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Ecosystem Services of Mangroves and their Interaction with Aquaculture Activities

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Abstract

For sustainable coastal development, the dynamic interaction between aquaculture and mangrove ecosystems poses both opportunities and challenges. Mangroves act as a natural buffer that maintain shorelines, shield aquaculture infrastructure from severe weather, and improve water quality by retaining sediment and cycling nutrients. Their intricate root systems immediately increase aquaculture productivity by serving as vital nursery grounds for fish and shellfish species. But the fast and frequently unchecked growth of aquaculture, particularly shrimp farming has resulted in the extensive conversion of mangrove forests, which has harmed habitat, reduced biodiversity, and made coastal ecosystems more susceptible to the effects of climate change. Aquaculture plays an important role in rural lives and global food security, but its ecological impact on mangrove systems needs to be carefully considered. Mangroves both support and are affected by aquaculture, highlighting the need for mangrove-friendly practices for economic and ecological sustainability.

Introduction

Mangrove ecosystems are extremely important because they offer a variety of biological supports that contribute to the sustainability of coastal aquaculture. Mangroves' ability to anticipate and lessen the effects of storms and tsunamis in coastal areas can minimize damage and provides security of aquaculture infrastructure and products. Storms and tsunamis can have a catastrophic effect on aquaculture activities because they increase water level, which may result in overflow into the aquaculture pond and change the salinity level, which will ultimately impair the development and output of aquaculture products. Although mangroves cannot completely prevent the effects of hurricanes and tsunamis, their intricate structure might lessen the turbulence caused by these natural disasters, which will benefit the aquaculture sector in the area. Mangroves' intricate root systems along the aquaculture site which may play a significant role in pond protection by binding and insulating the soil from wave action, therefore reduce the issue of erosion. Mangroves are considered as a natural jewel to the coastal environment because they play important roles in meeting socioeconomic requirements and performing essential ecological functions, even though they exist in an extremely harsh coastal climate. Another essential ecological function that may play a significant role in reducing the

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increasingly difficult effects of global climate change is the capacity of mangroves to absorb carbon and store it as part of their biomass for an extended period of time. Mangroves are regarded as a significant ecosystem for the coastal community in terms of socioeconomic significance, because they provide wood for commercial products like Charcoal and Timber. Furthermore, because they contain a large number of excellent marine habitats, mangroves have been shown to be a crucial ecosystem for the coastal aquaculture and commercial fishing sectors (Hashim *et al*., 2021), mangroves also offer employment opportunities, such as providing household income for the local community by fishing in the mangroves and coastal aquaculture companies.

