Socio-Economic Analysis of Marine Fisheries and Mariculture: Data Collection and Analytical Framework

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Fisheries sector plays an important role in the Indian economy with significant contribution to national income, employment generation and food security to millions of people. Fisheries sector sustains the livelihoods of around 30 million people in India mostly belonging to the marginalized and vulnerable communities. India is the third largest fish producing country in the world accounting for 8% of global production and contributing about 1.09% to the country's Gross Value Added (GVA) and over 6.724% to the agricultural GVA. Fish production in India reached 17.54 million tonnes in FY 2022-23. The fisheries sector recorded an outstanding double-digit annual growth of 10.87 per cent since 2014-15 (Economic survey, 2021-22). The marine fish landings in India pegged at 3.74 million tonnes in 2023. The mechanised sector contributed 2.8 million tonnes (79%), motorised sector contributed 0.71 million tonnes (20%) and nonmotorised sector 0.03 million tonnes (1%) (CMFRI, 2024). The estimated value of marine fish landings at landing centre level was ₹58,240 crores and at retail level at ₹79,860 crores (CMFRI, 2023).

Human behavior significantly influences the availability and distribution of fishery resources, and hence it is essential to evaluate the biological, social, and economic status of fisheries in order to assess their performance. Socio-economic assessments give insights to guide decisions before, during and after an intervention. The economic and financial indicators act as decision making tools for investment in marine capture fisheries and mariculture activities. Economic analysis is the key to assess the prospects of any technology and it helps in devising policies on public expenditure, promotional schemes, subsidy programmes as well as private investment decisions for achieving the desired progress in technology adoption. The ecological and socioeconomic vulnerability assessments are fundamental towards developing and implementing regional adaptation strategies to climate change. The economic indicators also serve as useful additional tools by providing criteria for a better fisheries management.

The socio-economic analysis in marine fisheries and mariculture include cost-benefit analysis, bio-economic analysis, factor productivity analysis, risk analysis, marine fish marketing and price analysis, supply-demand analysis, economic loss and damage analysis, technology assessment and refinement, livelihoods and gender studies and socio-economic impact assessment (SEIA) of fisheries-related policies, programmes and projects. SEIA is the systematic analysis used to identify and evaluate the potential socio-economic and cultural impacts of a proposed development on the lives and circumstances of people, their families and their communities (MMO, 2024). Socioeconomic impact assessments of technologies give insights on the economic benefits realised from different technologies to society

Financial ratios such as Operating Ratio, Input-Output ratio, Gross ratio and discounted measures like Net Present Value (NPV), Internal Rate of Return *(*IRR) and Benefit-Cost Ratio (BCR) are generally used to analyse the financial feasibility of marine fisheries or mariculture at micro level (Table 1).

Table 1. Economic and financial feasibility indicators

1.	Gross revenue per trip	Σ Landings of resource (Q_i) x Price /kg of resource (P_i)
2.	Net profit	Gross revenue-Total cost (include operational expenses, depreciation and Interest on fixed capital)
3.	Operating ratio	Operating cost/Gross revenue
4.	Input-output ratio	Input cost/ Gross revenue
5.	Gross value added	Net operating profit + Labour wages
6.	Rate of return (%)	Net profit/Initial investment
7.	Payback period (in years)	Initial Investment /Average annual net profit
8.	Net present value (NPV)	$\sum_i Bi/ (1+r)^i\}-\{\sum_i Ci/1+r)^i$
9.	Benefit cost ratio (BCR)	$\{\sum_i Bi/ (1+r)^i\}/ \{\sum_i Ci/1+r)^i\}$
10.	Internal of return (IRR)	NPV= $\sum_i Bi/ (1+r)^i-\sum_i Ci/1+r)^i=0$

Note: Bi is the total revenue in year i, Ci is the total costs in year i, i is the no of years of farming and r is the discount rate. IRR of an investment is the discount rate at which the net present value of costs (negative cash flows) of the investment equals the net present value of the benefits (positive cash flows) of the investment.

Advanced socio-economic analysis tools help to address the complexities of fisheries management by integrating social, economic and ecological considerations. Fishery Performance Indicators (Anderson *et al.*, 2015) employ 68 economic and community related metrics of fishery management. Fishery Socio-economic Outcomes Tool is a novel tool for rapid assessment of socio-economic performance of fisheries management. Indicators of these outcomes are scored by key informants and weighted according to the importance of particular fishery management objectives, resulting in standardized scores of fishery management outcomes (Smith *et al*., 2019). The Integrated Social-Economic-Ecological model for Fisheries (ECOST) model is structured with three modules to characterize some relevant aspects of social, economic and ecological systems, respectively (Failler *et al*., 2022).

