. Given this, bubbler irrigation is applied to tree crops as a water-saving irrigation method.

c) Sprinkler Irrigation for Pastures

Sprinkler irrigation is one of the most popular irrigation methods in the world. Although irrigation intensity varies, depending on wind conditions and evaporation loss, sprinkler irrigation is applied to pastureland as a water-saving method of irrigation, reflecting the difficulty of applying drip irrigation. With sprinkler irrigation in high temperature arid lands, high levels of saline in the irrigation water kills foliage. Consequently, they are traditionally operated in the early morning, when the temperature is comparatively low. Considering the low-lifting discharge and small scale of pasture land for each farm, the center pivot system is not economical. From the view of labor force requirement such as in manual harvesting, the fixed type sprinkler system is applied.

Filter, strainer and intermixture system are always to be installed for all types/models of the above irrigation system.

(4) Irrigation Water Requirement

The irrigation water requirement is determined after consideration of the crop water requirement, effective rainfall, leaching water, irrigation efficiency, etc.

As effective rainfall is small in amount and uncertain, it is not included in the irrigation water requirement. In the estimation issued by UNDP/FAO, 5% of the total crop water requirement was calculated as leaching water.

a) Irrigation Efficiency

The following irrigation efficiency is achieved by each irrigation method:

Irrigation Method	Conveyance Efficiency	Application Efficiency	Irrigation Efficiency
Drip Irrigation	0.9	0.95	0.85
Sprinkler Irrigation	0.9	0.85	0.75
Bubbler Irrigation	0.9	0.85	0.75
Improved Basin Irrigation	0.9	0.70	0.65

b) Net Irrigated Area

Considering the emitter interval and drip outlet interval, the actual irrigated area of drip irrigation for vegetables is considered to be 50 % of the total cultivation area, which is applied in the wet zone. Given the area for farm access roads, the actual area of sprinkler irrigation for dates is estimated to be 90% of the total cultivation area. From the number of trees and the area of basin irrigation, the actual area of effective bubbler irrigation is considered to be 30 % of the total cultivation area.

c) Irrigation Water Requirements

The monthly net irrigation water requirement is estimated based upon the crop water requirement and actual irrigated area. The monthly gross irrigation water requirement is calculated based on the monthly net irrigation water requirement and irrigation efficiency, considering the irrigated area. The results are shown in Tables 5.3.3. and 5.3.6. Total gross irrigation water requirement for Option One Plan is 21.5 MCM/a, and for Option Two Plan is 55.4 MCM/a.

5.3.5. Improvement of Infrastructure

(1) Improvement of Agricultural Infrastructure

In this master plan, it is necessary to consider the improvement of the agricultural infrastructure with such things as embankments for flood control, a road network for agricultural production activities and shipping, and collecting and shipping facilities for agricultural products.

(2) Flood Control Embankments

Flood damage occurs on the farm land near the wadis in the winter season, which is one of the peak periods for farming activities. At present, embankments are constructed using surplus soil with a high gravel content which is found lying around the farm, mostly debris from of land reclamation work, if there is a possibility of flooding. Flooding is controlled by use of toe bund constructions and their maintenance is the responsibility of each individual farm.

(3) Farm Road Net Work

There are three paved roads which give access to the main consumption areas in the Study Area. They are Sharjah-Massafi, Umm Al Qaiwain-Madam, Manamma-Ras Al Khaimah roads.

The access roads from trunk road to farm are without any pavement. Some part of these access roads is maintained by town office. At the time of rainfall or flood, passing by these roads are rather difficult but it is possible to access to the each farm using the four-wheel-drive vehicles. As the Study Area is flat land with sand and gravel generally, improvement of the new road network for the agricultural development is not planned.

(4) Collecting and Shipping Facilities for Agricultural Products

Considering the current situation, with its secured advantage on selling price, it is necessary to install marketing facilities. The construction of collecting center with collecting, selecting, cooling, storage and shipping facilities is planned at Al Dhaid. This center is to be constructed by MAF and maintained by farmers as a cooperative organization under the supervision of MAF. The operation fee will be collected from the farmers as the shipping commission.

5.3.6. Farm Facilities

(1) Layout of Water Sources and Farming Facilities

Figure 5.3.2. shows the layout of water sources and farming facilities that follows the previous Sections, "5.3.3. Farming Plan" and the "5.3.4. Irrigation Plan". The cultivated areas for

dates, vegetables, and alfalfa were given by the proportion shown in Option One or Option Two. In Option One, when the total farming area is 4 ha, the cultivated area allocated to dates is 2.7 ha, 0.4 for vegetables, and 0.09 for alfalfa in the Option One Plan. On the other hand, in Option Two Plan the cultivated area for dates is 1.0 ha, 1.6 ha for vegetables, and 1.4 ha for alfalfa. The farm in Figure 5.3.2. has 4.68 ha total area and was just drawn to estimate the facility cost per unit area.

(2) Preliminary Cost Estimation for Construction

Both farms in Figure 5.3.2. adopt the water-saving irrigation method described in the previous Section "5.3.4. Irrigation Plan." Bubbler or drip irrigation is applied to area where vegetables and dates are grown, while sprinkler is applied for alfalfa. Basin irrigation is not applied.

Water for irrigation is pumped up from a well or wells in the farm, delivered and collected to the on-site tank. Next, water stored in the tank is boosted by pump and distributed by pipeline for irrigation. In Option One, the construction cost of a water source facility, which includes the well, pipeline, tank and booster pump, and construction of a farming facility, which includes distribution pipeline, sprinkler, bubbler, and greenhouse is US$ 262,390 or Dh. 958,000 per 4 hectares (US$ 65,600/ha) for Option One Plan. The cost in Option Two is estimated to be US$ 149,500 or Dh. 546,000 per 4 hectares (US$ 37,375/ha).

5.3.7. Operation and Maintenance of Farm Facilities

(1) Operation and Maintenance Plan

Presently, the irrigation period and amount of irrigation water are determined by the manager of each individual farm. The water from the water source of each farm is used for irrigation. In cases where the individual water source has dried up, cultivation is abandoned, except in the rare case that the farm manages to get water from a neighboring farm when the farms were using falajes before starting the use of individual wells, and the collaborative use of groundwater was carried out. In other areas, the collaborative operation of wells is observed. Considering the conditions in the Study Area whereby most of farms are in the possession of absentee owners, it is impossible to apply an irrigation system which uses the collaborative operation of wells. Consequently, the present irrigation operation system is applied. In the Option Two Plan, the desalinated water would be distributed to the water tank installed on each individual farm.

(2) Estimated Operation and Maintenance Cost

In the Option One Plan, the operation and maintenance costs, inclusive of the amortization cost of the facilities, the maintenance cost of facilities, and their operation costs, is estimated to be

US$ 11,900 or Dh. 43,400 per 4 ha/year (US$ 2,550/ha/year). In the Option Two Plan, it is US$ 11,800 or Dh. 43,100 per 4 ha/year (US$ 2,530/ha/year).

5.3.8. Agricultural Support Services

It is impossible to promote agricultural development without the participation of the farmers, particularly the absentee farm owners, who require a businesslike attitude and awareness as to the nature of the limited water resources. Consequently, agricultural extension activities will play an important role in any future agricultural development. Furthermore, agricultural support services are needed for smooth implementation of the proposed cultivation plan.

(1) Adjustment of Cultivation Area

Over-production of certain high-value vegetables, with many farmers producing the same crop at the same time, is another risk. To control such over-production, it is necessary to adjust the cultivation area among the farmers, especially in regard to vegetables. Allotment of areas for vegetable cultivation on each farm are shown in Tables 5.3.8. and 5.3.11. Based on these Tables, it is necessary for the MAF extension staff to offer support to facilitate a smooth adjustment among the farmers.

(2) Establishment of Supply System for Seeds and Production Materials

It is necessary to establish a supply system for seeds and other materials which correspond to the needs of farms; especially, the supply system for high quality date seedlings needs to be improved. Considering the 272 ha of area proposed for dates cultivation, it is necessary to prepare around 42.5 thousand of dates seedlings (156 seedlings/ha). Dates seedlings are produced at the Agricultural Experimental Center of the Central Region Agricultural Division in Al Dhaid. This Center acts as one of the agencies for the production of tree crop seedlings in UAE. As there is 419 ha of area for cultivation under this Center, it is necessary to extend support for the Center by having the Government supply facilities and materials.

(3) Technical Extension Services

There are five extension units in the Study Area. One to Two extension officers are working in each unit. Presently, the distribution of fertilizers, agricultural chemicals and seeds are their main activities. It is necessary to strengthen the technical extension services with regard to vegetable cultivation and irrigation technology. There is serious problem of salinization caused by over-irrigation in the Al Dhaid area, and guidance on suitable irrigation technology is necessary for

effective water use and to prevent further salinization. For this purpose, it is necessary to increase the number of extension staff by another two people in each unit.

Improvement in the technical abilities of the extension staff is also important. A seminar for extension staff was convened for this purpose. From the results of the inventory survey, however, further technical assistance needs to be offered by the extension officers, and reliance on the extension officer has decreased recently. Consequently, a further technical training course at the Agricultural Experimental Center is suggested.

(4) Implementation of Practical Experiments

It is necessary to suggest suitable crops, optimum farming practices and appropriate irrigation methods based on the results of practical experiments to the farmers. Systematic field experiments on these matters were carried out by UNDP/FAO in 1982-1983. It is recommended that the experiments be continued at the Agricultural Experimental Center of the Agriculture Division of Central Region. In particular, suitable crops for the present off-crop season (July to October) are required. Consequently, the implementation of research and development for suitable crops and related technology is suggested.

(5) Training for Farmers

It is suggested that the government provide training for the farmers. Facilities at the Agricultural Experimental Center may be available. Guidance on technology of production, post-harvest and food processing, the introduction of new varieties of crops, and the supply of marketing information would important contents of such training.

(6) Strengthening of the Government Subsidy and Support System

Several low-priced vegetables are imported into UAE. The agriculture of UAE is forced to compete with such imported foods. It is necessary to maintain the present governmental subsidy system for agriculture. Technical and financial assistance for farmland reclamation and introduction of water-saving irrigation systems are also to be maintained and expanded.

5.3.9. Marketing and Processing

(1) Marketing System and Organization

A lot of vegetables, fruit and food are imported duty-free into UAE from all over the world. Vegetables and fruit produced in UAE are forced to compete with those imported items in price and

quality. Regarding the price, the present financial support as supplied by MAF is to be continued. Concerning the quality, it is necessary to improve the marketing system for keeping the freshness.

In the present traditional agriculture in the Study Area, production is mainly for self-consumption, and the establishment of a marketing system and organization is indispensable for agricultural development in the Area. In the production plan, as 50 tons/day of each vegetable production is expected, and a maximum of six kinds of vegetables are harvested at the same period (Table 5.3.6.), a maximum of around 300 tons/day of vegetables will be shipped (80% of production will be shipped). Consequently, the organization, facilities and equipment, such as trucks for collecting and shipping will be required. As a maximum 150 kg/day of vegetables are expected to be shipped by each farm, the introduction of group shipping, having one small truck shared between five farms, is proposed.

At present, the average farm gate price is 70% of the wholesale price. It will be more profitable for vegetable producers to ship directly to market, even after paying the 10% commission. On the other hand, alfalfa is sold on a contract-production basis, and the current practice is expected to continue in the near future. From the results of the farm inventory survey, some farmers indicate that an unjust benefit is enjoyed by brokers, and the establishment of a fair marketing system is necessary.

(2) Processing

In order to increase the added value and to prevent over-production, the processing of agricultural products is to be promoted. Cucumber is the second-highest profitable crop next to melon among the planned vegetables. As farmers clearly intend to continue producing cucumber, it is necessary to consider processing some to the cucumbers as pickles. The technology for bottling and processing cucumber pickles is not difficult, and facility costs are not very high. Cucumber pickles is one of main processed foods in UAE and its price is highest in June to September, which is the fallow season. The processing of tomatoes into juice and pure, and dates, which can be dried and packed, can add value to the goods without the need for high-technology or high costs of facilities.

5.3.10. Farmer's Organization

For the smooth and effective production and sale of large quantities of agricultural goods, it is necessary to establish a farmer's organization under MAF supervision and with the support of extension officers. The main activities of such an organization would include the collaborative purchasing of agricultural equipment (garden tractors, equipment for disease and pest control, materials for greenhouses and irrigation, fertilizers, pesticides, etc.), installation of collecting and

shipping facilities, group shipping, construction and operation of agricultural processing facilities, adjustment of the cultivation plan, and supplying information on marketing and agricultural technology.

5.4. Groundwater Monitoring and Database System

5.4.1. Introduction

The purpose of the Groundwater Monitoring System is to monitor the wasteful mining of limited groundwater resources. Consequently, the range of observation is to cover all parts of the Study Area, and records must be kept long-term and in full. In addition, observation data is to be closely linked to the management model, for immediate evaluation of the current status of groundwater reserves.

The Database is to be renewed using the information obtained from the monitoring system, and the user must be able to examine the data whenever needed. The information to be entered into the Database refers only to data that is related to a particular topic or purpose. These would be the results of farm surveys, well records, rainfall and flood records, and even the farmowner's address and employees lists. Each of these collections would be stored in various forms such as spread sheets and document files, and not used in conjunction with one another. Furthermore, a function is required whereby the user may extract only the desired information from the basic data.

The management model needs to be built to include all hydraulic information from the groundwater basin. The model output following the actual observation is to provide the figure for each respective block, and if the actual amount pumped is greater than the planned rate, a definite warning regarding the drying-up of the groundwater resources is to be issued.

5.4.2. Groundwater Monitoring System

In the Study Area, 12 observation wells were set up between by MAF 1977 to 1995, and well hydrograph records have functioned efficiently from the start of observation. In spite of some unrecorded or inaccurate data, the original charts obtained from the record are stored in full in MAF library. Observations made by the meteorological and hydrological station have been made over a long period of time.

The monitoring system, including these existing observatory stations, was organized to relate to the model for groundwater balance in this Study. The model would be then revitalized as a management model to control the groundwater basin in the Study Area.

(1) Management and Organization of Monitoring System

The sections for the actual observations are in several parts, depending upon their main role. The meteorological record, hydrological record and groundwater withdrawal are to be separately collected by each different section. This system is also adopted in the plan for Groundwater Monitoring. From the view of an alarm system to warn against over-pumping from groundwater basins, the collected data is to be closely controlled between the Database System and the Management Model. The database is to be managed by all people who are involved with it. The actual operational work of inputting data, however, is to be carried out by the observer who recorded that particular item of data as part of his normal tasks and duties. Furthermore, the Database is not to be the sole preserve of the management, but open to every section so that all data, including items entered by another person, can be viewed.

(2) Observation

The observation items in the Monitoring System are as follows:

Meteorological Items:	Rainfall, Temperature, Wind direction ,Wind velocity, Sunshine
Hydrologic items:	Surface Runoff
Groundwater items:	Groundwater Head, Water Quality (Ec, Temperature, pH)
Groundwater Use:	Groundwater Withdrawal

As a Groundwater Monitoring System, the supplementary stations are to be installed in vacant areas which not covered by existing stations. In order to perform the routine work of observation, a transducer or automatic recorder is to be installed.

a) Meteorological Observation

There are 10 stations (including Gyle and Marbat Stations) in the Study Area. Of these 10 stations, two are meteorological stations and the others are all rain-gauge stations. The network made of the existing stations shows an uneven distribution by which most of stations are located in the mountain areas around Wadi Siji and Wadi Khadrah. In addition, the rainfall has been sporadically showery and their amounts are always different at different sites. In spite of these characteristics shown by the rainfall, there is no observation station in the southern area or on the Bahada Plain. Five new rain-gauges are therefore planned for these areas. Furthermore, two of the existing meteorological stations are also to be integrated into the Monitoring System.

b) Hydrological Station

In the Study Area, there are six wadi-gauges which still function at present. All six stations, however, are concentrated in the mountain wadis. In the monitoring plan, four stations are to be

installed in the following four wadis: Wadis Dhaid, Tiqubah, Hamdah, Shoukah, and a further two stations are planned for the Bahada plain. A total of 12 stations with six new and six existing stations are therefore planned to be built into the Monitoring System.

c) Groundwater

There are six groundwater observatories around the Study Area, but most stations are set only in the major farming areas, such as Mileiha and Dhaid. Moreover, most wells are not designed for monitoring of the groundwater head in the Lower Aquifer. Consequently, with the exception of only two wells, only the Upper Aquifer has ever been measured. Even in the seven stations drilled during the Study, only one well is installed with a screen deep enough to measure the groundwater head in the Lower Aquifer. In the Monitoring System, three stations for measuring the groundwater head of the Lower Aquifer, and five stations for measuring the water quality, are to be added. The former stations are located to the east of Fili, the west of Hamdah and the north of Dhaid. The later stations are to be set at Falaj Al Mualla, Dhaid, Wishah, Khadrah, Mileiha and Bahayis and Fili.

Of a total of 33 stations, 17 stations are for measuring the groundwater head, 11 for the Upper Aquifer and six for the Lower Aquifer, and five stations are for measuring the water quality (see Figure 5.4.1.). Observations in these wells, including the borehole and test wells made through the Study and planned wells, are to be carried out by using a transducer and automatic recorder with data logger. Furthermore, the execution of a ground level survey is also required for all observatory wells, not only newly-installed wells but the pre-existing wells also.

(d) Groundwater Utilization for Irrigation

To operate the management model, an estimation of groundwater withdrawal for irrigation will be required every few years. For this estimation, the basic data consisting of pumping rate, farming area and farm inventory are to be renewed by field surveys. The installation of flow meters is to be carried out in 20 typical farms to obtain the flow rate, and aerial photography mapping is to be conducted to determine the latest farming area. All the data obtained from the survey must be categorized in the Database as required.

