CHAPTER 3

DEVELOPMENT PROPOSAL

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3-1 Objectives of Development

The socio-economic development of Egypt has been greatly dependent on the development of its agriculture sector. To achieve better food security and contribute more to the economic development of the country whose population is growing at a rate of more than two (2) percent, the development of agriculture is particularly important. The present cultivated lands occupy nearly 7.5 million feddans (3.15 million ha), mostly confined to the Delta, and it presents only 0.13 feddans per capita.

The land area in Egypt is almost one million km^2 of which only four (4) percent is inhabited; the remaining land is desert. About 99% of population concentrate in the Delta, being one of the most densely populated countries. Egypt is becoming progressively more urbanized, and consequently fertile Delta land is being converted to village/urban land.

Egypt experiences the arid climate characterized by high evaporation rates and little rainfall (5 - 200 mm/year). Thus agriculture in Egypt can not be sustained without application of proper irrigation water. The Nile river is the primary source of irrigation. Given limited water resources, MPWWR is making every effort to increase the rate of growth in agriculture through the improvement of water use in the existing irrigation systems and development of water resources. The construction of the Suez siphon and the Shikh Gaber El Sabah canal, which is the extension of the El Salam canal, is urged to make the Nile water available for use in North Sinai.

Under the situation, the government of Egypt gives high priority to reclamation and cultivation of 400 thousand feddans in the Northern part of Sinai, as one of the important sectoral policies in its Third Five Year National Plan, with broad objectives of ensuring food security for a rapidly growing population and generation of rural employment.

In line with the policies of the Third Five Year National Plan, this North Sinai integrated rural development project has proposed to develop the new land of 135,000 feddans for agriculture, entailing the implementation of related development plans; land reclamation with measures aimed at maintain soil fertiltities, reducing salinity and better soil conservation; irrigation and drainage development with control of distribution to farm land for efficient use of the Nile water; agricultural development in terms of crop and livestock production to provide foodstuff to consumers with intensive backup from agricultural extension services, especially to small farmers and graduate farmers to be newly settled.

The proposed development project will be implemented in an integrated manner so as to establish new rural communities in North Sinai, the eastern gate of Egypt. This project has also proposed to implement the settlement plans with the construction of social infrastructures, and develop small-scale agro-processing industries which will provide opportunities for the private sector to contribute to growth and employment.

3-2 Land Development

3-2-1 Land Type

Out of 153,900 feddans of the land area investigated, 18,900 feddans of lands were excluded from the project including 6,700 feddans of movable sand dune and 12,200 feddans of lands for other land uses as envisaged by the governorate, thus resulting in a gross area of 135,000 feddans for agricultural development.

According to the soil classification made by GARPAD, lands in the Study area are classified into four (4) types: nearly leveled sedimentary land, simple corrugated land covered with gravel, gypsum land and light to heavy corrugated land formed my movable sand, as given below:

Land Types and Land Area

Land Type	Area (feddans)
Nearly leveled sedimentary land	33,472
Simple corrugated land	54,142
Gypsum land	8,038
Light to heavy corrugated land formed by mobile sand	58,204
Total	153,856

Light to heavy corrugated lands formed by movable sand is important for agricultural use as far as soil properties are concerned. These type of lands occupy 38% of the total land area. Sandy soils used for vegetable growing are often affected by wind. The most effective control of wind erosion is provision of windbreaks and vegetative covers. Tenacious grasses and shrubs are effective vegetations.

3-2-2 Land Management Category

The land classification systems adopted by the previous studies are; 'Land Resources Unit (LRU)' based on the USDA land capability classification, land capability classification of the US Soil Conservation Services, USDA, and 'Land Management Categories (L/C) which was employed for the study of Land Master Plan. The land management categories of the selected 135,000 feddans fall within III and IV (GARPAD, 1994) as given below (refer to Figure 3-1):

Land Management Categories

Category	Sub-category	Evaluation	Area (feddans)
I	Ia, Ib	Excellent	0
II	IIa, IIb	Good	0
III	IIIa, IIIb, IIIc	Moderate	70,567
IV	IVa, IVb	Poor	64,433
V	-	Barren	0
Total			135,000

In the Study area, categories of III and IV are corresponding to silty/silty clay soils and sandy soils, respectively. Category III includes land with flat to undulating topography in various desert land forms. The soils are deep and the texture is predominantly silty with a total available moisture of 5 - 10% by volume. With the exception of rice and cotton, it is possible to grow a wide range of crops using irrigation. Category IV includes sandy soils with a total available moisture of 5 - 10% by volume, which are situated in undulating topography including low and medium-high dunes. The crops that can be grown are the same as on the land in Category III.

The land in Category III and IV are rated as the same class, being 'moderately good arable', in the capability system for irrigated land use of the US Bureau of Land Reclamation (USBR, 1953). Therefore, all the land selected for the Study is suitable for development of agriculture.

3-2-3 Land Use

The land allocated for use of village development and construction of road and canal networks and others necessary for the establishment of new communities totals 17.8% of the Study area. This project will provide for 111,000 feddans of farm lands, which is equivalent to 82.2% of the Study area. It is recommended that small farmers and graduates settle land in category IIIa, which is nearly leveled and/or simple corrugated land, in order to encourage them in their farming. A summary of the land use plan is as follows:

Land Use Plan

Utilized Unit	Area (feddans)	Percentage (%)
Farm Land	111,000	82.2
Village Land	5,860	4.4
Irrigation and Drainage Canal	15,420	11.4
Social Utility Land	2,720	2.0
Total	135,000	100.0

3-3 Water Conveyance and Water Management

3-3-1 El Salam Canal and Shikh Gaber El Sabah Canal

(1) El Salam Canal on the Western Bank

The construction works of the El Salam canal have been completed over a distance of 87 km between the Damietta intake and the Suez Canal. The designed intake capacity at the Damietta intake is 109 m^3/sec. The canal capacity increases to 214 m^3/s at the confluence of Hadous drain to allow mixing of 86 m^3/sec of drainage water. Three (3) pumping stations have been built; two (2) stations, No.1 and No.2, are operated to raise the canal water level, and station No.3 is operated to take drainage water into the canal.

All the canals are of the earth canal type. Gabions and concrete slurry walls were constructed at several locations to protect canal embankments from sliding and control seepage losses from the canals.

(2) Suez Siphon

The Suez siphon with a total length of 820 m is presently under construction to allow crossing of the Suez Canal, using the shield tunneling method. Of the four (4) tunnels with an inside diameter of 5.1 m, two (2) tunnels have been completed, and the construction works are scheduled to be finished by the middle of 1997. The siphon provides regulating gates at inlet and outlet sides. The total design capacity is 160 m^3/s.

(3) Shikh Gaber El Sabah Canal on the Eastern Bank

After crossing the Suez Canal, the extension of the El Salam canal is named Shikh Gaber El Sabah canal which commands 400,000 feddan of land in North Sinai. Designs of the canal systems have been completed for a total distance of 86.5 km to command 265,000 feddans of land excluding the El Sir & El Kawareer Zone of 135,000 feddans (the Study area), and the construction is now underway.

Earth canals are designed for the upstream reach, which is 24.5 km long. Over a distance of 21.5 km between station 24.5 KM and station 46.0 KM , canals are lined with concrete because of the sandy soils prevailing on the routes. Original plans propose o provide four (4) pumping stations, namely, station No.4, No.5 and No.6 to maintain canal water levels and pumping station No.7 at station 86.5 KM to lift the water to El Sir & El Kawareer Zone. The design capacity at the end point of the canal is 52.66 m^3/s.

3-3-2 General Conditions on Water Conveyance

(1) Hydraulic Dimensions at BP

The hydraulic design dimensions at station 86.5 KM, hereinafter referred to as Beginning Point (BP) for this Study, are as follows:

Water Level:	NWL 15.49 m MSL
	LWL 14.49 m MSL
Discharge:	52.66 m^3/s at maximum
	29.52 m^3/s at minimum
Upstream canal:	12 m bottom width
	8 cm/km canal slope with concrete lining
	0.86 m/s water velocity

(2) Topography

The Study area is located south east of the BP. The distance is about 40 km between the BP and the western edge of the Study area of which ground elevations range from 90 to 110 m. The lowest ground elevation is around 50 m at the northeastern end of the Study area.

The BP is at N 30° 59' 44" Lat. and E 33° 08' 04" Long., where heavy sand dunes were observed. In the area south of N 31° Lat. undulated sand dunes with a height of about 20 m are present. These dunes presumed to be shifting, whereas in the area north of the same Latitude, sand dunes and plains alternate at an interval of around 10 km with the difference in elevation of approximately 10 m. Sand dunes located south of the national highway are covered with vegetation; it is presumed that sand dunes are stable.

3-3-3 Alternative Study

(1) General

A pumped pressure system is inevitably required for water conveyance due to the topographic condition of the area. Water is transported from the source to the Study area in open and closed conduits, depending on topography and available materials, with the necessary energy being provided by gravity or pumping. The water conveyance system may follow the hydraulic grade line, as open canals and box culvert canals dug through the ground, or it may depart from the hydraulic grade lines, when it consists of pressure pipelines of fabricated materials following the ground surface.

Because open canals and box culvert canals are constructed as far as possible using a balanced cut and fill method, they are cheap to build. Open canals are troubled by drifting sand dunes. Box culvert canals will be constructed for the reaches with active sand dunes. Pipelines usually follow the profile of the ground surface quite closely. In long pipelines, frictional resistance offered by the pipe interior is the dominant element.

In the context of the above, alternative studies have been carried out in order to select the best conveyance system that is technically sound and economically feasible. This is especially important since the system conveys a large amounts of water (52.66 m^3/s) over a long distance of more than 40 km, thus resulting in a large investment costs. In the study of alternatives, the following parameters are important: type of conduits, material of conduits, and delivery water level at the western edge of the Study area. These will determine the capacity of the pumping station(s) and the route of the canal.

(2) Canal Types and Materials

(a) Open Canal

Open canals have advantages such as low unit construction costs and little water loss in canals; however, canals have to follow topography of land, and can silt up due to drifting sand. Open canals will be proposed to be constructed in general for areas with flat to gentle slopes including desert lands. Hydraulic dimensions and structures of canals will be similar to those of upstream canals as presented in 3-3-2.

(b) Box Culvert Canal

Box culvert canals will be constructed for desert lands with a flat to gentle slope where drift sand dunes are present. The design flow velocity of canals is 1.2 times that of the design velocity for upstream open canals so as to prevent canals from sedimentation of sands. The proposed dimensions of the box culvert canals are as follows:

Cross section:	3.8 m x 3.8 m x 4 sections
Water depth:	3.3 m
Velocity:	1.05 m/s
Bed slope:	19.1 cm/km, or 1/5,236

(c) Pipelines

Pipelines and pumping station(s) have high unit construction costs and high operation costs, and will be proposed in areas where no other method can be applied. Due to the large discharge (52.66 m^3/s) and high pressures ranging from 9.5 to 17.5 kg/cm^2 (static water pressure plus water hammer pressure), four (4) kinds of pipe materials are selected for alternative studies, all of which are being fabricated in Egypt; they are steel pipes, prestressed cylinder concrete pipes, fiber reinforced pipes and ductile cast iron pipes.

<u>Steel Pipe (SP)</u>: SPs with a diameter upto 2,000 mm have been fabricated in Egypt, and those with diameters of more than 2,000 mm can be fabricated on demand. SPs are widely utilized throughout the world for its high reliability and capacity to take hydraulic pressure. The strength of SP with the welded joint is determined by the thickness of the pipes, as required for its ability to resist internal pressures and external loads.

<u>Prestressed Cylinder Concrete Pipe (PCCP)</u>: PCCPs are manufactured in Egypt according to AWWA C 301. PCCPs with diameters of 600 - 2,000 mm are normally fabricated. The pipes are hydraulically tested in the factory up to a pressure of 32 bar. Pipe bodies are generally strong enough to withstand the test pressure of 32 bar. The heavy weight of PCCP often results in a problem of settlement of joints. PCCPs are composed of steel cylinder pipes, as a core, with a concrete lining and steel spigots and bells with rubber gasket rings at the joints to maintain water tightness. The allowable pressure of a joint is about 10 kg/cm^2 for a static pressure and 12 kg/cm^2 for the design pressure.

Fiber Reinforced Pipe (FRP) : FRPs can be manufactured in Egypt to the size of 2,500 mm diameter according to the standards of AWWA and ASTM. The test hydraulic pressure is 32 bar. It is reported that a total length of 100 km of pipes with a diameter of 400 mm (12 bar) and 90 km of pipes with a diameter of 700 mm (15 bar) have been fabricated so far. FRPs have a smooth inside surface with a low surface resistance, a light weight and a strong anti-corrosiveness. Water hammer pressure waves propagate so slowly in FRP that the pressure fluctuation appears with comparatively slight changes. FRPs have problems at the joints similar to PCCP, and the strength against internal pressures is almost the same as that of PCCP.

Ductile Cast Iron Pipe (DCIP) : DCIPs are produced to a diameter of 1,000 mm in Egypt. Similar to SP, DCIPs are also known throughout the world for their high reliability.