Economic evaluation in marine fishing operations: Data collection and analytical tools

The economic performance of marine fishing units is assessed based on the primary data on operational costs, fixed costs and revenues collected from fishing units operating in selected fishing harbours and fish landing centres of the country following stratified multistage random sampling method. The operating costs in marine fishing consists of expenses on fuel, (diesel/kerosene), ice, food for the crew, crew bata, crew share, repair and maintenance of crafts, gears and engine, water charges, auction charges, landing charges and other miscellaneous expenses. The input costs consist of operational costs excluding the crew wages. The crew wages are paid either as fixed monthly payments or as a share of the net income earned per fishing trip. The crew share varied from 35-50% of the net income for mechanized fishing units.

The mechanized fishing sector in India consists of trawlers, purse seiners, gillnetters, dolnetters and liners. There are many types of trawlers varying in size from open boats, powered by inboard engines to huge factory ships, which can fish in the most distant waters. Shrimp trawlers are commonly seen in the west coast, especially in Kerala and Karnataka. Pair trawlers are seen in Maharashtra and Gujarat coasts. Danish seiners are used for deep sea trawling. Otter trawlers, the common trawler seen in various maritime states in India is the single most productive method of fishing. Based on the microlevel indicators calculated for different states, the macroeconomic indicators are calculated. The macro level indicators such as gross value added in the marine fisheries sector, per capita earnings of marine fisherfolk, gross earnings at landing centre and retail levels give insights on the significance of marine fisheries sector to the economy. Gross value added (GVA) is the measure of the value of goods and services produced in an area, industry or sector of an economy, net of purchased inputs. GVA excludes 'intermediate consumption', i.e. goods and services consumed or used up as inputs in production, such as raw materials (Table 2).

Table 2. Marine fisheries in Indian economy: Macroeconomic indicators

Macroeconomic indicators	**Value**
Value at LC level (in ₹crores)	58247
Total operating cost (in ₹crores)	27087
Net operating income: (in ₹crores)	31160
Average capital productivity	0.47
Gross value added (GVA) (in ₹crores)	43420
GVA as a percentage of Gross Revenue (%)	74.54

Marine fish marketing and price spread analysis

The marine fish marketing studies are conducted to assess the efficiency of fish marketing and to devise strategies for improving the efficiency of commodity supply chains. The real time fish price collected from landing centre and, wholesale and retail levels provide information on marketing efficiency and helps to develop Fish Market Price Information System' (FMPIS). Fishermen' Share in the Consumer's Rupee (FSCR) is the ratio of the price received by the fishermen to the price paid by the final consumer indicates the efficiency of marketing. The Department of Fisheries through National Fisheries Development Board (NFDB) has initiated 'Fish Market Price Information System' (FMPIS) in year 2018, to capture and disseminate fish market prices of commercially important marine and inland fishes from selected wholesale and retail fish markets. FMPIS present the real time fish price is captured from 88 retail & wholesale fish markets and are uploaded in FMPIS web portal (www. pib.gov.in). Fish Market Price information system (FMPIS) create an enabling environment where stakeholders in the fish value chain are better informed. It provide fishermen, traders and consumers easy access to price information, and empowers the value chain agents to operate efficiently. The fish price indices are developed to assess the inflation in domestic fish markets and its impacts on producers and consumers.

