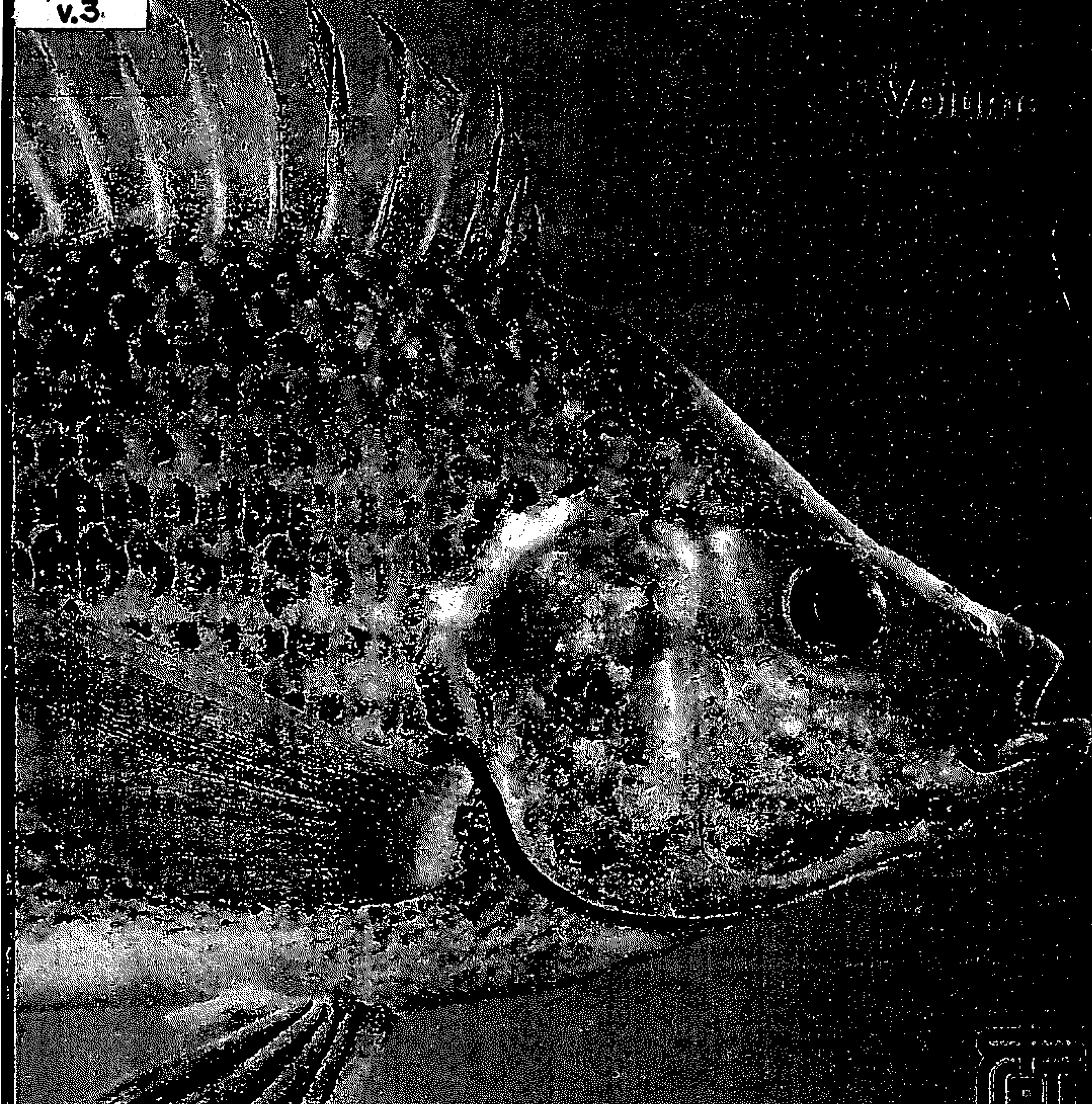
TILAPIA CULTURE IN KUWAIT

A FEASIBILITY STUDY

Volume



KUWAIT INSTITUTE FOR SCIENTIFIC RESEARCH

TECHNOLOGY INVESTMENT COMPANY

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

Tilapia culture in Kuwait: a feasibility study.

FEASIBILITY OF PRODUCTION TILAPIA IN KUWAIT

Volume 3
Technical Design and Appendices

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PREFACE TO VOLUME 3

This is the third volume in a three volume study which examines the feasibility of culturing tilapia in brackishwater in Kuwait. This volume contains the technical details of the proposed fish farm and various appendices. The other 2 volumes contain the marketing and economic analysis and the summary report.

CONTENTS OF VOLUME 3

CHAPTER 10. OPERATIONAL DESIGN

GENERAL

This chapter presents the operational design of the fish farm. Included are the design parameters and operational guidelines. The design parameters are based on using either *Oreochromis aureus* (blue tilapia) or *O. spilurus*. In order to accelerate the commissioning of each farm phase, a complete complement of fingerlings will be purchased from outside sources at the start of each phase. Fully grown breeding stock will also be purchased in phase I to accelerate development.

The standard production module will produce 100 t of 300 g (average) tilapia in one year. All computations in this chapter are based on this module. As the module is designed for continuous sales of fish throughout the year, average weekly production is 6400 fish weighing a total of 1920 kg. Maximum density is 50 kg/m^3. In order to harvest at the rate of one tank per week, 40 m^3 grow-out tanks should be used. To maximize tilapia growth, temperatures should be maintained as close to 28-30°C as possible (A detailed discussion of heat management in the fish tanks is presented in Chapter 13).

Tank utilization efficiency is maximized by using a multi-stage production system. There are eight stages (Table 10.1) with a duration of approximately 37 weeks from egg collection to delivery of market-size fish. Small fish are kept at high densities (number/m^3) in small tanks and are moved to larger tanks as they grow. This reduces density. As fish are harvested from the cleansing tanks, small fish are shifted throughout the system to the emptied tanks. Overall survival from egg to market-size is estimated to be 44%. From swim-up fry (0.02g) to market, survival is 73%.

BREEDING AND HATCHING STAGES

A conservative fry production estimated of 10 fry/kg ♀/day for a 365 day spawning season was selected. Thus, 130 kg of females will be required in the spawning tanks. The males/females ratio will be 1 : 3. As males often weigh approximately twice as much as females, 100 kg of males are needed. Approximately 300 kg of females and 200 kg males are kept as reserve breeders for replacement of breeding stock that become exhausted. The density in the breeding tank will be 1 kg +/m^2. The reserve breeders are to be kept at a density of 6 kg/m^3 in cages placed in two 40m^3 D-end tanks. The fish in the breeding tanks are to be fed 1 percent body weight per day (% bw/d) to minimize debris on the tank bottoms which might hinder egg collection. The reserve breeders are to be fed 2% bw/d.

In addition to the breeders described in the preceeding paragraph, another 40 m^3 D-end tank will hold the 1000 replacement breeding stock which are to be imported each year. These fish are to be imported as 1 g fingerlings and grown to breeders size using standard feeding rates (see Tables 10.2 and 10.3).

The exact size and number of breeders to be used has not been determined. Small (less than 100 g) female breeders are reported to produce

The exact size and number of breeders to be used has not been determined. Small (less than 100 g) female breeders are reported to produce more eggs/kg than large female breeders but this advantage will probably be offset by the handling labor required to check a large number of small breeders for eggs. The optimum size will have to be determined empirically during the first and second years of farm operation.

Only about 60% of tilapia eggs collected on a batch basis are viable. Assuming 100 eggs/ml (exact volume depends on brood fish size), approximately 150 ml of eggs will be collected each week to provide 8800 fry for sex-reversal. Eggs should be stocked at a density of 3000 eggs/l of

Table 10.1. Stages in Production of Tilapia

Culture Weeks	Stage	Duration week	Fish Size (g)	Number Stocked		Stocking Density (No/m^3)	Survival Rate (%)
				Weekly	Yearly		
-	Breeding	Continuous	100-500	-	800-2000	21-53/m^2 [a]	-
0	Hatching	3 - 6 d	egg-0.02	14700	763,000	3000/liter	60
1-6	Fry	6	0.02-0.6	8800	6457,000	4400	90
7-12	Fingerling	6	0.6-5	7900	411,000	790[b]	90
13-18	Juvenile	6	5-50			355[c]	
19-34	Grow-out	16	50-288	7115[e]	370,000[e]	178	90[e]
35-36	Cleansing	2	288-300			178[d]	
37	Packing	1-5 d	300	6400	332,800	69	100

[a] Breeding is related to surface area not volume
[b] 10m^3 section inside a 20m^3 tank
[c] 20m^3 section inside a 40m^3 tank
[d] Same tank used for growout but water supply is changed
[e] Allocation of mortalities to specific stages can not be made at present

hatching jar. The hatching jars use an upward flowing stream of highly aerated water to mimic the rolling motion which the eggs are subjected to in the mouth of the mother. The time required for hatching and absorption of the yolk sac will average 3-5 days at 28°C.

FRY STAGE

The fry stage lasts for six weeks starting with the removal of swim-up fry from the hatching jars. The swim-up fry will be approximately 8-9 mm in total length (none longer than 10 mm) weighing 0.02 g each. The fry for production will be sex-reversed by feeding them with a diet containing 100 mg ethynyl testosterone/kg feed. The fry required for brood stock replacement will be fed on untreated diet. The fry will be fed at a rate of 20% bw/d and will reach an average weight of 0.06 g by the end of six weeks. Based on an average weekly production o 8800 fry, average density will be 4400 fry/m^3. The average daily feed requirement for the fry will be 1.7 kg (620 kg/yr) (Table 10.2).

FINGERLING STAGE

The fingerling stage lasts six weeks and grows the fish from 0.6 g to 5 g. Two weeks production of fish are kept in the same tank at a density of 790 fish/m^3. Feeding rate is 15% bw/d. The fish are then transferred to the recirculating system for the later production stages. The fingerlings will need 12.2 kg of crumbled feed per day (4.5 t/yr) (Table 10.3).

JUVENILE STAGE

The juvenile stage lasts for six weeks also. The fish are grown from 5 to 50 g in the recirculating system at a density of 355 fish/m^3. The feeding rate is slowly adjusted from 14% bw/d to 6.5% bw/d (Table 10.4). Sixty-nine kg of pellets will be required every day. When the fish reach 50 g, the stocking density is decreased by transferring half of a tank population to an empty tank.

GROW-OUT STAGE

From 50 to 288 g, the fish are kept at a density if 178 fish/m^3. This stage is 16 weeks long and occurs in the recirculating system. The initial feeding rate of 6% bw/d is progressively decreased to reach a final 1.7% bw/d (Table 10.5). The total amount of feed needed for this stage is 477 kg/day.

CLEANSING STAGE

A major problem with recirculating systems is the build-up of complex organic compounds such as geosmin which cause off-flavor in fish. Off-flavor can be eliminated by flushing with clean water for 1 to 2 weeks. Thus, a two week cleansing stage is included in the production cycle. During these two weeks, the fish remain in their grow-out tanks but the tank is disconnected from the recirculating system. The water supply comes directly from the well. The first week, the fish are fed at 1.5% bw/d while in the second week, the feeding rate is dropped to a maintenance level, 0.4% bw/d, to minimize the production of metabolic by-products (Table 10.5). Only 38 kg of feed/day will be given to the fish undergoing cleansing. At the completion of this stage, the fish are harvested and moved to the packing unit.

PACKING STAGE

The fish harvested from the cleansing tanks are moved to the packing unit and are loaded into a cage which is suspended by an overhead crane. When a full load is reached (based on the desired quantity of fish to be sold on a given day), the cage is hoisted and moved to a holding tank. Other cages are then loaded.

In the early morning on the day of shipping, the cage containing that day's fish is hoisted and placed into a cooling tank. This cold water lightens the color of the fish and reduces their activity. The fish are then removed from the cooling tank, sorted, packed, and sent to the market.

Table 10.2. Growth Rate, Feeding and Water Requirement During Fry Stage

Culture week	Initial Weight (g)	Feeding Rate (% bw/d)	Final Weight[a] (g)	Feed Amount[b] (g/d)	Flow Rate[c] (m^3/d)
1	0.02	20	0.04	35	2
2	0.04	20	0.08	70	2
3	0.08	20	0.15	140	4
4	0.15	20	0.3	265	7.6
5	0.3	20	0.4	530	15
6	0.4	20	0.6	704	20

a) Based on growth rate observed at MFD
b) Based on a stocking rate of 8800 fry/week with weekly feed adjustments.
c) Flow required to maintain unionized N-NH_3 levels below 0.05 mg/liter at pH 7.8 and 30°C. Total N-NH_3 output = 0.03 × (weight of feed). Minimum flow rate = 1 exchange per day.

Table 10.3. Growth Rate, Feeding and Water Requirements During Fingerling Stage.

Culture week	Initial Weight (g)	Feeding Rate (% bw/d)	Final Weight[a] (g/fish)	Feed Amount[b] (g/day)	Flow Rate[c] (m^3/d)
7	0.6	15	0.9	710	10
8	0.9	15	1.2	1065	16
9	1.2	15	1.7	1420	21
10	1.7	15	2.4	2015	30
11	2.4	15	3.5	2815	42
12	3.5	15	4.9	4150	61

a) Based on average feed conversion ration (FCR) of 2.5:1
b) Based on a stocking rate of 7900 fingerlings/week with weekly feed adjustment.
c) Flow required to maintain unionized N-NH_3 level below 0.1 mg/liter at pH = 7.8 and T = 30°C. Assuming Total N-NH_3 output = 0.03 × (weight of feed).

Table 10.4. Growth Rate, Feeding and Oxygen Requirements During Juvenile Stage.

Culture Week	Initial Weight (g/fish)	Feeding Rate[a)] (% bw/d)	FCR[b)]	Final Weight (g/fish)	Feed Amount[c)] (Kg/day)	O_2 Requirement[d)] (g/hr)
13	5	14	1.5	8	5	52
14	8	14	1.5	14	8	83
15	14	13	1.5	22	13	135
16	22	7	1.5	29	11	115
17	29	7	1.5	38	14	146
18	38	6.5	1.5	50	18	188

a) Based on Melard and Philippart (1981)
b) FCR = Feed conversion ratio
c) Based on a stocking rate of 7100 fish/wk
d) Based on O_2 consumption = 0.25 × (amount of feed) (Willoughby et al., 1972 and Liao, 1970 as cited in Muir, 1982)

Table 10.5. Growth Rates, Feeding and Oxygen Requirements During Grow-out and Cleansing Stages

Cultural Week	Initial Weight (g/fish)	Feeding Rate[a] (% bw/d)	FCR[a]	Final Weight (g/fish)	Feed Amount[b] (Kg/d)	O_2 Requirement[c] (g/hr)
19	50	6.0	1.5	64	21	219
20	64	5.5	1.5	80	25	260
21	80	5.0	1.5	99	29	302
22	99	4.5	1.5	120	32	333
23	120	4.0	2.2	135	34	354
24	135	3.5	2.2	150	34	354
25	150	3.0	2.2	164	32	333
26	164	3.0	2.2	180	35	365
27	180	2.5	2.2	194	32	333
28	194	2.0	2.2	208	28	292
29	208	2.0	2.3	221	27	281
30	221	1.9	2.3	234	28	292
31	234	1.9	2.3	6248	29	302
32	248	1.8	2.4	261	29	302
33	261	1.8	2.4	275	30	313
34	275	1.7	2.5	288	32	333
35	288	1.5	2.5	300	30	313
36	300	0.4	-	300	8	83

[a] Based on Melard and Philippart (1981). Maintenance ration for week 36 is based on a maintenance energy requirement of 13 kcal/kg fish/d (Cowey and Sargent, 1979) and a digestible energy content of 3000 kcal/kg in tilapia feed.
[b] Based on a stocking rate of 7100 fish/wk.
[c] Based on 0.25 × (amount of feed).

WATER QUALITY

Breeding Tanks are operated on a batch basis with weekly water exchange. Two hundred and fifty kg of breeders in 120 m^3 of water fed at 1% bw/d, will reach an unionized $N-NH_3$ level of 0.1 mg/liter (total $N-NH_3$ = 2.2 mg/liter) with biweekly water exchanges, a pH of 7.8 and temperature of 30°C. Water requirement for the breeding tanks is 17 m^3/d. Based on an oxygen requirement of 25 percent of feed weight (Willoughby et al., 1972 cited in Muir, 1982) the amount of oxygen required for the breeders is 26 g/hr.

Fry and Fingerling Tanks are operated on a flow through basis in order to maintain unionized $N-NH_3$ levels below 0.05 mg/liter and 0.1 mg/liter respectively (Colt and Armstrong, 1981). A minimum exchange rate of 1 complete exchange per day is used and increases as the fish grow (Tables 10.2, 10.3). Water requirements are 51 m^3/day and 180 m^3/d for fry and Fingerling tanks respectively. Total oxygen requirements for fry and fingerlings are 18 and 127 g/hr respectively. Peak oxygen requirements occur during the last week of each stage.

The Recirculating System contains the breeder holding tanks, juvenile tanks, and grow-out tanks in addition to the filters. Assuming that the average pH has been reduced from 7.8 to 7.5 by CO^2 output and that the maximum allowable unionized $N-NH_3$ level is 0.5 mg/liter total allowable $N-NH_3$ can be 20 mg/liter at 30°C. When the juveniles are stocked into the recirculating system, they are accustomed to the 0.1 mg/liter unionized $N-NH_3$ level in the fingerling tanks. To acclimate them to the 0.5 mg/liter average unionized $N-NH_3$ level, new water should be mixed with an increasing proportion of recycled water for the first 3-4 days after stocking.

The total feed consumption of fish kept in tanks connected to the recirculating system is 606 kg/d. This amount of feed will produce 18 kg $N-NH_3$/d in the recirculating system. Based on a 30 percent removal rate, 6 mg/liter total $N-NH_3$ will be removed in each pass through the biological filter. Thus, 3×10^6 liter/day must pass through the biological filter (3000 m^3/day) (neglecting NH_3 losses in farm effluent). This flow rate is considerably below the rate needed for self cleaning of the tanks so a bypass around the filter directly to the return pump will probably have to be provided. Using 3000 m^3/day and a residence time of 15 min, total biofilter volume must be 31 m^3. A 30 percent reserve to cope with peak load gives a total biofilter volume of 40 m^3. The ammonia removal rate is 500 $g/m^3\ d^{-1}$ and hydraulic load is 75 $m^3/m^3\ d^{-1}$. These values are well within observed levels in operating aquaculture systems (Muir, 1982).

The maximum oxygen requirements are approximately 365 g O_2/hr/fish tank. Stoichiometric requirements for oxygen in a biological filter are up to 4-5 mg/mg N oxidized (Haug and McCarty, 1971 cited in Muir, 1982) hence, the filters need 3370 g O_2/hr.

Solids production can be assumed to be 0.3 times feed rate (Willoughby et al., 1972 and Kawamoto, 1961 as cited in Muir, 1982). Total solids production is estimated to be 180 kg/day. Most of the heavy solids will be removed in the solids collcting chamber in each tank if water flow is at least 20 m^3-40 m^3 tank/hr. These chambers, in combination with plate separators loaded approximately 60 m^3/m^2 surface/day (200 m^2 total area required) should remove about 95 percent of all solids. Five percent of 180 kg/d is 9 kg/d. Based on 340 m^3 of new water per day and an evaporation rate of 2% of system volume (1030 m^3 for tanks and filters - see Chapter 11), total non-settleble solids should equilibrate a 28 mg/liter. This level is of no concern.

Assuming a well concentration of 40 mg NO_3/liter, a NO_3 production rate of 4.43 times the $N-NH_3$ removed, and an input of 340 m^3/d of well water (51 m^3/day for sex reversal, 180 m^3/day for fingerlings plus 109 m^3/day for cleansing), an evaporation rate of 2 percent of system volume, *an average* NO_3 level of 292 mg/liter can be computed using simple mass balance equations. This is considerably below the 2000 mg/liter limiting concentrations for NO_3 (Colt and Armstrong, 1981).

Nitrification requires approximately 7 mg bicarbonate alkalinity expressed as $CaCo_3$ to neutralize the hydrogen ions produced during the oxidation of 1 mg $N-NH_3$. Thus, 126 kg of $CaCO_3$ are required per day. Assuming the incoming water supplies 76.5 kg $CaCO_3$ (225 mg/l $CaCO_3$), a sizable deficit appears to exist. However, this deficit will probably be met by the movement of respiratory CO_2 into the alkalinity cycle.

Cleansing Tanks do not receive water from the recirculating system. New water is used to dilute metabolic by-products. If the pH of this new water is about 7.8, a total $N-NH_3$ level of 10.4 mg/liter will yield an unionized $N-NH_3$ level of 0.5 mg/liter at 30°C. Total $N-NH_3$ output in the two tanks undergoing cleansing is 1.14 kg total N_2NH_3/day so 109 m^3/day is needed to dilute this to 6.7 mg/l total $N-NH_3$.

WATER CHEMISTRY MONITORING

As the farm system relies on the filters and artificial aeration to maintain water quality, it is essential that a close watch be kept on the efficiency of the operation. It is suggested that dissolved oxygen, pH and total ammonia be measured daily. Nitrite should be measured daily when biological filters are starting up. Nitrate and total suspended solids should be measured weekly.

DISEASE CONTROL

As the grow-out tanks are interconnected via the filters, any disease problems will quickly spread throughout the system. This was one of the main reasons why there are two recirculating systems per module. If problems occur in one system, the other system should be unaffected. It is essential that the fish not be subjected to any unnecessary stress. If treatment of a tank is required, the treated water should not be discharged into the drain channel (and on the filters) but should be discharged into the sludge channel.

OPERATIONAL DETAIL SUMMARY

A detailed summary of this chapter is presented in Appendix A.

CHAPTER 11. DESIGN OF FACILITIES

This chapter presents the design of the farm components. Exact requirements for each of the four farm sizes, 100 t, 200 t, 400 t and 800 t are tabulated in Appendix A. These details are tentative and will have to be finalized during the design portion of phase I after a site has been selected.

WATER SUPPLY

The standard deep well in Kuwait is drilled to a depth of 250 to 300 m. Drilling is done by an international contractor accredited by the Ministry of Electricity and Water. Each well should deliver 1.4 - 1.6 m^3/min (300 - 350 UK gpm). The riser pipe is usually 100 mm. A pump house contains the controls for each pump. As a 100 t farm requires 357 m^3/d, one well will be sufficient for 560 - 650 tonnes of capacity. A single well will be located adjacent to the hatchery. The second well for farms larger than 650 t of capacity will have to be positioned 1 km away. A 100 mm pipeline will be used to transport water to the farm from the wells. An insulated steel reservoir tank is required to minimize pumping time and to maintain water pressure in the farm. Each 100 t module will require 100 m^3 of water reservoir capacity.

GREENHOUSES

The production unit is housed inside glass greenhouses. The greenhouses are required to protect the tanks from winter winds and, by covering the greenhouses with shade net, from the summer sun. Exhaust fans will maintain summer temperatures in the greenhouse at tolerable levels for the workers. The greenhouses will also reduce dust accumulation within the system.

The greenhouses are standard glass units erected on compacted soil. The roof design is A-frame with 6.4 m spans. Civil works consist of pillar supports and perimeter blocks. The total floor area of a 100 t module is 1924 m^2. Exhaust fans, 1200 mm diameter complete with shutters and guards, will maintain an air flow within the greenhouses of at least 45 complete air exchanges per hour. This air flow over the tank water surfaces and agricultural shade netting with a rating of at least 75% shade, should maintain air temperatures within the greenhouse at less than 35°C during most summer days. During winter, the shade netting will be removed and stored for use the next summer and the exhaust fans will not be operated. A three meter wide road and gravel (10 cm thick) walkways provide access.

TANKS AND HATCHING JARS

A hatching rack containing Zuger-type up-flow hatching jars will be installed adjacent to each utility room. One liter plastic Imhoff cones can be used as inexpensive jars. Five jars will be needed for normal production with an extra 10 jars for peak levels.

The recommended breeding tank is a 5 m × 5 m × 0.8 m deep tank produced by EWOS. This type of tank, which is coated on-site with 25 mm polystyrene insulation, is also used for the fingerling stage. Six tanks are required for breeding and three tanks for fingerlings. The fry tanks are also produced by EWOS and are 2 m × 2 m × 0.55 m deep. Six fry tanks handle normal production with an additional four tanks for peak loads and holding. All of the EWOS tanks are fiberglass, have rounded corners, and use telescopic drains.

The recommended tank for juveniles, grow-out and breeder holding is a 40 m^3 capacity D-end Kingfisher tank, 15 m long, 3 m wide, 1.2 m deep. This tank was selected after an exhaustive examination of possible tank designs. It maximizes space utilization in the expensive greenhouses. The tank is constructed of glass-reinforced concrete (GRC) sandwich panels. These panels consist of rigid foam insulation between two skins of GRC. Included with the tank are its base panels, inlet pipework and valves, solids removal chamber and discharge pipework. A central baffle is used to direct water flow (Figure 11.1). Eighteen tanks are used for grow-out, three for juveniles, two for breeder holding and one for rearing of new breeders. The two tanks used for breeder holding will be subdivided with 20 cages, 2 m × 2 m × 1 m deep. Two spare cages will be provided.

The tank layout within a 100 t module is shown in Figure 11.2. As the Kingfisher tanks are adjacent to each other, access is provided by a catwalk.

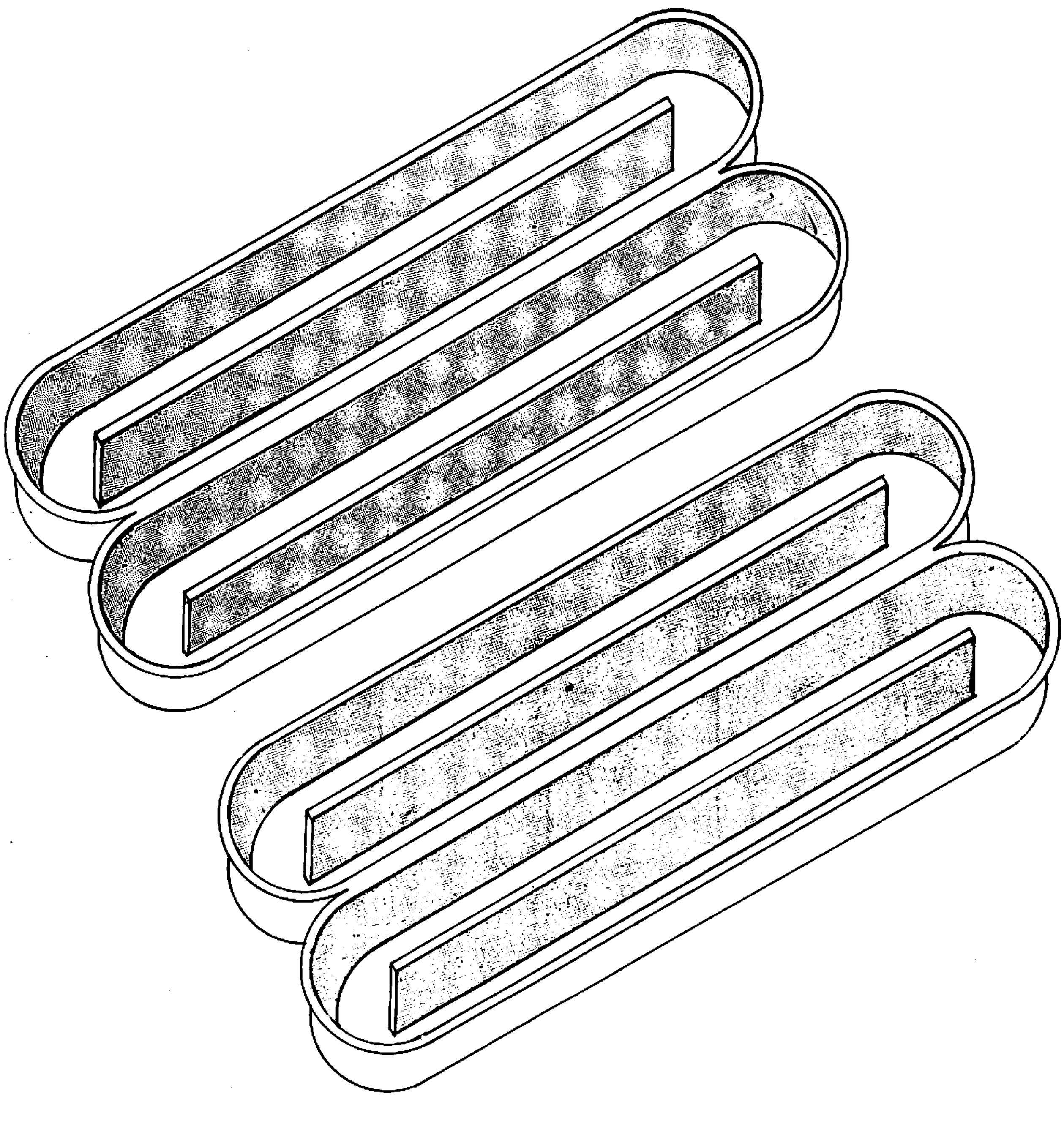


Figure 11.1. Two pairs of 40 m^3 Kingfisher Tanks.

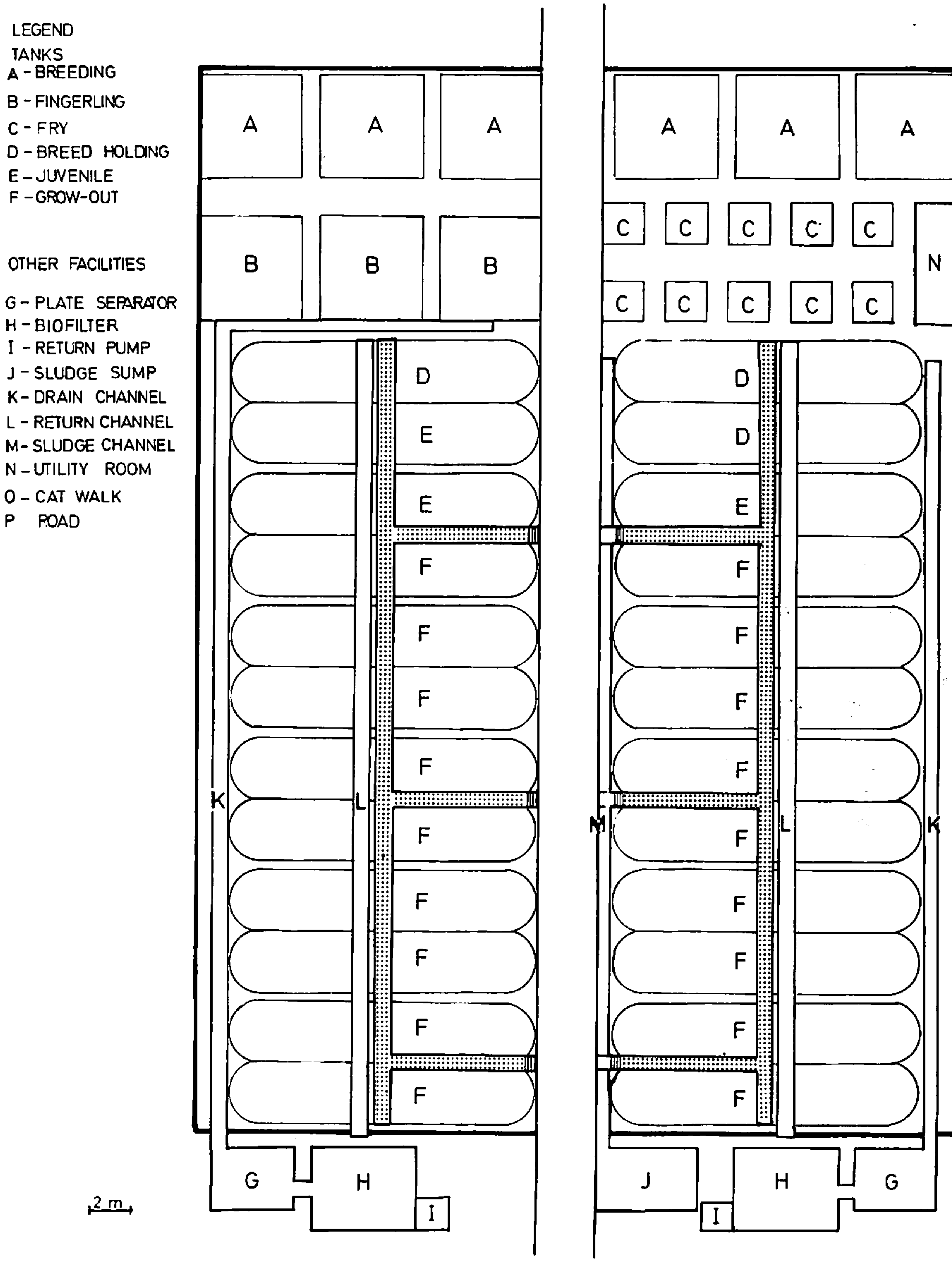


Figure 11.2. Floor Plan of 100 t Production Unit.

