IMPACT ON THE MARINE ENVIRONMENT BY SHRIMP FARMS

INTERNATIONAL CASE STUDY

JULY 2020

Project of The Pearl Protectors

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The Pearl Protectors

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Abbreviations

NOAA - NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NAQDA - NATIONAL AQUACULTURE DEVELOPMENT AUTHORITY

EFL – ENVIRONMENT FOUNDATION LIMITED

MSGS - MONODON SLOW GROWTH SYNDROME

WWF – WORLD WILDLIFE FUND FOR NATURE

WSSV – WHITE SPOT SYNDROME VIRUS

Project Title

- An investigation into the impact on the marine environment due to shrimp farming in the world.

Project Objective

- The main aim of this report is to identify the impacts of the marine environment due to shrimp farming. This country profile analysis examines and identifies the major impacts while highlighting reactions taken by the respective countries.

Introduction

Aquaculture is the breeding, rearing and harvesting of fish, shellfish, algae and other organisms as in all types of water environments. (NOAA,2011) Aquaculture serves many purposes such as:

Food production for human consumption

Rebuilding of populations of threatened and endangered species

Habitat restoration

Wild stock enhancement

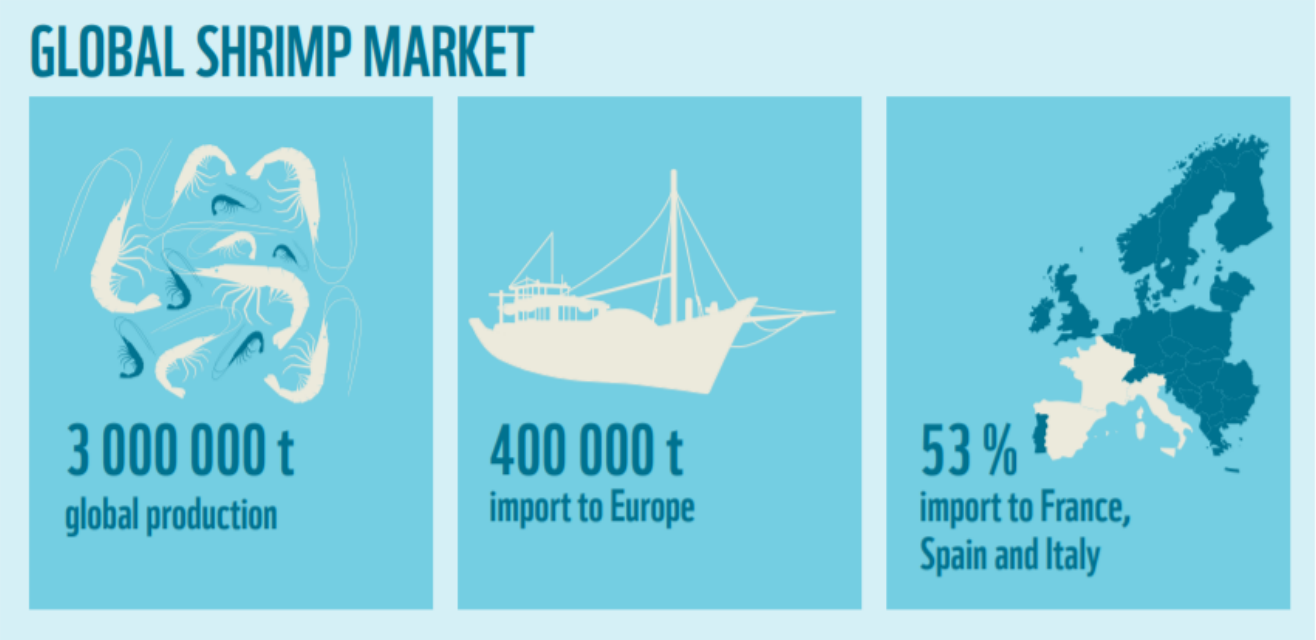
Production of baitfish, Fish culture for zoos and aquariums.

Aquaculture is one of the world's fastest-growing production systems at an annual rate of 8% and contributes 44.1% of the world fish supply of 167.2 million tones. (FAO,2016) It is also mentioned that 500 million people of developing countries directly or indirectly reply through fisheries and aquaculture (Jayanthi,2018).

In general, referring to aquaculture techniques and technologies there are 3 types of farming: marine water, freshwater, brackishwater and mariculture aquaculture. Shrimp production mainly belongs to marine aquaculture. There are also 3 culture technologies such as extensive, semi-intensive and intensive

culture. Shrimps are the second most traded seafood commodity in the world with exporting $11 billion, 15% of the worldwide seafood business.

Although in present global attention has drawn to shrimp aquaculture was not because of economic upliftment but also due to environmental issues raised over the unregulated and unsustainable development acts. (FAO,2016) According to researchers, it indicates that one-third of mangrove forests worldwide have disappeared in the last 20 years, 35% lost aquaculture and may reach up to 60% by 2030.



(WWF,2017)

Accordingly, the negative impacts of Shrimp farming (Geo Sri Lanka,2018)

- Rich and diverse mangrove trees and marshlands that bear a distinct number of species and animal lives are cleared for pond construction and fringing habitats get heavily degraded. That can lead to the reduction of animal breeding and feeding habitats.

- More possibility of eroding the coastal areas and facing natural disasters severely, such as Tsunami.

- Managing shrimp farms requires the application of nutrients and chemicals (pesticides, lime). When discharged, this polluted water cause eutrophication which blooms algal and severs oxygen depletion which leads to higher levels of shrimp mortalities.

- Salinization of freshwater aquifers which degrades domestic use and agricultural water supplies. The abstraction of groundwater to freshwater may cause pollution.

- Constructions of artificial shallow ponds for farming disturbs the drainage pattern in the area resulting inundation of areas during monsoon rain.

- The self-pollution of the tanks may cause shrimp diseases reducing prawn productivity and increasing the vulnerability which impacts farmers' household income. Mainly fishermen who rely on daily income will be highly affected.