(3) Cost of Materials and Equipment for Observation

An estimate for the materials and equipment related to newly installed observatories is given as follows:

Facility	Unit	Amount (US$)
Meteorological Station	L.S.	53,500
Hydrological Station	L.S.	64,200
Groundwater Station	L.S.	687,400
Groundwater Withdrawal	L.S.	38,400
Total	L.S.	843,500
		or Dh. 3.08 million

(4) Cost of O&M of System

Both the operation and maintenance of the system are to be managed by MAF who already conducts the existing observations. The cost per year related to all above O&M items is as follows:

Item	Unit	Amount (US$)
O&M Groundwater Monitoring System	L.S.	42,200
O&M Data Base System	L.S.	2,800
Aerial Photography (every 5 years)	L.S.	6,000
Well Inventory Survey (every 5 years)	L.S.	20,900
Total	L.S.	71,900
		or Dh. 262,000

5.4.3. Database Plan

It is necessary to have a DataBase which can be easily operated by any observer, Database manager and operator of the management model so that they can manipulate the information necessary for maintaining the groundwater monitoring system. The small-sized computer network called LAN (Local Area Network) is to be installed for this purpose. Five sets of machines, including servers and terminals, are planned to deal with all the tasks related to groundwater monitoring. Similarly, four terminals used for the input of data are to be installed at the meteorological, hydrological, irrigation and groundwater and dam sections, and another server which controls the Database and manages the basin model is to be installed at the groundwater and dam section.

The conventional software built into the Relational Database, customized for hydrological and groundwater purposes, is the basic model to be applied to this System. The software must be accessible to both the basin model constructed in the Study and GIS system described below.

(1) Database

The data from farms and well inventories is to be stored on a spread sheet. The groundwater quality analysis is to be kept in an ASCII file. Soil analysis and other irrigation and farming records

are in to be kept the form of datasheets. From these various types of data, the user can extract just the information required. The software currently on the market in conventional form is to be customized for groundwater management with all the functions of a Relation Database.

(2) Management Model

The model for the groundwater balance constructed in the Study is to be used in the management model as a model parameter. If new parameters are entered, the model can then forecast new hydrological conditions. On the other hand, the model must be verified by the latest observation data to tune up the precision of the model.

(3) Geographical Information System (GIS)

On the basis of Orthophoto Images, aerial photography mapping is to be conducted every few years to estimate the amount of groundwater withdrawal through estimation of the farming area. For this purpose, GIS would be used to draw the image map, trace changes to the farming area and visualize the observation data.

(4) Cost for Database Construction

The cost for construction of the Database described above is as follows:

Item	Unit	Amount (US$)
Hardware of Survey and Terminal	L.S.	52,000
LAN and Data Base Software	L.S.	1,500
Construction of LAN	L.S.	2,000
Total	L.S.	55,500
		or Dh. 203,000

5.5. Project Plan

5.5.1. Water Source Plan

(1) Groundwater Augmentation Plan (Refer to Section 4.5.)

To increase the groundwater recharge in the Study Area, three flood detention dams and three recharge trenches are planned. 1.97 MCM/a is expected from these facilities as the total groundwater, which is the total amount of available groundwater which the Option One Plan can support, The storage capacity of Siji dam will be 2.57 MCM,, Khadrah dam will be 3.25, and

Shoukah dam will be 2.66 MCM. The height of Siji dam will be 20.5 m, Kahdrah will be 16.5, and Shoukah will be 27.5 m.

(2) Alternative Water Source Plan

In addition to groundwater resources, the scheme to construct a desalination water pipeline which conveys 34 MCM/a of water from Sharjah City to the farms in the Study Area may supply enough water to support the option Two Plan.

The pipeline system consists of 58 km of delivery pipes and 46 km of distribution pipelines. The delivery pipeline is made of steel and has a diameter of 1,000 mm. It has three pump stations to maintain a flow rate of 1.58 m^3/sec and a velocity of 2.0 m/sec. The distribution pipeline is made of steel and has a diameter of 700 or 600 mm. The line to Fili village has a pump station and three pipe siphons. Other lines are designed to flow by gravity.

5.5.2. Farm Facility Plan

(1) Water Sources Facility

The water sources of the Option One Plan depend on groundwater. Most farms are using movable hoses with a diameter of 30 to 60 mm for water delivery from their well to their tank. However, since they obstruct to work in the harvesting area since they cross the fields and prevent the workers from going about their business, it would be useful and more efficient if the delivery PC pipeline were laid under the ground. The capacity of an on-farm tank is 100 m^3 (=10m×5m×2m) for 4 ha farm.

In the Option Two Plan, the capacity of the on-farm tank should be twice as large than that in the Option One Plan because the water supply from the desalinated pipeline has to be stored. The dimensions of a tank in this Plan would need to be 200 m^3 (=10m×10m×2m).

(2) Irrigation Facilities

On the way to the cultivated area, the water in the on-farm tank passes the following devices: a booster pump, a filter, a fertilizer injection, flow gauge, and a distribution and PC pipeline; then, when it reaches the cultivated area, the distribution pipe is connected to a bubbler. In the case of alfalfa, it is connected to sprinkler.

(3) Greenhouses

Greenhouses have been introduced for vegetable cultivation. Although several farms in the Study Area have already installed different types, the greenhouse in this Plan is designed with

dimensions of 36 m × 8m. Drip or bubbler irrigation should be applied in the greenhouse. The working life of the plastic sheets used in greenhouse construction is considered to be two years.

5.5.3. Marketing Facility

As was already described in Section 5.3.5. (Improvement of Infrastructure), the market facility is planned to maintain a steady income to farms.

The facility includes collecting and shipping quarters and packaging and pre-cooling devices. For both Option One and Two Plans, pre-cooling devices which have a capacity of 300 ton/day are required. Since both Plans were designed in different cultivation areas, the facility cost for Option One Plan is estimated at US$ 1.00 million or Dh. 3.65 million, and that for Option Two Plan is US$ 1.50 million or Dh. 5.48 million.

5.5.4. Project Cost and Project Implementation Plan

(1) Preliminary Cost Estimation

Tables 5.6.1. and 5.6.2. show the estimated project cost for both Option One and Two Plans. The project cost estimated for Option One Plan is to be US$ 385 million or Dh. 1,405 million and for Option Two Plan is US$ 935 million or Dh. 3,413 million.

(2) Implementation Schedule

The implementation schedules for the Option One Plan and the Two Plan are shown in Figure 5.5.1. The construction period for the recharge dam is three years. If the work on the three dams is started simultaneously, the construction period can be reduced. The construction should be implemented one at a time, however, because the transportation costs of heavy machinery and project costs may be too high to pay all at once. This scheme is planned in the target year to 2015. The dimensions of facility is shown in Table 5.5.1.

5.5.5. Operation and Maintenance Plan

MAF and each farm will share the operation and maintenance duties for all facilities that are constructed by the Project. On-farm facilities that include a water source and irrigation facilities should be operated and maintained by each farm individually. Other facilities should be operated and maintained by MAF.

(1) Recharge Dam and Recharge Trench

In addition to the daily check up of the recharge facilities, the removal of sediment carried by floods, and repair of minor damage to the surface of embankment by flooding should be done by MAF after each flood as soon as possible.

(2) Pipeline for Alternative Water

The third sector that is supervised by MAF should operate and maintain the pipeline system for the desalinated water. The O&M cost for this system would be supported by a water fee which is collected from each farm and relates directly to the amount of water consumption; also, the government would bear part of the cost through the payment of subsidies.

Periodically, the delivery pipeline, booster pumps, discharge chamber, and other devices are to be checked an engineer from the third sector. Once a year during the non-irrigation period, a thorough overhaul of all facilities is to be carried out

(3) Marketing Facilities

The third sector supervised by MAF operates the marketing facility. The produce supplied by the farms are selected, packed, and, if necessary, processed for pre-cooling in the marketing facility. With the analysis of market information, the third sector decides on items appropriate for marketing and sends the information to the farms. These operations are supported by the farm group fee and by MAF subsidies

(4) On-farm Water Sources and Farming Facilities

With intensive extension services that encourage farm managers to save water for irrigation, a whole on-farm facility can be operated by each farm.

5.6. Project Evaluation

5.6.1. Objectives of Project Evaluation

The objectives of the present project evaluation are to assess the viability for implementation of the project from a financial point of view. It must be noted that due to the free-market policies applied by UAE Government, it can be assumed that the price markets reflect the true scarcity of resources. In other words, market distortions can be assumed to be absent for relevant production and costs items. Consequently, an economic evaluation of the project shall not be carried out due to the reasons above mentioned.

5.6.2. Project Evaluation Method

For the present project, the methodology applied for evaluation consists of identifying and valuing the project costs and benefits that will arise with the project, under the two Development Options mentioned in previous chapters, and to compare them with the situation as it would be without the project. Once financial pricing, or pricing carried out at market prices has been established for both project costs and benefits, cash flow consisting of these costs and benefits will be prepared to cover the whole project life and, on the basis of this cash flow, the internal rate of return (IRR) that sets the discounted net benefit stream (discounted benefits minus discounted costs) equal to zero. This project is considered acceptable if the IRR exceeds the opportunity cost of capital in UAE. For practical purposes, the cost is considered to be 5% as this rate is the rate charged by commercial banks for their loans.

After determining the total project cost, a financial analysis will be made taking into consideration financing sources; that is, foreign loans and government budget, and the implications at the moment of contracting the loan.

As costs and benefits of the project at the implementation phase are subject to increase/decrease due to fluctuations in yield, prices and other parameters, due to the change of project circumstances from the time of project evaluation for the feasibility study, a sensitivity test shall be conducted to find out what parameters shall have the strongest effect on the project for a given percentage variation (increase in construction and O/M cost, decrease in yield, and extension of construction period).

5.6.3. Costs and Benefits of the Project

(1) Costs of the Project

The costs of the project which are subject to project evaluation shall consist of the initial investment, operation and maintenance cost and replacement costs.

a) Initial Investment Costs

Initial investment costs of the Project are composed of the following items:

- Construction works for recharge dam and trench, and irrigation facilities,
- Construction works for water source facilities such as wells and pumping systems at farm level,
- Construction of irrigation facilities,
- Installation of greenhouse,

- General administration cost (Considered to be 2% of construction works cost),
- Consulting services,
- Physical Contingencies (Considered to be 10% of summitry of construction works cost plus administration cost); and
- Price Contingencies (Considered to be 9% of summitry of construction works plus administration cost plus consulting services).

The project total costs are shown in Tables 5.6.1. and 5.6.2. The disbursement schedule of the Project cost are shown in Tables 5.6.3. and 5.6.4.

b) Operation and Maintenance Costs

Annual operation and maintenance costs of the Project include the operation and maintenance costs of irrigation facilities and groundwater augmenting facilities.

In the Option Two Plan, US$ 1.27/m^3 which is estimated production cost over UAE of desalinated water was applied as the purchasing unit price.

c) Replacement Costs

Replacement costs of the Project include costs of replacement of facilities, structures and machinery according to their durable life.

(2) Benefits of the Project

Increase of agricultural production and profits due to improved irrigation and the introduction of profitable crops is considered to be the benefits of the project. In the evaluation, 85% of market price is considered as farm gate price considering transportation cost and administrative commission. The annual net benefits of the project for Option One is estimated to be US$ 61.3 million or Dh. 224 million, and Option Two US$ 125.1 million or Dh. 457 million. A decrease in agricultural production caused by loss of irrigation water in quantity and quality without the project are also considered, namely, balance of the net return for the whole development area between With Project situation and Without Project situation.

5.6.4. Financial Evaluation

Tables 5.6.5. and 5.6.6. show the estimates for the income resulting under the Without-Project scenario. The following assumptions have been adopted:

Available water volume for agricultural purposes decreases following the pattern shown in the simulation model. It is supposed that water decrease starts from the year 1997 and continues to decrease up until 2014 in a constant and linear manner; consequently, cultivated areas decrease and

income levels also decrease. From the year 2015 it is assumed that the water level available for agricultural purposes will become steady and, as a consequence, the income levels do so too.

The life of a recharge dam is considered to be 50 years; consequently, the project is considered to have 50 years of life following the commencement of the consulting service.

The project benefit is expected within five years following completion of the recharge dam and trench constructions.

The estimate was done based on US$ currency (exchange rate US$ 1 = Dh. 3.6).

Based on the conditions mentioned above, the financial internal rate of return was calculated as below:

Option	Internal rate of return
Option One	6.50 %
Option Two	0.44 %

From this result, IRR for Option One is cleared by the evaluation criteria set out above, but IRR for Option Two is less than 5 %. By comparing the two IRRs, it is possible to say that Option One is the most attractive.

5.6.5. Sensitive Analysis

Based on the results of the evaluation mentioned above, sensitive analysis was carried out and the results are summarized below:

Case	Condition	Internal Ratio of Return
1	Project cost is escalated by 10%	5.02 %
2	Completion of construction works is delayed by 1 years	6.45 %
3	Production declined by 10%	5.06 %

Note: detailed calculation of each case is shown in Volume II: Sector Report

5.6.6. Financing Plan

It is assumed that from the point of view of financial sources, two-thirds (2/3) of the initial investment costs will be financed by a loan and one-third by the government. (The government also will cover the O/M costs and replacement costs under the figure of government subsidy).

- Interest : 3% per annum
- Repayment term: 20 years (grace period: 10 years)

The maximum amount to be repaid shall be US$ 161 million or Dh. 588 million at year 2005, which amount is equivalent to 5 times the MAF annual budget (Table 5.6.5.).

5.6.7. Conclusions

The project is attractive not only for the profitability shown above, but also for the impact on the availability of water resources and their rational use. It must be mentioned that this rational use of water comes accompanied by an expected increase in income levels, which in turn could be a dynamic factor in the Study Area's economy, increasing the possibilities both for employment and the potential for post-harvest processing.

As economic conditions improve, the absentee farmowner could be motivated to pay more attention to the farm, not only as a week-end villa, but also as a potentially economically active and viable workplace.

5.7. Environmental Assessment and WID

5.7.1. Initial Environmental Examination (IEE)

Social and natural environmental impacts related to implementation of the Project have been assessed. The IEE system prepared by JICA is applied to the Study under an agreement between the Study Team and Director General of Federal Environmental Agency because no system has yet been established in UAE.

Table 5.7.1. summarizes the potential environmental changes; assessment of the influence of the changes; and environmental items for requiring screening, which are discussed as follows:

(1) Social Environment

a) Resettlement

The Study does not includes work which necessitates resettlement of inhabitants.

b) Economic Activities

The economic activities in the Study Area will be stimulated with the implementation of the project because of the increase in agricultural production due to groundwater development. However, the environment will not be affected.

c) Traffic and Public Facilities

The project does not greatly affect traffic facilities because the project mainly consists of improvements to the water supply system.

d) Splits to Community

There are no communities at the well drilling site.

e) Cultural Property

There are cultural treasures or remains in the area but they are still under excavation. The project does not affect them because it does not include an increase in farm land.

f) Water Rights

There are no private water rights relating to groundwater in the Area.

g) Public Health Conditions

The project does not include any works which may cause deterioration in sanitary conditions such as might lead to an increase in rubbish, human waste, or outbreak of mass infections.

Application of agricultural chemicals may increase due to development associated with groundwater development. On the other hand, to protect groundwater quality, and human and animal health, a MAF decree (Decree No. 97, Enacted in 1993) bans the application of the powerful toxic pesticides shown in Table 4.10.3.. The importation of such chemicals is also banned.

Other chemicals used in the Study Area are mainly applied to vegetables, and the amounts are very small; only 0.9 % of the farmers in the Study Area apply pesticides; the average is 0.17 kg/ha and 0.44 L/ha, and their toxicity is lower than that of the banned chemicals. The application amounts are unlikely to increase because the total area of farmland is not expected to be expanded in the future.

Application of the chemicals in the Study Area, consequently, would have little effect on groundwater and human health.

Based on the chemical analysis of groundwater collected during the test drilling of the Study, contents of fluoride, at 5 to 14 mg/lit., and chromium, at 0.8 to 1.7 mg/lit. are high in the southern part of the Study Area (PW-2, -3, and -5). According to WHO criteria, however, the upper limits of these elements are set at 1.7 for fluoride and 0.05 mg/lit for chromium. Consequently, it is necessary to seek out other drinking water resources in the area as soon as possible to avoid risk to health.

h) Waste

Residual materials will not be produced.

i) Hazard

There is no risk of hazard because the project does not include any big construction works.

(2) Natural Environment

a) Topography and Geology

Though the project does not include land reclamation, it will not induce any topographic change.

b) Soil and Land

According to data collected by MAF in 1993, 40% of farmers in the Study Area apply traditional irrigation methods and 60% apply modernized methods. There is, however, a small amount of salt damage in the area.

The SAR value of groundwater is comparatively low and symptoms of salt damage are hardly ever observed in the Study Area. This issue is very important, however, for agriculture in arid regions.

Generally, salinization of soil is affected by the water quality and by irrigation methods. To avoid salt accumulation in soil, the following countermeasures are proposed in the Study:

- Introduction of a water-saving cropping pattern.
- Water-saving irrigation to meet crop water requirements.
- Water-saving water distribution system and irrigation methods to reduce water loss during conveyance.
- Improvement of drainage facilities for leaching of salts.

Consequently, by applying the above mentioned countermeasures, salt damage could be minimized. Monitoring of salt accumulation in the soil, however, would remain a necessity for any sustainable agricultural development.

c) Groundwater

Groundwater resources consumed in the area are divided into two types: fossil and rechargeable water. It is estimated that rechargeable water represents about 30% of total irrigation water used in the Study Area. Water-saving and increasing the amount of rechargeable groundwater are given a high priority in the Study.

From the point of view of water-saving the following policies are recommended:

- Establishment of water-saving cultivation systems including crop selection and irrigation methods.

- Establishment of a sustainable water amount based on evaluation of groundwater consumption, development potential and recharge rate.
- Other water resources for irrigation may be proposed.

To increase groundwater recharge for continuous use of water resources the following countermeasures are also proposed:

- Recharge dam
- Recharge trenches

Through these countermeasures a successful, sustainable use of the resources may be achieved. However, monitoring of the groundwater level will be necessary to guarantee the effect of the measures with regard to the sustainability of water resources, and apply the data for further development.

d) Hydrological Situation

There are no rivers or lakes into which to discharge drainage water.

e) Flora and Fauna

The project does not contemplate any new farm land expansion. Consequently, the implementation of the recommendations of the Study will not affect to the indigenous species of flora and fauna shown in Tables 4.10.1. and 4.10.2.

f) Meteorology

There are no large construction works which may have meteorological effects.

g) Landscape

Topographic changes are not expected to take place because the project does not include land reclamation or large construction works.

