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Offshore aquaculture in Sri Lanka: Possibilities and challenges

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Abstract

Sri Lanka has a long coastline with a vast oceanic area included within its EEZ (Exclusive Economic Zone). The increasing demand for local fish consumption has highlighted the necessity to develop aquaculture in Sri Lanka. At present, the fisheries sector remains as the main source of animal protein requirement for the local population with a gradual increase in aquaculture. Inland-based aquaculture is the main type of fish farming with shrimps and several freshwater fishes being the main culture species. Aquaculture has been identified as a potential sector that can contribute to the national economy in the future. The recent interest towards the development of offshore aquaculture in Sri Lanka is evident with the entering of several public and private institutions in establishing sea cage farming. However, it is necessary to address the environmental, social and economic challenges of establishing offshore aquaculture in Sri Lanka. This paper reviewed the potential of offshore finfish farming in Sri Lanka including a SWOT analysis, the positive and negative environmental conditions, recent involvements from the private sector, the possible conflicts that can arise among stakeholders and future recommendations.

Keywords: aquaculture, sea cage, Sri Lanka, offshore, finfish, mariculture

1. Introduction

Sri Lanka, being an island nation in the Indian ocean has a long coastline rich in marine fishery resources. The country has a 1700 km long coastline and 30,000 km² continental shelf with up to 120 m depth^[5]. Exclusive economic zone of Sri Lanka spans over 517, 000 km² of ocean corresponding to 7.8 times than the land area of the country. Figure 1 shows the coverage of Exclusive Economic Zone (EEZ) of Sri Lanka. Fish is a common complement with rice in Sri Lankan diet with an increase of fish consumption by locals in the recent past from 41.3 g in 2013 to 46.7 g in 2016^[6]. In addition to its vast sea area, the country has a large number of natural and man-made inland water bodies that are home to many aquatic fauna and flora.

1.1 Brief history of aquaculture in Sri Lanka

Despite the presence of large water bodies (freshwater and brackish water) in the country, Sri Lanka did not have a tradition of aquaculture until the beginning of 1980^[7]. Early beginnings of aquaculture were based on fish culture in rural tanks and marine shrimp farming in coastal ponds. Ornamental fish farming has reached commercial status with exports to foreign markets. Finfish and shellfish culture for food purposes is yet to be developed to reach a larger commercial scale production.

Over the past decades, inland aquaculture has shown a developing trend than marine aquaculture in Sri Lanka. Freshwater fish culture in inland tanks was initiated in the 1970s. Shrimp culture showed better prospects in terms of production and profit, however, suffered serious economic losses in the 90s due to viral disease outbreaks^[7]. After several modifications in production systems and stocking densities, the shrimp aquaculture managed to revive from the disease outbreak, yet significant shortcomings are yet to be addressed to reach higher production potential. In addition to these, crab fattening takes place in several areas along the coastal belt of Sri Lanka^[8] and has shown promising results^[9]. Introduction of exotic fish species led to the development of commercial inland aquaculture especially, tilapia (*Oreochromis mossambicus*) and several species of carps.