With respect to the selection of pipe materials, the following criteria are employed:

SP: The maximum diameter is 3,000 mm. Wall thickness of pipes is determined so it can withstand the inside hydraulic design pressure.

PCCP: The maximum diameter is 2,000 mm. The limit of static water pressure is 10 kg/cm^2 and design pressure is 12 kg/cm^2.

FRP: The maximum diameter is 2,000 mm. The limit of static water pressure is 10 kg/cm^2 and design pressure is 12 kg/cm^2.

DCIP: The maximum diameter is 2,600 mm. The limit of the design pressure is 38 kg/cm^2.

(3) Delivery Water Level (DWL)

The proposed farm irrigation systems include sprinkler irrigation methods and drip irrigation methods. Water delivery to farms from the water conveyance system is by gravity flow through canal networks to be provided by the irrigation projects. Energy required for operating the mechanized facilities of farm irrigation systems is generated by electric motors owned by the farmers.

The proposed water conveyance system delivers the water to the western edge of the Study area which has ground elevations of 90 - 110 m. In determining the delivery water level (DWL), two (2) alternative levels were selected: 110 m at which all farms are able to receive water by gravity, and 90 m, the lowest delivery water level, at which 63,000 feddans of land (or 47% of the Study area) are commanded by gravity, while booster pumps are required to deliver the water to the remaining 72,000 feddans of lands.

(4) Canal Route

In due consideration of topographic conditions and the characteristics of canals, three (3) basic canal routes were selected based on the results of the analysis of topographic maps and reconnaissance field survey as summarized below (refer to Figure 3-2):

Route A: The route is selected to minimize the length of conveyance canals as preliminarily planned by MPWWR; however, it requires a long pipeline section to cross sand dunes. The total length is around 41 km.

Route B: The route is selected to shorten the length of the pipeline section envisaged in Route A. The route is planned to run along the national roads as close as possible to avoid the sand dune areas. The total length is around 45 km.

Route C: The route bifurcates from route B at the 16.5 KM point in east-south direction to traverse the desert lands taking the shortest route. The route is selected so that the pipeline section is of the possible shortest. The total length is around 45 km. Route C cross the route A at the 19.3 km point, and a combination of route A and C is a possible alternative.

In addition to the above basic routes, all routes have two (2) sub alternative routes nearby the Study area depending on DWL; A-1, B-1 and C-1 for DWL of 90 m, and A-2, B-2 and C-2 for DWL of 110 m, thus totaling eight (8) alternative routes as given below:

DWL of 90 m:	A-1/A, C-1/B-1/B, C-1
DWL of 110 m:	A-2/A, C-2/B-2/B, C-2

(5) Alternative Plans

With respect to the types of conduits, the following 10 alternative plans are formulated for the eight (8) alternative canal routes:

	Canal	Length of Canals (km)			
DWL (m)	Route	Pipeline	Box Culvert	Open Canal	Total
90	A-1	39.6	-	2.2	41.8
90	A-1	20.3	19.3	2.2	41.8
90	B-1	16.7	7.8	21.1	45.6
90	A, C-1	10.6	19.3	13.1	43.0
90	B, C-1	10.6	7.8	26.6	45.0
110	A-2	40.5	-	-	40.5
110	A-2	21.2	19.3	-	40.5
110	B-2	18.2	7.8	18.9	44.9
110	A, C-2	12.6	19.3	8.5	40.4
110	B, C-2	12.6	7.8	22.0	42.4

Further consideration was given to the materials of pipes. Four (4) materials are applicable; SP, PCCP, FRP and DCIP. Accordingly, 40 alternatives in total are formulated. Main features of the alternatives are presented on Table 3-1.

(6) Pipelines

Given the design discharge, numbers and sizes of pipelines can be determined using hydraulic and economic considerations. The controlling hydraulic factors are available heads and allowable velocities. The maximum velocities should be selected so that the pipeline is not danger of collapse, due to excessive water hammer pressure. From experience, velocities of pumped pipelines with diameters of 1,400 to 3,000 mm range from 1.4 to 2.5 m/s. In general the average velocities are less than 2.0 m/s. Through a preparatory study to examine the correlation between velocities and number of pipelines, the following dimensions are proposed:

Pipe Materials	Diameter (mm)	Nos. of Pipeline	Velocities (m/s)
SP	3,000	4	1.862
PCCP	2,000	10	1.676
FRP	2,500	6	1.788
DCIP	2,600	6	1.653

(7) Regulating Reservoir

To meet the seasonal fluctuation of water demand, varying pump discharge are required. Pumps can be operated by means of speed control method, valve control method or on-off operation method. Speed control devices are expensive for large scale pumping stations. The valve control method is not proposed for discharge control due to its high energy consumption for large scale pumping stations. The on-off operation method is therefore proposed for discharge control due to its relative ease of operation and low construction and maintenance costs. This method requires regulating reservoirs at both the upstream and downstream end of the pipeline system.

The capacity of reservoirs needs to be sufficient to regulate the difference between inflow discharge and pumping discharge. In the case of seven (7) pump units with a discharge of 451.4 m^3/min/unit, the required regulating capacity is around 32,000 m^3.

(8) Pumping Station

(a) Division of Pump Head

The estimated internal pressures are about 14 to 17.5 kg/cm^2 including the water hammer pressure of about 4.5 kg/cm^2. SP and DCIP can withstand the high internal pressure of a single pumping station (station No.7); however, PCCP and FRP need two (2) pumping stations (station No.7 and No.8) to reduce the internal pressure. Pumping station No.8 will be located at the middle reach of the pipelines with a ground elevation of around 50 m.

(b) Total Pump Head

The height of lifting the water from the source to the downstream regulating reservoir determines the total head of the pumping system. The total head of the system includes the height of the lift from suction water levels to discharge water levels, and friction losses in the pipelines, pumps and fittings. The suction water levels and discharge water levels are designed depending on the conduit types to be connected with the station and the pipelines. The Hazen-Williams formula is used for computing head losses in the pipelines, in which the Hazen-Williams coefficient (C) of 150 for FRP and 130 for SP, PCCP and DCIP are applied. Five (5) percent of the friction loss and 1.5 m of head loss are added to the calculation of total pump head.

(c) Type and Number of Pump

Pumping units are chosen in accordance with the total heads and pump characteristics. Two (2) types of pumps are applicable to the proposed pumping stations. They are a vertical shaft single suction diffuser and volute type and a horizontal shaft double suction volute type. The vertical type pump is proposed because of its better performance and safety in case of submergence of the pump units.

Eight (8) units of vertical pump type with a nominal bore diameter of 2,000 mm are planned to be installed and operated in series at pumping station No.7 and No.8, including one (1) standby pump.

(d) Motor Output

Electric motors are recommended as prime movers. The motor output is estimated using the following equation

$$P = 9.8 \times Q \times H \times (1.0 + 0.1)/0.9$$

Where, P is motor output, Q is water discharge in m3/s, H is a total head in meter, and 0.9 is a pump efficiency.

(e) Booster Pumping Station

In case of a delivery water level of 90 m, three (3) booster pumping stations will be provided to command land areas of 72,000 feddans: station No.1, No.2-1 and No.2-2 as shown in Figure 3-3. Pump units of No.2-1 and No.2-2 are installed in one building. Outlines of the booster pumping stations are as follows:

Booster Pumping Station

Particulars	Unit	No.1 Station	No.2 Station	
			No.2-1	No.2-2
Location	km	4.5	14.0	14.0
Command Area	feddan	4,300	33,900	33,800
Discharge	m^3/s	1.68	13.22	13.19
Pipelines (SP)				
- Length	km	1.0	1.4	0.6
- Diameter	mm	1,200	2,000	2,000
- Nos. of Pipelines		1	3	3
Pump: Vertical Type				
- Nos. of Pumps	unit	2 + 1	4 + 1	4 + 1
- Total Head	m	29.5	29.2	18.6
Motor Output	KW	643	4,779	3,035

(9) Electric Transmission Line

Electric requirements of the proposed pumping stations are approximated as follows:

Electric Requirements (MVA)

DWL (m)	Pipeline	Main Station		Booster Station	
		No.7	No.8	No.1	No.2
90	SP, DCIP	80	-	1	11
90	PCCP, FRP	40	45	1	11
110	SP, DCIP	100	-	-	-
110	PCCP, FRP	40	65	-	-

The length of electric transmission lines was determined using topographic maps. The lines run along the proposed water conveyance canals, starting from the national road to the respective stations. The main electric transmission trunk line (220 KV) is being constructed along the national road under the national network program.

(10) Cost Estimate

(a) Construction Cost

The construction costs of the water conveyance system include main pumping station(s), conveyance canals, booster pumping stations in the Study area and electrical works. The costs required for construction of regulating reservoirs and irrigation networks are not included for the sake of comparison, as such costs are common to all alternatives. The estimated construction costs fluctuate between 1,332.8 million LE for alternative 37 and 5,440.1 million LE for alternative 4. Alternative 37 with the route of B, C-2 (DWL of 110 m) provides for pumping station No.7 and 42.4 km of canal system, of which the SP pipeline section is 12.6 km long, while alternative 4 with the route of A-1 (DWL of 90 m) provides for pumping station No.7, booster pumping stations and 41.8 km of canal systems, of which the DCIP pipeline section is 39.6 km long. The high costs of alternative 4 are mainly due to the high costs of DCIP. The top five (5) alternatives with low construction costs are given below (refer to Table 3-2 and 3):

Construction Costs in Million LE

Alternatives					Pumping Station	
No.	Route	DWL (m)	Cost	Pipe	Main	Booster
37	B, C-2	110	1,333	SP	No.7	-
17	B, C-1	90	1,449	SP	No.7	No.1, No.2
33	A, C-1	90	1,543	SP	No.7	No.1, No.2
38	B, C-2	110	1,556	PCCP	No.7, No.8	-
39	B, C-2	110	1,572	FRP	No.7, N0.8	-

(b) Operation and Maintenance Cost

The estimated operation and maintenance (O&M) costs include power costs to operate pump units, operation costs of engineering facilities and maintenance costs of the system. The annual operation costs are dominated by the costs of power. The power costs are estimated based on motor output, irrigation water requirements and operating hours(Table 3-4). Annual O&M costs range from 53.3 million LE (alternative 17, DWL of 90 m) to 74.0 million LE (alternative 22, DWL of 110 m). Details of annual O&M costs are presented on Table 3-5.

(11) Economic Comparison of Alternatives

The sum of the present value of a series of future costs for construction and O&M of the alternative water conveyance systems has been computed to compare the economic preference among the alternatives; benefits to be generated from the Study area are equal for all alternatives.

The present value of costs were determined by multiplying the future costs by an annual interest rate of 12 percent on conditions that the project life is 50 years, the useful life is 25 years for pump equipment with a scrap value of 20 percent and 50 years for canal systems and civil works, and the system will take four (4) years to complete at annual rates of investments of 15, 30, 30 and 25 percent of the total construction costs. The estimated present value of costs is given on Table 3-6.

The alternative with the lowest present value of cost is No. 37, being followed by No. 17. Both the alternatives take the route B to C using steel pipelines. The difference between the two is the delivery water level: 110 m for the alternative No. 37 and 90 m for No. 17. In case of the 90 m alternative, booster pumping stations need to be built in the Study area. Annual operation and maintenance costs of alternative No. 17 is lower than that of alternative No. 37. However, the present value of costs is higher than that of No. 37, which may be attributed to the additional construction costs to provide the booster pumping stations. In this context, a case study has been added to evaluate economic advantage of the alternative No. 37.

The case study is based on the route through B to C-2 and a delivery water level of 100 m at which 99,260 feddans of lands are commanded by gravity flow, and compared with 63,000 feddans in case of DWL of 90 m. Booster pumping stations supply 35,740 feddans of land. The pipe material is steel, and the pipelines have total length of 12.6 km. The total pump head of main pumping station No.7 decreases from 115.3 m for No.37 to 105.32 m. Annual power costs are 48.2 million LE for the main and booster pumping stations while these costs are 52.8 million LE for alternative No. 37. The present value of costs for the additional case ranks second lowest as is given below:

Comparison of Present Value of Cost

Alternatives				Construction	Annual O&M	Present Value	
No.	Route	DWL (m)	Pipe	Cost (M LE)	Cost (M LE)	(M LE)	Ratio
37	B, C-2	110	SP	1,333	56.2	1,457	1.00
	B, C-2	100	SP	1,437	52.3	1,525	1.05
17	B, C-1	90	SP	1,449	53.3	1,541	1.06
33	A, C-2	110	SP	1,543	56.8	1,636	1.12
38	B, C-2	110	PCCP	1,556	61.5	1,683	1.16
39	B, C-2	110	FRP	1,572	59.5	1,684	1.16

As can be seen from the above table, alternative 37 gives the lowest present value of costs. As for the case study with DWL of 100 m, costs of canals are the same for alternative 37, construction costs of pumping station No.7 are slightly lower, however, it needs an additional investment to build booster pumping stations. The total construction cost of the case study comes to 1,437 million LE, higher than that of the alternative 37. On the contrary, power costs decrease from 52.8 million LE for the alternative 37 to 49.1 for the case study.

