6. Coffer Dike

6.1. Staging of Dam Construction

Since the river course is almost dry throughout the year except the winter season in November to March in which flood comes occasionally and it flows with a width about 650 m, a two-stage diversion method is introduced to construct the detention dam.

In the first stage, while the existing flood course near the right bank will be utilized as temporary open by-pass channel, the construction of left side of the dam body including the service and emergency outlets will be completed. During the above stage, the construction of service and emergency spillways will also be made.

The remaining construction works of dam body and service spillway will be carried out during the second stage in the summer season.

6.2. Design Flood Discharge

From the above staging, it is inevitable to pass one winter season in the construction schedule of the detention dam. Therefore, the coffer dike shall be planned at the first stage to protect the construction area of the river course against occasional floods during the winter season. The design flood discharge for the coffer dike varies case by case, and is decided in due consideration of such conditions as quantities of treatment at the dam foundation, construction schedule, dam scale and damages from shortage of the design discharge.

According to the hydrological analysis based on the rainfall data at the Sohar observation station, the peak flood discharges for each return period are as shown in the following table.

	Return Period				
	10-yrs	50-yrs	100-yrs	300-yrs	500-yrs
Peak Flood Discharge(cu.m/sec)	800	1,200	1,400	1,600	1,700

Judging from the construction schedule of the detention dam for about 20 months and location of rural towns and cultivated lands in the downstream, the value of 1,700 cu.m/sec is adopted as the design flood discharge for the coffer dike which corresponds to about 500 years return period. Since the catchment of detention dam separates into two sub-basins at the dam site; namely the Wadi Jizzi with about 692 sq.km of the catchment area and the Wadi Awhin with about 120 sq.km, the design flood discharge of 1,700 cu.m/sec is divided into both sub-basins based on the occupied catchment area as shown in the followings.

Wadi Jizzi sub-basin	Q = 1,450 cu.m/sec
Wadi Awhin sub-basin	Q = 250 cu.m/sec

6.3. Crest Elevation

The crest elevation of the coffer dike must be equal to the maximum water surface level in the by-pass channel plus freeboard which determines based on the wave height due to wind.

1) Water depth

The water depth in the by-pass channel can be obtained as a uniform flow by the following equation.

$$\frac{n \cdot Q}{I^{1/2} \cdot b^{8/3}} = \left(\frac{d}{b} \right)^{5/3} \cdot \left[\left(1 + z \cdot \frac{d}{b}\right)^{5/3} / \left(1 + z \cdot \frac{d}{b} \cdot \sqrt{1 + z^2}\right)^{2/3} \right]$$

Where, n: coefficient of roughness, adopted by 0.038
Q: design flood discharge
I: bottom slope of channel, adopted by 1 on 125
b: bottom width of channel
d: water depth of channel
z: side slope of channel, adopted by 1 on 3.0

From the above equation, the water depth in the by-pass channels at the Wadi Jizzi basin and dam axis are obtained as follows under the bottom widths of 120 m and 310 m, respectively.

Wadi Jizzi basin channel .... Water depth 2.619 m
(Q = 1,450 cu.m/sec)
Dam axis channel ..... Water depth 1.667 m
(Q = 1,700 cu.m/sec)

2) Crest elevation

The maximum water surface levels which shall be the basis of determining the crest elevation of the coffer dike can be estimated considering the water depth, velocity head and bottom elevation at the channels (EL.155.0m +).

For the crest elevation of coffer dike, the value of about 0.7 m is added to the above maximum water surface levels considering the wave height due to wind and confluent effect of the channels around the dam axis.

Therefore, the crest elevation of coffer dikes are fixed as follows:

Wadi Jizzi basin channel
EL.155.0 + 2.619 + 0.957 + 0.70 = EL.159.276 m ≒ EL.159.50 m

Dam axis channel
EL.155.0 + 1.667 + 0.535 + 0.70 = EL.157.902 m ≒ EL.158.0 m

From which, the higher crest elevation is adopted for the upstream coffer dike and another for the downstream coffer dike, respectively.

D-2. Dispersion Facilities

1. General

From the viewpoint of effective utilization of the excess flood discharge flowing out through the spillways, the dispersion facilities will be provided on the recent wadi course about 3.3 km downstream of the detention dam site. The facilities consist of over-topping type's dispersion dike to dam up a stream flow with outlet conduits located on the main water course at the recent wadi and connecting canal to divert the dispersion discharge to the terrace wadi courses which form a reticulate shape isolated by small sand bank on the wadi courses.

These reticulated wadi courses will be rejuvenated by the dispersion discharge through the connection canal and the ground water discharge will be increased by the percolation on the wadi courses.

2. Dispersion Discharge

According to the result of hydrological analysis in the Definitive Plan Report, a recharge potential in the downstream of the detention dam site was estimated at 13.0 cu.m/sec.

Since the total length of the dendriform wadi curses was estimated about 200 km, the potential recharge rate at the unit length is estimated as follow;

$$13.0 \text{ cu.m/sec}/200 \text{ km} = 0.065 \text{ cu.m/sec/km} \fallingdotseq 0.1 \text{ cu.m/sec/km}$$

From the results of infiltration test executed during the Feasibility Study, the rate of potential recharge for both the courses in recent wadi and terrace wadi were assumed at 3 mm/min and 2 mm/min, respectively.

As a result of the above assumption and total length of wadi courses at the terrace wadi (about 100 km), an increased recharge amount by the dispersion facilities is estimated as below;

100 km x 0.1 cu.m/sec/km x 2/3 = 6.67 cu.m/sec = 7.0 cu.m/sec

From which, the dispersion discharge to the terrace wadi courses through the connecting canal is designated at 7.0 cu.m/sec.

3. Hydraulic Dimensions

3.1. Outlet Conduit

Since a circular section of corrugated steel pipelines with inside diameter of 1.1 m are employed as the outlet conduit at the dispersion dike, the outlet discharge of these pipes can be obtained by the following equation.

$$Q = \frac{\sqrt{2g} \cdot A}{\sqrt{fe + fr + fv}} \sqrt{H} \times N = 2.5613 \sqrt{H} \times N$$

Where, Q: outlet discharge at dispersion dike, adopted by 12.0 cu.m/sec (13.0 cu.m/sec- 10.0 km x 0.1 cu.m/sec/km

g: acceleration of gravity, adopted by 9.8 m/sec^2

A: flow area of pipeline, $A = 0.7854\ D^2 = 0.9503\ m^2$

D: inside diameter of pipeline, adopted by 1.1 m

fe: coefficient of entrance loss, adopted by 0.5

fr: coefficient of friction loss at the pipeline $fr = 124.5\ n^2/D^{4/3} \times L$

n: coefficient of roughness, adopted by 0.024

L: length of pipeline, adopted by 18.972 m (0.612 m x 31 pcs.)

fv: coefficient of changing velocity loss, adopted by 1.00

H: total head, measured from top of crown at the end of pipeline

N: number of pipelines

The calculation results under various numbers of pipeline are shown in the following table.

	Numbers of Pipeline			
	2 Lines	3 Lines	4 Lines	5 Lines
Total Head (m)	5.488	2.439	1.372	0.879
Crest Elevation of Dike (m)[1/]	EL.138.29	EL.135.24	EL.134.17	EL.133.68
Height of Dike (m)[2/]	6.59	3.54≒3.6	2.47	1.98

Judging from the water surface elevation at the inlet portion of connecting canal (refer to the following paragraph and obtained by EL.135.29 m), 3 pipelines with 3.6 m height of dike are recommendable as the outlet conduit of the dispersion facilities.

3.2. Connecting Canal

The water depth of uniform flow in the connecting canal is obtained by the following equation under various bottom widths of the canal and calculation results are as blow.

$$\frac{n \cdot Q}{I^{1/2} \cdot b^{8/3}} = \left(\frac{d}{b}\right)^{5/3} \cdot \left[\left(1 + Z \cdot \frac{d}{b}\right)^{5/3} / \left(1 + 2\frac{d}{b} \cdot \sqrt{1 + Z^2}\right)^{2/3}\right]$$

Where, n: coefficient of roughness, adopted by 0.025
Q: dispersion discharge, adopted by 7.0 cu.m/sec
I: bottom slope of canal
b: bottom width of canal
d: water depth
z: side slope, adopted by 2.0

1/ Crest elevation = EL.132.80 m + Total head

2/ Height of dike = crest elevation - EL.131.70 m

	Bottom Slope I = 1/500			Bottom Slope I = 1/1,000		
Bottom Width (m)	10.0	12.5	15.0	10.0	12.5	15.0
Water Depth (m)	0.559	0.493	0.442	0.687	0.605	0.541
Velocity (m/sec)	1.126	1.053	0.997	0.896	0.844	0.805
Required Head (m)	0.624	0.550	0.493	0.728	0.641	0.574
Water Surface[1/] Elevation (m)	EL135.36	EL135.29	EL135.23	EL135.00	EL134.91	EL134.84

Assuming that the maximum permissible velocity is 1.0 m/sec under the canal body consists of sand and gravel materials, the value of 12.5 m is suitable as the bottom width of connecting canal. The bottom elevations at the inlet and outlet portions of the connecting canal are as follows:

Inlet bottom, EL.133.80 + 468.5/500 = EL.134.737 m = EL.134.74 m

Outlet bottom, EL.133.80 m

1/ I = 1/500, water surface elevation = EL.133.80+468.5/500+d+V^2/2g.

I = 1/1,000, water surface elevation = EL.133.80+468.5/1,000+d+V^2/2g.

ANNEX E COST ESTIMATION

ANNEX E

CONTENTS

E. COST ESTIMATION

1. Construction Method

The major construction works in the Project are the earth works consisting of embankment of the dam body and excavation of the service and the emergency spillways.

The dimensions of the Wadi Jizzi detention dam are 20 m of dam height, 866 m of dam length and 6.0 m of crest width. The base stratum of the foundation consists of Hawasina group of limestone. The river bed at the dam construction site is wide and the cord-height ratio (dam length/dam height) is 43.3. The dam will be constructed in two portions, i.e., left and right portions. Firstly the right side of river bed where the river course has developed will be excavated for the use as a temporary diversion channel which accommodates the flood flow during the construction period. The capacity of this diversion channel shall be 1,700 cu.m per sec which corresponds to about 500 years return period. The dam body embankment will be commenced from the left side. The outlet conduits will be laid before the embankment works.

a) Construction

1) Workable Days

It is known that the construction of earth dams is largely affected by meteorological and seasonal conditions, especially by rainfall. The annual rainfall, however, is observed at the site as little as 100 mm on a average, and the construction materials available consist of sand and gravel containing a little silt and clay (less than 10%). Therefore, no particular attention has been paid to the meteorological conditions of the Area for the Project Works. The workable days were taken by 25 days per month

and 275 days per year in taking into account the religious, national and calendar holidays, and the construction schedule was prepared on this basis.

2) Workable Hours

The standard workable hours for one(1) day was determined at eight (8) hours and actual operation time of construction equipment were adopted at seven(7) hours. Based on those data, the unit costs of works to be carried out by equipment and manpower were estimated.

b) Temporary Works

1) Access Road

Prior to commencement of the dam construction, an access road of about 4.0 km from National Road to the damsite will be constructed to transport equipment and construction materials. The proposed width of the road is six meters in gravel paving and with some crossing structures.

2) Diversion Facilities

The embankment works of the dam body will be commenced from left side of the river bed in view of the construction of outlet conduits, so that the river discharge shall be diverted to right bank of the river bed by a by-pass channel. In addition, in considering the occurrence of floods during the construction of the conduits and dam embankment, a coffer dike will be constructed so as to protect the said work sites from the flood.

Dimension of the coffer dike and by-pass channel were determined on the basis of flood discharge of 1,700 cu.m per second. The designed dimensions of the facilities are as follows:

Coffer Dike	Height	3 to 4.5 m
	Width of crest	4 m
	Length of coffer dike	400 m
	Up/downstream slopes	1:2.0/1:1.5
By-pass Channel	Bottom width	310 m
	Slope of both sides	1:3.0
	Maximum depth	2.62 m
	Available flow discharge	1,700 cu.m/sec

2) Contractor's Camp

The Contractor's camp will be constructed in the vicinity of the dam site. The camp includes the Contractor's offices, living quarters, a consultant's field office, labours' quarters, workshops, those facilities for water supply, electricity, communication between the site and Sohar/Muscat, etc. The capacity of those facilities was roughly estimated as follows;

Contractor's Office	300 sq.m
Quarters	250 "
Consultant Office	150 "
Labours' Quarters	800 "
Workshop	750 "
Ware House	500 "
Guest House	60

c) Main Works

1) Main Dam

i) Excavation of Dam Base

Geology of the dam foundation consists of the recent river deposits, middle terrace deposits, upper terrace deposits

and bed rocks. As for the river portion, the deposit is composed of very loose sand and gravel, and the thickness is about 3.0 meters. While the both banks consist of the upper terrace deposit, which is well consolidated sand and gravel having permeability coefficient more than 100 Lugeon.