- According to (Abdullah,2016) says Bangladesh has lost a huge amount of mangroves and associated biodiversity due to shrimp aquaculture expansion. Also converting agricultural land into shrimp farms made a loss of agro-biodiversity and livestock and increased soil salinity. Which predicts these ecological impacts may likely be exacerbated by climate change.

Positive Impacts of shrimp farming

- Generate income for farmers
- Creates and boosts the income of the country mainly foreign exchange earnings from exports.
- Able to represent the country in the world economy.
- Opens the trade into new industries and exchanges.

Most recent and current issues in Sri Lanka

- According to (EFL) Wedithalathive Nature Reserve is situated in the North-Western coast, which adjoins Vankalai Sanctuary in Mannar District. This location is a very rich and vibrant ecosystem consisting of mangroves, tidal, mudflats, saltmarshes, seagrass beds and coral reefs. It was declared as a Nature Reserve in 2016 February 25th under Flora and Fauna Protection Ordinance Wedithalathive.

- As reported by (EFL) the Aquaculture project proposed by NAQDA in 2017 (NAQDA) was to de-gazette the reserve. The paper was co-sponsored by the Minister of Fisheries and Aquatic source and Minister of Sustainable Development, Wildlife Conservation and Buddhasasana. The main objective of the project according to NAQDA is to pave the way to foreign currency to enter the country's economy. The main project proposed is to grow fish and shellfish, including exotic prawn species named *Litopenaeus vannamei*. In 2016 the government declared nearly 30,000 ha of the area.
- The main importance of this location Wedithalathive is, it hosts three main ecosystems that are essential to the biodiversity such as mangroves, coral reefs and seagrass meadows.

Wedithalathive Nature Reserve. (Rodrigo,2020)

- Shrimp aquaculture is one of the major threats for mangroves which causes distraction both environmental and social problems. (Guebas,2002)

- Aquaculture is focused on relation to natural ecosystems and human-built agro-ecosystems in inland terrestrial and aquatic, coastal offshore, land and waterscapes. This is known as a traditional practice up to less than 30 years in Asia as locally available resources were nutritional inputs available for farmers. (Edwards,2015)

International Analysis on Shrimp Farming

Thailand

Referring to (FAO,2016) The shrimp farms began in the 1930s because of the dependence on natural tidal flow for seed and naturally occurring food organisms. Semi-intensive farming started in the 1870s and was replaced with intensive farming beginning in 1987.

Gradually by 1987 Thailand involved in intensive farming with Penaeus monodon was the most favoured species as they were able to produce hatchery of postlarvae and grow faster under semi-intensive conditions. Comparing intensive farming with intensive farming methods, semi-intensive used smaller ponds 1-8 ha densities range from 5 post larvae per square meter to 10 PL/m^2, Which has now doubled to 20 PL/m^2. The farm productions raised from 1000kg/ha/yr. to 4000-10,000 Kg/ha/yr.

Although higher stocking densities and productions have increased the negative impacts of shrimp farming such as yellow head virus in 1992 and white spot syndrome virus 1994. To neutralize this problem semi-closed intensive shrimp farming was introduced where stocking densities were 40 – 60 PL/m^2 which increased the production from 309,862 tons. By 2002 Thailand faced the most significant outbreaking disease named, monodon slow growth syndrome (MSGS) which ended P. Monodon farming and introduced a new type Pacific white shrimp P. Vannamei from 2003-2004. Due to the lack of care for various diseases rose up and its rapid growth ushered in problems with environment and food safety. Which during the outbreak from 65,000 – 78,000 million PL/year fell to 52,000 million PL/year.

Major issues in shrimp farms

- Seed supply can be poor quality diseases or unavailable.
- Increases in outbreaks of Black Gill disease in grow-out ponds lead to crop failure.
- Lack of effluent of management has led to excessive use of chemicals, pesticides and nutrients

Concerning all these issues, the main sustainable practices followed by Thailand were

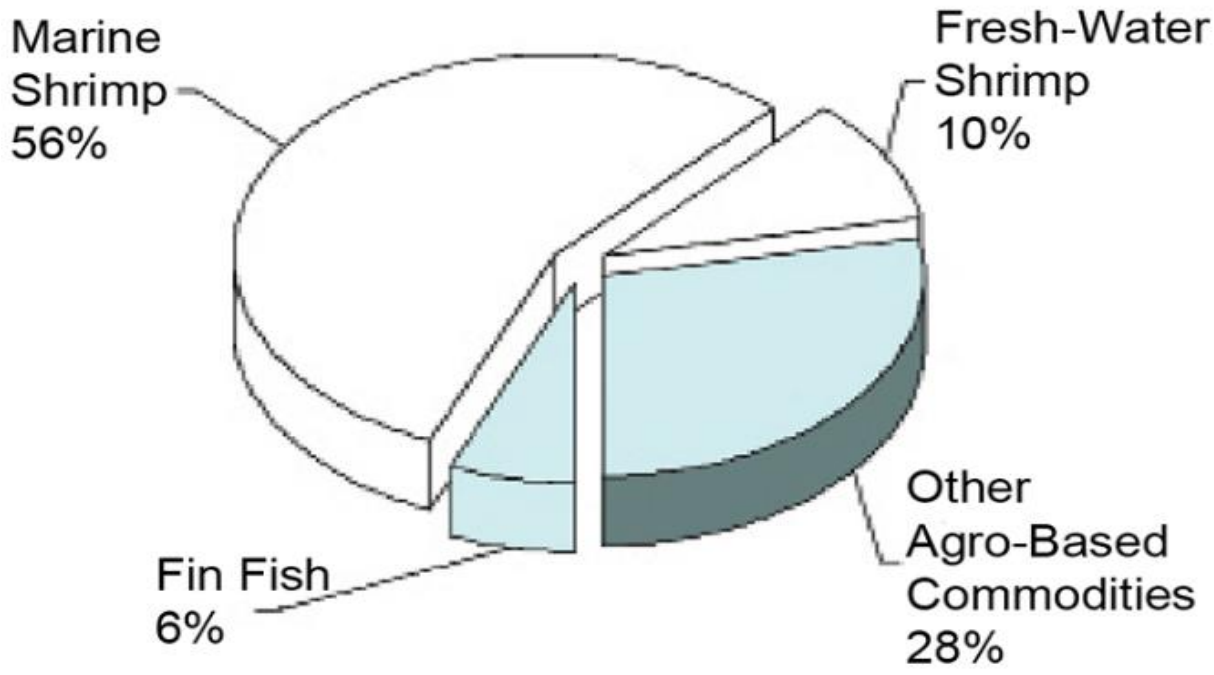
Feeding for shrimp farms in Thailand registered with feed producers with the department of fisheries. 50 to 100 companies started supplying farm chemicals and materials for water disinfection, improvement and management. They used high quality, high protein feed. Automatic feeders are introduced.

