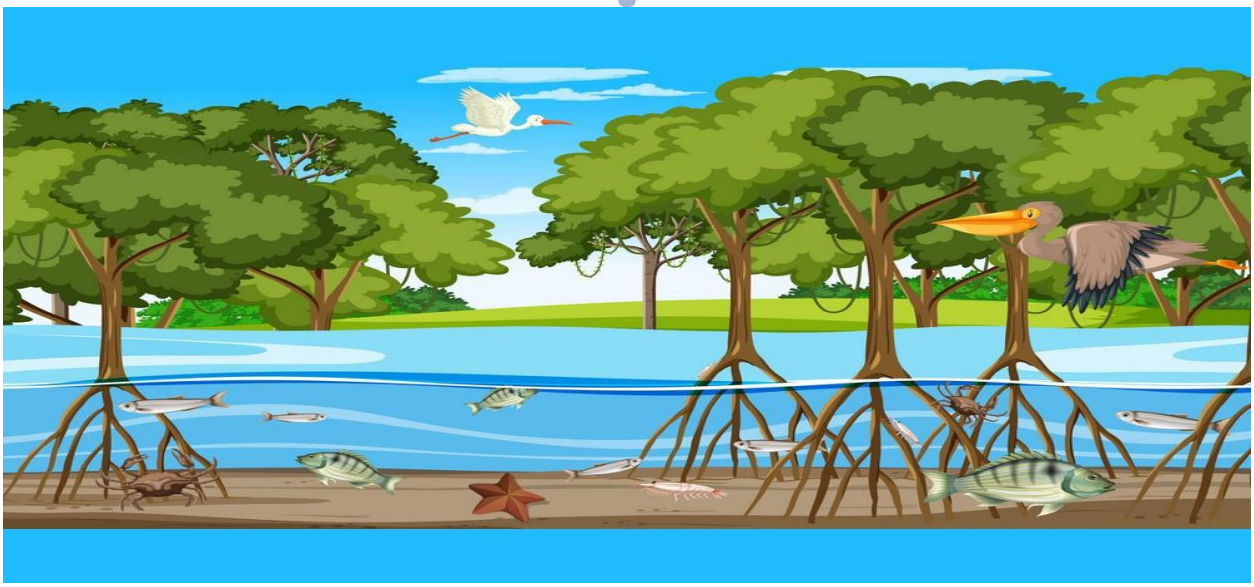
EUROPEAN UNION

german cooperation
DEUTSCHE ZUSAMMENARBEIT

MANGROVE FRIENDLY AQUACULTURE

AQUACULTURE DEVELOPMENT IN PAUK TAW PROJECT



Implemented by:

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

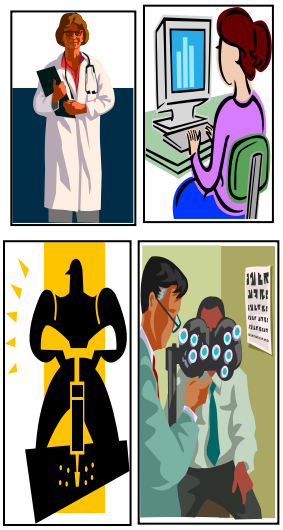
Table of Contents

1. Resources

Resources are materials or substances occurring in nature which can be exploited for fulfilling the needs of human beings.

1.1. Types of resources

Human Resources



Professionals, technicians, skilled laborer, economists, communities, and religious personnel, national and international organizations

Natural Resources

Terrestrial and aquatic animals, trees and forest, landscape, geographical resources – air, water, climate

1.2. Types of natural resources

Types of resources are specified as follows.

Table 1: Different types of resources with examples

Type of resources	Examples
Renewable resources	Sunshine, air, water, tide
Non-Renewable resources	Charcoal, petroleum, natural gases, minerals
Replaceable resources	Forest, agricultural crops, farm animals, aquaculture animals

Implemented by:

1.3. Costal resources

Coastal resources mean useful and valuable natural products and substances for people which can be produced from coastal regions.

1.4. Natural resources at the coastal region

- Seashore, brackish water, creeks, lakes
- Aquatic animals such as crab, fish, shrimp etc.
- Aquatic plants such as sea grass, algae and seaweed, phytoplankton etc.
- Mangrove plants, other trees, and forest
- Farmland, mountain, hills, sandbank, rocks
- Wild animals

1.5. The key benefits of coastal resources on the natural environment and local communities

- Food security
- Job opportunities
- Usable river system for transportation
- Supportive water resources for drinking, agriculture
- Ecosystem for wildlife and aquatic animals
- Enhance local climate
- Reduced the risk of natural disasters

1.6. Threats to the coastal fishery resources

- Overfishing
  (Uncontrollable fishing from growing numbers of fishermen and fishing utensils)
- Uncontrolled fishing
  (Fishing in closed seasons, poisoning, electrocuting, illegal fishing by using extra fine mesh and inhibited utensils)
- Destroyed the spawning habitats
  (Trawling in shallow areas, damaging mangrove forests, blocking waterways)
- Catching and trading of pregnant fish, fish/shrimp with unmarketable size.
- Water pollution

(Disposal of industrial and agricultural toxic materials into the water)

- Use of farming system which can destroy mangrove ecosystem and habitats. (Shrimp production by closing water ways, intensive shrimp aquaculture without water purification system)
- Solely relies on natural water environment without having proper planning for systematic aquaculture production

2. Natural environment and climate change

What is the environment? What components are included in it?

Environment is all of the circumstances and objects from our surrounding which can be living, or non-living, visible, or invisible, touchable, or untouchable. It includes all the facts related to soil, water, air, climate, sound, smell, taste, animals and plants, biodiversity, history, culture, social and beauty from surrounding of human being that exist on the planet earth naturally and benefiting to each other. Climate, weather, and natural resources encourage survival of human beings and economical welfares.

Is the natural environment damaged? And What are the causes?

- Overall ecosystem of the earth is being destroyed more or less by human activities.
- When living or non-living matter of the ecosystem transform from its original state, it can damage the rest of the organisms and non-living thing.
- Reducing biodiversity, water (spring water, creek water, underground water), soil layer etc. are the visible example of mass destruction of the forest trees.

Basic causes of the deterioration of the natural environment

- Population Growth
- Economic Development Activity
- Poverty

The causes of the natural environmental deterioration

- Over usage of fossil fuel
- Over production from the forest
- Uncontrol waste disposal
- Disposal of polluted water etc. can severely damage the natural environment.

Environmental issues

Environmental problems according to Environmental Performance Assessment, 2006.

1. Deforestation
2. Damaging biodiversity
3. Damaging soil resource
4. Damaging water resource (potable water/agricultural water)
5. Waste disposal
6. Various pollution
7. Climate change
8. Toxification due to mining activities

3. Climate change

Weather

Weather is the mix of events that happen each day in our atmosphere. The condition of a region such as rainy, windy, hot, cold, snowing etc. are the weather of such region and that can be different from one to another.

Climate

The weather conditions prevailing in an area in general or over a long period. Overall estimation of local weather situation depending on long time weather status within the region. (Weather forecast within 30 years)

Climate change

Variation from normal condition within a season apart from changing one season from another such as summer to raining season, raining season to winter etc.