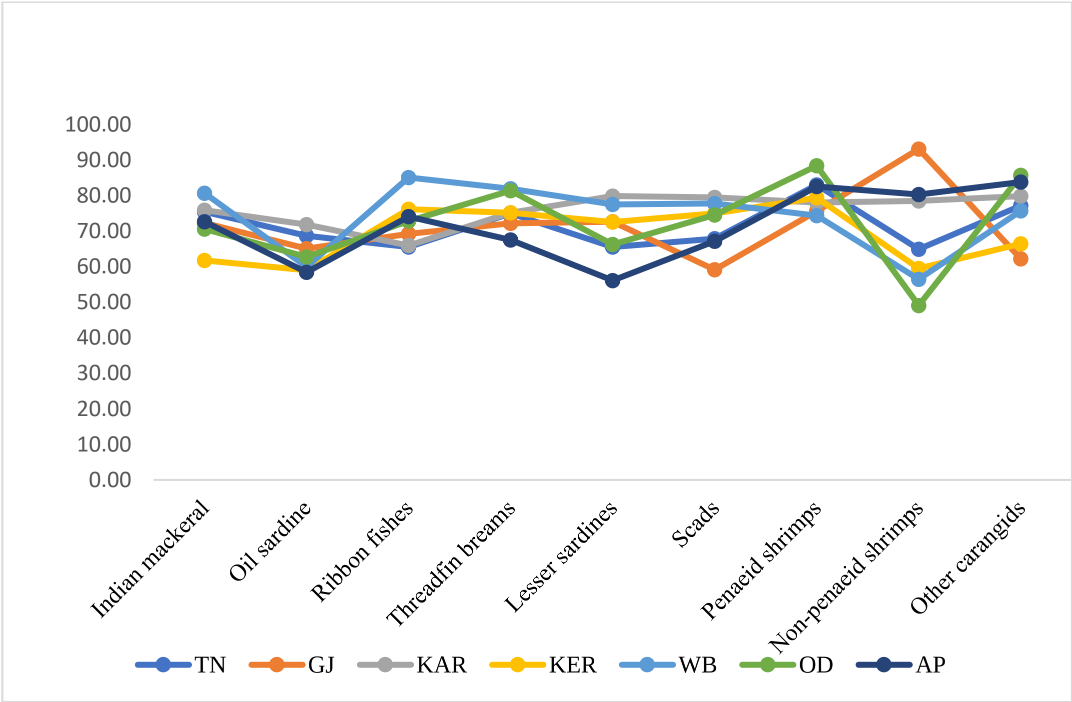

Fig. 1. Fishermen's Share in the Consumer's Rupee of selected states in India

Socio-economic assessment of mariculture operations

Aquaculture is one of the fastest growing animal food sectors and a significant contributor to the global economy. Global aquaculture production including algae reached 214 million t, generating a first sale value of $406 billion in 2020 (FAO, 2022). Mariculture holds huge prospects for boosting the fish production and livelihoods across the globe. Mariculture technologies had evolved in India in the 1970s with the introduction of seaweed farming followed by bivalve mariculture in the 1980s. However commercial mariculture began in the India only in the 1990s with mussel and edible oyster farming by the self-help groups in Kerala. The potential mariculture technologies in the country consist of seed production and farming of finfishes (cobia, pompano, sea bass, groupers, snappers, breams and ornamental fishes), shellfishes (mussels, oysters, clams, lobsters, green tiger shrimp, blue swimmer crab, ornamental shrimps) and seaweeds. These technologies offer immense scope for generating substantial revenues and fish production for the country.

Economic analysis of finfish mariculture

Mariculture of finfishes in India started with open sea cage farming in 2005 by the ICAR-Central Marine Fisheries Research Institute through development of HDPE cage structures suitable for farming in the open sea. Cage farming technology has advantage over other aquaculture technologies in terms of high yield, low initial investment cost, easy maintenance and limited space requirements. Successful cage farming demonstrations were carried out in different maritime states of the country which led to the popularisation of the technology. The major finfishes suitable for marine cage farming in India include seabass, cobia, pompano, groupers, snappers, shrimps and lobsters. Integrated multitrophic aquaculture involving culture of finfishes along with seaweeds and mussels also proved successful in various regions of the country. Development of hatchery techniques for high value finfishes, culture protocols, low capital investment, vast areas suitable in marine, estuarine and coastal waters, economic viability and socio-economic feasibility contributed to the success of the technology in the country.

Asian sea bass, cobia and silver pompano are the major species cultured through cage farming. Asian seabass, *Lates calcarifer* which has fast growth rate, tolerance to varying salinity levels, crowding and temperature variations is highly suitable for cage farming in marine, estuarine and coastal waters. CMFRI has standardised culture of seabass in different types of cages in the marine, estuarine and brackish water areas with good economic returns (Rao *et al.*, 2013). The culture of seabass in HDPE cages of 6m dia in the open sea yielded gross revenue of ₹10 lakhs and net profit of ₹5.59 lakhs during a culture period of 7 months. (Table 4).

Table 3. Investment and annual fixed cost of 6m dia HDPE cage for open sea cage farming

	Particulars	**Amount (₹)**
I.	**Capital investment**	
1.	Cost of HDPE cage frame	140000
2.	Mooring materials	80000
3.	Nets (2 Inner net and one outer net with ballast pipe)	80000
	Sub Total	300000
4.	Depreciation	47429
5.	Interest on fixed capital	36000
	Annual fixed cost (A)	**83429**

Cobia (*R. canadum*) is another fast-growing fish preferred for open sea cage farming. It attains weight upto 4-5 kg within one year. Cobia has been successfully cultured in the open sea in various maritime states of the country through frontline demonstrations of CMFRI and participatory cage farming with the involvement of fisherfolk. Cobia farming in 6m dia HDPE cage yielded 2.4 t and realised a net profit of 3.44 lakh per cage. The benefit -cost ratio was 1.58 for a project period of 7 years at 15% discount rate.

