AQUA-MANGROVE INTEGRATED FARMING: SHRIMP AND MUD CRAB CULTURE IN COASTAL AND INLAND TIDAL FLATS WITH EXISTING REFORESTED OR NATURAL GROWTH OF MANGROVES

Avelino T. Triño
SEAFDEC Aquaculture Department
Iloilo, Philippines

I. Introduction

Throughout the tropics, mangroves are being destroyed at an increasing rate for the development of aquaculture ponds. In the Philippines, for instance, mangroves were about 400,000 to 500,000 ha in 1918 but were reduced to 100,564 ha in 1987. On the average, about 3,500 ha of mangroves are lost every year in the country to accommodate the aquaculture industry (Baconguis et al., 1990). Loss of mangroves means loss of habitat, fishery, income, and livelihood for many coastal inhabitants. The annual catches of major fishing grounds in the Philippines were positively correlated with the areas of existing mangroves (Bagarinao, 1998). Restoration programs of the government such as mangrove reforestation and afforestation were attempted but could not catch up with the unending destruction. An alternative source of income which is directly supportive of resource management was therefore proposed to mitigate ecosystem degradation with the fisher communities in mind.

Fishing villages in the Philippines are generally located in the fringes of arable land along coastal plains and are dependent on fishing as a source of income. The common denominator of these villages is the presence of large areas of tidal flats with existing mangroves. To utilize the aquaculture potential of these mangroves, aqua-mangrove integrated farming development projects were introduced to provide alternative livelihood for the fishers in the village. This integrated approach to conservation and utilization of mangrove resource allows for maintaining a relatively high level of integrity in the mangrove area while capitalizing on the economic benefits of brackishwater aquaculture. The projects took off from the concept of co-management, that is, taking into account the partnership between the local community, the local government unit, and the SEAFDEC Aquaculture Department (SEAFDEC/AQD) in the management of the project.

II. Site Specification

Selection of suitable area is important in siting a rearing system designed for aqua-mangrove integrated culture of fish or crustaceans. Once the selection fails, remedial measures will be too expensive to undertake. The following are the recommended site specifications:

A. *Soil*

Physically, most mangroves are found on tidal flats with alluvial soils and situated adjacent to rivers or creeks near coastal shores and estuaries at almost sea level elevation. If you pick up a handful of soil from the mangrove area and examine it closely, you will find that it is made up of mineral and organic particles of varying sizes. The mineral particles are clay, silt and sand while the organic particles are organic matter of various stages of decomposition.

Depending on the relative proportion of the sand, silt and clay, soils are of varying texture such as silty clay, clay loam, and sandy clay. A sandy clay soil is more porous than a clay loam or silty clay, and a clay loam or silty clay will hold more nutrients and retain more water than a sandy clay. Soils with high clay and silt or loam contents are most desirable as materials for diking and can retain desirable water depth for the ponds.

B. *Environmental conditions*

Mud crabs and shrimps (e.g., *P. monodon)* are generally tolerant to a wide range of temperature and salinity. They can withstand water temperature from 12 to 35°C but their activity and feeding fall rapidly below 20°C. They are able to survive in a salinity range of 2-43 ppt.

Crabs have a well developed ability to exploit oxygen from the air. Under severe conditions of hypoxia, crabs leave the water and breathe air. But when crabs molt, they are unable to leave the water that is depleted with oxygen and consequently die. Like shrimps, they should also be provided with their daily oxygen needs for growth and survival.

The optimum water conditions required of crabs and shrimps are:

Water temperature (°C)	23-32
Water salinity (ppt)	15-30
D.O. Concentration (ppm, min)	not < 4
pH	7.0-8.5
Water depth (cm)	≥ 80

C. *Other factors*

These factors include available source of stocking materials; free from pollution; and sufficient supply of cheap trash fish or brown mussel meat. Storage facilities should also be available for fresh unprocessed feed and the site should be secured from poachers.

III. Design and Construction of Aqua-Mangrove Pond/Pen

A. *Design of aqua-mangrove pond*

Aqua-mangrove integrated farming or aqua-silviculture is an ancient coastal resource management concept which has been put into practice in many Asian countries. The design of the system is similar to a pond where there is a big perimeter dike and a sluice gate to fully control the water but mangroves in this system are left untouched. This particular design was recently adopted by SEAFDEC/AQD.

Existing aqua-silviculture pond design in the Philippines included the project exemplified by Mr. & Mrs. Melchor Sur of Puerto Galera, Mindoro, Philippines, and the SEAFDEC/AQD project in Bugtong Bato, Ibajay, Aklan, Philippines. The Surs built canals around a soil flatform with existing natural growth of mangroves using the 70:30 mangrove covered soil flatform to open pond area. The same ratio of flatform to canal is implemented by SEAFDEC/AQD only that central canals are dug in addition to the peripheral canals.

B. *Design of pens*

SEAFDEC/AQD has also developed a pen designed for aqua-mangrove integrated culture that preserves the vital role of mangroves as nursery grounds for finfish and crustaceans. The design allows flooding of the culture area at high tide, while structures are installed to prevent siltation of pen canals and maintain the required water depth of the cultured species. Such pen design is demonstrated in SEAFDEC/AQD's project in New Buswang, Kalibo, Aklan and in Bugtong Bato, Ibajay, Aklan, Philippines.

The Kalibo project is situated in coastal tidal flats at the mouth of Aklan river about 200 m from the sea and with existing reforested mangroves. The ratio of mangrove covered soil flatform to canals (peripheral and central) is 70:30. The set up is flooded at high tide when tide level is $\geq$ 0.8 m. On the other hand, the project in Ibajay is situated in inland tidal mud flats with existing natural growth of mangroves. The site is about 2 km from the mouth of a creek. The mangrove covered soil flatform to canal (peripheral and central) ratio is 70:30. The set up is inundated when tide level reached 1.5 m. Water can still be replenished in pens by opening the pen gate at tide level of 1.3-1.4 m. Below this level however, water change is no longer feasible.

C. *Construction of ponds*

Construction of aqua-silviculture pond follows the specific strategies and work program when all the general design features and other technical factors have already been considered such as size, shape, and orientation of the pond and the size and height of the perimeter dike. In general, the pond is built using mainly manual labor because mangroves are not accessible for the movement of heavy equipment.

Normally, the first structure to be constructed is the perimeter dike which measures 4 m at its base in order to control the level of water inside the site. Without any control, water in the job site will rise and fall with the tide which makes programming extremely difficult if not impossible. Simultaneous with the construction of the perimeter dike, work on the main gate may be started once its exact location has been fixed. The main gate is generally located at the lowest portion closest to the source of water but strategically located so as to distribute water effectively into the pond. The gate may be made of wood or reinforced concrete and provided with two pairs of middle grooves, one pair each towards the end of each gate. The two pairs of middle grooves are 30 cm apart for occasional needs to soil seal the gate. The pair of grooves on both ends are used for the installation of screens. As the work in the perimeter dike progresses, construction of peripheral and central canals representing about 30% of the pond area may be undertaken. Canals 50-100 cm wide and 50 cm deep are dug carefully so as not to destroy the mangroves inside. Soil excavated from canals may be used for diking. The dike is constructed layer by layer of neatly placed mud blocks (like mounting hollow blocks in the construction of a building) allowing each three layers to shrink and settle before piling another layer.

