Assessing The Economic Impact Of Sustainable Aquaculture Practices On Coastal Communities.

Abstract

Just as the cultivation of crops and livestock is known as agriculture, the practice of growing and preserving aquatic life is referred to as aquaculture. The Blue Revolution in India began to enhance aquaculture and achieve economic prosperity while addressing sustainability and environmental concerns. India has been successful to a great extent in this sector and is known as the second-largest fish-producing country in the world.

This research paper aspires to assess the economic impact of sustainable aquaculture practices, the socio-demographic status of coastal communities in India, the challenges faced by coastal communities, and the recommendations for future initiatives. In addition, it seeks to raise awareness about the significance of aquaculture while examining the diverse approaches to enhance its outcomes.

Methodology

The underlying focus of the study is to assess the economic impact of sustainable aquaculture practices on coastal communities. This paper is solely based on secondary data. To understand the economic impact various indicators that add to the economic development were identified. Various research papers and data provided by the Government were referred to gain information regarding the topic of study. The collected data were evaluated and analyzed to understand and narrow down the challenges faced by the coastal communities as well as the Government while implementing various schemes. After a critical analysis of the challenges, recommendations have been made which can provide a way forward to address those issues.

Introduction

From deep seas in the peninsular region to the cold Himalayan rivers, India is blessed with rich marine and inland water resources, sharing about 10% of global aquatic biodiversity. India has been practising sustainable aquaculture for ages which can be traced back to the days of the Harappan Civilization. Aquaculture can be explained as fish farming which consists of breeding, growing, or harvesting of aquatic organisms. It deals with various aspects of sustainable use of aquatic resources such as regular stocking, feeding, protection from predators, pond preparation, etc. As the aquaculture sector flourished, it also brought various challenges to the environment as well as other stakeholders such as environmental degradation, water scarcity, limited availability of land for aquaculture, and high input cost. Due to this sustainable aquaculture has become an important subject of matter. Sustainable

aquaculture predominantly focuses on environmental, economic, and social sustainability to improve capacity building and utilize land effectively for the aquaculture sector. It is a more socially and environmentally sound form of food production.

India is the second largest fish-producing country in the world accounting for 7.56% of global production. It supports the livelihood of over 28 million people in India, especially the marginalized and vulnerable communities. It contributes about 1.24% to the country's GVA and over 7.28% to the agricultural GVA. This sector has demonstrated an outstanding annual growth of 10.87% since 2014-15 with a record fish production of 145 lakh tons in 2020-2021.[1] India has become the 4th largest exporter of fish and fisheries products taking Brand India from 'Local to Global'. The Fish production reached an all-time high of 16.25 MMT during FY 2021-22 with marine exports touching ₹ 57,586 Crores.[2]

Many communities have relied on aquatic food as their primary proteins. As protein-rich seafood demand has increased, practices such as capture fisheries and fish trapping which do not manage or influence captured organisms have put immense pressure on the fisheries sector, deteriorating the aquatic lives. Sustainable Aquaculture is widely accepted for food security reasons and its assistance in economic welfare. Currently, 42% of the seafood we consume comes from fish farming.[3] The global aquaculture market size was valued at $285,359.7 million in 2019 and is projected to reach $378,005.5 million by 2027.[4] Sustainable Aquaculture helps to attain the 2030 Agenda for Sustainable Development adopted by the United Nations.

Thus, Aquaculture has the potential to meet not only food security and nutrition goals but also play a significant role in providing livelihood to the coastal communities, boosting the economy, and increasing foreign exports as well. Aquaculture can be mainly categorized into three types.

1. *Freshwater Aquaculture* deals with organisms in freshwater such as rivers, streams, canals, reservoirs, ponds, etc. It includes organisms such as fishes, prawns, mussels, frogs, crabs, shellfish, aquatic plants, etc. India is rich with inland freshwater fish with about 940 species well known from its rivers and lakes.[5]
2. *Brackish water Aquaculture* also known as coastal aquaculture in which soil and water qualities are similar to freshwater aquaculture except for its water salinity. Estuaries, coastlines, Backwaters, Mangroves & Lagoons are the resources in which organisms such as fish, the seed of milkfish, Elops, Megalops, Polymers, Lates, Etroplus, and tilapia shrimp are obtained. Brackish water farming in India is an old system confined mainly to bheris(man-made impoundments in coastal wetlands) of West Bengal and pokkali (salt-resistant deepwater paddy) fields along the Kerala coast involved in trapping of naturally bred juvenile fish and shrimp seed.

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[1] India Budget
[2] PIB
[3] The Ocean Foundation
[4] Allied Market Research
[5] Agri Farming

3. *Mariculture* mainly consists of aquaculture practices in marine environments and underwater habitats. The culture of Mussels is practiced in Kerala and Karnataka. General characteristics such as tidal influence, wave action, shallowness, turbidity, etc are the major concerns that must be taken into account as cages, rafts, etc that are erected in the sea may get washed away.

Socio-Demographic Status

The Socio-Demographic status will assist in understanding the development of coastal communities and areas of improvement. To understand economic development, it is important to examine the availability of some basic facilities which determine the livelihood of the community such as household facilities, educational status, supply of electricity, etc.

