

A Strategic Analysis of a Decade of India's Climate-Resilient Initiatives for Sustainable Fisheries (2014 – 2023) under the Pradhan Mantri Matsya Sampada Yojana

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Abstract:

The Indian Fisheries sector is grappling with anthropogenic climate change related challenges such as rising sea temperatures, dwindling catch volumes, migration of favourable species from traditional breeding grounds. Climate change is generally considered anthropogenic as it is caused by human activities such as increased maritime trade, oil spills, GHG emissions, large mechanised trawlers which make governance of oceans particularly difficult. The Blue Revolution Scheme for Integrated Development and Management of Fisheries (FY 2015-16), with a budgeted expenditure of Rs.3000 crores over five years, laid the foundation for targeted policy intervention to make the fishery sector sustainable. The Pradhan Mantri Matsya Sampada Yojana (PMMSY, 2020 -2025), further integrated efforts of research institutions such as the ICAR-Central Marine Fisheries Institute, Institutional lending institutes, fish farmer co-operatives, the Ministry of Fisheries, Animal Husbandry and Dairying and various State governments to make the fisheries sector climate-resilient and sustainable. This paper examines the effect of aquaculture investment in cage farming, sea-weed cultivation, shrimp culture, ornamental fisheries on production, productivity and export earnings of the fisheries sector. There is a significant reduction in marine dependency and a shift towards climate resilience lowering the vulnerability of fishers to climate change induced disruptions in catch volume and earnings.

1.0 INTRODUCTION

India, with a coastline of 11,098.81 km and 3477 coastal villages, is a major revenue generating country in the global marine ecosystem. “India is the second largest producer of fish after China, producing around eight percent of global output in 2024-25” (Press Information Bureau, Government of India, 2025). The last decade has seen a tremendous transformation of India's fishery sector beginning with the launch of the Blue Revolution Scheme for Integrated Development and Management of Fisheries in FY 2015-2016 with a budgeted outlay of Rs.3000 crores for five years. In continuum, the Pradhan Mantri Matsya Sampada Yojana - a policy aimed at the holistic development of inland and marine fisheries across all states and Union territories in India was implemented for the policy period FY2020 - FY2025 (now extended to FY2026). The scheme comprises of a Central Sector Scheme which is wholly sponsored by the GOI and a Centrally Sponsored Scheme where both the state government and central governments pool in funds in predetermined ratios as per certain criteria. The Centrally Sponsored Scheme is an amalgamation of beneficiary oriented and non-beneficiary oriented sub-components which were categorised into three verticals: Production and Productivity Enhancement, Management of Post-Harvest Infrastructure and Regulatory Framework for Sustainability. The various initiatives of the Blue Revolution Scheme and the PMMSY which has led to a hundred and six percent growth in India's fish output in a decade from 95.79 lakh tonnes in 2013-14 to 197.75 lakh tonnes in 2024-25 (PIB, GOI, April 2026). The integrated policy intervention focuses on laying down a regulatory framework for sustainable harvesting through various aquaculture initiatives and technology adoption by the fishermen. The three-pronged approach targets increase in fish production and productivity, inclusive growth for fish farmers and those engaged throughout the fisheries value chain and formalisation of the sector through an institutional framework which encompasses infrastructural development, registration on the National Fisheries Digital Platform and regulatory compliance in the Exclusive Economic Zone. In view of the strategic importance of this sector in economic growth and development, the Department of Fisheries, has approved investment to the tune of Rs.21,274.16 crores for the development of the fisheries sector in India which comprised of a central share of over Rs. 9,189.79 crores in March 2026 (Press Information Bureau, GOI, 2026).