AIR SUPPLY

The oxygen requirements of the fish and biological filter were presented in the preceding chapter. Based on an oxygen transfer efficiency of 1 percent (one quarter the efficiency attained under standard conditions for small bubbles at 3 foot depth (Aquatic Ecosystems, no date) with a weight of air at 30°C of 1.647 g/liter, and an O_2 content in air of 23% by weight), each breeding tank requires 149 liter of air/hr and a fry tank requires 2737 liter of air/hr (1493 liter/hr = 0.9 cfm, 2737 liter/hr = 1.6 cfm). An airstone, 8 cm × 4 cm, handles approximately 0.3 - 0.4 cfm at 3 foot depth so 3 airstones are needed for each brood tank and 4 airstones for each fry tank.

Oxygen for fingerlings, reserve breeders, juvenile and grow-out tanks will be supplied by Kingfisher directional flow aerators which operate on an airlift principle. Two units will be installed in each tank (1.6 kg O_2/kWh/unit at standard conditions, 0.41 kw/hr/unit power consumption, assuming 25 percent effectively under culture condition). One unit requires 1.56 m^3 of air/min at 812 mm water pressure (= 55 cfm at 32 inch water pressure).

The biofilter air supply is through a pipe grid in the bottom of the filter. The biofilters requires 21 m^3 air/min.

The air supply comes from four turbo blowers each producing 50 m^3/min at 100 mm Hg (approximately 2000 cfm at 3 PSI each). Two blowers are in use at any time with the other two as back-up. Air is distributed via two 150 mm pipelines adjacent to the grow-out tank catwalks.

EMERGENCY OXYGEN SYSTEM

The emergency oxygen system will be used in case the blowers stop. It consists of one oxygen cylinder, regulator and airlines for every two grow-out tanks. One cylinder is used for breeding tanks, another for the fry tanks and a third for the fingerling tanks.

WATER DISTRIBUTION IN PRODUCTION UNIT

There are four water distribution networks in a production unit: new water from well and reservoir; overflow from fry and fingerling tanks which enters the recirculating system; the recirculating system; and the discharge network (Figure 11.3).

The water supply from the well and reservoir is distributed in the tanks via 75 mm PVC main lines with 25 mm valves to the fry tanks and 50 mm valves to the other tanks. The overflow from the tanks receiving water from the well (fry tanks, fingerling tanks, cleansing tanks) will flow into 80 cm wide by 50 cm deep drain channels which flow to the filtration block. The channels are constructed of 10 cm thick concrete coated with Chevron industrial membrane (an in-situ sprayed plastic membrane). They are insulated with 25 mm polystyrene and are covered during the winter.

The juvenile, grow-out and reserve breeders tanks are connected together into a recirculating system. There are two recirculating systems in each 100 t module. Each system contains twelve 40 m^3 tanks, a plate separator, a biofilter, and a return pump. The overflow through the standpipe in each tank is received by the drain channels which have a slope of approximately 1% and lead to the sumps containing plate separators. Then, 25% of the water flows through the biofilters before joining the other 75% in the return pump sump. The water is pumped from the sump and returned to the tanks. The return channel is 80 cm wide and 50 cm deep fiberglass. It is mounted adjacent to the catwalks on the 40 m^3 tanks. The channel is connected to the inlet pipework via 100 mm flanges.

Discharge from the breeding tanks and the system overflow drains into a sludge channel, 50 cm wide × 30 cm deep. This channel also receives any contaminated water (e.g., water containing drugs for disease treatment). It drains directly to the sludge sump. The sludge sump is 5 m × 3 m × 1 m deep plastic lined concrete. A sludge pump with a capacity of at least 30 liter/sec moves the discharge water to the lagoons. The sludge channel could be used as a harvest channel if cleaned before use.

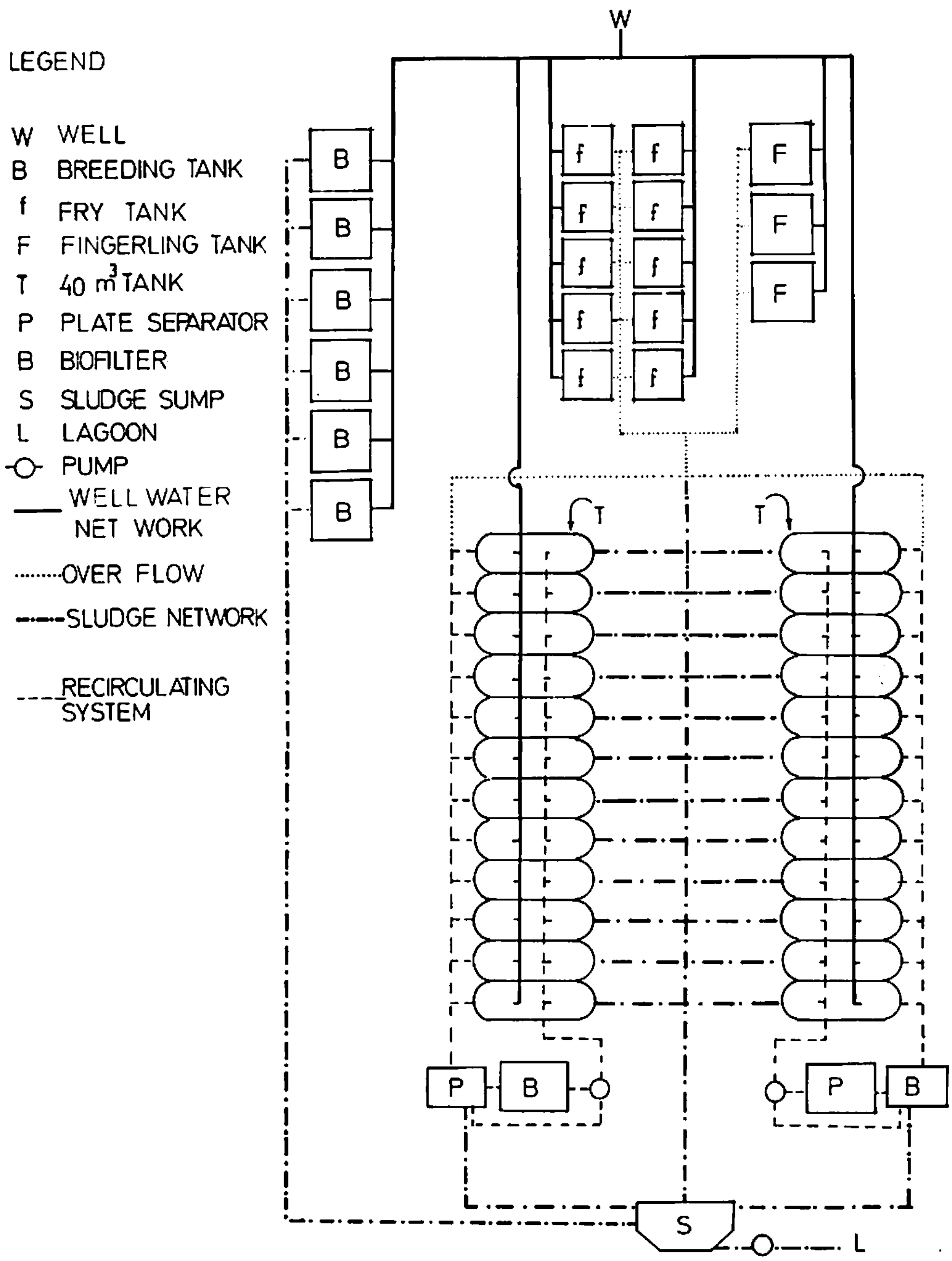


Fig. 11.3. Water Distribution in the Production Unit.

FILTERS

There are two plate separators each with at least 100 m^2 of plates. The plates are contained in 4 m × 3 m × 1 m deep sumps constructed of 10 cm concrete coated with plastic membrane and insulated with 25 mm polystyrene. The sump is covered by a plywood cover. The overflow from the recirculating system leaves through bottom water take-offs in the plate separator sumps. This automatically removes sludge from the plate separator.

Each biofilter has two parallel streams with a downflow and upflow compartment in each stream and a bypass directly from the plate separator to the pump sump. The filters are buried and are constructed of 10 cm insulated concrete coated with plastic membrane. Each filter is 4 m × 5 m × 1 m deep and contains 20 m^3 of submerged plastic ring substrate. The biofilters are covered. They are cleaned by either increasing the water or air rates.

RETURN PUMP

Two 1.5 m × 1.5 m × 1 m insulated concrete sumps adjacent to the biological filters receive water from the biological filters and the remaining overflow from the plate separators. A return pump in each sump pumps at least 70 liter/sec to the return channel to the tanks.

HEATERS

The fingerling and fry tanks will require individual immersion heaters with thermostats to maintain temperatures at 28-30°C during the winter, 4 kW and 300 W respectively (See details in Chapter 16 - temperature management).

HAULER

A fish hauler mounted on a forklift pallet will be used (with the forklift) to move fish around inside the production unit.

UTILITY ROOM

An insulated air conditioned utility room, 3 m × 4 m, with electronic balance, 16 kg × 0.1 g is provided for every two production modules.

FEED SYSTEM

Automatic feeders are provided for the 40 m^3 tanks. Each feeder should have a capacity of at least 40 kg. By placing the feeders over the center baffle in each tank, feed can be delivered to both sides of the tank via chutes. Belt feeders are used for the fry tanks (2 feeders per tank) and fingerling tanks (4 per tank). Breeders in the holding cages will be fed with demand feeders while the breeding tanks will be fed by hand. Spare feeders will have to be available.

For a 100 t farm, only an air-conditioned feed store, 125 m^2, is needed. For larger sizes an on-site feed mill will be added (see chapter 15). Feed delivery to the feeders in each tank will be done by hand for 100 t. A mechanical delivery system based on overhead delivery pipes directly from the feed storage silos will be used for 200-800 t farms.

LAGOONS

The lagoon system consists of a sludge settling tank (a 100 m^3 plastic pool) and a butyl-rubber lined pond. The pond is constructed by excavating the bottom and fashioning the excavated material into dikes with side slopes of 5:1, water depth 2.4 m, freeboard 0.5 m, and crown of 5 m, the bottom of the pond will be approximately 2 m below original ground level. An extra settling tank must be provided for use when the main tank is being cleaned. Expansion to large sizes is by addition of lagoon area and settling tanks. Exact details will depend on the scale of expansion.

ELECTRICAL SUPPLY

It is assumed that electrical power will be available from the government power grid. An electrical substation will have to be provided to use the grid. The power requirement of the farm

Table 11.1. Power Requirement of Tilapia Farm

	Power Requirement (kW)			
	100 t	200 t	400 t	800 t
ESSENTIAL SERVICES				
Pumps, recirculating, 3 kW each	6	12	24	48
Pumps, sludge, 15 kW each	2	3	6	12
Pump, well	50	50	50	100
Blowers, 20 kW each	40	80	160	320
Air conditioning	20	20	20	20
Refrigerators and freezers	5	5	10	10
Lights	5	10	20	40
Sub-total	128	180	290	550
Emergency capacity includes 20% margin	154	216	348	660
OCCASIONAL USE				
Heaters	40	80	160	320
Exhaust fans	45	90	180	360
Processing unit cooler	5	15	15	15
Processing crane	—	1	1	1
Feed mill	—	65	65	65
Sub-total	90	251	421	761
Total	218	431	711	1311
+25% margin	55	108	178	328
Maximum Power Requirement	275	540	890	1640

is shown in Table 11.1. Emergency generators must be provided to ensure the continuity of the essential services.

PACKING UNIT

For the 100 t farm, the only packing equipment needed is a mobile tank cooled by a small refrigeration unit, a platform balance, sorting table and packing boxes.

For the 200 t and larger farm the packing unit is sheltered by a prefabricated steel building, 35 m long × 8 m wide (Figures 11.4 and 11.5). The building has a concrete floor and an overhead crane system. Two 1200 mm exhaust fans will be used during the summer. A 5 m × 3 m × 1.25 m deep cage loading sump is located at one end of the building. This loading sump drains to a pump sump, 1 m × 1 m × 2 m deep. The water in the pump sump can be redirected into a transport truck or to the plate separators in the rearing units. A 5-10 liter/sec pump is used in the sump. Two concrete tanks, one 18.5 m × 5 m × 1.25 m deep, the other 5 m wide × 3 m long × 1.25 m deep, both constructed in 20 cm thick concrete with plastic membrane coating are contained in the building. The larger tank has 25 mm thick insulation and the smaller tank, which is used for cooling fish, has 75 mm. The cooling tank also has an insulated cover. The refrigeration unit for the cooling tank should be of approximately 100 t capacity.

Rigid cages, 4 m × 2.5 m × 1.25 m deep with door in the lower mid-section are used to transport and hold fish in the processing unit. Six cages are used with one spare. When emptying the cages, they are set on a steel cage support adjacent to a stainless steel sorting table, 2 m × 1.5 m. Adjacent to the sorting table are platform balances used when packing fish. The fish are packed into plastic stackable fish shipping boxes, each holding approximately 10 kg.

A vacuum fish harvest system with a 850 liter tank is used to remove fish from the production unit to the packing unit. Two standard fish haulers, each with three compartments, are maintained as standby.

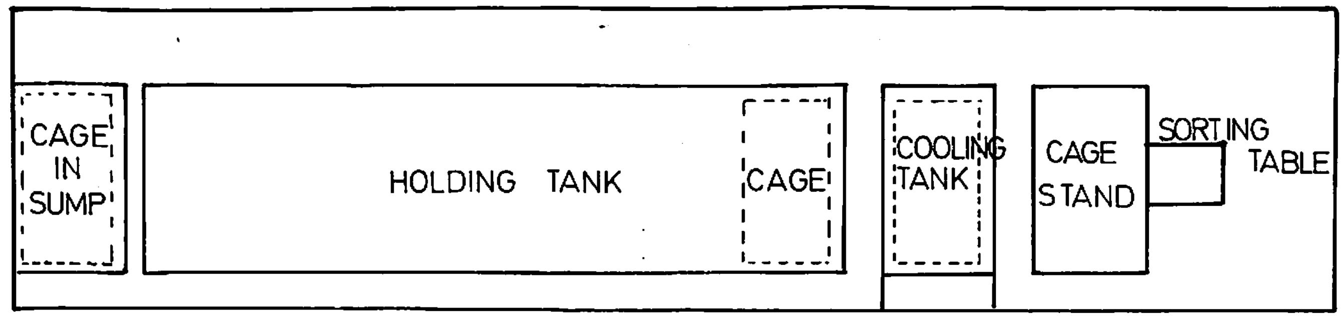


Figure 11.4. Floor Plan of Packing Unit.

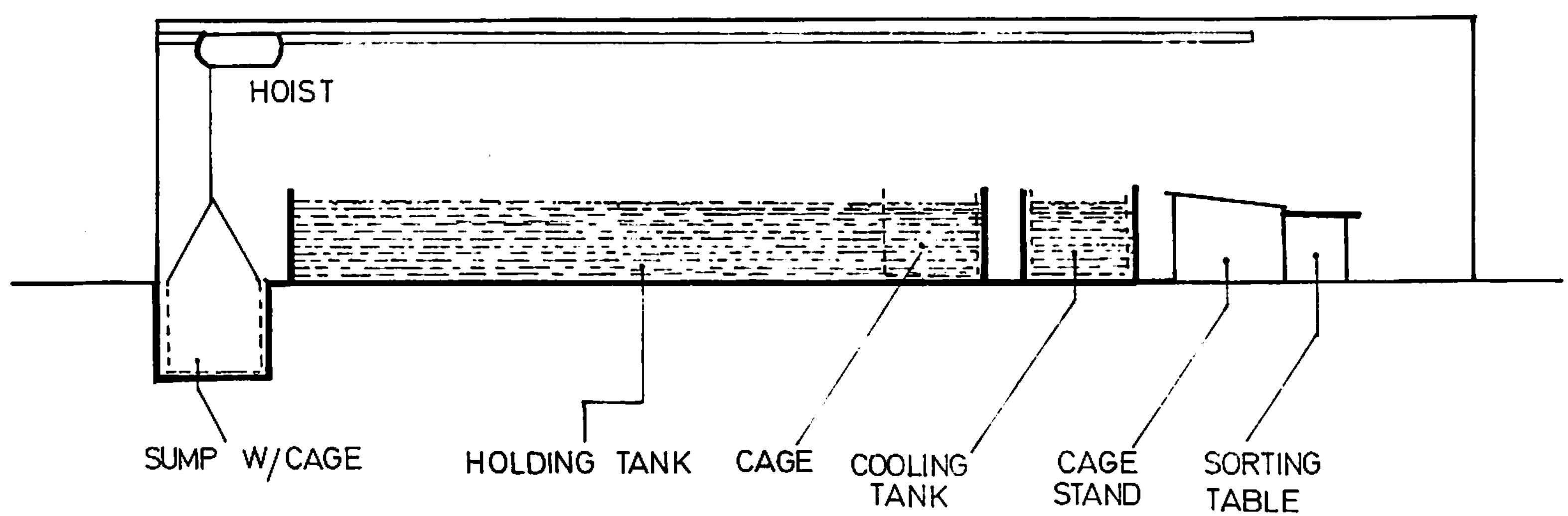


Figure 11.5. Elevation Plan of Packing Unit.

VEHICLES

Two four wheel drive pick-up trucks for farm use, a refrigerated delivery truck and a fork lift are needed on the 100 t farm. One of the pick-up trucks should be dual cab so that it can be used to transport staff.

When the farm expands to 200 t or above, a small bus will be required to transport staff. A second forklift will be required for the largest farm sizes.

OFFICE/LABORATORY

The office and laboratory will be housed in a steel building of approximately 50 m^2. The manager and engineers office will occupy approximately 30 m^2 and 20 m^2 will be required for the laboratory. The office will be equipped with standard office furniture and equipment. The laboratory will be equipped to monitor ammonia, nitrite, suspended solids, oxygen and other parameters.

COMPUTER SYSTEM

For farm sizes larger than 200 t, a computer system will be installed. One computer will be reserved for use by the manager and engineer and the other will be dedicated to technical data entry by the technicians.

WORKSHOP/GENERAL STORAGE

A workshop and storage building is required. A prefabricated steel building (50 m^2) will be used. The workshop (20 m^2) and indoor storage will be airconditioned. Outside the building there are 25 m^2 of covered storage for durable items.

HOUSING

On the 100 t farm, housing will be provided for the manager and engineer. Additional space for a workers' lounge and shower/toilet area must also be provided. If the farm expands to 400 t, it is suggested that on-site housing be provided for the technicians and labourers. The housing will be prefabricated steel structures, insulated and completely furnished. Potable water and sewage disposal will also be provided.

ROADS/FENCES/WINDBREAKS

Paved roads will provide access to the packing unit, office, and feed mill. Access around the perimeter of the farm will be by four wheel drive vehicles.

The perimeter of the farm will be surrounded by a chain link security fence. Five to 10 meters inside the fence, a double line of trees will be needed as windbreaks.

ALARM SYSTEM

The perimeter fence should be guarded with micro-wave alarms to prevent trespassing. Water level alarms should be provided in each return channel and return pump sump. Pressure alarms should be installed on each 150 mm air line. A main power shut-off alarm will warn of power loss so that the generators will be started. Each 100 t module will have two movable oxygen monitors connected to the alarm control panel which can be installed wherever needed.

FARM LAYOUT

The farm layout was designed so that expansion in capacity is easy. Figure 11.6 shows the layout of a 100 t farm while Figures 11.7, 11.8, 11.9 show the layouts for larger farm sizes. A 100 t farm requires 13300 m^2, 200 t farm - 20900 m^2, 400 t farm - 40800 m^2 and 800 t farm - 71400 m^2.

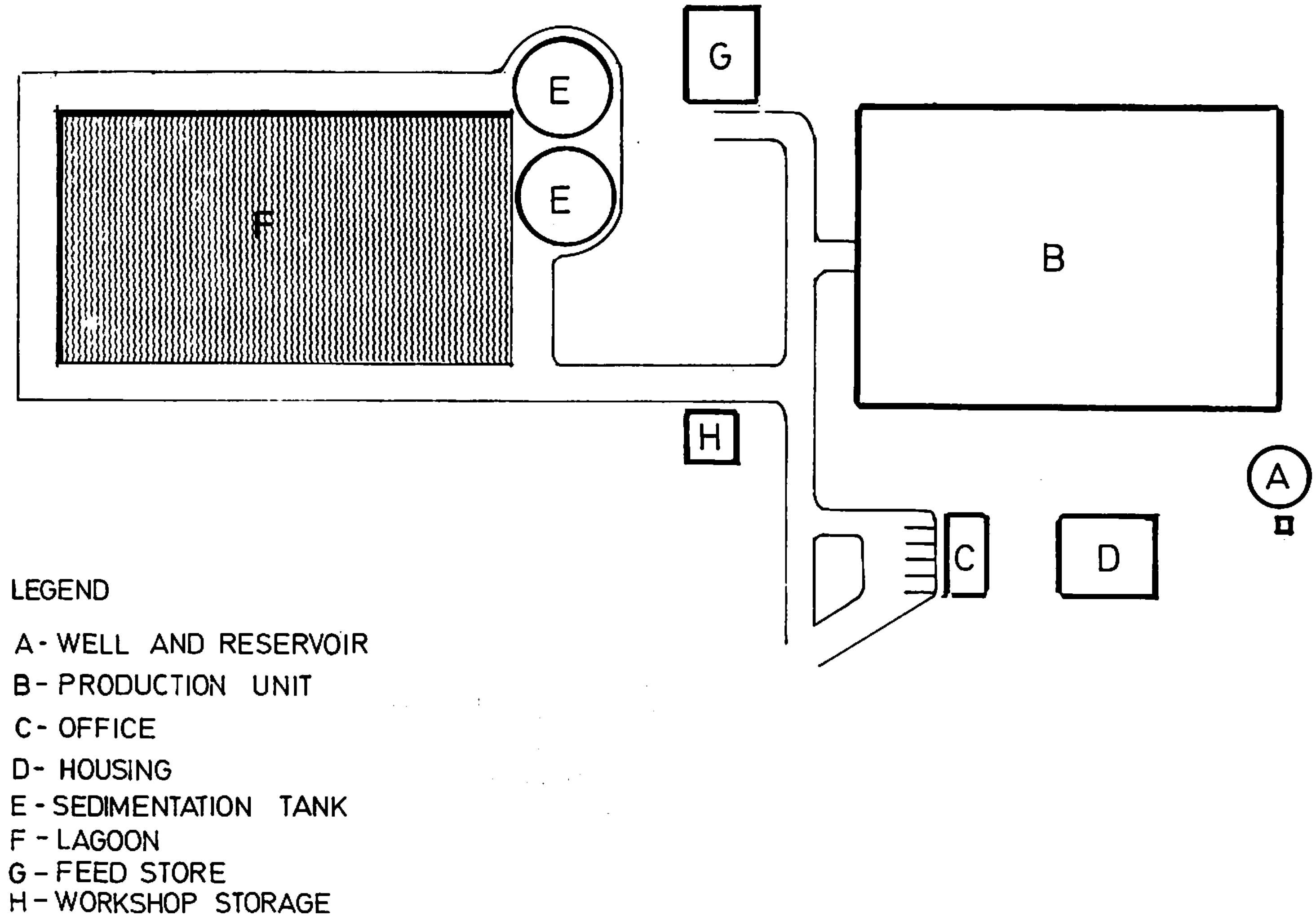


Figure 11.6. Layout of 100 t Farm.

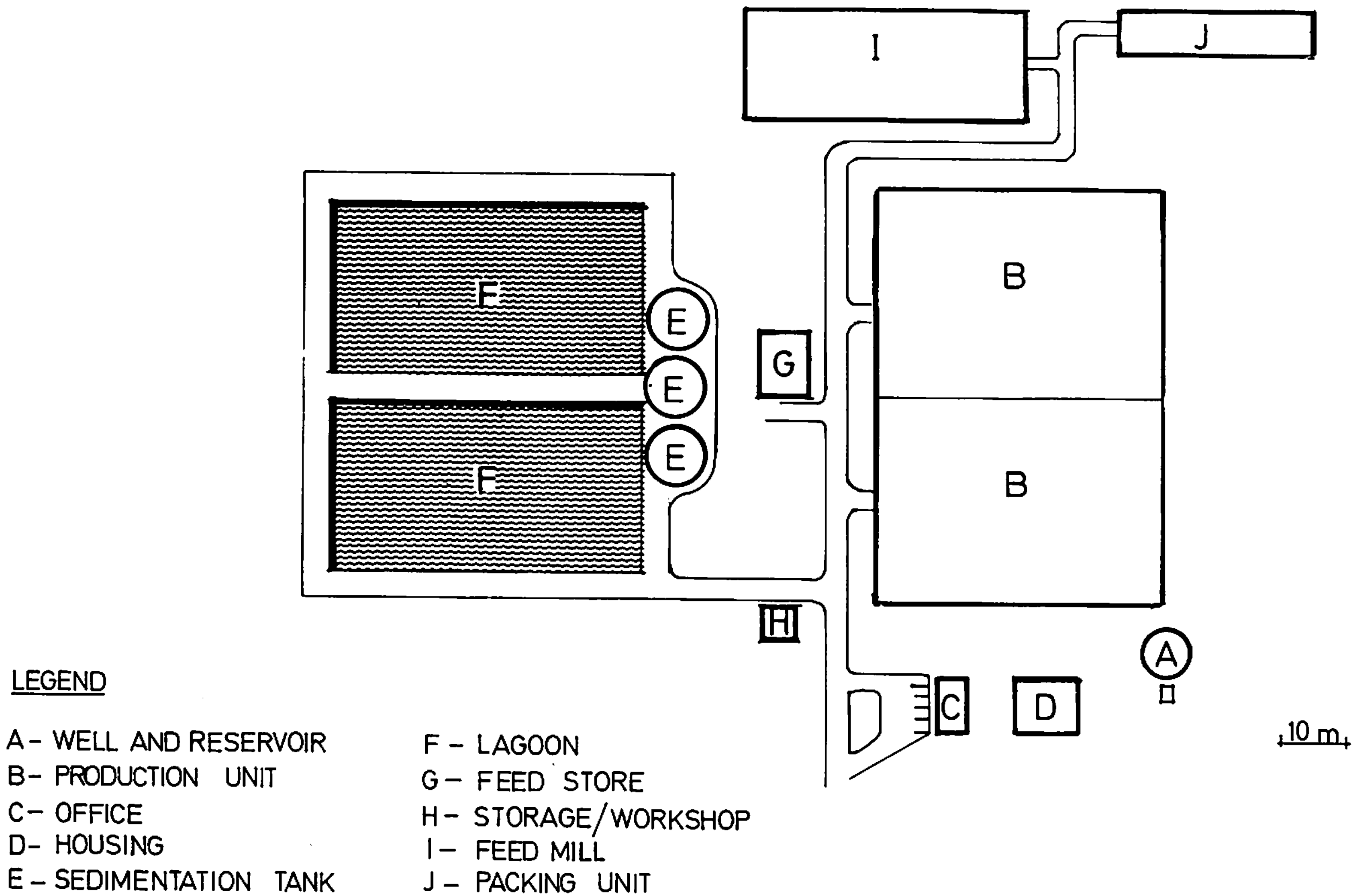


Figure 11.7. Layout of 200 t Farm.