On the other hand, the dam base will be cleaned by the excavation of 0.25 meters on an average in order to remove the top soils, big stones, miscellaneous things which will interfere the dam embankment works.

The excavation of the dam foundation will be divided into two(2) works; stripping and core trench. The stripping work will be made by bulldozer of 21 ton class, and the excavated sand and gravel will be utilized as embankment materials of the coffer dike which will be constructed at the location of about 70 meters up/downstream from the dam axis. For the core trench works, the excavation will be carried out at 3.0 meters deep in average by backhoe shovels of 1.2 cu.m class and this material will be used as dam embankment of downstream portion from the vertical filter (intercepter).

Combination of the construction equipment is as follows:

Bulldozer (for stripping)	21 ton class
Backhoe shovel (for trench excavation)	1.2 cu.m class

ii) Borrow Area of Embankment Material

It was planned that the sand and gravel materials excavated from both spillways would be used as the embankment materials of the dam body through the grizzly plant for the separation of cobbles and boulders from

economical point of view. Therefore, no consideration was given to special borrow areas.

iii) Filter Material

A vertical filter (intercepter) is constructed at seven meters downstream from the dam axis and the thickness is two meters. The filter materials are required to have the quality as mentioned in Chapter IV Detention Dam 4-3-5, Stability Analysis. Therefore, the filter will be produced by the screening plant for the arrangement of gradation from the river deposit sand and gravel. Required equipment to be produced the filter are as follows:

Bulldozer (for collection)	21 ton class
Front-end loader (for loading)	4 cu.m bucket capacity
Dump truck (for transportation)	20 ton class
Screening plant (for selection)	screen area 1.5m x 3.6m

iv) Embankment of Dam Body

Embankment works of the dam body are divided into three steps, that is, spreading, water sprincle and compaction works. Excavation, loading and transportation works of the materials are included in the spillway excavation works. The embankment method will be determined on the basis of the result of embankment test which will be conducted at the dam site prior to commencement of the embankment work.

The construction cost of embankment works was estimated on the basis of the construction method supposed from the post experiences.

- Spreading

Spreading works will be carried out by bulldozers of 18 ton class with spreading thickness of 0.3 meters. However, the final decision of the spreading thickness will be determined by the embankment test.

- Water Sprinkle

The most important point among the embankment works is to control moisture contents of the embankment materials. If the moisture content is more (or less) beyond an allowable value determined in the dam design, the design values on density, permeability and shearing strength would not be obtained from the embanked materials.

Since the field moisture content of 2.5 percent for the embankment materials is located at the dry side from an optimum moisture content of 5 - 7 percent on an average which obtained from laboratory tests, the water about 5.0 percent by weight will be sprincled in the embankment materials prior to commencement of its compaction. The water will be transported from vicinity of Sohar by water tankers of 10 ton.

- Compaction

The compaction work will be carried out by vibrating rollers of 11 to 15 ton class. Numbers of the roller's pass shall be determined by the embankment test. However, regarding the estimation of construction costs for the compaction work, the pass of six times, as an output of the roller, was determined.

Required equipment to be used for the embankment works are as follows:

Bulldozer (for spreading)	18 ton class
Water tanker (for watering)	10 ton class
Vibrating roller (for compaction)	11 to 15 ton class

v) Construction of Filter

The filter collection from the river bed will be used as the vertical and horizontal drains. The vertical filter zone will be excavated by backhoe shovels after the dam embankment has been filled about 1.5 meter thick from previous filter zone, and the filter materials are filled in the trench with compaction of 100 kg class vibrating compactor.

For the horizontal drain, the materials will be spreaded by bulldozers of 21 ton class with 0.3 meter thick and compacted by vibrating roller of 11 to 15 ton class.

vi) Riprap

Prior to commencement of the riprap work, filter collected from the river bed will be constructed in 0.25 meter thick under the riprap rocks.

The equipment to be used for the riprap work are as follows:

Riprap Material

Front-end loader (for loading)	4.0 cu.m bucket capacity
Dump truck (for transportation)	20 ton class
Manpower (for construction)	

Filter

Front-end loader (for loading)	4.0 cu.m bucket capacity
Dump truck (for transportation)	20 ton class

vii) Slope Trimming for Dam Surface

The slope trimming will be carried out by backhoe shovel of 0.6 cu.m class after the dam embankment has been filled about 1.5 meter thick from previous embankment surface. The final trimming will be done by manpower based on fixed ruler made on the slope surface.

2) Spillway

An open type and ungated service and emergency spillways with the chute was designed from the view point that a fill type dam is non-resistance of itself for overtopping and the topographical and economical conditions.

i) Excavation of Spillway

The excavation of spillways will be divided into two works, stripping and excavation. The stripping work will be carried out by bulldozers of 21 ton class with 0.25 meter thickness on an average and these materials will be transported to spoil banks located dam site.

Construction equipment will be selected as follows:

Stripping

Bulldozer (for stripping)	21 ton class
Front-end load (for loading)	4.0 cu.m bucket capacity
Dump truck (for transportation)	20 ton class

On the other hand, the excavation will be carried out from upstream toward downstream of the spillway by combination of bulldozers, front-end loaders and dump trucks, and the excavated sand and gravel will be transported to the dam body to use as its embankment materials. Finishing of the design excavation lines will be carried out by manpower. Construction equipment will be selected as follows:

Excavation

Bulldozer (for stripping)	21 ton class
Front-end load (for loading)	4.0 cu.m
Dump truck (for transportation)	20 ton class

ii) Concrete

Concrete Plant

A batching plant with 0.5 cu.m mixer will be installed at the river bed and the mixed concrete will be transported to pouring places (services and emergency spillway) by carriers of one(1) cu.m bucket and placed by manpower.

Concrete aggregates (fine sand coarse) will be produced by screening deposited sand and gravels. Prior to commencement of mixing, mixing of concrete for each structure shall be determined by field mixing tests based on the specified mix proportion of each structure.

iii) Placing

Plain concrete will be placed at portions where the reinforced concrete contracts with the excavated surface. After placed the plain concrete, the reinforcing bars will be arranged on concrete according to the construction drawings. The crest concrete of the service spillway composes of reinforced and boulder concretes, and the boulder concrete will be placed enclosing by the reinforced concrete. A construction method of the boulder concrete is as follows:

- Plain concrete of about 0.3 meter thickness is placed.
- Clean boulders are placed in the plain concrete and spaces of at least 5 cm are kept for each boulder.

- Next, concrete is placed on the firstly-placed concrete to cover the boulders.
- Thickness of the boulder concrete placed continuously shall be limited to 0.5 meters at maximum taking into account temperature of the concrete which rises by chemical reaction between cement and water during hardening.

Since apron concrete of the service spillway was designed at 0.9 meter thick, the maximum thickness of concrete placed continuously shall be limited to the thickness less than 0.5 meter:

The placed concrete will be covered with sheets or mats and kept in wet conditions for more than one week.

iv) Concrete Form

Metal forms will be used for main structures, and the forms shall be so used as to make the line of joints and the form panels have sufficient strength in vertical and horizontal directions. Wooden forms will be used for the crest and complicated structures.

v) Reinforcing Bar

Reinforcing bare will be manufactured in the length and bending in exact accordance with the substance described in the Drawings. In the case that a part of the bars is exposed from the structures for the future extension, the portion shall be covered by vinyl bag in order to protect from damages and/or corrosion.

vi) Dowel Bar

Dowel bars will be installed as illustrated in the Drawings. The half of those bars will be fixed in the first placed concrete, and the rest will be covered with paper or asphalt painting so as not to be fixed in concrete placed continuously.

vii) Drain

Drains will be constructed at the side walls and bottom of apron for the spillway in order to protect the structures from back water pressures and uplifting. When the concrete is placed on the drain, the drain shall be covered with paper so as to prevent its drain function by filling up cement milk. All works will be constructed by manpower.

The equipment to be used for concrete placing works are as follows:

Screening plant

Carrier (for transportation)	1.0 cu.m bucket capacity
Concrete batching plant	0.5 cu.m mixer
Carrier (for transportation)	1.0 cu.m bucket capacity
Vibrator (for concrete placing)	

viii) Gabion

Gabions consist of wire cages and stones packed uniformly in the cage, and the stone will be limited to the size larger than that of the cage mesh size. At first, the cage will be set at the designated place and filled with the stones. the cage shall be connected tightly to other gabions by wires.

The stone will be selected by the screening plant and transported to stock-piles selected at vicinity of the work site. From the stockpiles to work sites, carriers of one(1) cu.m bucket capacity will be used.

xi) Stone Masonry

Stones for masonry shall be best in quality with soundness and durability, free from weathering and decomposition.. The stones will be collected from river plain by manpower and transported by dump trucks of 20 ton class.

All stones will be dressed roughly and smoothly on the concrete bed placed previously at 0.15 meter thick, and the half of every stone will be embedded in the concrete. Remained half will be filled by mortar which removed coarse aggregate from the concrete up to surface of the stone.

Every work will be carried out by manpower, and after completion of the works, the stone masonry will be covered by mats with curing water.

3) Outlet Conduit

i) Excavation

The outlet conduits of two steel pipe lines with diameter 1,500 mm will be embedded in the dam foundation. The trench will be excavated by backhoe shoves of 1.2 cu.m bucket capacity. The excavated sand and gravel with be used as dam embankment materials.

ii) Concrete

After the trench excavation is finished, base concrete will be placed at the bottom of the trench with 0.5 meter thickness, and anchor bolts made by steel bars with 25 mm diameter will be embedded in the base concrete at the three meter intervals. The steel lines will be fixed to the anchor bolts by steel belts. The pipe joints shall be welded both inside and outside of the pipes with care.

Concrete will be placed in using chute pipes and poured in the same level at both sides of the pipe. Especially, the bottom concrete of the pipe shall be poured with special care so as to transmit the load equally to the bed concrete and foundation.

The same equipment that is used for the works of the spillway will be appropriated to the concrete placing of outlet conduit.

iii) Emergency Gate

A gate will be installed at the end of emergency outlet conduit. Since the gate is operated by manpower, its operation speed shall be less than 0.3 meters per minutes.

The equipment for this work is as follows:

Backhoe shovel (for excavation)	1.2 cu.m
Concrete batching plant	0.5 cu.m mixer
Carrier (for transportation)	1.0 cu.m bucket capacity
Vibrator (for concrete placing)	
Crane (for installation)	20 ton class
Welders (for pipe welding)	300A

4) Dispersion Facility

In order to effectively utilize the flood discharge flowing from two spillways and the released water from the conduits, a dispersion facility was planned at 3.3 km downstream of the detention dam site. The facilities consist of a gabion dike to dam up a stream water with outlet conduits of three numbers of corrugated steel pipe and a connecting channel to divert the discharge to old reticulated tributaries isolated by small sand bank on the Wadi course.

The gabion dike will be constructed with filling materials which will be available by excavation at the connecting channel. The gabion protecting the dike surface will be constructed at the same way as that of the spillway gabion.

Corrugated steel pipes are embedded in the gabion dike in order to allow the limited discharge to flow in considering the percolation on the tributary Wadi courses extending to downstream of the dispersion facilities.

The equipment to be used for this work is a backhoe shovel of 1.2 cu.m bucket capacity, dump trucks of 20 ton class and bulldozer of 21 ton class. In addition, a crane will be used for the installation of corrugated steel pipes in the gabion dike. Some stone masonry works will be

constructed at inlet and outlet of the pipes in order to protect its surface from flood discharges. The construction method is the same as that of the spillway.

Backhoe shovel (for excavation)	1.2 cu.m
Dump truck (for transportation)	20 ton class
Bulldozer (Spreading & compaction)	21 ton class
Crane (Installation of pipe)	20 ton class

5) Monitoring Facilities

In the conception of mentioned in Chapter III, the following monitoring facilities are prepared at the Project site.

i) Surface Water Hydrology

In order to measure the direct inflow into the reservoir, outflow through the spillway as well as through the outlet conduit, an automatic water level gauge will be installed within the reservoir area near the dam body and two staff gauges at both spillways.

The water gauge will be composed of steel, pipes, supports and an automatic recorder and installed at the designated place. Gabions will be placed surrounding the base of the gauge to project the base from scoring by floods. The equipment to be required for this work will be as follows.