As a result of the comparison of alternatives, it can be concluded that with a delivery water level lower than 110 m for pumping station No.7, the water conveyance system inevitably requires the construction of booster pumps in the Study area, total power costs to operate the main pumps and booster pumps decrease to less than that of the case with a delivery water level of 110 m, which does not need booster pumps in the Study area (Figure 3-4); however the construction costs of pumping stations significantly increase. Thus, the study leads to the selection of alternative 37 with the delivery water level of 110 m as the proposed water conveyance system. The construction costs, O&M costs and present value of costs are summarized for the above three (3) alternatives as follows:

Comparison of Costs for Three Alternatives

Cost Items	Alt. No.37 DWL: 110m	Case Study DWL: 100m	Alt. No.17 DWL: 90m
Canals			
- Length in km	(42.4)	(42.4)	(45.0)
- Construction Cost (M LE)	947.7	947.7	867.4
No.7 Pumping Station			
- Total Head in m	(115.3)	(105.3)	(94.2)
- Construction Cost (M LE)	382.9	380.1	376.6
Booster Pumping Station			
- Command Area in fed.	-	(35,740)	(72,000)
- Construction Cost (M LE)	-	107.0	183.2
Electric Works (M LE)	2.2	2.2	21.5
Total Construction Cost	1,332.8	1,437.0	1,448.7
Annual O&M Costs (M LE)	56.2	53.3	53.3
Present Value of Costs (M LE)	1,457	1,525	1,541

3-3-4 Water Management

(1) Present Situation

(a) Canal Systems

The El Salam canal system is composed of: Damietta intake, three (3) pumping stations, two (2) drainage intakes, one (1) spillway and nine (9) offtakes to command 212,000 feddans of land, having a total length of 87 km. Two (2) drainage siphons were built to cross the canal. Table 3-7 presents a list of structures related to the water control of the El Salam canal system.

The Shikh Gaber El Sabah canal begins at the Suez siphon and extends over a distance of 129.0 km to command 400,000 feddans of land. The Suez siphon is presently under construction. The construction of the upper reaches (earth canal) from station 0 KM to 24.5 KM has been completed, and is underway for the reaches (concrete lining canal) from the station 24.5 KM to 46.0 KM. The proposed water conveyance canal starts from station 84.9 KM to command 135,000 feddans of lands in the Study area with a total length of 44.1 km. The canal system is composed of: the Suez siphon, four (4) pumping stations, five (5) cross regulators, 31 offtakes to command 265,000 feddans and one (1) spillway, of which one (1) pumping station and one (1) spillway are proposed under this water conveyance program. The list of structures related to water control of the Shikh Gaber El Sabah canal system is given on Table 3-8.

No cross regulator has been built across the El Salam canal. Delivery water to the secondary canals is regulated through the control of the downstream water levels of the head regulators provided for the secondary canals. In the Tina Plain project, also supplied by the Shikh Gaber El Sabah canal, it is designed to install automatic gates to maintain the constant downstream water levels for all secondary canals, and constant discharge gates for tertiary canals.

(b) Operation of Existing Facilities

MPWWR is responsible for operation and maintenance of the main and secondary level irrigation systems, while farmers are responsible for operation and maintenance of the tertiary level irrigation systems, as well as water use at the farm level.

The Damietta barrage, about three (3) km downstream of the Damietta intake, built across the Damietta branch of the River Nile, is composed of rock-fill dams, navigation locks and five (5) regulating roller gates with flap control gates on top. The upstream water levels of the barrage are maintained by the regulating gates to keep a water level of about 1.65 m above mean sea level. At present the operation console in the control house is under repairs so that the gates are manually operated.

Only one (1) or two (2) pump units are operated at present for each pumping station as water demand is far less than the total pumping station capacity. The pumps operate approximately 10 hours per day compared with 24 hour operation of the El Salam canal. Only pumping station No.3 is equipped with a remote control system which is installed at the supervisory station. Communication between the supervisory station and the pumping station is made by the wireless radio transmission system using the 70 MHz band.

(c) Telemetry System

Under the irrigation management system project initiated by MPWWR, the main system management component was implemented with the objectives to improve distribution and eliminate wasteful water practices, promote reuse of agricultural irrigation water, provide protection of the water quality of the Nile flows, and allow development of groundwater sources to augment the Nile supply. This project is known as the telemetry project.

The telemetry project consists primarily of installing a country-wide telemetry system, from Lake Nasser to the Mediterranean Sea, that will provide the Ministry with real time data related to the physical status of the Nile River irrigation system. The telemetry system consists of two (2) subsystems that were implemented in phases. Phase I consists of the meteor burst data collection system with 200 remote sites. Phase II consists of a voice and data communication system (VDCS) with 630 remote sites.

The meteor burst data collection system is designed to operate with very low power consumption with solar powered batteries. It does not have voice capability. The water level gages at the pumping stations of the El Salam canal were connected to this system.

VDCS provides voice and data communication services individually within 21 directorates (sub-master station) and between the directorates and operation center (master station) located at Qanater. VDCS provides for real time, remote data collection of information pertaining to water of the River Nile, primary and secondary irrigation canals and pumping stations through 630 remote data collection units. The data collected include the upstream water level, the downstream water level, gate position or pump status and others. VHF radio communication has been used for data collection and voice communication, for which fixed, mobile and portable radios are provided.

(2) Proposed Water Management

(a) Objectives of Water Management

With respect to water management, the canal systems of the El Salam and the Shikh Gaber El Sabah are characterized as follows:

- The main canal systems are operated by MPWWR. Water is distributed according to a rigid supply system, in which all parameters are fixed in advance. Farmers will arrange their cropping patterns and watering under the monthly allocation of water.
- The scale of systems is large, covering the area of 620,000 feddans with long main canals of about 200 km.
- Water levels in the main canal are maintained by operation of three (3) pumping stations for the El Salam system, and four (4) pumping stations and five (5) cross regulators for the Shikh Gaber and El Sabah system.
- Agricultural drainage water is mixed at a predetermined rate.
- Water is delivered to the secondary canals through manual sluice gates attached to the offtakes at 50 locations.
- The systems have no flow measurement device, nor regulating reservoir at the pumping stations.

Under the above situation, it has been proposed to establish a water management system for the El Salam canal and the Shikh Gaber El Sabah canal with the objectives of effective use of the limited water resources through minimizing waste water, maximum use of agricultural drainage water through control of its quality and quantity, and security for canal safety.

To obtain the objectives of water management, observation of water levels and water flows and establishment of a data transmission system are proposed. The proposed data transmission system will be incorporated into the irrigation management system project under the control of MPWWR.

(b) Water Control

Observation of water in terms of water levels, flow and water quality and pump status will be carried out for the following hydraulic structures and pumping stations.

Damietta Intake:	water level and quality
Serw Drain:	water quality
Serw Drain Confluence:	water quality
No.1 and No.2 Pumping Station:	water flow and pump status
No.3 Pumping Station:	water flow, water quality and pump status
Hadous Drain Confluence:	water quality
Baker Syphon:	water level
No.4,5,6 and 7 Pumping Station:	water flow and pump status
Cross Regulators (5 locations):	water level and gate position
Spillway at station 102 KM:	water level

The control of water level variations in the canals is to facilitate the flow control and measurement of water at offtakes. The intake water discharge at Damietta may be calibrated from water levels observed at the River Nile and downstream of the intake gates. The drainage water amount mixed into the canal may be estimated by deducting the Damietta discharge from the discharge of pumping station No.1 that is calibrated based on actual head, pump characteristics and the number of pump units operated. Through these observations, general conditions of canal flow can be grasped as well as detection of a trouble with canal water flow.

(c) Data Transmission

In conformity to the current organization system for water management, this water management system will need two (2) supervisory stations: one is the existing Mansura El Salam canal project directorate and a proposed new station to be established by NSDO in Kantara. The former covers the El Salam canal system on the western bank of the Suez Canal, while the latter covers Shikh Gaber El Sabah canal system on the eastern bank of the Suez Canal. The two (2) station will function as the sub-master station of VDCS that acts as the centralized data collection point and the man-machine interface for the system operator to monitor and control irrigation operations.

The VHS radio system will be used to communicate to the 16 proposed remote terminal units (RTU): six (6) RTU for the El Salam canal system and 10 RTU for the Shikh Gaber El Sabah canal system (refer to Drawings).

3-4 Agricultural Development

3-4-1 Land Allocation

This agricultural development plan intends to allocate 25% of the entire farmland to small farmers and graduate farmers, 15% to small investors, and 60% to large investors according to the standard established by the Ministry of Public Works and Water Resources (MPWWR). In the MPWWR plan, the farm size of the settlers will be considered as 10 feddans for small and graduate farmers, 10 to 500 feddans for small investors, and more than 500 feddans for large investors. However this plan assumes that the farm size will be 10 feddans for small and graduate farmers, 100 feddans for small investors, and 720 feddans for large investors. Thus, each farming plan has been examined according to the above mentioned farmland allocation and farm sizes.

It is also planned that small and graduate farmers will be allocated the farmland having the highest productivity within the district classified as Class III (IIIa/IIIb) and support will be provided to them.

3-4-2 Farming Patterns and Crop Selection

(1) Farming Patterns

In the plan, small and graduate farmers will operate the complex farming of vegetables and small scale livestock mainly depending on family labor. Small investors will concentrate on raising livestock or fruit farming and cultivate vegetables to supplement the raising of livestock and fruit farming. Large investors will exclusively operate land use farming, dairy farming, fattening of beef cattle, and fruit farming. The nine (9) farming patterns considered in the plan are shown below for each category.

Farming Patterns

Category	Farming Patterns	No. of Households
Small Farmers	Vegetable + Livestock	1,665
Graduate Farmers	Vegetable + Livestock	555
	Vegetable + Fruit	555
Small Investors	Livestock + Vegetable	83
	Fruit + Vegetable	83
Large Investors	Land use farming	23
	Dairy farming	23
	Livestock raising	23
	Fruit growing	23

(2) Crop Selection

In selecting the crops, the following points are considered in addition to the soil texture of the Study area, the salt tolerance of crops, the sodium absorption rate (SAR) of soil, and the salt concentration of the irrigation water.

- Crops having high economic value
- Crops which have already been exported
- Vegetables and oil crops for agro-industrial use
- Soilage for livestock raising

The following twenty-five crops have been selected.

Wheat: Recommended to small farmers carrying out vegetable and livestock farming and large investors operating land use, dairy, and livestock farming. Cultivation of wheat through farm mechanization is recommended to large investors in order to meet the great demand in Egypt. Straw, which is the by-products of wheat, are used as the roughage for livestock. Small farmers will harvest wheat with combine harvesters.

Barley (grain): Recommended to small farmers carrying out vegetable and livestock farming, graduate farmers doing vegetable and livestock farming, and large investors carrying out land use, dairy, and livestock farming. Barley is an indispensable crop to livestock feeding as a concentrated feed and it is marketable. Farm machinery for wheat cultivation are used for seeding and harvesting of barley. Barley straw are used as crude feed for livestock.

Maize (grain): Recommended to large investors carrying out land use, dairy, and livestock farming. Cultivation of maize, which is a summer crop, is selected for providing the concentrated feed throughout the year along with barley.

Sorghum (green): Recommended to small farmers carrying out vegetable and livestock farming, graduate farmers practicing vegetables and livestock farming, small investors practicing livestock and vegetable farming, and large investors practicing dairy and livestock farming. Growing of sorghum is proposed as fodder crop during summer. Small farmers will harvest sorghum three times a year with hand mowers and investors will harvest sorghum with mowers attached to farm tractors. The chemical composition of feeding values includes moisture (80.5%), digestible crude protein (0.12%), and starch equivalent (11.1%).

Berseem (short season): Recommended to small farmers carrying out vegetable and livestock farming, graduate farmers practicing vegetable and livestock farming, small investors practicing livestock and vegetable farming, and large investors practicing dairy and livestock farming. Berseem is the predominant green fodder crop during winter and an acceptable crop to livestock such as cattle and sheep. Berseem can be harvested three times in winter with hand mowers: the first crop can be harvested 40 days after seeding, then the second and the third crops can be harvested at one month and two months after the first one. Feeding value is high in the order of the third, the second, and the first crops. The overall chemical composition of the feeding value is moisture (84.1%), digestible crude protein (2.1%), and starch equivalent (7.8%).

Alfalfa is rich in digestible crude protein and can be cropped for three years consecutively and therefore resulting in a farm labor saving. However the average annual yield is less than that of the combination of sorghum and berseem. Therefore, alfalfa has not been selected in this plan.

Berseem (long season): Recommended to large investors carrying out livestock farming. Long cultivation of berseem is proposed for livestock farmers to provide stable supply of green or hay fodder throughout the year.

Fodder beat: Recommended to large investors carrying out dairy farming. Fodder beet is proposed for dairy farming because of its high feeding value. Care should be taken to protect the crops from soil nematode diseases.