Table 4. Economic analysis of open sea cage farming (Cage size: 6 m dia x 5 m depth)

Particulars		**Amount (₹)**	
		Seabass	**Cobia**
I.	**Annual fixed cost (A)**	83429	83429
II.	**Operating costs (B)**		
1.	Cost of seeds	90000	25000
2.	Cost of feed	200000	200000
3.	Labour charges @ ₹6000/month for 7 months	42000	42000
4.	Boat hire & fuel charges	10000	10000
5.	Harvesting & miscellaneous expenses	15000	15000
	Total operating cost(B)	357000	292000
	Total cost(A+B)	440429	375429
III.	**Returns**		
1.	Production	2.5 t	2.4 t
2.	Gross revenue	1000000	720000
3.	Net profit	559571	344571
4.	Cost/ kg of fish (₹)	176	156
5.	Price/ kg of fish (₹)	400	300
6.	Operating ratio	0.36	0.41
7.	Pay-back period(years)	0.53	0.87
8.	NPV	1752593	1003930
9.	B-C Ratio	1.86	1.58
10.	IRR	95%	68%

Source: Aswathy *et al.*, 2020

A macro level economic impact assessment of the sea cage farming technology using economic surplus model indicated that the technology holds huge potential in terms of economic benefits and welfare to the society. The net present value (NPV) during 2005 to 2030 period was estimated at ₹5260 crores and the return to research investment was 48%. Though the technology holds immense potential for augmenting fish production and generating revenues, the large-scale commercialisation is constrained by lack of suitable mariculture policies and regulations.

Economics of seaweed farming

The seaweed industry in India is worth $600 million and the sector provides employment to nearly 20,000 people (www.asiafarming.com). India has the potential to produce around 9.7 million t of seaweed per year (CMFRI, 2022). Government of India has earmarked ₹640 crore exclusively under the Pradhan Mantri Matsya Sampada Yojana (PMMSY) for promotion of seaweed farming in the country (CMFRI, 2022). Sea weeds have good market demand for manufacturing agar, agarose, carrageenan and alginates. *Kappaphycus alvarezii* is the major species cultured in India and the farming is widely carried out by floating bamboo raft, longline or monoline and tube net. The economics of *Kappaphycus* farming using raft method generates an annual net profit of ₹127,380 and B-C ratio of 2.3 (Table 5).

Table 5. Costs and returns of seaweed (*Kappaphycus alvarezii*) cultivation

Particulars	**Unit of 45 rafts 5 cycles/ year**
Initial investment (@₹1300/raft)	**58500**
Depreciation	19500
Interest on fixed capital (12%)	7020
Annual fixed cost(A)	**26520**
Operational costs (B)	
Seeds (60kg/ raft @ ₹8/kg)	21600
Recurring expenses (labour, transportation, and miscellaneous expenses) @ ₹220/raft/cycle	49500
Total cost (A+B)	**97620**
Annual dried seaweed production (100 kg/raft)	4500 kg
Price of dried seaweed (₹/kg)	50
Annual revenue	225000
Annual net profit	127380
B-C Ratio	2.3

Note: Calculated based on Johnson *et al*. (2020)

Socio-economic surveys of fisher households

Socio-economic surveys are conducted either by complete enumeration of fisher households (census) or though sampling. The socio-economic information primarily consists of socio-demographic particulars, income, consumption, savings, indebtedness, women empowerment etc. Socio-economic surveys help to assess the extent of socio-economic development contributed by technology adoption or development projects to fisher communities. Socio-economic impact assessment (SEIA) is the systematic analysis used to identify and evaluate the potential socioeconomic and cultural impacts of a proposed development project or technology on the lives and circumstances of people, their families and their communities.

Livelihood status assessments are key to understanding the vulnerabilities of households or communities and for developing policies to reduce poverty and improve livelihoods. The Sustainable Livelihoods Approach (SLA) helps to organize the factors that constrain or enhance livelihood opportunities and shows how they relate to one another. It helps to plan development activities and assess the contribution that existing activities have made to sustaining livelihoods. Livelihood strategies and outcomes are dependent on access to capital assets comprising natural, physical, social, human and financial and are transformed by the environment of structures and processes. Structures are the public and private sector organizations that set and implement policy and legislation; deliver services; and purchase, trade, and perform all manner of other functions that affect livelihoods. Processes embrace the laws, regulations, policies, operational arrangements, agreements, societal norms, and practices that, in turn, determine the way in which structures operate (Serrat, 2008). Exploring the dynamics of the livelihoods of the poor in the fish production and marketing chain will support for the development of policies to ensure sustainable fish production, marketing and livelihood sustainability.

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