Backhoe shovel (for excavation)	0.6 cu.m
Crane (for installation)	1.5 ton
Concrete mixer (for concrete placing)	0.5 cu.m

ii) Groundwater Measurement

In order to confirm the groundwater conditions, five(5) of observation wells were planned in the up/downstream from the detention dam in the Wadi Jizzi basin. Dimensions of those wells are as follows:

Nos of Well	Depth (m)	Diameter (mm)
NJ-1	40	100
NJ-2	70	100
NJ-3	70	100
NJ-4	70	100
NJ-5	20	100

Seasonal flactuation of groundwater table will be recorded by the automatic water level recorder to be installed at the wells. At first, the excavation of about four meters from the surface will be carried out and a steel casing of 250 mm diameter will be installed in the excavated pit. A boring machine with bit of 10 inch will set up on the casing and will drill until 100 meter from the surface. A PVC casing with screen (diameter of 100 mm) will be set up in the hole and the space between hole wall and outside casing will be packed by sand and gravels. After the work has been completed, pumping up test will be conducted using a submersible pump in order to investigate transmissibility and storage coefficient of the aquifer. The equipment to be required for the works is as follows:

Boring machine	diameter 250 mm
Submersible pump	diameter 40 mm

6) Associated Facilities

The associated facilities include a relocation road and protection of historical monuments.

i) Relocation Road

At present, a road running between the National Road and the proposed damsite is used for transporting the local people and daily commodities. However, a part of road across the proposed reservoir area, the said road shall be relocated so as to avoid the reservoir area.

ii) Protection of Historical Monuments

There are historical monuments found at two(2) km upstream from the dam site, are will be submerged when the reservoir water surface reaches the full water level by floods.

In order to protect the monuments from inundation, a protection dike will be constructed in immediate front of them. The crest elevation was determined at EL 170.0 m taking into account the crest elevation of the dam body.

2. Output of Construction Equipment

The output of the construction equipment was estimated in using the empirical equation authorized by the Ministry of Agriculture, Forestry and Fisheries in Japan. The formulas applied and the outputs of each equipment are shown in the following pages.

Production of Construction Equipment

a) Bulldozer 18 and 21 ton

i) Excavation

$$Q = \frac{60 \times q \times f \times E}{Cm}$$

Where, Q ; Production volume per hour (m^3/hr)

q ; One cycle performance volume (21 ton - 2,846 m^3, 18 ton = 2,050 m^3)

f ; Swell factor

E ; Coefficient of work

Cm; One cycle time (min) Cm = 0.034L + 0.25

L : Distance (m)

Item	Kind of Works	Specification (ton)	q (m^3)	f	E	Cm (min)	L (m)	Q (m^3/hr)	Remarks
Dam body & Spillway	Stripping	21	2.846	0.85	0.40 0.40	1.95 0.59	50 10	44.66 98.40	Sand & Gravel
Dam Body	Excavation	21	2.846	0.85	0.50	0.93	20	78.03	- ditto -
Spillway	Excavation	21	2.846	0.85	0.40	1.27	30	45.72	- ditto -
Dam Body	Spreading	18	2.050	0.85	0.60	0.93	20	67.45	- ditto -
Aggregate	Collection	21	2.846	1.00	0.60	0.93	20	110.17	- ditto -

Note: Spreading quantity at the dam body is 60 percent of the actual embankment quantity
Q = 67.45 x 1/0.6 = 112.41 cu.m/hr

b) Backhoe Shovel

$$Q = \frac{3,600 \times q \times f \times E}{Cm}$$

Where, Q ; Production volume per hour (m^3/hr)

q ; One cycle performance volume (m^3) $q = q_o \times 0.9$

f ; Swell factor

E : Coefficient of work

Cm; one cycle time (sec)

q_o ; nominal bucket capacity

Item	Kind of Works	Specification	q (m^3)	f	E	Angle (°)	Cm (min)	Q (m^3/hr)	Remarks
Conduit	Excavation	1.2 m^3	1.08	0.85	0.55	135	30	60.59	Sand Gravel
Dam Body	Slope trimming	0.6 m^3	0.54	0.85	0.20	135	30	11.00	"

c) Front-end Loader

$$Q = \frac{3,600 \times q \times f \times E}{Cm}$$

Where, Q ; Production volume per hour (m^3/hr)

q ; One cycle performance volume (m^3) $q = q_o \times 0.9$

f ; Swell factor

q_o ; nominal bucket capacity

E : Coefficient of work

Cm; one cycle time (sec)

Item	Kind of Works	Specification (m^3)	Wheel or Crawler	q (m^3)	f	E	Cm (sec)	Q (m^3/hr)	Remarks
Spillway	Sand & Gravel	4.0	Wheel	3.6	0.85	0.6	40	137.70	
Spillway	Boulder	4.0	"	2.4	0.57	0.55	45	60.19	$q = q_o \times 0.6$
Spillway	Aggregate	4.0	"	3.6	0.86	0.65	40	150.80	

d) Compaction

$$Q = \frac{60 \times V \times W \times D \times E}{N}$$

Where, Q ; Production volume per hour (m^3/hr)
V ; Compacting speed (m/min)
W ; Effective compacting width (m)
D ; Thickness after compaction (m)
E ; Coefficient of work
N ; Compacting times

Item	Kind of Works	Equipment	Specification	60V	W (m)	D (m)	N	E	Q (m^3/hr)
Dam Body	Compaction	Bulldozer	21 ton	3,500	0.9	0.35	6	0.65	119.44
Dam Body	- ditto -	V-Roller (Self-propeller)	11 ton	1,000	1.5	0.35	3	0.60	105.00

e) Dump Truck

$$Q = \frac{60 \times q \times f \times E}{Cm}$$

Where, Q ; Production volume per hour (m^3/hr)

q ; One cycle performance volume (m^3)

f ; Swell factor

E ; Coefficient of work

Cm; One cycle time (min)

$q = T/W$ (m^3)

T ; Allowable loading volume of dump truck (t)

W ; Unit weight t/m^3

$Cm = 0.005L + 10.5$ (min)

L ; Distance

Item	Kind of Works	Specification	W (t/m^3)	q (m^3)	L (m)	Cm (m^3/hr)	f	E	Q	Remarks
Dam Body	Excavation	20 t	1.9	10.53	150	11.25	0.85	0.90	42.96	Sand and Gravel
Spillway	Stripping	20 t	1.9	10.53	700	14.0	0.85	0.90	34.52	ditto
Spillway	Dam Body	20 t	1.9	10.53	2,000	20.5	0.85	0.90	23.51	ditto
Conduit	Excavation	10 t	1.9	5.26	150	11.25	0.85	0.90	21.48	ditto
Boulder	Riprap	20 t	1.9	10.53	2,000	20.5	0.90	0.80	22.19	Boulder
Filter	Dam body	20 t	1.7	11.76	1,000	15.5	0.90	0.80	32.78	Sand
Aggregate	Screening Plant	20 t	1.9	10.53	1,000	15.5	1.00	0.85	34.65	Sand and Gravel

f) Spreading

$$Q = 10E(18D + 13) \quad (m^3/hr)$$

Where, q ; Spreading volume per hour (m^3/hr)

E : Coefficient of work

D : Thickness after finish (m)

Item	Kind of Works	Specification	D	E	Q (m^3/hr)	Remarks
Dam Body	Spreading	21 ton Bull	0.35	0.75	144.8	
Dam Body	Compaction with Spreading					

$$Q = \frac{144.8 \times 119.4}{144.8 + 119.4} = 65.44 \ m^3/hr$$

3. Project Cost

Table E-1. Construction Cost

Item	Unit	Quantity	Unit Cost (R.O)	Amount (R.O)
I Mobilization, Re-mobilization and Services				
1) Construction Camp	L.S			200,000
2) Access Road	km	4		10,000
3) Communication System	L.S			1,000
4) Lighting Facilities	L.S			20,000
5) Soil and Concrete Test Apparatus	L.S			12,000
6) Warning signs	L.S			2,000
7) Commemoration plaque	L.S			5,000
8) Driver and Labours	L.S			40,000
Total				290,000
II Main Works				
2-1 Dam Body				
1) Clearing and stripping	cu.m	21,800	0.920	20,056
2) Common excavation	"	44,700	1.451	64,860
3) Dam embankment	"	629,300	1.763	1,109,456
4) Filter (Vertical)	"	25,600	2.342	59,955
5) Filter (Horizontal)	"	20,200	2.078	41,976
6) Slope surface trimming (machine)	sq.m	76,900	0.659	50,677
7) Hand placed riprap	cu.m	31,700	12.680	401,956
8) Riprap filter	"	12,200	4.417	53,887
9) Shoulder protection of dam crest	"	4,400	15.216	66,950
Sub-total				1,869,773

Item	Unit	Quantity	Unit Cost (R.O)	Amount
		(R.O)		
2-2 Service Spillway				
1) Clearing and stripping	cu.m	44,200	1.873	82,787
2) Common excavation (use for dam)	"	315,000	1.800	567,000
3) - do - (use for dike)	"	37,800	0.911	34,436
4) - do - (to spoil-1)	"	283,000	1.406	397,898
5) - do - (to spoil-2)	"	365,000	1.635	596,775
6) Reinforced concrete	"	5,460	60.032	327,774
7) Reinforced bar	ton	60.0	287.000	17,220
8) Dowel bar	"	9.3	287.000	2,669
9) Plain concrete	cu.m	340	54,595	18,562
10) Wet masonry	"	790	32,370	25,572
11) Boulder concrete	"	1,150	36.137	41,557
12) Gabion	"	42,400	15,588	660,931
13) Hand placed riprap	"	9,000	12.680	114,120
14) Dike embankment	"	37,800	0.840	31,752
15) Spoil bank treatment	"	648,000	0.264	171,072
16) Slope surface trimming (manpower)	sq.m	6,080	0.835	5,077
17) Common excavation (manpower)	cu.m	600	2.506	1,504
18) Underdrain	"	150	7.806	1,171
19) Geotexicle mat	sq.m	55,400	1.000	55,400
Sub-total				3,153,277
2-3 Emergency Spillway				
1) Clearing and stripping	cu.m	26,000	1.586	41,236
2) Common excavation (use for dam)	"	302,000	1.800	543,600
3) - do - (use for dike)	"	4,300	0.911	3,917
4) - do - (to spoil-4)	"	62,000	1.635	101,370
5) - do - (manpower)	"	330	2.506	827
6) Plain concrete	"	1,500	54.595	81,893

	Item	Unit	Quantity	Unit Cost (R.O)	Amount (R.O)
7)	Wet masonry	cu.m	2,800	32.370	90,636
8)	Gabion	"	14,600	15.588	227,585
9)	Hand placed riprap	"	8,140	12.680	103,215
10)	Dike embankment	"	4,300	0.840	3,612
11)	Slope surface trimming (manpower)	sq.m	700	0.835	585
12)	Spoil bank treatment	cu.m	62,000	0.264	16,368
13)	Underdrain	"	200	7.806	1,561
14)	Geotexicle mat	sq.m	23,500	1.000	23,500
	Sub-total				1,239,905
2-4	Service Outlet Conduit				
1)	Common excavation	cu.m	5,000	1.454	7,270
2)	Backfill	"	900	1.690	1,521
3)	Plain concrete	"	190	54.595	10,373
4)	Reinforced concrete	"	800	60.032	48,026
5)	Reinforcing bar	ton	26.1	287.000	7,491
6)	Steel liner (ϕ1,500mm t=6mm)	m	114	300.000	34,200
7)	Trashrack	ton	1.3	1,000.000	1,300
8)	Perforated PVC pipe (ϕ300mm, L=1.0m)	m	6	6.600	40
9)	Wet masonry	cu.m	320	32.370	10,358
10)	Hand placed riprap	"	180	12.680	2,282
11)	Debris deflector	set	1		2,070
	Sub-total				124,931
2-5	Emergency Outlet Conduit				
1)	Common excavation	cu.m	4,600	1.454	6,688
2)	Backfill	"	1,700	1.690	2,873
3)	Plain concrete	"	190	54.595	10,373
4)	Reinforced concrete	"	490	60.032	29,416
5)	Reinforcing bar	ton	12.6	287.000	3,616