(3) Pollution

a) Air Pollution

There are no air pollution sources.

b) Water Pollution

There are no water pollution sources.

c) Soil Contamination

There are no soil contamination sources.

d) Noise and Vibration

Noise and vibration will occur during drilling activities. However, they will not affect human activities because drilling areas are very far from the town.

e) Land Subsidence

Land subsidence is not expected to occur after drawing groundwater because the land foundation consists of limestone and sandstone which does not have a soft nature like that of clay.

f) Offensive Odors

There are no sources of offensive odors.

(4) Result of the Initial Examination

Social and natural environmental impacts related to the implementation of the project have been assessed.

Table 5.7.1. summarizes the estimation of the environmental changes and assesses the influence of those changes. Since very few people live in the Study Area and the project does not include any new land reclamation, implementation of the project will have little impact on local dwellers as far as resettlement is concerned.

It is clear that groundwater resources in the Study Area become very limited and valuable. Water resources are crucial for irrigation to sustain agriculture, as well as to provide drinking water for the inhabitants. For sustainable use of the resources, the appropriate amount for consumption should be evaluated. In this context, the groundwater should be monitored continuously.

According to the farm inventory survey, otherwise, groundwater quality varies depending on depth and area. Consequently, in some cases salinization would be a problem affecting soil characteristics. Once the soil deteriorates, it becomes unsuitable for cultivation and its rehabilitation is very difficult. Based on the field survey and results of water analysis, it seems that deterioration may occur in the Study Area. It is recommended that groundwater quality and soil monitoring are to be continuously carried out.

From the IEE, EIA is necessary as the next stage of study, in particular on the subject of groundwater level, groundwater quality and soil.

5.7.2. Women's Role in the Development

In recent years, the government has pursued a policy of promoting the role of women in society. Taking this fact into consideration, the project should involve women; they are expected to play the following roles:

(1) Management of Marketing Information

According to the survey, one of the problems of agriculture in the area is that marketing information does not reach the farmers. This situation creates disadvantages from the point of view of farm income. Consequently, the Study recommends the establishment of a market information system. The business of information management, and the transmission of information suit the abilities of women. It is recommended that women's abilities should be adequately applied to these activities.

(2) Campaign for Water Conservation Education

Women can also participate in the sense that they can teach the importance of groundwater conservation resources to their children as, by tradition, they are responsible for education. In this context, it is recommended that the project should involve women in the promotion of the concept of the sustainability of water resources in the desert.

Table 5.3.1. Net Income per Unit Water Consumption of Vegetables (1/2)

Crops	Source of Data	Yield (ton/ha)	Unit Price (Dh/kg)	Gross Income (Dh/ha)	Production Cost (Dh/ha)	Net Income (Dh/ha)	Water Consumption (m^3/ha)	Net Income per W.C. (Dh/m^3)	Growing Period in Main Field	
									Days	Period
Musk Melon	(E)	22.00	18.12	398,640	72,330	326,310	2,300	141.9	113	15/Oct-5/Feb
Sweet melon	S	20.60	18.00	370,714	22,722	347,992	3,100	112.3	90	16/Jan-15/Apr
Jews mallow	F	86.40	2.50	216,000	35,112	180,888	1,800	100.5	50	16/Feb-6/Apr
Musk Melon	(E)	11.65	20.00	233,000	72,060	160,940	1,800	89.4	92	15/Oct-15/Jan
Cucumber	(F)	69.40	3.33	231,102	86,259	144,843	1,900	76.2	87	18/Nov-12/Feb
Sweet melon	F	14.89	18.00	268,038	39,693	228,345	3,100	73.7	90	16/Jan-15/Apr
Cucumber	F	91.98	2.03	186,721	23,711	163,011	2,500	65.2	100	23/Sep-31/Dec
Jews mallow	S	27.10	4.50	121,941	17,942	103,999	1,700	61.2	50	16/Feb-6/Apr
Sweet Pepper	(E)	153.95	2.62	403,349	50,924	352,425	7,500	47.0	207	12/Oct-11/June
Spinach	E	48.40	2.83	136,972	15,988	120,984	2,800	43.2	120	1/Nov-1/Mar
Cabbage	E	32.40	2.17	70,308	11,798	58,510	1,500	39.0	62	27/Oct-28/Dec
Cabbage	E	46.23	2.17	100,308	12,434	87,874	2,700	32.5	89	18/Sep-16/Dec
Spinach	E	45.47	2.75	125,032	16,312	108,720	3,400	32.0	136	3/Oct-16/Feb
Cauliflower	S	22.22	3.17	70,444	14,448	55,996	1,800	31.1	55	10/Oct-3/Dec
Cabbage	S	26.40	2.17	57,278	11,840	45,438	1,600	28.4	65	19/Oct-27/Dec
Sweet Melon	(F)	50.00	3.50	175,000	73,000	102,000	3,667	27.8	140	14/Nov-2/Apr
Cabbage	E	36.30	2.17	78,771	12,260	66,511	2,400	27.7	74	18/Sep-1/Dec
Cowpea	S	22.09	4.25	93,877	28,720	65,157	2,400	27.1	70	16/Sep-24/Nov
Sweet Pepper	(E)	77.90	2.77	215,783	50,276	165,507	6,300	26.3	114	15/Feb-27/July
Cucumber	(E)	84.83	2.05	173,908	87,069	86,839	3,400	25.5	136	12/Sep-26/Jan
Squash	F	46.50	1.84	85,553	27,701	57,851	2,300	25.2	100	23/Sep-31/Dec
Cauliflower	F	20.22	3.14	63,497	20,279	43,218	1,800	24.0	55	10/Oct-3/Dec
Sweet Pepper	(E)	105.50	2.29	241,595	51,218	190,377	8,000	23.8	232	3/Sep-1/June
Cauliflower	E	24.50	3.00	73,500	14,814	58,686	2,500	23.5	71	19/Sep-29/Nov
Cucumber	(E)	109.00	1.79	195,110	87,717	107,393	4,600	23.3	109	12/Jan-28/May
Cabbage	F	25.67	2.17	55,695	18,713	36,982	1,600	23.1	65	19/Oct-27/Dec
Cucumber	(E)	102.60	1.79	183,654	87,501	96,153	4,200	22.9	111	6/Feb-19/May
Cauliflower	E	14.60	3.17	46,282	14,256	32,026	1,400	22.9	57	29/Oct-25/Dec
Cabbage	E	52.70	1.08	56,916	12,056	44,860	2,000	22.4	84	27/Oct-19/Jan
Cucumber	(E)	104.20	1.94	202,148	88,065	114,083	5,200	21.9	119	12/Jan-11/June
Musk melon	E	15.60	8.50	132,600	23,682	108,918	5,100	21.4	106	27/Mar-11/July
Sweet Pepper	(E)	90.10	2.29	206,329	50,978	155,351	7,600	20.4	217	16/Sep-5/June
Bean	S	15.07	4.67	70,394	38,388	32,006	1,600	20.0	70	1/Nov-11/Feb
Spinach	E	16.90	2.75	46,475	15,364	31,111	1,600	19.4	79	30/Nov-17/Feb
Dwarf Bean	(E)	34.20	4.73	161,766	59,779	101,987	5,300	19.2	177	16/Nov-12/May
Tomato	E	142.59	1.07	152,571	20,142	132,429	7,100	18.7	200	23/Oct-11/May
Cucumber	(E)	87.20	1.79	156,088	87,231	68,857	3,700	18.6	96	12/Jan-19/May
Bean	F	14.24	4.67	66,487	21,977	44,509	2,400	18.5	103	1/Nov-11/Feb
Musk melon	E	21.18	9.00	190,575	25,710	164,865	8,900	18.5	172	15/Feb-6/Aug
Sweet Pepper	(E)	85.40	2.29	195,566	51,218	144,348	8,000	18.0	232	3/Sep-1/June
Musk melon	E	12.08	8.50	102,638	23,382	79,256	4,500	17.6	95	26/Mar-29/June
Parsley	F	15.67	3.25	50,918	18,095	32,823	1,900	17.3	70	16/Sep-24/Nov
Carrot	E	27.24	2.00	54,480	15,218	39,262	2,300	17.1	92	27/Nov-27/Feb
Turnip(Laft)	S	30.44	1.45	44,144	15,418	28,726	1,700	16.9	50	1/Sep-20/Oct
Cucumber	(E)	70.40	1.95	137,280	86,853	50,427	3,000	16.8	115	14/Sep-7/Jan
Radish	E	14.50	1.37	19,865	6,456	13,409	800	16.8	31	27/Oct-27/Nov
Tomato	E	107.37	1.15	123,471	20,184	103,287	6,200	16.7	160	2/Dec-11/May
Carrot	F	24.00	2.00	48,000	9,807	38,193	2,300	16.6	90	1/Oct-29/Dec
Cauliflower	E	22.30	3.17	70,691	15,288	55,403	3,400	16.3	99	9/Sep-17/Dec
Carrot	E	26.81	2.00	53,618	15,248	38,370	2,400	16.0	104	15/Nov-27/Feb
Cucumber	(E)	82.60	1.79	147,854	87,285	60,569	3,800	15.9	99	9/Feb-19/May
Water Melon	E	24.10	3.31	79,771	16,112	63,659	4,000	15.9	91	1/Mar-31/May
Spinach	E	29.45	2.00	58,900	15,934	42,966	2,700	15.9	111	30/Nov-21/Mar
Cauliflower	E	16.10	3.17	51,037	14,730	36,307	2,300	15.8	78	1/Oct-18/Dec
Carrot	S	25.07	2.00	50,131	15,218	34,913	2,300	15.2	90	1/Oct-29/Dec
Dwarf Bean	(E)	23.60	5.15	121,540	59,185	62,355	4,200	14.8	155	15/Nov-19/Apr
Tomato	E	101.55	1.07	111,869	19,902	91,967	6,300	14.6	197	23/Oct-8/Mar
Pepper	F	15.00	2.50	37,500	9,621	27,879	2,000	13.9	110	5/Sep-23/Dec
Cucumber	(E)	53.32	2.15	114,629	86,343	28,286	2,100	13.5	96	4/Oct-8/Jan
Tomato	E	94.10	1.07	100,687	19,680	81,007	6,200	13.1	162	30/Nov-11/May
Dwarf Bean	(E)	22.20	5.15	114,330	59,239	55,091	4,300	12.8	130	4/Jan-14/May
Lettuce	S	18.73	2.42	45,317	16,218	29,099	2,300	12.7	97	27/Oct-31/Jan
Dwarf Bean	(E)	24.00	4.75	114,000	59,401	54,599	4,600	11.9	147	16/Dec-12/May
Pepper(L.C)	E	52.60	2.29	120,454	24,760	95,694	8,200	11.7	231	20/Sep-9/May
Squash	S	28.65	1.84	52,707	18,596	34,111	3,000	11.4	110	6/Sep-24/Dec
Cucumber	S	28.62	2.00	57,238	34,604	22,634	2,000	11.3	60	60(1/Sep-30/Oct)

Table 5.3.1. Net Income per Unit Water Consumption of Vegetables (2/2)

Crops	Source of Data	Yield (ton/ha)	Unit Price (Dh/kg)	Gross Income (Dh/ha)	Production Cost (Dh/ha)	Net Income (Dh/ha)	Water Consumption (m^3/ha)	Net Income per W.C. (Dh/m^3)	Growing Period in Main Field	
									Days	Period
Tomato	E	91.27	1.07	97,659	20,142	77,517	7,100	10.9	199	23/Oct-10/May
Eggplant	S	37.97	1.00	37,972	12,248	25,724	2,400	10.7	85	30/Sep-23/Dec
Dwarf Bean	(E)	20.40	4.64	94,656	58,729	35,927	3,400	10.6	146	15/Oct-10/Mar
Radish	S	19.61	1.37	26,860	7,002	19,858	1,900	10.5	60	16/Sep-14/Nov
Tomato	(E)	96.70	1.31	126,677	51,656	75,021	7,400	10.1	129	14/Feb-27/July
Tomato	F	48.91	1.09	53,310	24,909	28,401	3,100	9.2	115	8/Oct-30/Jan
Water melon	S	21.20	3.00	63,594	17,066	46,528	5,500	8.5	150	16/Jan-14/June
Radish	E	15.24	1.25	19,050	6,834	12,216	1,500	8.1	58	4/Oct-1/Dec
Dwarf Bean	(E)	20.80	4.85	100,880	59,671	41,209	5,100	8.1	187	16/Oct-21/April
Cucumber	(E)	46.72	2.15	100,448	86,181	14,267	1,800	7.9	92	19/Oct-19/Jan
Water Melon	E	18.58	3.00	55,740	16,682	39,058	5,100	7.7	103	1/Mar-12/June
Radish	F	26.00	1.37	35,620	22,351	13,269	1,900	7.0	60	16/Sep-14/Nov
Okra	F	12.67	3.53	44,715	20,119	24,595	3,600	6.8	75	1/Aug-14/Oct
Tomato	S	27.04	1.42	38,398	18,102	20,296	3,100	6.5	115	8/Oct-30/Jan
Cabbage	E	31.60	1.08	34,128	12,920	21,208	3,600	5.9	123	18/Sep-19/Jan
Musk melon	E	5.55	10.73	59,552	24,384	35,168	6,400	5.5	119	15/Feb-14/June
Tomato	(E)	63.88	1.31	83,676	51,146	32,530	6,500	5.0	114	17/Jan-1/July
Onion	F	32.50	0.82	26,650	15,092	11,558	2,500	4.6	110	9/Nov-26/Feb
Jews Mallow	(F)	9.30	3.33	30,969	24,367	6,602	1,890	3.5	110	9/Nov-26/Feb
Okra	S	10.59	4.06	43,012	32,944	10,068	3,600	2.8	75	1/Aug-14/Oct
Cucumber	(E)	48.30	1.97	95,151	86,853	8,298	3,000	2.8	118	12/Sep-8/Jan
Water melon	F	13.91	3.00	41,739	26,541	15,198	5,500	2.8	150	16/Jan-14/June
Pepper(L.C)	E	20.47	2.29	46,876	24,760	22,116	8,200	2.7	231	20/Sep-9/May
Potato	S	23.61	1.25	29,511	22,802	6,709	2,500	2.7	100	21/Oct-28/Jan
Okra	E	15.90	3.88	61,692	36,346	25,346	9,900	2.6	172	15/Feb-6/Aug
Potato	F	20.09	1.33	26,724	21,362	5,362	2,500	2.1	100	21/Oct-28/Jan
Okra	E	11.70	4.25	49,725	34,942	14,783	7,300	2.0	123	15/Mar-16/July
Okra	E	11.50	4.25	48,875	35,482	13,393	8,300	1.6	143	23/Feb-16/July
Okra	E	11.10	4.25	47,175	35,104	12,071	7,600	1.6	136	1/Mar-16/July
Onion	E	34.43	0.65	22,376	14,350	8,026	5,500	1.5	135	3/Jan-18/May
Okra	E	12.20	3.88	47,336	35,860	11,476	9,000	1.3	144	15/Mar-6/Aug
Okra	E	11.90	3.88	46,172	35,968	10,204	9,200	1.1	158	1/Mar-6/Aug
Onion	E	25.70	0.66	16,962	13,372	3,590	3,600	1.0	106	3/Jan-19/Apr
Onion	E	24.88	0.90	22,392	15,868	6,524	8,400	0.8	178	3/Jan-30/June
Okra	E	10.35	3.88	40,158	35,482	4,676	8,300	0.6	143	23/Feb-16/July
Onion(L.C)	E	29.30	0.65	19,045	15,190	3,855	7,100	0.5	195	3/Nov-17/May
Sweet Pepper	(E)	24.80	2.02	50,096	48,824	1,272	3,700	0.3	146	16/Aug-9/Feb
Green beans	F	10.49	2.33	24,437	23,786	651	2,400	0.3	103	1/Nov-11/Feb
Onion	E	18.76	0.90	16,884	15,868	1,016	8,400	0.1	177	4/Jan-30/June
Tomato(L.C)	E	19.61	1.07	20,983	20,874	109	8,500	0.0	223	13/Oct-24/May
Sweet Pepper	(E)	23.70	2.02	47,874	48,824	-950	3,700	-0.3	146	16/Aug-9/Feb
Pepper	S	10.42	2.00	20,843	21,532	-689	2,000	-0.3	50	5/Sep-23/Dec
Sweet Pepper	(E)	24.80	1.80	44,640	48,230	-3,590	2,600	-1.4	123	3/Sep-9/Feb
Onion	S	7.90	0.82	6,480	12,802	-6,322	2,500	-2.5	110	9/Nov-26/Feb
Radish	E	1.83	1.37	2,511	6,618	-4,107	1,100	-3.7	42	4/Oct-15/Nov
Parsley	S	1.80	3.25	5,856	16,050	-10,194	1,900	-5.4	70	16/Sep-24/Nov
Eggplant	F	24.43	1.00	24,433	40,764	-16,331	2,400	-6.8	85	30/Sep-23/Dec
Sweet Pepper	S	1.54	3.00	4,616	20,032	-15,416	2,000	-7.7	50	15/Sep-3/Nov
Cucumber	(E)	32.28	2.15	69,402	86,229	-16,827	1,800	-9.3	84	27/Oct-19/Jan

Notes :

1) Unit price was adopted the average unit price in Dubai wholesale market during the harvesting months of each vegetables in 1993

2) Production cost was estimated as the total of open field costs(statistic data) and green house material cost

3) Unit price and production cost of musk melon were adopted those of sweet melon

4) F: farm household inventory survey, AF: Al Ain farm data, S: statistic data of MAF, E: experimental data of UNDP/FAO in UAE, ( ) : greenhouse cultivation