Low water exchange culture was practised to minimize the discharge of pollutants and reduce the risk of contamination with diseases or new predators entering the pond with water from external sources. Low water exchange must be complemented with sufficient aeration for low levels of oxygen. Poor water quality is treated with lime, dolomite, zeolite or water exchange.

Biosecurity with the intensification of shrimp farming. To disinfect water and hatchery materials quarantined broodstock, certified specific pathogen-free methods are practised. Physical measures are taken such as wearing necessary clothing materials to prevent new vectors entering the water body.

Bangladesh

The background for agriculture activities in Bangladesh is quite low. Although the shrimp farming in rural Bangladesh rose up as a significant economic activity for reducing poverty, generating employment and increasing exports earnings. The annual contribution in the U.S $360 to 365 million. The shrimp export ranks second in earning foreign exchange for Bangladesh. The below diagram indicates the contribution of shrimp and fisheries export. Bangladesh is known as the 5th largest aquaculture production, which is 1986 to 2,203,554 metric tons in 2016, 15 times of increment.



Bangladesh has over 55,000 marine shrimp farms that have an average size of 3 ha and a single pond are larger than 40ha. The shrimp farms currently cover 170,000 ha coastal districts. In Bangladesh, brackish water shrimp culture is most popular and practiced in low-lying tidal flood plains within water development boards. Also, in some areas, domestic ponds connected by tidal creeks are used for shrimp farming other than domestic washing.

The production technology differs from other countries as 55 marine shrimps' operations are located along high salinity southeastern coasts while some remain in closed type hatcheries in low salinity of southwestern zones. Brackish water aquaculture is alternated with a variety of salt resistance. During the high salinity period from February to July is shrimp- farming season, while rice is cultivated during freshwater months from August to December. In some high salinity areas aquaculture is rotated with saltwater.

One of the specialties in Bangladesh shrimp farming is that the farmers do not use artificial feeds or antibiotics, it is mostly done associated with naturally occurring brackish-water fish and other shrimp species. The mixed culture of black tiger Penaeus monodon is common to be grown in low salinity areas.

White spot disease was common in Bangladesh during 1994. The closed system culture managed to reduce the cause by using bleaching powder to disinfect ponds from 70ppm and recently trichlorfon was used at 2ppm.

Current issues faced by farmers are

- promotion of group farming to benefit small farmers.
- Increased availability of diseases screened post larvae.
- Farmers seek more sustainable methods for disinfecting and feed at the same time inexpensive.
- Seeks for field kit equipment for quick screening for WSSV.

Alabama State in USA

As for (Whitis,2007) the shrimp farming industry in Alabama began in 1999 in Greene Country with active producers of 25 pounds spread over 75 acres. Alabama has hit up to $1 million, 350,000 pounds sales of live shrimps. Inland marine shrimp farming is quite common in Alabama with the presence of two deep ancient deposit undergrounds that are known as saltwater aquifers. This water is extremely salty which cannot be used for human consumption but for aquaculture to grow shrimps. The shrimps were grown mostly with a mix of catfish which became more popular where many farmers were inspired from Eastern and Southern areas of Alabama. The farmers continued digging new wells, expanded their production acreage, built new ponds. For each pond, the crop average was 16 shrimp to the pound. Shrimp production runs from May to October.