If the pond is intended for rearing mud crab, additional structure such as net enclosure, will have to be installed along the inner side of the pond dike to prevent crab stocks from escaping. A green net, 12 mm mesh size and 2 mm twine diameter are used with bamboo as structural framework. The lower end of the net is buried about 60 cm below the pond bottom surface to prevent the escape of the crabs through burrows. The inner side of the upper end of the enclosure is lined with 30 cm wide thick plastic sheet (gauge #18 or 20) to prevent crabs from escaping over the enclosure.

D. *Pen construction*

Pen for the culture of aquatic species in tidal flats with existing mangroves should have a minimum area of 200 m^2 or a maximum of 1200 m^2 to enable all households in a fishing village to avail of mangroves adjacent to or near the village. A green nylon net 12 mm mesh size is used and 2 mm diameter twine with bamboo as structural framework. The height of the enclosure should be 30-40 cm above the highest tide. The lower end of enclosure is buried 40 cm below the pen bottom for shrimp culture or 60 cm for mud crab culture. Fine-meshed nylon screen is fitted on the inner side of the enclosure and its lower end buried about 30 cm below the pen bottom for shrimp culture. For mud crabs, fine-meshed screen is not needed, instead a 30 cm wide thick plastic sheet is fitted on the inner side of the enclosure to about 30 cm from the top end.

About 30% of the total area of pen is allocated for 50-100 cm wide and 50 cm deep peripheral and central canals which may be dug between mangroves being careful not to damage or cut the mangroves. The canals are intended to retain 50 cm water during lowest tide. A 50-60 cm wide and 50 cm high dike is installed surrounding the enclosure to retain additional water level of 50 cm during lowest tide, thus meeting the optimum water depth requirement of crabs and shrimps. The set up is intended to be inundated during highest tide. A 50-60 cm wide and 50 cm high wooden gate (made of wood and marine plywood) is installed for draining the water every 7 days (for 3 continuous days) during night time only, to allow exposure of mangrove roots. Continuous submergence of mangrove roots will lead to the death of the mangroves. Fine-meshed nylon screen with bamboo framework is also installed surrounding the dike to minimize if not totally prevent siltation of the canals. A wider meshed B-net set in a half round is placed fronting the gate.

IV. Mud Crab Culture

Mud crab is an aquaculture commodity which is well liked for its taste, texture and nutritional value. It has high potential for commercial aquaculture production in the Indo-Pacific region, and a promising alternative to the weakening shrimp aquaculture especially in the Philippines. With high market demand and lucrative domestic and export price of live mud crabs coupled with available technology and adequate capitalization, opportunities for a profitable mud crab farming are very encouraging.

Studies at SEAFDEC/AQD have addressed constraints in the management of mud crab aquaculture in mangroves. Management and operations described in this lecture are the results of research studies, either funded by SEAFDEC/AQD alone or by SEAFDEC/AQD in collaboration with the Australian Centre for International Agricultural Research (ACIAR) under Project No. 9217. We take note and accept the fact that more efforts need to be done in relation to the development of the mud crab culture technology.

A. *Species of commercial value*

1. *Scylla serrata* (Forsskal)

Locally called "giant crab", this species is morphologically characterized as greenish in color with white polygonal markings on the swimming and walking legs, chelipeds, carapace, and with orange claws. It has deep serrated and pointed frontal spines with prominent spines at the dorso-posterior side of the merus.

2. *Scylla tranquebarica* (Fabricius)

This species, locally called "manginlawod" or "lawodnon" has almost the same features as the *S. serrata* species except that the polygonal markings are only prominent at the chelipeds and swimming legs gradually fading towards the anterior walking legs. It has shallow serrated and blunt frontal spines, while the spines at the dorso-posterior side of the merus are not as prominent as the *S. serrata* species. These differences however, can not be identified while the crabs are at the juvenile stage. When their sizes reach sub-adult weighing > 90 g, *S. serrata* can be differentiated easily from *S. tranquebarica*. Sex however, can be identified even at the juvenile stage.

3. *Scylla olivacea* (Herbst)

Locally called "pulang alimango" or "native", this species has deep green to grayish green color of the carapace, rusty brown chelipeds, swimming and walking legs. Unlike the other species mentioned, *S. olivacea* has no polygonal pattern. The frontal spines are shorter, rounded with shallow interspaces while the spine at the outer side of the merus is absent.

B. *Transport, stocking and acclimation*

Mud crabs (juveniles or lean marketable size) are normally contained in wicket basket or "bakag" or pandan bags during transport from the dealers to pond/pen site for stocking. The survival of crabs depends on how it is packed and cared for during transport. Although mud crab can tolerate a wide range of temperature and salinity, they also need to be acclimated before stocking to prevent death due to thermal and salinity shock.

1. Procedure for transporting mud crab juveniles for grow-out culture

   a. Provide transport containers with fronds of mangroves;
   b. Remove chelipeds ("sipit", "kagat") of crabs weighing < 30 g. Do not remove when weight is > 30 g. Chelipeds of the latter will regenerate but no longer of equal size;
   c. Place 500 crab juveniles, chelipeds removed, in a big transport container; and
   d. Pour seawater frequently into the container while in transport to keep crabs moist.

2. Procedure for transporting lean marketable size mud crabs for fattening

a. Provide transport containers with fronds of mangroves;
b. Buy lean marketable size crabs ("Pulang alimango": 100-150 g females, 200-250 g males; giant crab: 300-350 g females, 350-400 g males) by contracting on-site collectors or buy them from local markets;
c. Tie crab chelipeds firmly to prevent antagonistic behavior among crabs while in transport;
d. Place 150-200 lean crabs in big transport containers ("bakag" or "bayong"); and
e. Pour seawater frequently into the container while in transport or while waiting for additional crabs to be bought.

3. Procedure for stocking and acclimating mud crab juveniles for grow-out culture

a. Stock crab juveniles early in the morning (0600-0800 H) or late in the afternoon (1630-1800 H);
b. Stock 1.5-2.0/m^2 7-11 g or 16-20 g crab juveniles;
c. Stock males separately from females (monosex culture);
d. Sort according to size and sex, and count according to desired stocking density for each pond/pen;
e. Acclimate crab juveniles before releasing them in pond or pen, to pond water temperature and salinity by placing them in plastic basins. Moisten them first, then gradually pour pond/pen water into the basin until crabs are soaked; and
f. Release crab juveniles in pond/pen by floating the basin with crabs for 5-10 min, then tilting the basin to allow the crabs to crawl out or be released.

4. Procedure for stocking and acclimating lean marketable size mud crabs for fattening

a. Stock crabs early in the morning or late in the afternoon;
b. Stock 2 lean marketable size crabs/m^2. Stock together male and female of the same species;
c. Remove the movable parts of the mud crab claw and apply Povidone-Iodine (Betadine) to the injured part to prevent infection;
d. Place crabs in basins, acclimate to pond water temperature and salinity by moistening, then gradually pour pond/pen water into the basin until crabs are soaked; and
e. Acclimate crabs further in pond/pen by floating the basin with crabs for 5-10 min before they are released. Remove cheliped ties when crabs are released into the pond/pen.

C. *Quality monitoring and management*

Water quality is the most important factor affecting the production of cultured aquatic species. Good water environment is necessary for growth and survival. Hence, water quality parameters have to be monitored as a tool for management since these parameters directly or indirectly affect the behavior of cultured species, and thus, measures can be done immediately to prevent the occurrence of conditions harmful to the animals. Water quality parameters like water temperature, salinity, DO concentration, pH, water color, and transparency should be monitored daily. taking note of the crab conditions like feed consumption, signs of disease, swimming behavior, mass climbing in net enclosures, etc.

