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AQUASILVICULTURE: A NOVEL SAFEGUARD FOR MANGROVE ECOSYSTEM

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Introduction:

Aquasilviculture can be defined as the integration of aquaculture with (mangrove) forestry. It is a mangrove friendly aquaculture technique. This management strategy combines and harmonizes fish production and mangrove development. Such system commonly used in Indonesia and Vietnam. An example of aquasilviculture in the Philippines is the 4.4 hectare farm of Melchor and Necitas Sur in Puerto Galera, Mindoro. Most countries of Asia don't have any systematic aquasilvicultural and the countries where mangroves are being continuously harvested for fuel, wood construction fetching material and other things reached its maximum level of sustainability. It is not only confined to subsistence small-scale fisheries but also occurs on a commercial scale (Castanos, M.T., 1999). India has a vast area of mangrove and management strategy should take place. In India, pilot studies are being done for the past few years. In, 2010 National Institute of Ocean Technology (NIOT), Chennai has practiced Aquasilviculture in Andaman & Nicobar Islands for fattening of crabs such as *Scylla tranquebarica*, *S. olivacea* and *S. serrata* in the available mangrove area. 60-80% of the total area was allotted for mangroves. Within 30-35 days they achieved 85% survival and 8% increase of the initial stocked weight (Santhanakumar *et al.*, 2010). This new emerging technique in aquaculture will help in resource management and help address problem such as reforesting the disappeared mangrove forests, utilization of available coastal resources in proper way without affecting the native living forms, providing additional employment to local fisher folks and also support fishermen during banned seasons.

Types of Aquasilviculture:

There are two types of system: Mixed system and Separate system (Johnston et al., 1999; Clough *et al.*, 2002). The mixed system has channels dug through the mangroves with vegetated dikes or levees whereas in separate system the mangroves are grown separately

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next to the pond and levees. The systems can be classified into four different types based on reflecting intensity and species focus such as:

(1) The traditional mixed mangrove farming system relying on natural stocking (mainly *Metapenaeus* species and to some extent also *Penaeus indicus*). Secondary fisheries products in this system consist of fish (mullet) and mud crabs.

(2) Natural stocking and also hatchery reared shrimps.

(3) Both hatchery reared shrimps and mangrove crabs (Scylla serrata).

(4) Blood cockles (Anadaragranosa) are added to the shrimps and the crabs (Minh, Yakupitiyage and Macintosh, 2001; FitzGerald 2002).

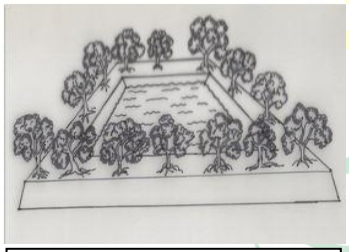
Recommended models for Aquasilviculture:

i) Peripheral model:

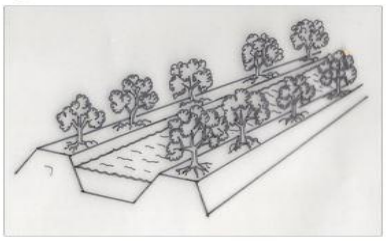
In this model mangroves are placed outside the pond with ratio of 70:30 or 80:20 mangrove plantations to pond area. This way, the fish farmers save the mangrove stand against illegal mangrove cutting and benefits from the sale of seedling (propagules) produced for contract reforestation of denuded mangrove areas. This act as a natural fencing for the pond as well as prevent soil run off.

ii) Canal model:

In this model mangroves are placed on the periphery of the canal.



Peripheral Model



Canal Method

Aquasilviculture technique around the world

INDONESIA

In Indonesia, the integrated practice of mangrove plants and aquatic species is called *Silvofishery*. There are two basic silvofishery models used in Indonesia. One of the models consists of mangroves within the pond with a ratio of 60-80 percent mangroves and 20-40 percent pond canal for aquaculture. This is called *Empang Parit* in Indonesian language. The rest one consists of mangroves outside the pond with similar mangrove to water ratio. There

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are a variety of designs within these basic models. The silvofishery farm ranges in size from one hectare to thousands of hectares at each site. The fact is that this integrated silvoaqua-culture is practiced in the mangrove area. It represents the greatest level of reforestation or maintenance of existing forest.