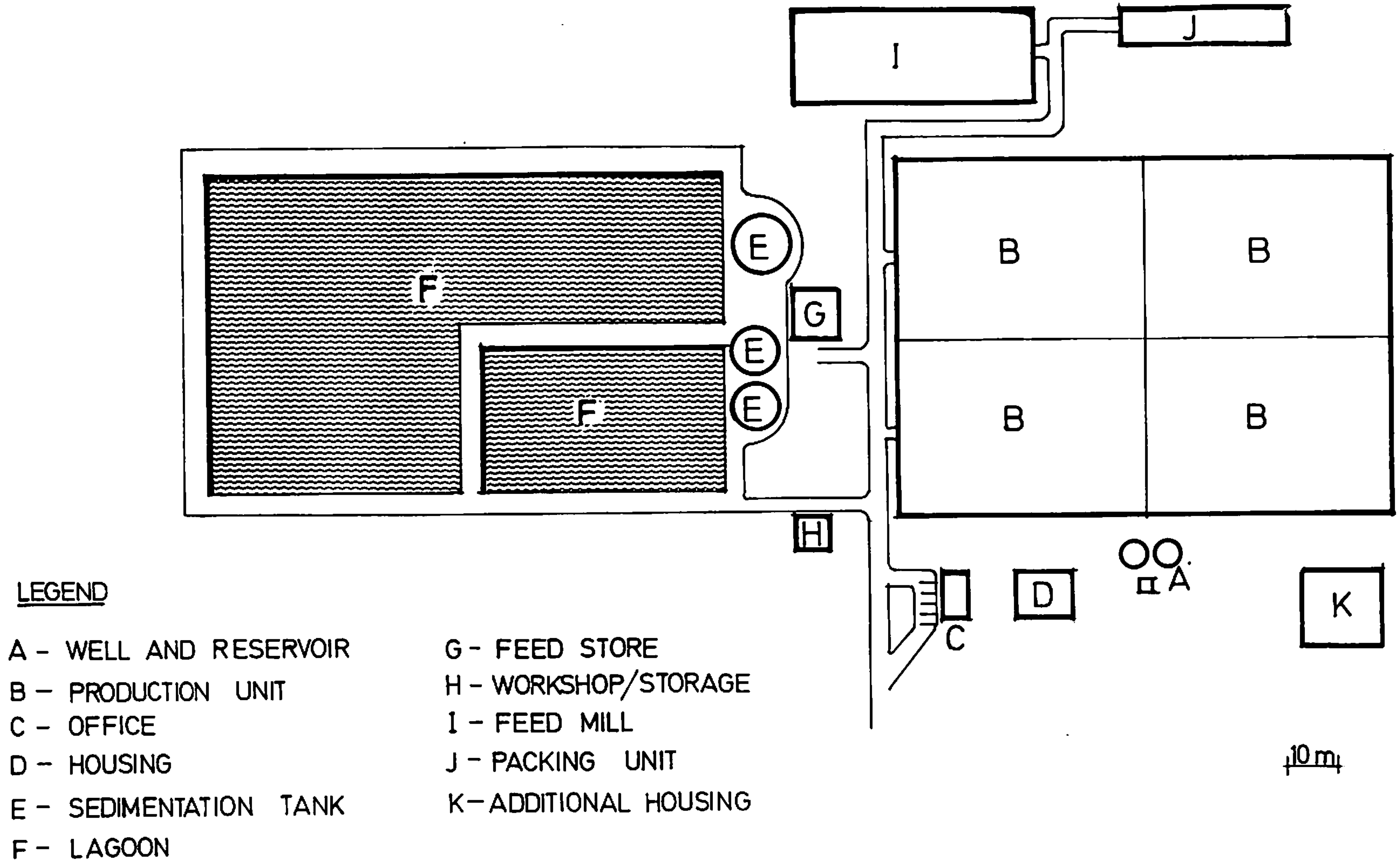
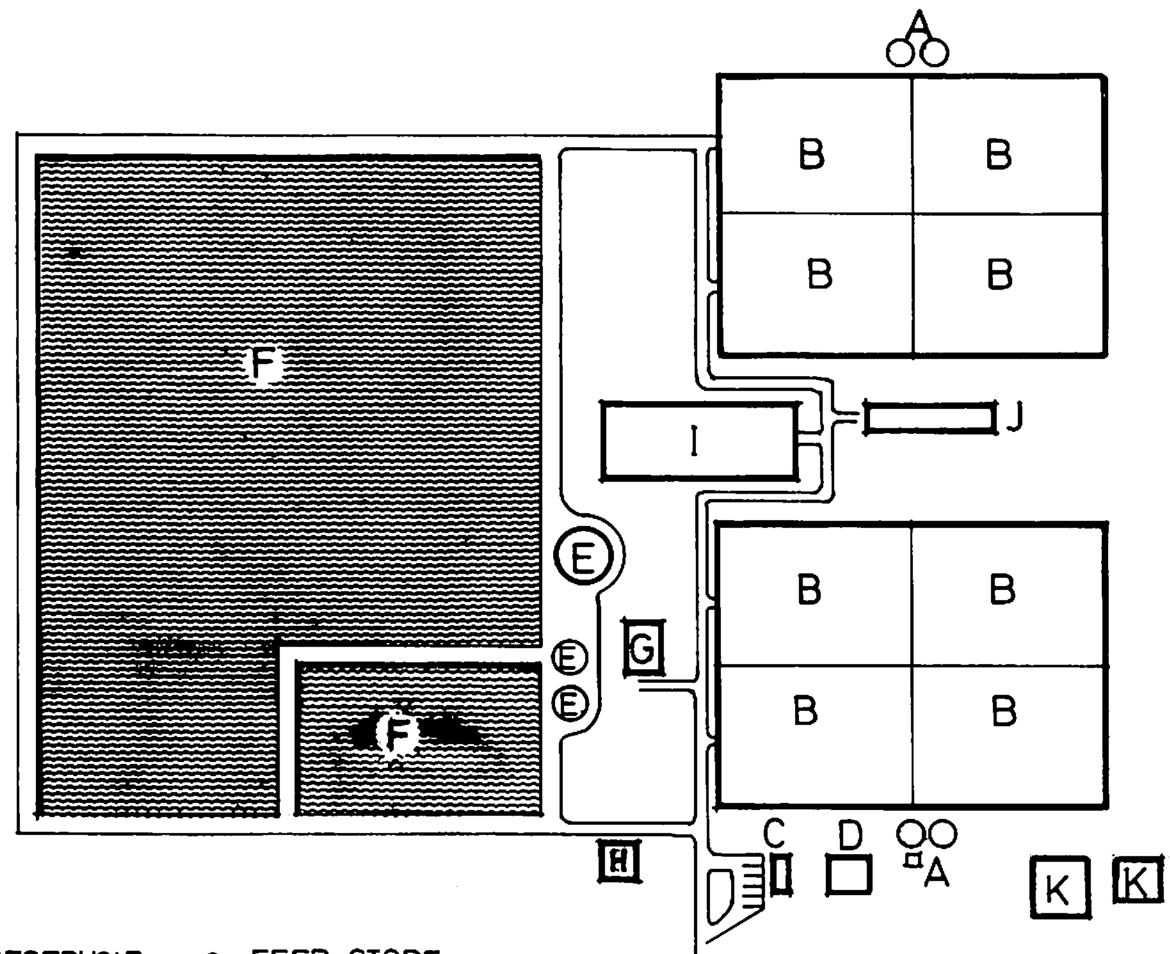


Figure 11.8. Layout of 400 t Farm.



LEGEND

A - WELL AND RESERVOIR
B - PRODUCTION UNIT
C - OFFICE
D - HOUSING
E - SEDIMENTATION TANK
F - LAGOON
G - FEED STORE
H - WORKSHOP/ STORAGE
I - FEED MILL
J - PACKING UNIT
K - ADDITIONAL HOUSING

Figure 11.9. Layout of 800 t Farm.

FACILITIES SUMMARY

The fish farm has 13 components:

1. Production unit - Hatchery and grow-out facilities located inside a greenhouse. Includes external filter blocks and blowers.

2. Feed system - Air conditioned feed storage in phase I. Expands to complete feed mill in phase II.

3. Water supply - Deep well, water reservoir and pipelines to production unit.

4. Lagoons - Sedimentation tank and lined lagoon to hold discharge water for irrigation.

5. Electrical supply - Substation from MEW, electrical wiring and emergency generators.

6. Packing unit - Holding and cooling tanks and packing facilities to prepare tilapia for shipment. Separate building present in Phase II only.

7. Vehicles - Delivery truck, four wheel drive pickups on farm, forklift(s) and bus. Bus in phase II only.

8. Office/laboratory - Minimal on-site office facilities for manager and engineer. Laboratory for water chemistry and preliminary disease diagnosis.

9. Computers - Micro-computer network for farm operations management in phase II only.

10. Workshop/general storage - Facilities to repair farm equipment and store supplies.

11. Housing - Manager and engineers on-site housing for phase I. Includes lounge and showers/toilets. Housing for all staff in phase II.

12. Roads/fences/windbreaks - Paved roads in site for delivery trucks. Perimeter fence for security. Trees to minimize blowing of sand.

13. Alarm System - Security and operational alarms.

A farm producing 100 t/yr will require 13300 m^2, 200 t/yr - 20900 m^2, 400 t/yr - 40800 m^2 and 800 t/yr - 71400 m^2.

CHAPTER 12. TILAPIA FEED[a]

Feed costs are the primary variable cost in an intensive fish culture operation, therefore considerable effort must be expended to determine the type and quantities of feed required and to estimate the cost of that feed. In intensive culture, the fish must be provided all of their nutrient requirements by the feed. Table 12.1 shows the proximate analysis of a feed which would be appropriate for the intensive culture of tilapia. The protein level is higher than the level usually encountered in tilapia feed because tilapia are usually grown in ponds or lakes where they obtain some nutrients from the natural environment.

The nutritional requirements of tilapia, like those of other fish, vary according to their age, size, and the culture system employed. Therefore, feeding is usually divided into two or more phases, each involving a diet of different nutrient composition. However, the successful use of different diets for different growth stages must be based on extensive knowledge of the nutritional requirements under different culture conditions. Unfortunately, such information is still lacking for tilapia so feeding the fish with just one diet over the entire period may be more practical, at least during the early years of the project.

Tilapia feed can be obtained in three ways. It can be imported ready made from reputable foreign suppliers, it can be manufactured by local feed mills or it can be produced at the fish farm by an on-site feed mill.

FEED IMPORTATION

The recommended diet specifications were sent to several reputable feed millers for cost estimation. Responses from three of them are presentated in Table 12.2. Cost varies from KD 154/t to KD 193/t C&F Kuwait. A major difficulty with imported feed is a shelf life of only three months. Assuming a two month sea voyage, the feed will have to be consumed within one month. Thus, monthly shipments of feed would have to be made. This allows little margin for error or delay.

LOCAL FEED MILLS

Four local feed mills were visited and their capability of producing fish feed evaluated (Table 12.3). A fifth mill in Sharjah (UAE) was also evaluated. The Kuwait United Poultry Company (KUPCO) feed mill is the largest and most sophisticated feed mill in Kuwait. The plant has fully electronic mixing of feed ingredients and can manufacture fish feeds with only minor modifications to the plant. The plant has spare capacity and KUPCO management has shown an interest in producing fish feeds. The Mubarakiya Poultry Company feed mill could be modified to produce fish feed at minimal cost but the mill is already working two shifts so no spare capacity is available at the present time. The Kuwait Livestock Trading and Transportation Company mills would require extensive and costly modifications to produce fish feed. The GADCO feed mill in Sharjah can produce fish feed with the addition of a small screen to their facilities. GADCO has excess capacity and has shown an interest in producing fish feed. In addition to these mills, a feed mill in Damman, Saudi Arabia is already producing tilapia feed for a project in Hofhof, Saudi Arabia. This mill was not evaluated but they could possibly encounter difficulties in exporting feed because many feed ingredients are subsidized in Saudi Arabia. Based on the preceeding, KUPCO and GADCO appear to be the best "local" sources of tilapia feed.

[a] Based largely upon a report by Al Fraih and Chow, 1984

Table 12.1. Specifications of Recommended Tilapia Diet.

Component	Value
Crude protein, minimum %	35
Digestible Energy, minimum kcal/g	3.1
Lysine, minimum %	1.8
Methionine + Cystine, minimum %	1.1
Calcium, minimum %	0.9
Phosphorus, minimum %	0.8
SUPPLEMENTARY VITAMINS/KG DIET	
Vitamin A	5000 i.u.
Vitamin D	1000 i.u.
Vitamin E	10 mg
Thiamine	2 mg
Riboflavin	5 mg
Calcium Pantothenate	15 mg
Niacin	25 mg
Pyridoxine	2 mg
Vitamin C	150 mg

Table 12.2. Specifications and Prices of a Complete Feed for Tilapia Imported into Kuwait in 1984.

Nutrient	Source: A-Holland	B-Taiwan	C-France
Protein (minimum %)	35	35	35
Fat (minimum %)	5	5	9
Fibre (maximum %)	3	5	6
Calcium (%)	1.2	N.A.	N.A.
Phosphorus (%)	1.0	N.A.	N.A.
Lysine (%)	2.6	N.A.	N.A.
Methionine + cystine (%)	1.3	N.A.	N.A.
Vitamin A (IU/kg)	110,000	N.A.	N.A.
Vitamin D3 (IU/kg)	2,000	N.A.	150,000
Vitamin E (mg/kg)	50	N.A.	1,500
Thiamine (mg/kg)	20	N.A.	50
Riboflavin (mg/kg)	20	N.A.	N.A.
Calcium pantothenate (mg/kg)	80	N.A.	N.A.
Pyridoxine (mg/kg)	20	N.A.	N.A.
Vitamin C (mg/kg)	200	N.A.	N.A.
Energy (kcal/g) Gross	N.A.	4,500	3,500
Energy (kcal/g) Digestible	N.A.	3,000	N.A.
Size (mm)	N.A.	4	4.5
Price per tonne C & F Kuwait (KD)	154	185-193 [a]	163-167 [a]

[a] Depends on quantity.
N.A. = information not available.

Table 12.3. Characteristics of Major Livestock Feed Mills in Kuwait

Facilities	KUPCO	Mubarakiya	Kuwait Livestock Trading [a] Mill 1	Mill 2
Feed Type	Poultry	Poultry	Sheep	Sheep
Large Silos				
Number	12	4	4	5
Total Capacity	10000 t	4400 t	9000 t	750 t
Inside Silos				
Number	10	6	8	N.A.
Total Capacity	300 t	96 t	2000 t	N.A.
Silos for Finished Product				
Number	6	8	N.A.	2
Total Capacity	180 t	128 t	N.A.	400 t
Grinders				
Total Capacity	10 t/hr	8 t/hr	15 t/hr	12 t/hr
Sieve Size	2.5 mm	N.A.	N.A.	N.A.
Pelletizer				
Smallest die size	2.5 mm	5 mm	8 mm	None
Total Capacity	5 t/hr [b]	2 t/hr	5 t/hr	None
Spare Capacity?	Yes	No	N.A.	N.A.
Required Modification[c]	Screen, die, crumbler	Sieves die, crumbler	Substantial	Extensive
Cost of Modification (KD)	1500	1500	High	High

[a] These mills are not designed to produce fine products suitable for fish or poultry.
[b] Planned expansion to 10 t/hr.
[c] Modification required to produce fish feed.
N.A. = information not available.

KUPCO and GADCO will prepare diets to customer specifications with costs and profits to be negotiated. These costs will reflect the cost of raw materials, operational costs, etc. KUPCO management has indicated that it would generally ask for addition of 10 per cent above the cost of raw materials available in the feed mill, and 15 per cent of materials imported specially for the fish feed, such as fish meal and concentrate. For operation, bagging and local delivery, KUPCO suggests to add about KD 25 per metric ton. Purchasing feed from GADCO would entail additional costs for shipment.

Raw material costs are shown in Table 12.4 and 12.5 for Kuwait and Sharjah, respectively. These prices follow the international market prices (Rotterdam prices plus shipping). Soya bean mill and wheat bran are produced in Kuwait as a by-product from the Kuwait Flour Mill Company. These products are both subsidized by the Kuwait government and are sold through the Kuwait Supply Company. Kuwait Protein and Fat Production Company has just started production of meat and bone meal which will be available locally.

A least cost feed formulation which meets the specifications in Table 12.1 was made using linear programming. The specifications and prices for Kuwait ingredients (Table 12.4) were used. The resulting formulation is that shown in Table 12.6. This formulation, like all least cost formulations, will have to be tested thoroughly.

The unsubsidized prices for ingredients included in the recommended formulation are the same in both Kuwait and Sharjah. Thus, it should be cheaper to procure the feed in Kuwait because shipping costs will be lessened. When subsidies are available, purchasing feed in Kuwait should be substantially less expensive than purchasing it from Sharjah. Table 12.6

Table 12.4. Specifications and Costs of Feed Ingredients in Kuwait, July 1984

Ingredient Name	Protein (%)	Calcium (%)	Phosphorus (%)	Lysine (%)	Methionine + Cystine (%)	Metabolizable Energy (kcal/g)	Cost (KD/kg)	
							unsubsidized	subsidized
Meat meal, imported	60	8	4	3.1	1.08	3.2	0.113	
Meat meal, local	60	8	4	3.1	1.08	3.2	0.095	
Soya meal	48.1	0.2	0.8	3	1.41	3	0.093	0.075
Corn	8.3	0.02	0.3	0.28	0.18	3.1	0.06	0.03
Barley	10	0.1	0.6	0.4	0.48	2.8	0.054	0.034
Rice Bran	15	0.4	1.5	0.68	0.42	2.2	0.04	
Wheat Bran	15	0.14	1.1	0.58	0.55	2.8	0.052	0.024
Fish Meal	72	4	2.3	4.98	2.42	3.9	0.155	
Pre-mix	46.5	0.2	0.8	3	1.4	3	0.211	

Table 12.5. Specifications and Costs of Feed Ingredients in Sharjah, U.A.E., July 1984

Ingredient Name	Protein (%)	Fat (%)	Fibre (%)	Calcium (%)	Phosphorus (%)	Cost/kg	
						(Dirham)	(KD)
Meat Meal	63	2.3	—	8.0	4	1.415	0.113
Soyabean meal	48.1	1.1	2.8	0.2	0.8	1.160	0.093
Yellow corn	8.3	3.7	6.5	0.02	0.3	0.750	0.06
Barley	10	2.0	6.5	0.1	0.6	0.650	0.05
Rice Bran	15	1.1	16	0.4	1.5	0.500	0.04
Wheat Bran	15	4	10	0.14	1.1	0.650	0.052
Molasses	6.5	0.2	—	0.16	0.3	0.605	0.048
Di-Ca-ph	—	—	—	21	18	0.975	0.077
Limestone	—	—	—	36	—	0.200	0.016
Maize Bran	8	6.3	8	—	0.8	0.570	0.045
Soya Meal Flakes	49	1.2	6.7	0.2	0.6	0.910	0.073

Table 12.6. Estimated Cost of Producing a 35% Protein Tilapia Feed by KUPCO, Kuwait, July 1984

Item	Composition (% of total)	Costs (KD/t feed[a])	
		unsubsidized	subsidized [b]
Ingredients			
Wheat Bran	59.3	30.8	14.2
Fish Meal	27.6	42.8	42.8
Soyabean Meal	8.1	7.5	6.1
Vitamin Premix	5.0	10.6	10.6
Total Cost of Ingredients		92	74
Profit on Ingredients[c]		12	10
Production Cost plus Local Delivery		25	25
Total Cost		129	109

[a] Feed ingredient prices are presented in Table 12.4
[b] Where present
[c] 10% of local ingredients (e.g., wheat bran and soyabean meal), 15% of imported ingredients (e.g., fish meal and vitamin premix)

presents an estimate of the costs of producing the recommended formulation at KUPCO. The unsubsidized price is KD 129/t which is considerably cheaper than the KD 154/t minimum price for feed imported from Europe or S.E. Asia. The subsidized price is only KD 109/t.

ON-SITE FEED MILL

The tilapia farm will require approximately 200 to 1600 t of feed per year. For this small capacity, the size of an on-site feed mill should be minimized. As this feed mill must produce pellets, minimum plant size is determined by the smallest size of commercial pelletizing plant, which is about two tonnes per hour.

The plant should be simple without any automatic machinery and complicated operation. This design is based on a quick and low cost installation. The plant must be capable of manufacturing various types of feed rations composed of any number of dry materials.

Assuming a single shift of 8 hours per day and 300 working days per year, the total output can be estimated at approximately 3000 tonnes. Since the required capacity is less than that, the feed mill should be initially operated one or two days per week for the requirement of the project. The feed mill should be operated with one supervisor and three workers only. The staff can also work on other farm activities.

The structure and assembly of the mill could be conventional inside a covered area, or prebuilt in a containerised form and assembled at the site. We recommend pre-assembly in the factory to save erection time and space in the store area.

The investment cost for a small feed mill is estimated to be KD 86,000 (Table 12.7). A preliminary estimate of the costs of producing tilapia feed at an on-site feed mill is shown in Table 12.8. Figure 12.1 shows a comparison of the costs of buying the feed from KUPCO and producing the feed on-site. The comparison was made using the present values of the initial investments and the discounted operating costs. At farms requiring less than 300-400 t/yr of fish feed, feed should be purchased from KUPCO. For larger quantities, the cost of making the feed on the farm is lower. Also an on-site feed production process offers greater flexibility in feed production and

Table 12.7. Estimated Investment Cost for a 2t/hr Feed Mill with Pelletizing Plant.

ITEM	COST (KD)
Mixer, 1 t	4000
Hammer Mill	3800
Elevators/Screw Conveyor	4100
Pelletizing Press for 2 t/hr	10950
Steam Boiler/Water Softner/Tanks	4200
2 Silos, Each 10 t	3950
Industrial Building Insulated, 944 m^2	25500
Cold Storage, 147 m^3	8500
Freight, Two 40 ft Containers	3000
Installation	4000
Concrete Works	14000
Total	86000

Table 12.8. Preliminary Estimate of Annual Operating Costs for an On-Site Feed Mill

Farm Size (t fish/yr)	100	200	400	800
Feed Produced (t/yr)	200	400	800	1600
Fixed Cost				
Insurance	400	400	400	400
Total Fixed Cost	400	400	400	400
Variable Costs				
Feed Ingredients[a]				
Unsubsidized	18400	36800	73600	147200
Subsidized	14800	29600	59200	118400
Labour[b]	1200	2400	4800	9600
Electricity/Diesel	130	260	520	1040
Maintenance	240	480	960	1920
Miscellaneous	160	320	640	1280
Total Variable Costs				
Unsubsidized	20130	40260	80520	161040
Subsidized	16530	33060	66120	132240
Total Operating Costs				
Unsubsidized	20530	40660	80920	161440
Subsidized	16930	33460	66520	132640

[a] Based on cost shown in Table 12.6.
[b] Based on 1 technician and 3 labourers at a total cost of KD 450/mo and KD 350/mo, respectively, 25 d/mo and a production rate of 10 t/d. Labor = KD 6/t feed. Labor used for other jobs on farm when not at mill.

feed formulation and higher quality control in addition to the extra capacity present for expansion and the capability of manufacturing fish feed for other fish farms. Thus it appears that an on-site feed mill should be used if the farm requires 400 t of feed or more per annum.

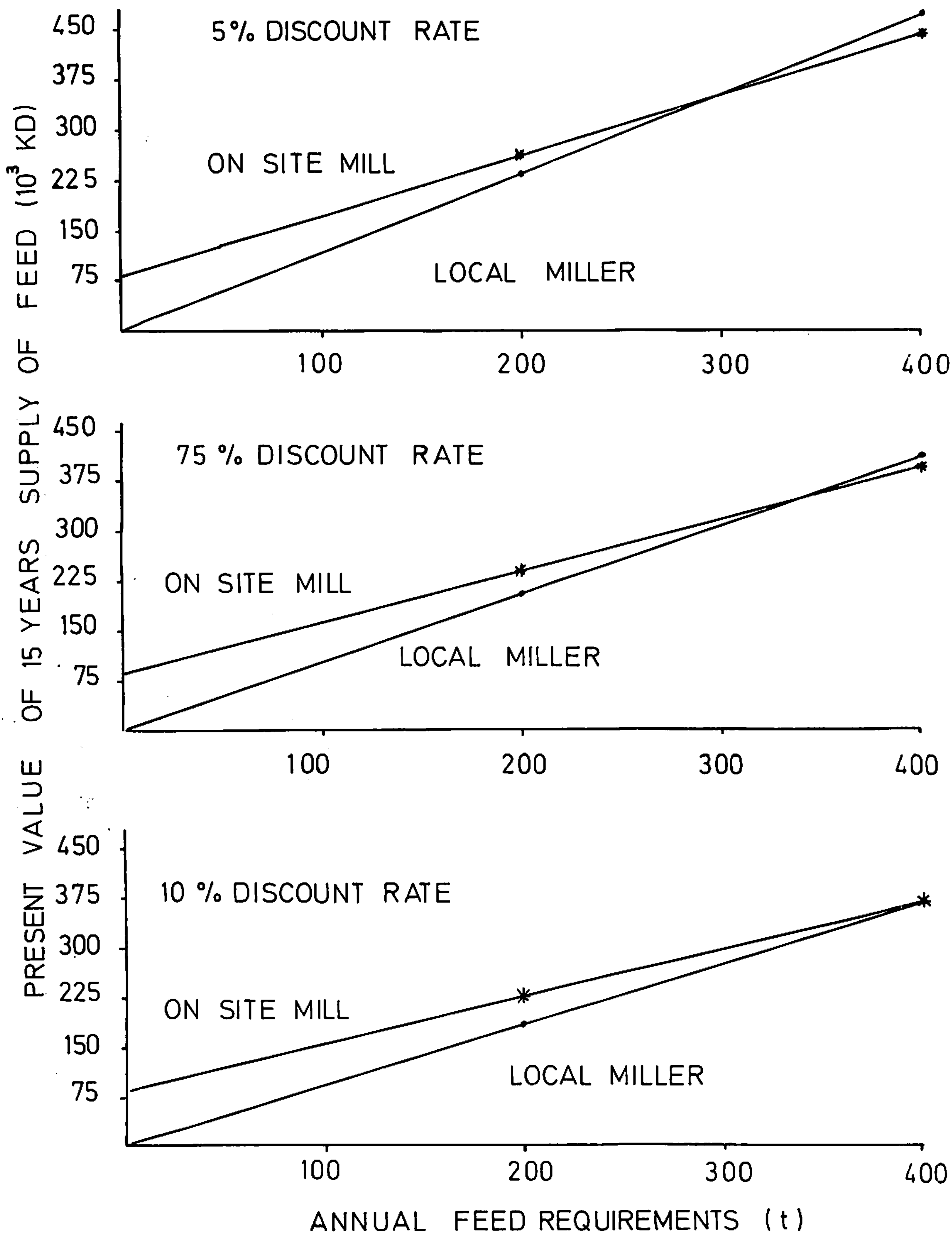


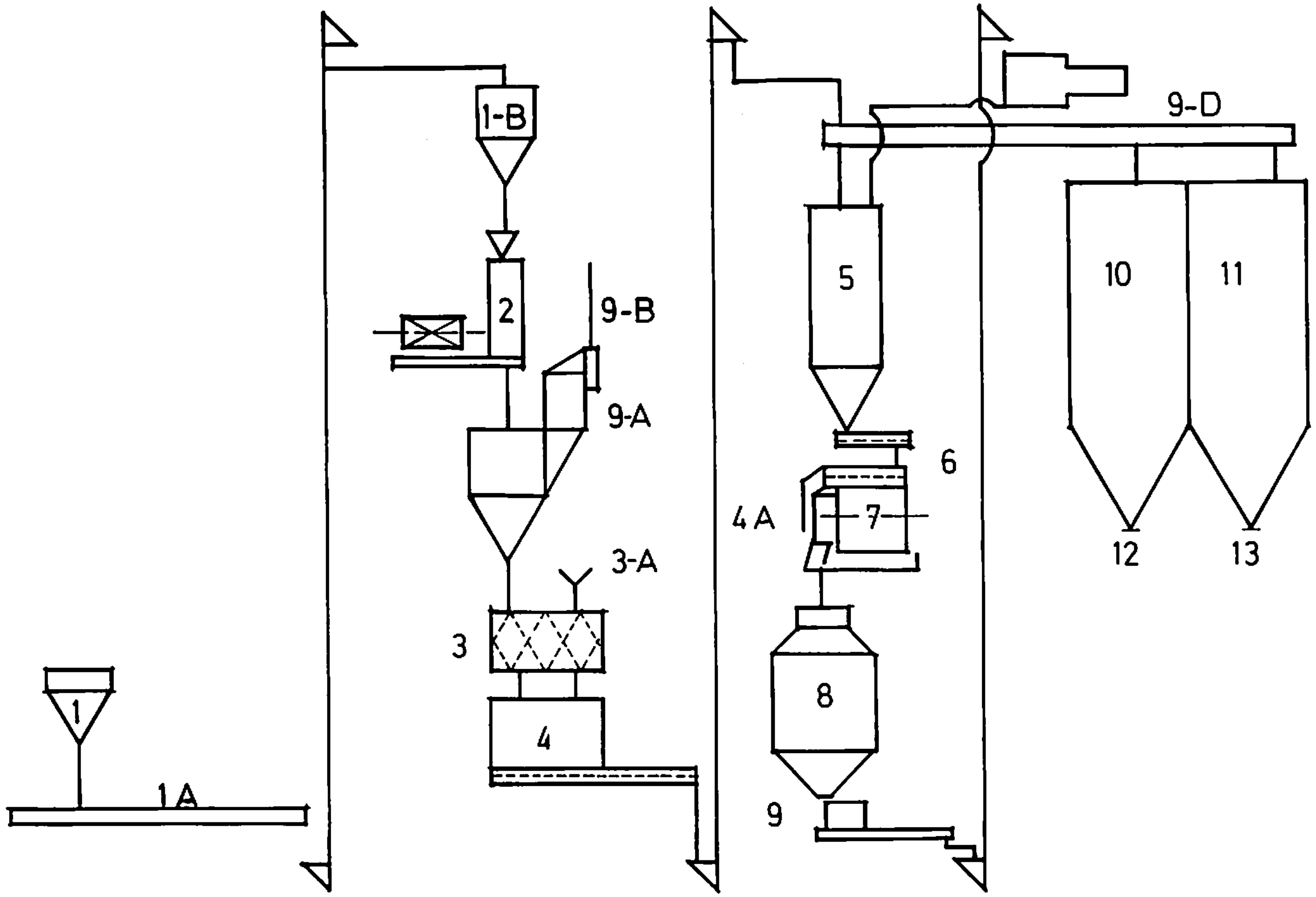
Figure 12.1. Cost Comparison of Purchasing Feed Produced With Subsidized Ingredients From Local Millers or Producing Feed On-site in Kuwait, 1984.

FEED MILL DETAILS

Figure 12.2 presents a schematic diagram of the proposed 2 t/hr feed mill. Table 12.9 contains a summary of the equipment required. Operation of the mill is envisioned as follows:

1) All materials are delivered to the feed storage area in bags, concentrate is stored in cold storage.
2) Materials necessary for ration are measured by weight or number of bags, and are loaded directly in the tipping bin.
3) From the tipping bin, the materials are transported by an auger to the weighing bin above the hammer mill. Capacity of bin: 100 kg
4) Feed is ground in the hammer mill to the desired size. Particle size can be changed by changing the size of the outlet screen. The capacity of a given hammer mill varies with the product, moisture content and screen size. Thus, it is standard practice to order a higher capacity hammer mill than actually required.
5) The ground feed ingredients then fall into the horizontal mixer. Two types of mixers are available in the feed mill industry: horizontal and vertical. The horizontal mixer is recommended for this feed mill. The horizontal mixer operates at a slower speed, but it usually requires less time to mix a batch after it is charged. Horizontal mixers will load and unload faster than vertical mixers. The mixing cycle in the horizontal mixer is usually six to eight minutes. As it is more completely cleaned out between batches than the vertical mixer, contamination of different feed batches is minimized. The mixer should have a double spiral blade connected to the main shaft to ensure proper mixing. A special opening at the top is provided to allow the addition of any additives in small quantities.
6) After the mixer, the feed goes to a buffer bin. From here, the feed can be conveyed to the mash (i.e., unpelleted) silo or to the press meal bin above the pellet mill.
7) After the feed is discharged in the press meal bin, it is transported by auger directly to the press. The mixed feed is processed with steam, and fed into the press. The size of the desired press is determined by the hole diameter of the die.
8) The pellets are then transported to the counter flow cooler where the pellets are immediately cooled. This makes the pellets durable, thus suitable for both transport and storage. Air cooling must be in gradual steps to prevent breakage from temperature shock. The pellets should move only slightly in relation to each other during conveying.
9) After cooling, the feed can be crumbled to provide small pellets, if required. A pellet mill cannot make small pellets economically in one operation because of the greater amount of friction involved in the small die openings and because of the greatly reduced capacity. Using patent cut rolls, plates or burrs, the feed is crumbled to the desired size and screened to remove fines. The fines are either repelleted or used as mash.
10) Materials are lifted by transport elevator to pass through a screen, which transfers the pellets to the pellet silo or mash silo. The two 10 m^3 silos should provide adequate feed storage.
11) From the silos, the feed is discharged manually directly to a container or a cart for transportation to the fish tanks or by auger for automatic transport.