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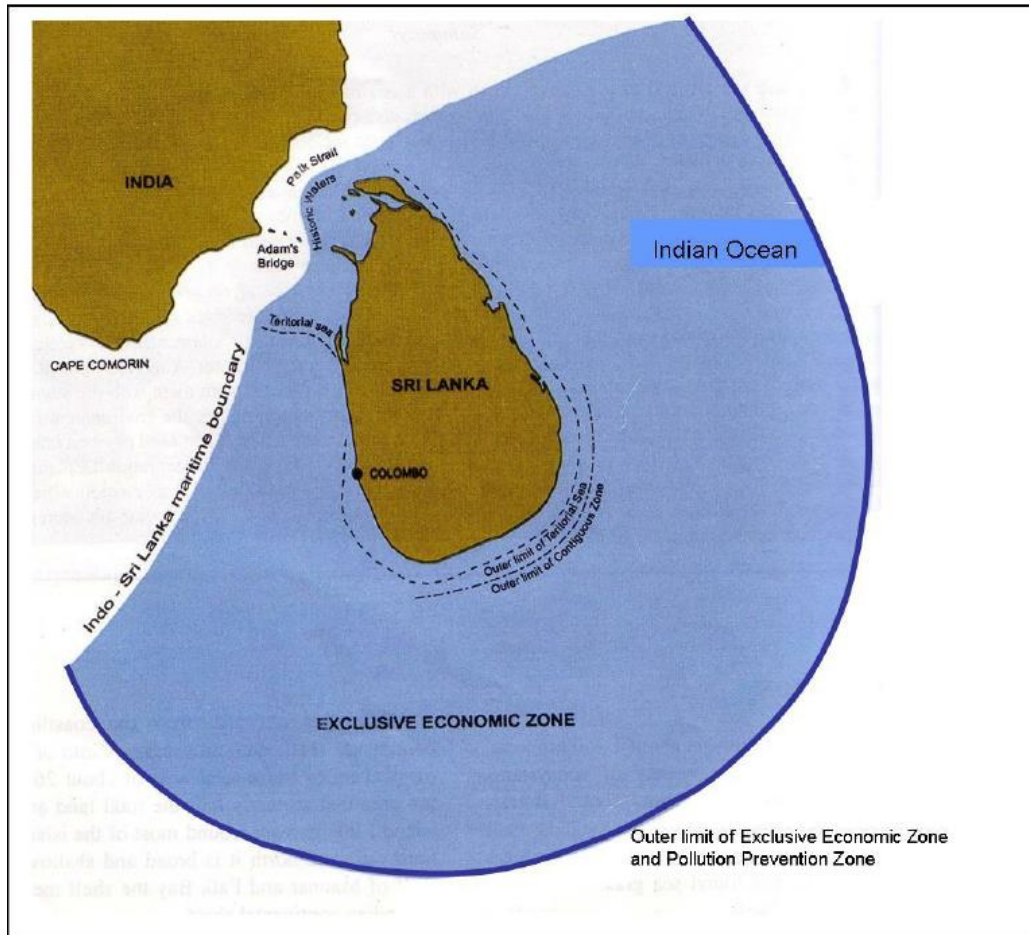


Fig 1: Exclusive Economic Zone (EEZ) of Sri Lanka ^[2]

2. Offshore mariculture potential in Sri Lanka

The possibilities for offshore mariculture in Sri Lanka has been analyzed in this paper based on several factors considered in the FAO publication that focused on a global assessment of potential sea areas for offshore mariculture ^[3]. This FAO publication provided a detailed analysis of suitable regions for offshore aquaculture in the world. This paper analyzes the positive and negative factors that can affect the establishment of a successful mariculture industry in Sri Lanka based on several factors discussed in the above mentioned FAO publication. Several important factors are considered in this paper in terms of establishing mariculture sites in Sri Lanka. The factors are as follows:

- The status of water depth and current speed in offshore waters
- Cost-effective area for development of offshore mariculture within EEZ of Sri Lanka with consideration of access to a port, especially area/areas that lie within 25 nm of a port
- The distribution of seawater temperature in Sri Lankan waters
- The existence of Marine Protected Areas (MPAs) that can cause conflict situations in the establishment of

mariculture sites

In addition to these factors, the current status of offshore aquaculture is discussed with future trends that can lead to development of this sector in Sri Lanka. The forthcoming challenges in progressing towards offshore aquaculture are also discussed.

2.1 Status of water depth

Depth is an important factor which must be considered during the establishment of sea cages. The locations must meet adequate depths to ensure sustainable and long lasting sea cage farming. Sufficient depth is crucial to ensure maximum water exchange and maintain the cage bottom well above the seafloor. Adequate depth will avoid oxygen depletion, accumulation of uneaten food, feces and debris and build-up of unfavorable gases including H_2S ^[10]. A depth of 6-10 m at low tide can be considered as ideal range for sea cage ^[11]. Very limited depths can lead to chemical and bacterial interactions that can damage nets. Predation by bottom-dwelling organisms on fish can also become a problem due to unfavorable depths. Figure 2 shows the global distribution of sea depths within EEZs.