1. **Housing and Basic Amenities**

   Household facilities and basic amenities are essentials that indicate the standard of living and economic status. According to the Marine Fisheries Census conducted in 2016, 69.7% of fisher families reside in pucca houses which are designed to be solid and permanent. This indicates that nearly 30% of farmers still live in kutcha houses and have vulnerable dwelling conditions. Nearly 94% of the houses are electrified. Hardly 59% of the houses have access to toilets and the rest have to rely on common public toilets or open areas. Over 51.6% of households are supplied with potable tap water and the rest of them have to rely on water from wells, hand pumps, bore wells, and other sources. The improvement in basic facilities is important as it also concerns the health of the fishing community residing in that area. However general progress has been recorded in various researches conducted in different coastal zones of India. According to some recent research conducted, many coastal villages now have pucca houses and sanitary latrines due to various rural development schemes and the provision of subsidized installations. A considerable number of families have access to electricity connections. The availability of other facilities such as hospitals, schools, banks, police stations, transportation facilities, post, etc is also an important factor that must be taken into consideration for holistic development.

2. **Education Status**

   Education is an important factor that affects the life of an individual. Basic education enhances understanding and creates awareness which also influences their decision and quality of life. The literacy rate according to the Marine Fisheries Census in 2016 is considerably lower at 57.8 % which constitutes 59.6% male and 55.8% female population. According to various research conducted in different coastal parts of the country, it has been observed that a substantial number of people only had primary education, and very less of them complete their secondary education. A very limited number of people pursue other higher studies. There can be various reasons due to which the literacy rate of coastal communities is low. Firstly, coastal areas have one important occupation which is fishery due to which the young population starting from an early age starts engaging in such activities mainly because of

weaker economic conditions of the family. Also, education has less importance in such rural societies majorly due to the unavailability of proper schools and education facilities which could encourage them to take education.

3. **Government Institution**

   The Government of India made transformational changes through constructive reform in the fisheries sector. It also created the Department of Fisheries in February 2019 which was followed by the creation of an independent **Ministry of Fisheries, Animal Husbandry and Dairying** in June 2019. By creating a separate ministry, it could focus on the major concerns of this sector and make policy decisions accordingly. It is one of the most important decisions made by the Government of India.

   National Fisheries Development Board is an autonomous body under the Ministry of Fisheries, established in 2006 to accelerate the overall growth of the fisheries sector. It works for the development of the fisheries sector, aquaculture, processing and marketing of fish, and application of modern technology and tools to optimize production and productivity in the sector. It creates employment opportunities and gives special attention to the development of women in this sector.

   Marine Products Export Development Authority (MPEDA) was set up in 1972 to develop the fisheries industry with a special focus on exports of the country. It acts as a nodal agency that focuses on the development and expansion of the seafood industry by collaborating with other governments and meeting the seafood requirements globally. It is empowered to carry on all the measures required for the sustainability of the exports. It can take measures for training, marketing, and carrying out inspections.

   Various other important Government institutions are working in the Fisheries sector such as Coastal Aquaculture Authority(CAA), Central Marine Fisheries Research Institute(CMFRI), Central Fisheries Nautical and Engineering Training(CIFNET), Network for Fish Quality Management and Sustainable Fishing(NETFISH), National Centre for Sustainable Aquaculture(NaCSA) and State Fisheries Department.

4. **Other Institutions**

   Various institutions that play an instrumental role in this sector:

   a) **Community Institutions** include traditional groups of coastal communities which have been practicing fisheries from generation to generation. Such groups are often based on caste or religious affiliation or geographical origin, etc. These groups have their own distinct social and cultural practices such as Kolis is known for its *dol net* (a type of bag net) fishing sector whereas Kharwas usually operate trawl units. Such community institutions have their governance system such as the network of *ur panchayat* (village council) in the dominant fishing community of Pattinavars. These traditional governance systems have very elaborate and intricate codes of conduct and play an effective role in solving fisheries-related disputes as it exists at the local level.

Such communities must be considered during policy-making as they will strongly help in the implementation of the policy.

b) **Non-governmental organizations** are nonprofit organizations working in the interest of coastal communities. They need economic support to carry out their work for which they rely on various sources such as private donations, membership dues as well as funds from the government. NGOs either work for a specific purpose or are multipurpose. There are various international, national, state, and local level NGOs working for the coastal communities. For instance, the South Indian Federation of Fishermen Societies (SIFFS) of Kerala is an apex body of organizations of small-scale artisanal fish workers. It has played an effective role in the issues of the fisheries sector.

c) **Cooperatives** - The coastal communities have faced various challenges in their profession which encouraged them to come together to solve these challenges for their upliftment. It gave rise to the Cooperatives Societies in this sector. The size of the cooperatives can be from six to thousands of members. The smaller ones are usually engaged in production while the bigger ones are engaged in marketing and supply. Presently, there is one national-level Federation, 7 state-level federations, 108 central Level federations, and 12,427 primary fishery societies functioning in different parts of India.[6] The National Federation of Fishers Cooperatives Ltd. (FISHCOPFED) is a national-level federation of fisheries cooperatives and the apex institution of the Indian Fisheries Cooperative. There are different types of cooperatives in this sector. Some of the cooperatives focus on a specific demand or purpose whereas some of them focus on overall socio-economic development. They led various movements among which the first movement was led in Maharashtra by the first Cooperatives Society named Karla Machimar Cooperative Society. A recent study reviewed the fishermen's cooperatives in India. It discovered that there were regional imbalances and constraints in many prospects of the functioning of the co-operatives. It observed that sustainable management of both marine and freshwater aquatic ecosystems in India has been largely neglected. The cooperatives can play a noteworthy role in enhancing the socio-economic status of the fishing community and for that reason, it must be acknowledged.

d) **Self-Help Group -** A Self-Help Group is a community-based group that usually consists of around 10-20 members. They are a homogeneous group of coastal communities with similar economic conditions voluntarily coming together to save money collectively. The fund raised by collecting money is used for productive and emergency credit needs. In this way, fisherfolks come together to solve their problems in the form of self-help groups. Upliftment of coastal communities especially those below the poverty level has been noticed due to self-help groups. The observation has

[6] Lucknow University

also shown that these groups have developed their micro-enterprises by identifying the major availability of resources and culturing them.