Figure 1: Melting ice because of global warming as part of climate change

3.1. Symptoms of climate change

- Shorter raining days in some regions and longer duration of drought in some regions
- Melting of glacier from the world's roof; Arctic region, world's bottom; Antarctica and Himalayas.
- Gradual increase of sea level.
- Changes in crops' ripening, sowing season.
- Consistent increase in scope and quantity of outbreak due to the invasion of diseases carrying tropical species to temperate zone.
- Gradual increase in extinction of living species which are sensitive to climate change.
- Accelerating damages of underwater coral reefs.
- Progressive development of desert.

3.2. Causes of climate change

- Global warming (releasing carbon dioxide into the atmosphere by combusting fossil fuel from the people)
- Temperature increases on the surfaces of air, water, and seawater.
- Deforestation
- Increasing greenhouse gases in the air

What is happening in the world we lived in?

- Global warming
- Draught, flood
- Landslides, erosion of agricultural land, riverbank erosion
- Forest fire
- Vulcanic eruption
- Earthquake
- Frequent storm, acid rain
- Glacier melting
- Extinction of biodiversity
- Disappearance of habitat for biodiversity

- Food and water shortage
- Water, air, soil pollution
- Increasing disease symptom

Environmental problems of the world

- Acid rain (industrial burning combine with atmospheric snow and acidic rainfall onto the land)
- Deforestation (uncontrol cutting down of trees to be used as fuel and in production of furniture)
- Air pollution (smokes released from industries and vehicles)
- Formation of deserts (formation of plains due to the lack of forest, trees and cold to collect precipitation)
- Energy crisis (mass production of petroleum from underground fossil layer and charcoal etc.)
- Land depletion
- Depletion of ozone layer
- Toxification (foul smell from atmosphere and odor of food and households' products from industries)
- Traffic, crowded vehicles usage
- Extreme population
- Environmental degradation
- Contaminated drinking water, shortage
- Waste problem
- Noise pollution
- Visual pollution
- Running out of fishes in the sea

3.3. What are the remedies to maintain the environment?

- Maintain forest and trees
- Avoid cutting down the trees
- Plant more trees, conserve the trees
- Replace plastic lunch boxes with steel lunch boxes

- Replace plastic water bottle with steel water bottle
- Replace Styrofoam materials with steel
- Reuse cotton shopping bags instead of plastic bags, recycle
- No lighting unless necessary
- Use water efficiently etc.

3.4. Climate change and its impacts on aquaculture

Natural disasters can occur suddenly or gradually either by the climate change or naturally or human activities. For the affected area, it is difficult to recover to its original situation after the disaster. Many rehabilitations assistance is needed.

Generally, there are two types of natural disaster –

- **Naturally occurring disasters** – storm, flood, draught, earthquake, mountain erosion, riverbank erosion, tornado.
- **Man-made disasters** – water pollution, fire, deforestation, climate change.

Preparation of natural disaster prevention at fish/shrimp farming

- Choose bigger fishes from the pond and catch them before monsoon.
- Raise the height of pond dike, make it stronger, cover in surrounding if possible.
- Safely store the fish feed etc.
- Collect information to prevent seawater introduction to aquaculture ponds due to the storm.
- Maintain the water gates properly.
- Feed the fishes adequately, cover in tree branches.
- Learn the emergency response training in case of storm.
- Follow the last update announcement of disaster prevention.

Post-disaster activities

- Remove wild fishes.
- Remove trashes, broken trees, and fallen trees from the pond surrounding.
- Apply lime powder for sanitation and disease control.
- Check the numbers of fishes in the pond in case of overflow.
- Restock fishes if the quantity of fish decreases.
- Clear and maintain the water inlet and outlet.
- Maintain pond dikes.

- Record the damages that have been caused to the pond.

4. What is mangrove forest?

Figure 2: Mangrove Forest in Myanmar

A mangrove or mangrove tree is a tree with roots which are above the ground and that grows along the coastal riverbanks in tropical countries.

4.1. The principles of mangrove forest

- Fruits, leaves, and branches from mangrove forests which fall into the water fortify the nitrogen to the water that enhances the growth of phytoplankton, algae, grass, and aquatic weed and becomes the major food resource for fishes and shrimp.
- Mangrove trees not only provide shelters for fish but also purify the toxic included in the water.
- Mangrove trees also reduce and protect the natural disasters such as storms, tsunami.
- Mangrove tree received oxygen from the air through the respiratory roots during the fall of sea level. Therefore, pen aquaculture of fishes/shrimp by introducing water until the mangrove tree roots immersed under the water, could lead the mangrove trees to dead. This leads the trees in this area to decay and acidify after 3-5 years which transform to an inappropriate area to use for aquaculture.

4.2. Myanmar Mangrove forests

There are over 1.7 million acre of mangrove forest in Myanmar. According to the study, 29 species of mangrove have been recorded and study still ongoing. There are 65 fish species, 13 shrimp species and 39 wildlife species have been recorded within Myanmar mangrove forest. The changes of Myanmar mangrove forest are as follow:

Table 2: Areas of mangrove forests in Myanmar

No.	Region	Area (Acre) Year 1980	Area (Acre) Year 2007	Area (Acre) Year 2013
1	Rakhine costal	414,470	408,059.78	254,124.47
2	Ayeyarwady delta	679.019	228,747.89	11,317.60
3	Tanintharyi division	647,571	427,120.14	373,131.88
		1,741,060	1,063,928	738,575

4.3. Benefits of mangrove forests

Direct benefits	Indirect benefits
• Availability of wood for construction, docking, aquaculture activities • Availability of fuel (wood, charcoal) Other products which can be available from mangrove forest • Honey • Vegetables (fruits, leaves) • Palm – sugar, palm sugar • Salt • Animal feed • Raw materials for construction, small-scale machinery • Raw trees for industries • Dyes, Herbs, and Algae Animals etc. • Aquatic animals such as fishes, shrimp, crabs, and crustacean • Artemia (marine shrimp) • Other aquaculture animals	• Habitat for fish/shrimp • Biodiversity • Protection from storm, waves • Reducing riverbank erosion • Protection of introducing seawater to freshwater ways • Carbon absorbing mangrove forest that can resist global warming • Growth of aquatic plants which can absorb nutrients • Food supply chain • Ecotourism and recreation businesses • Research and education

4.4. Aquaculture as a driver of mangrove destruction

Aquaculture system of fish/shrimp by closing water ways with dike and destruction of mangrove forest can damage the mangrove forest which has been providing benefits for the region and local communities. If the mangrove forests are damaged, the abundancy of fishes and resistance to natural disasters can be decreased.

Although 0.15 million of 0.2 million shrimp farming acres are existed in Rakhine coastal region, due to this shrimp farming system with closing waterway, Rakhine's shrimp production rate per acre is 20-40 times less than that from other regions. After 3-5 years of farming period, the rate of fish/shrimp entering to the farm and survival has reduced and leading to the condition that the farm becomes filthy and inappropriate for aquaculture related activities.