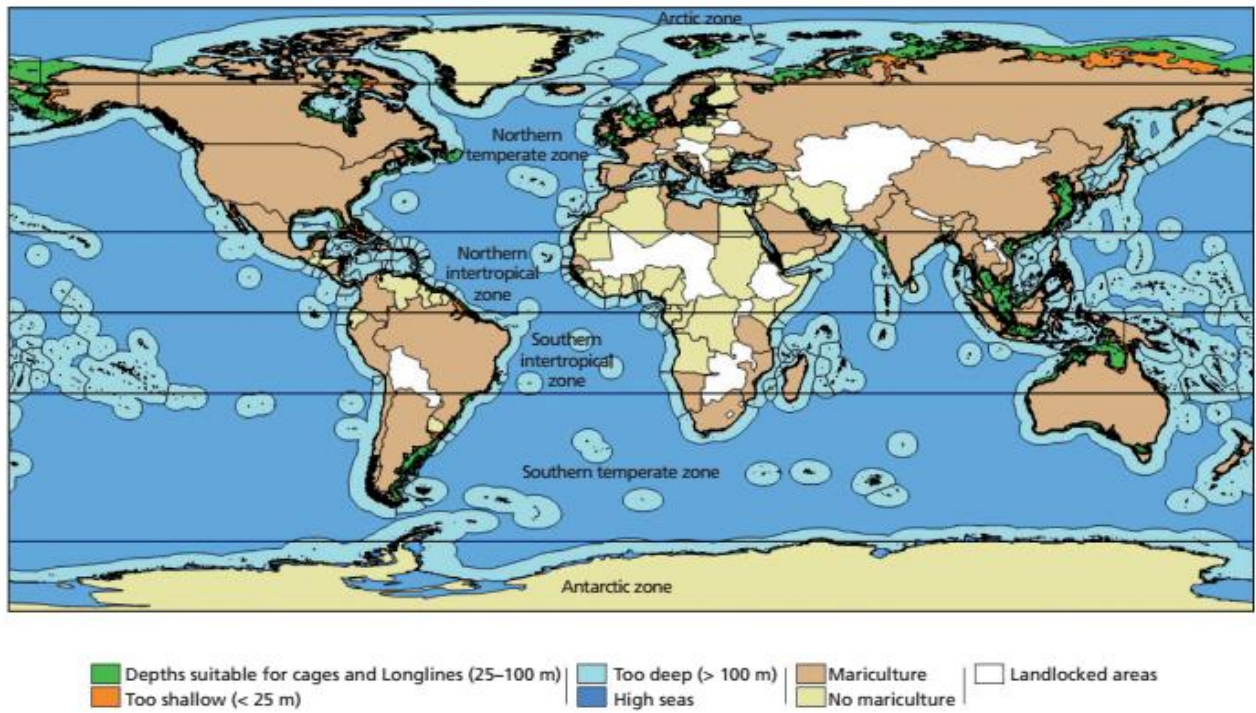


Fig 2: Globally distributed areas with suitable depths for sea cages and long lines within EEZs of respective countries [3]. The sea area around Sri Lanka is shown as having higher depth of more than 100 m considered as too deep for sea cages

2.2 Suitability analysis based on current speed

Tidal current conditions affect the supply of fresh oxygen-rich water and facilitate removal of waste from the cages. Larger tidal ranges will be beneficial to manage high stocking densities. Global current speed distribution within EEZs is shown in figure 3. Stronger current speeds can have adverse effects on cage stability, causing damages

and distortion to cage structures. Fish may experience slow growth due to the need to swim against the strong currents. Cages must be positioned against the current at locations with weaker current speeds and positioned parallel to the current at places with stronger currents. Maximum recommended current speed should be less than 50 cm/sec and not exceeding 100 cm/sec [10].