2.0 RATIONALE AND STATEMENT OF THE STUDY

“Sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future” (Brundtland, 1987). The fisheries sector provides staple food and livelihood to around twenty-eight million people and contributes around 7.43 percent of the agricultural Gross Value Added as of 2025-26 (Press Information Bureau, Government of India, 2026). Fisheries sector

also generates export revenue with the value of fish and fish product exports reaching its all-time high of Rs.62,408 crores in FY2024-25 with two-thirds of the export value derived from aquaculture initiatives (Press Information Bureau, Government of India, 2026). Existing literature is fragmented and delves on documenting physical outcomes, one initiative at a time. However, revamping the fisheries sector in terms of the economic, community based and environmental aspects of sustainability involves an integrated approach and collaborative effort by the Ministry of Fisheries, Animal Husbandry and Dairying (MoFAHD), National Fisheries Development Board (NFDB), Indian Council of Agricultural Research-Central Marine Fisheries Research Institute (ICAR-CMFRI) and State Fisheries Departments. This study attempts to bring out the interlinkages and complementarities between these strategic policy interventions. In view of the significance of this sector in accelerating sustained development and high rate of inclusive economic growth, this study aims to analyse India's climate resilient initiatives for sustainable marine fisheries under the umbrella of the Pradhan Mantri Matsya Sampada Yojana in the period 2014-2023.

3.0 SIGNIFICANCE OF THE STUDY

The study will assess the efficacy of targeted policy intervention through adoption of climate resilient technologies and regulatory compliance on the production and productivity of this sector. The marine fishery sector in India is facing numerous challenges due to global warming namely rise in sea temperature, ocean acidification, migration of favoured species from traditional breeding grounds. Moreover, socio-economic thrust on development through construction of infrastructure for instance coastal roads and harbours and disruption of traditional drying grounds. Fragmented regulatory policies with different norms and different penalties have led to over-capitalisation of fishing vessels leading to catch volume depletion, marginalisation of traditional fishing communities due to the entry of large multinationals and depletion of the fishing stock. It is in this backdrop that systematic and integrated policy intervention can ensure sustainability in terms of natural capital as well as livelihood protection for marine fishers.

4.0 STRATEGIC IMPLEMENTATION OF AQUACULTURE INITIATIVES

The Ministry of Fisheries, Animal Husbandry and Dairying and The Department of Fisheries sanctioned the amount of Rs.7522.48 crores in 2018-19 to set up the Fisheries and Aquaculture Development Fund (FIDF) over five years for building national level infrastructure for marine and inland fisheries. This includes smart harbours, landing centres for fish, cold storage warehousing facilities, brood banks, setting up hatcheries, fish feed mills, disease diagnostic laboratories, bi-valve and pearl culture and aquatic quarantine facilities. The fisheries department is overseeing cluster-based development in 34 notified centres engaged in fish production and processing. It has partnered with nodal financial institutions such as NABARD to offer loans to eligible beneficiaries through interest subvention schemes at three percent per annum.

The National Fisheries Policy was drafted in 2020 and was an amalgamation of past developments and future possibilities in the dynamic fisheries sector with vast potential. It established a comprehensive framework for the transformation of the sector through targeted intervention to promote sustainable use of marine resources, responsible fishing practices in inland reservoirs, skill development and investment in human -capital formation for small-scale fishery units, fisherwomen self-help groups, medium and small scale fishing units engaged in fish drying, processing and pickling for export and standardised marine regulations which ensured the preservation of marshlands, mangroves and marine bio-diversity.

The collaborative effort of extension activities conducted by research institutes under the umbrella of ICAR-CMFRI has helped diffuse advanced techniques of production as well as educate the entrepreneur usually a fish farmer, a fishery self –help group, on the measurable outcomes of adopting inland aquaculture. Establishment of dedicated fishery education institutes such as the Central Institute of Fisheries Education (CIFE), intensive research on brood banks, high-yielding seeds, nutritionally adequate fish-feed, water quality management, adequately oxygenated aquatic reservoirs laid the foundation of a productive sector with potentially high rates of gross value added. The entire value chain right from fish seeds that support spawning, to fish feed and meal that support maturation, to the banning of purse seine nets and fishing during breeding season to support stock replenishment, finance the repair and maintenance of fishing boats and traditional nets, acquiring deep-sea fishing vessels and trawlers to capitalise on the Exclusive Economic Zone, post-harvest management in the form of packaging to prevent spoilage due to oxidation, refrigerated cold storage, adequate dehydration equipment and market linkages focus on beneficiaries.