Table 5.3.2. Net Income per Unit Water Consumption of Tree Crops and Field Crops

Crops	Data Sources	Yield (ton/ha)	Unit Price (Dh./kg)	Gross Income (Dh./ha)	Production Cost (Dh./ha)	Net income (Dh./ha)	Water Consumption (m^3/ha)	Net Income per W.C. (Dhs/m^3)
[Fruit Tree]								
Improved Date Palm	(S)	19.2	7.00	134,586	42,992	91,594	14,800	6.2
Pomegranate	S	20.9	4.57	95,572	43,130	52,442	9,500	5.5
Lime	S	12.7	5.76	73,433	30,508	42,925	10,200	4.2
Lime	F	7.15	5.76	41,184	15,072	26,112	10,200	2.6
Date Palm	S	19.2	4.00	76,906	42,992	33,914	14,800	2.3
Almond	S	3.0	17.08	50,389	16,640	33,749	16,000	2.1
Fig	S	4.8	8.12	38,783	21,630	17,153	9,500	1.8
Fig	F	4.26	8.12	34,592	17,746	16,846	9,500	1.8
Mango	F	4.61	7.63	35,203	19,564	15,639	9,500	1.6
Other Citrus	F	12.85	2.26	29,036	18,525	10,511	10,200	1.0
Guava	S	11.9	3.53	41,865	35,630	6,235	9,500	0.7
Lemon	S	15.7	2.02	31,727	27,508	4,219	10,200	0.4
Date Palm	F	6.23	4.00	24,925	21,470	3,455	14,800	0.2
Grapes	F	1.25	4.29	5,363	6,685	-1,322	9,400	-0.1
Grape fruit	S	11.6	2.20	25,568	27,508	-1,940	10,200	-0.2
Guava	F	4.83	3.53	17,050	20,108	-3,058	9,500	-0.3
Mango	S	6.4	7.63	48,870	52,130	-3,260	9,500	-0.3
Other Citrus	S	11.8	2.26	26,720	30,508	-3,788	10,200	-0.4
Lemon	F	6.36	2.02	12,838	20,478	-7,640	10,200	-0.7
Orange	F	3.08	4.75	14,633	23,350	-8,717	10,200	-0.9
Banana	S	3.3	4.40	14,667	32,288	-17,621	17,200	-1.0
Pomegranate	F	1.37	4.57	6,266	16,952	-10,685	9,500	-1.1
Chico	F	1.98	4.00	7,920	20,350	-12,430	9,500	-1.3
Grape fruit	F	2.56	2.56	6,560	26,773	-20,213	10,200	-2.0
Grapes	S	2.5	4.25	10,749	45,076	-34,327	9,400	-3.7
[Field Crops]								
Alfalfa	S	90.9	1.40	127,203	18,710	108,493	15,700	6.9
Green fodder	S	77.0	1.10	84,667	15,500	69,167	15,000	4.6
Green fodder	F/S	77.0	1.10	84,667	20,190	64,477	17,300	3.7
Alfalfa	F	91.55	1.06	97,044	37,113	59,931	15,700	3.8
Methapleon (Missiblo)	F	154.03	0.48	74,072	42,964	31,108	15,000	2.1
Rhodes Grass	F	100.92	0.42	42,846	33,170	9,675	15,000	0.6
Tobacco	S	8.7	1.80	15,661	19,134	-3,473	5,000	-0.7

Notes:
1) Unit price was adopted the average unit price in Dubai wholesale market during the harvesting months of each fruits in 1993
2) Unit prices of field crops except Alfalfa are applied the data of farm household survey.
3) Unit price of Alfalfa of the statical data of MAF in 1993 is applied.
4) F: farm household inventory survey. S: statistic data of MAF

Table 5.3.3. Crop Cultivation Plan of Option-1

Crop	Type Of Culti-vation	Area to be Cultivated (ha)	Unit Yield (ton/ha)	Production (ton)	Unit Price (Dh/kg)	Gross Income (1000Dhs)	Production Cost (Dh/ha)	Production Cost (1,000Dh)	Net Income (1,000Dh)	Unit Water Consump-tion(m^3/ha)	Water Consumption (m^3)	Net Income Per W.C. (Dhs/m^3)	Net Water Consump-tion(m^3)*	Gross Irrigation Amount(m^3)*	Net Income per Net W.C. (Dhs/m^3)*	Net Income per G.W.A. (Dhs/m^3)*	Growing Period In Main Field	
																	Days	Period
[Vegetables]																		
Bean	D	52.7	14.2	750	4.67	3,503	21,978	1,158	2,345	2,400	126,431	18.5	156,985	92,344	14.9	25.4	103	1/Nov-11/Feb
Cabbage	42	15.4	32.4	500	2.17	1,085	11,798	182	903	1,500	23,148	39.0	28,704	16,885	31.5	53.5	62	27/Oct-28/Dec
Cabbage	31	18.4	46.2	850	2.17	1,845	12,434	229	1,616	2,700	49,648	32.5	54,062	31,801	29.9	50.8	89	18/Sep-16/Dec
Cauliflower	40	22.5	22.2	500	3.17	1,585	14,448	325	1,260	1,800	40,500	31.1	45,675	26,868	27.6	46.9	55	10/Oct-3/Dec
Cucumber	(27)	33.0	109.0	3,600	1.79	6,444	87,717	2,897	3,547	4,600	151,927	23.3	187,266	110,157	18.9	32.2	110	8/Feb-28/May
Cucumber	(35)	32.4	69.4	2,250	3.33	7,493	86,211	2,793	4,699	1,900	61,560	76.3	71,928	42,311	65.3	111.1	87	18/Nov-12/Feb
Dwarf Bean	(D)	171.1	34.2	5,850	4.73	27,671	59,779	10,225	17,445	5,300	906,579	19.2	1,176,842	692,260	14.8	25.2	177	16/Nov-12/May
Eggplant	45	52.7	38.0	2,000	1.00	2,000	12,248	645	1,355	2,400	126,408	10.7	155,903	91,708	8.7	14.8	85	30/Sep-23/Dec
Green beans	D	56.6	22.1	1,250	4.25	5,313	29,272	1,657	3,656	2,400	135,817	26.9	167,507	98,534	21.8	37.1	70	16/Sep-24/Nov
Lettuce	25	53.4	18.7	1,000	2.42	2,420	16,218	866	1,554	2,300	122,824	12.7	139,379	81,988	11.1	19.0	97	27/Oct-31/Jan
Musk Melon	(D)	47.7	22.0	1,050	18.12	19,026	72,330	3,452	15,574	2,300	109,773	141.9	146,045	85,909	106.6	181.3	113	15/Oct-5/Feb
Musk melon	D	259.7	21.2	5,500	9.00	49,500	25,710	6,678	42,822	8,900	2,311,688	18.5	2,841,558	1,671,505	15.1	25.6	172	15/Feb-6/Aug
Parsley	45	95.7	15.7	1,500	3.25	4,875	18,095	1,732	3,143	1,900	181,911	17.3	232,655	136,856	13.5	23.0	70	16/Sep-24/Nov
Pepper	35	200.0	15.0	3,000	2.50	7,500	9,621	1,924	5,576	2,000	400,000	13.9	874,000	514,118	6.4	10.8	110	5/Sep-23/Dec
Pepper(L.C)	35	173.0	52.6	9,100	2.29	20,839	24,760	4,284	16,555	8,200	1,418,631	11.7	1,773,289	1,043,111	9.3	15.9	231	20/Sep-9/May
Radish	D	3.4	14.5	50	1.37	69	6,456	22	46	800	2,759	16.8	3,586	2,110	12.9	21.9	31	27/Oct-27/Nov
Spinach	D	76.4	48.4	3,700	2.83	10,471	15,988	1,222	9,249	2,800	214,050	43.2	272,149	160,088	34.0	57.8	120	1/Nov-1/Mar
Squash	D	32.3	46.5	1,500	1.84	2,760	27,701	894	1,866	2,300	74,200	25.2	195,501	115,000	9.5	16.2	100	23/Sep-31/Dec
Squash	D	32.3	46.5	1,500	1.84	2,760	27,701	894	1,866	2,300	74,194	25.2	95,484	56,167	19.5	33.2	100	1/May-8/Aug
Sweet melon	D	48.6	20.6	1,000	18.00	18,000	22,722	1,103	16,897	3,100	150,520	112.3	167,515	98,538	100.9	171.5	90	16/Jan-15/Apr
Sweet Pepper	(35)	45.1	154.0	6,950	2.62	18,209	50,924	2,299	15,910	7,500	338,584	47.0	421,650	248,029	37.7	64.1	207	16/Nov-11/Jun
Sweet Pepper	(48)	49.4	77.9	3,850	2.77	10,665	50,276	2,485	8,180	6,300	311,361	26.3	392,413	230,831	20.8	35.4	114	4/Apr-27/Jul
Tomato	31	33.3	142.6	4,750	1.07	5,083	20,142	671	4,412	7,100	236,517	18.7	295,147	173,616	14.9	25.4	200	23/Oct-11/May
Tomato	(34)	41.4	96.7	4,000	1.31	5,240	51,656	2,137	3,103	7,400	306,101	10.1	409,514	240,891	7.6	12.9	130	20/Mar-27/Jul
Turnip(Laft)	D	32.8	30.4	1,000	1.45	1,450	15,418	506	944	1,700	55,839	16.9	69,964	41,155	13.5	22.9	50	1/Sep-20/Oct
Water Melon	D	33.2	24.1	800	3.31	2,648	16,112	535	2,113	4,000	132,780	15.9	166,307	97,828	12.7	21.6	91	1/Mar-31/May
Subtotal	-	1,712.6	39.59	67,800	139.23	238,450	30,255	51,815	186,635	6,155	8,063,751	23.1	10,541,028	6,200,605	17.7	30.1	-	-
[Fruit Trees]																		
Date Trees	-	272.0	19.2	5,229	7.00	36,603	42,992	11,692	24,911	14,800	4,025,141	6.2	5,006,949	2,002,780	5.0	12.4	-	-
[Field Crops]																		
Alfalfa	-	563.6	90.9	51,209	1.40	71,693	18,710	10,545	61,148	15,700	8,848,630	6.9	11,080,514	13,296,616	5.5	4.6		-
Total	-	2,548.2		124,238	3.08	346,746		74,052	272,693	10,450			26,628,491	21,500,001	10.2		-	-

Note:
1) ( ) : Green house cultivation
2) D : Direct sowing
3) Figures in type of cultivation show nursery period.
4) * results of detailed estimation of irrigation water requirment

Table 5.3.4. Present and Option-1 Plan Agriculture in the Study Area

Crop	Cultivation Area (ha)			Production (ton)			Net Income (1,000 Dh)			Gross Irrigation Amount (1,000 m^3)		
	Present (A)	Plan (B)	B/A (%)	Present (A)	Plan (B)	B/A (%)	Present (A)	Plan (B)	B/A (%)	Present (A)	Plan (B)	B/A (%)
egetable	1,158	1,713	148%	25,600	67,800	265%	22,197	186,635	841%	2,067	6,201	300%
ruit Tree	1,825	272	15%	29,681	5,229	18%	24,911	24,911	100%	14,764	2,003	14%
ield Crop	1,601	564	35%	136,561	51,209	37%	168,554	61,148	36%	35,985	13,297	37%
Total	4,584	2,548	56%	191,842	124,238	65%	215,662	272,693	126%	52,816	21,500	41%

Table 5.3.5. Average Farm in the Study Area under Option-1

Crop	Type of Cultiva-tion	Area to be Cultivated (m^2)	Unit Yield (ton/ha)	Production (kg)	Net Income (Dh)	Water Consump-tion(m^3)	Gross Irrigation Water (m^3)
[Vegetables]							
Bean	D	261	14.2	372	1,162	63	46
Cabbage	42	76	32.4	248	447	11	8
Cabbage	31	91	46.2	421	801	25	16
Cauliflower	40	111	22.2	248	624	20	13
Cucumber	(27)	164	109.0	1,784	1,758	75	55
Cucumber	(35)	161	69.4	1,115	2,329	31	21
Dwarf Bean	(D)	848	34.2	2,899	8,645	449	343
Eggplant	45	261	38.0	991	671	63	45
Green beans	D	280	22.1	619	1,812	67	49
Lettuce	25	265	18.7	496	770	61	41
Musk Melon	(D)	237	22.0	520	7,717	51	43
Musk melon	D	1287	21.2	2,725	21,220	1,146	828
Parsley	45	474	15.7	743	1,557	90	68
Pepper	35	991	15.0	1,487	2,763	198	255
Pepper(L.C)	35	857	32.6	4,509	8,204	703	517
Radish	D	17	14.5	25	23	1	1
Spinach	D	379	48.4	1,833	4,583	106	79
Squash	D	160	46.5	743	925	37	57
Squash	D	160	46.5	743	925	37	28
Sweet melon	D	241	20.6	496	8,373	75	49
Sweet Pepper	(35)	224	154.0	3,444	7,884	168	123
Sweet Pepper	(48)	245	77.9	1,908	4,053	154	114
Tomato	31	165	142.6	2,354	2,186	117	86
Tomato	(34)	205	96.7	1,982	1,538	152	119
Turnip(Laft)	D	163	30.4	496	468	28	20
Water Melon	D	164	24.1	396	1,047	66	48
Subtotal	-	8,487		33,598	92,485	3,996	3,073
[Fruit Trees]							
Date Trees	-	1,348	19	2,591	12,344	1,995	992
[Field Crops]							
Alfalfa	-	2,793	91	25,376	30,301	4,385	6,589
Total	-	12,627		61,565	135,130	10,375	10,654

Note: 1) ( ): Green house cultivation
2) D : Direct sowing
3) Figures in type of cultivation show nursery period.

Table 5.3.6. Crop Cultivation Plan of Option-2

Crop	Type Of Culti-vation	Area to be Cultivated (ha)	Unit Yield (ton/ha)	Production (ton)	Unit Price (Dh/kg)	Gross Income (1000Dhs)	Production Cost (1000Dhs/ha)	Production Cost (1000Dhs)	Net Income (1000Dhs)	Unit Water Consump-tion(m^3/ha)	Water Consumption (m^3)	Net Income Per W.C. (Dhs/m^3)	Net Water Consump-tion(m^3)*	Gross Irrigation Amount(m^3)*	Net Income Per W.C. (Dhs/m^3)*	Net Income Per IWA (Dhs/m^3)*	Growing Period In Main Field	
																	Days	Period
[Vegetables]																		
Bean	D	35.6	14.2	507	4.67	2,368	22.0	783	1,585	2,400	85,473	18.5	106,129	62,429	14.9	25.4	103	1/Nov-11/Feb
Cabbage	42	10.4	32.4	338	2.17	734	11.8	123	610	1,500	15,649	39.0	19,405	11,415	31.5	53.5	62	27/Oct-28/Dec
Cabbage	31	12.4	46.2	575	2.17	1,247	12.4	155	1,092	2,700	33,565	32.5	36,548	21,499	29.9	50.8	89	18/Sep-16/Dec
Cauliflower	40	15.2	22.2	338	3.17	1,072	14.4	220	852	1,800	27,380	31.1	30,878	18,164	27.6	46.9	55	10/Oct-3/Dec
Cucumber	(27)	22.3	109.0	2,434	1.79	4,356	87.7	1,959	2,398	4,600	102,709	23.3	126,600	74,471	18.9	32.2	110	8/Feb-28/May
Cucumber	(35)	21.9	69.4	1,521	3.33	5,065	86.2	1,888	3,177	1,900	41,618	76.3	48,627	28,604	65.3	111.1	87	18/Nov-12/Feb
Dwarf Bean	(D)	115.6	34.2	3,955	4.73	18,706	59.8	6,913	11,794	5,300	612,887	19.2	795,597	467,998	14.8	25.2	177	16/Nov-12/May
Eggplant	45	35.6	38.0	1,352	1.00	1,352	12.2	436	916	2,400	85,457	10.7	105,397	61,998	8.7	14.8	85	30/Sep-23/Dec
Green beans	D	38.3	22.1	845	4.25	3,591	29.3	1,120	2,472	2,400	91,818	26.9	113,242	66,613	21.8	37.1	70	16/Sep-24/Nov
Lettuce	25	36.1	18.7	676	2.42	1,636	16.2	586	1,051	2,300	83,035	12.7	94,226	55,427	11.1	19.0	97	27/Oct-31/Jan
Musk Melon	(D)	32.3	22.0	710	18.12	12,862	72.3	2,334	10,529	2,300	74,211	141.9	98,733	58,078	106.6	181.3	113	15/Oct-5/Feb
Musk melon	D	175.6	21.2	3,718	9.00	33,464	25.7	4,515	28,950	8,900	1,562,803	18.5	1,921,018	1,130,011	15.1	25.6	172	15/Feb-6/Aug
Parsley	45	64.7	15.7	1,014	3.25	3,296	18.1	1,171	2,124	1,900	122,980	17.3	157,285	92,520	13.5	23.0	70	16/Sep-24/Nov
Pepper	35	135.2	15.0	2,028	2.50	5,070	9.6	1,301	3,769	2,000	270,418	13.9	590,862	347,566	6.4	10.8	110	5/Sep-23/Dec
Pepper(L.C)	35	117.0	52.6	6,152	2.29	14,088	24.8	2,896	11,192	8,200	959,057	11.7	1,198,821	705,189	9.3	15.9	231	20/Sep-9/May
Radish	D	2.3	14.5	34	1.37	46	6.5	15	31	800	1,865	16.8	2,424	1,426	12.9	21.9	31	27/Oct-27/Nov
Spinach	D	51.7	48.4	2,501	2.83	7,079	16.0	826	6,253	2,800	144,707	43.2	183,984	108,226	34.0	57.8	120	1/Nov-1/Mar
Squash	D	21.8	46.5	1,014	1.84	1,866	27.7	604	1,262	2,300	50,162	25.2	132,167	77,745	9.5	16.2	100	23/Sep-31/Dec
Squash	D	21.8	46.5	1,014	1.84	1,866	27.7	604	1,262	2,300	50,158	25.2	64,551	37,971	19.5	33.2	100	1/May-8/Aug
Sweet melon	D	32.8	20.6	676	18.00	12,169	22.7	746	11,423	3,100	101,758	112.3	113,247	66,616	100.9	171.5	90	16/Jan-15/Apr
Sweet Pepper	(35)	30.5	154.0	4,699	2.62	12,310	50.9	1,554	10,756	7,500	228,898	47.0	285,054	167,679	37.7	64.1	207	16/Nov-11/Jun
Sweet Pepper	(48)	33.4	77.9	2,603	2.77	7,210	50.3	1,680	5,530	6,300	210,493	26.3	265,289	156,052	20.8	35.4	114	4/Apr-27/Jul
Tomato	31	22.5	142.6	3,211	1.07	3,436	20.1	454	2,982	7,100	159,896	18.7	199,532	117,372	14.9	25.4	200	23/Oct-11/May
Tomato	(34)	28.0	96.7	2,704	1.31	3,542	51.7	1,445	2,098	7,400	206,938	10.1	276,849	162,853	7.6	12.9	130	20/Mar-27/Jul
Turnip(Laft)	D	22.2	30.4	676	1.45	980	15.4	342	638	1,700	37,750	16.9	47,298	27,823	13.5	22.9	50	1/Sep-20/Oct
Water Melon	D	22.4	24.1	541	3.31	1,790	16.1	362	1,429	4,000	89,765	15.9	112,431	66,136	12.7	21.6	91	1/Mar-31/May
Subtotal	-	1,157.8	39.6	45,836	139.23	161,203	1.8	35,029	126,174	6,155	5,451,449	23.1	7,126,197	4,191,880	17.7	30.1	-	-
[Fruit Trees]																		
Date Trees	-	1,825.3	19.2	35,094	7.00	245,659	43.0	78,473	167,186	14,800	27,014,440	6.2	33,603,773	13,441,509	5.0	12.4	-	- -
[Field Crops]																		
Alfalfa	-	1,601.1	90.9	145,475	1.40	203,665	18.7	29,957	173,708	15,700	25,137,270	6.9	31,477,626	37,773,151	5.5	4.6		-
Total	-	4,584.2	49.4	226,405	3.08	610,527	15.0	68,666	467,068	15,751	72,207,596	6.5	72,207,596	55,406,541	6.5	8.4	-	-