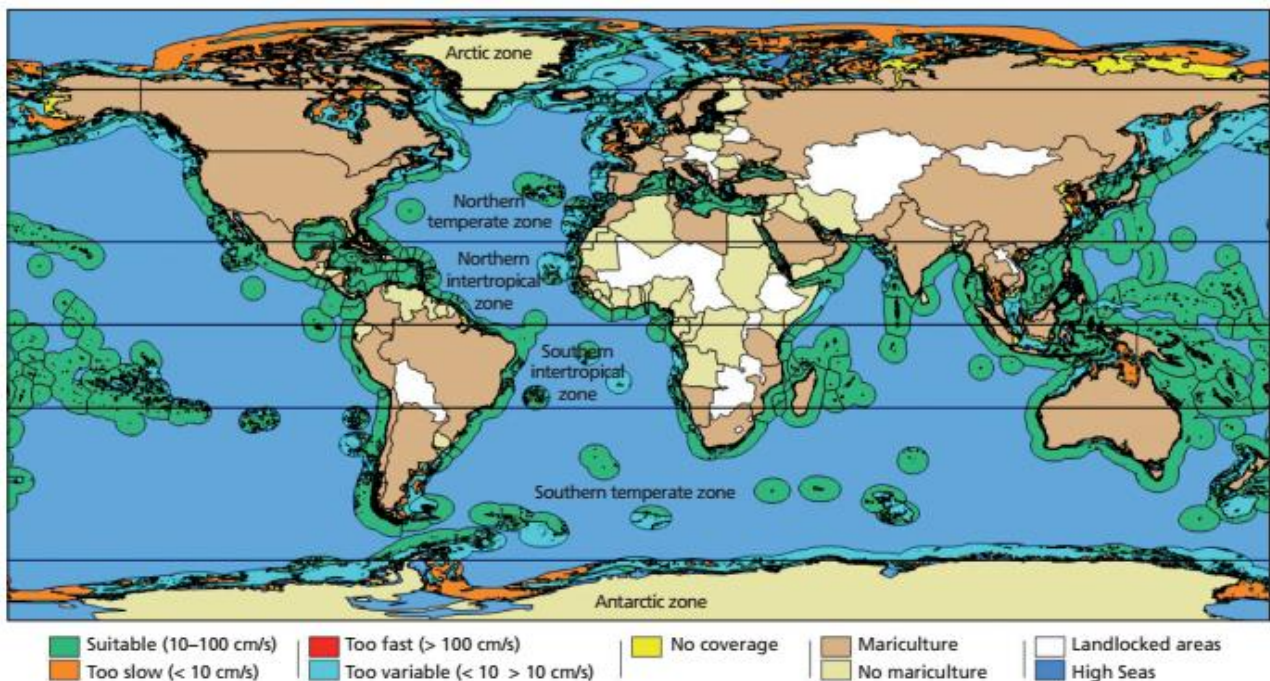


Fig 3: Global distribution of areas within EEZs with suitable current speeds for sea cages [3]. The EEZ area around Sri Lanka is shown with suitable current speed in the range of 10-100 cm/s for sea cages.

2.3 Suitability analysis based on cost-effective distance with access to ports

Distance from the coastline to an offshore installation is an important factor to be considered to ensure proper management of the sea cage systems. Therefore, a cost-effective distance has to be decided when installing an offshore aquaculture facility. Economic feasibility can

be achieved by constructing an offshore aquaculture facility within 25 nautical miles from the coastline [12]. Further increase in distance from coastline may lead to cost escalations and maintenance challenges. It can also alter the vessel operations to and from the coastline to the offshore facility. Another factor is the existence of onshore facilities that can provide access to the sea at all weather

conditions. Such locations can be based on existing ports in the coastline, thus enabling easy access to the offshore aquaculture facility. Considering the two factors leads to the selection of locations at sea that are within 25 nm radius from a port. Several locations around Sri Lankan waters can fulfill these two factors (figure 4).

Sri Lanka has several ports along its coastline (figure 5). Colombo

port is the most prominent among them with a significant contribution to the national economy. Due to Sri Lanka's strategic position in the Indian ocean, the Colombo port handles cargoes from various parts of the world. Trincomalee harbor which is located on the northeastern coast is a natural harbor which is ten times larger than the port of Colombo (SLPA, 2018). In addition to these two ports, Sri Lanka has several other ports in the south and north.