PHILIPPINES

In Philippines fishing villages are located in arable land plains along fringes of coastal lines. Sea is the main resources base of the villages. Adjacent to or near to the villages there are also large areas of tidal flats where mangroves have naturally developed. These areas are very much potential for aqua-mangrove integrated farming. The tidal flats with mangroves are also utilized for the culture of mud crabs which can provide the fishing communities with alternative livelihood option or source of additional income. In enhancement planting, horizontal branches of old trees are pruned to create an opening to permit sunlight enough to nourish young plants.

VIETNAM

Integrated mangrove-aquaculture farms are usually found at Camau Province of Vietnam. On each farm, forest cover accounts for approximately 60-80 percent of the total land area and the remaining 40-20 percent comprised of aquaculture canals (average: 3 m wide 0.3-0.7m deep) and levees. Each farm is operated by traditional mixed forest-aquaculture. It is a tidal sluice gate fishery based on both natural shrimp recruitment and stocking of black tiger shrimp and mud crab. Natural shrimp recruitment and harvest occurred, every 15 days, on consecutive flood and ebb tides for 4-5 days and nights of the spring tide period. On the flood tide, the sluice gate is opened for 3-6 hrs and shrimp post larvae (PL), juvenile shrimp and fish swim through the mesh of a bag net positioned in the sluice gate (mesh approximately 1.5-2.5 cm) into the pond while adult shrimp (mainly *Metapenaeus ensis* and *M. lysianassa*), mud crab and fish (mullet, rabbitfish, tilapia) are caught in the bag net. Following recruitment, the sluice gate is closed and once the tide turns, the gate is reopened and the canal system partially drained on the ebb tide with shrimp and fish caught in the bag net. Following recruitment and harvesting the sluice gate is closed for 10 days during which time the recruited aquatic species have a grow-out period of 10-14 days before the next recruitment/harvest.

HONG KONG

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Another traditional aquaculture system evolved in Hong Kong, perhaps centuries ago. Gei Wai basically utilizes the positive attributes of natural mangrove forests as nursery and breeding grounds for fish, crabs, mollusks, and shrimps. Wide channels, around 1-3 m in depth, are excavated around what becomes a small island of healthy mangrove forest. The channels allow the several hectares or more of each Gei Wai pond to hold sufficient waters at low tides to sustain the captured shrimp and fish. At high tides renewed sources of nutrients enter the ponds through constructed sluice gates to sustain pond life anew. Up to 1900 kg of shrimp can be raised and harvested annually from one Gei Wai. In the mid-1990's, there was only one remaining area of Hong Kong, called Mai Po, which borders Deep Bay, where Gei Wais were still found. These few remaining Gei Wais are protected as a nature reserve by the Hong Kong Government. The World-Wide Fund for Nature Hong Kong has managed this site since 1984, utilizing the sale of its harvested shrimp to help subsidize the expenses involved in site management. One of the greatest recent threats to the Mai Po reserve and its Gei Wais is the intrusion of mounting water pollution from mainland China. Fish and shrimp varieties and populations have already declined.

THAILAND

Ban Chi Mee village is located in Kapoe District, Ranong Province of Thailand. Since 2005, the villagers of Ban Chi Mee, Ban Dan and Ban Bang Lam Poo have been actively managing 686 rai of mangroves for the community to use. The community that uses the mangroves made up of approximately 210 households from the three villages: Ban Chi Mee (150 households), Ban Dan (30 households), and Ban Bang Lam Poo (30 households). They used the resource for collecting fish, crabs, and they collect mangrove wood for household building use. After the tsunami in 2005, these three villages decided to work together to conserve the mangroves because they noticed growing environmental problems and declining resources. A series of charcoal concessions were granted by the government to private investors to cut-down the mangroves. Several times a year the community does management activities, for example mangrove plantation days on father's and Mother's Day. The community participates very actively in these activities, and plantation days typically draw about 80% participation from the community. The community also runs a mangrove nursery with ten varieties of mangroves. Seedlings are sold for five baht each and profits made from

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the nursery cover most of the mangrove management costs (petrol for boats, transport to network meetings etc).