Such institutions can be considered important political actors as they can influence Government policy decisions. Also, by considering such institutions while making policy reforms and by taking their assistance during implementation, an unprecedented transition in the development of this sector can be perceived.

Government Initiatives

Foreseeing the potential of the fisheries and aquaculture sector, the Government of India has launched a scheme to bring about a significant change in the fishing and aquaculture sector

The ***Pradhan Mantri Matsya Sampada Yojana*** was launched on 10th September 2020 to bring about the Blue Revolution through sustainable and responsible development of this sector in India. This scheme is being implemented in all states and Union Territories for a period of five years from 2020-21 to 2024-25 with the highest ever investment of ₹ 20050 crores in the fisheries sector comprising of Central share of ₹ 9407 crores, State share of ₹ 4880 crore and Beneficiaries contribution of ₹ 5763 crores. The beneficiaries under PMMSY are Fishers, Fish farmers, Fish workers, Fish vendors, SCs / STs / Women /Differently abled persons, Self Help Groups (SHGs)/Joint Liability Groups (JLGs) in the fisheries sector, Fisheries cooperatives, Fisheries Federations, Entrepreneurs and private firms and Fish Farmers Producer Organizations/Companies (FFPOs/Cs) for taking up fisheries developmental activities. It involves joint efforts of the Central and State Governments and various stakeholders. The states are required to prepare proposals according to their needs and potential. The fund is released in a phased manner. There is a State Level Approval and Monitoring Committee (SLAMC) in each state. A similar Committee constituted for Union Territories (UTLAMC) supervises and monitors the implementation of the scheme. A District Level Committee is also formed under this scheme.

A subscheme under PMSSY named ***Pradhan Mantri Matsya Kisan Samridhi Sah - Yojana*** to enhance the earnings and income of the communities was announced in the budget for FY 2023-24. Various short-term, as well as long-term courses and training programs conducted under the institute of *CIFNET*, have been made available under PMMSY.

Although, various schemes were introduced by the Government for the sustainable aquaculture and fisheries sector. There were various problems faced by the fish farmers and fisherfolk community such as lack of technical knowledge of various modern technology and other processes in aquaculture practices. Also, they don't have sufficient knowledge about the credit facilities provided by the government. **S*agar Mitra*** is an initiative where youth is involved for the benefit of the fishing community at the grass-root level. They help in assisting the fisher community and fish farmers by solving their problems and educating them about the dynamics of fish farming, the know-how of modern technology, etc.

To make credit facilities easily available for the fish farmers, the ***Kisan Credit Card*** facility was extended to fish farmers, fishers, Self Help Groups, Joint Liability Groups, and Women's groups to help meet working capital requirements. Till date, 1,30,498 KCCs have been issued to fishers and fish farmers in the country.[7] Due to this, many of them got easy access to the subsidy provided by the Government by Kisan Credit Card.

The Fisheries and Aquaculture Infrastructure Development Fund (FIDF) with a total fund size of ₹7522.48 crore was also released.[8] It focuses on filling the infrastructural gaps in the fisheries sector in the country. It was generated to attract funding and investment from the private sector.

Sagar Parikrama is an initiative made by the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, and National Fisheries Development Board which started in 2023 to spread awareness about various schemes and programs related to fisheries in coastal and union territories.

It also tries to hear the grievances and appeals of the coastal communities. Sagar Parikrama exclusively took place to look into the execution and implementation of the Pradhan Mantri Matsya Smapada Yojana. The Government was able to realize various concerns of the fishers and fish farmers during Sagar Parikrama such as the issue of power consumption in fish farming (pointed out in Punjab), the demand for an increase in kerosene quota, the difficulty faced in the purchase of deep-sea fishing vessels due to technical specifications (Karnataka), the demand for a fish clinical laboratory at district headquarters and the demand for fish processing unit (by Kashmir farmers).

Through the PMMSY scheme Livelihood and nutritional support to 6,77,462 fishermen families. 70 Matsya Seva Kendra and 2501 Sagar Mitra were approved. The PMSSY scheme substantially helped in infrastructural development. Various unrecognized sectors having the potential to grow were taken into consideration. Such activities include Hatcheries, Re-circulatory
Aquaculture Systems, Biofloc, Aquaponics, Marine and Reservoir Cage Cultivation,
Development of aquaculture in Alkaline and Saline areas, Ornamental fisheries,
Seaweed Cultivation, Cold Chain, Marketing and Branding, Urban Market Chains,
Value addition, Startups, Incubators, Innovations, Traceability, Certification, etc.