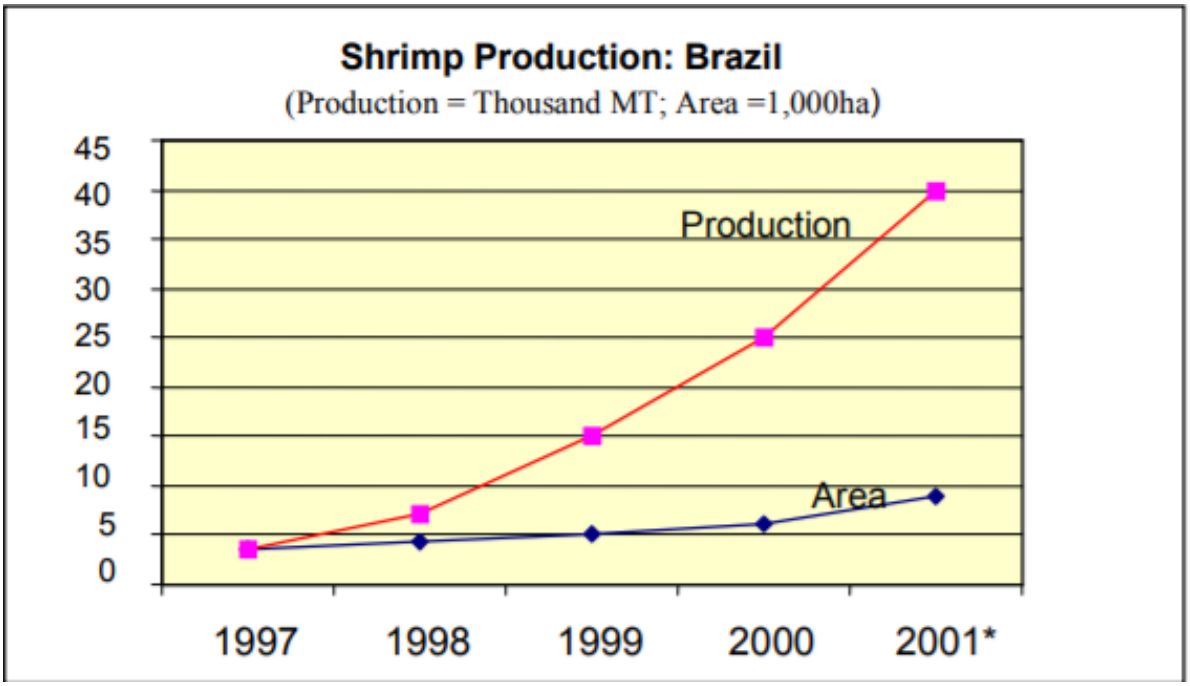
Issues in shrimp farming

- Farmers started destroying the natural environment to build more ponds that became unsuccessful. New problems rose after locating ponds more than 100 miles from the coast.
- Completely lost when heavy rainfall dilutes the pond's saltwater, the survival rates become very low.
- Although the shrimps had grown well their numbers were not high enough for commercially viable.
- Climate change is highly affected at the post larva stage.
- Aquatic insects such as dragonfly nymphs, green sunfish decimate the newly stocked shrimps. The post-larvae stage becomes their prey.
- Farmers have been unsuccessful in marketing their shrimps to large scale national food wholesalers due to price completions from producers in the area.

In 2000 the aquaculture specialist David Teichert Coddington conducted a researcher constructed 32 acres of shrimp wells drilling up to 650 foot-deep. The wells were filled with diluted seawater and stocked with postlarvae. The project was unsuccessful due to water chemistry.

Brazil

The shrimp farms in Brazil began between 1972 – 1974. The common type of shrimp was *Penaeus vannamei* in Brazil (Bunge,2015). *Penaeus vannamei* reached 90190 tonnes produced from 14 824 ha of shrimp ponds. In 1998 there were 100000 farms occupying an area of 80000 ha. From 1993 well-organized farms were showing profits although the production technology was not constant and being developed. By 1998 stocking density increased up to 30 PL/m^2. The farms that were stopped due to lack of technology were reactivated and new arms were built. The current state of Brazil is that most farms have implemented semi-intensive methods with *P. vannamei* and *p.subtilis* and adopted innovative management techniques. The production seems to have doubled every year. In present, the stocking density has increased up to 30 PL/m^2.



The graph above indicates the production in relation to the area for shrimp farming.

Brazilian shrimp production from 1997-2001

Year	1997	1998	1999	2000	2001*
Area (ha)	3,548	4,320	5,200	6,250	9,000
Production (MT)	3,600	7,260	15,000	25,000	40,000

Source: Brazilian Association of Shrimp Producers (ABCC). *ABCC projections.

Issues in shrimp farms

- Not enough production technology and developing cost a lot of money.
- Importing broodstock was extremely complicated for logistic reasons, also growing broodstock within Brazil posed formidable challenges.
- There had been a spread of diseases from time to time such as Taura syndrome in 1994, WSSV, NHP.
- The average stocking density of Brazil is 25 PL/m^2. The lack of infrastructure and technological skill to manage such high biomass of shrimp in their ponds.
- Due to lack of infrastructure facilities the survival rates and the appearance of diseases is high.
- Aquaculture is criticised due to the usage of large quantities of fishmeal. In future, it is expected to reduce fishmeal consumption which will decrease electrical energy use will rise.
- There's more tendency to rely on fossil-fuel power plants which are not environmentally sound.

In 1994, Brazilian shrimp farms were struck with Taura syndrome which arrives with a specific pathogen-free animal from Hawaiian causing spread among hatcheries and throughout the productions in the region. The farmers lose up to 80% in some farms. The farmers were able to adapt the animals to Taura by practicing more advanced methods of pond management.

Management Practices

Shrimp farming requires high technical practices to manage and increase productivity and to avoid contamination**.** The measure includes such as water exchange, chemical and biological treatments and the application of food to supplement the diet of animals. Some of the issues faced during shrimp management

- The exact amount of feed to administer to a shrimp pond or a fish cage when water quality conditions are below the optimal or when the biomass of naturally occurring food organisms is depleted is unknown.
- The stocking densities may vary from culture site to site depending on biotic and abiotic factors.
- Increment of feed input and excessive stocking densities can potentially exceed the maximum carrying capacity of the culture environment, which may lead to environmental damage and excessive aquaculture waste.

The pond construction in Brazil is limited to specific areas. Brazilian have an immense amount of land reserve apart from the mangrove regions. According to environmental laws, the cutting down of mangrove trees has been prohibited. The Brazilian believe cutting down of mangroves seems not to be a ‘good business. It is also stated that the mangrove areas are frequently affected by the tidal flow, which makes it difficult to harvest shrimps and to dry out ponds for the next harvest.

Environment agencies fail to control most of the small farmers who do not have the mobility to go elsewhere to farm and expand it as the farmers are large in number and due to strong local support. Most of the farmers do not give attention to sustainable practices or limit stock density but rather only in increasing the stock rates. These practices are not ecologically sustainable in along that causes a widespread of diseases.

The environment laws that are implemented against the mangrove environment are

- Farmers who develop aquaculture require an environmental license from appropriate authorities at the federal state levels such as (IBAMA) the National Agency for Environment. “Ecological Reserves or Stations” ARE PROTECTED BY National Law on the Management of Coastal Areas under (Law 7661/88).
- Construction of ponds requires another license from state-level and it is granted depending on the particular characteristics of the project: Environment assessment required.

The legal steps of developing shrimp farms

Licenses required	Construction of ponds (with local or state agencies for the environment) Introduction, reintroduction, and transportation of species (with appropriate federal authorities) Commercial cultivation (with appropriate federal authorities) Transportation of shrimp (with appropriate federal and state authorities)
Registration	In the General Fishers’ Registry
Land Tenure	Coordination with the appropriate authorities (Term of Lease), Payment of annual tax (the *foro*)
Use of Water Bodies	National Policy on the Use of Water Resources (Law 9433/97): In the near future it is highly likely that all Brazilian federated states will enact specific laws on local water concessions.