Aquasilviculture technique in India:

ANDAMAN AND NICOBAR

There are many forms of aquaculture, such as oyster, crab, fish and prawn culture enclosed either in pans or cages, which may be undertaken in mangrove swamps without destruction of the habitat. Mangroves apparently play an important role in the supply of nutrients to the fisheries in adjacent coastal areas and thus yield two main harvestable resources, timber and fish. In coastal areas shrimp culture is practiced by means of a pond constructed inside the natural mangrove forests. The ponds are connected to coastal waters through channels and during daily high tides the sea water flows into the pond. Outflow of water and shrimps is controlled by sluice gates. The shrimps feed naturally on minute organisms and other dead bodies. About 30 to 40 days of harvest is possible. Fish ponds may also be constructed behind mangroves without destruction of vegetation. Thus, the aquasilviculture system (called tumpang sari in Indonesia) in which the shrimp pond is built behind the mangroves (landwards) is a good approach for preserving and harvesting shrimps without any damage to the mangrove ecosystem. *Avicennia, Sonneratia, Rhizophora, Ceriops and Cynometra* mangroves are considered good fodder trees and may be raised in paired rows 1 m apart in mangrove swamps. Details of utilization and management of mangrove forests have been given by Dagar *et al.* (1991).

Advantages of Aquasilviculture

The main focus in this idea is to reforesting the disappeared mangrove forests, Utilization of available coastal resources in proper way without affecting the native living forms, providing additional employment to local fisher folks and also support fishermen during banned seasons**,** holds soil & prevents its erosion & pollution of sea, Input capital is low, Construction is easy with locally available materials. The unique roots system of these trees hold up the land tightly in this way the marine forest protect the terrestrial border from natural calamities, currents, tides, strong winds and waves. At the same movement, they can also provide food and shelter for many fish and other organisms.

Disadvantages:

- Greater difficulty to manage,

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- Reduced water circulation and greater potential for stagnant areas with low oxygen levels,
- Limitation on species cultured (**e.g.** seaweed would be shaded by trees, reducing growth),
- Mangrove trees reduce the penetration of sunlight to ponds lowering the productivity of phytoplankton and benthic algae,
- Potential toxicity of tannin from mangroves.

Construction of ponds

Site selection: The site should have a water depth between 30cm to1.0 m during high tide. There must be sufficient supply of marine/brackish water throughout the year. The site must be free from big waves and pollution and protected from environment hazards such as floods. It should be secured from poachers and must be accessible at all times.

Pond preparation: Design the enclosure with shapes that may vary from square, rectangular depending on the contour and vegetation of the area. Area of the enclosure may vary but manageable size range to 1,000 sq m. The net enclosures were installed (PE net 1-2 cm mesh size) and other materials (bamboos, netting materials and wooden post as structural frameworks. The upper portion of the net was extended not less than 30 cm above the water marks of the highest tide level. The net enclosure will be tilted 45 degrees inside the pond to prevent the escape of mud crabs. Ditches/puddles were dug with a depth of about 20- 40cm representing at least 30 percent of the total area of the enclosure. These were intended to hold the water in the enclosed area during lowest low tide.

NOTE: Cutting the main roots of mangrove during the digging must be avoided. Aquasilvi pond preparation, fertilization will be undertaken prior to stocking.

Maintenance: Regular monitoring of the stocks, cleaning and removing of decaying left over algae and other debris being entangled on the screen. Thinning is done to make sure that all of the stocks grow optimally. It is also necessary to guard the cages against poachers and vandals. Water quality parameters such as dissolved oxygen, temperature, salinity and turbidity were monitored also to determine fluctuations that may affect the condition of the cultured species.

Future prospects:

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The government is committed to achieve food security for the people, increase fish production and improve standard of living of coastal fisherfolks. Therefore, there should be continuing rehabilitation of denuded mangrove areas and make the coastal fisherfolks sustainably productive through aquasilviculture. Mangrove areas reported as rehabilitated should be validated and assessed in terms of surviving propagules planted, as well as to the extent of cover. Fisherfolk communities should be continuously organized and empowered through training and information dissemination to conserve and protect mangrove areas. Stock assessment studies should be conducted in this area to determine the improvement of catch in fisheries products.

Conclusion

The decline of mangrove resources in our country has significantly reduced the productivity of coastal fisheries due to a continuous decrease in fish capture by the fisherfolks. This is an alarming scenario that could be prevented through the collaborative efforts of the government**.** Many trail experiments have taken place around the world and proved its worth. This culture practice is still in the subsistence level not in the intensive or commercial farming in general. With better planning aquasilviculture technique economically sound good and ecologically sustainable and socially acceptable. This culture technique deserves to be recommended as one of the best coastal adaptation practices.

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