Soybean: Recommended to small investors carrying out livestock and vegetable farming as well as those practicing fruit and vegetable farming. Also recommended to large investors practicing land use farming. Cropping of oil crops is proposed for small investors and large investors through the introduction of mechanized farming. Leguminous bacteria of soybean contributes to soil improvement. Soybean grains are easily transported to oil seed factories located around Cairo.

Sesame: Recommended to small investors carrying out fruit and vegetable farming and large investors practicing land use farming. Cropping of sesame, one of oil crops, by means of mechanized farming is recommended to small investors and large investors.

Broad bean: Recommended to small farmers carrying out vegetable and livestock farming and graduate farmers practicing vegetable and livestock farming as well as vegetable and fruit farming. Among the pulse, the broad bean has a soil salinity tolerance of ECe=1.6ds/m. There is a great demand for broad beans. Broad beans need two-year rest for replant.

Potato: Recommended to small investors carrying out livestock and vegetable farming and those doing fruit and vegetable farming. Also recommended to large investors practicing land use farming. Potatoes, one of the main export crops, will be cultivated by investors through the introduction of mechanized farming.

Onion: Recommended to small investors carrying out livestock and vegetable farming and those practicing fruit and vegetable farming, as well as large investors practicing land use farming. Onion is the only winter crop that is exported. Cultivation of onion needs an intensive input of labor for transplanting seedlings and harvesting the crop.

Cabbage: Recommended to small investors carrying out livestock and vegetable farming and those practicing fruit and vegetable farming as well as large investors practicing land use farming. Cabbages will be transplanted through the introduction of mechanized farming.

Tomato (fresh): Recommended to small farmers carrying out vegetable and livestock farming and graduate farmers practicing vegetable and livestock farming and those doing vegetable and fruit farming. Cropping of tomatoes is proposed for small farmers and graduates for marketing them near the project area. Fresh tomatoes will be grown in plastic tunnel shaped hot houses.

Tomato (processing): Recommended to small investors carrying out livestock and vegetable farming and those practicing fruit and vegetable farming. Tomatoes for processing are proposed for small investors. Tomatoes will be grown in open culture.

Cantaloupe: Recommended to small farmers carrying out vegetable and livestock farming and graduate farmers practicing vegetable and livestock farming as well as vegetable and fruit farming. Cantaloupes are widely cropped under irrigated conditions in the open-field culture.

Watermelon: Recommended to small farmers carrying out vegetable and livestock farming. To establish a four-year crop rotation system for stable farm production, cultivation of watermelon in the open-field is proposed.

Squash: Recommended to graduate farmers carrying out vegetable and livestock farming and graduate farmers practicing vegetable and fruit farming. Cultivation of squash is proposed for graduate farmers as the summer crop. For the reduction of labor, hill seeding of squash is to be employed.

Green pepper: Recommended to small farmers carrying out vegetable and livestock farming and graduate farmers practicing vegetable and livestock farming as well as vegetable and fruit farming. As a succeeding crop of fresh tomatoes, green pepper is selected. Seedlings are raised in vinyl plastic hot houses. Green peppers are harvested from middle October to middle November.

Cumin: Recommended to small farmers carrying out vegetable and livestock farming and graduate farmers practicing vegetable and livestock farming as well as vegetable and fruit farming. Medical plants in Egypt show great potential. The total area used for farming medical plants in Egypt is about 50,000 feddans. The top five medical plants cultivated in Egypt in terms of the area cultivated are coriander, chamomile, cumin, geranium, and caraway. Medical plants can be grown at any time during summer and winter. Cumin, as a representative medical crop, is selected for its high economic value but also the winter crop to follow the summer crops.

Peach: Recommended to graduate farmers carrying out vegetable and fruit farming. Peach cultivation is suitable for sandy soils and North Sinai governorate is known to be one of the famous peach producing areas in Egypt. Approximately 5,300 feddans of peach orchards are located in North Sinai, this is 75 % of the entire cultivation area of peach in Egypt.

Almond: Recommended to large investors carrying out fruit farming. The cultivation area of almond in Egypt is about 50,000 feddans, among which 24% is located in North Sinai governorate. Almonds grow well in sandy/sandy loam soils.

Grape: Recommended for small investors carrying out fruit and vegetable farming. Cultivation of grapes is suitable for sandy soils. Apart from the cultivation of grapes in the project area, there are already several existing grape orchards in Raffa city.

Olive: Recommended for small investors carrying out fruit and vegetable farming. The cultivation area of olives in North Sinai governorate includes 13% of the entire cultivation area of olives in Egypt of about 68,000 feddans. Around the city of El Arish, there are an research and several olive oil extraction factories. Thus the Study area provides a favorable environment for olive cultivation.

Orange: Recommended to small investors carrying out fruit and vegetable farming. Oranges are the most popular fruits in Egypt. The cultivation area of oranges is presently 243,000 feddans, which is the largest cultivation area of any of the fruits grown in Egypt. The orange cultivation is suitable for sandy loam and loam soils. Because Study area consist of mainly sandy soils, introduction of compost and barnyard manure is indispensable for cultivation of oranges.

3-4-3 Cropping Patterns

With regard to the above mentioned nine farming patterns, the cropping patterns that can generate the highest possible cropping intensity have been formulated. In order to maintain these cropping patterns, the agricultural mechanization and the increase of soil fertility with the introduction of compost and barnyard manure are necessary.

(1) Small Farmers Practicing Vegetable and Livestock Farming

- They cultivate mainly fruit vegetables such as watermelons, tomatoes, and cantaloupes. The seedlings will be raised at the common use hot houses.
- Berseem and sorghum must be cultivated for fattening beef cattle. The barnyard manure will be composted.
- Cultivation of pulse crops such as broad beans and berseems are effective for maintaining field productivity.
- In order to relieve the peak labor demand and to avoid the replant failure, the cropping pattern must employ a four-year crop rotation system.

(2) Graduate Farmers

(a) Those practicing Vegetable and Livestock Farming

- The cropping patterns are almost the same as those of small farmers, but squashes will be cultivated in the open-culture to reduce the labor of raising seedling and planting.

- Part of the harvested berseem will be stored in dried condition to enable a stable through-year administration of fodder. Manure must be composted to maintain the productivity of farmland.

(b) Those practicing Vegetable and Fruit Farming

- Peaches of early maturing variety will be cultivated.
- For increasing the soil fertility, it is necessary to corporate with the farmers raising livestock to secure the barnyard manure.

(3) Small Scale Investors

(a) Those practicing Livestock and Vegetable Farming

- For fattening beef cattle, barleys must be cultivated as concentrate fodder and berseems and sorghums must be cultivated for soilage.
- With the mechanized cultivation, tomatoes for processing, cabbages, onions, potatoes, and soybeans will be cultivated to increase the cropping intensity.

(b) Those practicing Fruit and Vegetable Farming

- Grapes, olives, and oranges will be cultivated. For harvesting the crops, because about 150 days are needed consecutively, employment of farming staffs is necessary during the harvesting period.
- The cultivation of vegetables takes almost the same pattern as that of livestock and vegetable farming, but sesame will be introduced as the oil crop.
- To increase the soil fertility, it is necessary to secure the barnyard manure with the cooperation of livestock farmers, for example to exchange it for olive refuse.

(4) Large Scale Investors

(a) Those practicing Land Use Farming

- With the mechanized cultivation, various crops will be cultivated and the cropping intensity will be increased with the four-year crop rotation system. As the main crops, the cereal must be cultivated such as wheat for main grain as well as barley and maze for concentrate fodder, the oil crops such as soybean and sesame, and the vegetables such as potatoes, cabbages, and onions.
- To maintain the soil fertility, it is necessary to secure the barnyard manure by cooperating with livestock farmers to exchange, for example, by-products such as straw of grain products with the barnyard manure from livestock farmers.

(b) Those practicing Dairy Farming

- Dairy cattle will be raised using the fodder crops grown on the farm and will be self sufficient with respect to fodder supply. In addition, barley and maze will be cultivated for concentrate fodder, and berseem (short season), sorghum, and fodder beets will be cultivated as soilage. The straw of wheat will be used as roughage.
- Maze and sorghum will be cultivated in the two-year rotation crop system and wheat, barley, berseem, and fodder beets will be cultivated in the four-year rotation crop system.

(c) Those practicing Livestock Farming

- Beef cattle farms will also be self sufficient with respect to fodder supply. The difference between the cropping pattern of dairy farmers and the livestock farmers is that the large investors will cultivate berseem (long season) instead of fodder beets.

(d) Those practicing Fruit Farming

- Four (4) fruit trees will be cultivated: almond, grape, olive, and orange. Because it takes about 240 consecutive days for harvesting these fruit trees, it is necessary to employ workers mainly permanent employees as the harvesting labor.
- It is necessary to secure the manure in the same manner as in the land use farming.

(5) Land Use Intensity

Of 135,000 feddans of lands, 111,000 feddans will be developed for crop production. The proposed cropping area is 110,500 feddans in both summer and winter to achieve a 200 percent land use intensity, based on which the irrigation water requirements have been estimated. The peak irrigation water requirement of 29 m^3/day/feddan takes place in July, which is within the water right of 30 m^3/day/feddan. Table 3-9 shows the proposed cropping calendars.

3-4-4 Crop Production

(1) Yield Projection

Through the examination of the national agricultural statistics (average yields for the last 5 years from 1990 to 1994), the target yields of proposed crops have been projected as presented in the Table below as an achievable goal with the appropriate application of irrigation and drainage and with intensive backup from agricultural supporting services.

Target Yields in Ton/Feddan

Crops	Yield	Crops	Yield	Crops	Yield
Wheat	2.5	Broad Bean	1.2	Onion	10.8
Maize (grain)	2.7	Tomato (fresh)	40.0	Cumin	1.1
Barley (grain)	1.5	Tomato (processing)	25.0	Almond	5.0
Sorghum (green)	18.0	Cantaloup	10.0	Peach	7.3
Berseem (long)	25.0	Water Melon	10.0	Grape	8.1
Berseem (short)	16.5	Squash	8.0	Olive	7.0
Fodder Beet	50.0	Green Pepper	7.0	Orange	7.4
Soybean	1.2	Cabbage	20.0		
Sesame	0.7	Potato	12.0		

(2) Estimated Crop Production

In order to achieve the above mentioned target yields, the use of manure is indispensable because the soil fertility will degenerated rapidly due to the excess water supplied for the leaching of soil salinity. In addition, because some soil series (W, W_1, TG_2) in some districts have sodium absorption ratio (SAR) of more than 18.0, it is necessary to add gypsum every year at a rate of 1 ton/feddan to improve the plow layer. Such area amounts to 6,300 feddans (refer to Appendix F).

The ratios of the planted area for each crop are: vegetable 27%, fodder crops 23%, fruit trees 12%, oil crops 6%, and pulses and medical plants 4% each. The crop production based on the target yield is achieved is shown below:

Crop Production

Crops	Cropping Area (1000 fed)	Production (1000 ton)	Crops	Cropping Area (1000 fed)	Production (1000 ton)
Wheat	14.09	35.2	Watermelon	4.16	41.6
Maize (grain)	20.70	55.9	Squash	2.78	22.2
Barley (grain)	14.50	21.7	Green pepper	6.94	48.6
Sorghum (green)	24.19	435.3	Cabbage	7.88	157.5
Berseem (Long)	4.14	103.5	Potato	7.05	84.5
Berseem (Short)	14.24	235.0	Onion	7.88	85.1
Fodder beet	4.14	207.0	Cumin	6.94	7.6
Soybean	7.05	8.5	Almond	4.16	20.7
Sesame	4.97	3.5	Peach	1.39	10.1
Broad bean	6.94	8.3	Grape	5.80	47.0
Tomato (fresh)	6.94	277.5	Olive	5.80	40.6
Tomato (processing)	2.91	72.6	Orange	5.80	42.9
Cantaloup	6.94	69.4	Total	198.25	-

3-4-5 Farm Mechanization

(1) Farm Labor

The farming work of small and graduate farmers should be carried out mainly depending on the family labor. Because fruit and vegetables are harvested manually, seasonal workers must be employed. The farming work of investors should be carried out using large-scale mechanized systems using permanent labors. For the harvesting of fruits and vegetables, seasonal workers will be employed. The necessary labor requirement for each farming pattern is shown below.

Labor Requirement

Farming Patterns	Family Labor (Persons)	Permanent (Persons)	Seasonal (Man/days)
Small Farmers			
- Vegetable and livestock farm	3	-	213
Graduate Farmers			
- Vegetable and livestock farm	1	2	208
- Vegetable and fruit farm	1	2	185
Small Investors			
- Livestock and vegetable farm	-	9	435
- Fruit and vegetable farm	-	9	1,545
Large Investors			
- Land use farm	-	21	3,019
- Dairy farm	-	66	-
- Livestock farm	-	64	-
- Fruit farm	-	67	1,410

(2) Agricultural Machinery

The types and the number of agricultural machinery to be introduced for relieving the peak labor needs have been determined based on the type of crops and the size of the planted area. The machinery of the small and graduate farmers will consist of small-scale all-purpose hand tractors (8 ps) and four types of farm machineries to be attach to the hand tractors including trailers (0.5 t), rotaries (60 cm), drill seeders (4 lines), and lime sowers (1.5 m). In addition, knapsack power sprayers (2 ps), seedling transplanters (1 line, 7 ps), and grass mowers (1 to 2 ps) will be used as independent machines not requiring a tractor. Harvesting of self-support wheat will be subcontracted to combine harvesters and threshers (wage harvesting).