Water depth (install depth gauge) and net enclosures should be inspected daily for possible leakage and holes in nets. Water in pond should be changed for 3-4 continuous days every spring tides to about 30% of the pond water volume on the first month, 40% - 2nd month, 50% - 3rd month, and 60% on the 4th month onward of the culture period. Pen should be drained every 7 days for 3-4 continuous days at night time lowest tide to expose roots of mangroves while retaining water in the canals.

D. *Feeds and feeding*

Feed comprises 40-60% of the total cost of production. The use of cheap but effective feeds and the right amount will prevent feed wastage and pollution in ponds/pens and subsequently save on cost. Crabs are fed with fresh or frozen trash fish. If brown mussel meat is available and cheap, a mixed diet of 75% brown mussel meat and 25% trash fish may be used instead. Mud crabs given fresh brown mussel-based diet attain better growth performance.

Mud crabs in the grow-out culture are fed at the rate of 10% of the crab biomass per day when carapace length (CL) is < 6 cm and 5% when CL is 6 cm. On the other hand, mud crabs in the fattening culture are fed at the rate of 10% of the crab biomass per day. The same amount of daily ration is given through out the culture period.

The crab biomass is calculated as B = (ES)(INCS)(ABW), where B is the total weight (biomass) of the surviving crabs in pond/pen, ES is the estimated crab survival based on a linear decrease in survival from 100% at stocking to 70% one month before harvest, INCS is the initial number of crabs stocked, and ABW is the average weight of the estimated surviving crabs in pond/pen.

On the other hand, the total daily feed ration is calculated as DR = (B)(FR), where FR is the feeding rate and where 40% of the daily ration is given at 0700 H and 60% at 1700 H. Feed is broadcast evenly in the pond/pen. About 20-25 crab sub-samples are taken from each pond/pen monthly for weight and CL measurements. Daily feed ration is adjusted monthly based on the observations from the stock sampling.

V. Culture Technology

In the Philippines, mud crabs used to be incidental harvest with milkfish, five decades ago. Later with scientific research, and with the improvement in pond/pen design and construction, new technologies were developed out of which mud crab culture techniques and systems have evolved utilizing available resources and approaches to further increase production.

A. *Culture methods*

There are two existing forms of mud crab culture in the Philippines, grow-out culture and fattening culture. The grow-out culture period extends to more than 30 days and uses crab juveniles for stocking while fattening culture period extends to a maximum of 30 days and uses lean marketable size crabs for stocking.

B. *Culture systems*

Recently, three culture systems have evolved, namely: extensive, modified extensive, and semi-intensive. The systems are categorized according to sources of food and the inputs applied.

Under the extensive system, crabs are solely dependent on the natural food existing in the ponds. Thus, the only food available to crabs are benthos, zooplanktons, and other slow-moving aquatic animals present in ponds. Stocking density ranges from 0.1 to 0.2 individuals/m^2. Using this system, many fish farmers from Panay Island, Philippines claimed a survival of 60-70%. This system has not yet been tried in aqua-mangrove integrated culture of crabs in the Philippines but this system will surely work, considering that mangrove ecosystem supports a rich fauna in the form of plankton, benthos and nekton. Zooplankton is an important biotic component of the mangrove aquatic system. A hoard of aquatic fauna both in fauna and epifauna are the happy residents of mangroves. Nektonic groups include a great diversity of fish and prawn species which could be divided into residents and migrants.

In the modified extensive culture system, the crabs initially feed on natural food existing in pond/pen. After the food is depleted, supplemental feed is given to augment the already depleted natural food.

Semi-intensive system is considered a medium stocking density culture. The crabs are stocked at 2.0-3.0/m^2, and artificial diet is the main source of food. This is a recent development in the culture technology of mud crab in the Philippines after cannibalism, a major constraint in the culture of mud crab, has been addressed. Chen (1990) reported a much higher density (3-5/m^2) than what is being practiced now in the Philippines.

For all the culture systems mentioned, water exchange is still dependent on the tidal level in aqua-silviculture ponds. In pens, water exchange should be done twice in 24 hours as the site is inundated during high tide.

1. <u>Mud crab monoculture in aqua-mangrove pond</u>

a. Pond preparation

Ponds are prepared before stocking or releasing the mud crabs, and conditioned for the culture of *Gracilaria* or other macrophytes that can serve as shelter for the mud crabs.

b. Pond conditioning

Water is drained from the pond by closing the pond gate and sealing it with soil. Pond bottom is dried for 5-7 days or until the soil cracks. Hydrated lime is applied at the rate of 1 t/ha. Immediately after liming, ammonium sulfate is applied at the rate of 2 g for every 10 g of hydrated lime in 1.0 m^2 of undrained area (usually near the drain gate) with 5 cm water depth to eradicate unwanted species.

c. Culture of macrophytes

Organic fertilizer is applied at the rate of 2 t/ha, top dressing with inorganic fertilizer at the rate of 75 kg/ha using urea (45-0-0) and ammonium phosphate (16-20-0) at a ratio of 1:2. The pond is filled with water from the incoming high tide to about 10 cm deep, closing the pond gate and sealing it with soil. *Gracilaria* is planted using the rice planting method where a plant should weigh about 10 g of vegetative parts. Each plant should be spaced about 10-20 cm.

The pond should be gradually filled with additional 5-10 cm water level daily until water level of about 60 cm is attained. When luxurious growth of *Gracilaria* is noted, pond water level is increased to 100 cm, then stocking of mud crab could be made. *Gracilaria,* however, grows well only during the dry season. Hence, if mud crab culture is done during the rainy season, planting *Gracilaria* may no longer be carried out.

The color of the pond bottom should always be monitored. A thin green film appearing at the bottom of the pond suggests *lablab* growth. As soon as a prominent green color appears, pond should be gradually filled with additional 5-10 cm water level daily until a depth of 80-100 cm is reached. When the water level increases, *lablab* mats also thicken. But when water level reaches 60 cm and light no longer penetrates the pond bottom, *lablab* growth is suppressed and "lumut" starts to grow. "Lumut" occupying about 40-60% of pond area could serve well as shelter for crabs. Any other macrophytes like "kusay-kusay" (*R. mauritima*), and "digman" *(N. graminea)* could also serve as shelter. When such factors are noted, the pond should be ready for stocking.

2. Selective/progressive harvesting

Progressive harvesting is the removal of harvestable size and fat mud crabs from ponds several times over the culture period. Reports indicated that progressive harvesting enhances survival and improves growth. The removal of bigger and fat crabs minimizes competition for food and space, and reduces incidence of cannibalism since a more homogenous size range of crabs is maintained. This also allows smaller crabs to grow fatter thus shortening the culture duration.

a. Marketable size and fat crabs (150 g or more for females and 250 g or more for males of "pulang alimango", 350 g or more for female and 400 g or more for male giant crab) are selected and removed simultaneously with stock sampling from the end of the second month of culture by current method. Marketable size fat crab usually go against the current and congregate near the gate as water enters the pond/pen, and can be caught using a scoop net. A lift net method may also be used to catch crabs immediately after the water in the ponds has leveled off.

b. Crabs may also be totally harvested at the end of 120-150 days culture, using current and lift net method. Ponds are drained totally to manually collect the remaining crabs, making sure that crabs are not damaged during harvest. Loss of appendages in crabs will reduce their market value.

c. Harvested crabs should be kept moist by placing mangrove fronds in the harvest container and frequently pouring pond water into it. Crabs should not be exposed to heat and should not be hang as this reduces the turgidity of the crab muscles.