Indonesia

Accordingly, aquaculture and fisheries productions are the main sources of income in Indonesia. Aquaculture produces 30% while 70% is from fisheries production. In Indonesia aquaculture is divided into three main groups mainly freshwater culture, brackishwater culture and mariculture. Freshwater and brackishwater methods are very common among Indonesian farmers and the aquaculture is small in scale characterized by low technological inputs and high dependency on nature. By 1991 there were 1,600,000 in freshwater culture while 175,000 farmers in brackish water culture. (Yusuf, anon)

The Indonesian strategies for developing aquaculture are:

- Increase production levels of fish farmers through technological improvement.
- Increase and motivate more towards natural aquaculture production through the intensification of existing areas under culture.
- Encourage diversification in crop production which is for cultured species that have a high economic value.
- Maintaining and increasing the supply of non-commercial fish and other fish products for the benefits if low productivity and land particular.

The difference between freshwater and brackish water culture

- Freshwater culture is practised on static ponds, rice fields, fish cages, pens or floating nets and running water ponds while brackishwater culture was on ponds and mainly shrimps were considered as by-products.

The positive impacts

- Cage culture was more common among the farmers as it gave more benefits than other forms of freshwater fish culture due to lower production costs.
- The fish culture and aquaculture increased from 841 to 846 due to the rich climate.

Philippines

In the Philippines, shrimp culture production takes place both in brackish water and seawater. Although they face monsoon rains, typhoons and floods which affects shrimp farms badly. Pollution from watershed activities and from self-generated organic load has resulted in slower shrimp growth, higher susceptibility of shrimp to diseases and mass mortalities. The total area of shrimp farms in 1992 was 49,478 ha. Black tiger shrimp and endeavor shrimp and white shrimp were the most common in Philippine. (Corre,1993)

Issues of shrimp farming

Environmental – crowding of shrimp farms in some specific areas has overloaded the carrying capacities of drainage systems rendering them incapable of absorbing organic loads from shrimp ponds and other users of the river.

Major issues in site selections such as rice, coconut, sugar land converted to shrimp farms. The elevations are usually higher than the sea level and quite distant from water sources. The high cost is spent on energy to pump water.

Pumping groundwater in semi-intensive and intensive shrimps' farms has led to seawater intrusion of groundwater aquifers and loss of well waters in surrounding communities which has caused social conflict.

Diseases – Shrimp diseases have become more common in Philippine as part of this could be drought and part of it increased due to intensification of farming systems.

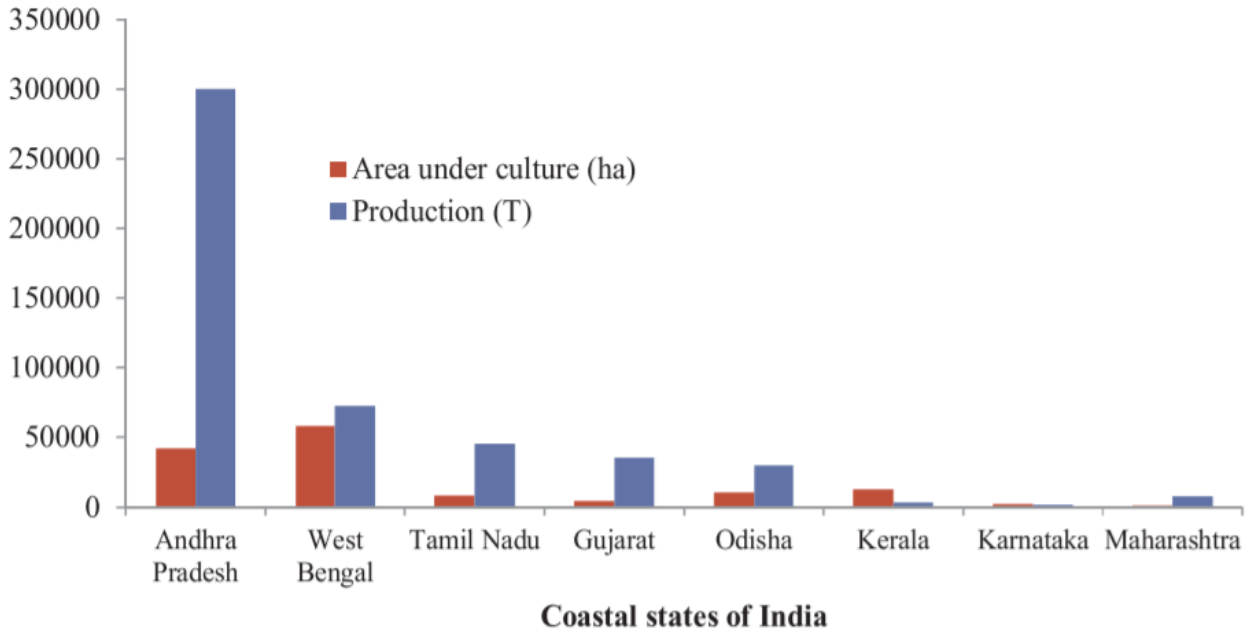
Feed quality – the quality has also become low. poor feed conversion results in uneaten feed decomposing in the pond bottom creates stress on the shrimp deteriorating the water quality.

aspects of sustainability	*extensive*	*semi-intensive*	*intensive*
financial viability (IRR, payback period)	low	medium	high
financial viability (profit margin)	low	high	medium
return on labour	low	medium	high
employment/ha	low	medium	high
land productivity (kg/ha; $/ha)	low	medium	high
water productivity (kg/m3)	low	low-medium	low-high
nutrient conversion efficiency	high	medium	low-medium
energy efficiency	high	high	medium
effluent quality	high	medium	low-high
risk of production failure	medium	medium	high
long term sustainability of production	?	?	?