The following section indicates physical units approved to date across 34 States and Union Territories

INLAND FISHERIES	
Bioflocs	2,693
Recirculating Aquaculture Systems	3,117
Cages	20,662
Fish/Prawn Hatcheries	380

[7] PIB
[8] PIB

MARINE FISHERIES	
Deep sea fishing vessels	276
Upgradation of existing vessels	527
Bio-toilets in mechanized fishing vessels	4,248
Sea Cages	1556
Marine finfish hatcheries	1,325
Brackish water hatcheries	11
COLDWATER FISHERIES	
New Raceways	2,560
Trout Hatched	19
Recirculating Aquaculture Systems	33
ORNAMENTAL FISHERIES	
Ornamental Fish Rearing units	1404
Integrated Ornamental Fish Rearing units	117
SEAWEED CULTURE	
Cultural Rafts	54,000
Monoline/Tubenet	63,531

Source: Department of Fisheries[9]

Also, it has been observed that a lot of significance is given to the inland and freshwater fisheries which have also raised concerns for the marine fisheries community. The total number of fishermen insured under the sub-component of Group Accident Insurance in 2019-2020 was 35,86,721. Odisha has the highest number of fishermen insured i.e.11,50,000 and Tamil has the second highest number which is 5,24,054. The relief assistance was provided under the sub-component of Saving-cum-Realief to 7,65,194 fishermen. For this purpose, ₹9566.77 lakh has been released in 2019-20.

Even though being such a rigorous job where fishermen face long hours of continuous labour in a hazardous occupation, many of them do not have any available health insurance or scheme. According

[9] Department of Fisheries

to the Handbook Fisheries Statistics of 2022 provided by the Department of Fisheries, it has been observed that in some major coastal states, no fishermen have been insured under the group accident insurance such as Kerala, Andhra Pradesh, and West Bengal. Also, in major coastal states such as Tamil Nadu, Telangana, Maharashtra, and Goa nobody received Saving-cum-Relief fund.

Implementation of the scheme has faced several constraints in some coastal regions. The fisheries and aquaculture sector has transformed hugely under the Government scheme, especially under the current leadership of Prime Minister Shri Narendra Modi. The series of events undertaken by the Government brought about an unprecedented amount of investment and recognition to this sector. It led to increased fish production, export earning alleviation, technological enhancement, and infrastructural development.

Economic Assessment

The economic assessment considers various factors that aid the economic activities of this sector.

1. **Occupational Status**

   The Fisheries sector is mainly informal, making it difficult to maintain records. It offers diverse opportunities for a large number of people to earn their livelihood. According to the statistics provided by the Department of Fisheries 2020-21, in India, there is a total of 2,80,63,538 fishermen population. It shows that approximately 2% of the population is engaged in fisheries. Further, 2,31,17,820 are engaged in inland fisheries and 49,45,718 are engaged in marine fisheries which demonstrates that more people are engaged in inland fisheries which majorly consist of fish farming and capture fisheries. Over 3,065,132 fishers are engaged full time whereas 2,340,233 are engaged part-time in this sector. Around 8,95099 are occasionally engaged and 43,87,443 people are engaged in deep-sea fishing. During the fishing ban period (monsoon season) fishers work as farmers or labourers.

   Historically, there have been divisions of labour in this sector based on gender. The men are engaged in the primary fishing activities whereas women are engaged in the secondary activities consisting of post-harvest activities. According to the data provided by the Department of Fisheries, 1,30,13,978 males and 1,01,03,842 females are engaged in inland fisheries whereas 26,51,652 males and 22,94,066 females are engaged in marine fisheries. Active fishing in India is dominated by men whereas women's fishing activities mainly include the marketing and handling of fish as well as its processing and value addition. Traditionally, women have a dominant role in the post-harvest processes and in the marketing system.

2. **Fish Production**

   World fish production in 2020 was 179 million metric tonnes among which India contributed 14.73 million metric tonnes. India contributed 16% of inland fish production and 5% of marine fish production. In India, steady growth in the production of fish and fish products

has been seen over a while. The major fish-producing states that evolved during 2021-22 are Andhra Pradesh, West Bengal, Gujrat, Odisha, and Karnataka.

Fish production reached an all-time high of 16.25 MMT during FY 2021-22 with marine exports touching Rs. 57,586 Crores. Total fish feed production is 5,40,690 fry in the year 2020-2021. Production of fish seed and feed must be prioritized for its easy availability in the local market and the growth of quality of production in the inland fisheries sector.

3. **Export Earnings**

   India has become the fourth largest exporter in the world. Many private companies and large-scale farmers have been able to engage in export activities, thereby increasing national income and foreign trade. India earned ₹57,586.48 crores by exporting 13,69,264 tonnes of fish and fish products in 2021–22.[10] The export was dominated substantially by frozen shrimp which was 7,28,123 metric tonnes with a value of ₹42706.04 crores and frozen fish which was 2,26,586 metric tonnes with a value of ₹3471.91 crores. Other exports include frozen cuttlefish, frozen squid, dried items, chilled items, etc. The top 5 ports which handled marine product cargo in 2020-21 were Vizag, Kochi, Kolkata, Chennai, and JNPT contributed a 69.65% share in US terms.[11] Major markets of Indian export include Japan, the USA, the European Union, China, Southeast Asia, the Middle East, and others. There has been substantial growth in the export of fish and fish products in India due to improved infrastructure of the landing centers, transportation development, and other facilities.

4. **Entrepreneurship**

   Fisheries and aquaculture are a livelihood for coastal communities. This sector has been instrumental in sustaining the livelihoods of over 28 million people in India, especially marginalized and vulnerable communities, and has contributed towards encouraging socio-economic development. [12]Due to increasing demand in the aquaculture sector, many people, especially youth, started to engage in sustainable aquaculture practices such as fish farming and started their businesses. A vibrant entrepreneurial class has driven economic growth in this sector. Entrepreneurs have earned a considerable profit in this sector either by directly engaging in the fish farming culture or post-harvest processes, including value-added products. Many young minds are engaging themselves in this field not just for business but as a passion.