Item	Unit	Quantity	Unit Cost (R.O)	Amount (R.O)
6) Steel liner (ϕ1500mm t=6mm)	m	66	300.000	19,800
7) Trashrack	ton	1.6	1,000.000	1,600
8) Steel gate	set	1	6,700.000	6,700
9) Wet masonry	cu.m	340	32.370	11,006
10) Debris deflector	set	1		1,106
Sub-total				93,178
2-6 Dispersion Facility				
1) Clearing and stripping	cu.m	1,300	0.920	1,196
2) Common excavation	"	500	1.451	726
3) - do - (backhoe shoval)	"	9,800	1.454	14,249
4) Sand bed	"	30	2.506	75
5) Dike embankment	"	4,200	0.840	3,528
6) Slope surface trimming (manpower)	sq.m	3,900	0.835	3,256
7) Corrugated pipe (ϕ1,200mm)	m	57	45.360	2,586
8) Gabion	cu.m	1,400	15.588	21,823
9) Hand placed riprap	"	1,200	12.680	15,210
10) Wet masonry	"	40	32.370	1,295
11) Debris deflector	set	1		728
Sub-total				64,672
Total				6,545,736
III Monitoring Facilities				
3-1 Water Level Gauge				
1) Common excavation	cu.m	40	6.960	278
2) Plain concrete	"	40	54.595	2,184
3) Gabion	"	50	15.588	779
4) Fabrication of steel tower	set	1	2,500.000	2,500
5) Automatic water gauge	"	1	1,000.000	1,000

Item	Unit	Quantity	Unit Cost (R.O)	Amount (R.O)
6) Installation of tower	set	1	500.000	500
7) Staff gauges	set	4	200.000	800
Sub-total				8,041
3-2 Observation Well				
1) Common excavation (manpower)	cu.m	30	6.960	209
2) Plain concrete pack	"	1	54.595	54
3) Drilling (10 inch)	m	270	80.000	21,600
4) Gravel pack	cu.m	15	10.000	150
5) Reinforced concrete	"	5	60.032	300
6) Reinforcing bar	ton	0.4	287.000	115
7) Provision and installation of 10 inch steel casing	m	20	90.000	1,800
8) Provision and installation of 4 inch PVC pipe	m	155	18.000	2,790
9) Provision and installation of 4 inch PVC screen	m	95	30.000	2,850
10) Pumping test (12 hr/well)	hr	60	30.000	1,800
Sub-total				31,668
Total				39,709
IV Associated Facilities				
4-1 Relocation Road				
1) Common excavation	cu.m	2,000	1.451	2,902
2) Grading of road surface	100 sq.m	150	36.800	5,520
3) Maintenance	L.S			842
Sub-total				9,264

Item	Unit	Quantity	Unit Cost (R.O)	Amount (R.O)
4-2 Protection of Histrical Facility				
1) Clearing and stripping	cu.m	1,400	0.920	1,288
2) Dike embankment	"	2,400	2.604	6,250
3) Hand placed riprap	"	700	12.680	8,876
4) Slope surface trimming by manpower	sq.m	2,300	0.835	1,920
Sub-total				18,334
Total				27,598
V Diversion Facilities (Coffer Dam and By-pass channel)				
1) Clearing and stripping	cu.m	5,100	0.920	4,692
2) Common excavation	"	66,600	1.451	96,637
3) Embankment	"	32,200	0.840	27,048
4) Hand placed riprap	"	750	12.680	9,510
5) Slope surface trimming by manpower	sq.m	2,500	0.835	2,088
Total				139,975
VI Maintenance Cost of Structures				
7,043,018 x 0.001				7,040
Grand Total				7,050,058

Table E-2 Disbursement Schedule

(Unit : R.O)

	Item	Total	1986	1987	1988
1.	Mobilization, Re-mobilization & Services	290,000	-	232,000	58,000
2.	Main Works	6,545,736	-	3,600,155	2,945,581
3.	Monitoring Facilities	39,709	-	-	39,709
4.	Associated Facilities	27,598	-	-	27,598
5.	Dispersion Facilities	139,975	-	139,975	-
6.	Maintenance Costs & Structures	7,040	-	-	7,040
	Sub-total	7,050,058	-	3,972,130	3,077,928
7.	Compensation	15,000	15,000	-	-
8.	Consulting Services	326,000	7,820	170,180	148,000
	Total	7,391,058	22,820	4,142,310	3,225,928
9.	Physical Contingency	705,942	-	397,210	308,732
	Grand Total	8,097,000	22,820	4,539,520	3,534,660

4. Maintenance Cost

1) Salaries and Wages

Description	No.	Salary p.a. (R.O)	Total Salary p.a. (R.O.)
Engineer	1	5,000	5,000
Security Guard	1	1,000	1,000
Sub-total	2		6,000

2) Operation of Machinery

Description	Qty.	Unit Cost (R.O.)	Total Cost (R.O)
Station Wagon, 4 x 4	1	5,500	1,100/1
Repairs	L.S.		275
Fuel and Oil	1	270/1	270
Sub-total			1,645

/1 ... 10,000 km/yr. x 0.2 1/km x 0.135 R.O./1 = 270

3) Maintenance of the Dam

Removal of sediment deposit of the dam

13,000 cu.m/yr x 1.235 R.O. / cu.m = 16,055

ANNEX F ECONOMIC EVALUATION

ANNEX F

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1. National Economy

Table F-1 Gross Domestic Product at Current Prices

(Unit: Million R.O)

	1976	1977	1978	1979	1980	1981	1982	1983
Industries								
Agriculture, Hunting Forestry and Fishing	18.3	24.1	30.7	40.3	52.6	62.1	66.1	80.5
Mining and Quarrying	517.5	532.8	493.8	719.7	1,285.9	1,495.5	1,424.7	1,384.6
Manufacturing	4.3	6.7	8.5	9.6	13.4	24.0	35.9	63.2
Electricity, Gas and Water	6.4	9.2	11.1	12.7	16.0	18.7	21.3	24.0
Construction	88.5	78.0	71.4	86.1	117.8	144.9	169.8	187.4
Wholesale and Retail Trade	76.5	94.2	104.0	137.1	188.3	251.3	299.5	315.7
Transport, Storage and Communications	13.5	17.6	20.7	25.5	38.3	53.8	64.9	72.9
Financing, Insurance, Real Estate	92.0	96.2	100.1	123.0	162.7	206.4	231.0	255.5
Community and Personal Services	4.4	5.8	7.6	9.6	13.0	16.9	20.7	25.4
Imputed Bank Service Charge	-10.9	-12.9	-14.2	-19.0	-24.6	-39.0	-43.9	-49.6
Producers of Government Services	69.3	90.5	109.2	137.9	194.6	260.5	305.0	360.0
Total	879.8	942.2	942.9	1,282.5	2,058.0	2,495.1	2,595.0	2,719.6
Import Duties	4.5	4.6	4.6	7.0	8.6	11.3	14.7	21.7
GDP at Purchaser's Value	884.3	946.8	947.5	1,289.5	2,066.6	2,506.4	2,609.7	2,741.3
Annual Growth Rate (%)	-	7.07	0.07	36.09	60.26	21.28	4.12	5.04

Table F-2 Foreign Trade

(Unit: million R.O)

Year	Total Recorded Imports	Exports			
		Oil	Re-export	Non-oil Export	Total
1971	13.8	87.6	N.A	0.4	88.0
1972	18.7	88.2	"	0.4	88.6
1973	40.7	114.3	"	0.6	114.9
1974	135.6	418.7	"	0.4	419.1
1975	264.3	488.1	"	1.1	489.2
1976	250.5	543.8	"	1.4	545.2
1977	302.1	545.9	"	1.5	547.4
1978	327.2	521.8	26.9	3.3	552.0
1979	430.5	745.7	37.0	4.7	787.4
1980	598.2	1,244.6	45.3	4.6	1,294.5
1981	790.3	1,526.4	88.9	6.6	1,621.9
1982	926.5	1,409.6	109.5	7.7	1,526.8
1983	860.9	1,346.6	110.0	10.7	1,467.3

Source: Statistical Year Book, 1983

Table F -3 Export and Re-export

(Unit: 1,000 R.O)

Items	1981			1982			1983		
	Re-export	Export	Total	Re-export	Export	Total	Re-export	Export	Total
Food and live animals	2,139.1	6,549.5	8,688.6	2,525.5	7,355.7	9,881.2	3,884.2	8,475.8	12,360.0
Beverage and tobacco	6,747.8	18.5	6,766.3	1,472.2	322.5	1,794.7	975.5	196.2	1,171.7
Crude materials, inedible, except fuels	707.5	15.8	723.3	717.0	59.9	776.9	799.4	85.3	884.7
Mineral fuels, lubricants and related materials	263.3	-	263.3	140.2	0.4	140.6	210.1	-	210.1
Animal and vegetable oils and fats	53.9	-	53.9	59.1	-	59.1	71.1	-	71.1
Chemicals	486.8	-	486.8	841.7	-	841.7	868.4	-	868.4
Manufactured goods	8,274.4	-	8,274.4	2,366.8	-	2,366.8	2,808.3	1,947.8	4,756.1
Machinery and transport equipment	62,688.1	-	62,688.1	92,416.7	-	92,416.7	86,823.2	-	86,823.2
Miscellaneous manufactured articles	3,006.0	-	3,006.0	1,359.9	-	1,359.9	1,517.6	-	1,517.6
Commodities & transaction not classified elsewhere	4,556.3	-	4,556.3	7,620.7	-	7,620.7	12,053.2	-	12,053.2
Total	88,923.2	6,583.8	95,507.0	109,519.8	7,738.5	117,258.3	110,011.0	10,705.1	120,716.1

Source: Statistical Year Book, 1983

Table F-4 Non-oil Exports

(Unit: 1,000 R.O)

Commodities	1981	1982	1983
Live animals	67.0 (1.0)	356.3 (4.6)	1,120.5 (10.5)
Fish frozen & dry	2,619.2 (39.8)	3,746.7 (48.4)	4,388.1 (41.0)
Wheat flour	838.6 (12.7)	850.0 (11.0)	664.3 (6.2)
Fruits & vegetables	2,850.6 (43.3)	2,270.0 (29.3)	1,888.9 (17.6)
Others	208.4 (3.2)	515.5 (6.7)	695.5 (6.5)
Copper	-	-	1,947.8 (18.2)
Total	6,583.8 (100)	7,738.5 (100)	10,705.1 (100)

Source: Statistical Year Book, 1983.

Note: Exports of copper commenced in 1983.

Table F-5 Proportion of Re-exported Goods

(Unit: %)

Commodities	1981	1982	1983
Food and live animals	2.4	2.3	3.5
Beverage and tobacco	7.6	1.3	0.9
Crude materials, inedible, except fuels	0.8	0.7	0.7
Mineral fuels, lubricants and related materials	0.3	0.1	0.2
Animal and vegetables oils and fat	0.1	0.1	0.1
Chemicals	0.5	0.8	0.8
Manufactured goods	9.3	2.2	2.6
Machinery and transport equipment	70.5	84.3	78.8
Miscellaneous manufactured articles	3.4	1.2	1.4
Commodities & transaction not classified elsewhere	5.1	7.0	11.0
Total	100.0	100.0	100.0

Table F-6 Non-oil Exports by Destinations, 1983

(Unit: 1,000 R.O)

Commodities	UAE	Qatar	Kuwait	Saudi Arabia	Bahrain	Lebanon	Jordan	Others	Total
Live animals	0.7	800.9	-	318.9	-	-	-	-	1,120.5
Fish frozen & dry	489.1	195.0	87.2	555.5	29.0	12.9	690.9	2,328.5	4,388.1
Wheat flour	664.3	-	-	-	-	-	-	-	664.3
Fruits & vegetables	606.8	265.4	547.1	17.6	323.9	-	8.0	120.1	1,888.9
Others	576.5	23.4	0.2	-	94.2	-	-	1.2	695.5
Copper	0.5	-	-	-	-	-	-	1,947.3	1,947.8
Total	2,337.9	1,284.7	634.5	892.0	447.1	12.9	698.9	4,397.1	10,705.1

Source: Statistical Year Book, 1983

Table F-7 Comparison between Imports and Exports of Foods and Live Animals

(Unit: 1,000 R.O)

Commodities	1981		1982		1983	
	Export	Import	Export	Import	Export	Import
Live animals	67.0	1,600	356.3	2,800	1,120.5	4,600
Meat and meat preparations	-	14,900	-	16,800	-	17,000
Dairy products and eggs	-	13,900	-	17,100	-	17,900
Fish and fish preparations	2,619.2	800	3,746.7	800	4,388.1	800
Cereals and cereal preparations	838.6	18,200	850.0	23,700	664.3	22,500
Fruits and vegetables	2,850.6	18,800	2,270.0	22,500	1,888.9	26,500
Sugar, sugar preparations and honey	-	5,600	-	4,400	-	4,800
Coffee, tea, cocoa, spices and manufactures thereof	-	6,300	-	6,200	-	6,400
Feeding stuff for animals (not including unmilled cereals)	174.1	1,200	132.7	2,100	414.0	1,700
Miscellaneous food preparations	-	3,400	-	3,700	-	4,900
Total	6,549.5	84,700	7,355.7	100,100	8,475.8	107,100
	(7.2%)	(92.8%)	(6.8%)	(93.2%)	(7.3%)	(92.7%)

Source: Statistical Year Book, 1983.