A feed mill can be constructed in 27-35 wk. The shorter period is possible if a containerized system is used. Table 12.10 lists reputable suppliers of feed mills.



Legend: 1. Tipping Bin; 1-A. Screw Transport; 1-B. Bin Above Hammer Mill; 2. Hammer Mill; 2-A. Transport Elevator; 3. Horizontal Mixer; 3-A. Vitamins Tip Bin; 4. Emptying Bin Under Mixer; 4-A. Transport Elevators; 5. Collecting Bin Above Pellet Mill; 6. Mixer; 7. Pellet Mill; 8. Cooler (C.F); 9. Crumbler; 9-A. Dust Filter; 9-B. Cyclone; 9-C. Transport Elevator; 9-D. Chain Conveyor; 10. Ready Made Feed Bins; 11. Wash /Crumbled Pellets; 12 & 13. Dosing Slides.

Fig. 12.2. Schematic Diagram of Feed Mill for Tilapia Feed.

Table 12.9. Summary of Equipment Required for a 2t/hr Fish Feed Mill.

Reference in Figure 15.2	Number of Units	Description
1-1A	1	Auger with dumping hopper, auger length 9 m
1-B	1	Weighing bin with hand operating outlet slide, capacity 100 kg
—	1	Auger, length 5.8 m
2	1	Hammer mill, 22 kW, 3000 RPM
9-B	2	Cyclone
—	2	Fan, 3 kW, 3000 RPM
9-A	1	Filter
—	2	Rotary Valve
3	1	Horizontal mixer, 2000 liter capacity, 11 kW, 1500 RPM
4	1	Bin under mixer 2000 liter capacity
—	2	Discharge conveyor, 6 m
4a, 9c	2	Elevator, 14 m
—	1	Screw conveyor, 6 m
1	1	Slide
—	2	Level indicator — press meal bin
5	1	Press meal bin, 12 m^3 capacity w/cover, outlet hopper, wall element and supporting structure
7	1	Pellet mill, proportioning conveyor drive — 1.5 kW, steam mixer driver — 11 kW, pellet mill driver — 75 kW
8	1	Counterflow cooler
9	1	Crumbler, type CRE 8
—	1	Screener, 800 × 2000 mm
—	2	Level indicator in feed bins
10,11	2	Finished feed bins, 10 m^3 each w/cover, wall elements, outlet hopper and supporting structure
12, 13	2	Slide, type 200, hand operated
—	—	Spouting
—	—	Support structure for mixing unit
—	1	Steam boiler complete w/water softner, dosing pumps, chimney and reducing group
—	1	Air compressor w/piping
—	1	Electrical control panel w/cabling
—	1	Building, 944 m^2
—	1	Cold Storage, 14 m^3

Table 12.10. Reputable Supplier of Feed Mills

- Amandus Khal Nachf GmbH & Co.,
  Postfach 1246
  D. 2057,
  Reinbek Bez,
  Hamburg
  West Germany,
- Blount/CDD
  2800 Rockcreek Parkway
  Suite 303,
  North Kansas City, 64117
  U.S.A.
- Heem Borst
  Mashinefabriek/Konstrucktiebedrijf B.V.
  Sluisstraat 6,
  7411 EG Deventer
  Postbus 485
  7400 Al Deventer
  Holland
- Jaybee Engineering Pty Ltd.,
  227 Princess Highway
  Dandenong
  Victoria — 3175
  Australia
- Mix-Mill Manufacturing Co.,
  Box : 256
  Bluffton
  Indiana 46714
  U.S.A.
- Ottevanger Machinefabriekin B.V.
  Moerkapelle
  Postbus — 3
  Holland
- Raison Tehtaat
  21200 Raisio
  Finland
- Simon Barron Ltd.,
  Bristol Road
  Gloucester, GL2 6BY
  U.K.
- Awila Maschinenfabrik GmbH
  4595,
  Lastrup
  West Germany
- Four-F International Ltd.,
  Daisy Hill
  Burstwick — Hull
  North Humberside
  England, U.K.
- Hough Kennebec International
  920 Farmington Avenue
  West Hartford
  Connecticut 06107
  U.S.A.
- Law Export Ltd.,
  Quarry Road
  Chipping Sodbury
  Bristol BS17 6AX
  England, U.K.
- Modern Farm Systems Inc.,
  1811 West Second Street
  Webster City, Iowa 50595
  U.S.A.
- President Mollerimaskiner A/S
  Box : 20
  DK — 4300, Holbaek
  Denmark
- Saeby Jernstoberi & Maskinfabrik A/S
  DK — 9300 Saeby
  Denmark
- Van Aarsen Machinefabriek B.V.
  Heelderweg 11
  P.O. Box : 5010
  6097 ZG, Panheel
  Holland.

FEED SUPPLY SUMMARY/CONCLUSION

1) The average cost of imported feed from Europe or Asian countries is between KD 154/t and KD 193/t, not including local delivery charges and duties.

2) Only KUPCO feed mill in Kuwait and GADCO feed mill in U.A.E. are able to produce fish feed locally with only minor modifications to existing plants. The average price per tonne of feed manufactured locally will be about KD 129, but if subsidized materials are used, the price will be KD 109. If feed is imported from GADCO, the cost will be higher due to transportation costs.

3) The total cost of building an on-site feed mill is about KD 86000.

4) The estimated time required to build the feed mill is 9 mo.

5) If feed demand exceeds 400 t/yr, an on-site feed mill is recommended. The advantages are:
   - ⋆ Lower prices per tonne feed.
   - ⋆ Better quality control.
   - ⋆ Installation of the plant adjacent to the fish farm will reduce management costs.
   - ⋆ By having the feed mill near the fish farm, the feed can be transported directly by mechanical transportation, which will reduce labor.
   - ⋆ More flexibility in changing formulas, adding additives, medical treatment, etc.

6) For feed requirements below 400 t/yr, it is recommended that the services of KUPCO feed mill be utilized.

7) Soyabean meal, wheat bran, and meat and bone meal are processed in Kuwait, and should be utilized whenever possible.

8) Subsidies for ingredients should be utilized whenever possible.

9) The possibility of buying feed ingredients in bulk, in association with other feed mills, should be explored to reduce costs.

10) Any least cost feed formulation should be tested before adoption on large (production) scale.

CHAPTER 13. TEMPERATURE MANAGEMENT

The growth rates and survival rates assumed for the proposed farm are based on a water temperature of 28 - 30°C. This temperature is considerably above the mean air temperature during winter and lower than the mean air temperature during summer. Thus, it is essential that the fish tanks be protected from the environment. The project staff must also be provided a "comfortable" environment in order to maximize productivity and minimize staff turn-over.

ENVIRONMENTAL CONDITIONS

Kuwait is subject to a very harsh environment. In summer, average maximum temperatures are 44°C and often approach 48°C to 50°C. In winter, minimum temperatures average 8°C to 9°C and occasionally drop to 0°C. Daily temperature fluctuations range from 13°C to 15°C in summer and 8°C to 10°C in winter (Table 13.1). Rainfall averages only 100 mm per year. Average solar radiation incident on a horizontal surface in January is shown in Figure 13.1. Dust storms, rising dust or suspended dust occur an average of 200 d/yr.

TEMPERATURE MANAGEMENT DURING SUMMER

The Mariculture and Fisheries Department has successfully operated tilapia culture tanks inside greenhouses covered with shade netting for several summers. The shading keeps the water cool while exhaust fans cause an evaporative cooling effect by drawing air through the greenhouse and across the exposed water surfaces. This minimal amount of environmental protection is sufficient for basic farm operations during the summer but air conditioning is required in the scale rooms, offices, housing, workshop and chemicals store.

TEMPERATURE MANAGEMENT DURING WINTER

In an effort to minimize heating costs during winter, the possibilities for passive solar heating were explored. A detailed analysis of thermal losses and gains in a 100 t production module on an average January day was made. Included is an estimate of the energy required to maintain water temperatures at 28°C.

In the analyses, it was assumed that the air inside the greenhouse was relatively static and to be saturated with water because of the large exposed water surface. Air temperature was assumed to be equal to the ambient air temperature. The water temperature is 28°C.

Heat loss can occur by six different means while energy can be passively obtained from solar radiation (Table 13.2). In order to estimate a daily energy balance, heat losses and gain were computed on an hourly basis for the 40 m^3 Kingfisher tanks, the water channels, filter tanks, 2 m^3 fry tanks and 20 m^3 breeding and fingerling tanks. All variables used in the analysis are defined in Table 13.2.

40 m^3 KINGFISHER TANKS

The heat loss by conduction from the sides and bottoms of Kingfisher tanks was estimated by using the following simplified heat conduction formula.

$$Q_t = A\,U\,(t_w - t_a) \qquad \dots\ 13.1$$

As the interior walls of the tanks are common, they are not included in the area exposed to conduction. These tanks are manufactured with insulation and have a heat transfer coefficient of 0.65 w/m²/°C.

Table 13.1. Hourly Mean Temperature (°C) Measured at Kuwait International Airport, 1962-1973

HOUR (GMT)	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	MEAN
0000	9.6	11.8	15.8	20.1	25.8	29.4	31.4	30.8	27.3	22.3	16.0	10.5	20.9
0100	9.3	11.4	15.3	19.7	25.3	28.7	30.7	30.3	26.8	21.9	15.7	10.2	20.4
0200	8.9	11.1	15.0	19.4	24.8	28.2	30.1	29.7	26.1	21.5	15.3	9.9	20.0
0300	8.7	10.8	14.6	19.3	25.2	28.7	30.2	29.5	25.7	21.1	15.1	9.6	19.9
0400	8.4	10.7	15.0	20.5	27.1	30.9	32.3	31.3	27.1	21.9	15.2	9.4	20.8
0500	9.4	12.1	17.2	22.9	29.7	33.9	35.2	34.4	30.4	24.8	17.2	10.7	23.1
0600	11.3	14.1	19.6	25.3	32.2	36.5	37.8	37.2	33.6	27.7	19.7	12.7	25.7
0700	13.3	16.2	21.7	27.0	34.0	38.8	40.1	39.7	36.4	30.5	22.0	15.1	27.9
0800	15.1	17.7	23.3	28.3	35.3	40.4	41.8	41.6	38.5	32.6	23.8	16.9	29.6
0900	16.3	18.9	24.2	29.1	36.2	41.5	42.9	42.7	39.8	33.9	25.1	18.1	30.7
1000	17.1	19.5	24.9	29.5	36.8	42.2	43.6	43.5	40.6	34.7	25.7	13.9	31.4
1100	17.5	19.9	25.2	29.6	36.9	42.5	43.9	43.7	41.0	34.7	25.9	19.3	31.7
1200	17.6	20.0	25.1	29.3	36.7	42.6	43.9	43.7	40.9	34.5	25.8	19.2	31.6
1300	17.2	19.6	24.6	28.7	36.2	42.1	43.6	43.2	40.2	33.6	25.1	18.7	31.1
1400	16.2	18.8	23.8	27.9	35.4	41.2	42.9	42.2	39.0	32.1	23.8	17.5	30.1
1500	14.9	17.5	22.4	26.6	34.2	39.9	41.6	40.7	37.0	30.1	22.3	16.2	28.6
1600	14.0	16.5	21.1	25.2	32.5	38.1	39.8	38.8	35.2	28.9	21.3	15.3	27.3
1700	13.3	15.7	20.2	24.4	31.3	36.5	38.2	37.3	33.8	27.7	20.3	14.4	26.1
1800	12.7	15.1	19.5	23.7	30.5	35.5	37.1	36.3	32.6	26.6	19.5	13.7	25.2
1900	12.0	14.5	18.7	23.1	29.5	34.2	35.9	35.0	31.3	25.5	18.7	13.0	24.3
2000	11.4	13.8	18.0	22.3	28.7	33.0	34.8	34.1	30.2	24.7	17.9	12.3	23.4
2100	10.9	13.3	17.4	21.6	27.7	31.9	33.8	33.1	29.3	23.9	17.3	11.7	22.8
2200	10.4	12.8	16.8	21.2	27.0	31.0	32.9	32.3	28.5	23.2	16.7	11.2	22.0
2300	10.0	12.3	16.3	20.7	26.5	30.2	32.2	31.5	27.7	22.6	16.2	10.8	21.4
Mean	12.7	15.2	19.8	24.4	31.1	35.7	37.4	36.8	33.3	27.5	20.1	14.0	25.7

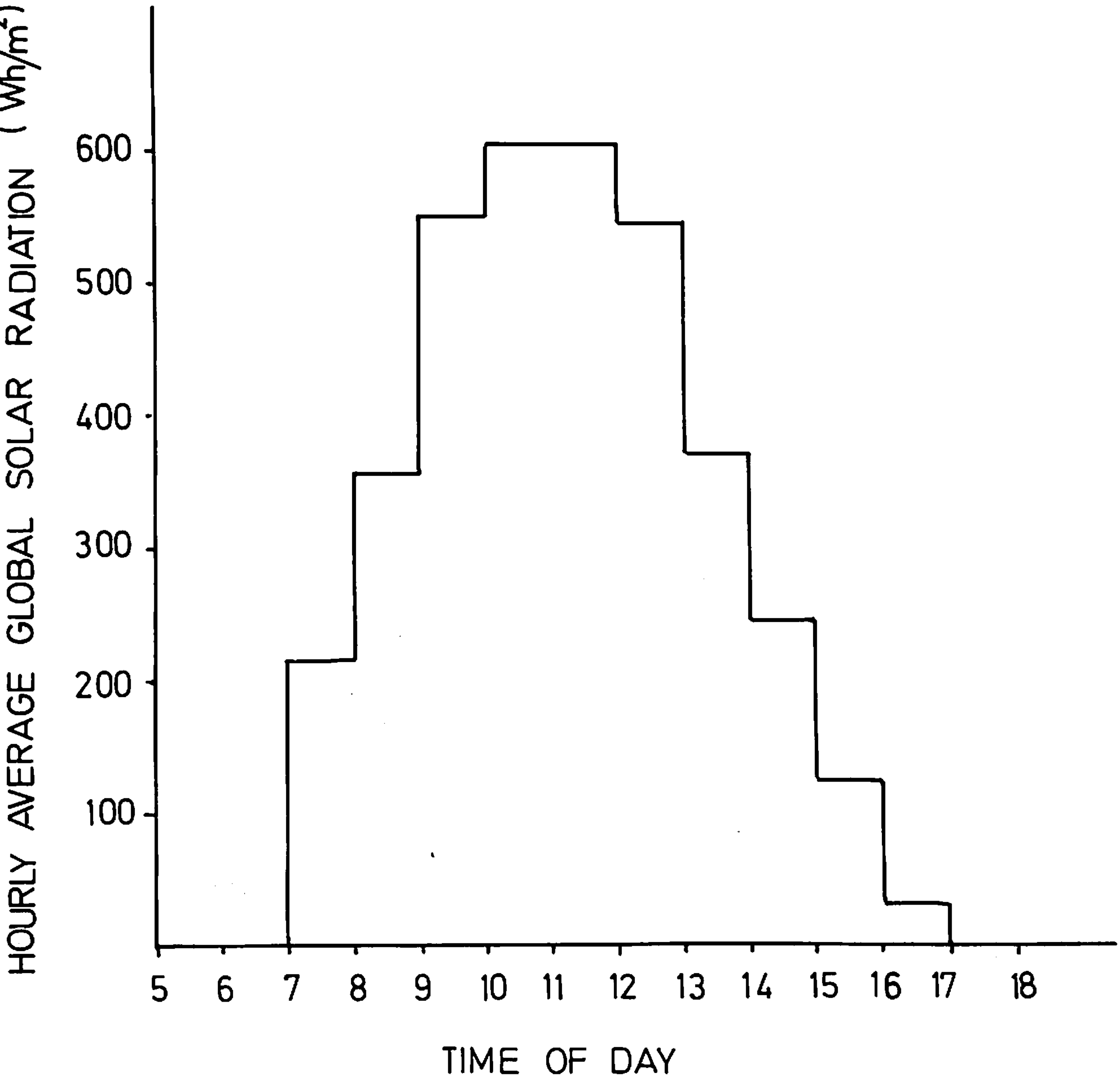


Figure 13.1. Average Solar Radiation During January at KISR, Kuwait. 1978, 1979, 1981

Table 13.2. Variable Used in Analysis of Heat Transfer

Variable	Definition
Q_t	Heat transfer by conduction (kWh)
Qa_a	Heat transfer by warming of air used for aeration (kWh)
Qa_w	Heat transfer by saturation of air used for aeration (kWh)
Q_e	Heat transfer by evaporation from water surface (kWh)
Q_c	Heat transfer by convection (kWh)
Q_r	Heat transfer by radiation (kWh)
Q_s	Heat transfer by solar radiation (kWh)
Q_T	Total heat transfer (kWh)
A	Area of tank sides and bottom (m^2)
U	Heat transfer coefficient ($W/m^2.°C$)
t_w	Water temperature (°C)
t_a	Ambient air temperature (°C)
t_a^*	Compressed air temperature (°C)
P_c	Compressed air pressure (2 PSI = 1.14 atm)
P_{atm}	Atmospheric pressure (1 atm)
K	Gas constant (1.4 for air): Ratio of specific heat at constant pressure to specific heat at constant volume
M_a	Mass of air flowing through the tank (kg)
C_p	Specific heat of air (0.24 Kcal/kg°C)
W_1	Absolute humidity of air entering the tank (kg water/kg dry air)
W_2	Absolute humidity of air leaving the tank (kg water/kg dry air)
L	Latent heat of water (530 Kcal/kg)
S	Water surface area (m^2)
V_p	Air velocity above water surface (assumed to be 0 as exhaust fans are turned off in winter)
P_w	Partial vapor pressure of water at 28°C
P_a	Partial vapor pressure of water at ambient temperature
h_r	Heat radiation coefficient
t_m	Mean temperature
T	Transmissivity of greenhouse cover (0.8)
R	Solar radiation (kWh/m^2)

The compressed air flowing through the tanks causes heat transfer because of the temperature variation between the incoming and the outgoing air and the latent heat of the water taken from the tank by the saturated air. Assuming that the process of air compression is isoentropic, heat loss caused by warming of the incoming air is:

$$Qa_a = M_a\, Cp\, (28 - t_a^*) \quad \ldots.\ 13.2$$

where
$$(t_a^* + 273.15)/(t_a + 273.15) = \left[\frac{P_c}{P_{atm}}\right]^{\frac{K-1}{K}} \quad \ldots.\ 13.3$$

Heat loss caused by saturation of the incoming air is:

$$Qa_w = M_a\, (W_2 - W_1)\, L \quad \ldots.\ 13.4$$

The vapor pressure differential induces a continuous flow of water vapor between the tanks surface and the surrounding air. This process causes a heat loss:

$$Q_e = S\, (3.1 + 4.1\, Vp)\, (Pw - Pa) \quad \ldots.\ 13.5$$

The temperature gradient between water and air causes a convection transfer

$$Q_c = S\, (3.1 + 4.1\, Vp)\, (t_w - t_a) \quad \ldots.\ 13.6$$

Energy is emitted in the form of radiation from the water. It is estimated by

$$Q_r = 0.95\, Sh_r\, (t_w - t_a) \quad \ldots.\ 13.7$$

The solar radiation falling on the water surfaces brings energy into the water

$$Q_s = S \times T \times R \times 0.95 \quad \ldots.\ 13.8$$

The total heat transfer is simply a summation of other heat transfers

$$Q_T = Q_t + Qa_a + Qa_w + Q_e + Qc + Q_r + Q_s$$

The heat transfer values for an average January day are shown in Table 13.3. Total energy loss was quite high, 2936 kWh. Most of this loss occurs by saturation of air used for aeration, convection, and radiation. Convection and radiation losses can be easily reduced to only 659 kWh by covering the tanks at night (Table 13.4). A cover material such as rolled greenhouse plastic should be sufficient.

The heat transfers computed in Table 16.3 and 16.4 assume an average January day. For a cloudy day, Q_s has been equated to zero. This results in a sizable energy loss if the tanks are uncovered during the day (Table 13.5). Thus, on a cloudy day, tanks should be kept covered if at all possible.

CHANNELS AND FILTERS

The channels and filters are constructed of 10 cm thick concrete which, if uninsulated, has a heat transfer coefficient of 9 $w/m^2 \cdot °C$. This could lead to very large heat losses so a simple analysis of insulation efficiency was conducted (Table 13.6). A 25 mm thickness of polystyrene insulation shows the most potential and was selected for use in both the channels and filters.

Based on the same formulas used for the Kingfisher tanks, the channels will lose 224 kWh per day without covers. As covers can be used continuously over the channels with little effect on management efficiency, the channels should always be covered during the winter in order to reduce heat loss to only 113 kWh per day (Table 13.7). Heat loss from covered filters is estimated to be 74 kWh per day.

Table 13.3. Heat Transfer Estimates for 24 Kingfisher Tanks with Common Sidewalls without Covers on an Average January Day.

Local time	t_a (°C)	Q_t (kWh)	$Q_a$air (kWh)	$Q_a$water (kWh)	Q_e (kWh)	Q_c (kWh)	Q_r (kWh)	Q_s (kWh)	Q_T (kWh)
0000-0100	10.65	18.6	10.1	61.8	7.9	55.5	96.4	0	250.3
0100-0200	10.2	19.1	10.9	61.8	8.1	57.0	89.9	0	255.8
0200-0300	9.8	19.5	11.5	61.8	8.3	58.2	100.8	0	260.1
0300-0400	9.45	19.9	12.1	61.8	8.3	59.3	102.6	0	264.0
0400-0500	9.1	20.3	12.6	61.8	8.4	60.5	104.3	0	267.9
0500-0600	8.8	20.6	13.2	65.4	8.5	61.4	105.8	0	274.9
0600-0700	8.55	20.9	13.5	65.4	8.5	62.2	107.0	0	277.5
0700-0800	8.9	20.5	12.9	69.0	8.4	61.1	105.2	-166.3	110.8
0800-0900	10.35	18.9	10.7	69.0	8.1	56.5	98.1	-287.1	-25.8
0900-1000	12.3	16.8	7.5	72.7	7.5	50.2	88.0	-376.5	-133.8
1000-1100	14.2	14.8	4.4	76.3	6.9	44.1	78.2	-411.0	-186.3
1100-1200	15.7	13.2	3.0	76.3	6.4	39.3	70.2	-411.0	-202.6
1200-1300	16.7	12.1	0.3	72.7	6.0	36.1	64.8	-373.3	-181.3
1300-1400	17.3	11.5	-0.6	69.0	5.8	34.3	61.6	-294.9	-113.3
1400-1500	17.55	11.2	-0.9	69.0	5.7	33.4	60.2	-185.1	-6.5
1500-1600	17.4	11.4	-0.8	65.4	5.8	33.9	61.0	-78.4	98.3
1600-1700	16.7	12.1	0.3	65.4	6.0	36.1	65.0	-18.8	166.1
1700-1800	15.55	12.5	2.2	65.4	6.4	39.8	71.0	0	197.3
1800-1900	14.45	14.5	4.0	61.8	6.8	43.3	76.9	0	207.3
1900-2000	13.65	15.4	5.3	61.8	7.1	45.9	81.0	0	216.5
2000-2100	13	16.1	6.4	61.8	7.3	48.0	84.4	0	224.0
2100-2200	12.35	16.8	7.5	61.8	7.5	50.1	87.8	0	231.5
2200-2300	11.37	17.5	8.4	61.8	7.7	52.1	91.1	0	238.6
2300-2400	11.15	18.1	9.3	61.8	7.8	53.9	94.0	0	244.9
Total		392.3	163.8	1580.0	175.2	1172.2	2054.3	-2602.4	2936.2

Table 13.4. Heat Transfer Estimates for 24 Kingfisher Tanks ($40m^3$) with Common Sidewalls and Covers on an Average January Day

Local time	t_a (°C)	Q_t (kWh)	Q_a air (kWh)	Q_a water (kWh)	Q_e (kWh)	Q_c (kWh)	Q_r (kWh)	Q_s (kWh)	Q_T (kWh)
0000-0100	10.65	18.6	10.1	61.8	0	0	0	0	90.5
0100-0200	10.2	10.8	10.9	61.8	0	0	0	0	91.8
0200-0300	9.8	19.5	11.5	61.8	0	0	0	0	92.8
0300-0400	9.45	19.9	12.1	61.8	0	0	0	0	93.8
0400-0500	9.1	20.3	12.6	61.8	0	0	0	0	94.7
0500-0600	8.8	20.6	13.2	65.4	0	0	0	0	99.2
0600-0700	8.55	20.9	13.5	65.4	0	0	0	0	99.8
0700-0800	8.9	20.5	12.9	69.0	0	0	0	0	102.4
0800-0900	10.35	18.9	10.7	69.0	8.1	56.5	98.1	-287.1	-25.8
0900-1000	12.3	16.8	7.5	72.7	7.5	50.2	88.0	-376.5	-133.8
1000-1100	14.2	14.8	4.4	76.3	6.9	44.1	78.2	-411.0	-186.3
1100-1200	15.7	13.2	3.0	76.3	6.4	39.3	70.2	-411.0	-202.6
1200-1300	16.7	12.1	0.3	72.7	6.0	36.1	64.8	-373.3	-161.3
1300-1400	17.3	11.5	-0.8	69.0	5.8	34.3	61.6	-294.9	-113.3
1400-1500	17.55	11.2	-0.9	69.0	5.7	33.4	60.2	-185.1	-6.5
1500-1600	17.4	11.4	-0.8	65.4	0	0	0	0	76
1600-1700	16.7	12.1	0.3	65.4	0	0	0	0	77.8
1700-1800	15.55	12.5	2.2	65.4	0	0	0	0	80.1
1800-1900	14.45	14.5	4.0	61.8	0	0	0	0	80.3
1900-2000	13.65	15.4	5.3	61.8	0	0	0	0	82.5
2000-2100	13.00	16.1	6.4	61.8	0	0	0	0	84.3
2100-2200	12.35	16.8	7.5	61.8	0	0	0	0	86.1
2200-2300	11.37	17.5	8.4	61.8	0	0	0	0	87.7
2300-0000	11.15	18.1	9.3	61.8	0	0	0	0	89.2
Total		392.3	163.8	1580.0	46.4	293.9	521.1	-2338.9	659.4

Table 13.5. Total Energy Loss from 24 Kingfisher Tanks (40 m^3) with and without Covering on a Cloudy January Day.

Tank Covers	Heat Loss (kWh)
None	5539
Night only	2998
Continuous	2137

Table 13.6. Energy Analysis of 10 cm Concrete with Different Insulation Thickness Insulation Material - Polystyrene (Isobard)

	Insulation thickness (mm)					
	0	25	40	50	65	75
Overall heat transfer coefficient (w/m^2.°C)	9.00	0.95	0.62	0.51	0.40	0.34
Annual thermal energy loss (kWh/m^2.Yr)	405.20	42.40	27.70	22.80	17.90	15.20
Annual energy saving (kWh/m^2.Yr)	0.00	362.80	377.50	382.40	387.30	390.00
Cost of Insulation (KD/m^2)	0.00	1.50	2.10	2.50	3.10	3.50
Annual cost of energy KD/m^2, at 0.002 KD/kWh (Present cost to consumer)	0.00	0.70	0.70	0.80	0.80	0.80
0.032 KD/kWh (Based only on fuel cost)	0.00	11.60	12.10	12.20	12.40	12.50
0.008 KD/kWh (Based only on fuel cost)	0.00	2.90	3.00	3.10	3.10	3.10
Simple payback period based on fuel cost (year)	—	0.50	0.70	0.80	1.00	1.10

Table 13.7. Heat Transfer from Channels and Filter Tanks to Environment on a Typical January Day.

Type of Transfer	Channels [a]		Covered[b] Filter Tanks
	Without Covers (kWh)	With Covers[b] (kWh)	(kWh)
Q_t	113	113	74
Q_e	25	0	0
Q_c	163	0	0
Q_r	285	0	0
Q_s	-362	0	0
Q_T	224	113	74

[a] Based on 179 linear meter of channel
[b] Continuously covered

FRY, BREEDING AND FINGERLING TANKS

The fiberglass tanks for fry, breeding and fingerlings are delivered without insulation and have an estimated heat transfer coefficient of 4.4. w/m² . °C. This would lead to unacceptable heat losses so these tanks will be covered on the outside walls and bottom with 25 mm thick polystyrene. As night-time covers saved energy with the Kingfisher tanks, covers will also save energy with these tanks. Energy analyses for a typical January day are shown in Table 13.8. The breeding tanks maintain a minimum temperatures of 28°C while the fry and fingerling tanks show a minor heat loss.

HEATER CAPACITY FOR PRODUCTION UNIT

The assumptions used in the analyses of heat loss are very conservative: the air temperature inside the greenhouse should be higher than ambient air temperature (which was used in the analyses) and solar radiation is not equal to zero on cloudy days. Thus heat losses will probably be less than computed. Also, it was assumed that temperatures should be maintained at 28°C. A drop of a few degrees for a few days will probably not effect fish yield substantially.

The temperature loss in uncovered and unheated Kingfisher tanks is relatively small but several days of poor visibility may cause the temperature to drop to levels which will depress fish growth. As covers impede fish management, they should be avoided. If, however, temperatures start dropping, covers will have to be used. The use of supplemental heating for the Kingfisher tanks will probably not be needed but this conclusion should be tested during the first winter of farm operation. Heaters of 20-40 kWh maximum, can be easily installed in the pump sump or return channels.

The small tanks should be covered at night and will require supplemental heaters (Table 13.9). Each heater should have an individual thermostat.

HEATER CAPACITY FOR STAFF

Standard heating will have to be provided in all living, office and laboratory spaces. Overhead space heaters will be required in the scale room and workshop.

TEMPERATURE MANAGEMENT SUMMARY

1. The fish tanks should be contained inside covered greenhouses to protect them from the very harsh environment.

2. During summer, the greenhouses have to be covered with shade net and exhaust fans will have to be used. In addition, scale rooms, offices, housing, workshop and chemical rooms have to be air-conditioned.

3. All tanks, filters and water channels must be insulated to maintain the water temperature during winter.

4. A polystyrene insulation of 25 mm thick is recommended for use in both the water channels and filters. The fry, breeding and fingerling tanks have to be covered with 25mm thick polystyrene on the outside walls and bottoms. The Kingfisher tanks are made with insulation.

5. Heat loss caused by convection and radiation can be substantially reduced by covering the tanks at night. Filters and water channels should be covered continuously during winter.

6. Supplemental heaters with individual thermostat are required for fry and fingerling tanks.

7. The Kingfisher tanks should not require supplemental heating. However, this conclusion should be tested during the first winter of farm operation.

8. The housing, offices and laboratory require standard heating while overhead space heaters are required in the scale room and workshop.

Table 13.8. Daily Energy Analysis for the Hatchery and Fingerling Tanks Which Are Covered During the Night.