5. **Women's Participation**

   Women constitute nearly half of the employed fisheries workforce globally, with the Indian fisherwomen population accounting for about 44% of the total fisher population. Women engage in various types of fish harvesting activities, including small-scale near-shore fishing activities, seaweed cultivation, fish cleaning, drying, salting, and industrial processing. Women in indigenous and local coastal communities have extensive local and traditional ecological

[10] Department of Fisheries
[11] Department of Fisheries
[12] PIB

knowledge, which contributes to the sustainable use and conservation of marine and coastal ecosystems.

Women face various problems in securing their rights as workers because their role is often unrecognized. They undertake fishing activities along with household responsibilities such as cooking, raising children, and other needs of the family. As marketing systems are subject to the risk of unsold fish, it further creates problems for them as they have to process the fish. Women face severe competition from fisherfolk of other villages who sell their fish at a lower rate. Also, the intervention of intermediaries has greatly affected their role in the marketing system. Due to various such constraints, the role of women has been greatly reduced. The Department of Fisheries hosted a webinar for women to understand and address critical issues. Through Government schemes, the conditions of women have improved. From setting up farms to the facilities required during marketing, the Government has given financial assistance and technical training to women across India. Due to this, there have been many women who have been successful entrepreneurs in aquaculture practices across the country.

6. Infrastructure

Aquaculture has been playing an important role in the national economy and has increased foreign exports. India is blessed with huge resources in the form of rivers, canals, lakes, tanks, ponds, and brackish water. Foreseeing the profit in this sector, there has been a need to develop infrastructure. The infrastructural facilities have been improved under the PMSSY scheme. The following are various facilities operating in the country:

Processing Plants	623
Storages Facilities	859
Handling Centres	230
Fishing Vessels	8,143
Conveyance	165
Ice Plants	50
Pre-producing Plants	605
Quality control Labs	05
Elisa Screening Labs	16

Source: MPEDA

7. **Technological Advancements**

The use of mechanical devices for fish boats was the first significant development of technology in the fisheries sector. A comparative study of the 2011 and 2016 censuses revealed a decrease in the fishing crafts as well as a decrease in the fisherfolk population and the landing centers. It indicates the migration of the fisherfolk population to the urban areas. Various factors such as job opportunities, education facilities, etc can be considered as reasons for the migration. The shift of fishing craft from non-motorized to motorized and mechanized has been recorded. But there has been an overall decrease in the fishing craft. It can be due to its high investment, maintenance cost, fuel expenses as well marine resources depletion. Many small-scale fishers do not have their fishing craft due to which they rely on retailers or wholesalers for equipment. Technological advancements have rendered the existing older units less economical leading to substantial idling of the fleet and underemployment. It has also disturbed the practices of artisanal fisherfolk and their livelihood at large.

There are various technologies promoted by the government, such as bio floc technology and the Recirculating Aquaculture System (RAS), which is land efficient, sustainable, and can be adopted by small-scale farmers. For instance, Odisha Biofloc Tech Fish Farming Scheme was initiated by the Government of Odisha to promote aquaculture with advanced technology. During the coronavirus pandemic period in India, it provided livelihood to the unemployed youth and fish farmers in Odisha. Various technological developments took place in the processing of fish products.

8. **Market Supply Chain**

The market and supply chain for diverse harvests in India depends on fishing gear, total volume, species, size, and quality of fish. They are interconnected and the activity carried out affects the whole market supply chain. Global market supply chains are always subjected to sustainability issues, fluctuations in demand and supply, Government policies, etc. There are various constraints in the market supply chain. The best quality often goes to the export or urban areas, whereas low quality is sold locally and the leftovers are commonly dried or salted to preserve the quality. The market supply chain includes fishers, agents, processors, distributors, and wholesalers/retailers working together. The major problem faced in the market supply is the intervention of intermediaries. This happens due to various reasons such as the huge distance from landing centers to the markets which involve intermediaries. As the number of intermediaries increases in the supply chain such as transport systems, preservation facilities, etc the share of the fishers gets reduced. Thus, the supply chain needs a lot of attention. The change in the market supply chain has also affected women as their role declined from critical links in the supply chain to being ancillary workers. The export market supply chain gets the attention of the government. Post-harvest products market chains are not fully developed. Also, there is no general pricing system for fish or fish products which creates confusion. The NFDB is working on a Fish Market and Price Information System

which will be in the form of a web application. The hygiene and sanitation of the handling centers and markets are not usually in good condition. The quality of raw fish or processed seafood in the marketing system is downgraded due to poor temperature control and a lack of ice storage facilities. The Consensus among the various stakeholders in the market supply chain will enable them to meet their interests as well as maximize the economic benefit of everyone.

9. **Labour Mobility**

   Labour mobility has been a major driver of demographic transformation within fishing communities. Labour mobility can be explained as fishers migrating to other places for employment. For instance, one of the major seasonal interstate migrations has been noted on the northwestern coast of Gujrat, which is also the largest fishing hub of India. The migrants according to the findings are usually from the coastal districts of Andhra Pradesh. They are hired by Gujrati vessel owners on an annual basis and receive their payment before the commencement of work. Another important place for fishing is Kerala where wage rates are substantially higher. In this way, various migrants across the country join such coastal fishing activities due to its growth, economic benefit, and guaranteed payment. According to the analysis of mobility in one study, such mobility also includes overseas migration to the coast of Qatar, Saudi Arabia, United Arab Emirates. Migrants coming from other parts of the country for employment in coastal areas further endanger and deprive the livelihood of the artisanal and traditional communities of the coastal area.