In tandem, institutional credit through lending institutes in the form of Kisan Credit Cards, registration on the national fisheries digital platform enabled access to identification details of individual fishers, members of self-help groups, investment in geographical information systems help to identify potential fishing zones to optimise effort and maximise return on investment. Performance grants and PMMSY financed subsidies of sixty percent for women/SC/ST beneficiaries compared to general category to achieve inclusive growth and women empowerment.

The government led modernisation program gave adequate importance to States and Union Territories to ensure localised governance at the grassroots level. An entire institutional hierarchy and chain of command was established to oversee effective implementation and garner outreach to the ultimate beneficiary at the district and sub-district level. Identification of hundred climate resilient coastal fishing villages across the States and UTs of India led to balanced development and creation of employment opportunities in the rural sector. The appointment of “Sagar Mitras” or friends of the ocean greatly enhanced the outreach programmes as fishers and small entrepreneurs could access guidance and customised solutions to localised issues. Group Accident Insurance Schemes and allowance of Rs.4500 per year with equal contribution from Centre, State and beneficiary to reduce variability in income during the months in which fishing is banned provided a safety net for marginalised fishers.

5.0 LITERATURE REVIEW

1. Ray et al., (1966); Ayyappan and Jena, (2005) have documented how climate change and overcapitalisation has increased the vulnerability of marine fishers who are facing dwindling catch volume due to acidification of seas, higher temperature, migration of favourable species and loss of breeding grounds
2. Modayil, M. J. et al. (2008) have documented the devastating effect of change in sea temperatures and climatic conditions on marine bio-diversity and recommended the immediate adoption of aquaculture and mariculture techniques such as fish seed production for commercial level fishing, ornamental fish rearing, sea-weed cultivation, sea cage farming to harness the potential of India's fishing sector.
3. Katiha, P. K., Jena, J. K., et al (2005) presented an extensive study on aquaculture technologies in both inland and coastal brackish waters in terms of inputs used and output generated, productivity analysis and the necessity of technology adoption to maximise yield.
4. Sudhakaran, B. V., & V, V. (2025) have researched Azheekkal a coastal fishing village in Kerala to devise a vulnerability score based on Garrett's Ranking to understand the impact of marine pollution, erratic climate events such as cyclones and habitat destruction resulting in loss of fishing days and lower income. The paper highlighted the need for adaptive strategies through policy intervention for mitigating the impact of climate change.
5. Raj, S. (2024) document how rising greenhouse gas emissions result in “coastal squeeze”, coral bleaching, loss of mangroves and marshy areas and disruption of the entire coastal ecosystem. Moreover, socio-economic impact of overfishing in marine capture fisheries, indiscriminate capture of juveniles, migration of desirable species from breeding grounds have heightened the need for immediate policy intervention through mitigation and adaptation initiatives.
6. Dharmamony, V. (2026) has attributed implementation shortcomings of marine fishing regulations due to fragmented approach by individual states are hampering the achievement of blue economy goals. The differences in seasonal fishing bans, gear restrictions, penalties among states forms a barrier to the long-term sustenance of India's marine coastal systems.
7. ICAR - Central Marine Fisheries Research Institute annual report (2024) and various Press Information Bureau of Government of India releases document the past decade as a decade of transformation for the fisheries sector. The initiatives of the PMMSY such as aquaculture, climate resilient coastal villages are a step in the direction of inclusive economic growth and productivity enhancement.
8. Lakra, W. S. et al (2021) has studied the depletion of stocks associated with overfishing, use of purse seine nets and other nets that result in juvenile capture across Maharashtra and highlighted the necessity of strict enforcement of marine regulations and investment in aquaculture and mariculture.