	Fry Tank	Breeding Tank	Fingerling Tank
Tank size (m)	2×2×0.8	5×5×0.8	5×5×0.8
Side and bottom area (m^2)	8	45	45
Water surface (m^2)	4	25	25
Water volume (m^3)	2	20	20
Insulation		25 mm thick polystyrene	
U (w/m^2/°C)	0.95	0.95	0.95
Q_t (kWh)	2.79	15.63	15.63
Q_a (kWh)	6.12	6.12	75.58
Q_r (kWh)	2.02	12.62	12.62
Q_c (kWh)	1.14	7.12	7.12
Q_e (kWh)	0.18	1.14	1.14
Q_s (kWh)	-9.06	-56.66	-56.66
Q_T (kWh)	3.19	-14.03	-55.43

Table 13.9. Heater Requirements for a 100t Tilapia Production Unit

	Total Heat Loss (kWh/d)	Recommended Heaters: Size [a] (kW)	Recommended Heaters: Number
Recirculating System			
Kingfisher Tanks	659	—	—
Channels & Filters	187	—	—
Total Recirculating	846	30.0	2 [b]
Fry Tanks	32	0.3	10
Breeding Tanks	-84	—	0
Fingerling Tanks	165	4.0	3

[a] Based on 18 hr/day operation plus a minimum of 30-50% over capacity.
[b] The heaters should not be installed until the need is empirically verified.

CHAPTER 14. INTEGRATION WITH AGRICULTURE

OBSERVATIONS ON INTEGRATION

It has been stated throughout this report that the tilapia farm will have to be integrated with agriculture. As the details of such integration are beyond the purview of this report and can only be completed when a farm site is selected, a few observations on integration and an example are presented here.

1) The fish farm will be discharging a constant amount of water throughout the year. As storage capacity is limited on the fish farm, the agricultural component must be able to utilize this amount of water throughout the year.
2) Irrigation needs vary depending on the time of year. If the fish farm is supplying all of the irrigation water, crop production will have to be cut back during periods requiring high irrigation rates. A more viable option is for the fish farm to provide only part of the irrigation needs of the agricultural farm.
3) The fish farm waste water will contain sizable quantities of NO_3 and solids. Care must be taken to ensure that the NO_3 level is not too high for the plants being grown. The solids content will restrict the choice of irrigation system unless adequate filtration is provided. Dilution of the farm waste water with other irrigation water would minimize these problems.
4) The NO_3 in the fish wastes could act as a fertilizer and minimize the requirement of commercial fertilizers.
5) It is suggested that preliminary experiments be conducted with the fish farm effluents before using it as a primary source of irrigation water.
6) The integration of tilapia culture with the irrigation of agricultural crops would increase the economic viability of both by spreading the cost of the water systems.
7) In a larger perspective, the integration of tilapia culture with irrigation will increase the efficiency of water utilization.

EXAMPLE [a]

A tilapia farm producing 400 t of tilapia per year would discharge 1420 m^3/d (216 UK gpm). As this quantity is discharged throughout the year but irrigation needs increase during the summer, the following crop pattern is suggested:

Date Palm	—	Year-round
Tomato	—	October to May
Cabbage	—	October to February
Cauliflower	—	October to February
Sweet Corn	—	February to May.

The water requirements of a date palm tree in Kuwait is approximately 36 liter/d (8 UK gal/d) during summer and half that amount in winter. If the palms use all of the fish farm's discharge water during summer, approximately, 39,000 palm trees could be irrigated. Assuming a space of 6 m between trees, 39,000 trees would need 142 ha (275 trees/ha). In the winter, half of the discharge water could be used for the other crops. Assuming a maximum evapotranspiration rate of 6 mm/day, approximately 12 ha could be intensively irrigated in addition to the palms.

INTEGRATION SUMMARY

The integration of tilapia culture in brackish water with agriculture will lead to a more efficient water utilization by producing fish in addition to the agricultural products.

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[a] Based on information provided by Dr. G Al-Nakshabandi, Agro-Production Department, KISR.

The fish farm discharges water continuously throughout the year while irrigation needs vary throughout the year. The matching of irrigation needs and fish farm water discharges will require close plannning. This problem can be minimized by integrating the fish farm with a large agricultural operation so that the fish farm's discharge is only a part of the water required for irrigation.

A 400 t/yr fish farm discharges enough water to irrigate 124 ha of date palms throughout the year and an additional 12 ha of intensively irrigated vegetables during the winter.

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APPENDIX A.
SUMMARY OF DESIGN PARAMETERS AND ASSUMPTIONS

The following tables present a quick reference to the design parameters and assumptions for the fish farm. The production module with an annual production of 100 t was used as the reference level. Farms with greater production will consist of multiples of this module.

Table A.1. General Design Parameters and Assumptions for a 100 t Tilapia Production Module

Parameter	Value
Annual production	100 t
Weekly production	1920 kg
Average size at harvest	300 g
Average number of fish harvested	6400/wk
Maximum density	50 kg/m^3
Harvest schedule	1 tank/wk
Grow-out tank size	40 m^3
Water temperature	28-30°C
pH incoming water	7.8
Oxygen requirements	25% of feed
Total N-NH_3 output	3 % of feed
Survival rates	
Egg to 0.02g	60 %
0.02g-1g	90 %
1 g-5 g	90 %
5 g-300 g	90%
Species	*Oreochromis aureus* or *O. spilurus*

Table A.2. Design Parameters and Assumptions for the Breeding Tanks and Hatchery

Parameter/Assumption	Value
Fry production	10 fry/kg ♀ /day
Spawning season	360 d/yr
Female breeding stock requirements including safety margin	150 kg
Male/female ratio of breeding stock	1/3
Average male weight/average female weight	2/1
Male breeding stock requirement including safety margin	100 kg
Reserve female breeding stock	300 kg
Reserve male breeding stock	100 kg
Breeding density	1 kg ♀/m^2
Area of breeding tanks	6 × 25 m^2
Density of reserve breeders	6 kg/m^3
Volume of tanks for reserve breeders	2 × 40 m^3
Feeding rate of breeding fish	1 % bw/d
Feeding rate of reserve breeders	2 % bw/d
Replacement breeding stock	1000 fingerlings/yr
Average egg viability	60 %
Average egg volume	100 eggs/ml
Average egg production/requirement	150 ml/wk
Hatching jar requirements including spare capacity	15 × 1 liter
Water exchange rate - breeding tanks	1 time/wk
Water exchange rate - reserve breeders	see grow-out
Unionized N-NH_3 in breeding tanks	0.1 mg/liter
Unionized N-NH_3 in reserve breeder tanks	0.5 mg/liter

Table A.3. Design Parameters and Assumptions for the Nursery

Parameter/Assumption	Value
FRY (0.02 g-0.6 g)	
Time required for sex reversal	6 weeks
Hormone (ethynyl testosterone) concentration	100 mg/kg feed
Feeding rate during fry stage	20 % bw/d
Fry stocking rate	8800 fry/wk
Fry density	4400 fry/m^3
Volume of fry tanks including spare capacity	10 × 2 m^3
Fry growth	see Table 12.2
Water flow in fry tanks	see Table 12.2
Unionized N-NH_3 in fry tanks	0.05 mg/liter
FINGERLINGS (0.6-5 g)	
Feeding rate for fingerlings	15% bw/d
Fingerlings stocking rate	15800/2 wks
Fingerlings density	790 fingerling/m^3
Volume of fingerlings tanks	3 × 20 m^3
Time required for growth to 5 g	6 weeks
Water exchange rate in fingerlings tanks	see Table 12.3
Unionized N-NH_3 in fingerlings tanks	0.1 mg/liter

Table A.4. Design Parameters and Assumptions for the Grow-out Tanks

Parameter/Assumption	Value
Time required for juveniles	6 weeks
Juvenile stocking rate	14200/2 weeks
Juvenile density	355 juveniles/m^3
Volume of juvenile tanks	3 × 40 m^3
Time required for final grow-out	18 weeks
Grow-out stocking rate	178 fish/m^3
Grow-out density	14200/2 weeks
Feeding rate for juveniles and grow out	see Table 12.4
Recycled water flow in tanks (for self cleaning)	20m^3/hr/tank
New water flow	from cleansing + hatchery
Unionized N-NH_3 level in tanks	0.5 mg/liter
pH in grow-out tanks	7.5
N-NH_3 removal efficiency in biofilter	30 %
Flow rate in biofilter	3000 m^3/d
Total biofilter volume including 33 % reserve	40 m^3
Ammonia removal rate	500 g/m^3/d
Hydraulic load in biofilter	75 m^3/m^3/d
O_2 requirement of biofilter	4.5 mg O_2/mg N oxidized
Cleansing water requirement	170 m^3/d
NO_3 production	4.43 mg NO_3/mg N-NH_3 removed
System evaporation rate	2%/d
Average NO_3 levels	292 mg/liter
Alkalinity requirement	to be determined empirically
Solids production	30 % feed
Total solids	180 kg/d
Settleable solids	95 %
Average non-settleable solids concentration	28 mg/liter
Size of plate separators	200 m^2
Hydraulic load in plate separators	60 m^3/m^2/d

Table A.5. Summary of Oxygen Requirements in a 100 t Tilapia Production Module

Parameter/Assumption	Value
Maximum Oxygen requirement - Breeding tanks	4 g/tank/hr
- Fry tanks	7 g/tank/hr
- Fingerling/grow-out	365 g/tank/hr
Oxygen transfer efficiency w/airstones	1%
Oxygen transfer rates for Kingfisher aerators	165 g O_2/hr
Number of Kingfisher aerators per fingerling/grow-out tank	2
Total number of Kingfisher aerators	54
Air requirement for breeding & fry	0.6 m^3/min
Air requirement for Kingfisher aerator	1.56 m^3/min/unit
Total air required for Kingfisher aerators	84.2 m^3/min
Air required for biofilters	20.5 m^3/min
Total air requirement	105 m^3/min
Air pressure	100 mm Hg

Note: 105 m^3/min at 100 mm Hg = 3700 cfm at 2 PSI

Table A.6. Summary of New Water Requirements for a 100 t Tilapia Production Module

Tank Type	Water Required (m^3/d)
Brood tanks	17
Fry tanks	51
Fingerling tanks	180
Cleansing tanks	109
Grow-out tanks	a)
Total new water required	357

Notes: 357 m^3/d = 47 UK gpm

[a] The grow-out tanks and filters use the discharge water from the fry, fingerlings and cleansing tanks.

Table A.7. Summary of Average Fish Biomass and Average Feed Requirements in a 100 t Tilapia Production Module.

Tank Type	Average Total Fish Biomass [a] (Kg)	Average Feed Requirement (Kg/d)
Brood tanks [b]	650	10.5
Fry tanks	11	1.7
Fingerling tanks	98	12.2
Juvenile and Grow-out tanks	20877	546
Cleansing tanks	4218	38
Total	25854	608

[a] Based on number stocked at each stage.
[b] Includes breeder holding.

APPENDIX B.

DETAILED LISTING OF FARM COMPONENTS

The tables in this appendix list all of the items which were included in the cost analysis. The unit prices were estimated from actual price quotations whenever possible and were valid for the period May - August 1984. The detailed specification, e.g. number of units, size, and expected life, are subject to change depending on the final design and purchase decisions. Thus, the costs developed from these lists can be considered to be indicative only, not definitive.

Table B.1. Production Unit Components.

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Greenhouse shell	15	m^2	1924	3848	7696	15392	13
Civil works	15	m^2	1924	3848	7696	15392	5
Exhaust fans	3	unit	15	30	60	120	275
Road ways	15	m^2	135	270	540	1080	5
Gravel walks	15	m^2	450	900	1800	3600	0.8
Shade netting	3	m^2	1924	3848	7696	15392	0.5
GRC tanks, 40m^3	15	unit	24	48	96	192	1550
Sand backfill	15	m^3	35	70	140	280	8
Aluminium walkways	15	m	130	260	520	1040	10
GRP tanks, 20 m^3	15	unit	9	18	36	72	710
GRP tanks, 2 m^3	15	unit	10	20	46	80	250
Drain Channel	15	m	93	186	372	744	22
Plate separator sump	15	unit	2	4	8	16	420
Plate separator	3	unit	2	4	8	16	350
Biofilter	15	unit	2	4	8	16	1900
Return pump sump	15	unit	2	4	8	16	100
Return pump	15	unit	3	5	10	20	990
Return channel	15	m	86	172	344	688	40
Insulation, exposed	3	m^2	320	640	1280	2560	1.5
Insulation covered	15	m^2	610	1220	2440	4880	1.5
Sludge channel	15	m^2	38	76	152	304	12
Sludge sump	15	unit	1	2	4	8	550
Sludge pump	15	unit	2	3	5	10	700
Lagoon line	15	m	100	200	400	800	3.4
Plastic liner for channel/sump	15	m	330	660	1230	2640	10
New water line	15	set	1	2	4	8	1020
Blowers, 2 psi	15	unit	4	8	16	32	2300
Blower platform	15	unit	1	2	4	8	550
Pipelines for air	15	set	1	2	4	8	900
Aerators, Kingfisher	3	unit	54	108	216	432	90.7
Airstone	3	unit	75	150	300	600	1
Utility room	15	unit	1	1	2	2	500
A/c for utility room	5	unit	1	1	2	2	100
Electronic balance	5	unit	1	1	2	2	800
Hatching rack	5	unit	1	2	4	8	250
Feeders, belt	3	unit	36	72	144	288	25
Feeders, automatic, 40 kg	3	unit	14	28	56	112	62
Feeders, demand, 40 kg	3	unit	24	48	96	192	25
Heaters, 4 kW, w/ thermostat	5	unit	4	8	16	16	140
Heaters 300W	3	unit	15	30	60	120	5
Cages	3	unit	22	44	88	172	40
Fish hauler	5	unit	1	1	1	2	250

Table B.2. Water Supply Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Well	15	unit	1	1	1	2	50000
Pump & riser	15	unit	1	1	1	2	10000
Pump house	15	unit	1	1	1	2	250
Pipeline to farm	15	m	100	100	100	1100	5.5
Reservoir	15	m^3	100	200	400	800	55
Insulation	3	m^2	120	240	480	960	12

Table B.3. Lagoon Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Sludge settling tank	5	m^3	200	300	500	900	8
Excavation	15	m^3	2000	4000	8000	16000	3
Liner	15	m^2	2800	5600	11200	22400	2

Table B.4. Electrical Supply Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Electrical substation	15	kW	275	540	890	1640	25
Wiring	15	set	1	1	1	1	a)
Emergency generator	15	kW	154	216	348	660	b)
Building	15	m^2	15	15	30	60	63

a) KD 12000 for 100 t, 16000 for 200 t, 48000 for 400 t, 80000 for 800 t.

b) KD 11090 for 100 t, 14580 for 200 t, 22010 for 400 t, 39580 for 800 t.

Table B.5. Alarm System Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Fence-Alarm	5	m	480	560	880	1060	1
Water level alarms	5	unit	4	6	10	18	20
Mains power alarm	5	unit	2	2	2	2	15
Pressure alarm	5	unit	4	6	10	18	20
O_2 meter	5	unit	3	5	9	17	177
Alarm panel	15	unit	1	2	3	6	350

Table B.6. Emergency Oxygen System Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Tank	15	unit	15	30	60	120	30
Regulator	5	unit	15	30	60	120	30
Distribution lines	3	unit	15	30	60	120	10

Table B.7. Packing Unit Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Building shell	15	m^2	—	280	280	280	94
Foundation	15	m^2	—	280	280	280	45
Concrete tanks	15	unit	—	1	1	1	3060
Cage loading sump	15	unit	—	1	1	1	360
Pump sump	15	unit	—	1	1	1	100
Pump	15	unit	—	1	1	1	700
Piping to rearing unit	15	set	—	1	1	1	380
Cooling tank	5*/15	unit	1	1	1	1	*250/1200
Refrigeration unit	5*/15	unit	1	1	1	1	*250/2500
Cages	3	unit	—	7	7	7	300
Cages support	15	unit	—	1	1	1	500
Sorting table	15	unit	1	1	1	1	*200/500
Balance	3	unit	1	4	4	4	300
Market boxes	5	unit	50	100	200	400	12
Harvest system	15	unit	—	2	2	2	1800
Hauler	15	unit	—	2	2	2	500
Exhaust fan	5	unit	—	2	2	2	275

* Use for 100 t farm, other values for other farm sizes.

Table B.8. Feed System Components

Item	Expected life (years)	Unit	Number of of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
General Storage							
Building	15	m^2	125	125	125	125	75
Foundation	15	m^2	125	125	125	125	45
A/C	5	m^2	125	125	125	125	7.5
Feed Mill							
Equipment	15	set	—	1	1	1	72000
Civil Works	15	set	—	1	1	1	14000
Feed Delivery	15	unit	—	1	2	4	12000

Table B.9. Vehicles

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Pick up, 4 WD	3	unit	2	2	2	2	2300
Truck, refrigerated	5	unit	1	1	1	1	9000
Bus	3	unit	—	1	1	1	2700
Fork lift	5	unit	1	1	1	2	3000

Table B.10. Office/Laboratory Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Building	15	m^2	50	50	50	50	75
Foundation	15	m^2	50	50	50	50	45
Ac/Heating	5	m^2	50	50	50	50	8
Desk	5	unit	2	2	2	2	100
Chairs	5	unit	4	4	4	4	50
File cabinets	5	unit	4	4	4	4	70
Bookcase	5	unit	3	3	3	3	60
Cabinet	5	unit	7	7	7	7	130
Laboratory Table	5	unit	1	1	1	1	800
Tables	5	set	1	1	1	1	250
Lamps	5	set	1	1	1	1	100
Calculators	3	set	1	1	1	1	150
Telephone/Intercom	15	set	1	1	1	1	500
Copier	5	unit	1	1	1	1	500
Paper cutter	5	unit	1	1	1	1	30
Oxygen meter	5	unit	1	1	1	1	800
Ion meter	5	unit	1	1	1	1	700
Spectophotometer	5	unit	1	1	1	1	400
Turbidimeter	5	unit	1	1	1	1	200
Balance	5	unit	1	1	1	1	1000
Voltage regulator	5	unit	4	4	4	4	30
Refrigerator	5	unit	1	1	1	1	100
Glassware	5	set	1	1	1	1	1200
Glass still	5	unit	1	1	1	1	700
Deioniser	5	unit	1	1	1	1	200
Balance table	15	unit	1	1	1	1	100
Microscope, dissecting	5	unit	1	1	1	1	200
Microscope, compound	5	unit	1	1	1	1	200
Vacuum pump	5	unit	1	1	1	1	100
Stirring hot-plate	5	unit	3	3	3	3	50
First aid kit	3	unit	1	1	1	1	50

Table B.11. Computer System Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
IBM PC, 512 K	15	unit	—	1	1	1	2000
IBM PC, 64 K	15	unit	—	1	1	1	1400
Printer	15	unit	—	1	1	1	900
Hard Disc	15	unit	—	1	1	1	1000
Back-up Power	15	unit	—	1	1	1	4000
Software, basic	15	unit	—	1	1	1	1000
Software, specialised	15	set	—	1	1	1	5000

Table B.12. Workshop/General Storage Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Building shell	15	m^2	50	50	75	125	75
Foundation	15	m^2	75	75	100	150	45
Overhang roof	15	m^2	25	25	25	25	25
A/C and Heating	5	m^2	50	50	50	50	14
Work benches	5	unit	1	1	1	1	250
Steel shelves	5	unit	1	1	1	1	900
Stools	5	unit	5	5	5	1	15
Storage cabinets	5	unit	6	6	6	6	100
Small electric tools	3	set	1	1	1	1	200
Band saw	15	set	1	1	1	1	700
Hand tools	3	set	1	1	1	1	200
Electrical tools	3	set	1	1	1	1	50
Pipe tools	3	set	1	1	1	1	100
Electric welding machine	5	unit	1	1	1	1	100
Gas welding machine	5	unit	1	1	1	1	100
Hoist	15	unit	1	1	1	1	600
Drill press	15	unit	1	1	1	1	990
Vise	5	unit	1	1	1	1	30
Spray gun	5	unit	1	1	1	1	30
Grinder	5	unit	1	1	1	1	50
Compressor	15	unit	1	1	1	1	500
Ladder	5	unit	1	1	1	1	60

Table B.13. Housing Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Building	15	m^2	120	120	380	600	75
Foundation	15	m^2	120	120	380	600	45
Ac/heating	5	m^2	120	120	380	600	14
Portable water tank	15	unit	2	2	2	4	200
Sewage system	15	set	1	1	1	1	a)
Bed	5	unit	2	2	15	23	100
Table and chair	5	unit	2	2	15	23	45
Wardrobe	5	unit	2	2	15	23	100
Chair	5	unit	8	12	16	24	10
Sofa	5	unit	3	4	6	9	150
TV and video	5	unit	1	1	1	2	400
Dining table	5	unit	2	2	2	2	100
Kitchen table	5	unit	2	2	2	2	300
Stove	5	unit	2	2	2	2	250
Refrigerator	5	unit	2	2	4	8	300
Freezer	5	unit	1	1	2	2	100
Misc. appliances	5	set	1	1	3	3	100
Washing machine	5	unit	1	1	2	2	160
Clothes dryer	5	unit	1	1	2	2	110
Lamp	5	unit	2	2	15	23	10
Floor lamp	5	unit	4	4	5	6	20
Kitchen cabinet	5	unit	2	2	4	4	50
Kitchenware	5	set	1	1	1	1	b)

[a] KD 400 for 100t, KD 400 for 200 t, KD 600 for 400 t, KD 800 for 800 t.
[b] KD 50 for 100 t, KD 60 for 200 t, KD 80 for 400 t, KD 120 for 800 t.

Table B.14. Roads, Fences and Windbreaks

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Fencing	15	m	520	600	920	1100	10
Trees	15	units	260	300	460	550	2.5
Water line	15	m	520	600	920	1100	1.25
Roads	15	m^2	500	650	800	800	15

Table B.15. Initial Stock Components

Item	Expected life (years)	Unit	Number of Units				Unit Price (KD)
			100 t	200 t	400 t	800 t	
Fingerlings	—	1000 pcs	147	294	588	1176	74
Brood stock	—	kg	300	300	300	300	5

APPENDIX C.
SUPPLEMENTAL ECONOMIC DATA AND ANALYSES

This appendix contains the following information related to the economic analysis of tilapia farms in Kuwait in 1984.

Notes on Estimation of Capital Costs.
Notes on Production Costs.

Table C.1.	Schedule of Phase I Preproduction Expenditures Over the Construction Period.
Table C.2.	Depreciation, Amortization and Replacement of Fixed Assets Over the Life of a 100 t Tilapia Farm.
Table C.3.	Working Capital Requirement Over Life of a 100 t Tilapia Farm.
Table C.4.	Total Initial Investment Cost of a 100 t Tilapia Farm.
Table C.5.	Fixed Investment Costs over Life of 100 t Tilapia Farm.
Table C.6.	Total Capital Investment Cost Over Life of 100 t Tilapia Farm.
Table C.7.	Analysis of Production Costs over Life of a 100 t Tilapia Farm Assuming 100% Equity Financing.
Table C.8.	Revenue Forecast for a 100 t Tilapia Farm.
Table C.9.	Cash Flow Analysis of a 100 t Tilapia Farm Assuming 100% Equity Financing.
Table C.10.	Discounted Payback Period for 100 t Tilapia Farm.
Table C.11.	Net Income Statement for a 100 t Tilapia Farm Assuming 100% Equity Financing.
Table C.12.	Schedule of Preproduction Expenditures During Phase II Expansion of a 200 t Tilapia Farm.
Table C.13.	Depreciation, Amortization and Replacement of Fixed Assets Over the Life of a 200 t Tilapia Farm.
Table C.14.	Working Capital Requirement Over the Life of a 200 t Tilapia Farm.
Table C.15.	Fixed Investment Costs Over Life of a 200 t Tilapia Farm.
Table C.16.	Total Capital Investment Over the Life of a 200 t Tilapia Farm.
Table C.17.	Analysis of Production Costs Over the Life of a 200 t Tilapia Farm Assuming 100% Equity Financing.
Table C.18.	Revenue Forecast of a 200 t Tilapia Farm.
Table C.19.	Cash Flow Analysis of a 200 t Tilapia Assuming 100% Equity Financing.
Table C.20.	Discounted Payback Period of a 200 t Tilapia Farm.
Table C.21.	Net Income Statement of a 200 t Tilapia Farm Assuming 100% Equity Financing.
Table C.22.	Sources of Finance of a 200 t Tilapia Farm Assuming External Financing of Phase II Expansion.
Table C.23.	Financing Obligations of a 200 t Tilapia Farm Assuming External Financing of Phase II Expansion.
Table C.24.	Cash Flow Analysis of a 200 t Tilapia Farm with External Financing of Phase II Expansion.

NOTES ON ESTIMATION OF CAPITAL COSTS

Capital costs were initially estimated by adding all the costs of items listed in Appendix B. From these totals, a set of cost functions was developed. Computation of the cost functions was complicated because many capital item which were purchased for phase I can also be used for phase II. Figure C.1 shows the relationship of capacity increase during phase II and the phase II preproduction costs. Figure C.2 shows the capital costs items for phase II not proportionally related to production level (e.g., only one feed mill is needed for a 200 t farm or an 800 t farm) while Figure C.3 shows the capital costs items proportionally related to production level (e.g. tanks). The phase II costs used in all of the analyses are a summation of the values from the functions in Figures C.1, C.2, and C.3. The following depreciation schedule for phase II capital items was also developed:

Life of Item	*Percent of Total Capital Cost*
3 years	$D_1 = 4.5\%$
5 years	$D_2 = 6.05 - 0.29(X)$
15 years	$D_3 = 100 - (D_1 + D_2)$

X equals total farm capacity (phase I + phase II) in 100 t/yr units, X = 2 for 200 t farm, X = 4 for 400t, etc. D_1 equals capital cost of items with an expected life of 3 years. D_2 equals the cost for items with 5 year life and D_3 is the cost of items with 15 year life.

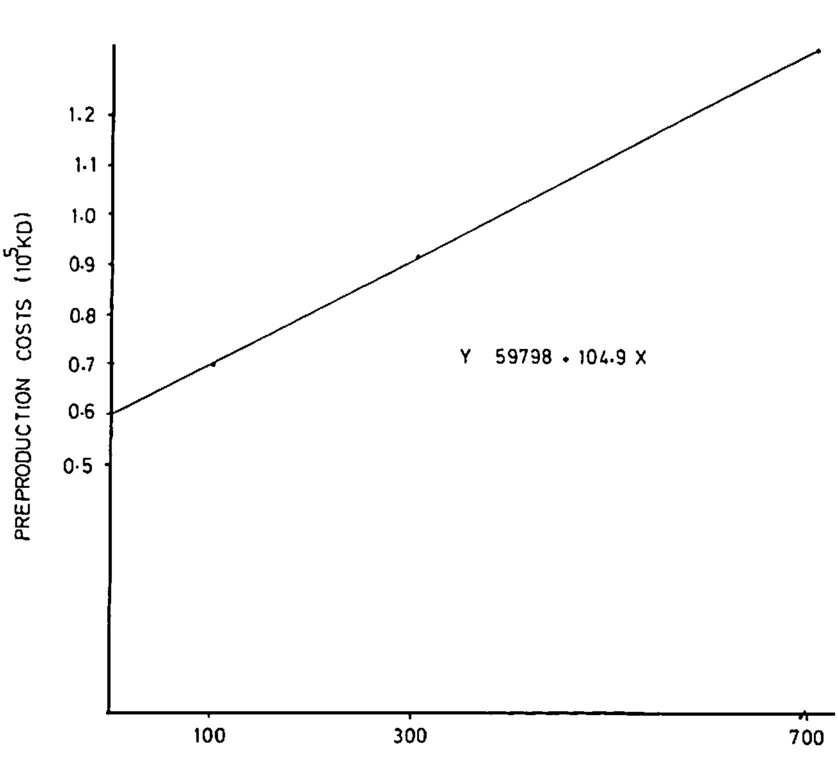

Fig. C.1. Relationship Between Preproduction Costs and Additional Capacity of Phase II.

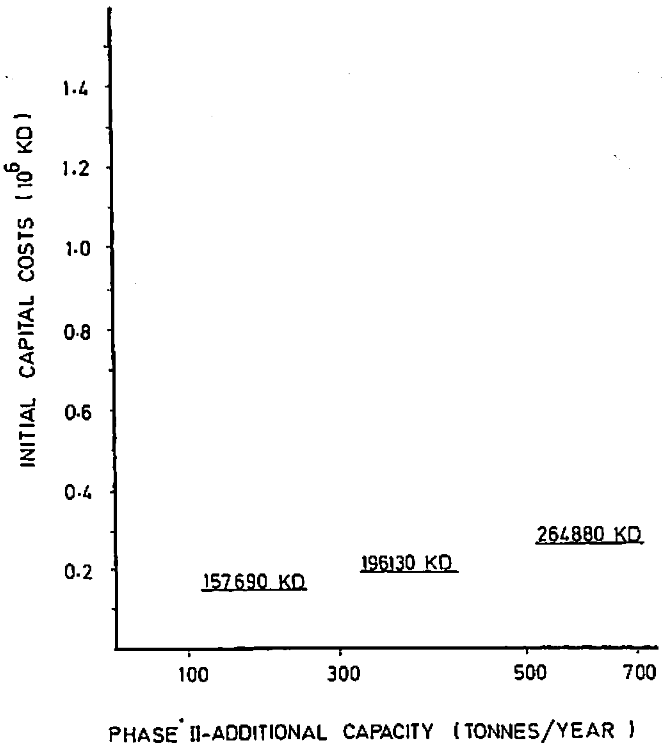

Fig. C.2. Capital Costs of Items Not Proportionally Related to Production Level.

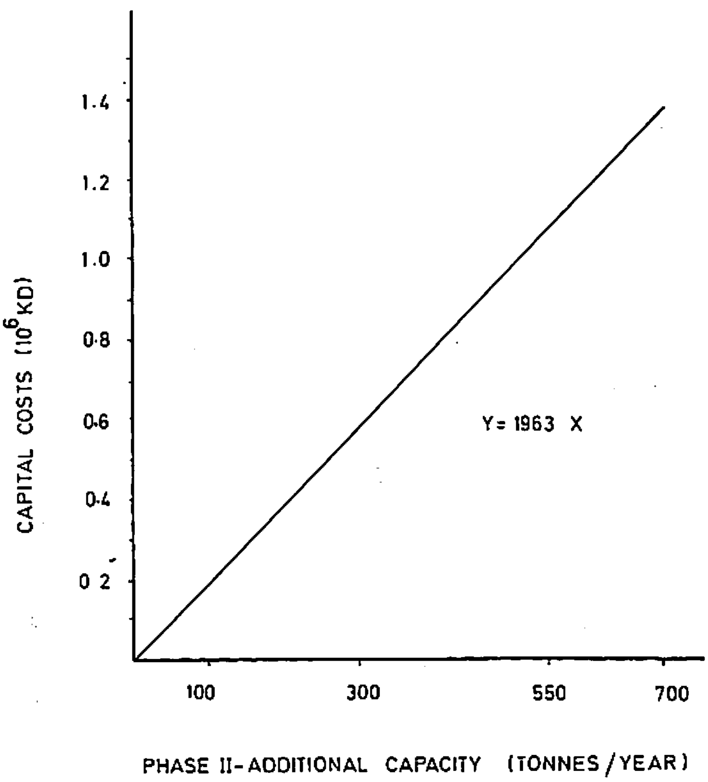

Fig. C.3. Capital Costs for Items Proportionally Related to Production Level.