Figure 3: Aquaculture activities found near the mangrove forest

5. Aquaculture

Aquaculture means the cultivation of aquatic animals and plants under controlled manner.

Nature of fishes/shrimp

Aquatic animals not only migrate to places and water depth depending on the age and genetic need, but also stay in group where –

1. Locations where feed is abundant
2. Water is purified
3. Place with suitable temperature
4. Place with less enemy
5. Place with better shelter

6. Mangrove Friendly Aquaculture

6.1. Definition

Mangrove-friendly aquaculture means farming aquatic animals in the mangrove forest without destruction by any means to the nature of the mangrove forest. (Destruction means cutting mangrove trees, and branches, blocking waterways, soil digging etc.)

NO MANGROVE, NO FISH

6.2. Mangrove friendly aquaculture techniques

Basically, there are 5 mangrove friendly aquaculture techniques

1. Mangrove cum Fish/Shrimp/Crab culture
2. Pen Culture
3. Floating cage culture
4. Posting/Hanging culture

5. Twig/Stone culture

In this manual, only 3 techniques will be mainly discussed.

6.2.1. Mangrove cum Fish/Shrimp/Crab culture

This is a type of aquaculture where mangroves are planted on elevated land within the pond and fishes/shrimp are stock into the rest of pond water area. This method is widely used in Vietnam and Thailand.

Figure 4: A mangrove forest in Myanmar

6.2.2. Pen culture

Like cage culture, pen culture is the most suitable aquaculture business for fisherman and small-scale farmers who has no land ownership to build the pond. Basic principle of pen culture is the aquaculture of marine species in bigger cage-like mangrove area where there is tidal action into the low land area by means of fencing with net or screen in the area. So, this principle is the same as cage culture.

Figure 5: Pen culture

Although pen culture is not yet popular among small-scale aquaculture farmers, there is some productions with pen culture for crab farming in Myanmar costal region.

Water quality, depth and tidal force should be considered when choosing the site selection for pen culture. The needs of the farmed species should also be considered. Water quality parameter such as salinity, pH, temperature, dissolved oxygen etc. should be appropriate for farm species. The recommended water depth is around 9 ft, bottom soil should not be too muddy. Water quality could be decrease rapidly when there is higher organic sludge. Location with water flow rate over 15 inch per sec should not be selected. Optimum flow rate is 4-8 inch per sec.

Pen culture is the most suitable business especially for crab, shrimp and seabass and there are different types depending on the farm aquatic species.

6.2.3. Floating cage culture

Floating cage culture method can be used either in small-scale or commercial scale aquaculture.

Cage culture techniques

Cage culture can be used either in small-scale or commercial scale aquaculture business. The size of the cage could be varying from very small cage to big cage. This aquaculture technique can be used not only in river and creek but also in several location such as reservoir, freshwater dam, and pond etc. There are two types of cages – floating cage and submerged cage at the bottom of the pond floor. Floating cages are used in rivers where there is deep water and submerged cages are used in shallow regions. Advantages of cage culture is unnecessity of water exchange for quality control. The most important fact is mesh size of the net should be small enough to maintain the farmed fish from releasing and big enough to allow proper water flow. And the net should be strong not to be destroy by big fishes or crabs. The net should be clean daily

for good water flow. The size of the mesh should be adjusted as needed depending on the size of the farmed fishes.

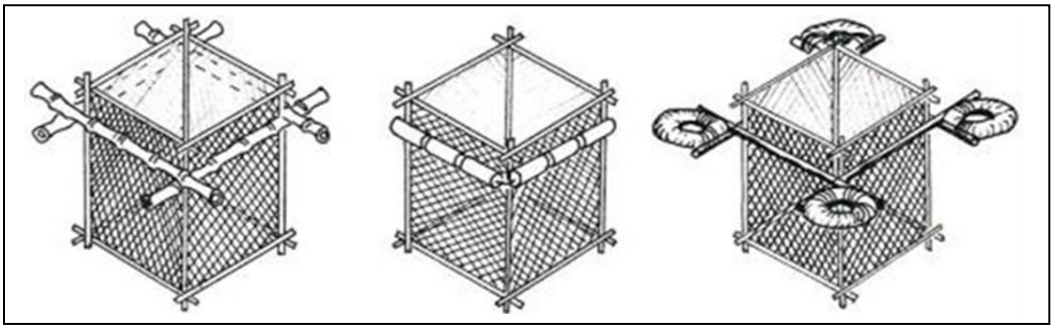


Figure 6: Different types of cage cultures

Types of Cages

The size of the cages varies starting from the size of 3 sq ft and 3 ft depth with 1 ton water capacity to big cages with hundreds water tons. Common shapes of the cages are circular and square shape. Components of the cages are as follow.

Cage Frame

This is the hard body part of the cage and can be constructed either in wood or iron.

Floating facilities for cages

This is the facilities used to support the cage to float on water. Generally, they used barrel, plastic tank, sealed PVC plastic pipe, plastic sponge etc. By systematically equipping the cage with these facilities, the cage can be float 1 ft above water surface.

Screen or net bags

The most common screen to put the fishes for farming are plastic net or nylon screen. Although iron screen is stronger, they do not used as they are heavier and expensive. Nylon screens are lighter, expensive but they cannot resist the damage caused by aquatic animals such as by turtle, crabs etc. When using nylon screen, it should be covered by strong plastic net with bigger mesh size from outside. The size of the mesh depends on the size of the farmed fishes. For e.g., mesh size of 1 cm (0.4 inch) has to use in farming 9 g (0.5 tickles) tilapia and mesh size of 2 cm (0.8 inch) has to use in farming 25 g (1.5 tickle) fishes. The main point is that the size of the mesh used in cage should be small enough to maintain the farmed fishes inside and should be big enough to allow proper water flow.

Cover of the cages

The cages should be covered with nylon or plastic screen to prevent the farmed fishes releasing and eating by birds.

Constructing feeding ground

To prevent the feed waste for floating feed by flowing outside the cages, starting from water surface of the cage until 1ft below should be covered with smaller mesh. This barrier should be fitted on water outlet part of the cage as it could disturb the water flow. When this barrier is too small, stronger fishes could dominate during feeding. When submerged feed are used, feeding should be done in feed tray submerged in the water of 1.5 ft depth to prevent feed waste.

Background technology for cage culture

Feeding is one of the critical practices in cage culture. In cage culture where there is limited natural food for fishes, sufficient feeding contributes good growth rate. In cage culture, the cost of feed could be about 60% of its total production cost. It is necessary to feed the fish twice, in the morning and in the evening. The feeding rate can be calculated the same as earthen pond but measuring fishes' growth rate and feeding rate adjustment should be carried out biweekly.

"Feed for fish from freshwater cage culture such as striped catfish, tilapia and rohu differ from feed for earthen pond fishes because the feed pellet should contain at least 32% protein and better if it is with 36% protein. It is recommended to feed the floating pellet type and the pellet should be insoluble in water within 24 hours. Where possible, automatic feeding machine should be used".