10. **Domestic Food Consumption**

    The growth in this sector also provides food security to its population. Fish being an affordable and nutritious food in India has helped to mitigate hunger and create nutrition efficiency in the country. Many communities in India have fish as their major food item. The consumption of fish is subjected to variations according to geographical areas, religious and ethnic beliefs, and other factors. The total consumption of fish is highest in states such as Kerala, Karnataka, Odisha, and Uttar Pradesh. The per capita consumption of fish and prawns is highest in Lakshadweep and Kerala respectively. Tripura emerged as a state with the highest number of households consuming fish. There are various ways of consumption of fish. The coastal villages have their distinct way of cooking fish. The economy of coastal villages has improved due to the distinct varieties of fish food which attracts people from other parts of the country.

11. **Potential Areas to Explore**

    By taking into consideration the potential of various elements as listed below, the effectiveness of aquaculture can be enhanced thereby acting as a catalyst for boosting the economy.

    a) **Value Addition** - The word Value-addition itself explains adding value to the product by various processes. A lot of time while fishing, some low-quality catches are often discarded. Fish being a perishable commodity, value-addition of it can be used to

retain its quality, and nutritional attributes and to reduce post-harvest losses. They can be processed by various techniques such as salting, drying, smoking, freezing, etc. Value-addition has gained much importance in food processing industries due to the export-oriented fish-producing industry and the increase in foreign exchange due to it. Such seafood or seafood-based products which are in ready-to-eat convenience form have huge demand in the domestic as well as global market. Marketing of such value-added products is different as it has to be made attractive. It will help to increase the consumption. Certain factors such as its packaging, appearance, and display play an important role in attracting consumers. A large number of value-added and diversified marine products both for export and internal market based on shrimp, lobster, squid cuttlefish, bivalves, certain species of fish, and minced meat from low-price fish have been identified. The technology for their production is readily available.[13] The technological dynamics of value-addition processes must reach the fisherfolk, fish farmers, and fish workers to avert the losses they face from low-quality fish. Women must be given special attention as mostly they are involved in the marketing sector and at the end of the sale, they have to process the remaining fish to increase their shelf life to sell it later.

b) **Seaweed Cultivation** - It is one of the commercially important marine living resources in the global market. Seaweed has a wide range of applications in the fields of food, textile, cosmetic, pharmaceuticals, fodder, and fertilizers, due to which its demand has increased tremendously in the recent past. Greenhouse gas emissions cause global warming and climate change, with most carbon ending in the ocean. Seaweed cultivation is a sustainable approach to mitigate global warming effects by attracting carbon from the ocean for photosynthesis thereby reducing ocean habitat disruption. Seaweed grows abundantly along the Tamil Nadu and Gujarat coast and around Lakshadweep and Andaman and Nicobar Islands. A substantial amount of seaweed is also available around Mumbai, Ratnagiri, Goa, Karwar, Varkala, and Pulicat in Tamil Nadu and Andhra Pradesh, and Chilika in Orissa. Around 844 species of seaweeds have been reported from Indian seas, and their standing stock is estimated to be about 58,715 tonnes (wet weight). Out of the 844 seaweed species, India possesses around 434 species of Red Algae, 194 species of Brown Algae, and 216 species of Green Algae[14]. Even though it has abundant biodiversity of seaweed species and a vast coastline of over 8000 km, the commercial cultivation of it has not yet taken place. This sector is largely unrecognized and unorganized. The major importer of seaweed includes Asian countries such as Japan, Korea, and China, and Western countries such as the USA and Europe. The recent Government scheme has recognized the

[13] Research Gate
[14] DOF

importance of this industry and invested in its development. There is plenty of scope for the development of this industry which will not only increase foreign exchange and economic revenue but also provide employment opportunities. India can play a major role in the cultivation of seaweed globally.

c) **Non-food fisheries** - Non-food fisheries are those which are not used for consumption but it is in great demand all over the world. It mainly consists of ornamental fisheries and pearl oyster fisheries. The ornamental fisheries have great demand in the global market. India can enhance its economy by developing ornamental fisheries. Inland and marine waters in India possess a rich diversity of ornamental fish, with over 195 indigenous varieties reported from North-East Region and Western Ghats, and nearly 400 species from marine ecosystems.[15] India is rich in biodiversity of species and other availability such as favorable climatic conditions, and low-cost labour. It offers a wide scope of development of ornamental fisheries. This hub supports wide areas of economic activities ranging from large and small scale production of ornamental fishes, their distribution to domestic and international markets, related logistical activities, production and distribution of aquarium and its accessories, life and formulated ornamental fish feed, etc. together constituting an elaborate business network. Training for the breeding of ornamental fisheries must be given to the fish farmers.

d) **Integrated fish farming** - It is a farming technique in which there are sequential linkages between two or more farming activities such as producing fish in combination with other agricultural or livestock farming centered around fish farms. For instance, fish-cum-cattle practice utilizes the waste produced by the cattle for the cultural practice of fish production. It not only efficiently utilizes the waste but also reduces the production cost, cleans the environment, and gives additional economic benefits of integrated production output. Such an integrated fish farming system can improve the livelihood of the weaker section of society.

e) **Biofertilizers** - The major cost in fish farming is spent on fish feed. The usage of certain bio-fertilizers can reduce the cost invested in feed. There are various bio-fertilizers that have been used traditionally by coastal communities. One such traditional practice is performed in Tripura where *duckweed* is used as feed. It provides various sources of nutrients and oxygen to the water. Another important bio-fertilizer traditionally used in aquaculture is *Azolla*. It has been used throughout Asia and parts of Africa for being a nitrogenous biofertilizer rich in nutrients. Biofertilizers can be used directly or with a combination of other feed components. By using fertilizers or by mixing them with the feed, the overall cost of the feed can be reduced.