NOTES ON PRODUCTION COSTS

The bases used in the computation of the production costs are presented in this section. The costs were derived from price quotations obtained during the middle of 1984.

Farm costs include costs of raw materials utilities, consumables and labour. The required unit of inputs for each farm size and its unit costs follow:

Item	Unit Cost	Number of Units			
		100 t	200 t	400 t	800 t
Raw Materials					
Feed, Complete	KD 109/t	221	—	—	—
Feed Ingredients	KD 74/t	—	442	884	1768
Utilities					
Electricity	KD 4/1000 kWh	955	1480	3115	5740
Potable Water	KD 10/mo/man	7	10	15	22
Consumables					
Chemicals	KD 20/t fish produced	100	200	400	800
Supplies	KD 10/t fish produced	100	200	400	800
Fuel for Vehicles	KD 40/1000 l	12.5	13.75	13.75	13.75
Labour					
Farm Manager	KD 12600/yr	1	1	1	1
Farm Engineer	KD 11400/yr	1	1	1	1
Technicians	KD 4800/yr/man	2	3	5	7
Labourers	KD 3600/yr/man	2	4	6	11
Driver	KD 3000/yr/man	1	1	1	1
Cook	KD 3000/yr/man	—	—	1	1

The unit costs for labour include basic salary, travel and food allowance and miscellaneous benefits such as life insurance, etc.

Position	Basic Salary	Travel Allowance	Food Allowances	Misc Benefits*	Total
Farm Manager	850	50	50	100	1050
Farm Engineer	750	50	50	100	950
Technicians	300	15	50	35	400
Labourers (Skilled)	200	15	50	35	300
Driver	200	—	50	—	250
Cook	150	15	50	35	250

* Does not include housing.

Farm Overheads are composed of building repair, equipment maintenance, spare parts, and miscellaneous supplies. Building repair was estimated to be 1% of civil works (civil works costs are approximately 53% of the costs of fixed assets). For all equipments on a 100 t farm and phase II, equipment maintenance was estimated to be 2% of equipment costs (equipment costs are approximately 41% of the costs of fixed assets). If an equipment is to be used longer than 15 years (e.g., phase I equipment on 200 t, 400 t, and 800 t farms), equipment maintenance is increased to 3.5%. Spare parts are estimated to be 2% of equipment costs while miscellaneous supplies are 1% of all other farm overheads.

Administrative Overheads consist of administrative services, research and development services, land and house rents, family expenses, communications, sales promotion, and insurance. Administrative services will be provided off-site by either the parent firm (of the fish farm) or on a contractual basis. These services include accounting, purchasing, etc. The cost is estimated to be KD 13200/yr regardless of farm size. Research and development services, particularly disease monitoring, will be provided by KISR on a retainer basis. Cost of these services are expected to be only KD 2400/yr. Land rental from the government is at KD 0.150/m^2/yr. Housing for technicians and labourers must be provided, off-site in the 100 t and 200 t farms and on-site in the 400 t and 800 t farms. The off-site housing costs KD 600/yr/man. When the farm expands to phase II, it is expected that the farm manager will live in town with his family. The rent for the manager's house is estimated to be KD 7200/yr. Assuming the manager brings a wife and three children to Kuwait, approximately KD 2400/yr must be allocated to vacation air fare for dependants and KD 3600/yr for schooling. Communication was estimated to cost KD 500/yr and minimal sales promotion will cost KD 500/yr, irregardless of farm size. Insurance on plant and machinery is estimated to be 1% of fixed asset costs. Insurance on stock was estimated to cost KD 27/t fish produced.

The insurance cost on stock was computed assuming a cost of 5% of the value of fish on hand. For a 100 t production module, the value of the fish stock on hand is KD 54,330 computed as follows:

Brood Stock	—	KD 1,500
Stock Cost	—	KD 0.074/fish
Fish Biomass	—	KD 1.500/kg fish

The cost of brood stock is the cost involved in procuring the brood stock. The cost of stock is the cost of replacing all fish with fingerlings. The cost for fish biomass corresponds to the amount spent on growing the fish (e.g. feed, chemicals, labour, etc.).

Table C.1. Schedule of Phase I Preproduction Expenditures Over the Construction Period.

Item	Expenditure (KD)											
Month	1	2	3	4	5	6	7	8	9	10	11	12
1. Incorporation/Organization	5,000	0	0	0	0	0	0	0	0	0	0	0
2. Feasibility Study	40,000	0	0	0	0	0	0	0	0	0	0	0
3. Administrative Support	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100
4. Detailed Designs												
Consultant Engineer	0	2,000	2,000	2,000	0	0	0	0	0	0	0	0
Housing/Food	0	1,050	1,050	1,050	0	0	0	0	0	0	0	0
Air fare	0	800	0	0	0	0	0	0	0	0	0	0
Draftsman	0	1,000	1,000	1,000	0	0	0	0	0	0	0	0
KISR Review	0	0	0	2,000	0	0	0	0	0	0	0	0
5. Site Development	3,500	3,500	3,500	3,500	0	0	0	0	0	0	0	0
6. Recruitment Costs												
Recruiting Trips	0	0	1,800	0	0	0	0	1,800	0	0	0	0
Air fares for Staff	0	0	0	0	500	0	0	0	0	0	500	0
Recruitment Agency Fee	0	0	0	0	0	0	0	0	0	0	0	0
7. Manpower												
Project Manager	958	958	958	958	958	958	958	958	958	958	958	962
Site Engineer	700	700	700	700	700	700	700	700	700	700	700	700
Guard	150	150	150	150	150	150	150	150	150	150	150	150
Farm Manager	0	0	0	0	0	0	0	0	0	0	1,050	1,050
Farm Engineer	0	0	0	0	950	950	950	950	950	950	950	950
Technicians (2)	0	0	0	0	0	0	0	0	0	0	0	0
Labourers (2)	0	0	0	0	0	0	0	0	0	0	0	0
Driver	0	0	0	0	0	0	0	0	0	0	0	0
8. House Rents												
Engineer	0	0	0	0	250	250	250	250	250	0	0	0
Technicians etc.	0	0	0	0	0	0	0	0	0	0	0	0
9. Electricity	10	10	10	10	10	10	10	10	10	10	20	20
10. Drinking Water	65	65	65	65	65	65	65	65	65	65	65	65
11. Insurance												
Plant/Vehicles	0	0	0	0	0	0	0	0	0	500	0	0
Fish Stock	0	0	0	0	0	0	0	0	0	0	0	0
12. Commissioning Costs												
Feed	0	0	0	0	0	0	0	0	0	0	0	
Chemicals/Drugs	0	0	0	0	0	0	0	0	0	0	0	0
13. Fuel for Vehicles	20	20	20	20	20	20	20	20	20	20	20	20
14. Supplies/Consumables	10	10	10	10	10	10	10	10	10	10	20	20
Grand Total (KD)	51,513	11,363	12,363	12,563	4,713	4,213	4,213	6,013	4,213	4,713	5,533	5,037

Table C.1. (Continuation)

Item / Month	Expenditure (KD) 13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
1. Incorporation/Organization	0	0	0	0	0	0	0	0	0	0	0	0	5.000
2. Feasibility Study	0	0	0	0	0	0	0	0	0	0	0	0	40.000
3. Administrative Support	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	26.400
4. Detailed Designs													
Consultant Engineer	0	0	0	0	0	0	0	0	0	0	0	0	6 000
Housing/Food	0	0	0	0	0	0	0	0	0	0	0	0	3 150
Airfare	0	0	0	0	0	0	0	0	0	0	0	0	800
Draftsman	0	0	0	0	0	0	0	0	0	0	0	0	3,000
KISR Review	0	0	0	0	0	0	0	0	0	0	0	0	2,000
5. Site Development	0	0	0	0	0	0	0	0	0	0	0	0	14,000
6. Recruitment Costs													
Recruitment Trips	0	0	0	1,600	0	0	0	0	0	0	0	0	5,200
Airfare for Staff	0	0	0	0	0	0	1,000	0	0	0	0	0	2,000
Recruitment Agency Fee	0	0	0	400	0	0	0	0	0	0	0	0	400
7. Manpower													
Project Manager	958	958	958	958	958	958	958	958	958	958	958	962	23,000
Site Engineer	700	700	700	700	0	0	0	0	0	0	0	0	11,200
Guard	150	150	150	150	150	150	0	0	0	0	0	0	2,700
Farm Manager	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	14,700
Farm Engineer	950	950	950	950	950	950	950	950	950	950	950	950	19,000
Technicians (2)	0	0	0	0	0	0	800	800	800	800	800	800	4,800
Labourers (2)	0	0	0	0	0	0	600	600	600	600	600	600	3,600
Driver	0	0	0	0	0	0	250	250	250	250	250	250	1,500
8. House Rents													
Engineer	0	0	0	0	0	0	0	0	0	0	0	0	1,500
Technicians, etc.	0	0	0	0	0	0	250	250	250	250	250	250	1,500
9. Electricity	20	20	20	20	20	20	60	100	100	100	100	100	820
10. Drinking Water	65	65	65	65	70	70	70	70	70	70	70	70	1,600
11. Insurance													
Plant/Vehicles	500	0	0	0	0	0	1,000	0	0	0	0	0	2,000
Fish Stock	0	0	0	0	0	0	1,400	0	0	0	0	0	1,400
12. Commissioning Costs													
Feed	0	0	0	0	0	0	270	0	300	0	300	0	870
Chemicals/Drugs	0	0	0	0	0	0	1,000	0	0	0	0	0	1,000
13. Fuel for Vehicles	20	20	20	20	20	20	20	20	20	20	20	40	500
14. Supplies/Consumables	20	20	20	20	20	20	40	40	40	40	40	40	500
Grand Total (KD)	5,533	5,033	5,033	7,033	4,338	4,338	10,818	6,188	6,488	6,188	6,488	6,212	200,140

Table C.2. Depreciation, Amortization and Replacement of Fixed Assets Over the Life of a 100 t Tilapia Farm.

Assets	Original Value (KD)	Service Life (Years)	Depreciation Accrual (KD)						
			1	2	3	4	5	6	7-15
Initial Fixed Investment									
3 Years Assets	15,650	3	5,217	5,217	5,217	5,217	5,217	5,217	5,217
5 Years Assets	36,900	5	7,380	7,380	7,380	7,380	7,380	7,380	7,380
15 Years Assets	307,140	15	20,476	20,476	20,476	20,476	20,476	20,476	20,476
Pre-production Expenditures	200,140	5	40,028	40,028	40,028	40,028	40,028	0	0
Total	559,830		73,101	73,101	73,101	73,101	73,101	33,073	33,073

Table C.3.

Working Capital Requirement Over Life of a 100 t Tilapia Farm

Item	Average No. of Days	Turnover coefficient	Amount (KD)
1. Accounts Receivable	30	12	12,500
2. Raw Materials Inventory	30	12	2,017
3. Spare Parts	180	2	1,465
4. Finished Products	30	12	12,500
5. Required Cash in Hand	60	6	13,176
6. Accounts Payable	30	12	500
7. Net Working Capital (1+2+3+4+5-6)			41,158

Table C.4.

Total Initial Investment Cost of a 100 t Tilapia Farm

Category of Investment	Total Amount (KD)	Percentage
1. Initial Fixed Investment Cost	359,690	60
2. Pre-production Expenditure	200,140	33
3. Working Capital (1st year)	41,158	7
4. Interest During Construction	0	0
Total Initial Investment Cost	600,988	100

Table C.5. Fixed Investment Costs over Life of 100 t Tilapia Farm.

Description/Year	Construction	Replacement															
	2 years	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTAL
Initial Fixed Investment																	
3 Years Assets	15,650	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15,650
5 Years Assets	36,900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36,900
15 Years Assets	307,140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	307,140
Replacement of Initial Fixed Investment																	
3 Years Assets	0	0	0	0	15,650	0	0	15,650	0	0	15,650	0	0	15,650	0	0	62,600
5 Years Assets	0	0	0	0	0	0	36,900	0	0	0	0	36,900	0	0	0	0	73,800
15 Years Assets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broodstock	0	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	3,000
Total Fixed Investment Cost	359,690	200	200	200	15,850	200	37,100	15,850	200	200	15,850	37,100	200	15,850	200	200	499,090

Table C.6. Total Capital Investment Cost over Life of 100 t Tilapia Farm.

Description/Year	Construction	Production Period															
	2 years	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTAL
1. Fixed Investment Cost																	
Initial Fixed Investment	359,690	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	359,690
Replacement Investment	0	200	200	200	15,850	200	37,100	15,850	200	200	15,850	37,100	200	15,850	200	200	139,400
2. Pre-production Expenditures	200,140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200,140
3. Working Capital	0	41,158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41,158
Total Capital Investment Cost	559,830	41,358	200	200	15,850	200	37,100	15,850	200	200	15,850	37,100	200	15,850	200	200	740,388

Table C.7. Analysis of Production Costs over Life of a 100t Tilapia Farm Assuming 100% Equity Financing.

Production Year	1		2		3		4		5		6-15	
Item	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%
1. Operating Costs (A+B)	109,745	60.0	109,745	60.0	109,745	60.0	109,745	60.0	109,745	60.0	109,745	76.8
A. Farm Costs	81,850	44.8	81,850	44.8	81,850	44.8	81,850	44.8	81,850	44.8	81,850	57.3
Raw Materials	24,198	13.2	24,198	13.2	24,198	13.2	24,198	13.2	24,198	13.2	24,198	16.9
Utilities	2,494	1.4	2,494	1.4	2,494	1.4	2,494	51.4	2,494	1.4	2,494	1.7
Consumables	3,500	1.9	3,500	1.9	3,500	1.9	3,500	1.9	3,500	1.9	3,500	2.5
Labour	43,800	24.0	43,800	24.0	43,800	24.0	43,800	4.3	43,800	24.0	43,800	30.7
Farm Overheads	7,858	4.3	7,858	4.3	7,858	4.3	7,858	4.3	7,858	4.3	7,858	5.5
B. Non-Farm Costs	27,895	15.3	27,895	15.3	27,895	15.3	27,895	15.3	27,895	15.3	27,895	19.5
Administrative Overheads	27,395	15.0	27,395	15.0	27,395	15.0	27,395	15.0	27,395	15.0	27,395	19.2
Sales and Promotion	500	0.3	500	0.3	500	0.3	500	0.3	500	0.3	500	0.4
2. Non-Operating Costs	73,101	40.0	73,101	40.0	73,101	40.0	73,101	40.0	73,101	40.0	33,073	23.2
Interest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Depreciation and Amortization	73,101	40.0	73,101	40.0	73,101	40.0	73,101	40.0	73,101	40.0	33,073	23.2
3. Total Production Costs (1+2)	182,846	100.0	182,846	100.0	182,846	100.0	182,846	100.0	182,846	100.0	142,818	100.0
Unit Product Cost (KD/t)	1,828		1,828		1,828		1,828		1,828		1,428	

Table C.8. Revenue Forecast for a 100 t Tilapia Farm over 15 Years

Item	Amount
Total Farm Capacity/t	100
Sales Price KD/t*	1,500*
Estimated Sales (KD)	150,000

* Delivery to customer site (store)

Table C.9. Cash Flow Analysis of a 100 t Tilapia Farm Assuming 100% Equity Financing.

Description / Year	Construction -2	Construction -1	Production Period 1	2	3	4	5	6	7
1. Cash In									
Equity Investment	0	0	0	0	0	0	0	0	[illegible]
Industrial Loan 5%	0	0	0	0	0	0	0	0	[illegible]
Sales Revenue	0	0	150,000	150,000	150,000	150,000	150,000	150,000	150,00
Total Cash In	0	0	150,000	150,000	150,000	150,000	150,000	150,000	150,00
2. Cash Out									
Fixed Assets	80,930	278,760	0	0	0	0	0	0	0
Payment of Replacement	0	0	200	200	200	15,850	200	37,100	15,85
Pre-production Expenditures	126,450	73,690	0	0	0	0	0	0	[illegible]
Operating Costs	0	0	109,745	109,745	109,745	109,745	109,745	109,745	109,74
Interest Payment	0	0	0	0	0	0	0	0	[illegible]
Loan Repayment	0	0	0	0	0	0	0	0	[illegible]
Dividends	0	0	0	0	0	0	0	0	[illegible]
Total Cash Out	207,380	352,450	109,945	109,945	109,945	125,595	109,945	146,845	125,59
3. Net Cash Flow (1-2)	(207,380)	(352,450)	40,055	40,055	40,055	24,405	40,055	3,155	24,40
4. Cummulative Cash Flow	(207,380)	(559,830)	(519,775)	(479,721)	(439,666)	(415,262)	(375,207)	(372,052)	(347,64

Description / Year	Production Period 8	9	10	11	12	13	14	15
1. Cash In								
Equity Investment	0	0	0	0	0	0	0	0
Industrial Loan 5%	0	0	0	0	0	0	0	0
Sales Revenue	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
Total Cash In	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
2. Cash Out								
Fixed Assets	0	200	15,850	37,100	200	15,850	200	200
Payment of Replacement	200	0	0	0	0	0	0	0
Pre-production Expenditures	0	109,745	109,745	109,745	109,745	109,745	109,745	109,745
Operating Costs	109,745	0	0	0	0	0	0	0
Interest Payment	0	0	0	0	0	0	0	0
Loan Repayment	0	0	0	0	0	0	0	0
Dividends	0	0	0	0	0	0	0	0
Total Cash Out	109,745	109,945	125,595	146,845	109,945	125,595	109,945	109,945
3. Net Cash Flow (1-2)	40,055	40,055	24,405	3,155	40,055	24,405	40,055	40,055
4. Cummulative Cash Flow	(307,593)	(267,539)	(243,134)	(239,979)	(199,925)	(175,520)	(135,466)	(95,411)

Note: IRR = -2%

Table C.10. Discounted Payback Period for 100 t Tilapia Farm.

Item	Original Value (KD)	Discount Factor 10%	Present Value (KD)	Unrecovered Investment at the end of the year (KD)
1. Total Initial Investment	600,988		565,209	
1st Year Construction	207,380		207,380	
2nd Year Construction	393,607	0.9091	357,829	
2. Net Profit				
1st Year Production	(32,846)	1.2101	(39,747)	(604,956)
2nd Year Production	(32,846)	1.3310	(43,718)	(648,674)
3rd Year Production	(32,846)	1.4640	(48,087)	(696,761)
4th Year Production	(32,846)	1.6106	(52,902)	(749,662)
5th Year Production	(32,846)	1.7715	(58,187)	(807,849)
6th Year Production	7,182	0.5132	3,686	(804,163)
7th Year Production	7,182	0.4665	3,350	(800,813)
8th Year Production	7,182	0.4241	3,046	(797,767)
9th Year Production	7,182	0.3855	2,769	(794,999)
10th Year Production	7,182	0.3505	2,517	(792,481)
11th Year Production	7,182	0.3186	2,288	(790,193)
12th Year Production	7,182	0.2897	2,081	(788,113)
13th Year Production	7,182	0.2633	1,891	(786,222)
14th Year Production	7,182	0.2394	1,719	(784,502)
15th Year Production	7,182	0.2176	1,563	(782,939)

Table C.11. Net Income Statement for a 100 t Tilapia Farm Assuming 100% Equity Financing.

Category/Production Year	1	2	3	4	5	6-15
1. Total Gross Income (Sales Revenue)	150,000	150,000	150,000	150,000	150,000	150,000
2. Operating Costs	109,745	109,745	109,745	109,745	109,745	109,745
3. Gross Profit (1-2)	40,255	40,255	40,255	40,255	40,255	40,255
4. Non-operating Costs	73,101	73,101	73,101	73,101	73,101	33,073
5. Net Profit Before Tax (3-4)	(32,846)	(32,846)	(32,846)	(32,846)	(32,846)	7,182
6. Dividends	0	0	0	0	0	0
7. Retained Earnings (5-6)	(32,846)	(32,846)	(32,846)	(32,846)	(32,846)	7,182
8. Earning Power Measurement Ratios						
A. Net Profits to Sales	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)	0.05

Table C.12. Schedule of Preproduction Expenditure During Phase II Expansion of a 200 t Tilapia Farm.

Item / Month	Expenditure (KD) 37	38	39	40	41	42	43	44	45	46	47	48
1. Detailed Designs												
Consultant Engineer	0	2,000	2,000	2,000	0	0	0	0	0	0	0	0
Housing/Food	0	1,050	1,050	1,050	0	0	0	0	0	0	0	0
Airfare	0	800	0	0	0	0	0	0	0	0	0	0
Draftsman	0	1,000	1,000	1,000	0	0	0	0	0	0	0	0
KISR Review	0	0	0	2,000	0	0	0	0	0	0	0	0
2. Site Development	1,500	1,500	1,500	1,500	0	60	0	0	0	0	0	0
3. Recruiting Cost												
Recruiting Trip	0	0	0	0	0	0	0	0	0	0	0	0
Recruiting Agency Fee	0	0	0	0	0	0	0	0	0	0	0	0
Airfare for Staff	0	0	0	0	0	0	0	0	0	0	0	0
4. Manpower												
Project Manager	958	958	958	958	958	958	958	958	958	958	958	962
Site Engineer	700	700	700	700	700	700	700	700	700	700	700	700
Technician	0	0	0	0	0	0	0	0	0	0	0	0
Labourers	0	0	0	0	0	0	0	0	0	0	0	0
5. House Rents: Technicians/ Labourers	0	0	0	0	0	0	0	0	0	0	0	0
6. Electricity	0	0	0	0	0	0	0	0	0	0	0	0
7. Drinking Water	0	0	0	0	0	0	0	0	0	0	0	0
8. Insurance												
New Plant	0	0	0	0	0	0	0	0	0	0	0	0
Stock	0	0	0	0	0	0	0	0	0	0	0	0
9. Commissioning Costs												
Feed	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals/Drugs	0	0	0	0	0	0	0	0	0	0	0	0
10. Supplies/Consumables	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total (KD)	3,158	8,008	7,208	9,208	1,658	1,658	1,658	1,658	1,658	1,658	1,658	1,662

Item / Month	Expenditure (KD) 49	50	51	52	53	54	55	56	57	58	59	60	Total
1. Detailed Designs													
Consultant Engineer	0	0	0	0	0	0	0	0	0	0	0	0	6,000
Housing/Food	0	0	0	0	0	0	0	0	0	0	0	0	3,150
Airfare	0	0	0	0	60	0	0	0	0	0	0	0	800
Draftsman	0	0	0	0	0	0	0	0	0	0	0	0	3,000
KISR Review	0	0	0	0	0	0	0	0	0	0	0	0	2,000
2. Site Development	0	0	0	0	0	0	0	0	0	0	0	0	6,000
3. Recruiting Cost													
Recruiting Trip	0	0	0	1,600	0	50	0	0	60	0	0	0	1,600
Recruiting Agency Fee	0	0	0	300	0	0	0	0	0	0	0	0	300
Airfare for Staff	0	0	0	0	0	0	750	0	0	0	0	0	750
4. Manpower													
Project Manager	958	958	958	958	958	958	958	958	958	958	958	962	23,000
Site Engineer	700	700	700	700	0	0	0	0	60	0	0	0	11,200
Technician	0	0	0	0	0	0	400	400	400	400	400	400	2,400
Labourers	0	0	0	0	0	0	600	600	600	600	600	600	3,600
5. House Rents:Technician/ Labourers	0	0	0	0	0	0	150	150	150	150	150	150	900
6. Electricity	0	0	0	0	0	0	110	110	110	110	110	110	660
7. Drinking Water	0	0	0	0	0	0	30	30	30	30	30	30	180
8. Insurance													
New Plant	0	0	0	0	0	0	1,800	0	0	0	0	0	1,800
Stock	0	0	0	0	0	0	1,400	0	0	0	0	0	1,400
9. Commissioning Costs													
Feed	0	0	0	0	0	0	270	0	300	0	300	0	870
Chemicals/Drugs	0	60	0	0	0	0	1,000	0	0	0	0	0	1,000
10. Supplies/Consumables	0	0	0	0	60	0	80	80	80	80	80	100	500
Grand Total (KD)	1,658	1,658	1,658	3,558	958	958	7,548	2,328	2,628	2,328	2,628	2,352	71,110

Table C.13. Depreciation, Amortization and Replacement of Fixed Assets Over the Life of a 200 t Tilapia Farm.

Assets	Original Value		Service	Depreciation Accrual by Production Year								
	Phase 1	Phase 2	Life	1	2	3	4	5	6	7	8	9-18
Initial Fixed Investment												
3 Years Assets	15,650		3	5,217	5,217	5,217	5,217	5,217	5,217	5,217	5,217	5,217
6 Years Assets	36,900		6	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150
18 Years Assets	307,140		18	17,063	17,063	17,063	17,063	17,063	17,063	17,063	17,063	17,063
Pre-production Expenditures	200,140		5	40,028	40,028	40,028	40,028	40,028	0	0	0	0
Incremental Fixed Investment												
3 Years Assets		15,930	3	0	0	0	5,310	5,310	5,310	5,310	5,310	5,310
5 Years Assets		19,363	5	0	0	0	3,873	3,873	3,873	3,873	3,873	3,873
15 Years Assets		318,697	15	0	0	0	21,246	21,246	21,246	21,246	21,246	21,246
Pre-production Expenditures		71,110	5	0	0	0	14,222	14,222	14,222	14,222	14,222	0
Total (KD)	559,830	425,100		68,458	68,458	68,458	113,109	113,109	73,081	73,081	73,081	58,859

Table C.14. Working Capital Requirement Over the Life of a 200 t Tilapia Farm.

Item	Average no. of Days	Turnover Coefficient	Production Year				
			1	2	3	4	5-18
1. Accounts Receivable	30	12	12,500	12,500	12,500	25,000	25,000
2. Raw Materials Inventory	30	12	2,017	2,017	2,017	2,738	2,738
3. Spare Parts	180	2	1,465	1,465	1,465	1,451	1,451
4. Finished Products	30	12	12,500	12,500	12,500	25,000	25,000
5. Required Cash in Hand	60	6	13,545	13,545	13,545	18,888	18,888
6. Accounts Payable	30	12	500	500	500	902	902
7. Net Working Capital (1+2+3+4+5-6)			41,528	41,528	41,528	72,176	72,176
8. Increase in Working Capital				0	0	30,648	0

Table C.15. Fixed Investment Costs Over Life of a 200 t Tilapia Farm.

Description/Year	Construction	Replacement								
		1	2	3	4	5	6	7	8	9
Initial Fixed Investment										
3 Years Assets	15,650	0	0	0	0	0	0	0	0	0
6 Years Assets	36,900	0	0	0	0	0	0	0	0	0
18 Years Assets	307,140	0	0	0	0	0	0	0	0	0
Replacement of Initial Fixed Investment										
3 Years Assets	0	0	0	0	15,650	0	0	15,650	0	0
6 Years Assets	0	0	0	0	0	0	0	36,900	0	0
18 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	0	200	200	200	200	200	200	200	200	200
Incremental Fixed Investment										
3 Years Assets	0	0	7,965	7,965	0	0	0	0	0	0
5 Years Assets	0	0	9,682	9,682	0	0	0	0	0	0
15 Years Assets	0	0	159,349	159,349	0	0	0	0	0	0
Replacement of Incremental Fixed Investment										
3 Years Assets	0	0	0	0	0	0	0	15,930	0	0
5 Years Assets	0	0	0	0	0	0	0	0	0	19,363
15 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	0	0	0	0	200	200	200	200	200	200
Total Fixed Investment Cost (KD)	359,690	200	177,195	177,195	16,050	400	400	68,880	400	19,763

Description	Replacement									
	10	11	12	13	14	15	16	17	18	Total
Initial Fixed Investment										
3 Years Assets	0	0	0	0	0	0	0	0	0	15,650
6 Years Assets	0	0	0	0	0	0	0	0	0	36,900
18 Years Assets	0	0	0	0	0	0	0	0	0	307,140
Replacement of Initial Fixed Investment										
3 Years Assets	15,650	0	0	15,650	0	0	15,650	0	0	78,250
6 Years Assets	0	0	0	36,900	0	0	0	0	0	73,800
18 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	200	200	200	200	200	200	200	200	200	3,600
Incremental Fixed Investment										
3 Years Assets	0	0	0	0	0	0	0	0	0	15,930
5 Years Assets	0	0	0	0	0	0	0	0	0	19,363
15 Years Assets	0	0	0	0	0	0	0	0	0	318,697
Replacement of Incremental Fixed Investment										
3 Years Assets	15,930	0	0	15,930	0	0	15,930	0	0	63,718
5 Years Assets	0	0	0	0	19,363	0	0	0	0	38,727
15 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	200	200	200	200	200	200	200	200	200	3,000
Total Fixed Investment Cost (KD)	31,980	400	400	68,880	19,763	400	31,980	400	400	974,775

Table C.16. Total Capital Investment Over the Life of a 200 t Tilapia Farm.

Description/Year	Construction	Production Period								
	2 Years	1	2	3	4	5	6	7	8	9
1. Fixed Investment Cost										
A. Initial Investment	359,690	0	0	0	0	0	0	0	0	0
Replacement	0	200	200	200	15,850	200	200	52,750	200	200
B. Incremental Investment		0	176,995	176,995	0	0	0	0	0	0
Replacement	0	0	0	0	200	200	200	16,130	200	19,563
2. Pre-production Expenditures	200,140	0	40,850	30,260	0	0	0	0	0	0
3. Working Capital		41,528	0	0	0	0	0	0	0	0
4. Increase in Working Capital		0	0	0	30,648	0	0	0	0	0
Total Capital Investment Cost	559,830	41,728	218,045	207,455	46,698	400	400	68,880	400	19,763

Description/Year	Production Period									
	10	11	12	13	14	15	16	17	18	Total
1. Fixed Investment Cost										
A. Initial Investment	0	0	0	0	0	0	0	0	0	359,690
Replacement	15,850	200	200	52,750	200	200	15,850	200	200	155,650
B. Incremental Investment	0	0	0	0	0	0	0	0	0	353,990
Replacement	16,130	200	200	16,130	19,563	200	16,130	200	200	105,445
2. Pre-production Expenditures	0	0	0	0	0	0	0	0	0	271,250
3. Working Capital	0	0	0	0	0	0	0	0	0	41,528
4. Increase in Working Capital	0	0	0	0	0	0	0	0	0	30,648
Total Capital Investment Cost	31,980	400	400	68,880	19,763	400	31,980	400	400	1,318,201

Table C.17. Analysis of Production Costs Over the Life of a 200 t Tilapia Farm Assuming 100% Equity Financing.