Although the submerged type of feed can be used in cage culture, it is necessary to reduce the feed waste during feeding. In cage culture of freshwater fish,

Feed Conversion Ratio (FCR) is from 1:1.5 to 1:1.8 and it means that 1.5 to 1.8 viss feed is required to increase 1 viss of fish body weight.

Stocking rate is 90 viss fish volume for 1 ton volume of water (volume of water exist in L 3.3 ft, H 3.3 ft, D 3.3 ft space). Fish volume is the multiplication of individual weight of the fish and quantity of fishes. Meaning that 90 viss fish volume is the stocking of 90 fishes with 1 viss weight individually or stocking 180 fishes with 50 tickles weight individually.

7. Mangrove and shrimp culture

7.1. Mangrove friendly shrimp culture

Highly intensive fish/shrimp aquaculture may severely harm the environment for the following reasons.

- Termination of natural mangrove forest to conduct aquaculture activities.
- Water pollution from excessive usage of chemicals in intensive aquaculture.
- Mortality of fish due to oxygen depletion in water from excessive fertilization by fish/shrimp wastes
- Higher acidity in the topsoil layer

Moreover, sustainability of livelihood for local coastal families may be threatened deeply due to the damages to the ecosystem and to the productivity of the mangrove system by the consequences of chemical wastes from agricultural and capture fisheries.

Although mangrove area can be specified as wetlands which supports remarkably to the food chain, at the same time, the permeability of carbon and nutrients into the water is related to the risk of oxygen depletion due to excess nutrients in water. Local costal families aware that nature friendly management especially benefits from mangrove forest could support the operational scope effectively.

- Growth and survival of farmed fish/shrimp is related to good water quality and environment.
- There are growing concern on sustainable activities and current market demands emphasizing on the environmental and social ethics.
- Markets are less preferred to fish/shrimp farming by means of chemicals.

Reforestation of mangrove can extend the sustainability of fish/shrimp ponds and change to integrated management, in parallel, it can maintain the long-term productivity of aquaculture ponds and regain to allocate food chain, the ecosystem services for the benefits between aquaculture ponds and local communities.

The existence of trees protects the pond dike from flood, wind, storm and assist natural percolation of nutrients, provide habitats for shelter and reproduction of aquatic animals.

In traditional aquaculture ponds, small amount of waste is produced due to the consumption of other animals and mangrove forest absorbs the excess natural nutrients. The role

of mangrove forest is critical as it can reduce the effect of contaminated chemicals on the pond soil where there is residual feed, dead fish/ shrimp, residue from shredded skin and feces.

> *"Disposing soluble waste materials exceeding the capacity of fish/shrimp farming ponds containing contaminated sludge, nutrients to the natural water sources beyond aquaculture area may create the condition for the multiplication of bacteria and spread them to the neighboring farms. For farms near the intensive farming ponds where there is a use of contaminated external water can increase the risk of pondwater pollution and infectious diseases in farmed species".*

Constant existence of sludge at the aquaculture pond bottom may enhance the growth of microorganisms and change to form the optimum condition for their survival. Deterioration of water quality increases the disease potential and stress in fish/shrimp. It can create the situation to use chemicals and veterinary drugs for disease control.

Primary factors for mangrove friendly aquaculture are –

- Small amount of stocking is preferrable to intensive farming
- Production of suitable amount appropriate for aquaculture pond capacity
- Nutrient absorption from the mangrove forest when the volume of mangroves covers 50% or more of the total pond area
- Prevent depletion of water quality
- Fish with the capacity of controlling the leaves and bottom sludge can be selected.

Therefore, the existence of mangrove forest is essential in contribution for the support to food chains. The existence of fish species can be considered depending on the extent of shrimp aquaculture management level.

- The existence of herbivorous fish in intensive shrimp ponds without supplementary feeding can support the control of phytoplankton growth with the nutrients from mangrove forest.
- In intensive farming, where there is no proper separation of herbivorous fish, the benefits of phytoplankton to control the excess nutrients of supplementary shrimp feed can be affected and eventually the quality of pond water deteriorates.

Anyhow, the presence of fish that eat bottom sludge accelerate the purification of water by collecting sludges and organic matter. Having carnivores or omnivorous fishes instead of herbivorous fish could rise the problem of consuming the farmed shrimp.

7.2. Sustainable mangrove system and shrimp farming

There are conditions to consider not only for environment and production but also social and economic roles in mangrove forest and shrimp farming in terms of sustainability.

Preserving and accelerating the production

Site location for shrimp culture should not be acidic sulphate soil and the site that can guarantee the suitable conditions should be selected. However, the soil with moderate acidity can be neutralized by applying lime. Select the site where there is no contamination of soil and water from former usage or no drainage from cities, industries, or agricultural discharges.

Figure 7: Performing farming activities near mangrove forest

Shrimp farm should be protected from entering of sludges to the pond with the tidal water. Farm should be able to take out the water completely by using proper drainage system. Shrimp farm design should be prepared to get the best productivity with the existing mangrove forest. By doing so, mangroves tree can receive the optimum nutrients.

In mangrove friendly shrimp farming, mangrove forest should be at least 50% of pond area. Although the production area is restricted by mangroves, survival rates are enhanced due to the better water quality by the existence of mangrove forest. Survival rates are increased by producing waste for herbivorous fish by the support of the food chain and decreasing water temperature.

Planting mangroves both inside and outside of pond dike or extending mangroves on water ways or parallel land or banks to increase connection between the trees and outflowing water.

Figure 8: Planting mangroves in dike

Introducing tide into the shrimp farm need to be maintained as mangroves do not prefer the permanent existence of tide. Permanent existence of water in shrimp ponds may delay the growth of mangrove trees as there is less rooting system. Pondwater should be in good quality and free from chemical residue which can contaminate the survival rates of fish/shrimp. Avoid using the contaminated water due to human activities.

Farm should be located in appropriate place where there is no production loss in grow out farming due to the flood. Pond dike erosion and storms could be protected by having green mangrove forest as medium in front of the sea to prevent from storms, massive wave, and strong winds.

7.3. Best management practices compatible to mangrove forest

In traditional grow-out farming system, environmental damages are neglected due to less organic debris as there is only one water inlet through water gate. Aquaculture pond dike of mangrove forest not only absorb the nutrients from the food chain in the pond water, but also decrease the water temperature by providing shades.

7.3.1. Stocking juveniles

Stocking only the farmed species to the pond is crucial and post larval stage shrimps should be protected from carnivorous fish. Shrimps with higher quality and survival rate can be received only when the healthy post larval stage shrimps are used for stocking. Although collecting and trapping post larvae entering with the tide via water gate is cost effective but less effective in terms of quantity. This type of stocking has the risk of carnivorous fish entering to the pond. The best approach is trapping the required post larvae while the tide is high and remove carnivorous fish. To maintain water quality and avoid water pollution, the pond should not be over-stocked with post-larvae beyond its carrying capacity.

Natural feed yielding from mangrove ecosystem or formulated feed can be used as shrimp feed. Phytoplankton from costal ecosystem, zooplankton, and invertebrates are the part of natural food chain.