3. Financial feasibility projections

a. For a 1.0 ha pond crab monoculture in tidal flats with existing mangroves on a per cropping basis.

(i) Technical assumptions

Species intended for culture: "pulang alimango" or giant crab

Stocking requirement per run (pc)	5,000
Duration of culture (mo)	4-5
Cropping per year	2
Survival per cropping (%)	85
ABW/cropping:	
"Pulang alimango"	250
Giant crab	400
Amount of feed needed/cropping (kg)	
"Pulang alimango"	2,678
Giant crab	14,000
Cost of feed (₱/kg)	10
Production output/cropping (kg)	
"Pulang alimango"	638
Giant crab	5,100
Estimated price/kg (mean of male and female ₱ price)	310

(ii) Financial assumptions

Miscellaneous costs are estimated at 2% of variable costs.
Caretakers salary at ₱1000/month
Interest rates on investment is 8% per year
Sales tax is 1% of revenues
Pond rent is in accordance with FLA rate

(iii) Investment (₱)

	Giant "alimango"	"Pulang alimango"
Development costs	₱ 27,445	₱ 27,445
Construction of enclosure		
(Pond development costs were assumed that pond already existed)		
Operating capital (₱)		
Variable costs		
Crab juveniles	142,500	75,000
Feeds	140,000	26,780
Seaweeds	5,000	5,000
Hydrated lime	1,250	1,250
Chicken manure	2,200	2,200
Inorganic fertilizer	463	463
Caretaker salary	5,000	5,000
Miscellaneous cost	5,928	2,214
Total variable cost	₱ 302,341	₱ 117,907
Fixed costs		
Pond rental (FLA)	500	500
Interest on capital investment	2,196	2,196
Total fixed cost	₱ 2,696	₱ 2,696
TOTAL OPERATING CAPITAL	₱ 305,037	₱ 120,603
TOTAL INVESTMENT	₱ 362,482	₱ 148,048

(iv) Cost-return analysis (₱)

Sales (crabs)	₱ 1,581,000	₱ 988,280
Less: Operating capital	305,037	120,603
Net income before tax	1,275,963	867,677
Less: Sales tax	15,810	9,883
NET INCOME AFTER TAX	₱ 1,260,153	₱ 857,794

4. Mud crab polyculture with milkfish in aqua-mangrove pond

Mud crabs dwell at the bottom of the pond while milkfish occupies the water column. Apart from this, they complement each other in their food needs. Mud crabs are carnivores while milkfish are herbivores. Stocking together complementary species in one pond was found to enhance the overall production of the pond per unit area.

a. Pond preparation

In addition to conditioning, pond used for the polyculture of mud crab with milkfish are prepared for the production of *lablab* as natural food base for milkfish. The pond preparation procedure starts with draining the pond water and drying the pond bottom for 5-7 days. This is followed by the application of hydrated lime at the rate of 1 t/ha and immediately top dressing with ammonium sulfate.

Organic fertilizer (chicken manure) is applied at 2 t/ha and top dressed with 75 kg/ha inorganic fertilizer using urea (45-0-0) and ammonium phosphate (16-20-0) at a ratio of 1:2. The pond is filled with water from the incoming high tide to about 10 cm deep. Water is maintained at this level for a few days while taking note of the color of the pond bottom. Patches of thin green film appearing at the bottom of the pond suggest *lablab* growth. When a prominent green color appears, the pond should be gradually filled with additional 5-10 cm water level daily until a depth of 50 cm is reached. When *lablab* mats thicken, water level is increased to 60 cm. As soon as "lumut" growth develops in pond some *lablab* will still survive. "Lablum" growth will then prevail in pond providing food for milkfish and shelter for the crabs. Then the pond is ready for stocking crab juveniles and milkfish.

b. Stocking density and water change

Crab juveniles and milkfish fingerlings should be stocked early in the morning or late in the afternoon at the rate of $1.5/m^2$ 7-11 g or 16-20 g crab juveniles and milkfish fingerlings at $0.25/m^2$. Male crabs should be stocked separately from female crabs. If milkfish fingerlings are not available, milkfish fry are stocked first in nursery pond 30 days ahead of the mud crab stocking.

Water is changed every spring tide for 3-4 consecutive days to about 30, 40, 50, and 60% of the pond water volume on the 1st, 2nd, 3rd, and 4th month onward of the culture period, respectively. Inorganic fertilizer is applied at the rate of 1/2 the basal rate (urea - 12 kg/ha, ammophos - 25 kg/ha) during pond preparation on the last day of the 3-day water change for the maintenance of natural fish food growth in the ponds.

c. Selective/progressive harvesting for mud crabs

The procedure for this operation is the same as that on total harvesting in the grow-out monoculture of mud crabs in aqua-mangrove ponds.

d) Financial feasibility projections on a per ha/crop basis

(i) Technical assumption

Species to be cultured: "Pulang alimango" or Giant "alimango" and milkfish

Stocking density requirement:	
Crab (1.5/m^2)	15,000
Milkfish (0.25/m^2)	2,500
Duration of culture (mo)	4-5
Cropping/year	2
Survival (%):	
Crab	80
Milkfish	90
ABW (g):	
Crab:	
"Pulang alimango"	200
Giant "alimango"	400
Milkfish	250
Total amount of feed needed (kg):	
"Pulang alimango"	7,875
Giant "alimango"	12,600
Milkfish	None
Estimated price per kg feed for crabs (₱)	10
Production output (kg):	
"Pulang alimango"	2,400
Giant "alimango"	4,800
Milkfish	563
Estimated price per kg produced (₱):	
Crab	310
Milkfish	60

(ii) Financial assumptions

Miscellaneous cost are estimated at 2% of variable cost.
Caretaker salary at ₱ 1000/month.
Interest rate on capital investment is 8% per year.
Sales tax is 1% of revenues.

(iii) Investment (₱)

	Giant "alimango"	"Pulang alimango"
Development Cost	₱ 27,445	₱ 27,445
Operating capital:		
Variable costs		
Crab juveniles	142,500	45,000
Milkfish fingerlings	5,000	5,000
Feed for crabs	126,000	78,000
Pond preparation materials	4,985	4,985
Caretaker salary	5,000	5,000
Miscellaneous costs	5,670	2,375
Total variable cost	₱ 288,655	₱ 141,110
Fixed costs		
Pond rental (FLA)	500	500
Interest on capital investment	2,196	2,196
Total fixed cost	₱ 2,696	₱ 2,696
TOTAL OPERATING CAPITAL	₱ 291,351	₱ 143,806
TOTAL INVESTMENT	₱ 318,796	₱ 171,251

(iv) Cost-return analysis (₱)

Sales:		
Crabs	₱ 1,488,000	₱ 744,000
Milkfish	13,780	13,780
Total sales	1,501.780	757,780
Less: Operating capital	291,351	143,806
Net income before tax	1,210.429	613.974
Less: Sales tax	14,880	7.440
NET INCOME AFTER TAX	₱ 1,195,549	₱ 606,534