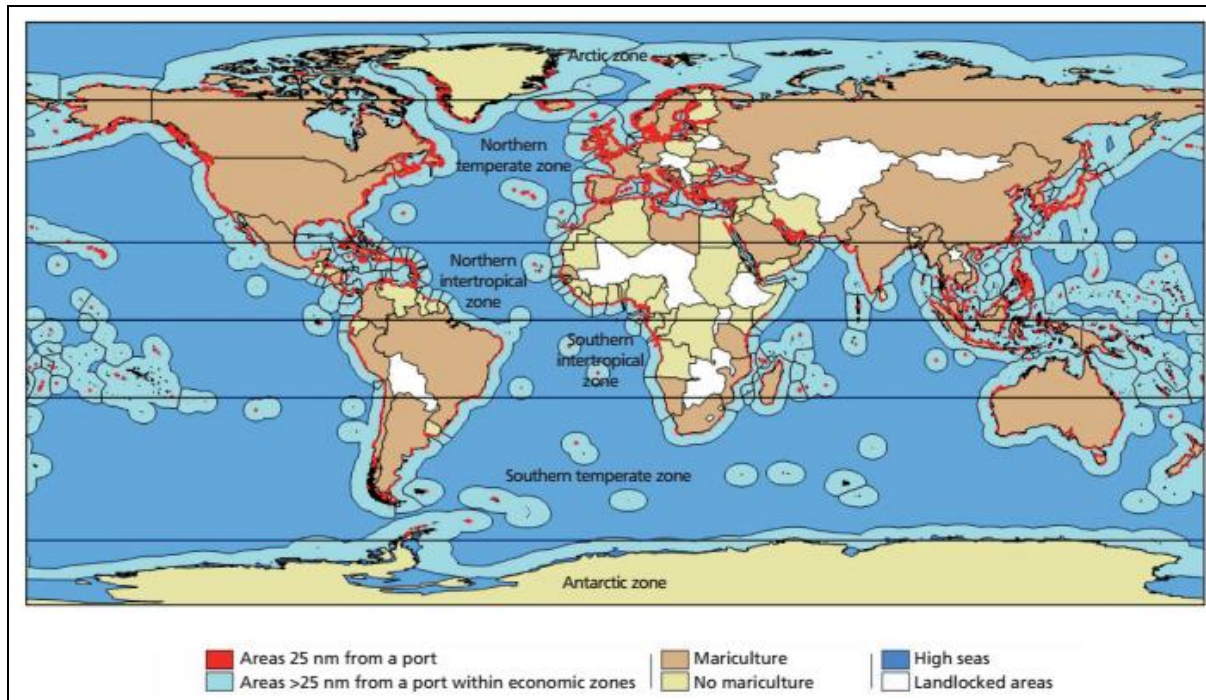


Fig 4: Cost-effective area for offshore mariculture establishment in a global scale [3]. Figure shows that several areas around Sri Lanka are within 25 nm from a port.



Fig 5: Distribution of ports along the coastline of Sri Lanka [1]. The Oluvil port is a newly proposed port to be developed in the Eastern province. The Colombo port and Trincomalee harbor are the major ports in the country. The Hambantota port is a port being developed with the cooperation of China. The significance of this port is its strategic location in the east-west shipping route.

2.4 Suitability of temperature for offshore aquaculture

The sea area around Sri Lanka has a temperature range of 22-32°C which is typical temperature range for tropical waters. This temperature range can be utilized for farming of various marine food fish species based on their market demands. Figure 6 represents areas within EEZs with temperatures for offshore aquaculture.

Potential fish species for mariculture in Indian waters such as Asian seabass (*Lates calcarifer*), Grouper (*Epinephelus spp.*), milkfish (*Chanos chanos*) and tuna species [13] could be suitable for Sri Lanka due to close proximity to India.

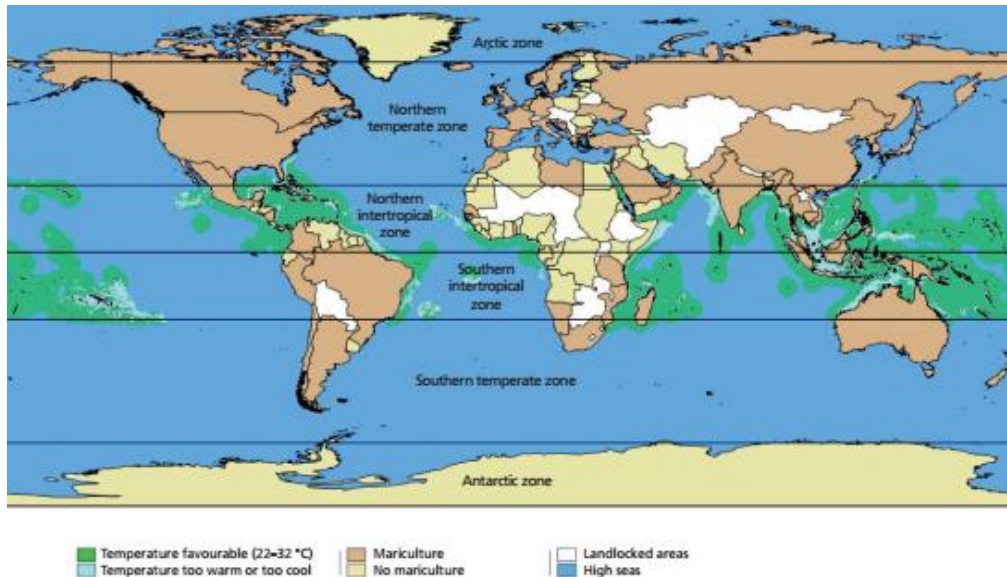


Fig 6: Global sea temperature of areas within EEZs that can be considered for offshore aquaculture establishment [3]. The sea area within EEZ of Sri Lanka is shown with a temperature range of 22-32 °C which is favorable for several tropical fish species.

2.5 Marine Protected Areas (MPA) in Sri Lanka

MPAs can be defined as spatially-delimited areas located in the marine environment that are managed, at least partially, to conserve biodiversity [14]. In addition to conservation of biodiversity, the value of MPAs is also related to research, generation of recreational activities, aesthetic and educational benefits. Research scientists use MPAs as reference areas to assess the scale of human impacts on the environment. MPAs can serve as important tools for management of marine environment. Threatened species are given a chance to recover from increased human intervention by designating affected areas as MPAs.