Note: Export means original Omani exports, not including re-export.

Table F-8 Proportion of each Commodities in Exports and Imports of Foods and Live Animals

(Unit: %)

Commodities	1981		1982		1983	
	Export	Import	Export	Import	Export	Import
Live animals	1.0	1.9	4.8	2.8	13.2	4.3
Meat and meat preparation	-	17.6	-	16.8	-	15.9
Dairy products and eggs	-	16.4	-	17.1	-	16.7
Fish and fish preparations	40.0	0.9	50.9	0.8	51.8	0.7
Cereals and cereal preparations	12.8	21.5	11.6	23.6	7.8	21.0
Fruits and vegetables	43.5	22.3	30.9	22.5	22.3	24.7
Sugar, sugar preparations and honey	-	6.6	-	4.4	-	4.5
Coffee, tea, cocoa, spices and manufactures thereof	-	7.4	-	6.2	-	6.0
Feeding stuff for animals (not including unmilled cereals)	2.7	1.4	1.8	2.1	4.9	1.6
Miscellaneous food preparations	-	4.0	-	3.7	-	4.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table F-9 Recorded Imports

(Unit: million R.O, %)

Commodities	1979		1980		1981		1982		1983	
	Value	%	Value	%	Value	%	Value	%	Value	%
Food and live animals	53.3	12.4	72.9	12.2	84.7	10.7	100.1	10.8	107.1	12.4
Beverage and tobacco	18.8	4.4	14.8	2.5	19.4	2.5	14.9	1.6	16.2	1.9
Crude materials, inedible, except fuels	5.1	1.2	9.9	1.7	11.4	1.4	13.3	1.4	12.6	1.5
Mineral fuels, lubricants & related materials	29.0	6.7	64.6	10.8	103.3	13.1	96.7	10.4	14.1	1.6
Animal and vegetable oils and fats	2.9	0.7	3.2	0.5	2.6	0.3	2.3	0.2	3.0	0.3
Chemicals	16.3	3.8	20.8	3.5	27.4	3.5	28.8	3.1	31.6	3.7
Manufactured goods	68.3	15.9	96.3	16.1	146.2	18.5	182.1	19.7	166.8	19.4
Machinery and transport equipment	171.4	39.7	235.7	39.4	312.6	39.6	390.1	42.2	396.2	46.0
Miscellaneous, manufactured articles	32.3	7.5	45.1	7.5	57.2	7.2	69.6	7.5	82.5	9.6
Commodities & transaction not classified elsewhere	33.1	7.7	34.8	5.8	25.5	3.2	28.6	3.1	30.8	3.6
Total	430.5	100	598.1	100	790.3	100	926.1	100	860.9	100

Table F-10 Recorded Imports by Regions and Countries

(Unit: %)

	1978	1979	1980	1981	1982	1983
Western Europe	41.4	41.9	35.7	29.9	36.1	38.8
United Kingdom	20.7	16.7	15.6	14.5	14.4	18.7
West Germany	6.4	6.2	5.6	4.3	8.3	7.3
Netherlands	2.5	7.8	5.6	2.5	3.0	3.3
France	2.8	3.5	1.8	2.4	3.3	2.2
Italy	2.0	2.2	1.8	1.9	1.7	2.1
Middle East	20.4	18.8	22.6	24.8	22.2	18.3
UAE	15.6	15.1	17.3	15.9	14.0	17.5
Iran	0.5	0.2	0.0	0.0	0.0	0.0
Kuwait	0.2	0.2	0.4	0.9	0.9	0.1
Lebanon	0.3	0.3	0.2	0.1	0.1	0.1
Bahrain	2.8	2.4	4.4	7.4	6.5	0.3
Others	1.0	0.6	0.3	0.5	0.7	0.3
Other Asia	27.8	27.0	30.5	32.8	29.6	31.2
Japan	15.5	15.4	19.7	22.6	20.7	22.0
India	4.4	3.7	2.9	2.6	2.2	2.3
Singapore	2.5	2.6	3.3	2.7	2.0	1.9
America	6.9	8.3	6.5	8.7	8.8	8.5
United States	6.3	8.0	5.7	7.7	8.0	7.7
Oceania	2.1	2.6	2.5	2.0	2.2	2.3
Australia	1.9	2.4	1.9	1.5	1.5	1.9
Eastern Europe	0.3	0.6	1.2	0.8	0.1	0.1
Africa	1.1	0.8	1.0	1.0	1.0	0.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table F-11 Price Index of Consumer Price of Foods at Capital Area

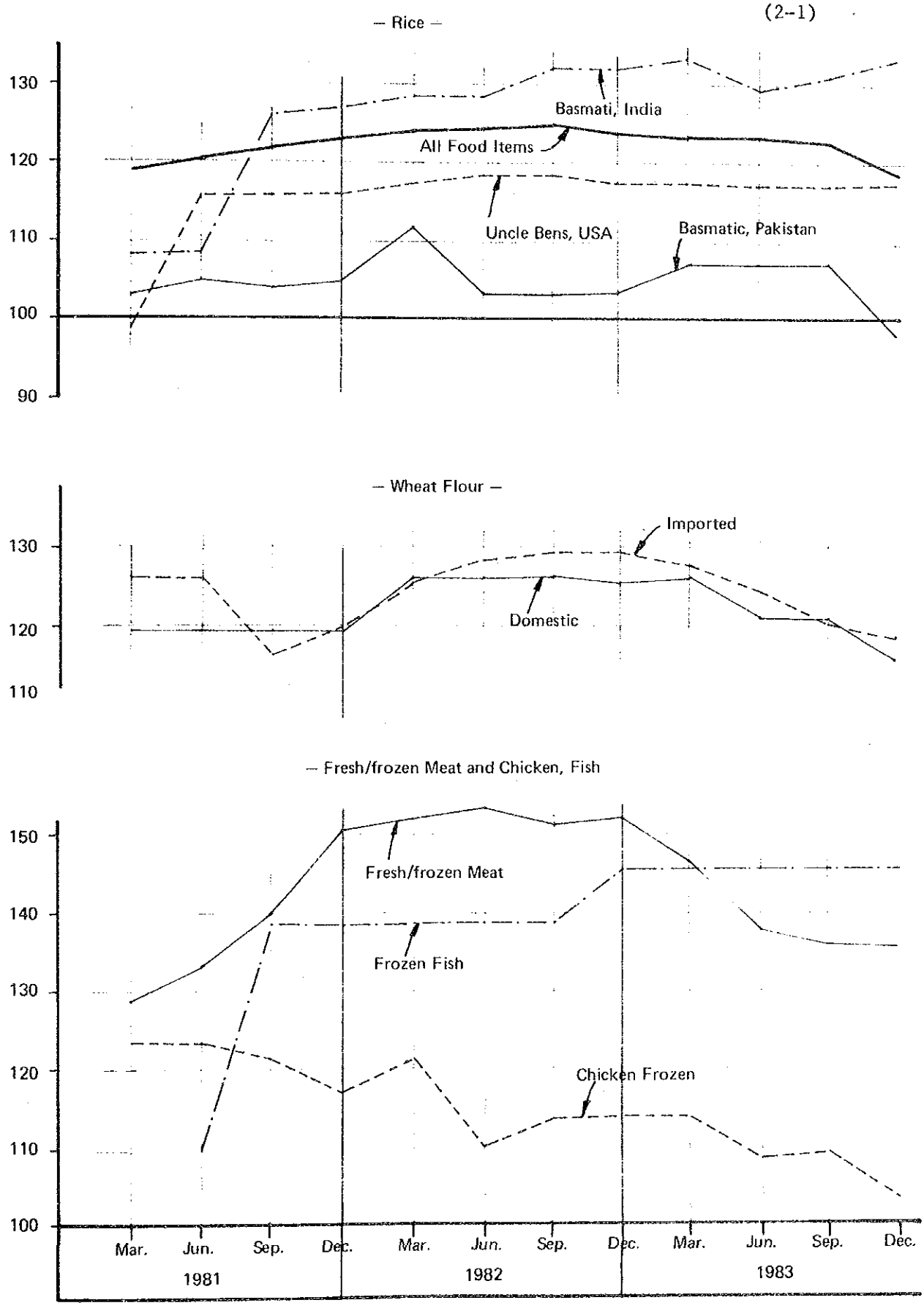
(1978 Price = 100)

	1981				1982				1983			
	Mar.	Jun.	Sep.	Dec.	Mar.	Jun.	Sep.	Dec.	Mar.	Jun.	Sep.	Dec.
Rice, Basmati, Pakistan	102.7	105.0	103.6	105.0	112.0	102.7	102.7	102.7	107.4	107.4	107.4	98.0
Rice, Basmati, India	108.3	107.6	126.6	127.0	128.5	128.5	132.3	132.3	133.3	129.8	131.0	133.6
Rice, Uncle Bens, USA	98.3	115.3	115.3	115.3	117.6	118.5	118.2	117.4	117.4	117.6	117.0	117.4
Wheat flour, domestic	119.3	119.3	119.3	119.3	126.0	126.0	126.0	125.1	126.0	121.6	121.2	116.3
Wheat flour, imported	125.7	125.7	116.6	119.8	125.7	128.1	129.6	129.6	127.2	124.0	120.1	118.3
Bread	122.0	122.0	122.0	122.0	128.0	128.0	129.4	131.1	129.4	131.1	131.1	129.9
Fresh/frozen meat	118.6	123.0	130.0	140.4	142.0	143.7	141.2	142.5	136.3	127.7	125.8	125.4
Chicken frozen	113.8	113.8	111.3	107.6	111.3	100.1	103.9	103.9	103.9	98.4	99.3	93.6
Eggs	148.3	135.6	133.5	144.3	150.1	153.5	153.5	153.5	153.5	153.5	153.5	153.5
Frozen fish	100.0	100.0	128.3	128.3	128.3	128.3	128.3	135.5	135.5	135.5	135.5	135.5
Fresh/evaporated milk	120.6	139.7	118.1	118.1	119.7	119.7	117.1	119.7	119.7	119.7	117.7	117.7
Butter/ghee	125.9	125.4	141.9	142.3	144.4	149.4	148.7	149.4	148.7	148.7	139.1	136.2
Fresh/dried fruits	111.7	114.8	125.2	122.4	113.9	121.6	119.3	118.0	122.7	133.6	133.6	115.0
Canned fruits	109.7	117.7	118.6	116.4	116.4	113.9	113.6	116.8	116.4	116.4	116.4	112.2
Fresh/dried vegetables	93.9	100.7	107.3	92.2	81.2	94.0	97.8	93.9	92.7	99.5	101.7	75.2
Canned vegetables	137.3	138.4	138.4	135.7	145.3	144.7	143.2	143.7	143.7	143.7	146.2	141.4
Frozen vegetables	135.2	134.2	136.5	135.6	108.8	105.6	104.0	105.9	108.3	106.0	105.3	98.6
Sugar	260.0	202.6	194.5	198.8	198.8	184.7	196.1	156.4	155.6	152.6	141.9	144.2

Source: Statistical Year Book, 1983

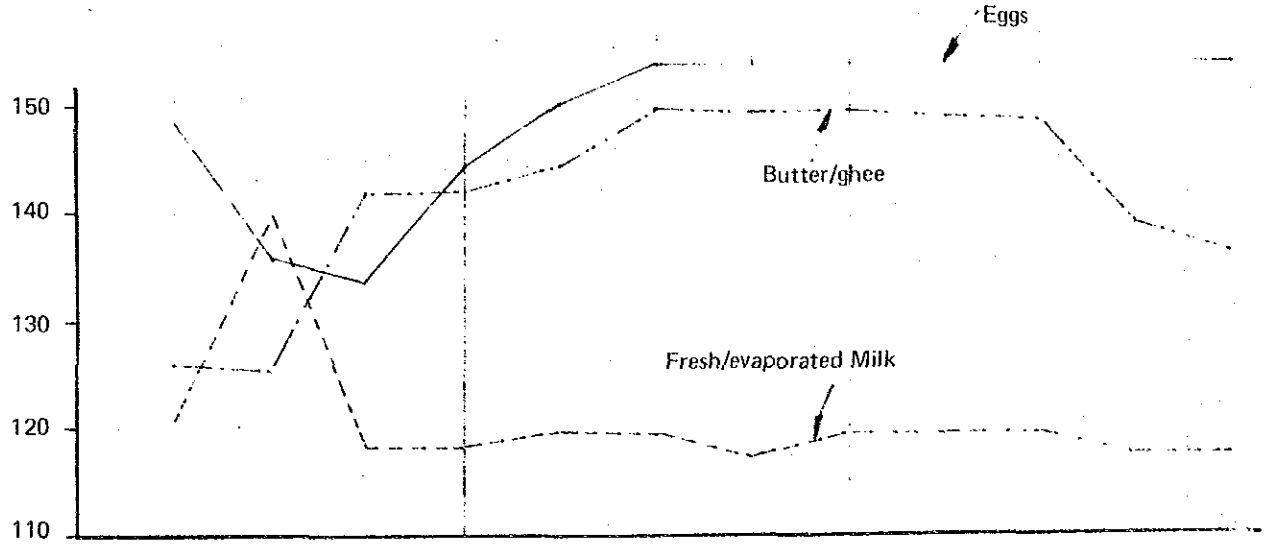
Figure F-1 Fluctuation of Consumer Price Index at Capital Area