5. <u>Monoculture of mud crab in pens set in tidal flats with existing mangroves</u>

a. Pen preparation

Hydrated lime is applied at 1 t/ha during lowest tide. then *Gracilaria* is planted during the dry season culture or other macrophytes that can grow well in the site during the rainy season. Aside from roots of the mangroves, macrophytes serve as additional shelter for crabs. When there is luxurious growth of macrophytes, the pen is ready for stocking.

b. Stocking density and water change

Crab juveniles should be sorted according to size and sex, and counted according to the stocking density desired, i.e., 2.0/m^2 with 7-11 g or 16-20 g crab juveniles. Males should be stocked separately from females (monosex culture). Crabs are acclimated to pen water salinity and temperature before releasing them into the pens. The pen design would allow a change of water twice per day since the area is usually inundated during high tide. At night time during low tide, water in the pens should be drained for 3 consecutive days after every 7 days to allow exposure of mangrove roots but the canals should always be filled with water.

c. Selective/progressive harvesting

Marketable size and fat crabs, 150 g or more for female and 250 g or more for male "Pulang alimango", 350 g or more for female and 400 g or more for male giant "alimango", are harvested simultaneously with the stock sampling from the 2nd month of culture using lift net or current method. Crabs may also be selected and removed manually by hand picking them during the weekly draining that falls towards the end of every month.

d. Total harvesting

Harvesting may be by lift net method which would involve total draining of the pens at lowest tide and collecting the remaining crabs manually.

e. Financial feasibility projections on a per 200 m^2 pen/cropping basis

(i) Technical assumption

Species to be cultured: "Pulang alimango" and Giant "alimango"

Stocking requirement (2/m^2)	400
Duration of culture (mo)	4-5
Cropping per year	2
Survival (%)	85
ABW (g):	
"Pulang alimango"	250
Giant "alimango"	400
Total amount of feed needed (kg):	
"Pulang alimango"	255
Giant "alimango"	375
Production output (kg):	
"Pulang alimango"	85
Giant "alimango"	136
Estimated price per kg (₱)	310

(ii) Financial assumption

Miscellaneous costs are estimated at 2% of variable costs.
Caretaker salary (family labor) at ₱ 100/mo (basis: 2 ha mud crab farm for every 1 caretaker paid at ₱ 5,000/mo)
Interest rates on capital investment is 6% per year.
Sales tax is 1% of revenues.

(iii) Investment (₱)

	Giant "alimango"	**"Pulang alimango"**
Development costs	₱ 5,275	₱ 5,275
Operating capital:		
Variable costs		
Crab juveniles	3,800	1,200
Feed	3,750	2,550
Pen preparation materials	355	355
Caretaker salary	500	500
Miscellaneous costs	168	98
Total variable cost	₱ 8,553	₱ 4,677
Fixed costs		
Interest on capital investment	211	211
Total fixed cost	₱ 211	₱ 211
TOTAL OPERATING CAPITAL	₱ 8,764	₱ 4,888
TOTAL INVESTMENT	₱ 14,039	₱ 10,163

(iv) Cost-return Analysis (₱)

Sales	42,160	26,350
Less: Operating capital	8,764	4,888
Net income before tax	33,396	21,462
Less: Sales tax	422	264
NET INCOME AFTER TAX	₱ 32,974	₱ 21,198

6. <u>Crab fattening monoculture in aqua-mangrove pond</u>

a. Pond preparation

The pond is prepared following the same procedures described in the grow-out monoculture of mud crab in ponds.

b. Selective/Progressive harvesting and restocking

One of the common features in mud crab fattening culture is selective/ progressive harvesting and restocking. At the end of the 20th day after stocking, fat crabs are selected and removed by harvesting fat female "pulang alimango" weighing 150 g or more, and male 250 g or more; fat female giant "alimango" weighing 350 g or more, and male 400 g or more. Not all crabs fatten at the same time in one culture duration, however observations indicate that about 50% of crabs fatten in 15-20 days.

Crabs harvested are replaced not later than a day after the removal of the fat crabs taking care to acclimate them, cutting movable parts of the claw, and disinfecting before releasing to the pond/pen. Crabs are harvested and replaced every 10 days. Each harvest should be about 30% of the stock assuming always a 100% survival at the end of the 130 days of culture if the culture period is 150 days or 20 days before the total harvest. A total of 14 selective harvesting and 12 restocking days can be attained in 5 months. However, harvested crabs should not be replaced on the 13th selective harvesting day.

Harvesting is by the current and lift net methods. Mud crabs that go against the current and congregate around or near pond gate are 98% fat, and therefore should be caught with a scoop net.

c. Total harvesting

Crabs are totally harvested at the end of the 120 or 150 days of culture by draining the pond and manually picking up the remaining crabs.

d. Financial feasibility projections on a per 200 m^2 aqua-mangrove pond/cropping basis

(i) Technical assumptions

Species: "Pulang alimango" and Giant "alimango"	
Stocking requirement (2/m^2)	2,098
Duration of culture	5
[(with progressive harvesting and restocking), (mo)]	
• 1st harvest and restocking is 20 days	
• after stocking; subsequent harvest and restocking is every 10 days	
Cropping per year	2
Survival (%)	
ABW at harvest (g):	
"Pulang alimango"	20
Giant "alimango"	400

Amount of feed needed (kg)	
"Pulang alimango"	1,070
Giant "alimango"	2,120
Cost of feed (₱/kg)	10
Production output (kg):	
"Pulang alimango"	357
Giant "alimango"	713
Estimated price/kg produced (₱)	310

(ii) Financial assumption

Miscellaneous costs are estimated at 2% of variable cost
Caretaker salary (family labor) at ₱ 100/mo.
Interest rates on capital investment is 8% per year
Sales tax is 1% of revenues

(iii) Investment (₱)

	"Giant alimango"	"Pulang alimango"
Development costs	₱ 5,275	₱ 5,275
Operating capital:		
Variable costs		
Lean crab	41,960	20,980
Feed	21,200	10,700
Pond preparation materials	438	438
Caretaker salary	500	500
Miscellaneous costs	1,282	652
Total variable cost	₱ 63,380	₱ 33,270
Fixed costs		
Interest on capital investment	211	211
Total fixed cost	₱ 211	₱ 211
TOTAL OPERATING CAPITAL	₱ 65,591	₱ 33,481
TOTAL INVESTMENT	₱ 70,866	₱ 38,756

(iv) Cost-return Analysis (₱)

Sales	₱ 221,030	₱ 110,670
Less: Operating capital	65,591	33,481
Net income before tax	155,439	77,189
Less: Sales tax	2,210	1,107
NET INCOME AFTER TAX	₱ 153,229	₱ 76,082

7. <u>Mud crab fattening monoculture in pens in tidal flats with existing mangroves</u>

a. Pen preparation

The procedure described in monoculture of mud crab in pen is followed for this operation.

b. Selective harvesting and restocking, and total harvesting

The procedures described in mud crab fattening monoculture in aqua-mangrove pond, are followed.

c. Financial feasibility projections on a per 200 m^2/cropping

(i) Technical assumptions

Species: "Pulang alimango" and Giant "alimango"	
Stocking requirement	
Initial	400
Total (include restocking)	2,098
Duration of culture (mo)	5
Cropping per year	2
Survival (%)	85
ABW at harvest (g):	
"Pulang alimango"	200
Giant "alimango"	400
Amount of feed needed (kg)	
"Pulang alimango"	1,070
Giant "alimango"	2,120
Cost of feed (₱/kg)	10
Production output (kg):	
"Pulang alimango"	357
Giant "alimango"	713
Estimated price/kg produced	310

(ii) Financial assumption

Miscellaneous costs are estimated at 2% of variable cost.
Caretaker salary (family labor) at ₱ 100/mo.
Interest rate on capital investment is 8% per year
Sales tax is 1% of revenues.