Each small investor will be equipped with one tractor (50 ps), and twelve types of farm working machines to be attached to the tractor. Livestock farmers will additionally need a rotary mower and rakes. Small investors will use planters, combines, and bean harvesters as machinery. Large investors will use seven tractors (50 ps) and various other types of machineries.

3-4-6 Livestock

(1) Number of Livestock

In Egypt, Baladi strain cows and water buffaloes are generally raised. However advanced livestock farmers raise Friesian or Brown Swiss breeds. The quality of the milk of water buffalo is high due to the high milk fat percentage, but in terms of production the quantity is low. The number of livestock that can be raised by self-feed fodder is obtained based on the nutritional value of the digestible crude protein (DCP). The required nutritional value of DCP for a head of cattle is 470 g/day (or 171.55 kg/year).

Feeding Plan

Farming Type	Fodder Crops	Product (ton)	DCP product (kg)	No. of Cattle (head)
(Beef Cattle :Baladi)				
Small Farmers	Sorghum	45.00	495	
	Berseem	24.75	527	
	Wheat Straw	2.50	7	
Total			1,029	6
Graduate farmers	Sorghum	45.00	495	
	Berseem	41.25	878	
Total			1,373	8

The number of livestock that can be raised on one farm of an investor is estimated in the same manner. The beef cattle farms of small investors can raise 80 Friesian cows. Among the large investors, the diary farmers can raise 1,372 Friesian cows and the beef cattle farmer can raise 1,510 Friesian cows. Because the feeding of roughage is basically a self-choice feeding, it is necessary to supplement the insufficient nutrients with concentrate fodder.

(2) Livestock Production

The annual production of fattening beef cattle and milk have been calculated under the following conditions: the calving duration of fattening beef cattle is 13 months; the cattle will be shipped at 24 months after they are born; their daily weight increase is 0.8 kg; with regard to the milk, the milking interval is 10 months after giving the first birth; mating will be conducted two months after giving birth; after six to seven calvings, they will be fattened as beef cattle, and; the culling rates are 5% for beef cattle and 10% for milking cow. In addition to raw milk production by the large investors as shown below, 8,000 ton of raw milk may be produced by the small farmers and graduate farmers.

Annual Slaughter Heads and Milk Production

Farming Types	No. of Farms	No. of Cattle Head/Farm	No. of Cattle Total	Slaughter Heads	Raw Milk (t)
Small Farmers	1,665	6	9,990	4,995	-
Graduate Farmers	555	8	4,444	2,222	-
Small Investors	83	80	6,640	3,320	-
Large Investors	23	1,372	31,560	-	113,600
	23	1,510	34,730	17,365	-
Total			87,360	26,906	113,600

(3) Manure from Livestock

The manure from livestock is a resource with high value. The total amount of manure produced must be collected and fully utilized. This requires cooperation between the livestock raising farmers and the fruit and vegetable farmers so that it can be utilized in organized manner. An adult cow with the weight of 500 kg produces 10.6 excrements and 4.9 t urine a year. The production of these resources in the total Study area is shown below:

Annual Production of Excrements and Urine

Farming Types	No. of Farms	No. of Cattle Heads	No. of Cattle Product (ton)	Total Product (ton)
Small Farmers	1,665	6	93	154,800
Graduate Farmers	555	8	124	68,800
Small Investors	83	80	1,240	102,900
Large Investors	23	1,372	21,266	489,100
	23	1,510	23,405	538,300

3-4-7 Processing of Agricultural Products

In order to increase the added value of agricultural products, the processing of agricultural products including barley, maize, tomato, olive, and livestock must be planned after examining the market trend. All of these products are produced at investors farms. Because the operation of processing facilities need information to analyze the demand and supply state in the market and requires technology for quality control, the processing should be carried by a private corporation. Establishment of the following five types of processing facilities of agricultural products is proposed.

Concentrated feed factory:

For the convenience of the distribution from grain production, transportation and processing, the concentrated feed factory will be established in the Study area. As for barley, 21,400 ton will be delivered to the factory in June and 55,800 ton in October. The concentrated fodder factory will be operated through the year to process 210 ton of raw materials a day.

Tomato paste factory:

The tomatoes for processing are produced at the small investors' farms and harvested for 100 days starting from the end of July. The total crop of tomatoes is 71,500 ton and the amount of raw materials that can be processed a day is 715 ton.

Olive oil press factories:

Olives are harvested during 80 days starting from the end of September at the rate of 11,6200 ton at the 83 farms of small investors and 28,980 ton at the 23 farms of large investors. The amount of raw materials to be processed a day is 508 ton.

Slaughterhouse:

A slaughter house will be built in the Study area and will be similar as the model beef cattle slaughter house in the city of Ismailia. The processing capacity of the slaughterhouse will be 150 heads a day.

Milk processing factory:

A factory having the daily processing capacity of 320 ton for the use of the investors will be built in the Study area. Small scale milk processing factories for the small farmers and graduate farmers may be built at three (3) satellite villages where they live in.

The agricultural production for processing and their processed products in the target year are estimated as follows.

Agricultural production and processed products

Items	Raw Materials (ton)	Processed Quantity (ton)	
Barley	21,400	Ground Barley	20,330
Maize	55,800	Ground Maize	53,000
Tomato	71,500	Paste	9,150
Olive	40,800	Olive oil	9,900
Milk	116,100	Milk	46,440
		Butter	11,610
		Cheese	896
Beef		Dressed weight	2,767

3-5 Irrigation and Drainage

3-5-1 Size of Irrigation Service Unit

An irrigation service unit is an irrigation area in which the farmers will be responsible for the operation and maintenance of the on-farm irrigation system. The service unit is supplied with irrigation water from the main distribution system, consisting of primary, secondary and tertiary canals, those of which are operated by the canal-related authority.

The service unit shall be 1) large enough to enable economic operation and maintenance of the irrigation system, 2) large enough to enable an efficient water delivery schedule and 3) sufficiently small and manageable to be operated and maintained by the farmers themselves.

The service unit will be equipped with night storage, booster pump(s), pressurized distribution pipelines as well as irrigation application systems such as sprinkler and drip. Those facilities will require cooperative based operation and maintenance where the size of each farm plot is relatively small. Therefore, the service unit must be suitably shaped, specially for those settlers other than investors, and take into consideration the manageable size of the farms to allow cooperation.

(1) Service Unit for Small Scale and Graduate Farms

The desirable number of small scale farms in each service unit is supposed to be not more than 20 from the view point of their inter-cooperation. Supposing the minimum farm size is 10 feddans, the service unit which can accommodate 10 to 20 number of farms will be 100 to 200 feddans in area.

With reference to the above and examples practiced in previous projects in Egypt, MPWWR has proposed that small scale and graduate farmers are to have a service unit of 100 feddans which accommodates 10 number of farmers having a 10 feddan farm plot each. The 10 number of farmers are largely expected to be able to manage and operate their service unit cooperatively. Figure 3-5 shows the typical layout of the service unit of 100 feddans, accommodating 10 number of farmers.

(2) Service Unit for Investors

Investors will mostly use automated irrigation systems such as fixed, center pivot type sprinkler or drip irrigation. The size of a service unit depends on their affordability and applicability of irrigation system to be introduced in the unit. Generally, small scale investors are allowed to have a 10 to 500 feddan farm, and large scale farmers are to have farms larger than 500 feddans. Regarding investors service unit, MPWWR has designed the size mentioned below:

Small Scale Investor:		
	Unit size:	between 10 and 100 feddans
	Farm area:	not more than 500 feddans
Large Scale Investors:		
	Unit size:	between 500 and 700 feddans approximately
	Farm area:	depending upon the affordability

For small scale investors, the allocation will be made in blocks with an area ranging from 10 to 100 feddans, and the investors can obtain more than one (1) unit but the total area obtained by an investor shall be not more than 500 feddans. For large scale investors, the allocation will be on the basis of a unit with area between approximately 500 and 700 feddans, and investors can obtain more than one (1) unit depending on their financial ability.

(a) Small Scale Investor

In this Study, the typical service unit of small scale investors is proposed to be 100 feddans which is the biggest among the allocated, taking into consideration the scale merit. The size of the service unit for small scale investors is thus the same as the unit for the small scale and graduate farmer's.

There are two (2) categories proposed in this Study for small scale investors; namely, vegetable & beef cattle growers and vegetable & fruits growers. It is proposed that the former investor will carry out practice four (4) kinds of crop plantings during a season in a rotational manner. Therefore, the 100 feddan service unit is to be divided into eight (8) plots, each of which is 12.5 feddan in area. The layout of the unit is shown on Figure 3-6. The latter investor, the vegetable & fruits growers, will have five (5) or seven (7) kinds of crop planting during a season, therefore the 100 feddan service unit should be divided into 10 plots of 10 feddans each. The layout of the service unit is exactly the same for small scale and graduate farmers.

(b) Large Scale Investor

According to the allocation mentioned above, a typical service unit for large scale investors will be between 500 and 700 feddans. In laying-out the investors service unit, the following shall be considered:

- There are four (4) types of large scale investors proposed in this Study. Of the four (4), dairy and beef cattle growers may prefer to introduce center pivot sprinklers. The investors will cultivate mainly fodder's such as berseem, sorghum, fodderbeet and barley. For these fodder, a center pivot sprinkler is suitable and the layout of the irrigation block should be square in order to accommodate the sprinkler moving in a circle.
- One irrigation block will be divided into ten smaller plots. A small plot is desirable and generally mostly used. It should be as close as possible to a 10 feddan rectangular plot. The number of rows and columns composed of these plots is expected to be an even number from the view point of layout of the distribution pipelines so that one pipeline installed along the road can command both sides' of the plots.

Based on the above, three (3) types of service units are taken into consideration as shown on Figure 3-7: type 1 is 720 feddans net area composed of 72(6x12) x 10 feddan plots (145m x 290m), type 2 is 600 feddan net area composed of 48(6x8) x 12.5 feddan plots (198m x 265m), and type 3 is 500 feddan net area composed of 48(6x8) x 10.42 feddan plots (181m x 242m). Type 1 is undertaken in this Study since the type is formed of generally practiced plot (10 feddans: 145x290m), and the peripheral dimension of the service unit is 1784m x 1760m.

3-5-2 Application of On-farm Irrigation System

The choice of the appropriate irrigation system is very important from the view point of not only making efficient use of irrigation water but also having economical irrigation facilities. In choosing the systems, consideration should be given to the type of crops, type of soils, topographic condition, operating labor requirement, available energy, farm size, investment and O&M costs, domestic marketability, and the farmer's familiarity with irrigation systems.

The Study area is mainly composed of sandy soils, and if surface irrigation scheme such as basin and furrow were introduced into the Study area, the irrigation efficiencies could be very low and wide-spread water logging could show up. In this regard, the choice of the on-farm irrigation facilities is apparently limited to sprinkler and drip systems.

(1) Type of Irrigation Systems

Various types of sprinkler systems exist, such as hand-move sprinkler called half-fixed sprinkler, hose-pull sprinkler, fixed sprinkler, side roll, center pivot and liner moved sprinklers. Following are the description of these systems including drip irrigation.

(a) Hand-moved Sprinkler

This type of sprinkler has been introduced in a good number of reclamation project areas. The laterals, on which sprinklers with intervals of 9 to 14 meters are mounted, are manually placed on the farm with intervals of 9 to 14 meters. The laterals are manually connected to a buried pipeline, through which irrigation water is supplied. This system can be employed in a wide variety of soils and crops, and the capital investment is low but it requires a high labor input. The high requirement of labor forces makes this type of sprinkler suitable for the application on small scale farms and soils with a relatively high moisture retention.

This system can be introduced to small farms less than 20 feddans. From experience with the Bustan project farmers with 20 feddan farm started growing orchards with drip systems requiring less labor forces after having faced difficulty in managing their farms with the hand-moved sprinkler.

(b) Hose-pull Sprinkler

This system has recently been introduced on an experimental farm in the Bustan project area in cooperation with the FAO. The flexible hose has a riser pipe with a height of about 40 cm, with a sprinkler mounted on the end of the pipe. The sprinkler is manually moved from one place to the next by pulling the hose at intervals required to achieve the necessary sprinkling hours.

Although some plots in Bustan project, that are utilized by graduate farmers, have been provided with this system, it is not yet popular in Egypt. To prove the efficiency, an experimental farm of the Desert Development Center under the American University in Cairo will carry out the experimental use in its 20 feddans plot during late 1996. The system's applicability appears almost the same as hand-moved sprinkler but probably less labor forces are required.

(c) Fixed Sprinkler

A fixed sprinkler system is composed of a buried main and sub-main pipelines and a complete set of laterals placed on the farm. Following land preparation on the farm, the laterals are placed, covering all farm areas, and will be operated until harvesting season. This system requires the highest capital investment per feddan and considerable number of temporary labor forces for laying down and removing the laterals.