(Hambrey,1996)

India

Developing countries like India have many urgent needs and objectives, which can be mutually conflicting, and the use of resources can be competitive due to less development**.** Although, there's a need for employment, foreign exchange earnings, national security and better living standards. In India Shrimp farm business started in the 1980s in the areas of Andhra Pradesh, West Bengal, Tamil Nadu, Gujarat and Odisha are major shrimp producing states. Out of the coastal areas, 1.2 million ha are salt-affected lands that are suitable for brackishwater aquaculture in India. (Jayanthi, 2018) Currently known as the second-largest farmed shrimp producer in the world (FAO,2016) Much of the shrimp culture development in India comes from the exploitation of natural resources such as mangroves and aquatic living organisms in the case of coastal and marine resources. (Rajitha,2007)



The above graph indicates the shrimp culture area and production in the coastal states of India.

Tamil Nadu, Gujarat and Odisha are the main shrimp producing states. In India consist of different shrimp farming systems ranging from extensive to intensive systems with a varying stocking density of 10-60/m^2. The types of farming systems are traditional, semi-intensive, extensive and intensive. The giant tiger shrimp *Penaeus monodon* and *Penaeus Vannamei* are the shrimp species being cultured in India. Overall 0.63% of mangroves were converted between 1988 and 2013 for aquaculture which represented 5% of the total shrimp farm area. Countries such as Indonesia, Thailand, Vietnam, Philippines earlier encouraged the use of mangrove lands for aquaculture to improve food security and

increase livelihood opportunities, however, reversed its stand now with new environmental regulations. Shrimp farming areas in India have increased from 65,100 ha in 1990–1991 to 150,000 ha in 2004. The production levels also have increased from 35,000 to 115,000 metric tonnes during the corresponding period.

The fast development of shrimps has destroyed mangrove environments converting in to flats coastal lands. About 5% of the land used for shrimp farms in India have been constructed in former mangrove areas has been taken by extensive and semi extensive farmers. For instance, in Godvari delta shrimp farms have been responsible for 80 percent of mangrove conversion in the last decade. (Hein, 2000)

In 1995 due to widespread shrimp disease in India, the productivity of shrimps was very low.

White feces syndrome caused by the *enterocytozoon hepatopenaei* parasite -- which affects the growth of the shrimp -- has been rampant across Indian farms since 2018. Although the disease hit last year remained stronger across Indian farms due to high temperature. White feces syndrome has discouraged farmers from stocking higher volumes. Farmers are focusing on preparing the ponds to prevent disease and get bigger sizes rather than out stocking (Navarro,2019).

Impacts of shrimp farming

- Shrimp culture contributes to a major portion of national income through high export earnings.
- confronted many developmental problems such as large-scale mortalities due to virus infection, environmental impact, sector competition, overproduction, trade restrictions, and overcapitalization.
- Large degradation of coastal wetlands such as mangroves systems, land subsidence, acidification, salinization of groundwater, pollution of agricultural land and coastal waters by pond effluents, the introduction of exotic species or pathogens into coastal waters, loss of wild larvae and subsequent loss of goods and services generated by natural resource system.
- Shrimp culture is affected by environmental problems such as poor water quality and disease leading to reduced productivity and abandonment of shrimp ponds.
- Clearfell a large amount of mangrove forest and construct dykes with sluice gates to retain water within these conditions mangrove tree species get totally disturbed. Most flora and fauna hardly survive in shrimp ponds areas of drastic causes due to drainage of farm effluents and nutrients depletion.

- The establishment of coastal aquaculture farms causes depletion of tidal wetlands. The loss of tidal wetlands is important as it provides a vital link in the marine energy flow through the transfer of solar energy into forms which are readily usable by a wide variety of estuarine organisms.
- Shrimp culture has affected food security through the loss of rice lands due to pond conversion or salinization.
- The heavy inputs of high energy feeds, use of drugs and chemicals result in discharge of highly polluted effluents into the sea, creeks. and on the sea coast by the shrimp farms. Also has adversely impacted on human health and environment.
- Pollutant laden discharge from shrimp ponds may help in nutrient enrichment but has also caused eutrophication of natural water bodies and its impact on coastal environment Increasing eutrophication in natural water can lead to ecologically undesirable consequences.
- Pumping large volumes of underground water to achieve brackish water salinity led to the lowering of groundwater levels, emptying of aquifers, and salinization of adjacent land and waterways. Salinization reduces water supplies not only for agriculture but also for drinking and other domestic needs
- Present shrimp farms are capital intensive rather than labour, employment of local people is often limited to low paying, unskilled jobs.
- Poor site planning has resulted in water quality deterioration, inadequate water supply, change of natural lands, coastal areas, mainly shoreline sedimentation patterns.
- Death or reduced productivity of shrimp due to pollution from upstream agricultural or industrial activity

Sustainable development

Brundtland Commission and FAO accepted sustainable development which promotes reducing and prevention of pollution.

- Maintenance of the productive potential of land resources and checking of land degradation.

- Utilization of the coastal and marine ecosystems on a sustainable basis forms and regulate the developmental activities in the coastal zone

- Better site selection followed by improved culture management, proper planning and monitoring.

- Already existing semi-intensive and intensive farms should follow updated technology and management techniques.