(iii) Investment (₱)\

	Giant "alimango"	"Pulang alimango"
Development cost	₱ 5,275	₱ 5,275
Operating capital:		
Variable costs		
Crab juveniles	41,960	20,980
Feed	21,200	10,700
Pen preparation materials	335	335
Caretaker salary	500	500
Miscellaneous costs	1,280	650
Total variable cost	₱ 65,275	₱ 33,165
Fixed costs		
Interests on capital investment	211	211
Total fixed cost	₱ 211	₱ 211
TOTAL OPERATING CAPITAL	₱ 65,486	₱ 33,376
TOTAL INVESTMENT	₱ 70,761	₱ 38,651

(iv) Cost-return Analysis (₱)

Sales	₱ 221,030	₱ 110.671
Less: Operating capital	65,486	33,376
Net income before tax	155,544	77,294
Less: Sales tax	2,210	1,107
NET INCOME AFTER TAX	₱ 153,334	₱ 76,187

VI. Shrimp Culture

In the Philippines, shrimp culture had been a very promising industry during the first few years, although the culture has not been that successful attaining only an average production of 500-800 kg/ha per crop even in areas where shrimp culture appeared to be highly suitable. With the technological advancement in pond engineering and culture methods, and the availability of feeds and hatchery produced fry, this production report has recently increased tremendously to a range of 3-12 t/ha/crop. Thus, production has increased a hundred fold. Since there was demand for shrimp in the world market, many pond operators switched from milkfish to shrimp production. Other shrimp ponds were built anew from mangroves or from lands previously planted to rice, sugarcane, and coconut. In many cases, intensive culture system was used.

The loss of mangroves associated with the rapid increase in the intensive pond production of cultured shrimp accompanied by rapid drop in fisheries yield and the occurrence of disease problems in ponds became a recent trend. This resulted in shrimp farms ceasing operations due to the prevalence of luminous bacteria resulting in almost total mortalities of shrimps through out the country. In itself, shrimp culture is a very good business. However, shrimp farmers should be convinced to incorporate environment-friendly methods in their operations. The industry should consider that shrimp farming is part and parcel of a bigger ecosystem.

In order to save the industry, two alternatives supportive of resource management for developing shrimp culture in the country, were introduced. Shrimp culture in ponds where natural stands of mangroves inside it are left untouched and shrimp culture in mangroves enclosed with a suitable netting or screening material, a process known as pen culture.

In view of the rich structural features of the mangrove ecosystem, certain clear advantages in shrimp-mangrove culture is envisage. Among these are: the mangroves can purify nutrients and inorganic matter from the waste water (Tam and Wong, 1995) and have the capacity to absorb pollutants in the water (Landers and Knuts, 1992) suggesting that shrimp culture in mangroves may prove an alternative rearing system that is technically appropriate and sustainable.

Being freely confluent with a large dynamic water system connected with the sea, it is assumed that oxygen deficiency, often experienced in ponds, would not occur in pens. Moreover, pen culture would not require expensive and complicated pond and sluice gate construction with highly technical expertise. It would not also require expensive mechanical assistance for filling, replenishing, exchanging and draining of water which are essential in shrimp ponds. Low investment and simple construction are other factors favoring pen culture of shrimps.

VII. Shrimp Culture System

The increasing demand for shrimp in the international market and the breakthrough in the mass production of shrimp fry under controlled conditions triggered the interest of both the government and private sectors, and thus marked the take-off point in the development of shrimp industry in the Philippines. Today, four different approaches or systems are practiced in the culture of shrimps, namely, extensive, modified extensive, semi-intensive, and intensive. The systems are categorized according to source of food, stocking density, and inputs more especially on the support facilities used. In these systems, an overall relationship of stocking rate with food is considered i.e., a balance of population with food. The estimated stocking rate is, therefore, respectively based on the amount of food in the pond whether it be on natural food available alone or with the addition of supplemental feed or solely on artificial feed.

A. *Extensive culture system*

Extensive culture is a low stocking density system where fry are stocked at 0.3-1.0/m^2 with natural food organisms available in the pond as the only source of food for the shrimps. Water exchange is undertaken during spring tides.

B. *Modified extensive culture system*

Locally called medium low stocking density system, the fry are stocked at over $1.0/m^2$ to $5/m^2$ with supplemental feeding on the 16th day after stocking. Water exchange is tidal (during spring tides). A standby water pump is provided for emergency use on the 4th month of culture when oxygen depletion is usually experienced especially with a stocking density of $5/m^2$.

C. *Semi-intensive culture system*

This is a medium high stocking density culture system. The fry are stocked at over $5.0/m^2$ to $15/m^2$. The shrimps subsist on natural food endemic in ponds for 7-10 days and feeding commences thereafter. At $5\text{-}7.5/m^2$, water exchange is tidal but a standby water pump is provided; beyond it water pump is a must and paddle wheel aerators are provided at 1 paddle wheel for every 50,000 shrimps/ha stocking density.

D. *Intensive culture system*

Stocking density is over 15 to a maximum of $50/m^2$. This is the latest technology generated as a result of advances in aquaculture engineering which enable fish farmers to control and maintain the limiting water quality factors and in shrimp nutrition which cater to the complete nutritional requirement for growth of the shrimps.

This system virtually increases the yield/ha/crop, however, it is not recommended because of the high risk, high capital inputs, and effects on the environment. Under conditions of mangrove-friendly aquaculture, the first three culture systems are recommended. It should be taken into consideration that based on experience recorded, disease problems are likely to appear under the intensive culture conditions.

VIII. Mangrove Pond Preparation

Pond preparation involved pond soil manipulations such as draining or flushing of ponds and subsequent reworking of the pond soil. The typical pond soil manipulations include draining of the pond, drying, liming, and fertilization, for the purpose of enhancing biological productivity in the pond.

A. *Pond drying*

Pond drying eliminates predators and competitors. It also oxidizes obnoxious gases harmful to the stock in the pond.

B. *Eradication of unwanted species*

There are some portions of the pond which could not be drained, hence, unwanted species could not be completely eliminated. An application of 10 g of ammonium sulfate and hydrated lime at a ratio of 1:5 on a per m^2 of water 5 cm deep effectively eradicates these unwanted species.

C. *Liming*

The application of lime after drying the pond, is an indispensable operation. This is intended to raise the low pH of the water to a slightly alkaline value which is more favorable to shrimp health and to the growth of natural food in the ponds. Lime is applied at the rate of 1 t/ha depending on the acidity of the pond soil.

D. *Fertilizing*

The application of fertilizer is essential in pond preparation to stimulate and develop the growth of natural food in ponds. There are two kinds of fertilizer used, namely, organic and inorganic fertilizers. Organic fertilizers are those of plant and animal origin, but the most commonly used is chicken manure, applied at the rate of 2 t/ha. Inorganic fertilizers are of mineral origin or manufactured chemical fertilizers containing plant nutrients such as nitrogen and phosphorus. Inorganic fertilizers consist of urea (45-0-0) and ammonium phosphate (16-20-0) at of 1:2 ratio, and applied at 75 kg/ha.