[15] NFDB

Challenges

Aquaculture growth has been hampered by several issues. Important constraints identified by the study are as follows:-

1) For small-scale farmers, their livelihood depends on this occupation. Due to unawareness of know-how of aquaculture practices and various preventive measures needed to be taken such as maintenance of hygiene, aeration facilities, etc leads to disease outbreaks, and high mortality rate due to lack of oxygen resulting in crop failure. It prevents farmers from further engaging in aquaculture practices.
2) Andhra Pradesh is the major shrimp-growing state with 150,000 ha of brackish water. The aquaculture in Andhra Pradesh was 40,445 ha in 2015 and 79,600 ha in 2000 which indicates that the area has decreased.[16] According to one of the case studies in Andhra Pradesh, lands that were converted into ponds or farms for fish farming have been abandoned after short-term use. It has been observed that aquaculture abandonment is due to the reduced environment suitability of sites for shrimp farming, disease outbreaks as well as unplanned expansion near ecologically important regions such as mangroves and agricultural land. Such abandoned land or ponds deteriorate and pose a threat to the neighbouring habitat. The impact of unused shrimp farms also adversely affects fish farmers' livelihoods.
3) Bottom trawling is an ecologically disruptive practice as it captures juvenile fish, thus exhausting the ocean's resources and affecting marine conservation efforts. This practice was started by Tamil Nadu fishermen in Palk Bay.[17] Many coastal communities from other states are engaged in Bottom trawling methods which deteriorates fish stock and creates a major problem for future aquatic life and livelihoods of artisanal fishers.
4) Fishing ban in the monsoon period which is considered a breeding period is imposed to protect spawning and marine habitat. Fishing during the monsoon period can lead to a decline in fish population. The Centre has the authority to regulate the activities in the Exclusive Economic Zone and states have the authority over their respective territorial waters. Maritime states are implementing a seasonal ban of 45-75 days for mechanized fishing vessels as a corollary to their Marine Fishing Regulation Acts. The seasonal fishing ban varies from state to state such as variation on the type of craft or vessel restricted. Some states have shorter ban periods whereas some states allow small-scale fishers with small engines to fish during the ban period. Earlier there was no uniform ban period but after the intervention of the Ministry of Agriculture, Government of India, a uniform ban has been made along the west coast

[16] Science Direct
[17] Insights of India

(June15-July31) and east coast (April 15-May 31) states and union territories.[18] It has been analyzed that these bans are also a result of the politics of small-scale fishing communities facing challenges due to the large-scale fishing sector. There have been instances of boats fishing during the restricted period. Such a problem has occurred in coastal areas of Mumbai which affected the Koli community.

5) The Coastal community in the Malvan region of Maharashtra is also facing a similar problem of a decline in fish stock. Various disruptive practices such as bottom trawling, LED fishing, and encroachment of fishermen from the neighbouring states into Malvan waters are the reasons why Malvan fisherfolks known for their artisanal fishing practices are facing problems.
6) The Central Government has cut down the State's share of kerosene by half which raised concern among fishermen as a large number of them depend on kerosene to power their outboard engine. As fisheries are their livelihood they have to obtain kerosene from the open market at a much higher price and such small fishers don't have adequate means to obtain kerosene at such a higher rate and due to this they are exploited. There has been a demand for an increased kerosene quota by the fishers.
7) Deficient working of Coastal Aquaculture Authority as since its establishment in 2006, an environment protection fund has not been created yet. The Coastal Aquaculture Authority did not fulfill the gaps in the existing regulation for the construction and operation of aquaculture farms within the coastal area. It lacks the procedure to ascertain compliance with the norms beforehand according to registration requirements. In addition, it did not direct any regulation for existing aquaculture farms to register with the authority. As cited in the CAG report of 2020, there may be instances of shrimp farms adjoining the agricultural lands. It leads to the seepage of saline water and pollution due to effluents from such farms into the agricultural land. This situation not only hurdles aquaculture culture growth but also the production of grains subsequently affecting the economy. CAA has not conducted any survey to ascertain whether the land is suitable for aquaculture or not. No adequate steps to test wastewater samples from shrimp farms that contain nutrients that are a threat to agricultural land and eventually seep into the agricultural land. No grievance redressal mechanism is set up as to in what time frame the action will be taken.
8) Some farmers are unaware of the credit facilities given by the government.
9) As per Government statistics, 62.5% of wastewater in urban India remained untreated or partially treated.[19] The wastewater usually comes from industries and is discharged into the water thereby depleting the water bodies and loss of marine organisms.
10) Storm surges, tides, floods, etc damage the coastal land and its surrounding area resulting in heavy loss of human life. Also, due to tides and floods in the ocean, the fish catch also

[18] CMFRI
[19] India Water Portal

decreases as the fishes go deep into the sea and it becomes difficult for the communities to sustain their livelihood.

11) Other problems usually faced by the farmers are a lack of trained manpower, diagnostic labs, cold storage facilities in the boats, issues of power consumption, fuel expenses, and technical illiteracy.

Recommendations

Aquaculture has been recognized for its social relevance not just because of food security measures but also for the development of coastal communities. The study's findings suggest various recommendations that can be worked upon for the enhancement of the aquaculture sector in India.