Note:
1) ( ) : Green house cultivation
2) D : Direct sowing
3) Figures in type of cultivation show nursery period.
4) * results of detailed estimation of irrigation water requirment

Table 5.3.7. Present and Option-2 Plan Agriculture in the Study Area

Crop	Cultivation Area (ha)			Production (ton)			Net Income (1,000 Dh)			Gross Irrigation Amount (1,000 m^3)		
	Present (A)	Plan (B)	B/A (%)	Present (A)	Plan (B)	B/A (%)	Present (A)	Plan (B)	B/A (%)	Present (A)	Plan (B)	B/A (%)
Vegetables	1,158	1,158	100%	25,600	45,836	179%	22,197	126,174	568%	2,067	4,192	203%
Fruit Trees	1,825	1,825	100%	29,681	35,094	118%	24,911	167,186	671%	14,764	13,442	91%
Field Crops	1,601	1,601	100%	136,561	145,475	107%	168,554	173,708	103%	35,985	37,773	105%
Total	4,584	4,584	100%	191,842	226,405	118%	215,662	467,068	217%	52,816	55,407	105%

Table 5.3.8. Average Farm in the Study Area under Option-2

Crop	Type of Cultiva-tion	Area to b Cultivate (m^2)	Unit Yield (ton/ha)	roductio (kg)	Net Income (Dh)	Water Consump tion(m^3)	Gross Irrigation Water (m^3)
[Vegetables]							
Bean	D	176	14.2	251	785	42	31
Cabbage	42	52	32.4	168	302	8	6
Cabbage	31	62	46.2	285	541	17	11
Cauliflower	40	75	22.2	168	422	14	9
Cucumber	(27)	111	109.0	1,206	1,188	51	37
Cucumber	(35)	109	69.4	754	1,574	21	14
Dwarf Bean	(D)	573	34.2	1,960	5,844	304	232
Eggplant	45	176	38.0	670	454	42	31
Green beans	D	190	22.1	419	1,225	45	33
Lettuce	25	179	18.7	335	521	41	27
Musk Melon	(D)	160	22.0	352	5,217	37	29
Musk melon	D	870	21.2	1,843	14,346	774	560
Parsley	45	321	15.7	503	1,053	61	46
Pepper	35	670	15.0	1,005	1,868	134	172
Pepper(L.C)	35	580	52.6	3,049	5,546	475	349
Radish	D	12	14.5	17	15	1	1
Spinach	D	256	48.4	1,240	3,098	72	54
Squash	D	108	46.5	503	625	25	39
Squash	D	108	46.5	503	625	25	19
Sweet melon	D	163	20.6	335	5,661	50	33
Sweet Pepper	(35)	151	154.0	2,328	5,330	113	83
Sweet Pepper	(48)	166	77.9	1,290	2,740	104	77
Tomato	31	112	142.6	1,591	1,478	79	58
Tomato	(34)	139	96.7	1,340	1,010	103	81
Turnip(Laft)	D	110	30.4	335	316	19	14
Water Melon	D	111	24.1	268	708	44	33
Subtotal	-	5,737		22,713	62,524	2,701	2,077
[Fruit Trees]							
Date Trees	-	9,045	19	17,391	82,847	13,387	6,661
[Field Crops]							
Alfalfa	-	7,934	91	72,089	86,080	12,457	18,718
Total	-	22,717		112,193	231,451	28,545	27,456

Note: 1) ( ): Green house cultivation
2) D: Direct sowing
3) Figures in type of cultivation show nursery period.

Table 5.5.1 Dimension of Facility

Option-1: Total Project Cost US $ 375,500,000

1 Recharge Dam		Crest Lenght*1 (m)	Crest Height*2 (m)	Volume of Embankment*3 (m^3)	Storage Capacity (MCM/a)
1-1	Siji	25.5	20.5	493,682	2.47
1-2	Khadrah	20.5	16.5	719,949	3.28
1-3	Shokah	25.5	27.5	778,831	2.46

2 Recharge Trench		Width (m)	Depth (m)	Extension (m)
2-1	Siji	1.5	6.0	1,000
2-2	Khadrah	1.5	6.0	1,000
2-3	Shokah	1.5	6.0	1,000

3 Groundwater Monitoring System	Material & Machinery for Observation

4 Farm Facility			Unit	Description
4-1	Water Source facility	2,018	no.	Well, Pipe and Tank
4-2	Water Distribution facility	2,548	ha	Booster Pump, Pipe
4-3	Irrigation facility	2,548	ha	Bubbler, Sprinkler
4-4	Green House	12,108	set	

Option-2: Total Project Cost US $ 935,300,000

1 Recharge Dam		Crest Lenght*1 (m)	Crest Height*2 (m)	Volume of Embankment*3 (m^3)	Storage Capacity (MCM/a)
1-1	Siji	25.5	20.5	493,682	2.47
1-2	Khadrah	20.5	16.5	719,949	3.28
1-3	Shokah	25.5	27.5	778,831	2.46

2 Recharge Trench		Width (m)	Depth (m)	Extension (m)
2-1	Siji	1.5	6.0	1,000
2-2	Khadrah	1.5	6.0	1,000
2-3	Shokah	1.5	6.0	1,000

3 Groundwater Monitoring System	Material & Machinery for Observation

4 Farm Facility		Area (ha)	Description
4-1	Water Source facility	4,584	Well, Pipe and Tank
4-2	Water Distribution facility	4,584	Booster Pump, Pipe
4-3	Irrigation facility	4,584	Bubbler, Sprinkler
4-4	Green House	4,584	

5 Desalinate Pipeline	
5-1	Pump and Operation System
5-2	Pump House
5-3	Pipeline, Discharge chamber

*1 *2 Crest Length and Crest Height for main dam

*3 Volume for main and saddle dam

Table 5.6.1. Summary of Project Cost of Option-1

Works	Name	Quantity	Unit	Unit Cost (US$X10³)	Cost (US$X10³)
Recharge Dam & Trench	Siji	1	set	19,486.79	19,486.79
	Kadrah	1	set	9,636.12	9,636.12
	Shokah	1	set	11,295.86	11,295.86
	Subtotal				40,418.76
Irrigation & Farming Facilities	Well & Submarsible Pump	2,018	no.	72.21	145,716.64
	Water Distribution Facilities	2,548	ha	2.22	5,668.70
	Irrigation Facilities	2,548	ha	1.15	2,937.84
	Greenhouses	12,108	set	1.39	16,818.01
	Subtotal				171,141.20
Groundwater Monitoring System		1	L.S.		8,435.00
Vegetable Center		1	L.S.		1,000.00
Subtotal					220,994.96
Administration Expenses			L.S.		5,524.87
Consulting Services					22,099.50
Investment Cost Total					248,619.33
Physical Contingencies			L.S.		22,651.98
Price Escalation (9%)			L.S.		113,811.86
Total Cost for Option-1					385,083.18

Table 5.6.2. Summary of Project Cost of Option-2

Works	Name	Quantity	Unit	Unit Cost (US$X10³)	Cost (US$X10³)
Recharge Dam & Trench	Siji	1	set	19,486.79	19,486.79
	Kadrah	1	set	9,636.12	9,636.12
	Shokah	1	set	11,295.86	11,295.86
	Subtotal				40,418.76
Irrigation & Farming Facilities	Wells, Pumps, Tanks, etc.	2,018	no.	72.97	147,248.33
	Water Distribution Facilities	4,584	ha	1.58	7,250.67
	Irrigation Facilities	4,854	ha	1.16	5,616.08
	Greenhouses	8,072	set	1.39	11,212.01
	Subtotal				171,327.08
Desalinized Water Supply	Pump & Control Facilities	1	set	4,975.00	93,046.68
	Pumping Houses	1	set	4,975.00	4,975.00
	Pipe lines, Tanks etc.	1	L.S.	146,857.77	146,857.77
	Subtotal				244,879.44
Groundwater Monitoring System		1	L.S.		8,435.00
Vegetable Center		1	L.S.		1,500.00
Subtotal					466,560.29
Administration Expenses					11,664.01
Consulting Services					46,656.03
Investment Cost Total					524,880.32
Physical Contingencies		1	L.S.		47,822.43
Price Escalation		1	L.S.		362,608.76
Total Cost for Option-2					935,311.51

Table 5.6.3. Annual Disbursement of Project Costs - Option-1

(Unit : US$X10^3)

Works	Name	Total Cost	0 1996	1 1997	2 1998	3 1999	4 2000	5 2001	6 2002	7 2003	8 2004	9 2005	10 2006
Consulting Services	Feasibility Study	3,314.9		3,314.9									
	Detailed Design	7,734.8			5,156.5	2,578.3							
	Construction Supervisson	11,049.7				1,004.5	2,009.0	2,009.0	2,009.0	2,009.0	2,009.0		
	Sub-total	22,099.5		3,314.9	5,156.5	3,582.8	2,009.0	2,009.0	2,009.0	2,009.0	2,009.0	0.0	0.0
Recharge Dam & Trenchi	Siji	19,486.8					6,495.6	6,495.6	6,495.6				
	Kadrah	9,636.1						3,212.0	3,212.0	3,212.0			
	Shokah	11,295.9							3,765.3	3,765.3	3,765.3		
	Sub-total	40,418.8		0.0	0.0	0.0	6,495.6	9,707.6	13,472.9	6,977.3	3,765.3	0.0	0.0
Irrigation and Farming Facilities	Water Sources Facilities	18,207.3			3,034.5	6,069.1	6,069.1	3,034.5					
	Water Distribution Facilitie	5,668.7			1,417.2	2,834.4	1,417.2						
	Irrigation Facilities	2,937.8			734.5	1,468.9	734.5						
	Green Houses	16,818.0				5,606.0	5,606.0	5,606.0					
	Subtotal	43,631.8		0.0	5,186.2	15,978.4	13,826.7	8,640.61	0.0	0.0	0.0	0.0	0.0
Water Extraction Facilities	Well	71,453.3			11,908.9	23,817.8	23,817.8	11,908.9					
	Submersible Pump	56,056.0			9,342.7	18,685.3	18,685.3	9,342.7					
	Subtotal	127,509.3		0.0	21,251.6	42,503.1	42,503.1	21,251.6	0.0	0.0	0.0	0.0	0.0
Groundwater Monitoring System		8,435.0					4,217.5	4,217.5					
Vegetable Center		1,000.0							1,000.0				
Administration Expenses		5,524.9	0.0	0.0	660.9	1,462.0	1,676.1	1,095.4	361.8	174.4	94.1	0.0	0.0
Investment Cost Total		248,619.3	0.0	3,314.9	32,255.2	63,526.3	70,728.1	46,921.7	16,843.8	9,160.8	5,868.5	0.0	0.0
Physical Contingencies		22,652.0	0.0	0.0	2,709.9	5,994.4	6,871.9	4,491.3	1,483.5	715.2	385.9	0.0	0.0
Price Escalation		113,811.9	0.0	298.3	6,576.9	20,510.6	31,938.7	27,692.3	12,409.4	8,177.7	6,207.9	0.0	0.0
Total		385,083.2	0.0	3,613.3	41,542.0	90,031.3	109,538.7	79,105.3	30,736.7	18,053.7	12,462.3	0.0	0.0

Table 5.6.4. Annual Disbursement of Project Costs - Option-2

(Unit : US$X10^3)

Works	Name	Total Cost	0 1996	1 1997	2 1998	3 1999	4 2000	5 2001	6 2002	7 2003	8 2004	9 2005	10 2006
Consulting Services	Feasibility Study	6,998.4		4,665.6	2,332.8								
	Detailed Design	16,329.6			4,082.4	8,164.8	4,082.4						
	Construction Supervision	23,328.0					2,120.7	4,241.5	4,241.5	4,241.5	4,241.5	4,241.5	
	Subtotal	46,656.0		4,665.6	6,415.2	8,164.8	6,203.1	4,241.5	4,241.5	4,241.5	4,241.5	4,241.5	0.0
Recharge Dam & Trenchi	Siji	19,486.8					3,247.8	6,495.6	6,495.6	3,247.8			
	Kadrah	9,636.1						1,606.0	3,212.0	3,212.0	1,606.0		
	Shokah	11,295.9							1,882.6	3,765.3	3,765.3	1,882.6	
	Subtotal	40,418.8		0.0	0.0	0.0	3,247.8	8,101.6	11,590.3	10,225.1	5,371.3	1,882.6	0.0
Irrigation and Farming Facilities	Water Sources Facilities	19,739.0			2,467.4	4,934.7	4,934.7	4,934.7	2,467.4				
	Water Distribution Facilitie	7,250.7			1,208.4	2,416.9	2,416.9	1,208.4					
	Irrigation Facilities	5,616.1			936.0	1,872.0	1,872.0	936.0					
	Green Houses	11,212.0			2,242.4	4,484.8	4,484.8						
	Subtotal	43,817.7		0.0	6,854.2	13,708.5	13,708.5	7,079.2	2,467.4	0.0	0.0	0.0	0.0
Water Source Facilities	Well	71,453.3			8,931.7	17,863.3	17,863.3	17,863.3	8,931.7				
	Submersible Pump	56,056.0			7,007.0	14,014.0	14,014.0	14,014.0	7,007.0				
	Subtotal	127,509.3		0.0	15,938.7	31,877.3	31,877.3	31,877.3	15,938.7	0.0	0.0	0.0	0.0
Desalinesed Water Supply	Pumping Station	93,066.7							18,609.3	37,218.7	37,218.7		
	Pipe Line Main/Distribution	4,975.0					452.3	904.5	904.5	904.5	904.5	904.5	
	Tank	146,857.8							73,428.9	73,428.9			
	Subtotal	244,879.4		0.0	0.0	0.0	452.3	904.5455	92,942.8	111,552.1	38,123.2	904.5	0.0
Groundwater Monitoring System		8,435.0						8,435.0					
Vegetable Center		1,500.0							1,500.0				
Administration Expenses		11,664.0	0.0	0.0	569.8	1,139.6	1,232.1	1409.942	3,111.0	3,044.4	1,087.4	69.7	0.0
Investment Cost Total		524,880.3	0.0	4,665.6	29,777.9	54,890.3	56,721.1	62049.1	131,791.5	129,063.1	48,823.3	7,098.3	0.0
Physical Contingency		47,822.4	0.0	0.0	2,336.3	4,672.5	5,051.8	5780.764	12,755.0	12,482.2	4,458.2	285.7	0.0
Price Escalation		362,608.8	0.0	419.9	6,040.7	17,572.8	25,424.6	36534.79	97,872.5	117,205.0	52,885.3	8,653.3	0.0
Total		935,311.5	0.0	5,085.5	38,154.9	77,135.5	87,197.6	104,364.7	242,419.0	258,750.3	106,166.8	16,037.3	0.0

Table 5.6.5. Project Costs, Benefits and Internal Rate of Return - Option-1

(Unit : US$ X10')