Organic fertilizer application is done immediately after liming, after which inorganic fertilizer may be applied. The pond is flooded through the incoming tide to about 10 cm deep. *Gracilaria* is planted using rice planting method, then the pond is gradually flooded 5-10 cm additional water depth each day until a desired depth of 100 cm, measured from the canal, is reached. When luxuriant growth of *Gracilaria* is observed, the pond is ready for stocking.

IX. Pen Preparation

Hydrated lime is applied during lowest tide at the rate of 30 kg/200 m^2. Ammonium sulfate is immediately used to top dress the undrained portion of the canal in order to eradicate unwanted species. *Gracilaria* is planted during lowest tide of the following day using rice planting method. Pen is ready for stocking after a luxuriant growth of *Gracilaria* is observed.

X. Fry Selection, Transport, Stocking and Acclimation

A. *Fry selection*

The selection of healthy fry will assure good growth and survival. Thus, MBV free or MBV negative fry should be selected since the growth of MBV infected fry is slow if not stunted. Buying fry from different batches for stocking in one pond or pen, should be avoided.

The antennules of the fry should be closed or drawn to each other, taking note that the antennules of a shrimp is separated as a V type at its front side. The antennules of a healthy fry (PL_{20}) are drawn close to each other; sometimes separating for a while then closing instantly. If the antennules are separated all the time but do not close, the fry is not healthy and should not be used for stocking.

Moreover, the abdominal segments should be long just like the long internode of a sugar cane, an indication of a healthy and fast growing fry. The uropod should be wide-open like a fan while swimming and muscles in the abdominal segment should be fully developed. Ocular inspection would show that healthy fry gather quickly towards a white board which is placed in tanks.

B. *Fry transport*

Plastic bags 50 cm wide, 83 cm long and 0.0075 cm thick are used in transporting shrimp fry. Around 5,000-10,000 fry are put in a plastic bag (two plastic bags, one placed over the other) with 1/3 full of water and with similar salinity as that of the tank water and source of the fry. The top of the inner plastic bag where the fry are contained is opened, bunched together and pressed down to remove air. Oxygen is pumped through a hose until the bag is inflated, then tightly closing the bag with a rubber band. The outer plastic is also closed with a rubber band

The filled plastic bag is placed in a "bayong" or woven bag made of pandan leaves if transported by land or if transported by air, the bags are placed inside Styrofoam boxes. Ice is placed outside the fry bags, in between the fry bag and the styrofoam container, to lower the temperature to 20°C. The fry are then ready for transport and be transferred to a previously prepared pond or pen.

C. *Fry acclimation and stocking*

Prior to the release of the shrimp fry, they should first be acclimated to the pond/pen water environment. The temperature and salinity of the transport water should be about the same as that of the pond/pen. In any case, the difference in salinity should not be more than 5 ppt.

Fry are acclimated and stocked during the cooler period of the day, that is, early in the morning (0600-0800 H) or late in the evening (1630-1800 H), by floating the oxygenated plastic bags with fry in the pond/pen water for 5-10 minutes or until such time that the temperature in the bag is similar to that of the pond/pen water. The bag is opened and pond/pen water poured into it gradually until the salinity in pond/pen water and water in the bag are about the same. The lid of the bag is lowered into the pond/pen water to allow gradual entrance of the pond/pen water into the bag. Healthy fry will usually swim out of the bag actively against the current and into the pond water.

XI. Water Quality Monitoring and Management

Water quality is the most important factor affecting successful shrimp grow-out culture. The required quality of water earlier mentioned is the function of the specific culture organisms and has many components that are completely interwoven. By monitoring water parameters daily, developing undesirable conditions will be known and corrective measures may be immediately done. Hence, the data should be used as a tool for the management of desirable water conditions in ponds.

Water temperature, salinity, DO concentration, pH, water color, water transparency, and water depth, should be monitored daily, while taking note of shrimp conditions like feed consumption, swimming behavior, and signs of disease. For instance, if shrimps swim to the water surface and float, and will not sink even if human shadow appears or moves, this indicate DO deficiency in the pond.

Water depth should be inspected daily through the installed depth gauge for possible leakage. Pond water should be changed regularly for 3-4 continuous days every spring tides to about 30% of the pond water volume on the first month, 40% - second month, 50% - 3rd month, and 60% on the 4th month onward of the culture period.

XII. Feeds and Feeding Management

Feeds consist about 50-60% of the total cost of production of shrimps. Using cheap but effective feed and the right amount will prevent feed wastage and therefore will minimize pollution and save on cost.

Artificial feeds in pelleted form are now available in the market, coming in three different kinds, namely: starter, grower, and finisher. The use of these feeds and feeding schedule are being recommended by the feed miller, which should be followed as these are based on successful field trials. Use a brand of commercial feed best reported by other shrimp growers in the site. A SEAFDEC/AQD study found out that brands of commercial feed are site specific, thus a brand best in one site may not perform well in other sites.

A. *Feed requirement for one cropping*

The feed requirement for one cropping is computed as TFR = (FS)(ES)(FCR), where TFR is the total feed requirement in kg, FS is the total number of fry stocked, ES is the estimated survival at harvest, ABW is the estimated average body weight of shrimp survivors in pond/pen at harvest, and FCR is the estimated feed conversion ratio of 1.75:1 at harvest

With TFR known, the computation for the different kinds of feed is as follows:

Starter = 0.0125 (TFR)
Grower = 0.2375 (TFR)
Finisher = 0.75 (TFR)

B. *Feeding rate*

Shrimps should be fed at a sliding rate of 10% of the shrimp biomass per day on the first month, 8% - second month, 6% - third month, 4% - 4th month onward of the culture period. The daily ration is computed as DR = (FS)(ES)(ABW)(FR), where DR is the daily ration, ES is the estimated survival in a linear decreasing order with 100% for the first 15 days to 75% 15 days before harvest, and FR is the feeding rate.

C. *Feeding scheme*

1. For modified extensive culture system

Days of Culture	Feeding Time (% of daily ration)				
	0600	1000H	1400H	1700H	2200H
1-15	Feeding on natural food organisms				
16-30	50			50	
31-45	30			50	20
46-60	30			50	20
61-75	30	10		40	20
76-90	30	.10		40	20
91-105	25	10	10	35	20
106-120	25	10	10	35	20

2. For semi-intensive culture system

Days of Culture	Feeding Time (% of daily ration)				
	0600	1000H	1400H	1700H	2200H
1-7	Feeding on natural food organisms				
8-15	50			50	
16-30	50			50	
31-45	30			50	20
46-60	30			50	20
61-75	30	10		40	20
76-90	30	10		40	20
91-105	25	10	10	35	20
106-120	25	10	10	35	20

3. Feed consumption monitoring

Although a daily feed ration is prescribed, feeding on demand is also recommended. It is therefore important that feed consumption is regularly monitored by providing feeding trays. 4 trays/ha in pond and 1 tray for the 200 m^2 pen. Catwalk should be installed, one on each side of the pond and one for the pen. Sufficient length of rope is used to connect each of these trays and to the catwalk.