Table 3: Juvenile stocking rate for mangrove friendly shrimp culture

Shrimp species to be stocked	Stocking quantity per 3 sq ft
Tiger shrimp	0.5 – 1 piece
Vannamei shrimp	1 – 5 pieces
White shrimp	1– 5 pieces

7.3.2 Feeding management

In a grow-out farm of the mangrove friendly aquaculture, production of natural feed from mangrove forest should be upgraded. Checking feeding tray along the pond dike should be carried out to monitor growth rate and health of shrimp.

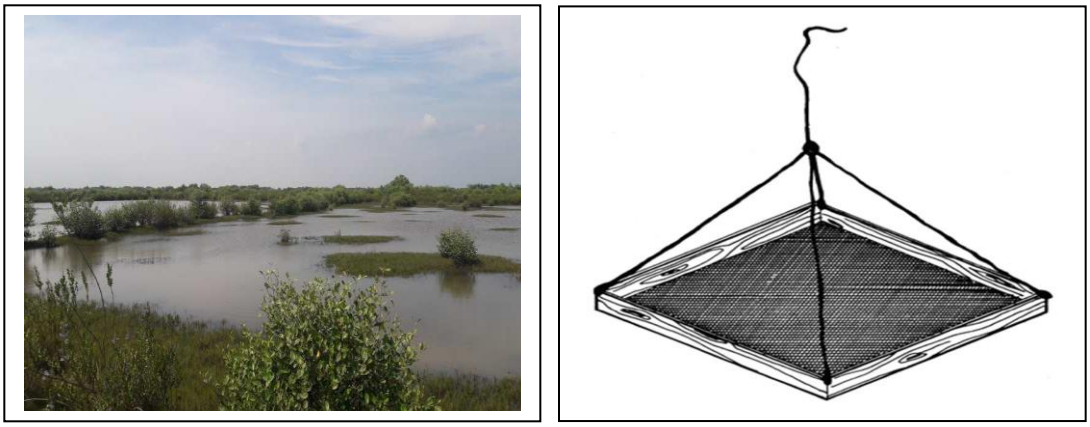


Figure 9: Feeding management at grow-out ponds

8. Mangrove and Mud crab farming

8.1. Mud crab fattening

Introduction

Mud crab can be spawned throughout the year despite some differences in quantity depending on the season, and the crab with larvae and marketed sizes can be collected easily from natural water as they have higher hatching rate. Farming can be easily done as any meat can be used to

feed them. Therefore, costal local communities are encouraged to farm mud crab either in small-scale or commercial scale depending on own's financial status.

Table 4: Egg laying capacity of some aquaculture species

Type of aquaculture species	Egg laying capacity
Freshwater adult female shrimp	From 80,000-100,000
Marine tiger shrimp	From 300,000-500,000
Adult crab	From 500,000-1,000,000

Mud crab at a glance

Mud crabs be found in Indo-Pacific region naturally. They can also be found in South Africa, along the cost of Indian ocean, Southern Japan, eastern Fiji – The southeastern beach of Australia and Samoa island. There are trial cultures of mud crab in Hawaii and Florida in America.

Mud crab farming started in 1890 at China where it was started as a small-scale together with fish/shrimp farming ponds. Later, crabs are farmed in pen, pond and become commercial scale in 1974. In 1990, crab farming in mangrove has been established.

> *"There are over 500 species of freshwater and marine crab. Among them, crab with higher market demand and economic benefits are Mangrove crab or Mud crab and black crab. Scientific name is Scylla".*

The hatchery business has developed in the past 10 years and become popular in most Southeast Asia countries very recently.

The life cycle of mud crab

Mud crabs are normally spawned on the ocean floor with the salinity rate of 25 ppt, young crabs (with 0.8-4-inch carapace diameter) are habitat in mangrove forest after passing 6 larval development stages. Sub-adult crab (with 4-6-inch carapace diameter) are migrating into the outer coastal region.

Mud crabs are high cannibalistic in nature. Soft-shelled crab during mating for the growth are being eaten by other hard-shelled crab. In aquaculture businesses, survival rates could be decreased as they eat each other when there is less feeding rate.

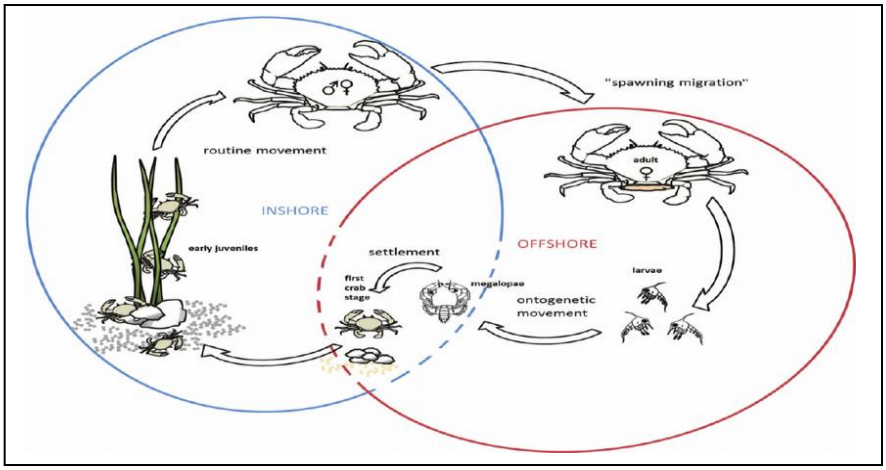


Figure 10: Life cycle of mud crabs

Table 5: Scientific classification of mud crab

Scientific classification of Mud Crab	
Kingdom:	Animalia
Phylum:	Arthropoda
Subphylum:	Crustacea
Class:	Malacostraca
Infraorder:	Brachyura
Family	Portunidae
Genus	Scylla
Species	*S.serrata*

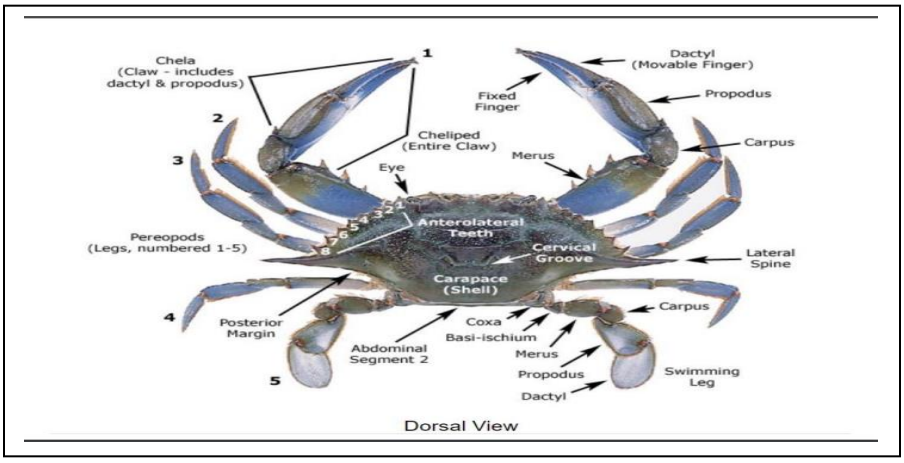


Figure 11: Dorsal view of mud crab

8.2. Fattening

Fattening is the culture of marketable crab in a short span of time. The soil should be clay type. Optimum water temperature should be between 23-32°C, salinity should be between 13-30 ppt and minimum dissolved oxygen should be at least 4 ppm and pH should be 8-8.5. Water depth should be 2.5-3.2 ft.