There is another type of fixed sprinkler, accompanying buried laterals onto which removable riser pipes are attached and detached, requiring less labor forces compared to conventional fixed type sprinklers. However, this system requires more investment cost. Therefore, these fixed sprinkler systems are not recommend for small scale and graduate farmers but only for investors who will grow selected high value crops specially on problem soils characterized by little water retention.

(d) Side Roll Sprinkler

This sprinkler has recently been introduced in Egypt. The side roll sprinkler has a lateral which is moved by large diameter wheels. When moving on a farm from one position to the next position, the lateral must be disconnected from the pressurized pipeline, and then again be connected to the next outlet of the pipeline. The roll is usually powered by a small engine located in the center of the roll.

This system requires less labor forces comparing to hand-moved and hose-pull sprinklers, and can be applicable to medium size farms ranging between 20 and 100 feddans. However the limited ground clearance, which is usually between 1.2 and 1.5m only, cannot irrigate tall crops such as maize and sorghum. This disadvantage has made the introduction of the sprinkler difficult, and unpopular in Egypt.

(e) Center Pivot Sprinkler

The center pivot sprinkler is an automated irrigation system and one of the more attractive systems for large scale farms. The lateral system is moved by rotating the line in a circle around a pivot point. The rate of application is adjusted to compensate for different rates of travel along the line. The wheels are usually powered by small motors mounted on each wheel, which are designed to produce a rate of travel proportional to the distance from the pivot.

Since this system is very versatile it is applicable to a wide variety of different crops up to 3 m height and can handle slopes up to 15 %, it has become very popular all over the world and also in Egypt. Due to its automated system, it can be used for frequent irrigations which is especially necessary on soils with little moisture retention.

(f) Linear Moved Sprinkler

The structure of a linear moved sprinkler system is very similar to that of a center pivot, but not fixed on one end. The lateral moves in a straight line over rectangular shaped farms. The system can cover the entire farm by moving laterally without leaving the corners as is the case with a center pivot.

The irrigation water is usually pumped from an open field channel by a mounted feeding machine and boosted into the lateral. This open channel makes it difficult to apply the system to land with slope exceeding 1%. In this system, another pump is also required to pump up the water from the night storage to the open channel since the low water level in the night storage is lower than the ground level.

There are other types of liner move which do not require open field channel. One is hose-fed liner type, to which the water is supplied through pressured pipelines. This liner type requires more labour forces to operate than open-channel-fed-type because of the need of manually connecting and disconnecting the lateral to the pipeline as the lateral moves. With such inconveniences, this system has been employed in a few farms only so far in Egypt.

(g) Drip Irrigation

Drip irrigation, also referred to as trickle irrigation, consists of an extensive network of pipes usually of small diameter that delivers filtered water directly to the soil near the plant. The water outlet device in the pipe is called an "emitter" discharging only a little amount of water. From the emitter, water spreads laterally and vertically by soil capillary forces augmented in vertical direction by gravity.

This irrigation system requires a control head which consists of flow control valves, measuring devices, pressure controls and filters, and usually accompanying fertilizer and chemical pesticide injection systems. Lateral lines are generally made of polyethylene pipe or flexible PVC with a diameter between 12 and 32 mm, into which emitters are inserted at a predetermined spaces chosen to fit the crops.

With this system, irrigation water can be applied very efficiently, with often 90% application efficiency, to small trees and widely spaced plants, where adequate water can be placed in the root zone without wetting the soils where no roots exists. It is also well known that greater crop yields and better crop quality are obtained. Fruits containing considerable moisture when harvested respond well to drip irrigation. This system has become more popular in Egypt recently, and is applied to a wide variety of plants such as tomato, melon, grape, egg plant, maize and orchards.

There are potential problems such as clogging of the emitters, and therefore requiring a well designed filter system, and accumulation of salt. Dissolved salt is left in and on the soil as the water is consumed by the plant and evaporates. The greatest deposition appears near the peripheral of the wetted zone at the soil surface. The salt must be leached by using the drip system itself or other means such as sprinkler which can discharge more water.

(2) Application of Irrigation System

(a) Small Scale and Graduate Farmers

This category of farmers will be allocated farm land of 10 feddans. A hand-moved sprinkler is the best suited system for small scale and graduate farmers since it is the least complex and least costly. Although the system is the most labour intensive method among those sprinklers mentioned above, a 10 feddans area can be managed by family laborers. In order to reduce the irrigation frequency, the small scale farmers are expected to be allocated higher moisture retaining soils.

Since the hose-pulled sprinkler is believed to be less labor intensive compared to the hand-moved type, the farmers may preferably use hose-pull sprinklers. The use of a hose-pulled sprinkler is also preferred on soils with a low moisture retention which require frequent irrigation. However, since the hose-pulled system is not yet common in Egypt, the introduction of the system must be made after experimental use proves satisfactory results.

Plants such as water melon, tomato, melon and onion are normally transplanted after being grown in a nursery bed. Because these crops are planted at a pre-determined interval, drip irrigation can be employed. This is now being practiced in many existing project areas, and enables effective water use and achieves high quality products.

Medium scale farms, those greater than 20 feddans and which are not investor farms, may be included in the service units composed of small scale and graduate farmers. Medium scale farms will develop in such cases when a number of small scale or graduate farmers try to practice cooperative agriculture. Side roll irrigation systems appear to be suitable on such medium scale farms. Because one booster pump commands one service unit of 100 feddans, cooperative agriculture is expected to be practiced over the whole service unit. The unit may be divided into several medium size farms, but having different irrigation schemes under one booster pump should be avoided. This makes it difficult to create medium scale farms, and thus side roll sprinkler should not be employed on the small scale and graduate farms.

If all the small scale and graduate farmers accommodated in one service unit of 100 feddans form cooperative organizations, linear moved sprinklers could be introduced in these service unit. The linear moved system should be of the hose-fed type which does not require open field channels in the service unit. However, individual farmers will then have less flexibility for planting crops based on their own choice, and operation/maintenance of the system by 10 farmers may be difficult since the settlers are not expected to be familiar with a cooperative type of agriculture. Therefore, introduction of this system can only be considered at such time when the farmers become familiar with cooperative activity through managing the booster pump which commands the service unit and after all farmers agree to practice cooperative agriculture.

(b) Small Scale Investors

Small scale investors are to be divided into two (2) categories in terms of cropping pattern; namely, 1) for vegetables & fodders and 2) for vegetables & fruits. The former category is expected to grow such vegetables as potato, soybean, onion, tomato and cabbage, such fodders as sorghum, barley and berseem, among which onion, tomato and cabbage, which require to be transplanted. Drip irrigation will be applied for onion, tomato and cabbage, while fixed type sprinklers will be applied for other crops. Although side roll sprinklers are less costly than the fixed type, the side roll system will not be used by small scale investors because it limits the height of the crops that can be grown.

For investors growing vegetables and fruits, such as tomato, cabbage and onion which require to be transplanted drip irrigation will be applied. Other vegetables as sesame, soybean and potato will be irrigated by fixed type sprinkler. The investor is expected to grow such fruits as grape, olive and orange, which are widely spaced and requires effective application of irrigation water. Drip irrigation is best employed for these fruits.

(c) Large Scale Investors

Large scale investors will be categorized into four (4) groups; namely, 1) land use crop investors, 2) dairy investors, 3) beef cattle investors and 4) fruit investors. The crops that will be grown include soybean, maize, potato, barley, sesame, onion, cabbage and wheat for land use crop investors; sorghum, maize, berseem and fodderbeet for dairy investors; sorghum, maize, berseem, wheat and barley for beef cattle investors, and those crops that are directly sown, except for onion and cabbage.

The directly sown crops will be irrigated by fixed type sprinkler or center pivot sprinkler, while onion and cabbage will be irrigated by drip irrigation systems. Drip irrigation will exclusively be applied to such fruits as almond, grape, olive and orange.

Of the two (2) types of sprinkler systems, fixed type sprinklers will be used by land use crop investors since the farm must be irrigated in combination with drip system. On the other hand, center pivot irrigation system may be preferred by dairy and beef cattle investors because of lower initial investment cost. Although the corners of a rectangular farm cannot be irrigated under the center pivot system, the unirrigated spaces can be used for other agricultural purposes such as establishing a warehouse, dwellings for laborers and a workshop for agricultural machinery. The corners could also be planted and irrigated with a combination of drip irrigation which is flexible and allows adjustment to the irregular land form.

3-5-3 Irrigation Efficiency

Irrigation efficiency should be estimated when calculating the total irrigation water requirement of the Project. The efficiency is normally sub-divided into three (3) stages as follows:

Conveyance efficiency (Ec):

The ratio between water received at the inlet of a service unit and that taken in at the Project headwork; namely, the conveyance efficiency which applies to Shikh Gaber El Sabah Canal starting at Suez Siphon and the branch canals within the Project area

Field distribution efficiency (Ed):

The ratio between the water received at the inlet of a service unit and that received at the outlet of an irrigation block; namely, efficiency which applies to the distribution pipe (so-called Mesqa) losses in a service unit

Field application efficiency (Ea):

The ratio between water directly available to the crops and that received at the outlet of the irrigation block, depending on the irrigation scheme applied, experience of the farmers, soil condition and climate

(1) Conveyance Efficiency

FAO irrigation and drainage paper No. 24 indicates the efficiency to be 0.9 in case of continuous supply with no substantial changes in flow, and the same ratio has been applied in the report of 400,000 feddans reclamation project (Arabic version). The Shikh Gaber El Sabah Canal and the branch canals are to be concrete-lined except for the Tina Plain project area which is composed of almost impervious clay soil. The loss related to the canal can therefor be expected to be small, and the efficiency of 0.90 is applied in this Study.

(2) Field Distribution Efficiency (Mesqa Efficiency)

While FAO paper No. 24 suggests the efficiency to be 0.9 in case of lined canals or pipe systems, FAO and WB preparation mission for the North Sinai development project in 1987 indicated a loss of 0.02; resulting in an efficiency of 0.98, which seems difficult to be achieved. Both reports of the 135,000 and 400,000 feddans (Arabic version) consider the loss to be 0.05; resulting in an efficiency of 0.95. With a complete pipeline distribution network in the field as proposed, the field distribution losses should not be high, and therefore an efficiency of 0.95 is employed in this Study.

(3) Field Irrigation Efficiency

The field irrigation efficiencies used in various reports and applied in Egypt are shown below. The 135,000 and 400,000 feddans reports show the biggest field irrigation losses; namely 25 % for sprinklers and 15 % for drip systems.

Field Irrigation Efficiencies

Report	Sprinkler	Drip
Land Master Plan (1985)	0.75/0.85*	0.90
FAO/WB Prepar'n Mission (1989)	0.80	0.85
135000 feddan (Arqabic,1994)	0.75	0.85
400000 feddan (Arabic,1995)	0.75	0.85

Note: * 0.75 applies to hand-move, and 0.85 to automated sprinkler.

With strict water application and management, efficiencies as high as 0.80 for sprinkler and 0.90 for drip irrigation can be achieved. Therefore this Study adopts the field irrigation efficiencies of 0.80 for automated sprinklers and 0.90 for drip irrigation systems. For hand-moved sprinklers, 0.75 is applied taking into consideration the inexperience of the settlers with this irrigation practice.

(4) Project Irrigation Efficiency (Ep)

The Project irrigation efficiency is the ratio between the water that is directly made available to the crops and the water taken in at the Project headwork (outlet of Suez siphon). The ratio is calculated by multiplying the aforementioned three (3) efficiencies Ep = Ec X Ed X Ea. The project efficiencies are as follows:

Hand-move Sprinkler:	Ep = 0.90 x 0.95 x 0.75 = 0.641
Sprinkler:	Ep = 0.90 x 0.95 x 0.80 = 0.684
Drip:	Ep = 0.90 x 0.95 x 0.90 = 0.770

3-5-4 Water Requirement

Total required water for the Study area is conceptually shown as follows:

TQ = NIR/Ep + LR + 500000

where:		
	TQ	= total requirement, m^3/day
	NIR	= net irrigation water requirement, m^3/day
	Ep	= project irrigation efficiency
	LR	= leaching requirement, m^3/day
	500000	= reserve for future industrialization, m^3/day

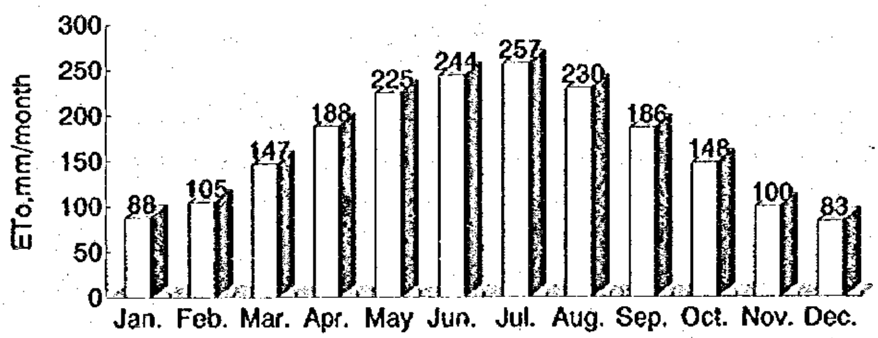
(1) Irrigation Water Requirement

For calculating crop water requirements, the modified Penman method usually gives most satisfactory results if compared with other methods such as Blaney-Criddkle method, Radiation method and Pan evaporation method on the condition that measured data are available such as temperature, humidity, wind velocity and direction and sunshine duration.