Several MPAs exist in Sri Lanka (figure 7), however, there is criticism that most of them are not fully managed, resulting in resource extraction and habitat degradation [4]. Declaration of MPAs is carried out without sufficient consideration of ecological aspects,

socioeconomic realities and long-term management sustainability. The Pigeon Island, located in the east (figure 7) was declared as a sanctuary in 1974 with incorporation of the surrounding coral reefs in 2003. In 1979, the Hikkaduwa Nature Reserve was declared as an MPA. Subsequently, several other MPAs were declared to provide a stronger legal mandate for management. However, critics suggest that little effort has been put forward to implement proper management measures in these declared areas [4].

It is evident that several MPAs exist in Sri Lanka and measures to protect and manage them have not been so successful in the past. When such situations exist, establishment of offshore aquaculture farms may lead to management of MPAs even more difficult, if adequate management plans are not undertaken. Therefore, installation of offshore mariculture facilities must be accomplished in a way that do not disturb MPAs.

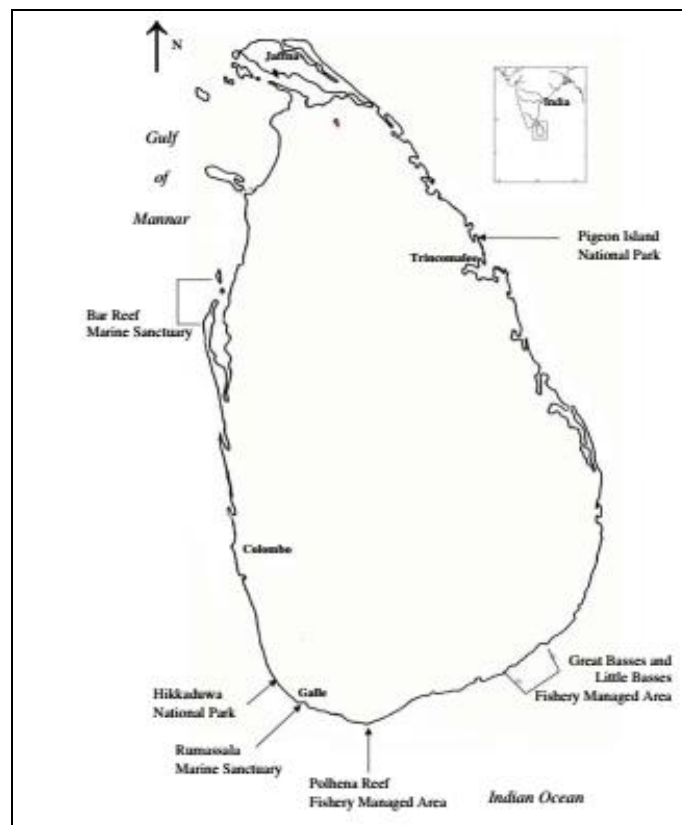


Fig 7: Location of Marine Protected Areas in Sri Lanka [4]

3. Current status of offshore aquaculture in Sri Lanka

Sri Lanka has been slowly progressing towards offshore mariculture of finfishes. Several trial projects have been established during the last few years with over 1000 smaller cages ^[15]. Interest has been shown in installing larger cages in the northeastern regions of the country.

The launching of Oceanpick (Pvt) Ltd in 2012, the first offshore aquaculture company can be considered an important stepping stone in Sri Lanka's offshore aquaculture sector. With the partnership of Scotland ^[16], the company has initiated the farming of Asian seabass (*Lates calcarifer*) in sea cages placed off the coast of Trincomalee, one of the strategic locations in Sri Lanka with a natural harbor ^[17]. Plans are underway to increase the production capacity and expand the exports to reach global markets.

4. SWOT analysis

A SWOT analysis (table 1) has been conducted for Sri Lanka's offshore mariculture potential. SWOT analysis considers the strengths and weaknesses of the internal operating environment and opportunities and threats caused by the external operating environment. All these components of a SWOT analysis will facilitate to determine the various impacts on this relatively new sector in Sri Lanka. Some of the components of SWOT analysis have been discussed briefly in the following sections.