1) It is suggested that the Government can set up fish farms on their owned lands in collaboration with private companies wherein it can employ farmers who are interested but are not prepared to start their business and provide internships to young students having a background of study in this field. In this way, the farmers will be able to learn about aquaculture practices under the supervision of experts, earn income, and later can set up their own farms. Also, students having technical knowledge about aquaculture practices will be able to gain practical experience.
2) To prevent the encroachment of fishers from other states into the coastal areas of other communities and to keep track of banned illegal practices, the Government can use drone technology to explore the concerned rivers or sea facing such issues. In this, the Government can know about the people engaged in encroachments and can fine them. For this purpose, fishing vessels or boats must have identification remarks such as vehicle number plates which can help to find out the identity of the owner of the boat, so that after being captured by the drone an automated message can be sent to them regarding a fine. Such an automated message will also work as maintenance of record. Later, the vessel or boat can be confiscated by the Government until the fine is paid. The fish caught by illegal fishing can be sold to the coastal communities at a lower rate. The record of the number of fish caught as well as the fine incurred should be maintained to prevent corruption practices.
3) There is a rise in the price of kerosene as the Government is longing to reduce the use of kerosene in the country, especially in cooking due to which critical problems arose for the fishermen. Short-term measures are needed to ensure that the livelihood of fishers is not at risk. This problem will not be solved until a long-term initiative is taken by switching to alternative technology. The electronic boat that works on solar energy can be one of them. NavAlt is an Indian eco marine tech company that has developed a solar-electric fishing vessel named SRAV. The company along with the Shell foundation aims to build 100 such vessels to uplift the life of the fishermen. Another such innovative vessel named Sagar Haritha was

constructed at the Goa shipyard by CIFT under a public-private partnership model. Here, it is suggested that the Government can invest in buying some of these vessels. It can form groups of fishermen in the coastal areas who are interested to switch from fuel-based boats to solar-electric ones and wish to buy them in the future wherein an entry amount (around ₹100-200) must be paid to become a member. It can provide one vessel per group for 1-2 months. By buying minimum numbers of such vessels, the Government can transfer them to the other groups in other areas as well. In this way, the fishermen can also become aware of such new technology which will reduce the burden of their fuel costs. In addition, it will also be a major move towards environmental protection.

4) To prevent bottom-trawling practices, the Palk Bay Scheme for Tamil Nadu was launched in 2017 under Blue Revolution. This initiative aimed to provide 2000 deep sea fishing boats with long lines and gill nets in three years to replace trawlers. A deep sea fishing plan where boats are designed in such a way that fishermen can get access to deeper parts of the ocean with no ecological damage can solve the issue of Bottom trawling. Such deep-sea vessels must be promoted.
5) A research conducted study of sewage treatment in Kolkata wherein all municipal waste passes through one or two fish ponds for treatment before being released to Hooghly River. As the wastewater passes through an ingenious system of ditches, they reduce the toxic compound and use it to produce 5-7 tone fish per hectare without any addition of feed or fertilizers. If such a system is enhanced and used all over India to treat wastewater and use it to produce fish, additional benefits can be gained. It is suggested that a suitable regulatory framework must be initiated by the central government. Participation of the private sector may improve the implementation. Allocation of treated water for aquaculture practices as well as irrigation facilities must be ensured. Also, health threats related to such water must be assessed and monitored regularly.
6) It is suggested that the Environment Protection Fund as directed must be created from the compensation received from the environmental polluters. It must be given to the people affected by it and must be used to restore environmental damage done. All the data should be maintained by the Coastal Aquaculture Authority. It will not only help in financially upgrading aquaculture but also restrict any person from harming the environment.
7) It is recommended that the authority responsible for regulations must list the prerequisites and look into the construction and operation of aquaculture farms. In addition, it must simplify the registration procedure and prescribe procedures to ascertain compliance with the norms. Also, it must be made mandatory to issue an order for the compliance of distance (which will be notified by authority) between the shrimp or any aquaculture farm and agriculture farm by which immediate actions can be taken to resolve the issue.

8) To promote sustainable aquaculture it is important to provide aquatic lives with a healthy and oxygen-rich environment. Therefore, wastewater tests must be carried out which will help to increase the quality of shrimp or fish.
9) It is a matter of concern to curb illegal shrimp farms or fishing. Therefore, an active grievance redressal mechanism with strict rules and regulations must be set up.
10) Many people who practice aquaculture hail from rural parts of India. Therefore, it is important to provide them with a list of prerequisites to aquaculture. It will include parameters on which land and sustainability can be confirmed. Also, a surprise inspection is necessary to regulate the aquaculture units. The data must be kept recorded and revised after every six months.
11) Stock enhancement of threatened and endangered species in the inshore water.
12) Stakeholder consultation and feedback mechanisms are required for better implementation of policy.
13) Collection and maintenance of data on coastal areas and related activities by the local authority. The fishermen must maintain a record of their daily activity. It will help in assessing the overall conditions of the community and implementing policy measures in the future.
14) It is suggested that the Government can set up district-wise fishers training Shivir (camp) every month to train fish farmers about the dynamics of fish farming.

Conclusion

Sustainable aquaculture practices have emerged as a viable option to curb overfishing. The initiatives taken by the Government have improved the conditions of the fishing community to a large extent. Various challenges faced by the fishing communities and fish farmers indicate areas for improvement. Several determinants postulate sustainable aquaculture becoming an indispensable sector in the foreseeable future of India. To promote the further development of this sector, a wide range of actors in the private sector, the government, and civil society must work together to assure success.

In conclusion, this paper has addressed several factors pertaining to the aquaculture sector that can uplift the socio-economic conditions of coastal communities. On the other hand, it can also help to improve the economy of the country.

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