The modified Penman method has been adopted in most agricultural development projects in Egypt. In this Study, this method is used for estimating reference crop evapotranspiration (ETo), using the last 10 years of meteorological data measured in El Arish which is the nearest station to the Study area and the cropping pattern proposed. The equation and the calculated monthly basis ETo values are shown below. The annual ETo is 2002mm.

ETo = C [W x Rn + (1-W) x f(u) x (ea-ed)]

where: ETo = reference crop evapotranspiration, mm/day
W = temperature related weighting factor
Rn = net radiation in an equivalent evaporation, mm/day
f(u) = wind related function
(ea-ed) = difference between the saturation vapour pressure and the mean actual vapour pressure, mbar
C = adjustment factor for day/night weather condition



Reference Crop Evapotranspiration, mm/month

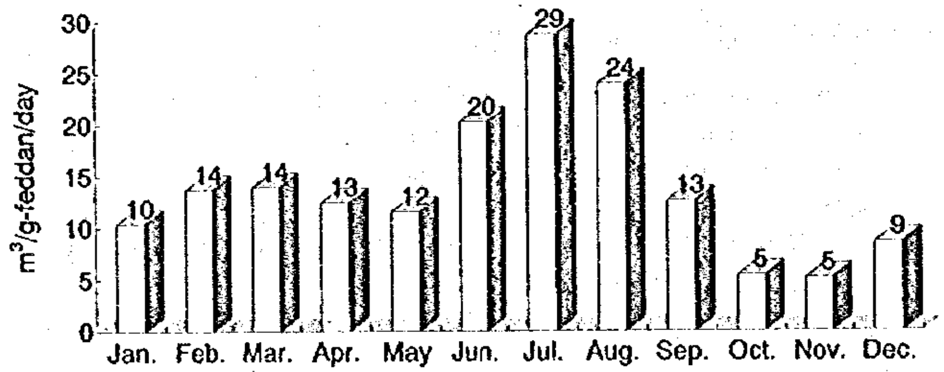
The crop evapotranspiration (ETcrop) is calculated by multiplying crop coefficients (Kc) which the ETo. The crop coefficients (Kc), to be applied in this Study, were decided on the basis of FAO paper No. 24 and coefficients used in GARPAD. The required irrigation water is worked out by summing up the ETcrop according to the planted area. Also, irrigation efficiencies are taken into consideration in calculating the gross irrigation water as already mentioned above.

ETcrop = Kc x ETo

where: ETcrop = crop evapotranspiration, mm/day
Kc = crop coefficient
ETo = reference crop evapotranspiration, mm/day

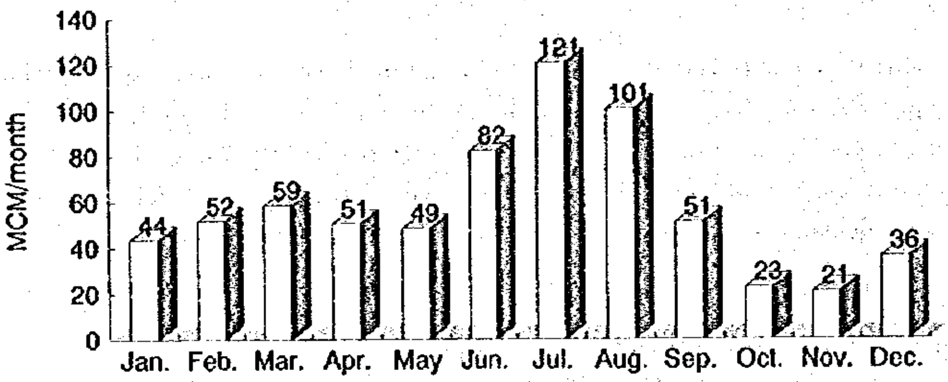
With the expectation that rainfall will be utilized effectively by the crops, the net irrigation water can be reduced by subtracting the effective rainfall from the ETcrop. However, the annual rainfall to be expected in the Project area is only about 100 mm. The rain is also known to fall locally and erratically, thus the rainfall is not considered to be very effective and should not be counted in estimating the net irrigation water. The net irrigation water is therefore, equal to the amount of ETcrop, which is normally the case in Egypt.

With reference to the cropping patterns and the area allocation among the farmers proposed in Chapter 3-4 "Agricultural Development", the irrigation water requirement per gross-feddan per day is worked out as shown on the figure below:



Daily Unit Irrigation Water, m^3/gross-feddan/day

The maximum requirement occurs in July, and the amount is 29 m^3/gross-feddan/day. The maximum is less than 30 m^3/gross-feddan/day which is the pre-requisition for the El Salam canal related projects. Thus, the proposed cropping patterns and the area allocation are satisfactory in terms of water quantity allocated. Using the daily unit irrigation water, the monthly gross irrigation water requirement for this Project can be calculated as is shown below, and the annual requirement can now be worked out as being 690 MCM.



Gross Irrigation Water Requirement (m^3/month)
(Annual Requirement: 690 MCM)

(2) Leaching Requirement

An example of leaching being practiced in Wadi El Arish area is mentioned in Chapter 2-6 "Irrigation and Drainage". Another example that was found on an investor's apricot farm in the North and East Lake Project gives an illustration of unintentional leaching. The trees are encircled by ridges of earth of about 50 cm in radius and 10-20 cm in height, into which irrigation water, is discharged via a drip system, allowing it to inundate the area around the tree. The farm has not developed salt accumulation, although salinization has already shown up in neighboring farms.

Leaching will obviously be required in one way or another for this project, taking into consideration the high salinity of the irrigation water ranging from 800 to 1000 ppm TDS. In this Study, leaching is studied with regard to the crop salinity tolerance, and will be introduced in the Project on the condition that the additional requirement will not exceed the total amount of allocated irrigation water which is the total unit water requirement composed of both the irrigation and leaching amount and should not exceed 30 m^3 per gross-feddan per day.

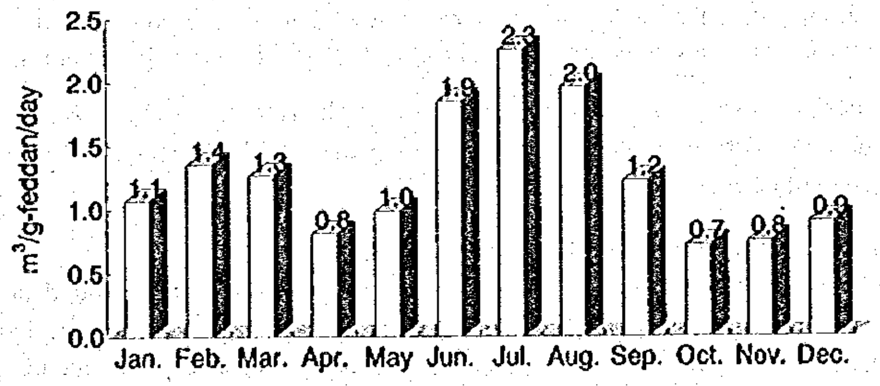
The amount of water required for leaching depends upon many factors such as amount of salts initially present in the soil and groundwater, type of salts, quality of leaching water, soil permeability, efficiency of the drainage system, depth of soil to be leached, and type of leaching such as continuous or intermittent. The depth and salinity level of the groundwater has a decisive effect on the efficiency of leaching. Namely, the deeper the groundwater and the drier the soil is before the leaching, the more effective the leaching will be.

The amount of leaching water is calculated in order to allow desalination of a given root zone and groundwater. The leaching requirement can also be explained as the minimum amount of irrigation water supplied that must be drained through the root zone to control soil salinity at the given specified level. The following equations are given to calculate the required leaching amount (FAO paper No.24):

$LR = ECw / (5ECe - EC)$ (1) in case of surface and sprinklers, not frequent irrigation
$LR = ECw / 2Max(ECe)$ (2) in case of drip and high frequent sprinkler, nearly daily

where:
- LR = the minimum leaching requirement needed to control salt within the tolerance (ECe) of the crop
- ECw = electrical conductivity of the irrigation water, mmhos/cm
- ECe = electrical conductivity of the soil saturation extract for a given crop, refer to Table 36 in FAO paper No. 24
- Max(ECe) = maximum tolerable electrical conductivity of the soil saturation extract for a given crop

Since rotational irrigation schedule is to be planned for sprinklers, equation (1) is employed to estimate the leaching amount. For drip irrigation, more frequent irrigation is to be practiced, requiring the leaching amount to be calculated by equation (2). For calculating the gross requirement, only the canal conveyance efficiency of 0.90 is to be considered since other losses can be effectively used as a part of the leaching amount. The figure below shows the calculated leaching requirement per gross-feddan per day:



Leaching Requirement, m^3/gross-feddan/day

It is understood that a part of the irrigation losses contribute to leaching. Seepage can be regarded as leaching and the seepage percentage to the irrigation water ranges between 15 and 10 % as explained in a later section regarding "design drainage discharge". The maximum irrigation requirement in July is now 29 m^3/gross-feddan/day as previously shown, while the maximum leaching requirement is 2.3 m^3/gross-feddan/day as is shown above. Therefore no additional leaching water is required since the amount incurred by irrigation losses exceeds the leaching requirement.

(3) Industrial Water

MPWWR proposes to introduce industrial water into the area with a total amount of 500,000 m^3 (half a million) per day for the purpose of future industrialization. The 500,000 m^3 per day is included in this Study, but for designing of the facilities only. These facilities include pipelines, canals, culverts and pumping stations which are located between the Bir El Abd Zone and the main canal in the Study area. The volume is not considered when calculating the operation cost.

3-5-5 Design On-farm Drainage Discharge

Based on the practice mentioned in Chapter 2-6 "Irrigation and Drainage" and recent practices in Egypt, on-farm drainage systems utilizing buried pipes will be introduced in this Study. The design of a buried drainage system in Egypt was based on criteria developed in the early 1960s by UNDP/FAO, but they were slightly modified, after the implementation of various projects. Until the middle of the 1980s, the following criteria concerning drainage discharge had been applied and they are still in use in most cases:

- A peak lateral drain discharge of 4 mm/day is considered safe.
- The design discharge of collectors in non-rice areas is taken as 3 mm/day, including a safety factor of 2.

With the great expansion and development of drainage projects, DRI started reviewing, verifying and modifying those criteria in the 1980s. DRI now recommends the following ways for determining the design drainage discharge based on their studies which included experimental practices (Land Drainage in Egypt 1989).

- Areas in the south of the Nile Delta and Upper Egypt where no rice is cultivated and natural drainage is enhanced by the groundwater potential, the drainage rate is less than 1.0 mm/day. Thus, a drainage rate of 1.0 mm/day is acceptable.
- Areas in the Central Delta where rice is cultivated and natural drainage is limited, the drainage rate exceeds 2.0 mm/day. Thus a design drainage rate of 2.0 mm/day is recommended.
- In designing the drainage, a safety factor has to be considered with all the above values.

In this Study, the design drainage discharge will be determined by referring to the above criteria, by estimating seepage amounts to groundwater, by considering the leaching amount, and by studying previous experimental practices.

(1) Design Drainage Discharge Based on Field Irrigation Losses

Field losses can be divided into three categories; namely, 1) evaporation from the ground surface, 2) surface runoff induced by excess application, and 3) seepage into groundwater. In designing the drainage discharge, only seepage into groundwater is of interest, and the seepage depends on field irrigation efficiency and field distribution efficiency. Based on the efficiencies already defined, the field losses are estimated to be 29 %, 24 % and 19 % in case of a hand-moved sprinkler, automated sprinkler and drip irrigation respectively:

Calculation of Field Losses

Irrigation Method	Irrigation Efficiency	Distribution Efficiency	Combined Efficiency	Losses, %
Hand-move Sprinkler	0.75	0.95	0.71	29
Automated Sprinkler	0.80	0.95	0.76	24
Drip Irrigation	0.90	0.95	0.86	14

Since little data exist on estimating how much losses will be seeping into groundwater, it is assumed that 50 % of the losses will evaporate for both the hand-moved and automated sprinkler and 30 % in case of drip system, and assuming surface runoff to be negligible. The seepage to groundwater is estimated as below, ranging between 10 and 15 % of the irrigation amount to be applied:

Calculation of Seepage Percent to Ground

Irrigation Method	Losses, %	Evaporation (%)	Surface Runoff	Seepage (%)
Hand-move Sprinkler	29	50	0	15
Automated Sprinkler	24	50	0	12
Drip Irrigation	24	30	0	10

Based on the crop water requirement, the seepage amount to groundwater can now be estimated. Although crop water requirements vary with crop type, growing stage and season, the maximum crop water requirement among the crops to be introduced in this Study reaches about 9 mm/day during July for such crops as sorghum, tomato and potato. Therefore, the seepage amount is calculated as below:

Calculation of Seepage Amount to Ground

Irrigation Method	Irrigation Application	Seepage %	Seepage Amount
Hand-move Sprinkler	12.6mm/day	15	1.9mm/day
Automated Sprinkler	11.8	12	1.4
Drip Irrigation	10.5	10	1.1

(2) Additional Drainage Discharge Incurred by Leaching

Additional drainage discharge incurred by leaching must be considered in deciding the design drainage discharge. It is understood that a part of the seepage incurred by irrigation losses constitutes a part of the leaching. However, no seepage amount is considered as part of the leaching in deciding the design drainage discharge for considering safety reasons and for simplifying the estimation of the drainage amount.