8.3. Fattening techniques

- Farming in earthen ponds
- Fattening in pens
- Fattening in floating cages

8.3.1. Farming in earthen ponds

The pond using this technique can be constructed in places where there is water salinity of 16-30 ppt and water exchange can be carried out with every tidal movement. However, it is necessary to avoid the places with waterway where there could be acute changes in salinity, for instance, a place nearby mountain torrent. Introducing male and female mud crab in shorter period for fattening. The height of the pond dike should be 3 ft and above of annual highest tidal level. In the middle of the pond, earthen platform should be constructed for mud crabs hiding. Always maintain the pond water depth at over 3 ft. Construct the pond floor to get harden texture.

Vertically insert the bamboo mesh in 5 ft height, with 1ft inside bottom soil along the inner dike of the pond to prevent the mud crab escaping. Connect water inlet/outlet cannel to the nearest creek or river for saving the cost. Exchange 30% of pond water in every high tide week.

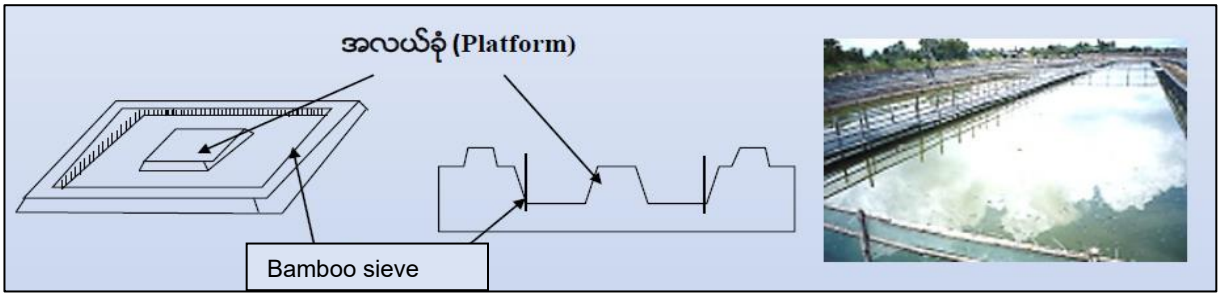


Figure 12: Pond for mud crab farming

Farming crab juveniles from hatchery

Crab juveniles of 0.6-1 cm in size can be farmed in 30-60 pieces per square meter. Crab juveniles can be fed twice per day with minced meat of less valued fish, mollusks, and crustaceans with

the rate in 100-150% of total biomass of the crab. Mud crabs gain marketable size in 4 months after the beginning of farming.

Farming crab juveniles from nature

The stocking rate of male and female crab juveniles with the carapace diameter of 4.2-inch in length and less than 3.5-inch in vertical size could be 5-8 pcs per 3 sq ft.

Feed such as disposed fishes and varieties of meat could be fed twice per day, especially in every morning and evening with the amount 5-10% of total biomass. Water exchange could be done twice per month in every high tide week.

Table 6: Feeding rate according to body weight

Amount of feed	Farming period (month)
10% of crab total biomass	First month
6-8% of crab total biomass	Second month
4-5% of crab total biomass	Third month
3% of crab total biomass	Fourth month and later months

Table 7: Survival rate according to the stocking rate to grow out ponds

Area	No. of crab	Stocking rate	Survival rate
100 ft x 100 ft	1200	1 pcs per 3 sq ft	77.03 %
100 ft x 100 ft	2400	2 pcs per 3 sq ft	65.00 %
100 ft x 100 ft	3600	3 pcs per 3 sq ft	49.17 %
100 ft x 100 ft	4800	4 pcs per 3 sq ft	32.06 %

8.3.2. Fattening in pens

Figure 13: Preparation for mud crab farming

This fattening culture technique in pens is one of the income generated business that do not cause damages to natural trees inside the mangrove forest. Since the technique itself is carried out in natural water inside mangrove forest, unlike pond water, there is very few physical and chemical problems in cultured water.

Site selection

The location for the farming site should -

- have shade by the trees, lower land area where there is tidal movement and contact such as the creek, mud flats (La Tar Pyin) etc.
- be in places with strict security
- be in place where there is easy access to collection, and procurement of crab juveniles

The capacity of the pen for crab culture should be specified depending on financial investment, human resources and availability of land. Land area can be ranging from 30 ft x 30 ft for small-scale to 1-2 acre and above for commercial scale production.

While constructing the pen, if plastic sieve or net with ½ inch mesh size is used for fencing, thick plastic sheet is sewed together in top 1.5 ft for the net with 6 ft height. 2 mm plastic string must be fitted in top and bottom of the fence.

Pillars for fence are inserted firmly throughout the area at least in every 9 ft distance. When fitting the net, cannel of at least 6-inch depth must be dig throughout the pen bottom line to bury the bottom part of the net with 1-1.5-inch bamboo stick. Cannel must be refilled with soil/mud by stepping force of the leg after inserting the net. Top and middle parts of the net must be tied in pillar to be fitted firmly.

Construct 1-1.5 ft depth and 2 sq ft wide cells for crab shelter during the lowest tide in the pen with the rate of 1 cell per 10 sq ft. Pathway should be include in the structure for feeding and checking the crabs.

Figure 14: Mud crabs in mangrove forest

Farmed crabs could be captured with crab trap. Restock young crabs as per quantities of harvest.

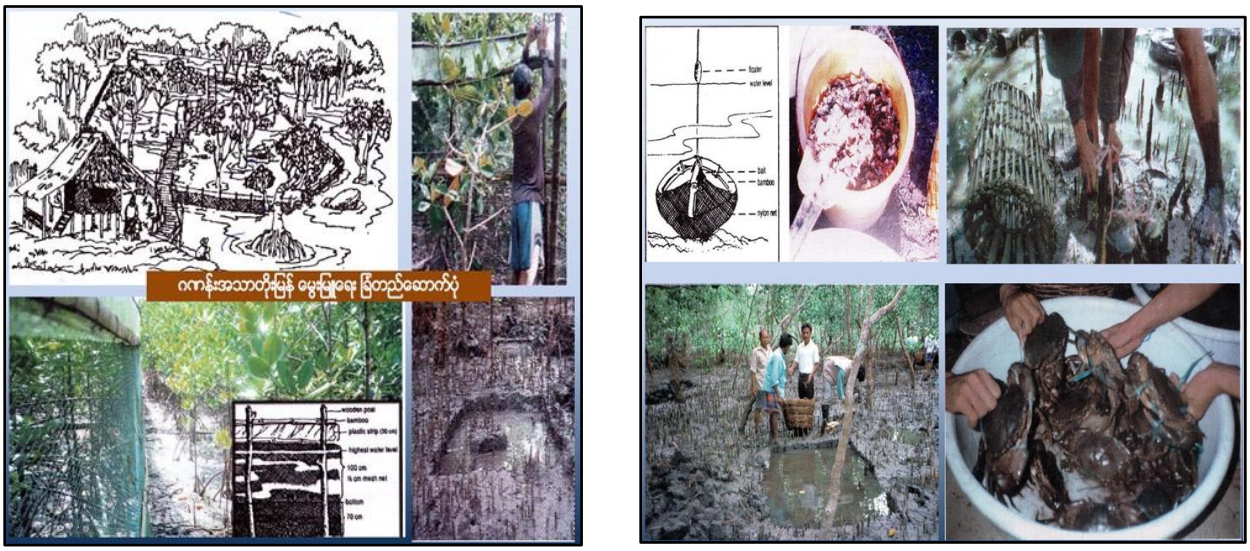


Figure 15: Constructing mud crab farm

8.3.3. Fattening in floating cages

Crab fattening in floating cages is used by local crab traders and fisheries company. Culturing crabs in cage become popular for crabs fattening and it is convenient to wait while the market price is declining.