(2-1)



— Dairy Products and Eggs —

(2-2)



— Vegetable and Fruits —

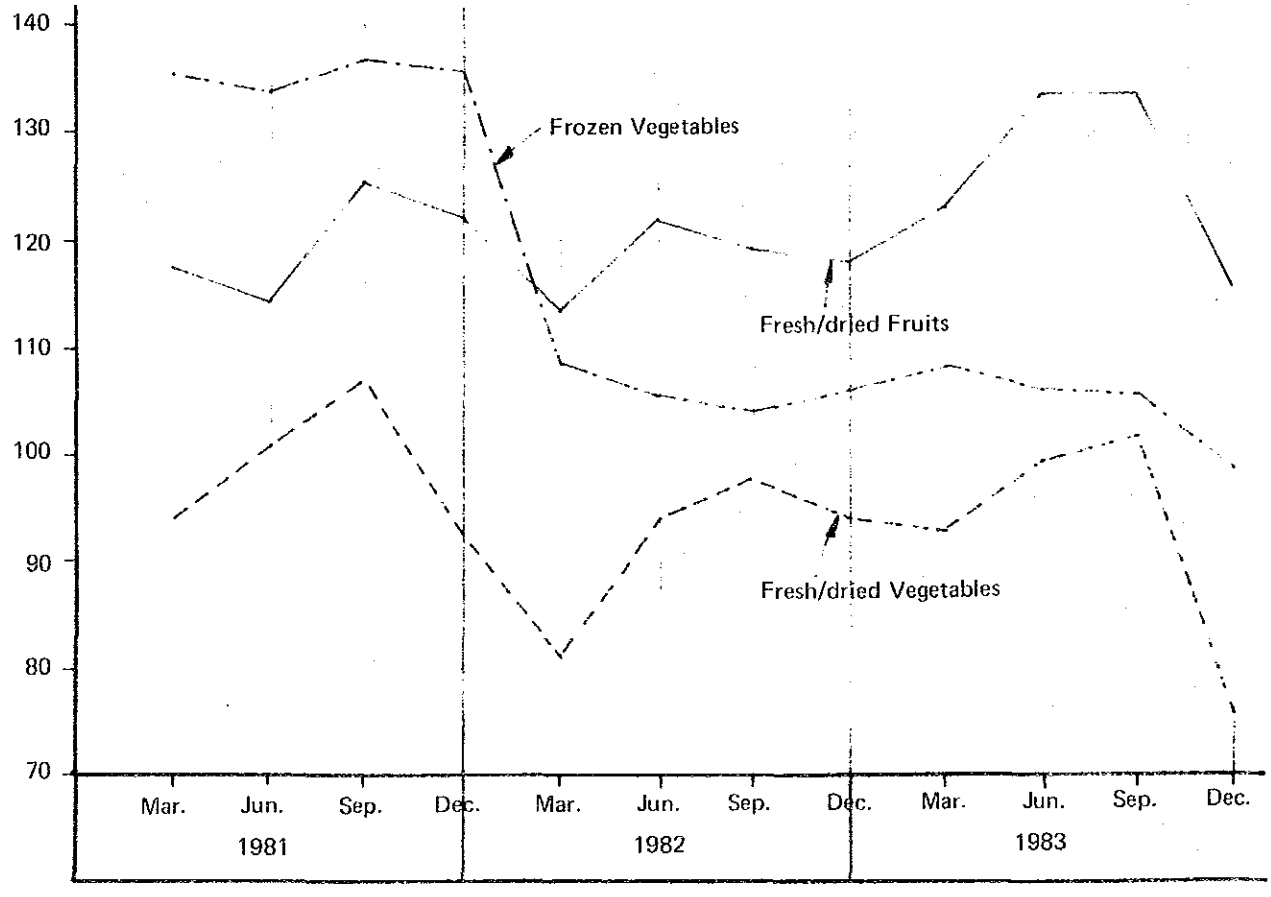


Table F-12 Consumer Price Index at Capital Area

(1978 Price = 100)

	1981				1982				1983			
	Mar.	Jun.	Sep.	Dec.	Mar.	Jun.	Sep.	Dec.	Mar.	Jun.	Sep.	Dec.
Cereal products	110.6	111.8	111.8	112.4	116.5	114.7	115.3	115.5	116.4	115.8	115.8	113.2
Meat and eggs	121.2	122.0	125.0	131.4	134.2	132.3	132.0	132.8	129.2	122.7	121.8	120.0
Fish	101.4	102.4	123.3	124.3	124.3	124.3	124.8	127.9	130.1	130.2	128.1	128.8
Milk products	120.7	124.5	123.7	128.1	132.8	132.0	131.7	131.0	129.9	129.5	125.2	124.3
Fruits and nuts	111.2	116.3	122.7	120.4	115.5	119.4	117.8	118.0	120.9	127.5	127.5	114.8
Vegetables	108.4	113.3	117.7	106.8	101.8	110.1	112.1	109.7	108.9	113.4	115.7	96.3
Sugar and Confectionery	205.1	167.9	162.8	163.9	163.0	155.5	160.8	134,6	134.3	129.5	127.9	129.7
Spices and salt	130.1	134.4	113.1	117.7	117.1	111.1	113.2	108.2	112.4	113.7	113.1	111.4
Fat and edible oils and ghee	123.8	123.8	119.9	124.0	119.8	121.3	120.9	124.5	119.8	119.3	134.0	134.3
Tea and Coffee	103.9	101.3	94.6	94.1	100.5	91.3	93.0	91.9	86.6	86.8	84.5	84.1
Beverages	131.8	129.6	131.4	132.9	132.5	152.6	153.2	152.1	146.9	145.9	142.0	141.9
Other food items	129.1	128.4	119.6	121.6	121.4	115.9	113.3	114.7	110.3	109.2	104.1	106.6
Cigarettes and tobacco	138.1	138.1	138.5	138.7	169.9	169.9	169.9	170.0	174.1	185.5	185.5	204.5
All food items	119.1	120.1	122.0	122.7	124.2	124.7	125.0	124.0	123.1	123.1	122.6	118.6

Source: Statistical Year Book, 1983

Table F-13 Price Index of the Building Materials

(1974 Price = 100)

	1979	1980	1981	1982	1983
Portland cement	112	137	128	93	64
White cement	109	145	148	127	108
Mild steel bars	97	97	89	64	57
Hard wood	121	124	169	140	134
Soft wood	75	87	70	62	60
Ply wood	106	108	171	137	118
Sand	121	158	163	177	200
Crusher	114	152	152	136	130
Pre-cast concrete blocks	152	165	159	156	153
Glass	111	112	126	123	125
PVC pipes	130	136	159	136	139
Cast iron pipes	119	117	124	127	111
Pitch fibre pipes	134	122	185	145	144
Emulsion paint	170	236	276	221	223
Gloss paint	155	190	225	224	184
Cement wash	140	152	217	236	210

Source: Statistical Year Book, 1983

Table F-14 Estimation of Shadow Exchange Rate

Imports	Value (million R.O)	(%)	Tariff (%)	Weighted Mean Tariff (%)
Beverages	8.2	0.01	75	0.75
Tabacco	8.6	0.01	30	0.30
Selected Construction Materials with 20% Tariff	96.8	0.11	20	2.20
Food, Free of Duty	87.8	0.10	0	0
Fertilizer	3.2	0.00	0	0
Cement	38.6	0.05	0	0
Petroleum Products	69.1	0.08	0	0
All Other Goods	546.9	0.64	2	1.28
Sub-total	859.2 (35.8)	1.00	-	4.53
Exports	1,538.6 (64.2)			
Total	2,397.8 (100.0)			

Source: Statistical Year Book, 1983 and Oman Facts and Figures

Note: Trading value was averaged for the period 1981 to 1983.

Import: 35.8% x 4.53 = 1.62%

Export: 64.2% x 0 = 0

Shadow Exchange Rate: 1.62 - 0 = 1.62% = 1.6%

Official Exchange Rate: US$ = 0.342 R.O

Shadow Exchange Rate : US$ = 0.347 R.O (0.342 x 1.016)

Standard Conversion Factor: 0.342/0.347 = 0.986

2. Estimation fo Agricultural Benefit

Table F-15 Economic Farm-gate Price of Crops

(Unit: R.O/ton)

Crops	Farm-gate Price BZ/kg	Farm-gate Price R.O/ton	Transportation Cost (R.O/ton)	Financial Farm-gate Price	Economic Farm-gate Price
Onion	300	300	0.4 1/	299.6	295 2/
Tomato	250	250	0.4	249.6	246
Watermelon	250	250	0.4	249.6	246
Cabbage	250	250	0.4	249.6	246
Eggplant	200	200	0.4	199.6	197
Red Pepper	300	300	0.4	299.6	295
Dates	200	200	0.4	199.6	197
Lime	650	650	0.4	649.6	641
Banana	250	250	0.4	249.6	246
Alfalfa	70	70	0.4	69.6	69
Cauliflower	300	300	0.4	299.6	295

Note: 1/ Transportation cost was estimated as fcllows.

Distance: farm to Sohar Market 8 km

Cost/km/ton: 50 Baiza

50 BZ/km/ton x 8 km = 0.40 R.O/ton

2/ Economic farm-gate price was calculated by using Standard Conversion Factor of 0.986 (refer to Table G-14)

Table F-16 Economic Farm-gate Price of Pesticides

(Unit: R.O/lit.)

	Financial	Economic
Diahane	1.6	1.58
Kafil	1.6	1.58
Dimethoate 40EC	1.6	1.58
Pirimor	0.1	0.10
Omit	1.6	1.58
Furadan	1.5	1.48
Nemacur	1.5	1.48
Nogos	0.03	0.03

Note: Economic price was calculated by using Standard Conversion Factor of 0.986

Table F-17 Economic Farm-gate Price of Seeds

(Unit: R.O/kg)

	Financial	Economic
Tomato	4	3.94
Watermelon (Winter)	4	3.94
Watermelon (Summer)	4	3.94
Cabbage	2.5	2.47
Red Pepper	2	1.97
Eggplant	2	1.97
Alfalfa	20	19.72
Dates	1.5	1.48
Lime	0.3	0.30
Banana	0.05	0.05

Table F-18 Price Structure of Urea

(Unit: R.O/ton)

	Item		1985 Financial	1985 Economic	1995 Financial	1995 Economic
1.	Export price, F.O.B. Europe (US$/ton)	(1)	190	190	265	265
2.	Ocean freight (US$/ton)	(2)	35	35	35	35
3.	Import price, C.I.F., Mutrah (US$/ton)		225	225	300	300
	(R.O/ton)	(3)	77	77	103	103
4.	Port handling, storage and processing	(4)	12	11.8	15	14.8
5.	Ex-godown price		89	88.8	118	117.8
6.	Transport cost from Port Mutrah to Sohar		13	12.8	14	13.8
7.	Unloading charge and others at warehouse		6	5.9	7	6.9
8.	Transport cost from warehouse to farm		2	2.0	2	2.0
9.	Farm-gate price per ton	(5)	110	109.5	141	140.5
10.	Farm-gate price, per 50 kg bag		6	5.5	7.1	7.0
11.	N: R.O. per kg (N = 45%)		0.27	0.24	0.32	0.31

Note: (1) Constant price in 1985 were estimated based on the "Price Prospects for Major Primary Commodities" by IBRD, January 1985.
(2) Ocean freight was assumed refering to the Appraisal Report of ADB on the irrigation project in other country.
(3) Official exchange rate is US$1.00 = R.O.0.342, R.O.1.00 = US$2.924
(4) Port handling, storage and processing cost was assumed at around 15 percent of R.O.88.
(5) Oman Sun Farm imported directly Urea with 120 R.O/ton from Saudi and Kewait.