Table 1: A SWOT table for offshore aquaculture development in Sri Lanka

Strengths	Weaknesses
Availability of site	Limited R&D
High biodiversity	Limited technology
Availability of labor force	High feed cost
Higher local market demand	Fragile economic status
Better global market demand	High production cost
Improved transportation facility	Limited experience in offshore aquaculture
Opportunities	Threats
Diverse species availability	Unstable national economy
Larger and cheaper labor force	Increasing cost of production
Potential to use local ingredients	Conflict with local fisheries
Improved government focus on aquaculture	Disease breakouts
Availability of long coastline	Large-scale production from overseas competitors
Favorable sea temperatures	Environment related issues
Favorable current speeds	
Possibility for foreign investments	

4.1 Availability of site

Being an island, it is possible to consider Sri Lanka having potential sites for offshore mariculture. As previously mentioned, the country has several ports in addition to its strategic location in the Indian ocean. Potential sites must be placed in close proximity to the ports, thus increasing the efficiency of transporting the products from the harvest site to global destinations. In contrast to a medium-level inland aquaculture, Sri Lanka has a very small offshore mariculture sector. However, there is a large potential to develop offshore aquaculture in terms of suitable sea temperatures for tropical finfish culture, current speeds among other factors. With the Trincomalee port being considered for further enhancement by the Sri Lankan government ^[18], the establishment of offshore aquaculture structures close to Trincomalee port will be beneficial.

4.2 High biodiversity in tropical waters

The presence of a wide range of tropical fish species present in the Indian ocean can be considered as an advantage for offshore farming of many species. The prevailing tropical sea temperatures are typical in South Asia, making offshore aquaculture of diverse species possible, in contrast with offshore aquaculture in Europe where species diversity is limited. The presence of tunas, milkfish and

barramundi or Asian sea bass in the Indian ocean shows the possibility to have species-diverse offshore aquaculture.

4.3 Availability of labor force

Aquaculture practices require a significant level of workforce, especially in Asia in contrast with Europe, where modern equipment and machinery replace manual work in the latter region. Sri Lanka can utilize its large labor force in the development of offshore mariculture, thus reducing the unemployment rate as well.

4.4 High market demand for fish products

The increasing trend of fish consumption by the local population ^[6] can be considered as a strength in developing aquaculture in Sri Lanka. With the inland aquaculture production being not fully enough to cater to the demand of the local market and depletion of wild fishery resources, the country needs to focus on improving offshore mariculture.

4.5 The global market for seafood from Sri Lanka

Sri Lanka has long been able to maintain a global market for its seafood exports, generating a significant income of foreign exchange. The seafood from Sri Lanka has been successful in reaching many member countries of the European Union such as Germany, Italy, the United Kingdom, France, the Netherlands and Ireland ^[19]. US and Canada have also been important markets. Japan, Malaysia, Singapore and South Korea are important market destinations for Sri Lanka's seafood products in Southeast Asia. The wider range of global market demand for seafood products is a key element that can influence the expansion of offshore aquaculture in Sri Lanka, ensuring a promising return of profit for the investment.

4.6 Better transport infrastructure

The development of highways and major road networks in the country with foreign financial aids has helped transportation become more efficient. Improved transport infrastructure can be considered as a strength to supply the products from offshore facilities to local markets.

4.7 Limited R&D and technological capability

Sri Lanka has shown slow progress in developing R&D capabilities to develop its local production capacity. The country is behind most other countries in Asia, the region facing major transformations in terms of technological advancements and economic development. Sri Lanka is behind many Asian countries in terms of provision of funding for R&D. The country has limited availability of technology to enhance its local manufacturing sector. Development of offshore aquaculture requires a significant level of technology to produce offshore sea cages that can withstand adverse weather conditions and systems to monitor culture species from land-based monitoring stations. R&D sector is required to conduct research to increase the growth and production of the culture species. Long-term R&D efforts will enable to introduce new and sustainable feed resources for offshore mariculture.

4.8 The high cost of feed

The high cost of commercial fish feed is one of the constraints for the development of aquaculture in Sri Lanka ^[20]. Imported fish feeds, which are commonly used for aquaculture are expensive and increase the production cost.

4.9 Fragile economic status

Sri Lanka managed to reach a middle-income country status in 2014 ^[21], however, the fragile economic status is a weakness for the improvement of large-scale offshore aquaculture which requires investment and advanced technology. Fragile economic conditions will only enable Sri Lanka to develop offshore aquaculture as a small-scale industry, being able to only feed the rural populations of the country.

4.10 Conflict with local fishery sector

Interactions between capture fisheries and offshore aquaculture have been considered as a threat in this analysis due to a relatively larger

fisheries sector prevailing in Sri Lanka in contrast with aquaculture. The physical occupation of the ocean space for fisheries and aquaculture can lead to many interactions between the two industries, consisting several adverse effects on both sectors [22].

5. Future trends and recommendations for mariculture

The proposed plan to start two industrial investment parks by National Aquaculture Development Authority (NAQDA) in Batticaloa and Mannar areas shows a keen interest by the government to develop the aquaculture sector in the country. The initial steps for establishment of aquaculture park in Batticaloa area in the eastern province, have already commenced. Although the focus is to develop shrimp farming in this region, consideration is also given for the establishment of mariculture.