As the culture is carried out in natural water, there are very few physical, chemical problems of water unlike in culture in the pond. Since the technique itself is carried out in natural water, unlike pond water, there is very few physical and chemical problems in culture water.

Crabs could be cultured in creek or pond with weak flow rate where there is steady wind and waves by inserting individual crab in bamboo cages which contain cells of 6-8- inch wide and 1ft depth or 4–8-inch plastic baskets used in soft-shelled crab farming. Feeding crabs, taking in or taking out could be done easily.

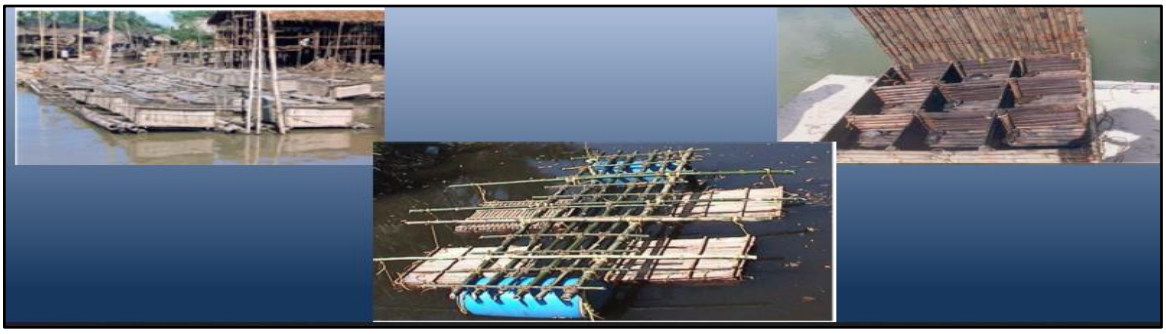


Figure 16: Use of floating cages for mud crab

Factors to be taken into account for the success of the business

- Avoid the locations where there can be sudden heavy rain falls, water pollution, places with pH lower than 4. Select the places where there is salinity 10 ppt and above, places where the tide can reach 20-25 days in a month, places with shadow and trees and secure locations (security is important).
- Do not culture only female crabs. Adequately feed the crabs as they can be fed any meat, if not they will eat each other.
- Constantly monitor the site. Keep an eye on the security and condition of the crabs.
- Provide shelters inside for hiding place and to avoid from high temperature during shell changing.
- Record income, expenditure, stocking, harvesting, numbers of crab, weight, and period.
- Evaluate the profit of the business.
- Harvest should depend on the market price. Do not let the investment lose.

Suggestions

At present, mud crab business earns daily income for local communities along the coastal region of Myanmar either by harvesting or trading. The following suggestions should be followed for the sustainable benefits.

- Avoid harvesting and trading young crabs and berried female mud crabs.
- Should also establish systematic aquaculture production instead of relying only on harvesting from nature.
- Follow the laws, restrictions periodically issued by Department of Fisheries.

9. Oyster and mussel farming

Oysters and mussels are -

- Types of species that access food by filtering out the particulates of food in the water
- Access to protein with low cost.
- Have 49 % production rate in global marine aquaculture business.
- Aquaculture of oysters and mussels does not need high investment and advanced technology.

Table 8: Global production of oyster and mussel

Species	Amount (ton)	Percentage (%)
Oysters	3,085,118	35.97
Scallops	1,269,033	14.80
Mussels	1,139,425	13.28
Clams/Cockles	1,948,934	22.72
Abalone	3,893	0.05
Other mollusks	1,130,065	13.18
Sources: FAO Fishstat in CD 1998		

(There is a wide range of production in Philippines, Thailand, Singapore, Malaysia in Southeast Asia)

9.1. Bio physiology of oysters

- Can attach to surfaces in nature.
- Difficult to differentiate whether male or female.
- Fertilization take place in the water.
- 24 hr. after hatching, spawn larvae can swim in the water independently.
- Larvae become spat after 2-3 weeks.
- Their main food includes planktons, diatom, bacteria, and organic particles.
- They have fast growth rate within 3 months.
- It takes 8-12 months to get marketable size (6 cm).