- Planning activities to promote and monitor the growth of aquaculture in individual countries inherently have a spatial component because of the differences among biophysical and socio-economic characteristics from location to location.
- Using technologies such as GIS to maintain the standards of the coastal areas as originals state.
- Adequate monitoring of the trophic states of coastal resources is required to adopt proper shrimp culture management practices and to maintain the pollutant levels below the carrying capacity of the environment

Sri Lanka

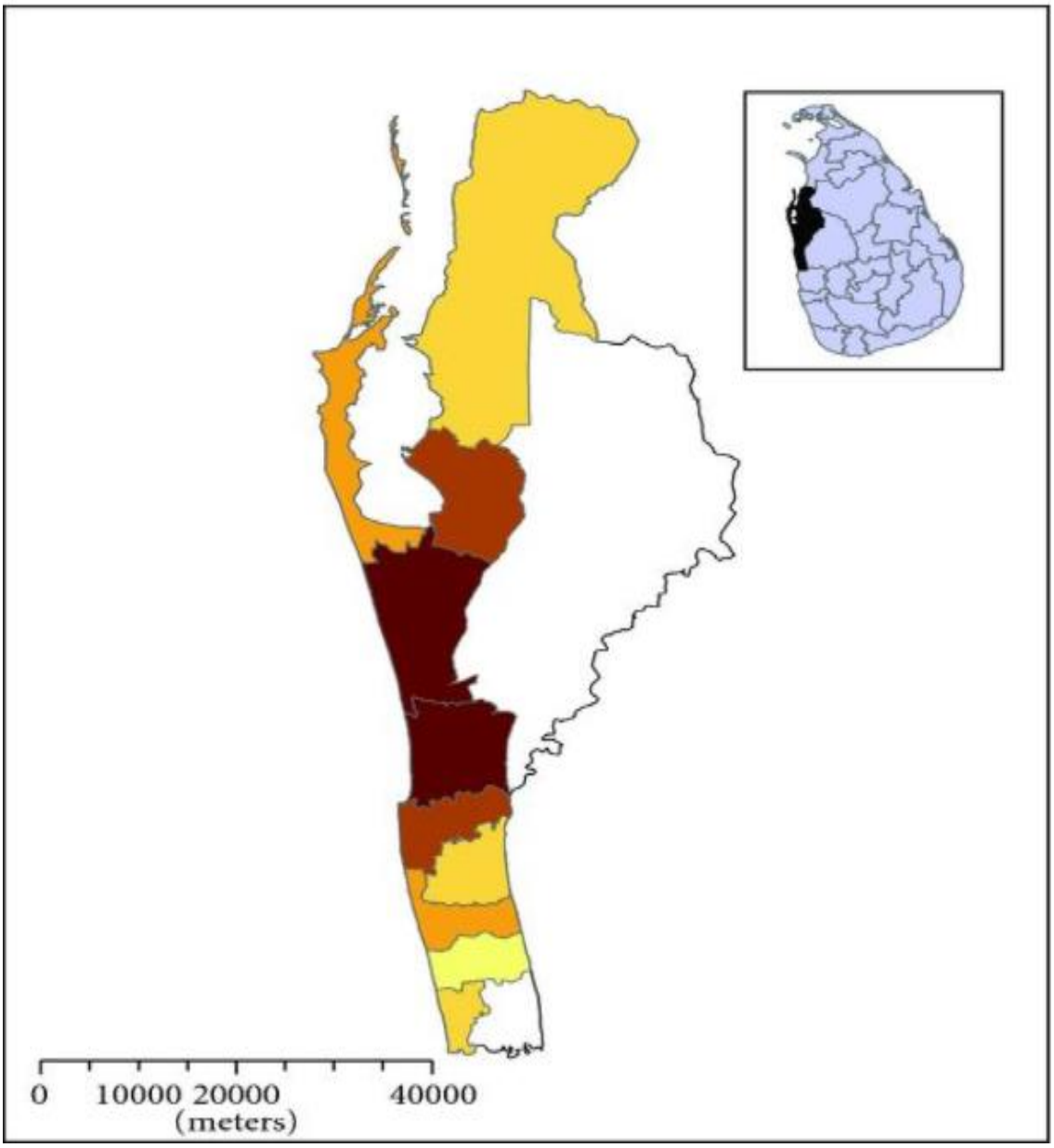
In a recent study, (Munasinghe,2010) shrimp farming has a great potential to diversify and secure income in Sri Lanka although the productions have declined due to civil conflicts and unsuitable practices and devastating outbreaks of disease. It is said that shrimp export accounts for approx. 50% of the total export earnings from Sri Lankan fisheries, the second most valuable export in 2007 generating 25 million USD. More than 90% of the harvested shrimps are exported to Japan, USA and countries of the European Union.

The Shrimp industry first began on the eastern coast in Batticaloa District in the late 1970s and revealed the industry in 1980s along the coastal borders of the Puttalam District of the North-Western region of Sri Lanka. It rapidly expanded for major three reasons:

- There were abundant natural resources – coastal lagoons, mangrove swamps, tidal flats and estuaries well suited for shrimp farming.
- Region had a very good transport network – road access from Katunayake international airport and Colombo harbors which allowed basic infrastructure needs to export fresh products.
- Industry development in the Puttalam district coincides with a heavy demand for shrimp in international markets.

- (Wijegoonawardena,1996) There is 6000 ha land suitable for farming in Sri Lanka which is 57% and 20% of the area situated along the northeast and northwestern coastal areas.
- The National Aquatic Resources Agency (NARA) identified 1200ha and 250ha suitable sites for shrimp farming in northwestern and southern areas (NARA,1989)

- Although by 1988-1990 resulted sever collapse of the prawn industry due to the disease in shrimps of Sri Lanka. (Wimalasena,2010)



Map taken from (Munasinghe, 2010) This map indicates the farming zones of the Puttalam district, Sri Lanka. Shading reflects the colours being of higher density.

- Referring to the Chilaw Mangrove Project (GeoSrilanka,2018) describes that the profits from shrimp fishing are high although the ecological footprint is higher than that which needs 27.86./ha of the large area of the lagoon for shrimp farming.

- To keep the farming profitable nearly 30ha of lagoon support is needed, which the lagoon would require 2478 ha.

- Considering the present state Sri Lanka has a bitter experience on shrimp farming with frequent outbreaks of disease that lead to 90% of farms being abandoned.

- The first disease outbreak affected the production was in 1988 to 1989 such as Micro fouling on shells, Reduced frequency of moulting, Reduced feeding, Black gills, Softshell conditions, Blackspot, ed/brown deposits on the belly and red colouration.