Table F-19 Price Structure of TSP

(Unit: R.O/ton)

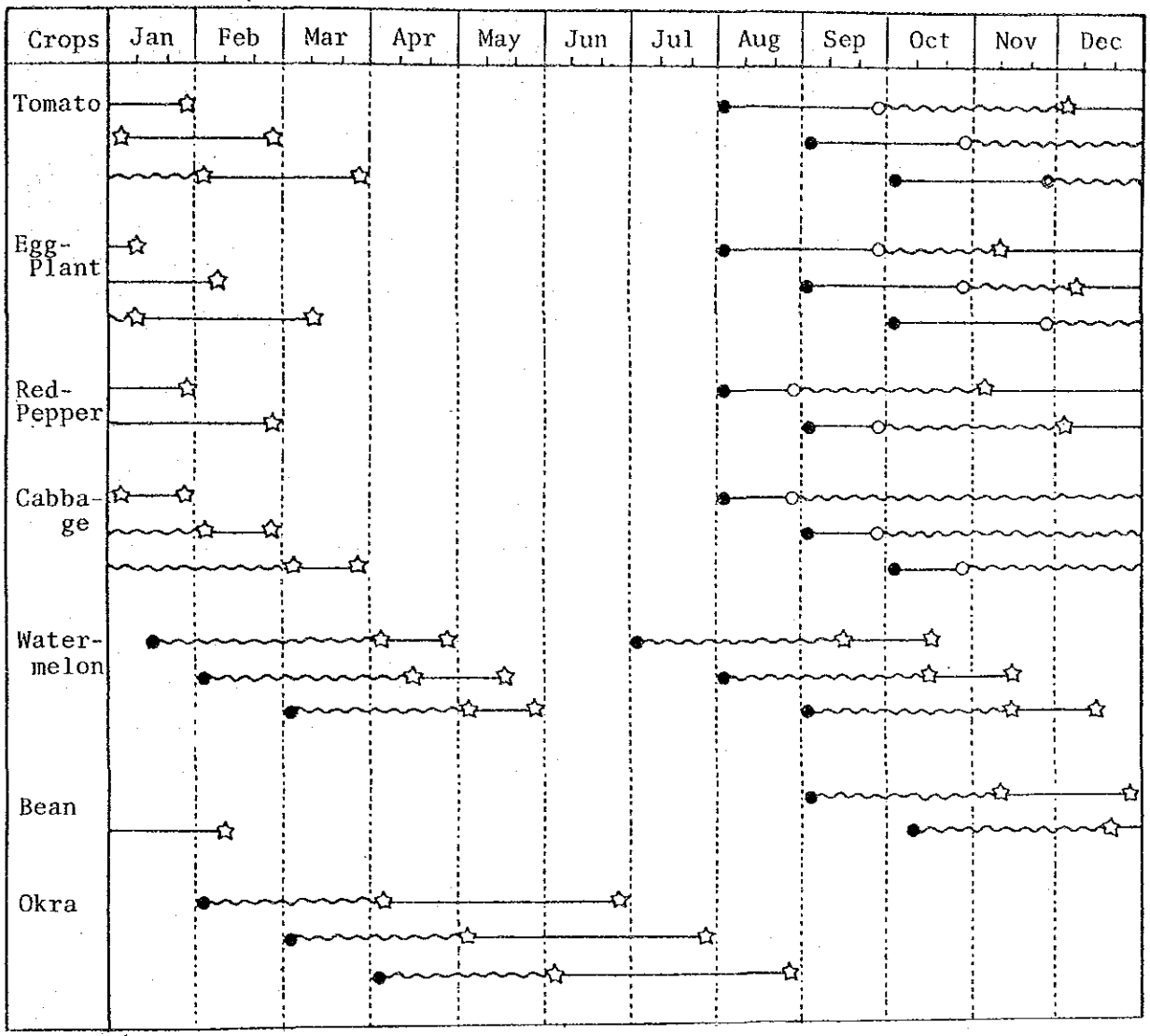
Item	1985 Financial	1985 Economic	1995 Financial	1995 Economic
1. Export price, F.O.B. U.S. Gulf (US$/ton)	150	150	173	173
2. Ocean freight (US$/ton)	50	50	50	50
3. Import price C.I.F. Mutrah (US$/ton)	200	200	223	223
(R.O/ton)	68	68	76	76
4. Port handling, warehouse and processing	13	12.8	15	14.8
5. Ex-godown price	81	80.8	91	90.8
6. Transport cost from Port Mutrah to Sohar	12	11.8	13	12.8
7. Unloading charge and others at warehouse	5	4.9	6	5.9
8. Transport cost from warehouse to farm	2	2.0	2	2.0
9. Farm-gate price per ton	100	99.5	112	111.5
10. Farm-gate price per 50 kg bag	5.0	5.0	5.6	5.6
11. P: R.O. per kg (P_2O_5 = 40%)	0.25	0.25	0.28	0.28

Table F-20 Price Structure of Potassium Chloride

(Unit: R.O/ton)

Item	1985		1995	
	Financial	Economic	Financial	Economic
1. Muriate of Potash (F.O.b. Vancouver) (US$/ton)	90	90	102	102
2. Ocean freight (US$/ton)	100	100	100	100
3. Import price, C.I.F. Mutrah (US$/ton)	190	190	202	202
(R.O/ton)	65	65	69	69
4. Port handling, warehouse and processing	10	9.9	11	10.8
5. Ex-godown price	75	74.9	80	79.8
6. Transport cost from Port Mutrah to Sohar	12	11.8	13	12.8
7. Unloading charge and others at warehouse	5	4.9	6	5.9
8. Transport cost warehouse to farm	2	2.0	3	3.0
9. Farm-gate price per ton	94	93.6	102	101.5
10. Farm-gate price per 50 kg bag	4.7	4.7	5.1	5.1
11. K: R.O per kg (K_2O = 60%)	0.16	0.16	0.17	0.17

Figure F-2 Proposed Cropping Pattern



Note;

- Nursery period
- Seedling
- Harvesting
- Planting and ripening

Table F-21 Present Labor Requirement by Crops

(Unit: hrs/ha)

Crops	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Dates	112	136	92	60	92	160	162	192	60	62	90	92	1,310
Lime	137	86	152	140	72	290	262	62	105	77	60	97	1,540
Banana	129	56	107	114	86	84	146	89	84	119	87	129	1,230
Tomato	272	135	34	-	-	-	-	160	100	134	1,005	212	2,052
Alfalfa	85	80	88	83	85	86	85	85	86	85	83	88	1,019
Okra	89	86	122	180	192	146	34	-	-	-	-	-	849
Cabbage	82	320	18	-	-	-	-	5	157	431	129	112	1,254
Eggplant	262	78	-	-	-	-	-	160	95	111	816	354	1,876

Table G-22 Total Labor Requirement in the Project Area

(Unit: 1,000 hrs)

Crops	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Dates (1,820 ha)	204	248	167	109	167	291	295	349	109	113	164	167	2,383
Lime (392 ha)	54	34	60	55	28	114	103	24	41	30	24	38	605
Banana (128 ha)	17	7	14	15	11	11	19	11	11	15	11	17	159
Tomato (17 ha)	5	2	1	-	-	-	-	3	2	2	17	4	36
Alfalfa (166 ha)	14	13	15	14	14	14	14	14	14	14	14	15	169
Okra (5 ha)	1	1	1	1	1	1	1	-	-	-	-	-	7
Cabbage (6 ha)	1	2	1	-	-	-	-	1	1	3	1	1	11
Eggplant (10 ha)	3	1	-	-	-	-	-	2	1	1	8	4	20
Total	299	308	259	194	221	431	432	404	179	178	239	246	3,390

Table F-23 Estimation of Available Labor Resources in the Project Area

(1) Total labor in Sohar Wilaya

	Family Labor		Hired Labor		Total	
	Percent	No.	Percent	No.		(%)
Full time labor	88.8	3,193	63.1	1,374	4,567	(79.1)
Part time labor	5.6	201	18.5	403	604	(10.5)
Casual labor	2.1	76	10.8	235	311	(5.4)
Full time x Part	2.1	76	3.1	68	144	(2.5)
Full x Casual	0.7	25	3.1	68	92	(1.5)
Part x Casual	0.7	25	1.4	30	55	(1.0)
Total	100.0	3,596 (62%)	100.0	2,178 (38%)	5,774 (100%)	(100.0)

(2) Labor Resources in the Project Area

Total households 3,564

No. of farm household 2,100

No. of family labor 3,596 persons x 2,100/3,564

= 3,596 x 0.589 = 2,118

No. of hired labor 2,178 persons x 0.589 = 1,283

	Family Labor		Hired Labor	
	Percent	Person	Percent	Person
Full time labor	90.9	1,925	69.3	889
Part time labor	6.3	134	19.9	255
Casual labor	2.8	59	10.8	139
Total	100.0	2,118	100.0	1,283

Source: Estimation by JICA F/S Team

Table F-24 Labor Resources (1)-Family Labor

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Working hour per day	8	8	8	8	5	5	5	8	8	8	8	8
Full time labor												
Working days per month	25	25	25	25	25	30	30	25	25	25	25	25
No. of laborers	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925	1,925
Working hours (1,000) (A)	385	385	385	385	241	289	289	385	385	385	385	385
Part time labor												
Working days per month	13	13	13	13	13	15	15	13	13	13	13	13
No. of laborers	134	134	134	134	134	134	134	134	134	134	134	134
Working hours (1,000) (B)	14	14	14	14	9	20	20	14	14	14	14	14
Casual labor												
Working days per month	25	25	25	25	25	30	30	25	25	25	25	25
No. of laborers	59	59	59	59	59	59	59	59	59	59	59	59
Working hours (1,000) (C)	12	12	12	12	7	9	9	12	12	12	12	12
(A) + (B) + (C)	411	411	411	411	257	318	318	411	411	411	411	411

Table F -25 Labor Resources (2) Hired Labor

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Working hour per day	8	8	8	8	5	5	5	8	8	8	8	8
Full time labor												
Working days per month	25	25	25	25	25	30	30	25	25	25	25	25
No. of laborers	889	889	889	889	889	889	889	889	889	889	889	889
Working hours (1,000) (A)	178	178	178	178	111	133	133	178	178	178	178	178
Part time labor												
Working days per month	10	10	10	10	10	15	15	10	10	10	10	10
No. of laborers	255	255	255	255	255	255	255	255	255	255	255	255
Working hours (1,000) (B)	20	20	20	20	13	19	19	20	20	20	20	20
Casual labor												
Working days per month	10	10	10	10	10	15	15	10	10	10	10	10
No. of laborers	139	139	139	139	139	139	139	139	139	139	139	139
Working hours (1,000) (C)	11	11	11	11	7	10	10	11	11	11	11	11
(A) + (B) + (C)	209	209	209	209	131	162	162	209	209	209	209	209

Table F-26 Estimation of Marginal Cost of Hired Farm Labor

(Unit: 1,000 hrs)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Requirement	299	308	259	194	221	431	432	404	179	178	239	246	3,390
Actual labor													
Family labor	411	411	411	411	257	318	318	411	411	411	411	411	4,592
Hired labor	209	209	209	209	131	162	162	209	209	209	209	209	2,336
Total	620	620	620	620	388	480	480	620	620	620	620	620	6,928
Ratio of hired labor (%)	34	34	34	34	34	34	34	34	34	34	34	34	34

Marginal salary of hired farm labor

Monthly salary rate 60 R.O x 0.632 = 37.9 = 38 R.O/month

Note: 1) Number of hired labor is estimated at 1,293 persons.