Production Year	1		2		3		4		5		6		7		8		9-18	
Item	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%
1. Operating Costs (A+B)	111,965	62.1	111,965	62.1	111,965	62.1	157,508	58.2	157,508	58.2	157,508	68.3	157,508	668.3	157,508	68.3	157,508	72.8
A. Farm Costs	84,070	46.6	84,070	46.6	84,070	46.6	107,237	39.6	107,237	39.6	107,237	46.5	107,237	46.5	107,237	46.5	107,237	49.6
Raw Materials	24,198	13.4	24,198	13.4	24,198	13.4	32,856	12.1	32,856	12.1	32,856	14.2	32,856	14.2	32,856	14.2	32,856	15.2
Utilities	2,494	1.4	2,494	1.4	2,494	1.4	4,272	1.6	4,272	1.6	4,272	1.9	4,272	1.9	4,272	1.9	4,272	2.0
Consumables	3,500	1.9	3,500	1.9	3,500	1.9	6,550	2.4	6,550	2.4	6,550	2.8	6,550	2.8	6,550	2.8	6,550	3.0
Labour	43,800	24.3	43,800	24.3	43,800	24.3	55,800	20.6	55,800	20.6	55,800	24.2	55,800	24.2	55,800	24.2	55,800	25.8
Farm Overheads	10,078	5.6	10,078	5.6	10,078	5.6	7,758	2.9	7,758	2.9	7,758	3.4	7,758	3.4	7,758	3.4	7,758	3.6
B. Non-Farm Costs	27,895	15.5	27,895	15.5	27,895	15.5	50,272	18.6	50,272	18.6	50,272	21.8	50,272	21.8	50,272	21.8	50,272	23.2
Administrative Overheads	27,395	15.2	27,395	15.2	27,395	15.2	49,772	18.4	49,772	18.4	49,772	21.6	49,772	21.6	49,772	21.6	49,772	23.0
Sales and Promotion	500	0.3	500	0.3	500	0.3	500	0.2	500	0.2	500	0.2	500	0.2	500	0.2	500	0.2
2. Non-Operating Costs	68,458	37.9	68,458	37.9	68,458	37.9	113,109	41.8	113,109	41.8	73,081	31.7	73,081	31.7	73,081	31.7	58,859	27.2
Interest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Depreciation and Amortization	68,458	37.9	68,458	37.9	68,458	37.9	113,109	41.8	113,109	41.8	73,081	31.7	73,081	31.7	073,081	317	58,859	27.2
3. Total Production Costs (1+2)	180,423	100.0	180,423	100.0	180,423	100.0	270,617	100.0	270,617	100.0	230,589	100.0	230,589	100.0	230,589	100.0	216,367	100.0
Unit Production Cost (KD/t)	1,804		1,804		1,804		1,353		1,353		1,153		1,153		1,153		1,082	

Table C.18. Revenue Forecast of a 200 t Tilapia Farm Over 18 Years.

Item	Amount
Total Farm Capacity/t	100
Sales Price KD/t*	1,500
Estimated Sales (KD)	300,000

* Delivered to customer site (store)

Table C.19. Cash Flow Analysis of a 200 t Tilapia Farm Assuming 100% Equity Financing.

Description/Year	Construction Period		Production Period							
	-2	-1	1	2	3	4	5	6	7	8
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	0	0	0	0	0	0	0
Sales Revenue	0	0	150,000	150,000	150,000	300,000	300,000	300,000	300,000	300,000
Total Cash In	0	0	150,000	150,000	150,000	300,000	300,000	300,000	300,000	300,000
2. Cash Out										
Initial Fixed Investment	80,930	278,760	0	0	0	0	0	0	0	0
Payment of Replacement (1)	0	0	200	200	200	15,850	200	200	52,750	200
Pre-production Expenditures	126,450	73,690	0	40,850	30,260	0	0	0	0	0
Incremental Fixed Assets	0	0	0	176,995	176,995	0	0	0	0	0
Payment of Replacement (2)	0	0	0	0	0	200	200	200	16,130	200
Operating Costs	0	0	111,965	111,965	111,965	157,508	157,508	157,508	157,.508	157,508
Interest Payment	0	0	0	0	0	0	0	0	0	0
Loan Repayment	0	0	0	0	0	0	0	0	0	0
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	207,380	352,450	112,165	330,010	319,420	173,558	157,908	157,908	226,388	157,908
3. Net Cash Flow	(207,380)	(352,450)	37,835	(180,010)	(169,420)	126,442	142,092	142,092	73,612	142,092
4. Cummulative Cash Flow	(207,380)	(559,830)	(521,995)	(702,005)	(871,426)	(744,984)	(602,892)	(460,801)	(387,189)	(245,097)

Description/Year	Production Period									
	9	10	11	12	13	14	15	16	17	18
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	0	0	0	0	0	0	0
Sales Revenue	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Total Cash In	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
2. Cash Out										
Initial Fixed Investment	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (1)	200	15,850	200	200	52,750	200	200	15,850	200	200
Pre-production Expenditures	0	0	0	0	0	0	0	0	0	0
Incremental Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (2)	19,563	16,130	200	200	16,130	19,563	200	16,130	200	200
Operating Costs	157,508	157,508	157,508	157,508	157,508	157,508	157,508	157,508	157,508	157,508
Interest Payment	0	0	0	0	0	0	0	0	0	0
Loan Repayment	0	0	0	0	0	0	0	0	0	0
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	177,272	189,488	157,908	157,908	226,388	177,272	157,908	189,488	157,908	157,908
3. Net Cash Flow	122,728	110,512	142,092	142,092	73,612	122,728	142,092	110,512	142,092	142,092
4. Cummulative Cash Flow	(122,369)	(11,857)	130,235	272,327	345,939	468,667	610,759	721,271	863,362	1,005,454

Note: IRR = 8%

Table C.20. Discounted Payback Period of a 200 t Tilapia Farm

Item	Original Value (KD)	Discount Factor 10%	Present Value (KD)	Unrecovered Investment at the end of the year
1. Total Initial Investment	601,358		565,545	
1st Year Construction	207,380	1.0000	207,380	
2nd Year Construction	393,977	0.9091	358,165	
2. Net Profit				
1st Year Production	(30,423)	1.2100	(36,812)	(602,357)
2nd Year Production	(30,423)	1.3310	(40,493)	(642,850)
3rd Year Production	(30,423)	1.4640	(44,540)	(687,390)
4th Year Production	29,383	0.6209	18,244	(669,146)
5th Year Production	29,383	0.5645	16,586	(652,560)
6th Year Production	69,411	0.5132	35,622	(616,938)
7th Year Production	69,411	0.4665	32,380	(584,558)
8th Year Production	69,411	0.4241	29,437	(555,121)
9th Year Production	83,633	0.3855	32,240	(522,881)
10th Year Production	83,633	0.3505	29,313	(493,568)
11th Year Production	83,633	0.3186	26,645	(466,922)
12th Year Production	83,633	0.2897	24,228	(442,694)
13th Year Production	83,633	0.2633	22,020	(420,673)
14th Year Production	83,633	0.2394	20,022	(400,652)
15th Year Production	83,633	0.2176	18,198	(382,453)
16th Year Production	83,633	0.1978	16,543	(365,911)
17th Year Production	83,633	0.1799	15,046	(350,865)
18th Year Production	83,633	0.1635	13,674	(337,191)

Table C.21. Net Income Statement of a 200t Tilapia Farm Assuming 100% Equity Financing.

Category/Production	1	2	3	4	5	6	7	8	9-18
1. Total Gross Income (Sales Revenue)	150,000	150,000	150,000	300,000	300,000	300,000	300,000	300,000	300,000
2. Operating Costs	111,965	111,965	111,965	157,508	157,508	157,508	157,508	157,508	
3. Gross profit (1-2)	38,035	38,035	38,035	142,492	142,492	142,492	142,492	142,492	142,492
4. Non Operating Costs	68,458	68,458	68,458	113,109	113,109	73,081	73,081	73,081	58,859
5. Net Profit B.T (3-4)	(30,423)	(30,423)	(30,423)	29,383	29,383	69,411	69,411	69,411	83,633
6. Dividends	0	0	0	0	0	0	0	0	0
7. Retained Earnings (5-6)	(30,423)	(30,423)	(30,423)	29,383	29,383	69,411	69,411	69,411	83,633
8. Ratios (Earning Power Measurement)									
Net Profit to Sales (Profit Margin)	(0.20)	(0.20)	(0.20)	0.10	0.10	0.23	0.23	0.23	0.28

Table C.22. Sources of Finance of a 200 t Tilapia Farm Assuming External Financing of Phase II Expansion.

	Phase I					Phase II				
	Fixed Investment	Pre-production Expenditures	Working Capital	Total Initial Investment (KD)	%	Fixed Investment	Preproduction Expenditures	Increase in Working Capital	Total Incremental Investment (KD)	%
Equity	359,690	200,140	41,528	601,358	100.0	176,995	71,110	21,454	269,559	59.1
Industrial Loan at 5%	0	0	0	0	0.0	176,995	0	9,194	186,189	40.9
Total	359,690	200,140	41,528	601,358	100.0	353,990	71,110	30,648	455,748	100.0

Table C.23. Financing Obligations of a 200 t Tilapia Farm Assuming External Financing of Phase II Expansion.

Item	Construction		Production Period										
	-2	-1	1	2	3	4	5	6	7	8	9	10	11-18
1. Industrial Loan													
Amount: KD 186,189													
Grace Period: 2 years													
Repayment Period: 5 Years													
Interest Rate: 5%													
Obligations:													
Principal	0	0	0	0	0	0	0	37,238	37,238	37,238	37,238	37,238	0
Interest	0	0	0	4,655	9,309	9,309	9,309	9,309	7,448	5,586	3,724	1,862	0
Total Obligations	0	0	0	4,655	9,309	9,309	9,309	46,547	44,685	42,824	40,962	39,100	0

Table C.24. Cash Flow Analysis of a 200 t Tilapia Farm with External Financing of Phase II Expansion.

Description/Year	Construction		Production Period							
	-2	-1	1	2	3	4	5	6	7	8
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	93,095	93,095	0	0	0	0	0
Sales Revenue	0	0	150,000	150,000	150,000	300,000	300,000	300,000	300,000	300,000
Total Cash In	0	0	150,000	243,095	243,095	300,000	300,000	300,000	300,000	300,000
2. Cash Out										
Initial Fixed Assets	80,930	278,760	0	0	0	0	0	0	0	0
Payment of Replacement (1)	0	0	200	200	200	15,850	200	200	52,750	200
Pre-production Expenditures	126,450	73,690	0	40,850	30,260	0	0	0	0	0
Incremental Fixed Assets	0	0	0	176,995	176,995	0	0	0	0	0
Payment of Replacement (2)	0	0	0	0	0	200	200	200	16,130	200
Operating Costs	0	0	111,965	111,965	111,965	157,508	157,508	157,508	157,508	157,508
Interest Payment	0	0	0	4,655	9,309	9,309	9,309	9,309	7,448	5,586
Loan Repayment	0	0	0	0	0	0	0	37,238	37,238	37,238
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	207,380	352,450	112,165	334,665	328,730	182,868	167,218	204,456	271,073	200,732
3. Net Cash Flow	(207,380)	(352,450)	37,835	(91,570)	(85,635)	117,132	132,782	95,544	28,927	99,268
4. Cumulative Cash Flow	(207,380)	(559,830)	(521,995)	(613,565)	(699,200)	(582,068)	(449,286)	(353,742)	(324,815)	(225 547)

Description/Year	9	10	11	12	13	14	15	16	17	18
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	0	0	0	0	0	0	0
Sales Revenue	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Total Cash In	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
2. Cash Out										
Initial Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (1)	200	15,850	200	200	52,750	200	200	15,850	200	200
Pre-production Expenditures	0	0	0	0	0	0	0	0	0	0
Incremental Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (2)	19,563	16,130	200	200	16,130	19,563	200	16,130	200	200
Operating Costs	157,508	157,508	157,508	157,508	157,508	157,508	157,508	157,508	157,508	157,508
Interest Payment	3,724	1,862	0	0	0	0	0	0	0	0
Loan Repayment	37,238	37,238	0	0	0	0	0	0	0	0
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	218,233	228,588	157,908	157,908	226,388	177,272	157,908	189,488	157,908	157,908
3. Net Cash Flow	81,767	71,412	142,092	142,092	73,612	122,728	142,092	110,512	142,092	142,092
4. Cummulative Cash Flow	(143,781)	(72,368)	69,723	211,815	285,427	408,155	550,247	660,759	802,851	944,942

Note: IRR = 8%

Table C.25. Net Income Statement of a 200 t Tilapia Farm with External Financing of Phase II Expansion.

Category/Production	1	2	3	4	5	6	7	8	9	10	11-18
1. Total Gross Income (Sales Revenue)	150,000	150,000	150,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
2. Operating Costs	111,965	111,965	111,965	157,508	157,508	157,508	157,508	157,508	157,508	157,508	157,508
3. Gross Profit (1-2)	38,035	38,035	38,035	142,492	142,492	142,492	142,492	142,492	142,492	142,492	142,492
4. Non Operating Costs	68,458	73,113	77,767	122,418	122,418	82,390	80,529	78,667	62,583	60,721	58,859
5. Net Profit B.T (3-4)	(30,423)	(35,078)	(39,733)	20,073	20,073	60,101	61,963	63,825	79,909	81,771	83,633
6. Dividends	0	0	0	0	0	0	0	0	0	0	0
7. Retained Earnings (5-6)	(30,423)	(35,078)	(39,733)	20,073	20,073	60,101	61,963	63,825	79,909	81,771	83,633
8. Ratios (Earning Power Measurement)											
Net Profit to Sales (Profit Margin)	(0.20)	(0.23)	(0.26)	0.07	0.07	0.20	0.21	0.21	0.27	0.27	0.28

Table C.26. Schedule of Preproduction Expenditures During Phase II Expansion of a 400 t Tilapia Farm.

Item	Expenditure (KD)											
Month	37	38	39	40	41	42	43	44	45	46	47	48
1. Detailed Designs												
Consultant Engineer	0	2,000	2,000	2,000	0	0	0	0	0	0	0	0
Housing/Food	0	1,050	1,050	1,050	0	0	0	0	0	0	0	0
Air fare	0	800	0	0	0	0	0	0	0	0	0	0
Draftsman	0	1,000	1,000	1,000	0	0	0	0	0	0	0	0
KISR Review	0	0	0	2,000	0	0	0	0	0	0	0	0
2. Site Development	1,500	1,500	1,500	1,500	0	0	0	0	0	0	0	0
3. Recruiting Costs												
Recruiting Trip	0	0	0	0	0	0	0	0	0	0	0	0
Air Fares for Staff	0	0	0	0	0	0	0	0	0	0	0	0
Recruitment Agency Fee	0	0	0	0	0	0	0	0	0	0	0	0
4. Manpower												
Project Manager	958	958	958	958	958	958	958	958	958	958	958	962
Site Engineer	700	700	700	700	700	700	700	700	700	700	700	700
Technicians	0	0	0	0	0	0	0	0	0	0	0	0
Labourers	0	0	0	0	0	0	0	0	0	0	0	0
Cook	0	0	0	0	0	0	0	0	0	0	0	0
5. Electricity	0	0	0	0	0	0	0	0	0	0	0	0
6. Drinking Water	0	0	0	0	0	0	0	0	0	0	0	0
7. Insurance												
New Plant	0	0	0	0	0	0	0	0	0	0	0	0
Stock	0	0	0	0	0	0	0	0	0	0	0	0
8. Commissioning Costs												
Feed	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals/Drugs	0	0	0	0	0	0	0	0	0	0	0	0
9. Supplies/Consumables	0	0	0	0	0	0	0	0	0	0	0	0
GRAND TOTAL (KD)	3,158	8,008	7,208	9,208	1,658	1,658	1,658	1,658	1,658	1,658	1,658	1,662

Item	Expenditure (KD)												
Month	49	50	51	52	53	54	55	56	57	58	59	60	Total
1. Detailed Designs													
Consultant Engineer	0	0	0	0	0	0	0	0	0	0	0	0	6,000
Housing/Food	0	0	0	0	0	0	0	0	0	0	0	0	3,150
Air Fare	0	0	0	0	0	0	0	0	0	0	0	0	800
Draftsman	0	0	0	0	0	0	0		0	0	0	0	3,000
KISR Review	0	0	0	0	0	0	0	0	0	0	0	0	2,000
2. Site Development	0	0	0	0	0	0	0	0	0	0	0	0	6,000
3. Recruiting Costs													
Recruiting Trip	0	0	0	1,600	0	0	0	0	0	0	0	0	1,600
Air Fares for Staff	0	0	0	0	0	0	1,750	0	0	0	0	0	1,750
Recruitment Agency Fee	0	0	0	700	0	0	0	0	0	0	0	0	700
4. Manpower													
Project Manager	958	958	958	958	958	958	958	958	958	958	958	962	23,000
Site Engineer	700	700	700	700	0	0	0	0	0	0	0	0	11,200
Technicians	0	0	0	0	0	0	1,200	1,200	1,200	1,200	1,200	1,200	7,200
Labourers	0	0	0	0	0	0	1,200	1,200	1,200	1,200	1,200	1,200	7,200
Cook	0	0	0	0	0	0	250	250	250	250	250	250	1,500
5. Electricity	0	0	0	0	0	0	350	350	350	350	350	350	2,100
6. Drinking Water	0	0	0	0	0	0	70	70	70	70	70	70	420
7. Insurance													
New Plant	0	0	0	0	0	0	3,950	0	0	0	0	0	3,950
Stock	0	0	0	0	0	0	4,200	0	0	0	0	0	4,200
8. Commissioning Costs													
Feed	0	0	0	0	0	0	810	0	900	0	900	0	2,610
Chemicals/Drugs	0	0	0	0	0	0	3,000	0	0	0	0	0	3,000
9. Supplies/Consumables	0	0	0	0	0	0	250	250	250	250	250	250	1,500
GRAND TOTAL (KD)	1,658	1,658	1,658	3,958	958	958	17,988	4,278	5,178	4,278	5,178	4,282	92,880

Table C.27. Depreciation, Amortization and Replacement of Fixed Assets Over the Life of a 400 t Tilapia Farm.

Assets	Original Value		Service Life	Depreciation Accruals								
	Phase 1	Phase 2		1	2	3	4	5	6	7	8	9-18
Initial Fixed Investment	359,690											
3 Years Assets	15,650		3	5,217	5,217	5,217	5,217	5,217	5,217	5,217	5,217	5,217
6 Years Assets	36,900		6	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150
18 Years Assets	307,140		18	17,063	17,063	17,063	17,063	17,063	17,063	17,063	17,063	17,063
Pre-production Expenditures	200,140		5	40,028	40,028	40,028	40,028	40,028	0	0	0	0
Incremental Fixed Investment		785,030										
3 Years Assets		35,326	3	0	0	0	11,775	11,775	11,775	11,775	11,775	11,775
5 Years Assets		38,388	5	0	0	0	7,678	7,678	7,678	7,678	7,678	7,678
15 Years Assets		711,316	15	0	0	0	47,421	47,421	47,421	47,421	47,421	47,421
Pre-production Expenditures		92,880	5	0	0	0	18,576	18,576	18,576	18,576	18,576	0
Total	559,830	877,910		68,458	68,458	68,458	153,908	153,908	113,880	113,880	113,880	95,304

Table C.28. Working Capital Requirement Over the Life of a 400 t Tilapia Farm.

Item	Average no. of Days	Turnover Coefficient	Year				
			1	2	3	4	5-18
1. Accounts Receivable	30	12	12,500	12,500	12,500	50,000	50,000
2. Raw Materials Inventory	30	12	2,017	2,017	2,017	5,476	5,476
3. Spare Parts	180	2	1,465	1,465	1,465	3,198	3,198
4. Finished Products	30	12	12,500	12,500	12,500	50,000	50,000
5. Required Cash in Hand	60	6	13,545	13,545	13,545	25,063	25,063
6. Accounts Payable	30	12	500	500	500	1,692	1,692
7. Net Working Capital (1+2+3+4+5-6)			41,527	41,527	41,527	132,046	132,046
8. Increase in Working Capital				0	0	90,519	0

Table C.29. Fixed Investment Costs Over the Life of a 400 t Tilapia Farm.

Description/Year	Construction (2 years)	Replacement 1	2	3	4	5	6	7	8	9
Initial Fixed Investment										
3 Years Assets	15,650	0	0	0	0	0	0	0	0	0
6 Years Assets	36,900	0	0	0	0	0	0	0	0	0
18 Years Assets	307,140	0	0	0	0	0	0	0	0	0
Replacement of Initial Fixed Investment										
3 Years Assets	0	0	0	0	15,650	0	0	15,650	0	0
6 Years Assets	0	0	0	0	0	0	0	36,900	0	0
18 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	0	200	200	200	200	200	200	200	200	200
Incremental Fixed Investment										
3 Years Assets	0	0	17,663	17,663	0	0	0	0	0	0
5 Years Assets	0	0	19,194	19,194	0	0	0	0	0	0
15 Years Assets	0	0	355,658	355,658	0	0	0	0	0	0
Replacement of Incremental Fixed Investment										
3 Years Assets	0	0	0	0	0	0	0	35,326	0	0
5 Years Assets	0	0	0	0	0	0	0	0	0	38,388
15 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	0	0	0	0	200	200	200	200	200	200
Total Fixed Investment Cost	359,690	200	392,715	392,715	16,050	400	400	88,276	400	38,788

Description/Year	Replacement 10	11	12	13	14	15	16	17	18	Total
Initial Fixed Investment										
3 Years Assets	0	0	0	0	0	0	0	0	0	15,650
6 Years Assets	0	0	0	0	0	0	0	0	0	36,900
18 Years Assets	0	0	0	0	0	0	0	0	0	307,140
Replacement of Initial Fixed Investment										
3 Years Assets	15,650	0	0	15,650	0	0	15,650	0	0	78,250
6 Years Assets	0	0	0	36,900	0	0	0	0	0	73,800
18 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	200	200	200	200	200	200	200	200	200	3,600
Incremental Fixed Investment										
3 Years Assets	0	0	0	0	0	0	0	0	0	35,326
5 Years Assets	0	0	0	0	0	0	0	0	0	38,388
15 Years Assets	0	0	0	0	0	0	0	0	0	711,316
Replacement of Incremental Fixed Investment										
3 Years Assets	35,326	0	0	35,326	0	0	35,326	0	0	141,305
5 Years Assets	0	0	0	0	38,388	0	0	0	0	76,776
15 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	200	200	200	200	200	200	200	200	200	3,000
Total Fixed Investment Cost	51,376	400	400	88,276	38,788	400	51,376	400	400	1,521,451

Table C.30. Total Capital Investment Over the Life of a 400 t Tilapia Farm.

Description/Year	Construction	Production Period								
	2 Years	1	2	3	4	5	6	7	8	9
1. Fixed Investment Cost										
A. Initial Investment	359,690	0	0	0	0	0	0	0	0	0
Replacement	0	200	200	200	15,850	200	200	52,750	200	200
B. Incremental Investment	0	0	392,515	392,515	0	0	0	0	0	0
Replacement	0	0	0	0	200	200	200	35,526	200	38,588
2. Pre-production Expenditures	200,140	0	40,850	52,030	0	0	0	0	0	0
3. Working Capital	0	41,527	0	0	0	0	0	0	0	0
4. Increase in Working Capital	0	0	0	0	90,519	0	0	0	0	0
Total Capital Investment Cost	559,830	41,727	433,565	444,745	106,569	400	400	88,276	400	38,788

Description/Year	Production Period									
	10	11	12	13	14	15	16	17	18	19
1. Fixed Investment Cost										
A. Initial Investment	0	0	0	0	0	0	0	0	0	359,690
Replacement	15,850	200	200	52,750	200	200	15,850	200	200	155,650
B. Incremental Investment	0	0	0	0	0	0	0	0	0	785,030
Replacement	35,526	200	200	35,526	38,588	200	35,526	200	200	221,081
2. Pre-production Expenditures	0	0	0	0	0	0	0	0	0	293,020
3. Working Capital	0	0	0	0	0	0	0	0	0	41,527
4. Increase in Working Capital	0	0	0	0	0	0	0	0	0	90,519
Total Capital Investment Cost	51,376	400	400	88,276	38,788	400	51,376	400	400	1,946,517

Table C.31. Analysis of Production Costs Over the Life of a 400 t Tilapia Farm Assuming 100% Equity Financing.

Production Year	1		2		3		4		5		6		7		8		9-18	
Item	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%
1. Operating Costs (A+B)	111,962	62.1	111,962	62.1	111,962	62.1	236,895	60.6	236,895	60.6	236,895	67.5	236,895	67.5	236,895	67.5	236,895	71.3
A. Farm Costs	84,070	46.6	84,070	46.6	84,070	46.6	178,766	45.7	178,766	45.7	178,766	51.0	178,766	51.0	178,766	51.0	178,766	53.8
Raw Materials	24,198	13.4	24,198	13.4	24,198	13.4	65,712	16.8	65,712	16.8	65,712	18.7	65,712	18.7	65,712	18.7	65,712	19.8
Utilities	2,494	1.4	2,494	1.4	2,494	1.4	7,752	2.0	7,752	2.2	7,752	2.2	7,752	2.2	7,752	2.2	7,752	2.3
Consumables	3,500	1.9	3,500	1.9	3,500	1.9	12,550	3.2	12,550	3.2	12,550	3.6	12,550	3.6	12,550	3.6	12,550	3.8
Labour	43,800	24.3	43,800	24.3	43,800	24.3	75,600	19.3	75,600	19.3	75,600	21.6	75,600	21.6	75,600	21.6	75,600	22.8
Farm Overheads	10,078	5.6	10,078	5.6	10,078	5.6	17,152	4.4	17,152	4.4	17,152	4.9	17,152	4.9	17,152	4.9	17,152	5.2
B. Non-Farm Costs	27,892	15.5	27,892	15.5	27,892	15.5	58,129	14.9	58,129	14.9	58,129	16.6	58,129	16.6	58,129	16.6	58,129	17.5
Administrative Overheads	27,392	15.2	27,392	15.2	27,392	15.2	57,629	14.7	57,629	14.7	57,629	16.4	57,629	16.4	57,629	16.4	57,629	17.3
Sales and Promotion	500	0.3	500	0.3	500	0.3	500	0.1	500	0.1	500	0.1	500	0.1	500	0.1	500	0.2
2. Non-Operating Costs	68,458	37.9	68,458	37.9	68,458	37.9	153,908	39.4	153,908	39.4	113,880	32.5	113,880	32.5	113,880	32.5	95,304	28.7
Interest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Depreciation and Amortization	68,458	37.9	68,458	37.9	68,458	37.9	153,908	39.4	153,908	39.4	113,880	32.5	113,880	32.5	113,880	32.5	95,304	28.7
3. Total Production Costs (1+2)	180,420	100.0	180,420	100.0	180,420	100.0	390,803	100.0	390,803	100.0	350,775	100.0	350,775	100.0	350,775	100.0	332,199	100.0
Unit Production Cost (KD/t)	1,804		1,804		1,804		977		977		877		877		877		830	

Table C.32. Revenue Forecast of an 400 t Tilapia Farm Over 18 Years.

Item	Amount
Total Farm Capacity/t	100
Sales Price KD/t	1,500
Estimated Sales (KD)	600,000

* Delivered to customer site (store).

Table C.33. Cash Flow Analysis of a 400 t Tilapia Farm Assuming 100% Equity Financing.

Description/Year	Construction Period		Production Period							
	-2	-1	1	2	3	4	5	6	7	8
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	0	0	0	0	0	0	0
Sales Revenue	0	0	150,000	150,000	150,000	600,000	600,000	600,000	600,000	600,000
Total Cah In	0	0	150,000	150,000	150,000	600,000	600,000	600,000	600,000	600,000
2. Cash Out										
Initial Fixed Assets	80,930	278,760	0	0	0	0	0	0	0	0
Payment of Replacement (1)	0	0	200	200	200	15,850	200	200	52,750	200
Pre-production Expenditures	126,450	73,690	0	40,850	52,030	0	0	0	0	0
Incremental Fixed Assets	0	0	0	392,515	392,515	0	0	0	0	0
Payment of Replacement (2)	0	0	0	0	0	200	200	200	35,526	200
Operating Costs	0	0	111,962	111,962	111,962	236,895	236,895	236,895	236,895	236,895
Interest Payment	0	0	0	0	0	0	0	0	0	0
Loan Repayment	0	0	0	0	0	0	0	0	0	0
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	207,380	352,450	112,162	545,527	556,707	252,945	237,295	237,295	325,172	237,295
3. Net Cash Flow	(207,380)	(352,450)	37,838	(395,527)	(406,707)	347,055	362,705	362,705	274,828	362,705
4. Cummulative Cash Flow		(559,830)	(521,992)	(917,519)	(1,324,226)	(977,172)	(614,467)	(251,762)	23,066	385,770

Description/Year	Production Period									
	9	10	11	12	13	14	15	16	17	18
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	0	0	0	0	0	0	0
Sales Revenue	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600;000	600,000
Total Cash In	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
2. Cash Out										
Initial Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (1)	200	15,850	200	200	52,750	200	200	15,850	200	200
Pre-production Expenditures	0	0	0	0	0	0	0	0	0	0
Incremental Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (2)	38,588	35,526	200	200	35,526	38,588	200	35,526	200	200
Operating Costs	236,895	236,895	236,895	236,895	236,895	236,895	236,895	236,895	236,895	236,895
Interest Payment	0	0	0	0	0	0	0	0	0	0
Loan Repayment	0	0	0	0	0	0	0	0	0	0
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	275,683	288,272	237,295	237,295	325,172	275,683	237,295	288,272	237,295	237,295
3. Net Cash Flow	324,317	311,728	362,705	362,705	274,828	324,317	362,705	311,728	362,705	362,705
4. Cummulative Cash Flow	710,087	1,021,815	1,384,520	1,747,225	2,022,0532,346,370		2,709,074	3,020,802	3,383,507	3,746,212

Note: IRR 17%

Table C.34. Discounted Payback Period of a 400 t Tilapia Farm.

Item	Original Value (KD)	Discount Factor 10%	Present Value	Unrecovered Investment at the end of the Year	Remarks
1. Total Initial Investment	601,357		565,545		
1st Year Construction	207,380	1,000	207,380		
2nd Year Construction	393,977	0.9091	358,165		
2. Net Profit					
1st Year Production	(30,420)	1.2100	(36,808)	602,353	
2nd Year Production	(30,420)	1,3310	(40,489)	642,842	
3rd Year Production	(30,420)	1,4640	(44,535)	687,377	
4th Year Production	209,197	0.6209	129,890	557,487	
5th Year Production	209,197	0.5645	118,091	439,395	
6th Year Production	249,225	0.5132	127,902	311,493	
7th Year Production	249,225	0.4665	116,263	195,230	
8th Year Production	249,225	0.4241	105,696	89,534	
9th Year Production	267,801	0.3855	103,237	(13,703)	
10th Year Production	267,801	0.3505	93,864	(107,567)	Investment
11th Year Production	267,801	0.3186	85,321	(192,888)	Recovery
12th Year Production	267,801	0.2897	77,582	(270,470)	
13th Year Production	267,801	0.2633	70,512	(340,982)	
14th Year Production	267,801	0.2394	64,111	(405,094)	
15th Year Production	267,801	0.2176	58,273	(463,367)	
16th Year Production	267,801	0.1978	52,971	(516,338)	
17th Year Production	267,801	0.1799	48,177	(564,515)	
18th Year Production	267,801	0.1635	43,785	(608,301)	

Table C.35. Net Income Statement of a 400 t Tilapia Farm Assuming 100% Equity Financing.