5.1 Research Gap

Existing data records the growth in output, export earnings and productivity. However, this study is focused on explaining the development of aquaculture as a policy measure to address unsustainable use of common pool resources such as marine capture fisheries resulting in the “Tragedy of the Commons”. The dissemination of innovative technology to transform quality of life by creating avenues for meaningful employment and generating profits for entrepreneurs is documented. The rise in the relative share of inland aquaculture in the total output of the fisheries sector signifies reduced dependence on marine production. This paper studies the extent of growth in inland aquaculture relative to marine fisheries and the consequent growth in export earnings through climate resilience.

6.0 OBJECTIVES

1. To examine the effect of PMMSY on marine production, inland aquaculture and total production in the fisheries sector.
2. To determine whether adoption of aquaculture initiatives under PMMSY has increased export earnings.
3. To analyse whether PMMSY financed aquaculture initiatives have reduced the dependence on marine capture fisheries.
4. To analyse whether PMMSY funded initiatives signify a structural shift indicated by an increase in the relative share of inland aquaculture with respect to marine output in total fish production in India.

7.0 RESEARCH HYPOTHESIS

1. NULL HYPOTHESIS: H_0 : PMMSY financed initiatives have not significantly increased marine production, inland aquaculture and total production in the fisheries sector.
ALTERNATE HYPOTHESIS: H_1 : PMMSY financed aquaculture initiatives have significantly increased marine production, inland aquaculture and total production in the fisheries sector.
2. NULL HYPOTHESIS: H_0 : Adoption of PMMSY financed aquaculture initiatives has not resulted in a significant increase in export earnings.
ALTERNATE HYPOTHESIS: H_2 : Adoption of PMMSY financed aquaculture initiatives has resulted in a significant increase in export earnings.
3. NULL HYPOTHESIS: H_0 : PMMSY financed aquaculture initiatives have not significantly reduced dependence on marine capture fisheries.
ALTERNATE HYPOTHESIS: H_3 : PMMSY financed aquaculture initiatives have significantly reduced dependence on marine capture fisheries.
4. NULL HYPOTHESIS: H_0 : High relative growth in the volume of inland aquaculture with respect to marine output does not signify climate resilience.
ALTERNATE HYPOTHESIS: H_4 : High relative growth in the volume of inland aquaculture with respect to marine output signifies climate resilience.

8.0 RESEARCH METHODOLOGY

This study uses macro level secondary data from the CMFRI annual reports and Press Information Bureau Fact Sheets to collate data on marine and inland aquaculture production for a decade from 2014 to 2023. Inland aquaculture includes shrimp harvesting, cage culture, bio-floc farming, sea-weed cultivation, ornamental fisheries, re-circulatory aquaculture systems and mariculture clusters. Marine Production includes output of marine capture fisheries. Export earnings are based on official data from the Marine Products Export Development Authority and includes non-edible dried items such as fish feed and meal. Time-series analysis of marine, inland and total production is conducted over a decade. Data is cleaned using pandas and analysed using statsmodel library for Python. Regression analysis is used to determine statistical significance. Marine dependency is calculated as the ratio of marine production to total production. Climate resilience is implied as the rapid increase in inland aquaculture output lowers the exposure of fishers to the risks associated with cyclones and marine pollution.