1. Importance of Aquaculture Activities

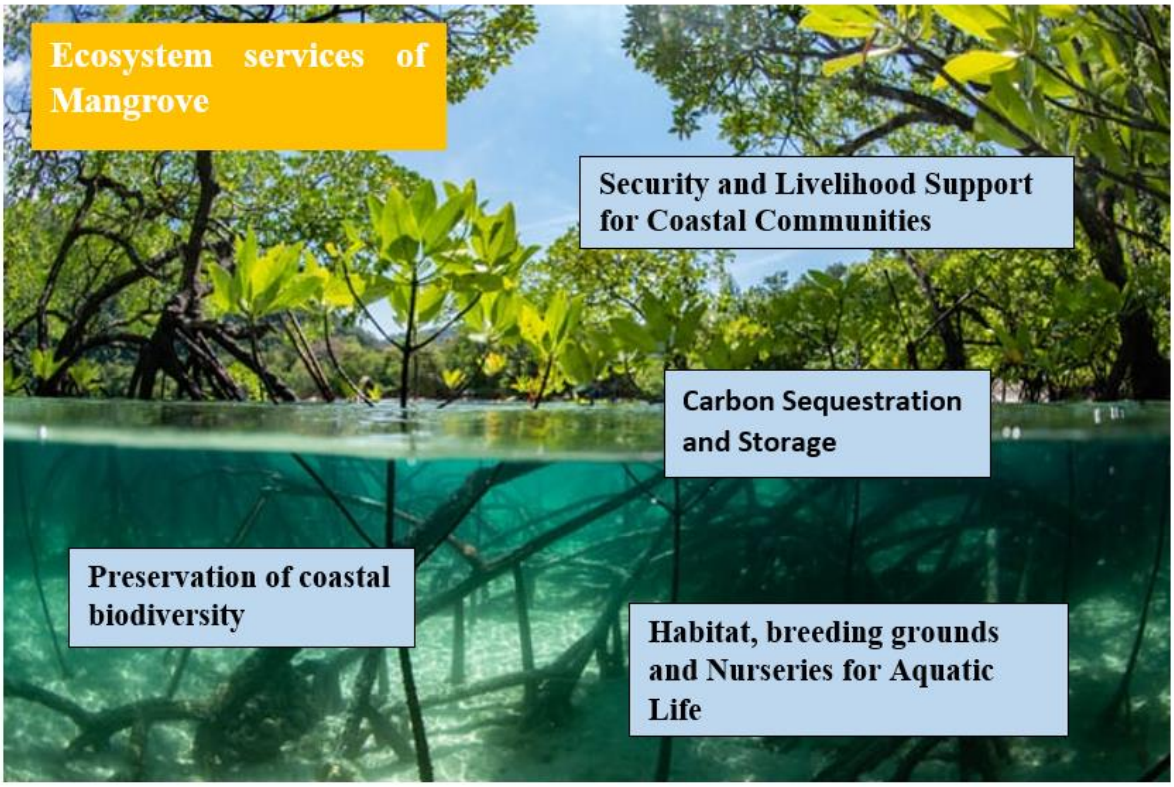
1.1 Food Security

Reducing the disparity in food consumption is one of the aquaculture industry's primary sustainability objectives. One of the main important criteria of the aquaculture industry towards human sustainability is minimizing the gap for food consumption. Aquaculture production accounts for over 50% of global fish consumption, making it an essential source of food along with deep sea and inland fish capture. Recent advancement and evolution of aquaculture technology and vast global market trade in recent years have resulted in an increase in the production of aquaculture products and have a significant impact to the consumption rate of human worldwide. According to FAO, in total, 89 percent of aquatic animals are produced, used for human consumption, equivalent to approximately 20.7 kg per capita in 2022. The anticipated yearly per capita consumption of aquatic animal products increased from 9.1 kg in 1961 to 20.7 kg in 2022.

1.2 Employment Opportunities

People are usually drawn to coastal places because of the alluring socioeconomic functions they provide. It is thought that frequent, drastic changes in land use have a significant impact on the coastal area's scenery caused, particularly in the mangrove areas by human development. A record of 120 million people lives in mangroves globally and rely heavily on their resources to survive. Coastal communities, on the other hand, are always thought of as being surrounded by poverty. Through its positive effects on the employment sector, which creates business possibilities and job opportunities, the aquaculture industry's recent boom benefits the local community and raises the socioeconomic standard of living for the coastal population. The primary production sector of aquaculture and fisheries employed an estimated 61.8 million people, primarily in small-scale businesses. According to sex-disaggregated data,

women made up 24% of fish farmers and fishermen and 62% of those working in the post-harvest industry (FAO, 2024).



2. Impact of Aquaculture in Mangroves

Aquaculture has profited over the past few decades from advancements in science and it has grown at an exponential rate. By the year of 2024, this upward tendency must continue to sustain the demand for food from over 9 billion people by 2050. Unfavorable social and environmental problems have also arisen as a result of aquaculture's success. These include the loss of biodiversity, the destruction of mangroves, and the unsustainable use of water or natural feed.

2.1 Loss of Mangrove Habitats

Due to the negative economic and environmental effects, the conversion of mangroves to shrimp farms has been strongly disapproved worldwide. Furthermore, a number of nations, including Malaysia, the Philippines, Bangladesh, China, Indonesia, Sri Lanka, Myanmar, India, Thailand, Brazil, Mexico and Vietnam have seen significant mangrove destruction as a result of unplanned and unregulated shrimp farming as well as high demands and financial returns in the global market. Since the 1960s and 1970s, the governments of numerous Asian nations have promoted the conversion of mangrove forests into aquaculture ponds as a means of addressing food security and livelihoods. Accordingly, Hamilton (2013) discovered that the

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conversion of aquaculture ponds was responsible for more than 54% of mangrove deforestation (28% of the previous mangrove lands).

2.2 Eutrophication

One of the biggest dangers to the coastal ecosystem is nutrient enrichment. The increased nutrient availability promotes the establishment of intertidal mangrove forests; nevertheless, plant growth is more favoured in the aboveground than in the root sections. As a result, plants that are subjected to high nutrient availability must be more susceptible to environmental stresses that necessitate significant root investment for tolerance, like drought. Early studies demonstrated that nutrient-induced mortality is higher in locations with little rainfall, low humidity, and high sediment salinity, and that mangrove ecosystems subjected to excess nutrient availability increase the death rate, particularly during drought. Numerous ecological issues, including extreme eutrophication and the frequent occurrence of toxic algal blooms, can be brought on by the flow of huge amounts of nutrients, such as N and P into coastal waters.

Key Findings (Hutchison *et al*., 2014)

- The highest levels of fish productivity will be found in areas with high mangrove productivity, where the high freshwater input from rivers and rains, and healthy mangroves are present.
- Mangroves with greater physical complexity, both in terms of patterns of channels, pools, and lagoons, as well as the structure of roots, which are important areas for shelter and for growth of some bivalves, will enhance fisheries to a greater extent.
- Fish productivity will increase with an increase in the total area of mangroves, but notably also with the length of mangrove margin, as fish populations are typically enhanced on the mangroves' edges.
- The greatest number of fish will be caught around densely populated locations that serve as both fishing grounds and markets for the catch. Naturally, some of these mangroves near communities are also probably more vulnerable than those in less crowded locations; they may be damaged, the waterways could be contaminated, or they could be overfished and so less productive. Such mangroves are expected to provide the most benefit when they are protected by suitable management regimes and their fisheries are properly maintained. As a result, conservation and restoration initiatives in these regions near populated areas are probably going to yield the highest return on investment.

Conclusion

Mangrove forests are extremely productive ecosystems that flourish in protected coastal zones of tropical and subtropical regions. Shoreline stabilization, coastal protection, erosion management, and nursery habitats for commercially significant species are just a few of the crucial ecological and social advantages they offer. Mangroves are also essential for carbon sequestration, sediment retention, and nutrient cycling. The sector has grown rapidly, extensive conversion of mangroves into aquaculture ponds, which has helped to meet the world's protein needs. However, water pollution, disease transmission, habitat degradation, and biodiversity loss are some of the environmental risks associated with aquaculture growth. To balance the growth of aquaculture with environmental preservation, sustainable management is essential.

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