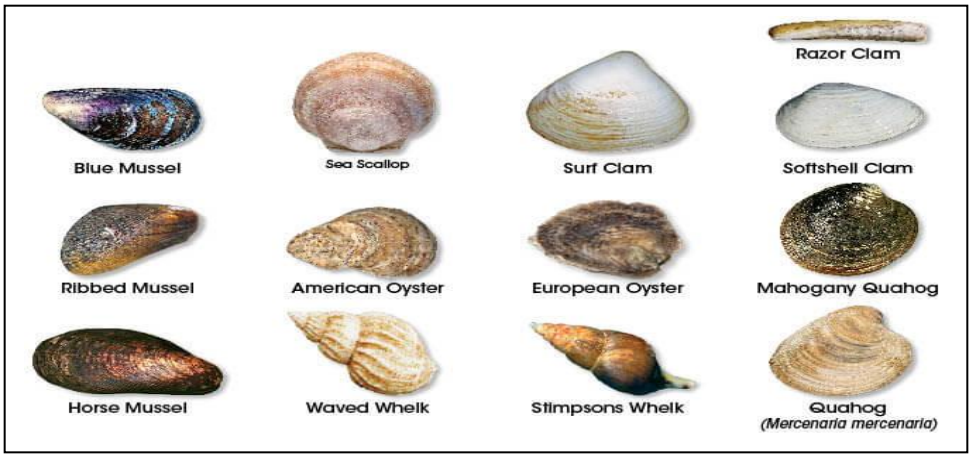


Figure 17: Difference types of shell fish

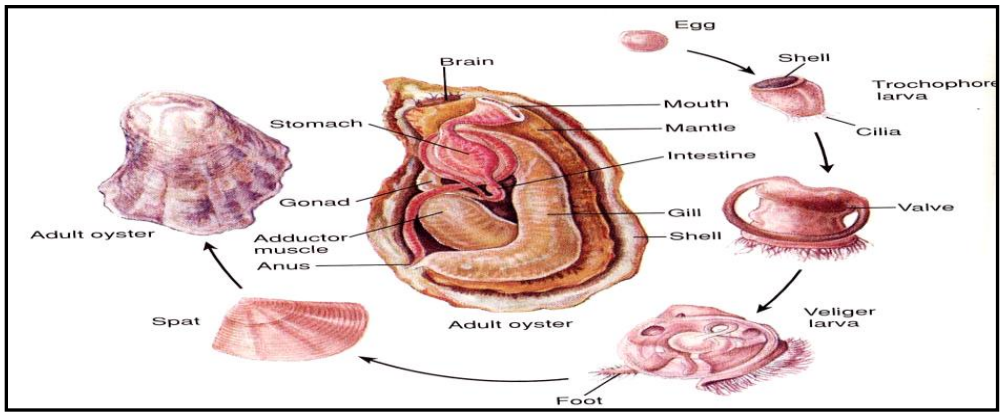


Figure 18: Life cycle and morphology of oyster

9.2. Morphology and life cycle of oysters

Anatomy of green mussel

- Adult mussels can attach to fibers growth on hard surfaces.
- Become adults as male or female when the carapace width arrived 20-30 mm (around 1 inch).
- Difficult to differentiate male female.
- Average growth rate = 1 cm per month (depend on availability of feed)
- Duration for marketable size=4-6 months.
- The flesh portion in 3-inch size mussel could weigh about 40-45 % of total body weight.
- Can fertilize in the water.
- Duration to reach fertilized larvae = 24 hr.
- Initial movement started in the water = 15-20 days

They start to attach and settle once they stop swimming.

9.3. Site selection for oyster farming

- Must be the place where there is high larvae attachment rate and sufficient male and female for the collection of young larvae.
- Must be the place protective to waves and wind. Should not be the outside of the shore and there should be some supporting for the attachment before the larvae flowing into the sea.

- Choose the place where there is greenish color water as such water have high concentration of food and nutrition.
- Tidal movement should be sufficient to exchange old water. The higher the tide, the faster the growth.
- Flow rate of the tide should not be more than 2 cm per sec. When there is slow tidal flow, growth rate of oysters and mussels are slow.
- The site should not be too far from source to prevent decrease in salinity during raining season. Salinity could also decrease when it is too far from the sea.
- The site should be near to market or the route to the market.
- The site should not be with water pollution. Although water pollution could not affect the oysters and mussels, but their flesh become unfit for human consumption.

9.4. Oysters and Mussels farming techniques

It took a year from spat collection to harvesting)

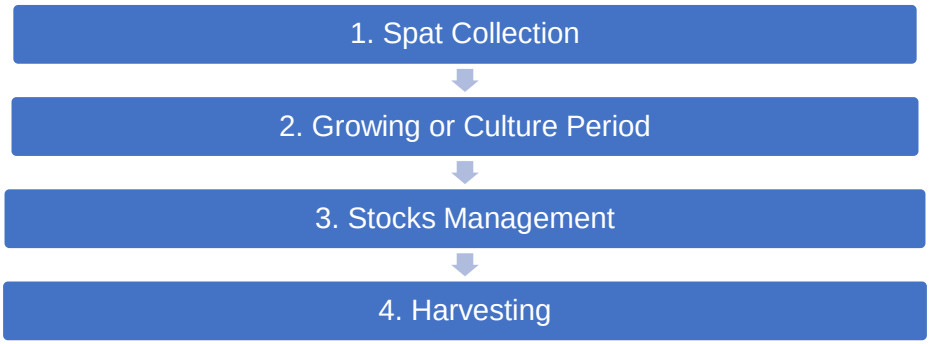


Figure 19: Farming procedures of oysters and mussels

9.4.1. Spat collection

Oysters and mussels farmers should be aware the spatfall season within the region. Spatfall season could be forecast and depends on the following environmental conditions.

- Yellowish and itchy water
- Condition of brackish water
- Attachment of barnacles in spat collection utensils

For the establishment of oyster spat collector equipment -

- Empty oyster shells
- Bamboo poles
- Nipa petioles
- Mangrove tree branches
- Old tires
- Straps – nylon, rubber, plastic

9.4.2. Common oyster farming techniques

- Bottom farming
  - This is the simplest and cheap technique.
  - Most commonly used attachment materials are–
    - Empty shell
    - Old tires
    - Stones
- Spread the materials for attachment in designated locations.
- Harvest the attached oysters and mussels after removing the materials for attachment.

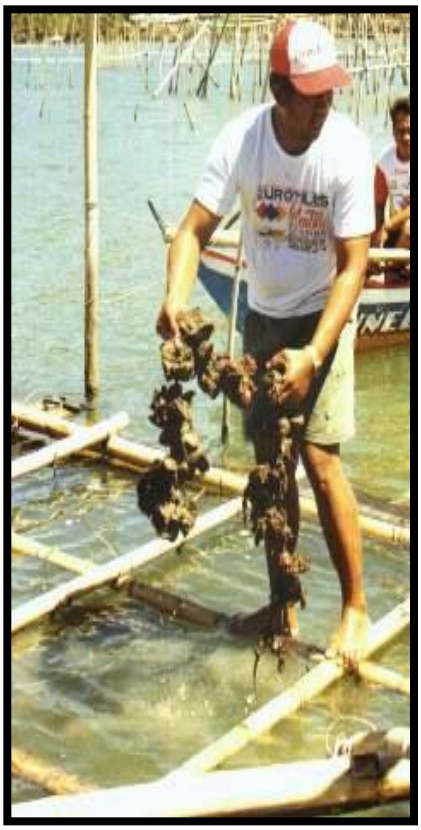
Figure 20: Oyster farming with rack and bag method

Figure 21: Oyster spat collection with bamboo poles at the water depth of 3-7 ft

Figure 23: Making floating raft with plastic container

Figure 22: Attaching plastic containers to raft

Figure 24: Setting raft for oyster farming



- *Oysters with marketable size can be harvested.*
- *The strings tied to the poles can be cut off for the entire harvest of oysters*

"Mangrove Forests"

(By Gangadharan nair Pulingat, 2014)

"Mangrove forests, beautiful mangroves
Vital for ecosystem and water species
Fishes, and shrimps they give protection
As well as convenient habitat in safety.
Mangroves place of biodiversity
Strengthens the ecosystems of rivers and lakes
An ideal place to fish farming it provides
As well as the natural beauty and greenery.
Mangrove forests in the brink of destruction
The human intervention and land filling
Conservation of mangroves a necessity
And planting mangroves is only solution.
Mangrove forests the great asset of earth
Water sources from rivers, lakes makes clean
The recharging of water through mangroves
May be a great boon to rejuvenation of rivers.
Visual treat, beautiful it is from mangroves
In distant vision it gives such pleasantry
The birds different types and colors plenty
Their lovely natural habitat one is mangroves.
May the coverage of mangrove forest increased
Through the tree sapling planting and conserve
Hundreds of acres of vacant river embankment
Make it green through mangrove planting
A great help to maintain the clean environment".

10. Reference:

- Mangrove Friendly Aquaculture Handouts by Win Sein Naing (MSN)
- Mangrove Friendly Aquaculture Manual by FAO