Sustainability of supply and quality of inputs **(Hambrey,1996)**

- **Seed** supply cannot be guaranteed as the availability is generally seasonal and it may carry diseases. Hatcheries that produce seeds, on the other hand, may also suffer from the erratic supply. The quality may be poor as a result of excessive use of chemicals, the practice of multiple spawning and poor feeding.
- **Feed** Imported feed degrades rapidly during storage in tropical countries and quality cannot be guaranteed.
- **Skills** required for aquaculture production increase steadily with increased levels of intensity.

Sustainability of Outputs

- **Disease** spreading is one of the serious threats to the sustainability of shrimp farming production. In Asia, the viruses MBV, Yellowhead, and white spot have caused devastation in many countries.
- **Water quality** is another important factor that has depressed survival and introduced new diseases through polluted water.

Financial Sustainability

- **Feed Costs** fish meals increase usually long term. Products such as Artemia used for hatchery production rise in cost as a result of steadily increased demand. This may have the possibility of buying less costly food without any standards.

- **Labour costs** more income opportunities rise up for farmers. Therefore different schemes can be introduced according to a plan.

Environment Sustainability

Shrimp farming is responsible for a variety of pollutants direct impacts including organic matter, nutrient enrichment, chemical discharges including antibiotics, pesticides and disinfectants.

Indirect impacts can be also identified such as wild seed fishery may also be affected by other species that depend upon food sources including shrimp fishermen. Direct caught through by-catch of species caught by default and discarded.

Intensive Shrimp Farming sustainability analysis table taken from (Hambrey,1996)

Sustainability Criterion	Current Status of Shrimp Farming	Potential Improvement
continuity of input supply	• wild seed supply erratic and seasonal; • hatchery supply may be erratic and subject to availability of wild broodstock; • feed shortage or expense may arise related to variations in industrial fisheries supplying fish meal	• further develop hatchery seed supply; • improve hatchery skills; close the breeding cycle; • reduce fishmeal content of diet; increase contribution of natural feed
quality of inputs	• seed from wild may carry disease; • hatchery seed may vary greatly in quality - multiple spawnings; poor feeding; excessive use of antibiotics; • feed formulation - quality may be compromized in favour of low cost; • feed quality may decline rapidly in tropical climate; • skills and training frequently inadequate; • quality and efficacy of many chemicals and other inputs questionable	• further develop hatchery production; • introduce seed quality certification; • introduce feed quality standards; • develop indigenous feedmill industry; • provide improved vocational training; • research efficacy of proprietory chemical products;

social, economic and environmental costs of inputs	• feed highly dependent on fishmeal from industrial fisheries, some of which are poorly managed and may not be sustainable; and whose intensive exploitation may reduce availability of other higher value marine species which feed on them. • a wide variety of impacts may be related to the production of chemicals • use of wild seed may reduce recruitment to capture fisheries; affect other species dependent upon them; and result in significant by-catch of discarded juveniles of other species	• reduce fishmeal content of feed; develop alternative protein /amino acid sources; • reduce dependence on chemicals through disease prevention: better husbandry, feed quality, site and water quality, water management, water supply and discharge design and infrastructure • increase hatchery production of seed.
continuity of output	• disease is a major factor reducing the quantity and continuity of output; • declining pond soil and water quality may result in a steady decline in growth and output and increased susceptibility to disease	• emphasise disease prevention: better husbandry, feed quality, site and water quality, water management, water supply and discharge design and infrastructure • better pond soil and water management - training; water supply infrastructure
financial viability	• very high while production is maintained; • often negative following poor management	• encourage moderate levels of intensity while skills are limited; intensify only slowly and steadily; • initiate, facilitate and encourage training

environmental impact	• previously unused brackishwater environments (eg mangrove, estuarine flats, saltmarsh) may be converted, resulting in destruction of relatively natural habitats; • significant quantities of nitrogen and phosphorus released to environment (water, pond soil, air); • significant quantities of organic matter (resulting in BOD) released to the environment; • a wide variety of chemicals released to the environment, including disinfectants, pesticides, and antibiotics, the latter having the potential to cause increased resistance in bacteria.	• identify high quality natural habitat and enforce protection; • set standards/guidelines/best management practice codes for effluent quality; encourage compliance through quality labelling initiatives related to both physical quality and production process; • ban excessive and inappropriate use of antibiotics, and use of those of particular value for the treatment of serious human disease; • research possible impact of chlorination (disinfection) and production of chloramines and other complex chlorinated organics;

Conclusion

In conclusion, compared to all the different countries mentioned, various methods and technology techniques can be identified. Some of the aquaculture productions have given more priority to the natural environment while other shrimp farming has given less priority to natural resources such as Thailand and Brazil. Most countries such as Indonesia and Bangladesh use domestic waters and paddy fields where they change the cultivation according to various seasons of the years. In general mangrove, environments face deforestation immensely. These environments should be protected and regrown as they contribute in protecting inland regions from natural disasters such as cyclones, damages caused by erosion, and prevent Tsunami. It acts as one of the first defences against global warming, they filter water and store carbon as terrestrial forests. Also, these environments stabilize and renew sediments and absorb pollutants and excess nutrients while providing habitat to various numbers of species to feed and breed. (WWF,2017)

Overall in most of the shrimp farms due to unsustainable practices and lack of technology has led to various diseases such viruses white spot syndrome, white feces, other bacteria, fungi and parasites. Apart from sustainability, lack of planning, developing sites and managing issues have become the main cause for it. Less developed countries in Asia face many consequences due to lack of financial state to spend

on the standard equipment and technology. Most farmers in south Asian countries have misused land for building ponds due to lack of knowledge and environment law interference. The practice of good sustainable techniques, management skills and implement new laws may reduce destruction cause to the environment. In general, although it is seeming to be a rich income to a country it harms the environment and spread diseases among shrimps as well as other invasive species also adding more chemicals to the land affecting human health. Therefore at the start of a shrimp farm culture environment authorities should strictly involve to ignore the errors caused by farmers using low income, low graded products and low management skills. Frequently the farmers should updated with new technology and standards to disregard the errors.

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