2) Available maximum hired labor per month is calculated as follows:

1,283 persons x 8 hour x 30 days = 307,920 ≈ 308,000 hours

3) $$\frac{\frac{209}{308}+\frac{209}{308}+\frac{209}{308}+\frac{209}{308}+\frac{131}{308}+\frac{162}{308}+\frac{162}{308}+\frac{209}{308}+\frac{209}{308}+\frac{209}{308}+\frac{209}{308}+\frac{209}{308}}{12} = 0.632$$

Table F-27 Net Production Value by Crop with Project

	Gross Prod. Value			Production Cost (RO/ha)							NPV
	Yield (ton/ha)	RO/ton	RO	Seed	Fertilizer	Chemical	Agri. Machine	Labor	Miscellaneous Cost	Total	(RO/ha)
Lime	20	641	12,820	-	216	11	630	243	1,260	2,360	10,460
Banana	13	246	3,198	-	145	160	770	194	1,260	2,529	669
Tomato	40	246	9,840	2	216	22	1,239	327	1,260	3,066	6,774
Cabbage	25	246	6,150	9	190	5	753	198	1,260	2,415	3,735
Watermelon (Winter)	15	246	3,690	14	216	-	390	125	1,260	2,005	1,685
Watermelon (Summer)	10	246	2,460	14	216	3	489	129	1,260	2,111	349
Eggplant	25	197	4,925	2	216	10	890	296	1,260	2,674	2,251
Redpepper	15	295	4,425	2	216	6	483	217	1,260	2,184	2,241
Alfalfa	60	69	4,140	-	190	46	1,084	160	1,260	2,740	1,400

Table F-28 Incremental Benefit by Protection of Salt Injury

Year	Without Project		With Project		Incremental Benefit
	Cropped Area (ha)	NPV (1,000 RO)	Cropped Area (ha)	NPV (1,000 RO)	(1,000 RO)
1986	1,100	52	1,100	52	-
1987	1,100	52	1,100	52	-
1988	1,100	52	1,100	52	-
1989	1,100	52	1,100	96	44
1990	1,100	52	1,100	96	44

Note: (1) Dates Yield

Present	1.3 tons/ha
With Project	1.5 tons/ha (+ 15%)

(2) NPV per ha

	GPV	PC	NPV
Without Project	1.3 x 197 = 256	209	47 RO/ha
With Project	1.5 x 197 = 296	209	87 RO/ha

NPV: Net Production Value

GPV: Gross Production Value

PC : Production Cost

3. Flood Damage Study

(1) The precipitation on February 12 to 14, 1982, was the largest one which have been observed by the rain gauge at Sohar Office of Department of Water Resources and Irrigation. This heavy rain damaged heavily to the North Batinah Region. After one week it rained again.

The precipitation on February, 1982 is shown as follows.

Feb. 12th	0.6 mm	22th	4.7 mm
13 "	91.0 "	23 "	17.0 "
14 "	16.0 "	24 "	7.9 "

(2) Flood flow down many Wadi spreading on the river bed and flow into the sea through mainly the Wadi Sallan and Wadi al Khadaq crossing the national road. The national road concerned in the Project Area has 10 crossing points, constituting eight culverts and four Irish-crossing.

The elevation at the Irish-crossing point where the Wadi Al Jizzi cross over the national road is 7.9 meters comparing with road surface with elevation of 13.5 meters. This point shows the lowest elevation on the national road concerned. Therefore, it is considered the greater parts of flood discharge will flow into the sea through the Irish-crossing point.

It is said that the overflow at above mentioned point has been caused from the precipitation of around 40 mm per day and over. But the staff at the Sohar Office of Department of Water Resources and Irrigation informed that the rainfall of 15.2 mm on April 30, 1981 brought the overflow at Irish-crossing point owing to the previous rainfall during April 26 to 28.

Considering above mentioned experiences, the frequency of flood and inundation at the Irish-crossing point would be assumed one time per year.

(3) Types of flood damage are classified as followings.

- ° Social and economic damages with the stop of traffic.
- ° Inundation of the upland along the national road.
- ° Vegetables in seaside area is also inundated.
- ° Loss of livestock.
- ° Damage of cars by flood stream.
- ° When the flood occurs at high tide time, the water in the river channel of Wadi Sallan will overflow the dike and inundates the residence area and flow into the sea through the road. A part of inundated water would give damages to vegetables.
- ° Many buildings in the farms located at the inside of the national road are constructed simply.
- ° Farm land along the Wadi is surrounded by sandy levees to protect floods. But the strong flush water destroy these levees and then the farm lands would be eroded.

Of the eight types of flood damage mentioned above, followings studied to measure as monetary terms.

1) Damaged value of vegetables will be estimated based on actual situation. Every farms are surrounded by the fence made of wire. The careful farmers have built small sandy levees with 30 to 50 centimeter high along the fence to protect invasion of flood water. Vegetables cultivated in the farms without levee or with incompleted levee have been suffered from floodwater. Especially, the field on which a seedling of vegetable has just finished or the vegetable which is in early growing stage were damaged

heavily. Some ridges in fields were eroded by floodwater and as the results farmers have to repair the ridges. These labors needed for repairing will be estimated in monetary terms based on some assumption.

2) Loss of livestocks was not found in the period of flood on February 14, 1982. Staff of Sohar Office of Department of Water Resources said that TV and radio forecasted weather correctly, then the inhabitants could avoid loss of livestock.

3) Both side of Wadi are natural earth bank. A part of banks have been destroyed by flood. Farmer lived in farm along the Wadi have to repair banks after flood. The repair cost of banks will be estimated as flood damage.

Estimation of Damaged Value

(1) Vegetable

1) Inundated area on February 12 to 14, 1982

a) Seasonal cropping field ..... 338 ha

b) Palm trees area ..... 275 ha

Total 613 ha

2) Inundated upland on February 12 to 14, 1982

	a)	b)	Total
Field area (total)	338	275	613
Cropped area (0.80)	270	220	490
Fruits	45	220	300
Vegetables	95	5	100
Fodder crops	80	5	85
Fallow	50	-	50

3) Growing stage of main vegetables on February 12 to 14, 1982: Tomato, eggplant, redpepper, cabbage and bean were in a harvesting season. Watermelon for winter season and okra were in the stage of seedling.

4) Damaged acreage of vegetables

a) Production loss

Watermelon	100 ha	x	20%	x medium matured	50%	= 10 ha
Tomato	100 "	x	10%	x		= 10 "
Eggplant	100 "	x	10%	x		= 10 "
Redpepper	100 "	x	5%	x		= 5 "
Cabbage	100 "	x	20%	x		= 20 "
Okra	100 "	x	5%	x		= 5 "
Bean	100 "	x	5%	x		= 5 "
			Total			65 ha

b) Area of eroded ridges ..... 100 ha

5) Damaged value

a) Production loss

Watermelon 1,020 R.O.

Seed cost	9.5 R.O.x 10 ha = 95 R.O.
Fertilizer	85 R.O. x 10 ha = 850 R.O.
Labor of seedling	46 hr x 10 ha = 460 hr 460 hr - 8 hr = 58 man-day 58 days x 1.3 R.O. = 75 R.O.

Okra 548 R.O.

Seed cost	10 R.O. x 5 ha = 50 R.O.
Fertilizer	85 R.O. x 5 ha = 425 R.O.
Labor of seedling	450 hr - 8 hr = 56 man-day 56 days x 1.3 R.O. = 73 R.O.

Tomato

NPV: 1,761 R.O/ha x 10 ha = 17,610 R.O.

Eggplants

2,981 R.O/ha x 10 ha = 29,810 R.O.

Redpepper

1,106 R.O/ha x 5 ha = 5,530 R.O.

Cabbage

5,241 R.O/ha x 20 ha = 104,820 R.O.

Bean

874 R.O. x 5 ha = 4,370 R.O.

Sub-total 163,708 R.O.

(2) Repair cost of ridges

100 ha x 15 days x 2 labor = 3,000 days

3,000 days - 30 days x 38 R.O/M.M = 3,800 R.O.

(3) Repair cost of bank

6 R.O/m^3/m x 0.632 (shadow rate) x 200 m x 11 bank

= 8,340

(4) Damage value (1,000 R.O.)

Production loss	163.7
Repair cost of ridges	3.8
Repair cost of Wadi bank	8.3
Total	175.8

Consequently, the damage value is estimated at 35,000 R.O per year taking into consideration the five year probability of precipitation.

4. Incremental Production of Existing Date Palm Orchards

The existing date palm orchards in the Project Area stretch in 3-4 km wide strip land along the sea shore.

The groundwater in the sea shore area, holding water table ranging from 1.5 m to 0 m, has a salinity concentration of 1,000 to 3,000 mmho/cm. The recent rapid increase of groundwater consumption suggests that the salinity concentration of the groundwater in this area will grow higher. The higher salinity concentration in the groundwater will result in lower quality of dates and decrease in their production. The Project, however, will allow to recharge the groundwater and prevent the sea water intrusion for saving dates production from yield decrease as well as from degrade the quality. The estimation of the benefits to be generated was made based on the estimation as follows.

The dates production was presumed at 1.5 ton/ha for the high class and 1.3 ton/ha for the low class in production, respecitvely.

The existing acreages of the date orchards developing in the related area of the project were estimated at 1,100 ha by measurement on the map. Consequently, the incremental production with the Project was estimated at 220 ton.

(1.5 ton/ha - 1.3 ton/ha) x 1,100 ha = 220 ton

5. Estimation of Water Supply Benefit

Table F-29 Water Cost per Cubic Meter per Year at Ghubrah Desalination Plant

(1) Capital Cost per cubic meter per year

Capital Cost per cubic meter .... 1.0 R.O.

Percentage of redemption by annual installments

$$R = \frac{i\,(1+i)^n}{(1+i)^n - 1}$$

n = 20

R = 0.1174

i = 0.10

Capital cost per cubic meter per year

1.0 R.O. x 0.1174 = 117 BZ.

(2) Variable Cost per cubic meter per year

Case 1 ..... 440 Baizer (refer to Table G-31)

Case 2 ..... 503 " (refer to Table G-32)

(3) Annual total water cost per cubic meter

Case 1 ..... 117 + 440 = 557 Baizer

Case 2 ..... 117 + 503 = 620 "

(4) Water Supply Benefit

* Case 1 0.557 R.O. x 1,060,000 m^3 = 590,420 R.O.

Case 2 0.620 R.O. x 1,060,000 m^3 = 657,200 R.O.

Note: Variable cost of case 1 is based on the Feasibility Report, The Wadi AL KHAWD, 1981 (refer to Table G-31) and case 2 is based on the information from Ministry of Electricity and Water (refer to Table G-32).

* For the project justification, water supply benefit of case 1 was used.

Table F-30 Capital Cost per Cubic Meter at Ghubrah Desalination Plant (Extension)

(1) Construction Cost ..... 10 million R.O.

This Plant is scheduled to supply water from July, 1982.

(2) Production ..... 6.0 million gallon per day

one cubic meter = 220 gallon (gallon = 4.546 liter)
6.0 million/220 = 27,272 cu.m per day
27,272 x 365 = 9,954,280 cu.m per year
(0.75 = optimal load factor)

(3) Capital cost per cubic meter

10 million R.O./9.954 MCM = 1.0 R.O per cu.m
= 4.5 BZ per gallon

Note: Above data is based on the information from the Ministry of Electric and Water, Directorate Planning and Project.

Table F-31 O & M Cost per Cubic Meter at Desalination Plant (1)
(based on the Feasibility Report, The Wadi Al Khawd)

(1)	Total production	6.21 MCM
(2)	Operating cost (1,000 R.O)	1,535
(3)	Fixed operating cost (1,000 R.O.)	262
(4)	Variable cost (1,000 R.O.) (2) - (3)	1,273
(5)	Variable treatment cost (1,000 R.O.)	267
(6)	Total variable cost (1,000 R.O.)	1,540
(7)	Variable cost per cubic meter	248 Baiza
(8)	The costs in 1985	

$$248 \times (1.10)^{6} = 440 \text{ Baiza per cubic meter}$$

Source: The Feasibility Report, The Wadi Al Khawd, Aquifer Recharge Project, 1981, Aug.

Table F-32 O & M Cost per Cubic Meter at Desalination Plant (2)
(based on the information from Ministry of Electricity and Water)

(1) Existing Ghubrah Desalination Plant was established in 1975 and have supplied water since 1977

(2) Production ..... 6.0 million gallon per day

6.0 million gallon/220 gallon/m^3 = 27,272 cu.m per day
27,272 x 365 = 9,954,280 cu.m per year
(Optimal load factor is not considered to estimate moderately)

(3) O & M Cost ..... 5.0 million R.O per year
5.0 million R.O./9.954 million cu.m = 502 BZ per cu.m
502 BZ/220 gallon = 2.28 BZ per gallon

(4) Delivery Cost 2.0 BZ per gallon

(5) Fixed O & M Cost 2.28 x 0.17 = 0.39 BZ per gallon
(17% is based on the Feasibility Report on the Wadi Al Khawd)

(6) Variable O & M Cost 2.28 - 0.39 = 1.89 BZ per gallon

(7) Variable Treatment Cost 0.40 BZ per gallon

(This figure was assumed based on the Feasibility Report on the Wadi Al Khawd)

(8) Total Variable Cost 1.89 + 0.40 = 2.29 BZ per gallon
One cubic meter = 220 gallon
Variable cost per cubic meter 2.29 x 220 = 503 Baiza

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