A site survey to identify potential offshore aquaculture areas in close proximity to commercial ports of Sri Lanka was commissioned by NORAD (Norwegian Agency for Development Cooperation) recently [23]. The site survey identified five sites (three in Trincomalee harbor, one in Galle harbor of the southern province and one in Olivil harbor of the eastern province) as having the potential to establish sea cage farming. However, the survey recommended the potential for small-volume cages due to the shallow waters of the selected sites. In addition to this, other alternative mariculture activities such as seaweed farming or longline mussel culture were also recommended. One particular site located in the Trincomalee port area being suitable to establish a large volume marine fish farm. The Koddiyur Bay in Trincomalee is proposed as the only suitable area for large volume marine fish farming due to the suitable depth range of 15-30 m. The well-protected nature of this bay area with the best water quality for larger sea cages are additional advantages of the proposed location. In addition to this, the area of Palk Strait from Mannar up to Jaffna, having a depth range 8-12 m, is noted as the real potential area for small-volume sea cages.

6. Potential conflict situations

The development of offshore aquaculture can cause several conflicts with other users. In contrast with land-based aquaculture, which requires a substantial amount of land area, the offshore aquaculture may have lesser conflicts in terms of usable sea area. However, proper regulations and monitoring must be followed to have sustainable offshore mariculture in Sri Lankan waters. The threats caused by pollution in ocean waters can adversely affect offshore mariculture and, at the same time the environmental pollution caused by sea cage culture itself must be minimized. Mariculture may trigger social and environmental issues if this sector is developed in an unsustainable manner. Conflicts can arise among different stakeholders such as local fishermen, tourism managers and the ports authority, all who are engaged in utilizing the marine waters of Sri Lanka. Offshore aquaculture facilities may face protests from environmental protection agencies and environmentalists who may perceive a negative image of offshore mariculture. Aquaculture in the open seas may disturb the livelihoods of coastal fishing communities by restricting their access to the ocean by encapsulating vast areas of sea farms. The fishing communities can be affected since the marine area they use, the wild stock they harvest, or the ecosystem they depend on are subject to changes due to the introduction of fish farms. Their socioeconomic activities can also get affected. This can hamper the economy of coastal fishing villages with considerable damage to their livelihoods. Such issues have been identified in mariculture in Europe, where even developed economies face similar challenges [24]. Therefore, a developing economy such as Sri Lanka will need to consider such conflicts, otherwise, severe economic challenges may be faced by the coastal fishing communities.

The conflicts with the flourishing tourism industry, especially in the eastern coastline must be taken into consideration when establishing offshore mariculture in the east. Being home to some of the most beautiful beaches, the eastern province must manage both industries in a sustainable manner without negative impacts on each other. The governing institutions need to take adequate measures to manage the possible conflicts and ensure that both industries can withstand in the

long term. In fact, policies can be implemented where tourism can support offshore aquaculture by allowing tourists to visit mariculture farms, thus, making aquaculture an attraction for tourists.

7. Conclusion

The offshore aquaculture is relatively a new sector for Sri Lanka, and initiatives have been taken to start and develop this sector in the future. A country with a long coastline and positioned in the tropical Indian Ocean, Sri Lanka has its positive side of arguments to venture into offshore fish farming. However, there are several key challenges that need to be addressed to become a successful offshore aquaculture nation and the country needs a longer period to overcome these challenges. The suitable sea depths around some areas of the island with favorable temperature ranges, ocean currents and economically viable ports show a promising future for offshore aquaculture in Sri Lanka. It is evident that few private enterprises have already started to participate in this sector with overseas involvement. Based on the recent site surveys and environmental factors it is questionable if Sri Lanka can start large-volume sea cages, but small cage farming is a possibility. Proper management measures must be taken by the governing institutes to ensure a long lasting mariculture sector with regulations on issuing licenses for aquaculture farms, else, the negative consequences of uncontrolled shrimp farming that took place in the past will happen to this relatively new, emerging sector as well. Conflicts among different stakeholders in terms of using the ocean space must be solved in a way that benefits all sectors involved. International collaboration with countries that have had a long tradition of offshore aquaculture is critical in establishing a rapidly developing and long lasting mariculture sector. Aquaculture business is viable in Sri Lanka, including offshore mariculture but it is limited to small volume production. If properly managed, it can become a significant contributor to the national economy as well as a sector that can provide employment for rural population.

8. Conflicts of interest

The author claims no conflicts of interest in preparation of this paper.

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