Category/Production Year	1	2	3	4	5	6	7	8	9-18
1. Total Gross Income (Sales Revenue)	150,000	150,000	150,000	600,000	600,000	600,000	600,000	600,000	600,000
2. Operating Cost	111,962	111,962	111,962	236,895	236,895	236,895	236,895	236,895	236,895
3. Gross Profit (1-2)	38,038	38,038	38,038	363,105	363,105	363,105	363,105	363,105	363,105
4. Non Operating Costs	68,458	68,458	68,458	153,908	153,908	113,800	113,800	113,800	95,304
5. Net Profit B.T (3-4)	(30,420)	(30,420)	(30,420)	209,197	209,197	249,225	249,225	249,225	267,801
6. Dividends	0	0	0	0	0	0	0	0	0
7. Retained Earnings (5-6)	(30,420)	(30,420)	(30,420)	209,197	209,197	249,225	249,225	249,225	267,801
8. Ratios (Earning Power Measurements)									
Net Profits to Sales (profit margin)	(0.20)	(0.20)	(0.20)	0.35	0.35	0.42	0.42	0.42	0.45

Table C.36. Sources of Finance of a 400 t Tilapia Farm Assuming External Financing of Phase II Expansion.

Source	Phase I					Phase II				
	Fixed Investment	Pre-production Expenditures	Working Capital	Total Initial KD	Investment %	Fixed Investment	Pre-production Expenditures	Increase in Working Capital	Total Incremental Investment KD	%
Equity	359,690	200,140	41,527	601,357	100.0	392,515	92,880	63,363	548,758	56.7
Industrial Loan at 5%	0	0	0	0	0.0	392,515	0	27,156	419,671	43.3
Total	359,690	200,140	41,527	601,357	100.0	785,030	92,880	90,519	968,429	100.0

Table C.37. Financing Obligations of a 400 t Tilapia Farm Assuming External Financing of Phase II Expansion.

Item	Construction		Production Period										
	-2	-1	1	2	3	4	5	6	7	8	9	10	11-18
1. Industrial Loan													
Amount: KD 419,671													
Grace Period: 2 years													
Repayment Period: 5 Years													
Interest Rate: 5%													
Obligations:													
Principal	0	0	0	0	0	0	0	83,934	83,934	83,934	83,934	83,934	0
Interest	0	0	0	10,492	20,984	20,984	20,984	20,984	16,787	12,590	8,393	4,197	0
Total Obligations	0	0	0	10,492	20,984	20,984	20,984	104,918	100,721	96,524	92,328	88,131	0

Table C.38. Cash Flow Analysis of a 400 t Tilapia Farm with External Financing of Phase II Expansion.

Description/Year	Construction		Production Period							
	-2	-1	1	2	3	4	5	6	7	8
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	209.835	209.835	0	0	0	0	0
Sales Revenue	0	0	150.000	150.000	150.000	600.000	600.000	600.000	600.000	600.000
Total Cash In	0	0	150.000	359.835	359.835	600.000	600.000	600.000	600.000	600.000
2. Cash Out										
Initial Fixed Assets	80.930	278.760	0	0	0	0	0	0	0	0
Payment of Replacement (1)	0	0	200	200	200	15.850	200	200	52.750	200
Pre-production Expenditures	126.450	73.690	0	40.850	52.030	0	0	0	0	0
Incremental Fixed Assets	0	0	0	392.515	392.515	0	0	0	0	0
Payment of Replacement (2)	0	0	0	0	0	200	200	200	35.526	200
Operating Costs	0	0	111.962	111.962	111.962	236.895	236.895	236.895	236.895	236.895
Interest Payment	0	0	0	10.492	20.984	20.984	20.984	20.984	16.787	12.590
Loan Repayment	0	0	0	0	0	0	0	83.934	83.934	83.934
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	207.380	352.450	112.162	556.019	577.691	273.929	258.279	342.213	425.893	333.820
3. Net Cash Flow	(207.380)	(352.450)	37.838	(196.184)	(217.855)	326.071	341.721	257.787	174.107	266.180
4. Cummulative Cash Flow		(559.830)	(521.992)	(718.176)	(936.031)	(609.960)	(268.239)	(10.452)	163.656	429.836

Description/Year	Production Period									
	9	10	11	12	13	14	15	16	17	18
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	0	0	0	0	0	0	0
Sales Revenue	600.000	600.000	600.000	600.000	600.000	600.000	600.000	600.000	600.000	600.000
Total Cash In	600.000	600.000	600.000	600.000	600.000	600.000	600.000	600.000	600.000	600.000
2. Cash Out										
Initial Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (1)	200	15.850	200	200	52.750	200	200	15.850	200	200
Pre-production Expenditures	0	0	0	0	0	0	0	0	0	0
Incremental Fixed Assets	0	0	0	0	0	0	0	0	0	50
Payment of Replacement (2)	38.588	35.526	200	200	35.526	38.588	200	35.526	200	200
Operating Costs	236.895	236.895	236.895	236.895	236.895	236.895	236.895	236.895	236.895	236.895
Interest Payment	8.393	4.197	0	0	0	0	0	0	0	0
Loan Repayment	83.934	83.934	0	0	0	0	0	0	0	0
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	368.011	376.403	237.295	237.295	325.172	275.683	237.295	288.272	237.295	237.295
3. Net Cash Flow	231.989	223.597	362.705	362.705	274.828	324.317	362.705	311.728	362.705	362.705
4. Cummulative Cash Flow	661.825	885.422	1.248.127	1.610.832	1.885.660	2.209.977	2.572.681	2.884.409	3.247.114	3.609.819

Note: IRR = 19%

Table C.39. Net Income Statement of a 400 t Tilapia Farm with External Financing of Phase II Expansion.

Category/Production Year	1	2	3	4	5	6	7	8	9	10	11-18
1. Total Gross Income (Sales Revenue)	150,000	150,000	150,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
2. Operating Cost	111,962	111,962	111,962	236,895	236,895	236,895	236,895	236,895	236,895	236,895	236.895
3. Gross Profit (1-2)	38,038	38,038	38,038	363,105	363,105	363,105	363,105	363,105	363,105	363,105	363,105
4. Non Operating Costs	68,458	78,950	89,442	174,892	174,892	134,864	130,667	126,470	103,698	99,501	95,304
5. Net Profit B.T (3-4)	(30,420)	(40,912)	(51,404)	188,213	188,213	228,241	232,438	236,634	259,407	263,604	267,801
6. Dividends	0	0	0	0	0	0	0	0	0	0	0
7. Retained Earnings (5-6)	(30,420)	(40,912)	(51,404)	188,213	188,213	228,241	232,438	236,634	259,407	263,604	267,801
8. Ratios (Earning Power Measurements)											
Net Profits to Sales (profit margin)	(0.20)	(0.27)	(0.34)	0.31	0.31	0.38	0.39	0.39	0.43	0.44	0.45

Table C.40.

Schedule of Preproduction Expenditures During Phase II Expansion of an 800 t Tilapia Farm.

Item	Expenditure (KD)											
Month	37	38	39	40	41	42	43	44	45	46	47	48
1. Detailed Designs												
Consultant Engineer	0	2,000	2,000	2,000	0	0	0	0	0	0	0	0
Housing/Food	0	1,050	1,050	1,050	0	0	0	0	0	0	0	0
Airfare	0	800	0	0	0	0	0	0	0	0	0	0
Draftsman	0	1,000	1,000	1,000	0	0	0	0	0	0	0	0
KISR Review	0	0	0	2,000	0	0	0	0	0	0	0	0
2. Site Development	1,500	1,500	1,500	1,500	0	0	0	0	0	0	0	0
3. Recruitment Costs												
Recruiting Trip	0	0	0	0	0	0	0	0	0	0	0	0
Airfare for Staff	0	0	0	0	0	0	0	0	0	0	0	0
Recruitment Agency Fee	0	0	0	0	0	0	0	0	0	0	0	0
4. Manpower												
Project Manager	958	958	958	958	958	958	958	958	958	958	958	962
Site Engineer	700	700	700	700	700	700	700	700	700	700	700	700
Technician	0	0	0	0	0	0	0	0	0	0	0	0
Labourers	0	0	0	0	0	0	0	0	0	0	0	0
Cook	0	0	0	0	0	0	0	0	0	0	0	0
5. Drinking Water	0	0	0	0	0	0	0	0	0	0	0	0
6. Insurance												
New Plant	0	0	0	0	0	0	0	0	0	0	0	0
Stock	0	0	0	0	0	0	0	0	0	0	0	0
7. Commissioning Costs												
Feed	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals/Drugs	0	0	0	0	0	0	0	0	0	0	0	0
8. Supplies/Consumables	0	0	0	0	0	0	0	0	0	0	0	0
9. Electricity	0	0	0	0	0	0	0	0	0	0	0	0
GRAND TOTAL (KD)	3,158	8,008	7,208	9,208	1,658	1,658	1,658	1,658	1,658	1,658	1,658	1,662

Item	Expenditure (KD)												
Month	49	50	51	52	53	54	55	56	57	58	59	60	Total
1. Detailed Designs													
Consultant Engineer	0	0	0	0	0	0	0	0	0	0	0	0	6,000
Housing/Food	0	0	0	0	0	0	0	0	0	0	0	0	3,150
Airfare	0	0	0	0	0	0	0	0	0	0	0	0	800
Draftsman	0	0	0	0	0	0	0	0	0	0	0	0	3,000
KISR Review	0	0	0	0	0	0	0	0	0	0	0	0	2,000
2. Site Development	0	0	0	0	0	0	0	0	0	0	0	0	6,000
3. Recruitment Costs													
Recruiting Trip	0	0	0	1,600	0	0	0	0	0	0	0	0	1,600
Airfare for Staff	0	0	0	0	0	0	3,750	0	0	0	0	0	3,750
Recruitment Agency Fee	0	0	0	1,500	0	0	0	0	0	0	0	0	1,500
4. Manpower													
Project Manager	958	958	958	958	958	958	958	958	958	958	958	962	23,000
Site Engineer	700	700	700	700	0	0	0	0	0	0	0	0	11,200
Technician	0	0	0	0	0	0	2,000	2,000	2,000	2,000	2,000	2,000	12,000
Labourers	0	0	0	0	0	0	2,700	2,700	2,700	2,700	2,700	2,700	16,200
Cook	0	0	0	0	0	0	250	250	250	250	250	250	1,500
5. Drinking Water	0	0	0	0	0	0	150	150	150	150	150	150	900
6. Insurance													
New Plant	0	0	0	0	0	0	8,200	0	0	0	0	0	8,200
Stock	0	0	0	0	0	0	9,800	0	0	0	0	0	9,800
7. Commissioning Costs													
Feed	0	0	0	0	0	0	1,890	0	2,400	0	2,400	0	6,690
Chemicals/Drugs	0	0	0	0	0	0	7,000	0	0	0	0	0	7,000
8. Supplies/Consumables	0	0	0	0	0	0	580	580	580	580	580	600	3,500
9. Electricity	0	0	0	0	0	0	820	820	820	820	820	820	4,920
GRAND TOTAL (KD)	1,658	1,658	1,658	4,758	958	958	38,098	7,458	9,858	7,458	9,858	7,482	132,710

Table C.41. Depreciation, Amortization and Replacement of Fixed Assets Over the Life of an 800 t Tilapia Farm.

Assets	Original Value (KD)		Service Life	Depreciation Accrual								
	Phase 1	Phase 2		1	2	3	4	5	6	7	8	9-18
Initial Fixed Investment												
3 Years Assets	15650		3	5,217	5,217	5,217	5,217	5,217	5,217	5,217	5,217	5,217
6 Years Assets	36900		6	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150	6,150
18 Years Assets	307140		18	17,063	17,063	17,063	17,063	17,063	17,063	17,063	17,063	17,063
Pre-production Expenditure	200,140		5	40,028	40,028	40,028	40,028	40,028	0	0	0	0
Incremental Fixed Investment												
3 Years Assets		73,754	3	0	0	0	24,585	24,585	24,585	24,585	24,585	24,585
5 Years Assets		61,134	5	0	0	0	12,227	12,227	12,227	12,227	12,227	12,227
15 Years Assets		1,504,092	15	0	0	0	100,273	100,273	100,273	100,273	100,273	100,273
Pre-production Expenditures		132,710	5	0	0	0	26,542	26,542	26,542	26,542	26,542	0
Total	559,830	1,771,690		68,458	68,458	68,458	232,084	232,084	192,056	192,056	192,056	165,514

Table C.42. Working Capital Requirement Over the Life of an 800 t Tilapia Farm.

Item	Average no. of Days	Turnover Coefficient	Year				
			1	2	3	4	5-18
1. Accounts Receivable	30	12	12,500	12,500	12,500	100,000	100,000
2. Raw Materials Inventory	30	12	2,017	2,017	2,017	10,952	10,952
3. Spare Parts	180	2	1,465	1,465	1,465	6,677	6,677
4. Finished Products	30	12	12,500	12,500	12,500	100,000	100,000
5. Required Cash in Hand	60	6	13,545	13,545	13,545	36,762	36,762
6. Accounts Payable	30	12	500	500	500	3,229	3,229
7. Net Working Capital (1+2+3+4+5-6)			41,527	41,527	41,527	251,162	251,162
8. Increase in Working Capital				0	0	209,635	0

Table C.43. Fixed Investment Costs Over the Life of an 800 t Tilapia Farm.

Description/Year	Construction (2 years)	Replacement 1	2	3	4	5	6	7	8	9
Initial Fixed Investment										
3 Years Assets	15,650	0	0	0	0	0	0	0	0	0
6 Years Assets	36,900	0	0	0	0	0	0	0	0	0
18 Years Assets	307,140	0	0	0	0	0	0	0	0	0
Replacement of Initial Fixed Investment										
3 Years Assets	0	0	0	0	15,650	0	0	15,650	0	0
6 Years Assets	0	0	0	0	0	0	0	36,900	0	0
18 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	0	200	200	200	200	200	200	200	200	200
Incremental Fixed Investment										
3 Years Assets	0	0	36,877	36,877	0	0	0	0	0	0
5 Years Assets	0	0	30,567	30,567	0	0	0	0	0	0
15 Years Assets	0	0	752,046	752,046	0	0	0	0	0	0
Replacement of Incremental Fixed Investment										
3 Years Assets	0	0	0	0	0	0	0	73,754	0	0
5 Years Assets	0	0	0	0	0	0	0	0	0	61,134
15 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	0	0	0	0	200	200	200	200	200	200
Total Fixed Investment Cost (KD)	359,690	200	819,690	819,690	16,050	400	400	126,704	400	61,534

Description/Year	Replacement 10	11	12	13	14	15	16	17	18	Total
Initial Fixed Investment										
3 Years Assets	0	0	0	0	0	0	0	0	0	15,650
6 Years Assets	0	0	0	0	0	0	0	0	0	36,900
18 Years Assets	0	0	0	0	0	0	0	0	0	307,140
Replacement of Initial Fixed Investment										
3 Years Assets	15,650	0	0	15,650	0	0	15,650	0	0	78,250
6 Years Assets	0	0	0	36,900	0	0	0	0	0	73,800
18 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	200	200	200	200	200	200	200	200	200	3,600
Incremental Fixed Investment										
3 Years Assets	0	0	0	0	0	0	0	0	0	73,754
5 Years Assets	0	0	0	0	0	0	0	0	0	61,134
15 Years Assets	0	0	0	0	0	0	0	0	0	1,504,092
Replacement of Incremental Fixed Investment										
3 Years Assets	73,754	0	0	73,754	0	0	73,754	0	0	295,016
5 Years Assets	0	0	0	0	61,134	0	0	0	0	122,268
15 Years Assets	0	0	0	0	0	0	0	0	0	0
Broodstock	200	200	200	200	200	200	200	200	200	3,000
Total Fixed Investment Cost (KD)	89,804	400	400	126,704	61,534	400	89,804	400	400	2,574,604

Table C.44. Total Capital Investment Over the Life of an 800 t Tilapia Farm.

Description/Year	Construction 2 Years	Production Period 1	2	3	4	5	6	7	8	9
1. Fixed Investment Cost										
A. Initial Investment	359,690	0	0	0	0	0	0	0	0	0
Replacement	0	200	200	200	15,850	200	200	52,750	200	200
B. Incremental Investment	0	0	819,490	819,490	0	0	0	0	0	0
Replacement	0	0	0	0	200	200	200	73,954	200	61,334
2. Pre-production Expenditures	200,140	0	40,850	91,860	0	0	0	0	0	0
3. Working Capital	0	41,527	0	0	0	0	0	0	0	0
4. Increase in Working Capital	0	0	0	0	209,635	0	0	0	0	0
Total Capital Investment Cost (KD)	559,830	41,727	860,540	911,550	225,685	400	400	126,704	400	61,534

Description/Year	10	11	12	13	14	15	16	17	18	Total
1. Fixed Investment Cost										
A. Initial Investment	0	0	0	0	0	0	0	0	0	359,690
Replacement	15,850	200	200	52,750	200	200	15,850	200	200	155,650
B. Incremental Investment	0	0	0	0	0	0	0	0	0	1,638,980
Replacement	73,954	200	200	73,954	61,334	200	73,954	200	200	420,284
2. Pre-production Expenditures	0	0	0	0	0	0	0	0	0	332,850
3. Working Capital	0	0	0	0	0	0	0	0	0	41,527
4. Increase in Working Capital	0	0	0	0	0	0	0	0	0	209,635
Total Capital Investment Cost (KD)	89,804	400	400	126,704	61,534	400	89,804	400	400	3,158,617

Table C.45. Analysis of Production Costs Over the Life of an 800 t Tilapia Farm Assuming 100% Equity Financing.

Production Year	1		2		3		4		5		6		7		8		9-18	
Item	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%	Cost (KD)	%
1. Operating Costs (A+B)	111,962	62.1	111,962	62.1	111,962	62.1	391,243	62.8	391,243	62.8	391,243	67.1	391,243	67.1	391,243	67.1	391,243	70.3
A. Farm Costs	84,070	46.6	84,070	46.6	84,070	46.6	309,180	49.6	309,180	49.6	309,180	53.0	309,180	53.0	309,180	53.0	309,180	55.5
Raw Materials	24,198	13.4	24,198	13.4	24,198	13.4	131,424	21.1	131,424	21.1	131,424	22.5	131,424	22.5	131,424	22.5	131,424	23.6
Utilities	2,494	1.4	2,494	1.4	2,494	1.4	14,197	2.3	14,197	2.3	14,197	2.4	14,197	2.4	14,197	2.4	14,197	2.5
Consumables	3,500	1.9	3,500	1.9	3,500	1.9	24,550	3.9	24,550	3.9	24,550	4.2	24,550	4.2	24,550	4.2	24,550	4.4
Labour	43,800	24.3	43,800	24.3	43,800	24.3	103,200	16.6	103,200	16.6	103,200	17.7	103,200	17.7	103,200	17.7	103,200	18.5
Farm Overheads	10,078	5.6	10,078	5.6	10,078	5.6	35,809	5.7	35,809	5.7	35,809	6.1	35,809	6.1	35,809	6.1	35,809	6.4
B. Non-Farm Costs	27,892	15.5	27,892	15.5	27,892	15.5	82,064	13.2	82,064	13.2	82,064	14.1	82,064	14.1	82,064	14.1	82,064	14.7
Administrative Overheads	27,392	15.2	27,392	15.2	27,392	15.2	81,564	13.1	81,564	14.0	81,564	14.0	81,564	14.0	81,564	14.0	81,564	14.6
Sales and Promotion	500	0.3	500	0.3	500	0.3	500	0.1	500	0.1	500	0.1	500	0.1	500	0.1	500	0.1
2. Non-Operating Costs	68,458	37.9	68,458	37.9	68,458	37.9	232,084	37.2	232,084	37.2	192,056	32.9	192,056	32.9	192,056	32.9	165,514	29.7
Interest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Depreciation and Amortization	68,458	37.9	68,458	37.9	68,458	37.9	232,084	37.2	232,084	37.2	192,056	32.9	192,056	32.9	192,056	32.9	165,514	29.7
3. Total Production Costs (1+2)	180,420	100.0	180,420	100.0	180,420	100.0	623,328	100.0	623,328	100.0	583,300	100.0	583,300	100.0	583,300	100.0	556,758	100.0
Unit Production Cost (KD/t)	1804		1804		1804		779		779		729		729		729		696	

Table C.46. Revenue Forecast of an 800 t Tilapia Farm.

Item	Amount
Total Farm Capacity/t	100
Sales Price KD/t*	1,500
Estimated Sales (KD)	1,200,000

* Delivered to customer site (store)

Table C.47. Cash Flow Analysis of an 800 t Tilapia Farm Assuming 100% Equity Financing.

Description/Year	Construction		Production Period							
	0	-1	1	2	3	4	5	6	7	8
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	0	0	0	0	0	0	0
Sales Revenue	0	0	150,000	150,000	150,0003	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Total Cash In	0	0	150,000	150,000	150,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
2. Cash Out										
Initial Fixed Assets	80,930	278,760	0	0	0	0	0	0	0	0
Payment of Replacement (1)	0	0	200	200	200	15,850	200	200	52,750	200
Pre-production Expenditures	126,450	73,690	0	40,850	91,860	0	0	0	0	0
Incremental Fixed Assets	0	0	0	819,490	819,490	0	0	0	0	0
Payment of Replacement (2)	0	0	0	0	0	200	200	200	73,954	200
Operating Costs	0	0	111,962	111,962	111,962	391,243	391,243	391,243	391,243	391,243
Interest Payment	0	0	0	0	0	0	0	0	0	0
Loan Repayment	0	0	0	0	0	0	0	0	0	0
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	207,380	352,450	112,162	972,502	1,023,512	407,293	391,643	391,643	517,947	391,643
3. Net Cash Flow	(207,380)	(352,450)	37,838	(822,502)	(873,512)	792,707	808,357	808,357	682,053	808,357
4. Cummulative Cash Flow		(559,830)	(521,992)	(1,344,494)	(2,218,006)	(1,425,299)	(616,943)	191,414	873,467	1,681,823

Description/Year	Production Period									
	9	10	11	12	13	14	15	16	17	18
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	0	0	0	0			
Sales Revenue	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Total Cash In	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
2. Cash Out										
Initial Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (1)	200	15,850	200	200	52,750	200	200	15,850	200	200
Pre-production Expenditures	0	0	0	0	0	0	0	0	0	0
Incremental Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (2)	61,334	73,954	200	200	73,954	61,334	200	73,954	200	200
Operating Costs	391,243	391,243	391,243	391,243	391,243	391,243	391,243	391,243	391,243	391,243
Interest Payment	0	0	0	0	0	0	0	0	0	0
Loan Repayment	0	0	0	0	0	0	0			
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	452,777	481,047	391,643	391,643	517,947	452,777	391,643	481,047	391,643	391,643
3. Net Cash Flow	747,223	718,953	808,357	808,357	682,053	747,223	808,357		718,953	808,357
4. Cummulative Cash Flow	2,429,046	3,147,999	3,956,356	4,764,712	5,446,765	6,193,988	7,002,344	7,721,297	8,529,654	9,338,011

Note: IRR = 25%

Table C.48. Discounted Payback Period of an 800 t Tilapia Farm.

Item	Original Value	Discount Factor	Present Value	Unrecovered investment at the end of the year	Remarks
1. Total Initial Investment					
1st Year Construction	207,380	1.0000	207,380		
2nd Year Construction	393,977	0.9091	358,164		
2. Net Profit					
1st Year Production	(30,420)	1.2100	(36,808)	602,353	
2nd Year Production	(30,420)	1.3310	(40,489)	642,842	
3rd Year Production	(30,420)	1.4640	(44,535)	687,377	
4th Year Production	576,672	0.6209	358,056	329,321	
5th Year Production	576,672	0.5645	325,532	3,790	
6th Year Production	616,700	0.5132	316,491	(312,701)	Investment Recovery
7th Year Production	616,700	0.4665	287,691	(600,392)	
8th Year Production	616,700	0.4241	261,543	(861,935)	
9th Year Production	643,242	0.3855	247,970	(1,109,905)	
10th Year Production	643,242	0.3505	225,456	(1,335,361)	
11th Year Production	643,242	0.3186	204,937	(1,540,298)	
12th Year Production	643,242	0.2897	186,347	(1,726,645)	
13th Year Production	643,242	0.2633	169,366	(1,896,011)	
14th Year Production	643,242	0.2394	153,992	(2,050,003)	
15th Year Production	643,242	0.2176	139,970	(2,189,973)	
16th Year Production	643,242	0.1978	127,233	(2,317,206)	
17th Year Production	643,242	0.1799	115,719	(2,432,926)	
18th Year Production	643,242	0.1635	105,170	(2,538,096)	

Table C.49.
Net Income Statement of an 800 t Tilapia Farm Assuming 100% Equity Financing.

Category/Production Year	1	2	3	4	5	6	7	8	9-18
1. Total Gross Income (Sales Revenue)	150,000	150,000	150,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
2. Operating Cost	111,962	111,962	111,962	391,243	391,243	391,243	391,243	391,243	391,243
3. Gross Profit (1-2)	38,038	38,038	38,038	808,757	808,757	808,757	808,757	808,757	808,757
4. Non Operating Costs	68,458	68,458	68,458	232,084	232,084	192,056	192,056	192,056	165,514
5. Net Profit B.T (3-4)	(30,420)	(30,420)	(30,420)	576,672	576,672	616,700	616,700	616,700	643,242
6. Dividends	0	0	0	0	0	0	0	0	0
7. Retained Earnings (5-6)	(30,420)	(30,420)	(30,420)	576,672	576,672	616,700	616,700	616,700	643,242
8. Ratios (Earning Power Measurements)									
Net Profits to Sales (profit margin)	(0.20)	(0.20)	(0.20)	0.48	0.48	0.51	0.51	0.51	0.54

Table C.50. Sources of Finance of an 800 t Tilapia Farm Assuming Extercing of Phase II Expansion.

	Phase I					Phase II				
	Fixed Investment	Pre-production Expenditures	Working Capital	Total Initial Investment KD	%	Fixed Investment	Pre-production Expenditures	Working Capital	Total Incremental Investment KD	%
Equity	359,690	200,140	41,527	601,357	100.0	819,490	132,710	146,745	1,098,945	55.5
Industrial Loan at 5%	0	0	0	0	0.0	819,490	0	62,891	882,381	44.5
Total	359,690	200,140	41,527	601,357	100.0	1,638,980	132,710	209,635	1,981,325	100.0

Table C.51. Financing Obligations of an 800 t Tilapia Farm Assuming External Financing of Phase II Expansion.

Item	Construction		Production Period										
	-2	-1	1	2	3	4	5	6	7	8	9	10	11-18
1. Industrial Loan													
Amount: KD 882,381													
Grace Period: 2 Years													
Repayment Period: 5 Years													
Interest Rate: 5%													
Obligations:													
Principal	0	0	0	0	0	0	0	176,476	176,476	176,476	176,476	176,476	0
Interest	0	0	0	22,060	44,119	44,119	44,119	44,119	35,295	26,471	17,648	8,824	0
Total Obligations	0	0	0	22,060	44,119	44,119	44,119	220,595	211,771	202,948	194,124	185,300	0

Table C.52. Cash Flow Analysis of an 800 t Tilapia Farm with External Financing of Phase II Expansion.

Description/Year	Construction		Production Period							
	-2	-1	1	2	3	4	5	6	7	8
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	441,190	441,190	0	0	0	0	0
Sales Revenue	0	0	150,000	150,000	150,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Total Cash In	0	0	150,000	591,190	591,190	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
2. Cash Out										
Initial Fixed Assets	80,930	278,760	0	0	0	0	0	0	0	0
Payment of Replacement (1)	0	0	200	200	200	15,850	200	200	52,750	200
Pre-production Expenditures	126,450	73,690	0	40,850	91,860	0	0	0	0	0
Incremental Fixed Assets	0	0	0	819,490	819,490	0	0	0	0	0
Payment of Replacement (2)	0	0	0	0	0	200	200	200	73,954	200
Operating Costs	0	0	111,962	111,962	111,962	391,243	391,243	391,243	391,243	391,243
Interest Payment	0	0	0	22,060	44,119	44,119	44,119	44,119	35,295	26,471
Loan Repayment	0	0	0	0	0	0	0	176,476	176,476	176,476
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	207,380	352,450	112,162	994,562	1,067,631	451,412	435,762	612,238	729,719	594,591
3. Net Cash Flow	(207,380)	(352,450)	37,838	(403,371)	(476,441)	748,588	764,238	587,762	470,281	605,409
4. Cummulative Cash Flow		(559,830)	(521,992)	(925,363)	(1,401,804)	(653,216)	111,021	698,783	1,169,064	1,774,473

Description/Year	Production Period									
	9	10	11	12	13	14	15	16	17	18
1. Cash In										
Equity Investment	0	0	0	0	0	0	0	0	0	0
Industrial Loan at 5%	0	0	0	0	0	0	0	0	0	0
Sales Revenue	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Total Cash In	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
2. Cash Out										
Initial Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (1)	200	15,850	200	200	52,750	200	200	15,850	200	200
Pre-production Expenditures	0	0	0	0	0	0	0	0	0	0
Incremental Fixed Assets	0	0	0	0	0	0	0	0	0	0
Payment of Replacement (2)	61,334	73,954	200	200	73,954	61,334	200	73,954	200	200
Operating Costs	391,243	391,243	391,243	391,243	391,243	391,243	391,243	391,243	391,243	391,243
Interest Payment	17,648	8,824	0	0	0	0	0	0	0	0
Loan Repayment	176,476	176,476	0	0	0	0	0	0	0	0
Dividends	0	0	0	0	0	0	0	0	0	0
Total Cash Out	646,901	666,347	391,643	391,643	517,947	452,777	391,643	481,047	391,643	391,643
3. Net Cash Flow	553,099	533,653	808,357	808,357	682,053	747,223	808,357	718,953	808,357	808,357
4. Cummulative Cash Flow	2,327,572	2,861,225	3,669,582	4,477,939	5,159,991	5,907,214	6,715,571	7,434,523	8,242,880	9,051,237

Note: IRR 29%

Table C.53. Net Income Statement of an 800 t Tilapia Farm with External Financing of Phase II Expansion.

Category/Production Year	1	2	3	4	5	6	7	8	9	10	11-18
1. Total Gross Income (Sales Revenue)	150,000	150,000	150,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
2. Operating Cost	111,962	111,962	111,962	391,243	391,243	391,243	391,243	391,243	391,243	391,243	391,243
3. Gross Profit (1-2)	38,038	38,038	38,038	808,757	808,757	808,757	808,757	808,757	808,757	808,757	808,757
4. Non Operating Costs	68,458	90,518	112,577	276,203	276,203	236,175	227,352	218,528	183,162	174,338	165,514
5. Net Profit B.T (3-4)	(30,420)	(52,480)	(74,539)	532,553	532,553	572,581	581,405	590,229	625,595	634,419	643,242
6. Dividends	0	0	0	0	0	0	0	0	0	0	0
7. Retained Earnings (5-6)	(30,420)	(52,480)	(74,539)	532,553	532,553	572,581	581,405	590,229	625,595	634,419	643,242
8. Ratios (Earning Power Measurements)											
Net Profits to Sales (profit margin)	(0.20)	(0.35)	(0.50)	0.44	0.44	0.48	0.48	0.49	0.52	0.53	0.54

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