Year		Costs				Benefit			Balance
		Investment	Replacement	O&M	Total	w/o Project	W/Project	Incremental	
0	1996	0	0	0	0	42,014	42,014	0	0
1	1997	3,315	0	1,275	4,590	39,625	39,625	0	-4,590
2	1998	32,255	0	1,275	33,530	37,236	37,236	0	-33,530
3	1999	57,920	0	1,534	59,455	34,847	34,847	0	-59,455
4	2000	66,511	0	2,165	68,676	32,457	32,457	0	-68,676
5	2001	46,922	0	2,818	49,740	30,068	30,068	0	-49,740
6	2002	25,667	0	3,276	28,944	27,679	27,679	0	-28,944
7	2003	10,161	734	3,546	14,441	25,289	25,289	0	-14,441
8	2004	5,868	1,469	3,685	11,023	22,900	22,900	0	-11,023
9	2005	0	734	3,761	4,495	20,511	30,580	10,069	5,574
10	2006	0	0	3,761	3,761	18,121	38,260	20,139	16,378
11	2007	0	0	3,761	3,761	15,732	45,940	30,208	26,448
12	2008	0	14,529	3,761	18,289	15,732	53,620	37,888	19,599
13	2009	0	29,058	3,761	32,818	15,732	61,301	45,568	12,750
14	2010	0	32,512	3,761	36,273	15,732	61,301	45,568	9,296
15	2011	0	17,983	3,761	21,744	15,732	61,301	45,568	23,825
16	2012	0	5,606	3,761	9,367	15,732	61,301	45,568	36,202
17	2013	0	734	3,761	4,495	15,732	61,301	45,568	41,073
18	2014	0	1,469	3,761	5,229	15,732	61,301	45,568	40,339
19	2015	0	734	3,761	4,495	15,732	61,301	45,568	41,073
20	2016	0	0	3,761	3,761	15,732	61,301	45,568	41,808
21	2017	0	0	3,761	3,761	15,732	61,301	45,568	41,808
22	2018	0	26,438	3,761	30,198	15,732	61,301	45,568	15,370
23	2019	0	52,875	3,761	56,636	15,732	61,301	45,568	-11,068
24	2020	0	56,906	3,761	60,666	15,732	61,301	45,568	-15,098
25	2021	0	30,753	3,761	34,513	15,732	61,301	45,568	11,055
26	2022	0	6,800	3,761	10,561	15,732	61,301	45,568	35,008
27	2023	0	1,353	3,761	5,113	15,732	61,301	45,568	40,455
28	2024	0	1,803	3,761	5,563	15,732	61,301	45,568	40,005
29	2025	0	734	3,761	4,495	15,732	61,301	45,568	41,073
30	2026	0	0	3,761	3,761	15,732	61,301	45,568	41,808
31	2027	0	0	3,761	3,761	15,732	61,301	45,568	41,808
32	2028	0	14,529	3,761	18,289	15,732	61,301	45,568	27,279
33	2029	0	29,058	3,761	32,818	15,732	61,301	45,568	12,750
34	2030	0	32,512	3,761	36,273	15,732	61,301	45,568	9,296
35	2031	0	17,983	3,761	21,744	15,732	61,301	45,568	23,825
36	2032	0	5,606	3,761	9,367	15,732	61,301	45,568	36,202
37	2033	0	734	3,761	4,495	15,732	61,301	45,568	41,073
38	2034	0	1,469	3,761	5,229	15,732	61,301	45,568	40,339
39	2035	0	734	3,761	4,495	15,732	61,301	45,568	41,073
40	2036	0	0	3,761	3,761	15,732	61,301	45,568	41,808
41	2037	0	0	3,761	3,761	15,732	61,301	45,568	41,808
42	2038	0	26,438	3,761	30,198	15,732	61,301	45,568	15,370
43	2039	0	52,875	3,761	56,636	15,732	61,301	45,568	-11,068
44	2040	0	56,906	3,761	60,666	15,732	61,301	45,568	-15,098
45	2041	0	30,753	3,761	34,513	15,732	61,301	45,568	11,055
46	2042	0	6,800	3,761	10,561	15,732	61,301	45,568	35,008
47	2043	0	1,353	3,761	5,113	15,732	61,301	45,568	40,455
48	2044	0	1,803	3,761	5,563	15,732	61,301	45,568	40,005
49	2045	0	734	3,761	4,495	15,732	61,301	45,568	41,073
50	2046	0	0	3,761	3,761	15,732	61,301	45,568	41,808
Total		248,619	563,513	177,517	989,649	960,032	2,789,938	1,829,906	840,257
IRR =		6.51%							

Table 5.6.6. Project Costs, Benefits and Internal Rate of Return - Option-2

(Unit : US$ X10')

Year		Costs				Benefit			Balance
		Investment	Replacement	O&M	Total	w/o Project	W/Project	Incremental	
0	1996	0	0	0	0	42,014	42,014	0	0
1	1997	4,666	0	1,275	5,941	39,625	39,625	0	-5,941
2	1998	29,778	0	1,275	31,053	37,236	37,236	0	-31,053
3	1999	54,890	0	1,320	56,210	34,847	34,847	0	-56,210
4	2000	56,721	0	1,410	58,131	32,457	32,457	0	-58,131
5	2001	62,049	0	1,727	63,776	30,068	30,068	0	-63,776
6	2002	131,792	0	2,294	134,085	27,679	27,679	0	-134,085
7	2003	129,063	936	3,105	133,104	25,289	25,289	0	-133,104
8	2004	48,823	1,872	3,821	54,516	22,900	22,900	0	-54,516
9	2005	7,098	1,872	4,197	13,167	20,511	20,511	0	-13,167
10	2006	0	936	65,042	65,978	18,121	41,424	23,303	-42,675
11	2007	0	0	65,042	65,042	15,732	62,338	46,606	-18,437
12	2008	0	16,104	65,042	81,146	15,732	83,251	67,519	-13,627
13	2009	0	32,207	65,042	97,250	15,732	104,165	88,433	-8,817
14	2010	0	32,207	65,042	97,250	15,732	125,078	109,346	12,097
15	2011	0	21,093	65,042	86,135	15,732	125,078	109,346	23,211
16	2012	0	28,084	65,042	93,126	15,732	125,078	109,346	16,220
17	2013	0	38,155	65,042	103,197	15,732	125,078	109,346	6,149
18	2014	0	39,091	65,042	104,133	15,732	125,078	109,346	5,213
19	2015	0	1,872	65,042	66,914	15,732	125,078	109,346	42,432
20	2016	0	936	65,042	65,978	15,732	125,078	109,346	43,368
21	2017	0	0	65,042	65,042	15,732	125,078	109,346	44,304
22	2018	0	25,035	65,042	90,078	15,732	125,078	109,346	19,269
23	2019	0	50,071	65,042	115,113	15,732	125,078	109,346	-5,767
24	2020	0	50,359	65,042	115,401	15,732	125,078	109,346	-6,055
25	2021	0	39,675	65,042	104,717	15,732	125,078	109,346	4,629
26	2022	0	38,043	65,042	103,085	15,732	125,078	109,346	6,261
27	2023	0	39,061	65,042	104,103	15,732	125,078	109,346	5,243
28	2024	0	39,567	65,042	104,609	15,732	125,078	109,346	4,737
29	2025	0	2,491	65,042	67,533	15,732	125,078	109,346	41,813
30	2026	0	1,841	65,042	66,883	15,732	125,078	109,346	42,463
31	2027	0	905	65,042	65,947	15,732	125,078	109,346	43,399
32	2028	0	17,008	65,042	82,050	15,732	125,078	109,346	27,296
33	2029	0	33,112	65,042	98,154	15,732	125,078	109,346	11,192
34	2030	0	33,112	65,042	98,154	15,732	125,078	109,346	11,192
35	2031	0	21,093	65,042	86,135	15,732	125,078	109,346	23,211
36	2032	0	28,084	65,042	93,126	15,732	125,078	109,346	16,220
37	2033	0	38,155	65,042	103,197	15,732	125,078	109,346	6,149
38	2034	0	39,091	65,042	104,133	15,732	125,078	109,346	5,213
39	2035	0	1,872	65,042	66,914	15,732	125,078	109,346	42,432
40	2036	0	936	65,042	65,978	15,732	125,078	109,346	43,368
41	2037	0	0	65,042	65,042	15,732	125,078	109,346	44,304
42	2038	0	9,097	65,042	74,139	15,732	125,078	109,346	35,207
43	2039	0	50,071	65,042	115,113	15,732	125,078	109,346	-5,767
44	2040	0	50,359	65,042	115,401	15,732	125,078	109,346	-6,055
45	2041	0	39,675	65,042	104,717	15,732	125,078	109,346	4,629
46	2042	0	38,043	65,042	103,085	15,732	125,078	109,346	6,261
47	2043	0	39,061	65,042	104,103	15,732	125,078	109,346	5,243
48	2044	0	39,567	65,042	104,609	15,732	125,078	109,346	4,737
49	2045	0	2,039	65,042	67,081	15,732	125,078	109,346	42,265
50	2046	0	936	65,042	65,978	15,732	125,078	109,346	43,368
Total		524,880	983,719	2,687,156	4,195,755	960,032	5,231,702	4,271,669	75,914
IRR =		0.44%							

Table 5.6.7. Cash Outflow and Inflow - Option-1

(Unit : US$ X10³)

	Year	Cash Outflow						Cash Inflow				Total	Accumulated
		Investment	Replacement	O&M	Loan Intrest	Loan Repayment	Total	Foreign Loan	Government Budget	Government Subsidy	Total	Balance	Loan
1	1997	3,315	0	1,275	66		4,656	2,210	1,105	1,341	4,656	0	2,210
2	1998	32,255	0	1,275	711		34,242	21,503	10,752	1,986	34,242	0	23,713
3	1999	57,920	0	1,534	1,870		61,325	38,614	19,307	3,404	61,325	0	62,327
4	2000	66,511	0	2,165	3,200		71,876	44,340	22,170	5,365	71,876	0	106,667
5	2001	46,922	0	2,818	4,138		53,878	31,281	15,641	6,957	53,878	0	137,949
6	2002	25,667	0	3,276	4,652		33,595	17,112	8,556	7,928	33,595	0	155,060
7	2003	10,161	734	3,546	4,855		19,296	6,774	4,121	8,401	19,296	0	161,834
8	2004	5,868	1,469	3,685	4,972		15,995	3,912	3,425	8,658	15,995	-0	165,746
9	2005	0	734	3,761	4,972		9,467		734	8,733	9,467	0	165,746
10	2006	0	0	3,761	4,972		8,733		0	8,733	8,733	0	165,746
11	2007	0	0	3,761	4,724	8,287	16,772		0	16,772	16,772	0	157,459
12	2008	0	14,529	3,761	4,475	8,287	31,052		14,529	16,523	31,052	0	149,172
13	2009	0	29,058	3,761	4,227	8,287	45,332		29,058	16,274	45,332	0	140,884
14	2010	0	32,512	3,761	3,978	8,287	48,538		32,512	16,026	48,538	0	132,597
15	2011	0	17,983	3,761	3,729	8,287	33,760		17,983	15,777	33,760	0	124,310
16	2012	0	5,606	3,761	3,481	8,287	21,135		5,606	15,529	21,135	0	116,022
17	2013	0	734	3,761	3,232	8,287	16,014		734	15,280	16,014	0	107,735
18	2014	0	1,469	3,761	2,983	8,287	16,500		1,469	15,031	16,500	0	99,448
19	2015	0	734	3,761	2,735	8,287	15,517		734	14,783	15,517	0	91,160
20	2016	0	0	3,761	2,486	8,287	14,534		0	14,534	14,534	0	82,873
21	2017	0	0	3,761	2,238	8,287	14,285		0	14,285	14,285	0	74,586
22	2018	0	26,438	3,761	1,989	8,287	40,475		26,438	14,037	40,475	0	66,298
23	2019	0	52,875	3,761	1,740	8,287	66,664		52,875	13,788	66,664	0	58,011
24	2020	0	56,906	3,761	1,492	8,287	70,445		56,906	13,540	70,445	0	49,724
25	2021	0	30,753	3,761	1,243	8,287	44,044		30,753	13,291	44,044	0	41,437
26	2022	0	6,800	3,761	994	8,287	19,843		6,800	13,042	19,843	0	33,149
27	2023	0	1,353	3,761	746	8,287	14,147		1,353	12,794	14,147	0	24,862
28	2024	0	1,803	3,761	497	8,287	14,348		1,803	12,545	14,348	0	16,575
29	2025	0	734	3,761	249	8,287	13,031		734	12,296	13,031	0	8,287
30	2026	0	0	3,761	0	8,287	12,048		0	12,048	12,048	0	0
31	2027	0	0	3,761			3,761		0	3,761	3,761	0	0
32	2028	0	14,529	3,761			18,289		14,529	3,761	18,289	0	0
33	2029	0	29,058	3,761			32,818		29,058	3,761	32,818	0	0
34	2030	0	32,512	3,761			36,273		32,512	3,761	36,273	0	0
35	2031	0	17,983	3,761			21,744		17,983	3,761	21,744	0	0
36	2032	0	5,606	3,761			9,367		5,606	3,761	9,367	0	0
37	2033	0	734	3,761			4,495		734	3,761	4,495	0	0
38	2034	0	1,469	3,761			5,229		1,469	3,761	5,229	0	0
39	2035	0	734	3,761			4,495		734	3,761	4,495	0	0
40	2036	0	0	3,761			3,761		0	3,761	3,761	0	0
41	2037	0	0	3,761			3,761		0	3,761	3,761	0	0
42	2038	0	26,438	3,761			30,198		26,438	3,761	30,198	0	0
43	2039	0	52,875	3,761			56,636		52,875	3,761	56,636	0	0
44	2040	0	56,906	3,761			60,666		56,906	3,761	60,666	0	0
45	2041	0	30,753	3,761			34,513		30,753	3,761	34,513	0	0
46	2042	0	6,800	3,761			10,561		6,800	3,761	10,561	0	0
47	2043	0	1,353	3,761			5,113		1,353	3,761	5,113	0	0
48	2044	0	1,803	3,761			5,563		1,803	3,761	5,563	0	0
49	2045	0	734	3,761			4,495		734	3,761	4,495	0	0
50	2046	0	0	3,761			3,761		0	3,761	3,761	0	0
Total		248,619	563,513	177,517	81,648	165,746	1,237,043	165,746	646,386	424,911	1,237,043	-0	2,721,588

Table 5.6.8. Screening and Scooping(1)

No.	Environmental Item	Discretion	Evaluation	Notes	Marks	Remarks
Social Environment						
a	Resettlement	Resettlement by land occupation (Transfer of rights of residence, land ownership)	No	No expansion of farm land	C	
b	Economic Activities	Loss of production base (land , etc.) and change of economic structure.	Yes	Acceleration of agricultural development	C	Positive effect on regional economy
c	Traffic and Public Facilities	Impacts on existing traffic, schools, hospitals, etc. (e.g., traffic jam, accidents)	No	Low traffic density	C	
d	Split of Communities	Separation of regional communities by hindrance of regional traffic	No		C	
e	Cultural Property	Loss or deterioration of cultural properties, such as temples, shrines, archaeological assets, etc.	No	There is cultural remains but the project does not affect them	C	
f	Water Rights and Right of Common	Obstruction of fishing rights, irrigation and water rights	No	No water right	C	
g	Public Health Condition	Worsening of health and sanitary condition due to generation of garbage and appearance of harmful insects, increasing of agricultural chemicals	Yes	Increasing consumption of agricultural chemicals	C	Ban on using of high toxic and residual chemicals
h	Waste	Generation of construction waste, surplus soil, sludge, domestic waste, etc.	No	No source	C	
i	Hazards(Risk)	Increase in risk of cave-ins, ground failure and accident	No	No large construction work	C	
Natural Environment						
a	Topography and Geology	Change of valuable topography and geology due to excavation and earthfill	No	No land reclamation	C	
b	Soil and land	Topsoil erosion by rainfall after land reclamation or deforestation, salt accumulation by irrigation, degradation of soil fertility	Yes	Salt accumulation by irrigation due to high contents of salt in water	B	Expansion of less salt accumulation methods
c	Groundwater	Lowering of groundwater table due to overdraft and turbid water caused by construction work	Yes	Deterioration of ground-water resource because of over consumption	A	Requirement of monitoring on ground water level

Table 5.6.8. Screening and Scooping(2)

d	Hydrological Situation	Change of discharge and water quality due to reclamation and drainage	No	No discharge of drainage water	C	
e	Flora and Fauna	Interruption of reproduction or extinction of species due to change of habitat condition	No	No expansion of farm land	C	
f	Meteorology	Change of micro-climate, such as temperature, wind, etc., due to large scale reclamation, and construction	No	Not large scale development	C	
g	Landscape	Deterioration of aesthetic harmony by structures and topographic change by reclamation	No	No expansion of farm land	C	
Pollution						
a	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles and factories	No	No source	C	
b	Water Pollution	Water pollution of river and groundwater caused by drilling mud and oil	No	No source	C	
c	Soil Contamination	Contamination caused by discharge or diffusion of sewage or toxic substances	No	No source	C	
d	Noise and Vibration	Generation of noise and vibration due to drilling and operation of pumping machines	Yes	Noise due to drilling machine	C	Far from resident area
e	Land Subsidence	Deformation of the land and land subsidence due to lowering of groundwater table	No	No land subsidence because the aquifer consist of limestone	C	
f	Offensive Odor	Generation of offensive odor and exhaust gases	No	No source	C	
Overall Evaluation :		EIA is necessary for the project implementation	Yes	EIA is need on groundwater for sustainable use		

Mark classification : A: Impact is deemed strong; B: Some impact; C: Impact is very small and not subject to Environmental Impact Assessment