As the crop water requirement increases, the leaching amount will also increase proportionally. However, it is proposed that leaching during July should be discontinued since the crop water requirement in that month is close to the design capacity of 30 m^3/gross-feddan/day. Therefore, no drainage discharge amount from leaching is considered additionally to the drainage discharge amount estimated based on 9 mm/day peak crop water requirement in July.

Therefore in designing the drainage rate the additional drainage discharges from leaching in June and August must be used instead, which will probably result in the biggest amount. The leaching amount of June is 1.7 m^3/gross-feddan/day which is equivalent to about 0.48 mm/day net. Also, the leaching amount of August is 3.80 m^3/gross-feddan/day after shifting the amount of July into August, and the equivalent in mm/day is 1.1 net. Both cases are presented below, showing that drainage discharge rates in August are bigger than those in June. The rates in August are 2.6, 2.2 and 1.9 in case of hand-moved, automated and drip respectively.

Drainage Discharge Rate including Leaching in June

Irrigation Method	Irrigation Application	Seepage %	Seepage Amount	Leaching Discharge	Sum mm/day
Hand-moved Sprinkler	10.1mm/day	15	1.52	0.48	2.0
Automated Sprinkler	9.5	12	1.14	0.48	1.6
Drip Irrigation	8.4	10	0.84	0.48	1.3

Note: Irrigation application is estimated based on 80 % of July.

Drainage Discharge Rate including Leaching in August

Irrigation Method	Irrigation Application	Seepage %	Seepage Amount	Leaching Discharge	Sum mm/day
Hand-moved Sprinkler	10.1mm/day	15	1.52	1.1	2.6
Automated Sprinkler	9.5	12	1.14	1.1	2.2
Drip Irrigation	8.4	10	0.84	1.1	1.9

Note: Irrigation application is estimated based on 80 % of July.

(3) Design Drainage Discharge Based on Experimental Practice

An experimental practice in estimating unit drainage discharge was carried out by DRI in the Mashtul pilot area located 7 km north of El Zagazig, El Sharkia Governorate. The area is rather flat and characterized by a deep clay layer on top of a sandy aquifer, separated by a transition zone of varying thickness. Although the soil configuration is different from that of the Study area, the data is referred to in estimating the design drainage discharge.

The drainage is composed of a number of laterals and a collector. The laterals are short in length, each of which commands about 2 feddans. The collector commands a much bigger area ranging between 50 and 300 feddans.

The experiment was conducted between 1983/84 and 1985/86. The discharge rate from laterals are summarized below for different crops. Each figure in the table represents an average value of the statistical parameter calculated separately for each crop season at each different location. A zero median value of the drainage discharge means that the drains were running dry for more than half the number of days during irrigation seasons.

Laterals Drainage Discharge Rates in mm/day

Crops	Maximum	Crops 90% (CFO)	Median	Mean
Wheat	3.2	0.3	0.0	0.1
Long Berseem	4.0	0.8	0.3	0.3
Short Berseem	3.1	0.2	0.0	0.2
Maize	2.4	1.2	0.3	0.4
Cotton	1.5	0.3	0.0	0.1
Rice	3.7	2.4	1.3	1.3

CFO: Cumulative frequency of occurrence

In designing the drainage system of Mashtul pilot area, a design discharge of 1.0 mm/day was employed. Although the maximum discharges shown in the table above are more than 1.0 mm/day, it is observed that the design discharge rate covers the actual drainage rates of the crops over the period for 90 % of the irrigation season except maize and rice.

The following table shows drainage discharges measured at the collectors serving different areas. Although peak discharges of relatively high intensity still occur in collectors, those are not as high as for laterals. The drainage discharge rates of 90 % CFO are mostly higher than those in aforementioned table since the discharge from rice fields enhances the drainage rate. With reference to the 90 % CFO, a drainage rate less than 2 mm/day prevails most of the time in the area.

Collector Drainage Discharge Rates in mm/day

Served Area	Maximum	90%(CFO)	Median	Mean
125 fed.	2.0	1.3	0.5	0.6
48	3.9	1.8	0.4	0.6
42	3.9	1.4	0.3	0.5

CFO: Cumulative frequency of occurrence

Based on the practice in the Mashtul pilot area, it may be concluded that the drainage discharge rate of 1.0 mm/day is acceptable where no rice is cultivated and natural drainage is relatively good.

(4) Design Drainage Discharge

The aforementioned unit drainage discharges are summarized below, based on which "2 mm/day" is proposed as the design drainage discharge in this Study taking into consideration the following:

- A maximum crop requirement of 9 mm/day was undertaken in estimating the seepage to groundwater. Therefore, the drainage discharges based on the seepage may be regarded as already including a safety factor since actual farming practice usually includes a combination of crops some of which requiring less water than 9 mm/day.
- Although unit drainage discharge for hand-moved sprinklers in August is more than 2 mm/day, the area irrigated by the sprinkler is not large. This sprinkler will only be employed in at the most half the area of small scale and graduate farms.
- Experimental practices in Mashtul suggests that the unit discharge of 90 % CFO may become less than half the amount of peak drainage discharge.
- Provided that 90 % CFO is about half the maximum amount, the 90 % CFO discharge in this Study area could be around 1 mm/day, and the design drainage discharge of 2 mm/day is regarded reasonable after applying safety factor of 2.

Summary of Unit Drainage Discharge, mm/day

Case	July no P'cng	August with P'cng	90%CFO	Maximum
[Estimated by Seepage]				
Hand-moved Sprinkler	1.9	2.6		
Automated Sprinkler	1.4	2.2		
Drip Irrigation	1.1	1.9		
[Observed in Mashtul]				
Laterals			0.2-2.4	1.5-4.0
Collectors			1.3-1.8	2.0-3.9

3-5-6 Water Users Association

(1) Irrigation Advisory Services

In this Project, small scale and graduate farmers have to establish water users association (WUA) in order to practice their farming on a cooperative basis. In organizing and legalizing WUA, an orientation shall be given to the farmers. Also, an advice and training for operating the on-farm irrigation facilities will be called by the farmers, as needs arise, since they are not familiar to irrigation agriculture.

Those tasks will need new section or department within NSDO. An example is referred to in establishing the new organization. There is an organization called Irrigation Advisory Services (IAS), which was established in 1989 within Irrigation Improvement Project under MPWWR with the major services: 1) to facilitate and assist WUAs in establishing, maintaining and managing their own organizations for improving irrigation system performance, and 2) to assist WUAs in planning, designing, implementing, operating, maintaining and managing the improved irrigation technology and the adoption of improved water user management technologies. NSDO is required to equip same function as IAS's but smaller scale.

New organization within NSDO is called the same; namely, Irrigation Advisory Services. The IAS deals with not only this Project area but also whole 400000 feddans north Sinai agricultural project area. The structure of IAS is proposed below:

Irrigation Advisory Services
- Formation of WUA
- Training
- Monitoring & Evaluation

The Services is composed of three (3) sections; namely, 1) Formation of WUA, 2) Training and 3) Monitoring & Evaluation. "Formation of WUA" gives orientation of the procedure of forming WUA and help WUA to be legalized. "Training" gives farmers technical assistance relating to sprinkler and drip irrigation. "Monitoring & Evaluation" monitors and evaluates farmers' improved irrigation and feedbacks the outcome in collaboration with "Training" section. The Services are headed by General Director and three (3) sections by each Director. To contact farmers are made by field agents who are employed/trained or experienced agents to be moved from present Governorate IASs on-loan.

(2) Water Users Association

As aforementioned in designing "service unit" in Chapter 3-5 "Irrigation and Drainage", small scale and graduate farmers who practice their farming in the service unit will have one set of booster pumps to irrigate their farming plots, so that they have to operate and maintain the pump by themselves on a cooperative basis. From this regard, a group responsible for operating and maintaining the pump shall be formed. The group, called Water Users Association (WUA), will be established in each service unit (100 feddans) comprising 10 number of the farmers.

Besides operating and maintaining the pump, following major roles of WUAs are pointed out:

- To develop and implement operational plans for irrigation schedule and regular facilities maintenance,
- To improve water use management through improved irrigation schedule and other useful irrigation practices,
- To develop roles and responsibilities of the WUA's members and local rules for resolving water-related conflicts,
- To develop and maintain close coordination and good working relationships with organizations for essential services such as banks, equipment firms, public and private lessor, local village councils, and NSDO as well as agriculture extension services,

- To develop and maintain an official and functional information linkage with the irrigation authority, and
- To develop a federation of WUAs, which commands a whole distribution canal (branch canal) in future. In this case, whole irrigation system concerning the distribution canal will be transferred to the federation.

In order to give financial arrangement to WUA and other inducements to the formation of WUA, a specific legislation is required. To legitimate such association is new concept in Egypt and started recently. Irrigation and Drainage Law No. 213 was passed by the People's Assembly and approved by the President in 1994, to authorize WUAs and permit the recovery of Mesqa construction cost. Also, Ministerial Decree No. 14900 was issued in February, 1995 in order to enable the application of the Law No. 213.

The Law and Decree contain the rights, roles and responsibilities as well as limitation of both the MPWWR and the WUAs. While the Law does not cover all aspects and specific procedures for establishing and maintaining legal WUAs, the Decree represents several important steps forward which are: 1) WUAs are now legal associations, 2) WUAs have clear roles and responsibilities under the law, 3) WUAs have clear rights and limitations, and 4) WUAs can buy and sell goods and property, make contracts, mobilize resources, obtain credit from financial institutions as a legal entity and enter into their own business activities.

With reference to the Decree, the representatives of a WUA are usually composed of five (5) members such as chairman, treasurer, secretary and two (2) members. However, since the water users association in this Project is small in size, following simple structure is proposed and they are elected by the members at the first general meeting and every two (2) years:

Chairman
Treasurer
Secretary
General Meeting

Chairman is responsible for his/her service unit and is to supervise the members' water use, rotational irrigation practice among the members, and be responsible for inspecting irrigation facilities such as night storage, pump house, booster pumps, filter system, distribution pipes, etc. Treasurer is responsible for collecting and bookkeeping such fees as electricity of operating the pump, replacement cost to be required in future, and so on. Secretary is responsible for performing administrative works related to the association, recording the works and resolutions of the meeting, and notifying the irrigation related authority with the resolutions of the meeting.

The general meeting, with the presence of all members, will be convened annually or as required in order to erect the representatives, audit the account, decide the fees required, adjust and fix the cropping patterns in the year, and rule rotational irrigation among the members.

Pump attendant is required to maintain and operate the booster pump. Although it is desirable that the attendant is from the members, it may be difficult to find out a person with certain knowledge about mechanical. In case the attendant can not be from the members, the association will employ him from outside, or the association has to make necessary arrangement to train a member about mechanical in coordination with Irrigation Advisory Services.

A water users committee in connection with a branch canal can be formed by gathering chairmen of service units which are commanded by the branch canal. The committee is supposed to contact the irrigation office when they need to consult with the office for the operation of the canal. Also, the Project related water users committee can be formed by gathering representatives of all branch canals' committees. The Project Water Users Committee will be convened when they need to consult each other about water allocations among the branch canals and access to the irrigation office. The structure is conceptually shown on the following figure:

- The Project Water Users Committee
  - Water Users Committee 1(Branch Canal 1)
  - Water Users Committee 2(Branch Canal 2)
  - Water Users Committee 3(Branch Canal 3)
  - Water Users Committee 4(Branch Canal 4)
  - Water Users Committee n(Branch Canal n)
    - Water Users Association 1(Service Unit 1)
    - Water Users Association 2(Service Unit 2)
    - Water Users Association 3(Service Unit 3)
    - Water Users Association 4(Service Unit 4)
    - Water Users Association n(Service Unit n)
      - Chairman
      - Treasurer
      - Secretary

Structure of Water Users Committee

After certain period has passed, the water users committee related to a branch canal can be transferred into Federation of WUAs, which will be responsible for operating and maintaining the branch canal.

No branch canal (excluding Mesqa level) can be, at moment, operated by any farmers organization with reference to the related legislation in Egypt. However, there is an example already practiced in Fayoum project area, in which farmers organization operates the secondary canal. Transferring operation and maintenance of branch canals and sometimes whole irrigation systems is profiling a trend over the world in order to attain sustainable irrigation development, and to release irrigation related authority from financial overburden.

MPWWR has now started to seek the way to transfer the operation and maintenance of branch canals to farmers organization. Therefore, transferring operation and maintenance of branch canal to the Federation of WUAs will probably be made in future in line with legislation to be required.