During feeding, 1% of the amount of feed intended for the feeding schedule should be placed equally in the 4 feeding trays. After 2 hours but not later than 4 hours after feeding, the trays are inspected. If the feeds are consumed or almost consumed, feed equivalent to 5% of the total amount of feed intended for the next feeding schedule should be added. Otherwise, feed should be reduced by 5% of the next scheduled ration.

4. Harvesting

Water should not be changed 5 days before harvest to prevent molting. Harvesting soft-shelled shrimps should be avoided. Usually, the buyer is informed ahead of time on the choice of the scheduled harvest, then his representative will be asked to take sub-samples from the pond as basis for the pricing of the harvest.

Harvest should be by total draining of the ponds and by providing "lumpot" (bag net) at the drain gate, taking note that the shrimp goes with the current. Shrimps are collected from bag net periodically and placed directly into chilling tanks. These are washed and transferred in boxes provided by the buyer for weighing. Once weighed, the buyer transfers shrimps to another box to be filled with cracked ice. The remaining shrimps in pond/pen are picked up and washed thoroughly before placing them in chilling tanks.

5. Post-harvest handling

Shrimps should not be taken out from chilling tanks before the arrival of a buyer. Once exposed and their heads redden, the shrimps may be rejected by the buyer. The buying price is based on the sub-samples taken a day before the scheduled harvest. From the samples, soft shelled and undersized shrimps could be usually determined by computing the % soft shelled and undersized shrimps from the total weight of the harvest. What remains is considered good shrimps.

For example in a sub-sampling, results showed an ABW of 32 g but 1% was found to be soft-shelled and 3% is below 18 g. Therefore from a total harvest weighing 2 tons, the expected volume of soft shelled is computed as 1% of 2000 = 20 kg, while the expected volume of undersized shrimps is computed as 3% of 2000 = 60 kg, giving a total of 80 kg. The total harvest less 80 kg (expected rejects) would therefore be 1,920 kg of expected good shrimps.

At ₱450.00/kg based at 30 g ±₱5.00, the price per kg of the shrimp harvest is ₱460.00, thus, the total revenue is: ₱460 x 1920 = ₱883,200. Adding the revenue of the rejects and soft-shelled: ₱180 x 80 = 14,400. Therefore the TOTAL REVENUE = P897,600

6. Financial feasibility projections

a. On a 1.0 ha pond shrimp monoculture per cropping basis using extensive culture

(i) Technical assumption

Stocking density (/m^2)	0.3
Duration of culture (mo)	5
Survival (%)	75
ABW (g)	30
Amount of feed (kg)	none
Estimated price/kg (₱)	450

(ii) Financial assumption

Miscellaneous costs are estimated at 2% of variable cost.
Caretaker salary at ₱ 1,000/month
Interest rates on investment is 8% per year
Pond rent is in accordance with FLA rate.

(iii) Investment (₱)

Development costs:	
Construction of dikes, canals and leveling	2,000
Operating capital:	
Variable costs	
Shrimp fry	750
Feeds	None
Pond preparation materials	11,985
Caretaker salary	5,000
Miscellaneous costs	355
Total variable cost	18,090
Fixed costs	
Pond rent (FLA)	500
Interest on capital investment	2,880
Total fixed cost	3,380
TOTAL OPERATING CAPITAL	21,470
TOTAL INVESTMENT	93,470

(iv) Cost-return analysis (₱)

Sales	30,375
Less: Operating capital	21,470
Net income before tax	8,905
Less: Sales tax	304
NET INCOME AFTER TAX	8,601

b. For a 1.0 ha pond shrimp monoculture on a per cropping basis using the modified extensive method

(i) Technical assumption

Stocking density (/m^2)	5
Duration of culture (mo)	5
Survival (%)	75
ABW (g)	30
Amount of feed (kg):	
Starter	25
Grower	467
Finisher	1,476
Cost of feed (₱):	
Starter	45
Grower	36
Finisher	35
Production output (kg)	1,125
Estimated price/kg produced	450

(ii) Financial assumption

Miscellaneous costs are estimated at 2% of variable cost
Caretaker salary at ₱ 1000/month
Interest rates on investment is 8% per year
Sales tax is 1% of revenues

(iii) Investment (₱)

Development cost	72,000
Operating capital:	
Variable costs	
Shrimp fry	12,500
Feeds	69,597
Pond preparation materials	11,985
Caretaker	5,000
Miscellaneous costs	1,982
Total variable cost	101,064
Fixed costs	
Pond rental (FLA)	500
Interest on capital investment	5,760
Total fixed cost	6,260
TOTAL OPERATING CAPITAL	107,324
TOTAL INVESTMENT	179,324

(iv) Cost-return analysis (₱)

Sales	506,250
Less: Operating capital	107,324
Net income before tax	398,926
Less: Sales tax	5,062
NET INCOME AFTER TAX	393,864

c. For a 1.0 ha pond shrimp monoculture on a per cropping basis (Semi-intensive)

(i) Technical assumption

Stocking density (/m^2)	15
Duration of culture (mo)	5
Survival (%)	75
ABW (g)	30
Amount of feed Kg):	
Starter	74
Starter	74
Grower	1,403
Finisher	4,430
Cost of feed (₱/kg):	
Starter	45
Grower	36
Finisher	35
Production output (kg)	3,375
Estimated price/kg produced	450

(ii) Financial assumption

Miscellaneous costs are estimated at 2% of variable cost.
Caretaker salary at ₱ 1000/month
Interest rates on investment is 8% per year
Sales tax is 1% of revenues

(iii) Investment (₱)

Development cost	72,000
Operating capital:	
Variable costs	
Shrimp fry	37,500
Seeds	208,888
Pond preparation materials	11,985
Caretaker salary	5,000
Miscellaneous costs	5,267
Total variable cost	268,640
Fixed costs	
Pond rental (FLA)	500
Interest on capital investment	5,760
Total fixed cost	6,260
TOTAL OPERATING CAPITAL	274,900
TOTAL INVESTMENT	346,900

(iv) Cost-return analysis (₱)

Sales	1,518,750
Less: Operating capital	274,900
Net income before tax	1,243,850
Less: Sales tax	15,188
NET INCOME AFTER TAX	1,228,662

d. For a 200 m^2 pen shrimp monoculture on a per cropping basis (Semi-intensive)

(i) Technical assumption

Stocking density (/m^2)	15
Duration of culture (mo)	5
Survival (%)	75
ABW (g)	30
Amount of feed (kg):	
Starter	2
Grower	28
Finisher	89

Cost/kg feed:	
Starter	45
Grower	36
Finisher	35
Production output (kg)	68
Estimated price/kg produced	450

(ii) Financial assumption

Miscellaneous costs are estimated at 2% of variable costs
Caretaker salary at ₱ 100/month
Interest rates on investment is 8% per year
Sales tax is 1% of revenues

(iii) Investment (₱)

Development cost	5,275
Operating capital:	
Variable costs	
Shrimp fry	750
Feeds (kg)	4,213
Pond preparation materials	346
Caretaker salary	500
Miscellaneous costs	116
Total variable cost	5,925
Fixed costs	
Interest rates on capital investment	211
Total fixed cost	211
TOTAL OPERATING CAPITAL	6,136
TOTAL INVESTMENT	11,411

(iv) Cost-return analysis (₱)

Sales	30,600
Less: Operating capital	6,136
Net income before tax	24,464
Less: Sales tax	306
NET INCOME AFTER TAX	24,158