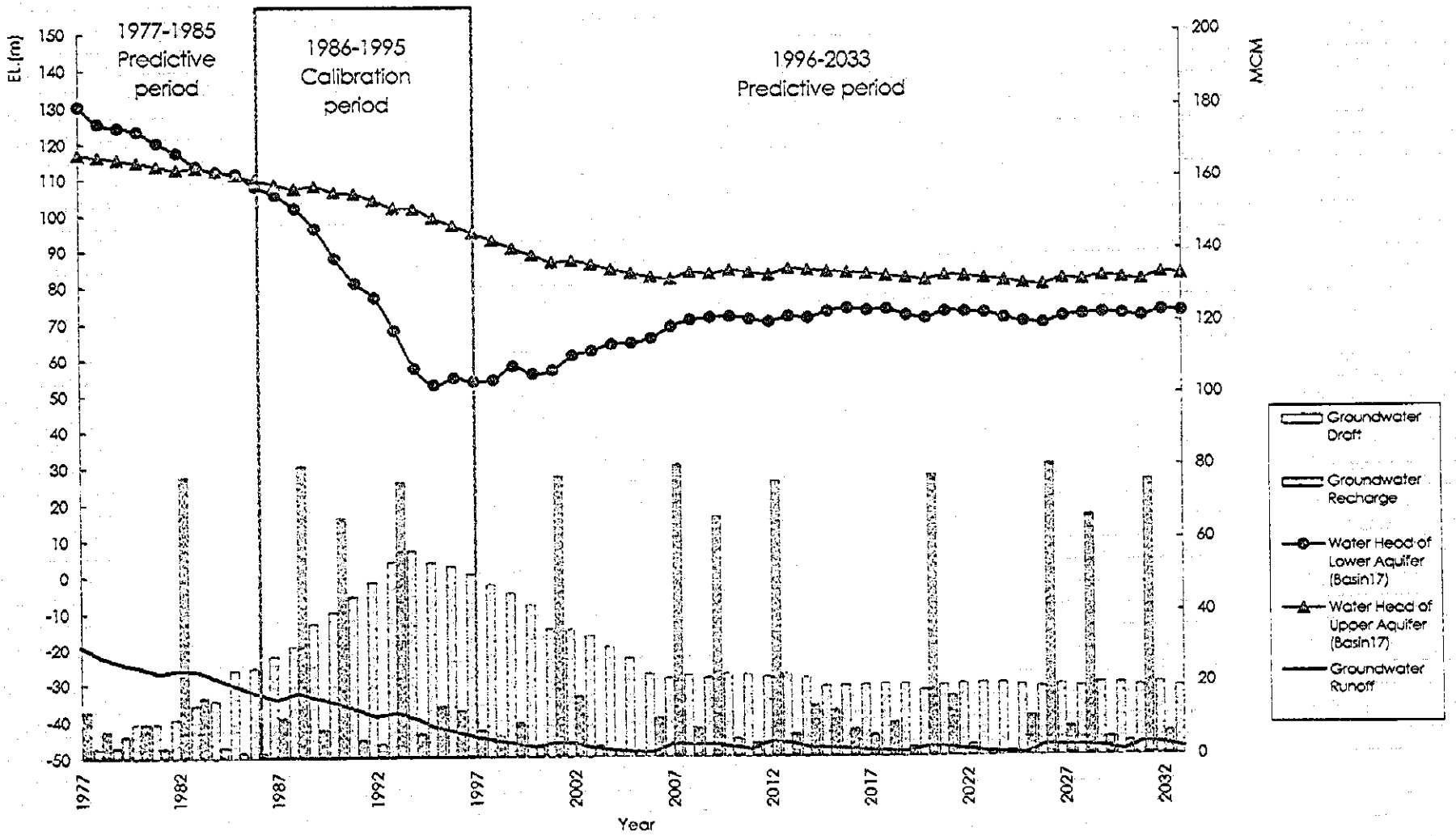
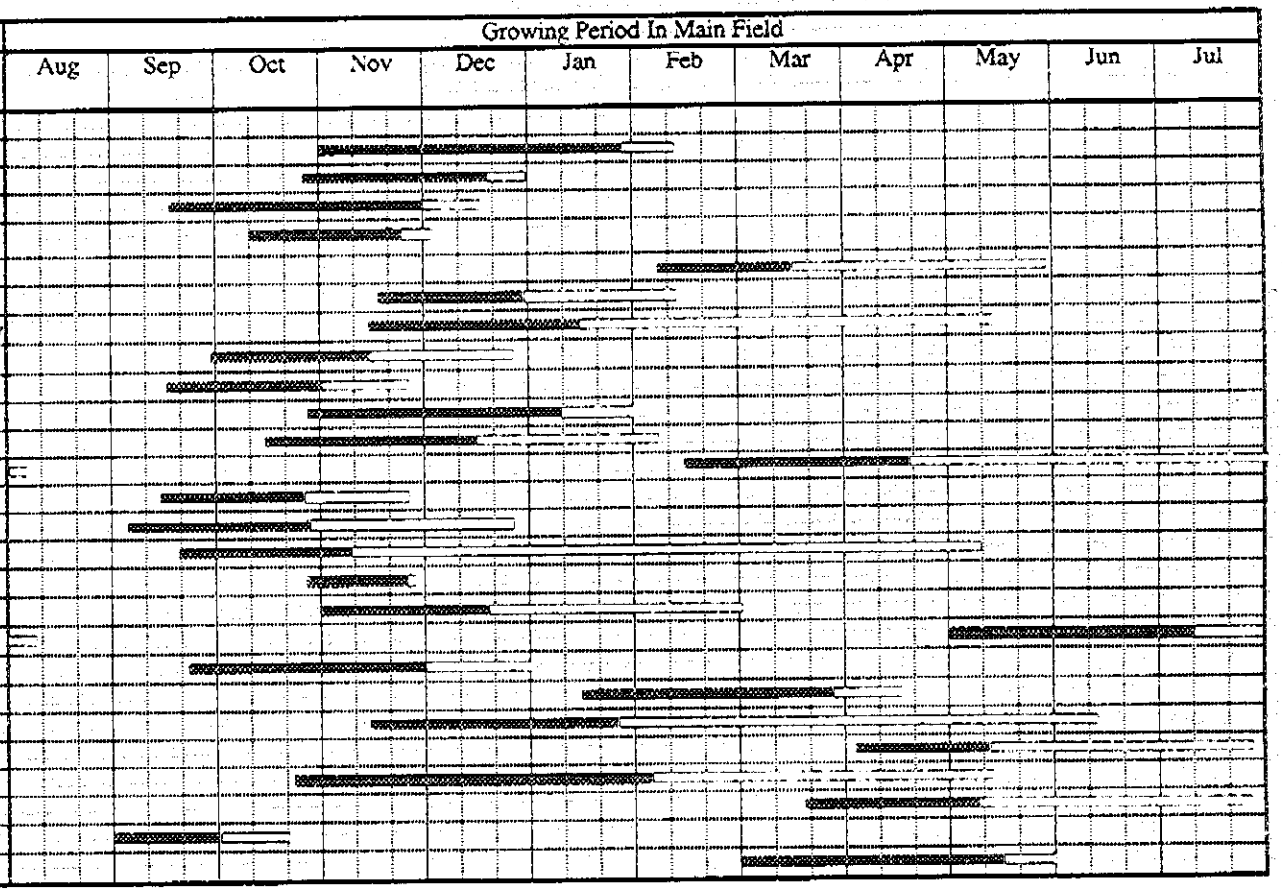


Figure 5.2.1 Sustained Yield and the Recovering of Groundwater Head

Figure 5.3.1. Vegetable Cropping Calendar under the Option-1 Plan

Crop	Nursery Period (Days)	Main Field Period(Days)		
		Before Harvest	Harves-ting	Total (Date)
[Vegetables]				
Bean	D	88	15	1/Nov-11/Feb
Cabbage	42	52	10	27/Oct-28/Dec
Cabbage	31	72	17	18/Sep-16/Dec
Cauliflower	40	45	10	10/Oct-3/Dec
Cucumber	-27	38	72	8/Feb-28/May
Cucumber	-35	42	45	18/Nov-12/Feb
Dwarf Bean	(D)	60	117	16/Nov-12/May
Eggplant	45	45	40	30/Sep-23/Dec
Green beans	D	45	25	16/Sep-24/Nov
Lettuce	25	77	20	27/Oct-31/Jan
Musk Melon	(D)	92	21	15/Oct-5/Feb
Musk melon	D	62	110	15/Feb-6/Aug
Parsley	45	40	30	16/Sep-24/Nov
Pepper	35	50	60	5/Sep-23/Dec
Pepper(L.C)	35	49	182	20/Sep-9/May
Radish	D	30	1	27/Oct-27/Nov
Spinach	D	46	74	1/Nov-1/Mar
Squash	D	70	30	1/May-8/Aug
Squash	D	70	30	23/Sep-31/Dec
Sweet melon	D	70	20	16/Jan-15/Apr
Sweet Pepper	-35	68	139	16/Nov-11/Jun
Sweet Pepper	-48	37	77	4/Apr-27/Jul
Tomato	31	105	95	23/Oct-11/May
Tomato	-34	50	80	20/Mar-27/Jul
Turnip(Laft)	D	30	20	1/Sep-20/Oct
Water Melon	D	75	16	1/Mar-31/May



Remarks ▬ : Before Harvesting period

═ : Harvesting period

Figure 5.3.2-1 Option-1 Farm Layout

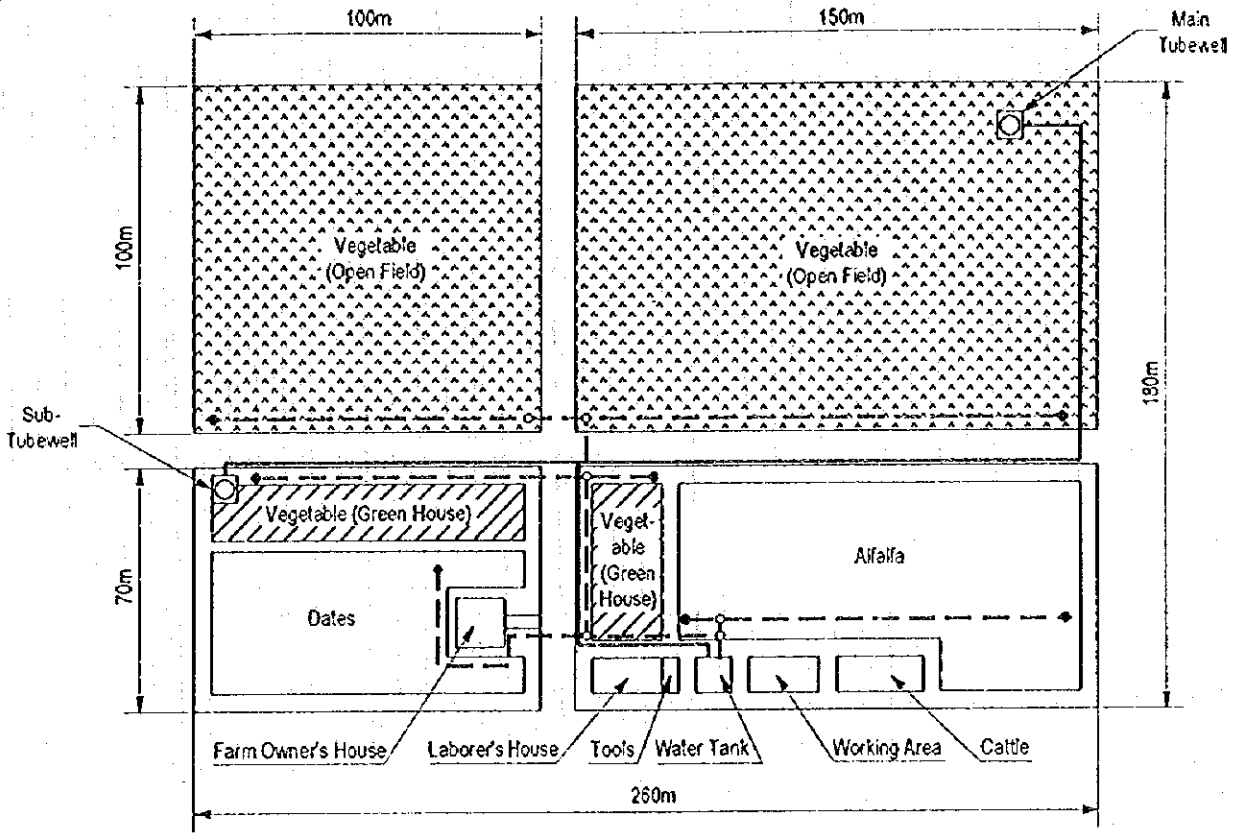
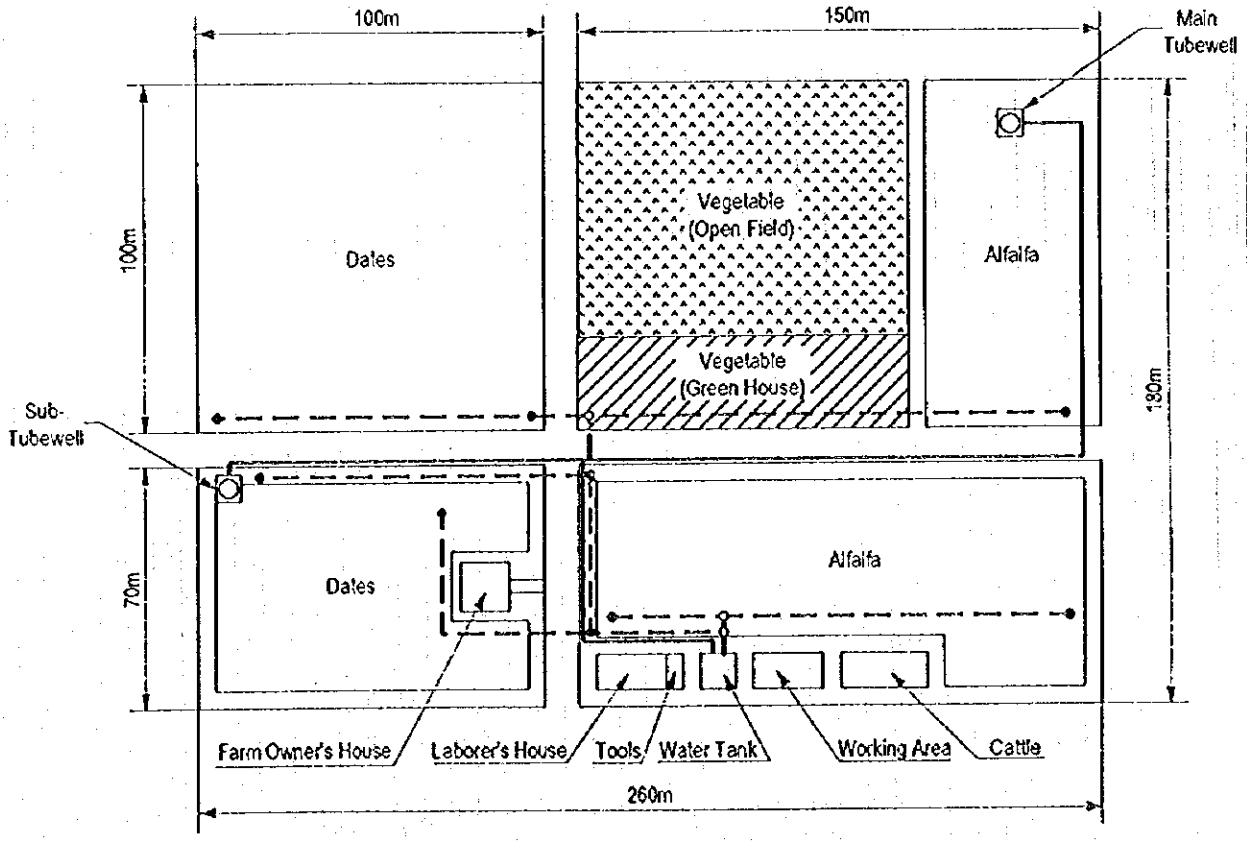


Figure 5.3.2-2 Option-2 Farm Layout



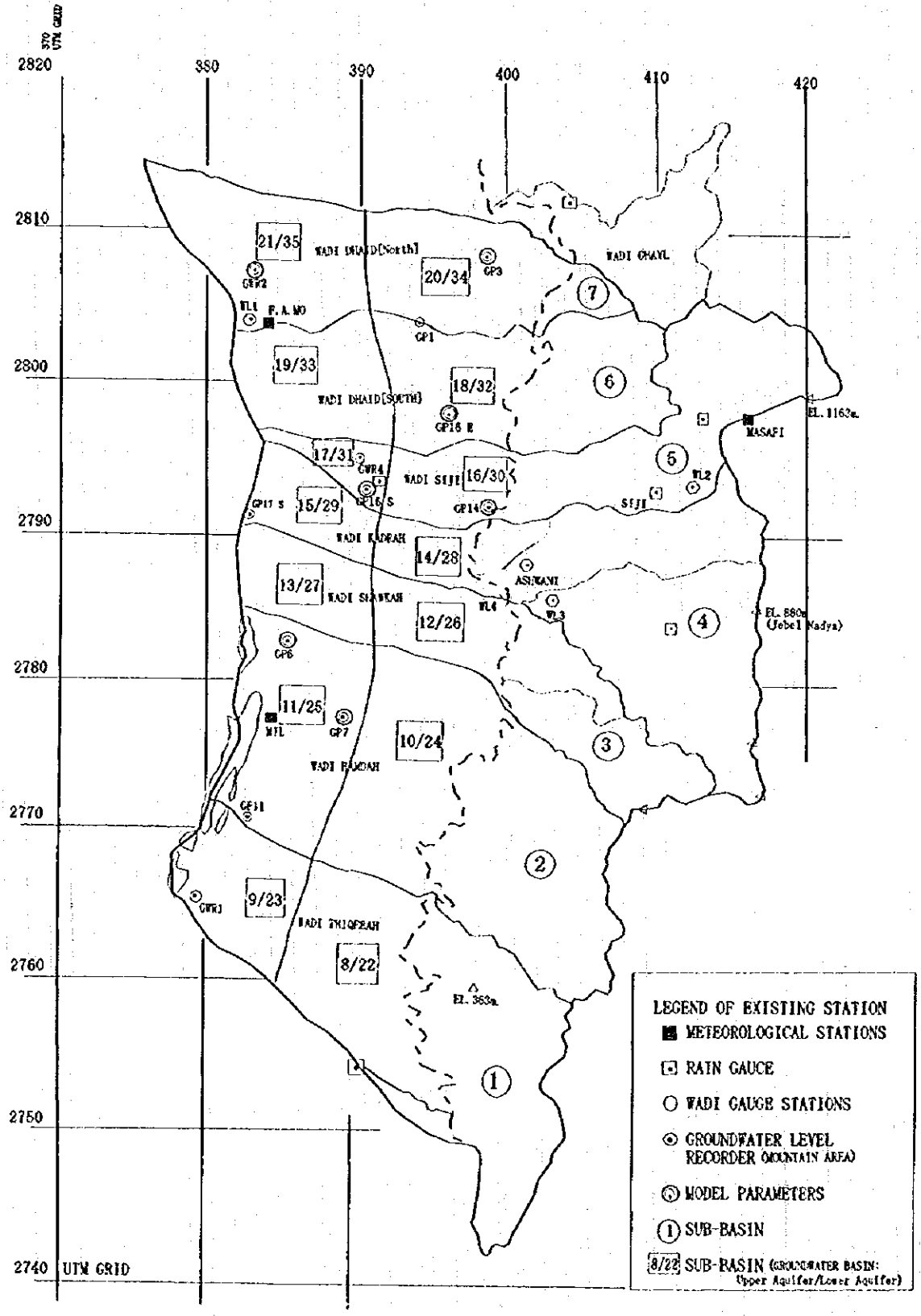


Figure 5.4.1 . Proposed Stations of Groundwater Monitoring System

Works	Name		Quantity
Consulting Services	Feasibility Study		
	Detailed Design		
	Construction Supervision		
Recharge Dam & Trench	Siji	Dam	1 unit
		Trench	1 unit
	Kadrah	Dam	1 unit
		Trench	1 unit
	Shokah	Dam	1 unit
		Trench	1 unit
Intake	Well, Pipe, and Tank		2,018 no.
Distribution	Booster, etc.		2,548 ha
Irrigation	Sprinkler, etc.		2,548 ha
Greenhouse			12,108 set
Monitoring			

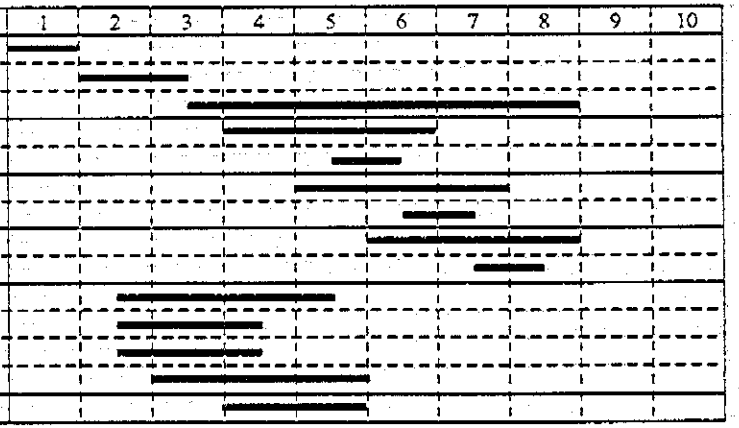


Figure 5.5.1-1 Implementation Schedule (Option-1)

Works	Name		Quantity
Consulting Services	Feasibility Study		
	Detailed Design		
	Construction Supervision		
Recharge Dam & Trench	Siji	Dam	1 unit
		Trench	1 unit
	Kadrah	Dam	1 unit
		Trench	1 unit
	Shokah	Dam	1 unit
		Trench	1 unit
Intake	Well, Pipe, and Tank		2,018 no.
Distribution	Booster, etc.		4,584 ha
Irrigation	Sprinkler, etc.		4,584 ha
Greenhouse			8,072 set
Desali-Pipeline	Main Pipe	No. 1, 2, 3	58 km
	Pumping Station	St. 1, 2, 3	3 unit
	Distribution Pipe	A, B, C, C'	45 km
	Pumping Station	St. C	1 unit
Others			

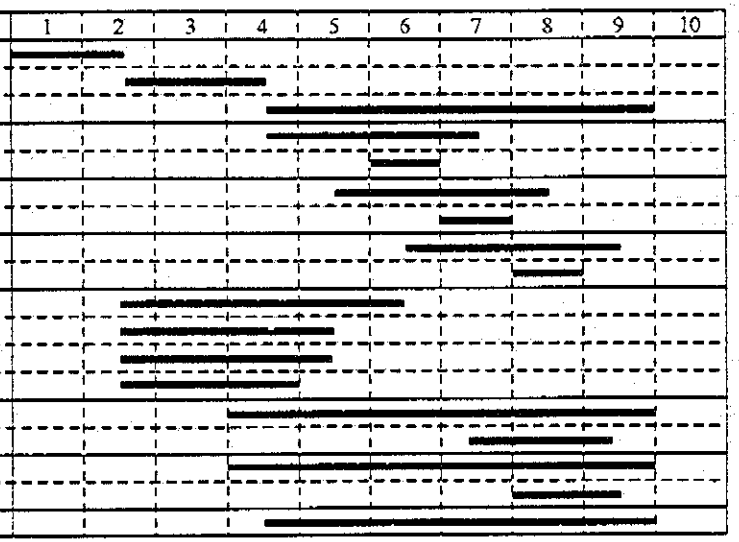


Figure 5.5.1-2 Implementation Schedule (Option-2)

CHAPTER SIX: CONCLUSION AND RECOMMENDATION

6.1. Conclusion

The Study Area covers some 850 sq.km around Al Dhaid.

At present, 2,018 farms with some 4,584 ha of total cropping area are in the Area cultivating vegetables, fruit trees and field crops.

The existing agriculture in the Area is summarized to be subsistence, low economic, high water-consumptive type in an extensive production of fruits and fodder crops.

The most (90 % or more) of farms in the Area are possessed by absentee owners and extensively and conservatively managed by employed foreign workers. The farm owners are usually reside in urban cities and engaged in another business for major means of their livelihood. They use their farm as weekend villa, and instruct their farm-manager to produce crops only for their own consumption, not for the market.

The existing water use in the Area depends upon solely the groundwater. There are some 8,000 tubewells for irrigation. The depth of tubewells ranges from 9 m to 609 m, 130 m on an average.

The existing groundwater use reaches some 54 million cubic meters a year (MCM/a) inclusive of some 2.0 MCM/a of domestic water supply. While, a simulation made through a mathematical model constructed under the present study shows that the sustainable potential yield of groundwater is limited at 20 MCM/a.

The existing triple-fold over-draft of groundwater resources in the Area has taken place gradually since 1970s, and results various obstructions in groundwater such as the drawdown of groundwater head to 40 m, the deterioration of water quality and so forth.

The simulation shows that, if the groundwater draft is left at the existing level, the groundwater head will drawdown to 100 m below the ground after 20 years (2015) and dry up after 45 years (2045). This means that, in case that the groundwater draft in the existing level is continued, the agriculture in the existing size in the Area could not be maintained after 2015 unless otherwise an alternative water resource is introduced into the Area.

Under the circumstance, the master plan was formulated under two policy options as below:

Option One: A master plan in an agriculture size (2,548 ha) to meet the sustainable groundwater potential (22 MCM/a) inclusive of the potential groundwater augment (2 MCM/a).

Option Two: A master plan in the existing agriculture size (4,584ha) introducing an alternative water resource (some 34 MCM/a of the desalinated water).

The agriculture development plan in both options was to aim to be sustainable, water-saving, high-income and market-oriented types. The project evaluation was made in view from socio-economy and environment. The target year of the Project was set forth at 2015 considering from the shift of agriculture size or water resource.

Master Plan in Option One:

Total cropping area is planned to be 2,548 ha, 56% of the existing area. The breakdowns of area by crop are to be 1,713 ha (67% of total area) of vegetables, 272 ha (11%) of Dates and 564 ha (22%) of Alfalfa. The cropping intensity of vegetable is 140 % in total.

The total annual productions by crop are planned at 67,800 tons of vegetables (265% to the existing production), 5,229 tons of Dates (18%) and 51,209 tons of Alfalfa (37%).

Although the total annual production of crops comes to 65% of the existing amount at 124,200 tons, the total net income increases to 126 % of the existing amount at Dh. 273 million (US$ 75 million) exclusive of an additional water cost required for the construction of groundwater augmenting facilities.

By application of the modern water-saving irrigation system (drip, bubbler or sprinkler systems), the total water requirement meets to the sustainable groundwater potential (21.5 MCM/a, 37% of the existing amount).

The project plan consists of:

- the construction of three (3) groundwater recharge facilities (set of recharge dam and recharge trench),
- construction of groundwater monitoring system,
- provision of modern irrigation system and greenhouse in all the farm; and
- others.

The project cost is estimated at Dh. 1,405 million (US$ 385 million).

The project is evaluated to be economically feasible showing the internal rate of return at 6.51 %.

Master Plan in Option Two:

The total cropping area is to be same as the existing size, 4,584 ha. The breakdowns by crop are also same as the existing areas; 1,158 ha (25% of total area) of vegetables, 1,825 ha (40%) of Dates and 1,601 ha (35%) of Alfalfa.

The total annual productions by crop are planned at 45,800 tons of vegetables, 35,100 tons of Dates and 145,500 tons of Alfalfa. With the selection of improved crops, the total annual

production of crops comes to 118% of the existing amount at 226,400 tons. The total net income increases to 217 % of the existing amount at Dh. 467 million (US$ 128 million), exclusive of an additional water cost.

By application of the modern water-saving irrigation system, the total water requirement reaches to 107% of the present amount, 55.4 MCM/a. The alternative water source of 33.9 MCM/a becomes required in addition to groundwater potential (21.5 MCM/a).

The mean farm size remains at 2.27 ha. The net income of Dh. 231,000 and an annual water requirement of 27,500 m^3.

The project plan consists of the construction of water pipeline from Sharjah and the same components as Option One project.

The project cost is estimated at Dh. 3,413 million (US$ 935 million). The economic internal rate of return of the project comes to only 0.44 %.

6.2. Recommendation

(1) Project Implementation by 2015

In order to conserve a mere natural water resource and maintain the agriculture in Al Dhaid area, the government is to decide one of proposed policy options; to set forth necessary legal and administrative measures; and to implement the proposed project by the year 2015.

(2) Legal and Administrative Measures

In case the Option One plan is taken up, the legal and administrative measures are selected among to limit number of farms of certain district(s) where soil condition is less appropriate for irrigated agriculture or to restrict the cropping area in each of existing farms or others. In both the option plans, one of measures may be to increase the tariff of electricity in order to limit the groundwater pumping.

It is recommendable that the administrative measures are to include the provision of groundwater augmenting facilities, groundwater monitoring system, marketing center and alternative water pipeline in case of Option Two plan, the provision of modern farm facilities, the promotion of marketing and processing of agro-products, the strengthening of the existing subsidy program, extension and support services by the government for both the absentee and fulltime farm-owners; and so forth.

The new subsidy program of the government is to cover the promotion of modern farm facilities such as water-saving irrigation system and greenhouse facility.

(3) Motivation of Absentee Farm Owners

As a link of extension and support services, the specific key issue seems to be the motivation of absentee farm-owners. They have to be encouraged to manage their farm in the modern, water-saving, high-valued and market-oriented type to contribute to the nation's agricultural production by marketing agro-products from their farms; and in a manner to conserve the precious mere natural water resource in the nation.

APPENDIX

APPENDIX - 1 : List of Member of the Study Team

1. JICA TEAM

Mr. Mitsuru Yoshikawa	Leader/Groundwater Development
Mr. Izumi Kato	Deputy Leader/Hydrogeologist
Mr. Keiji Matsumoto	Irrigation/Drainage Expert
Mr. Thomas Orland Miles	Geophysist
Mr. Nobuhiko Shiga	Geophysist
Dr. Michio Nozaki	Agronomist
Dr. Jorge E. Tokeshi N.	Economist
Dr. Toshihiko Kuno	Facility Planning/Cost Estimation Expert
Mr. Keiji Iizuka	Rural Sociologist
Dr. Michiaki Hosono	Environmental Conservation Expert
Mr. Eichi Shibata	Coordinator

2. COUNTERPART

Mr. Mohammed Sager Al Asam	Director, Soil and Water Dept., MAF
Mr. Abdulla Al Moalla	Director, Agriculture Office, Central Region, MAF
Mr. Mohammed Abdul Haq	Hydrogeologist, Soil and Water Dept., MAF
Mr. Mohammed Mustafa	Soils and Irrigation Engineer, Soil and Water Dept., MAF
Mr. Essa Busamra	Head of Soil & Irrigation Section, Agriculture Office, Central Region, MAF

APPENDIX - 2 : List of Persons Contacted

1. MINISTRY OF AGRICULTURE AND FISHERIES

1.1. Head Office, Dubai

H.E. Mr. Saeed Mohammed Al Raqabani	Minister of Agriculture and Fisheries
Mr. Hamad Abdullah Salman	Deputy Minister
Mr. Hamad Abdulla Al Mutawa	Assistant Deputy Minister
Mr. Habib Hussain Aboodi	Head, Planning Unit
Mr. Adnan Nassar	Assistant Head, Planning Unit
Mr. Mohammed Sager Al Asam	Director, Soil and Water Dept. (SWD)
Mr. Mohammed Abdul Haq	Hydrogeologist, SWD
Mr. Mohammed Abdullah	Soils and Irrigation Engineer, SWD
Mr. Salim Akram	Hydrogeologist, SWD
Mr. Mohammed Mustafa	Soils and Irrigation Engineer, SWD
Mr. Saeed Jahfar	Head, Statistics Section
Mr. Sabry F. Ismail	Statistician, Statistics Section
Mr. Hamza Nasser	Statistician, Statistics Section
Mr. Nizar Al Hendi	Statistician, Statistics Section
Mr. Ahmed Easa	Head Librarian
Mr. Abudulla A. Ben Abdulaziz Al Ahihhi	Director, Plant Protection and Extension Service Dept.
Mr. Basem Abu Ghazaleh	Director, Budget Dept.

1.2. Central Region Office, MAF Dhaid

Mr. Abdulla Al Moalla	Director, Central Regional Office
Mr. Ismail Hossein	Director, Agricultural Affairs
Mr. Essa Busamra	Head, Soil & Irrigation
Mr. Mohammed Reda Awadalla	First Engineer
Mr. Arif Hassan	Geologist
Mr. Basel Mubarak	Manager, Research Station
Mr. Haney	Agricultural Extension Officer, Dhaid-1
Mr. Farwaz	Agricultural Extension Officer, Dhaid-1
Mr. Ismail	Agricultural Extension Officer, Dhaid-1

1.3. **Research Station of Northern Region, MAF, Hamraniyah**

Mr. Saeed Al Bogan	Researcher, Vegetable Crops
Mr. Masood Aortani	Researcher, Irrigation
Mr. Abdrah Alrahman Awad	Researcher, Forage Crops

2. **MINISTRY OF PLANNING**

Mr. Mohammed Abu Holica	Secretary, Budget Committee
Mr. Rames Dhamesh	Agricultural Analyst

3. **UNITED ARAB EMIRATES UNIVERSITY**

3.1 **Facility of Agricultural Science**

Dr. Faisal K. Taha	Chairman, Plant Production Dept.
Dr. Ahmed A. Al Masoon	Professor, Plant Production Dept.
Dr. Yussuf Taha Gumaa	Professor, Agricultural Economics
Dr. Mahmood Sami	Professor, Rural Sociology
Dr. Bassam A. Hasbini	Professor, Irrigation
Dr. El Sayed A. Eikhatrib	Professor, Soil Science

3.2 **JICA Expert for UAE University**

Dr. Yokota	JICA Expert
Mr. Tomoo Shoji	JICA Expert
Mr. Masahiro Akiyoshi	JICA Expert
Mr. Masahiro Abe	JICA Expert

4. **FEDERAL ENVIRONMENTAL AGENCY**

Dr. Salem Al Dhaheri	Director General

5. **U.N. Economic Commission for Western Asia**

Mr. Sunna Sami	Regional Advisor in Agriculture

APPENDIX - 3 : List of Data Collected

A) Natural Conditions

1) Dams and Rechargeable Facilities in the United Arab Emirates: Preliminary Report, 1982, HALCROW, Ministry of Agriculture and Fisheries.

2) Project 21/81: Drilling of Deep Water Wells at Various Locations in the UAE, Volume I, December 1986, IWACO - Bin Ham Well Drilling Est.

3) Project 21/81: Drilling of Deep Water Wells at Various Locations in the UAE, Volume I, June 1985, GEOCONSULT - Bin Ham Well Drilling Est., Ministry of Agriculture and Fisheries.

4) World Soil Resources, FAO.

5) Daily rainfall records at the following rainfall stations; Siji, Sifuni, Masafi, Dhaid, Mileiha, Falaj Al Mualla, Fili, Marbad, Jebel Sharmah, and Sharjah airport.

6) Daily flood discharge records at the following gauge station; Siji, Sifuni, Khadrah, Ashwani, Falaj Al Mualla.

7) Well records at 12 stations in the Study Area.

8) Hydrology, Vol. No. 3, 1980-1991, Water & Soil Dept. MAF U.A.E.

B) Agricultural Conditions

1) Responses of Vegetable Crops to Fertilizers in Northern United Arab Emirates (1978-79), r., Y.S. Puh, H.Abu-Kibash, A. Mouti S. Nassar, UNDP, FAO, UAE Ministry of Agriculture and Fisheries (Water and Soil Investigations for Agricultural Development).

2) Irrigation Practices in Relation to Crop Response, Water Use, and Soil Salinity (1980-83), A.P. Savva, M. Sager Al Asam, et alt., Same as 1).

3) Irrigation Practices in Relation to Crop Response, Water Use and Soil Salinity Hamraniyah and Dhaid Research Stations (1978-80), A.P. Savva, R. Karam, et. alt., Same as 1).

4) Crop Water Requirements (Estimates and Field Measurements), A.P. Savva,S.B. Thanki, et. alt., Same as 1).

5) Hamraniyah Irrigation Practices Experiments (1976-78), A.P. Savva, R. Karam, et alt., Same as 1).

6) Results of Fertilizer Field Experiments on Vegetable Crops in UAE (1970-1980), Y.S. Puh, H. Abu-Kibash, et. alt., Same as 1).

7) Cropping Pattern and Irrigation Requirements Central Region, United Arab Emirates, Dr. C.R.K. Prashar, Sudhir B. Thanki, Same as 1).

8) Arab Agriculture 1995, Fanar Publishing Wll.

9) Design cases of modernized farm in the Study Area by MAF; 5 Dhaid cases and 1 Wishah case.

10) Price list of Irrigation Facilities by market survey.

11) Specification of existing dams.

12) Construction cost of dam and composite price of its material by market survey.

C) Economic and Social Conditions

1) Annual Economic Report, 1993, General Planning Department, Ministry of Planning.

2) Annual Statistical Abstract, General Planning Department, Ministry of Planning.

3) National Accounts for United Arab Emirates 1988-1993, General Planning Department, Ministry of Planning .

4) Statistical Yearbook 1992, Department of Planning, Emirate of Abu Dhabi.

5) Annual Statistical Bulletin of Agriculture and Fisheries 1993, Ministry of Agriculture and Fisheries.

6) Statistical Yearbook, 1994, Economic Department Government of Sharjah.

7) The Women of the United Arab Municipalities, Linda Usra Soffan, Barnes and Noble, 1980.

8) Social Development Indicators, 1994, World Bank.

9) The UAE Economy in 1993, B.M.I., Ltd., London, 1993.

10) The National Atlas of the United Arab Emirates, The United Arab Emirates University, Al Ain, 1993.

11) Average consumption of electricity and water in U.A.E.

12) Commercial Directory 1994/95, Sharjah Chamber of Commerce & Industry.

13) Electrical Energy & Water in Sharjah 1970-1991, Electricity & Water Department, Government of Sharjah.

14) National report of United Arab Emirates on the Development of Education from 1991/1992 - 1993/1994, Ministry of Education.

15) Annual Bulletin of Educational Statistics 1991/1992, Ministry of Education.

16) Annual Report for the Year 1993 (Electricity Affairs), Ministry of Electricity & Water.

17) Annual Report for the Year 1994 (Electricity Affairs), Ministry of Electricity & Water.

18) Unbottled Drinking Water (Gulf Standard and UAE Standard), Ministry of Electricity & Water.

19) Federal Law No. 8 Year 1980 Re, Ministry of Labor and Social Affairs.

20) Maps of Wells for Tap Water in the Study Area, Ministry of Electricity & Water