9.0 DATA ANALYSIS AND INTERPRETATION:

Relevant tables are presented in Appendix A

REGRESSION MODEL 1: The Regression Model for Inland Aquaculture & Export Earnings:

$$\text{Export Earnings}_t = \beta_0 + \beta_1(\text{Inland Aquaculture}_t) + \epsilon_t$$

Where:

- Dependent variable (Y) = Export Earnings (₹ Crore)
- Independent variable (X) = Inland Aquaculture Production (Million Tonnes)
- β_0 = Intercept
- β_1 = Slope coefficient
- ε = Error term
- After running the regression using Python (statsmodels):
- $Export\ Earnings = -14690 + 6276.94 \times Inland\ Aquaculture$

Key Results:

- $R^2 = 0.896 \rightarrow$ This implies that 89.6% of variation in export earnings is explained by growth in Inland Aquaculture Production. Therefore, there is a direct cause and effect relationship between growth in Inland Aquaculture Production and export earnings.
- Coefficient = 6276.94 ($p < 0.001$) $\rightarrow$ Since p value is less than .001, it implies that the direct correlation between aquaculture and export earnings is very strong and there is 1 in a 1000th chance that this relationship is random.
- Interpretation: A 1 million tonne increase in inland aquaculture production increases export earnings by approximately ₹6,277 crore.
- Strong F-statistic confirms overall model significance.

Regression Model 2: The Regression Model for inland aquaculture and marine dependency:

Regression Equation: Marine Dependency = $0.4133 - 0.0126 \times Inland\ Aquaculture$

Variable	Coefficient	Std Error	t-value	p-value
Constant	0.4133	0.021	19.47	0.000
Inland Aquaculture	-0.0126	0.002	-5.73	0.000

Marine Dependency is calculated as the ratio of marine production to total production.

Key Results:

- $R^2 = 0.804 \rightarrow$ 80.4% of reduction in marine dependency is explained by aquaculture expansion. This implies that the increase in the relative share of inland aquaculture in the total fish production in India, lowers the dependence on marine output.
- Coefficient = -0.0126 ($p < 0.001$) $\rightarrow$ Highly significant negative relationship.

Interpretation:

- Every 1 million tonne increase in inland aquaculture reduces marine dependency ratio by 1.26 percentage points.
- This statistically confirms structural diversification away from marine capture fisheries.

10.0 RESULTS AND FINDINGS

1. The findings of the regression analysis support a strong correlation between PMMSY initiatives and increase in marine production, inland aquaculture and total production. As per Table 1, total production has increased from 10.26 MT in 2014 to 16.25MT in 2023. This implies that PMMSY supported thrust on increasing production of the fisheries sector has achieved desired objectives in both the marine and inland aquaculture sector. However, inland aquaculture production has increased by twice as much as marine production. Moreover, through comprehensive policy orientation technology infusion has led to maintenance of production standards, quality and traceability. This is evidenced by CAGR of 6.23 percent for inland aquaculture which is almost twice the rate of 3.03 percent for Marine Aquaculture. H_1 is accepted and null hypothesis is rejected.
2. There is a strong positive relationship between aquaculture and export earnings. As The CAGR of export earnings of 7.47 percent which is higher than the CAGR of both Marine and Inland Aquaculture Output signifies rearing of high value species for export. H_2 is accepted and null hypothesis is rejected.
3. There is a highly significant inverse relation between aquaculture output growth and marine dependency with a p value less than 0.001. H_3 is accepted and null hypothesis is rejected.
4. There is a structural shift towards climate-resilient diversification towards inland aquaculture and this has reduced risk of exposure to adverse natural calamities and irreversible impacts of climate change. H_4 is accepted and null hypothesis is rejected.

11.0 CONCLUSION

The decadal push for innovations and a comprehensive policy framework that addressed the financial and technological constraints faced by small scale entrepreneurs and marginal fishers has definitely led to rapid and inclusive economic growth. This policy is in alignment with the UNDP Sustainable Development Goals especially goal 14 – Life under Water, which deals with conservation of marine bio-diversity and sustainable resource use to prevent overfishing. Public private partnerships and self-help groups such as farmer co-operatives have enabled high rates of technology adoption by reducing coordination failures and greater access to credit, therefore sub-schemes targeting fish farmers like the Pradhan Mantri Matsya Kisan Sampada Yojana are a step in the right direction. With co-ordinated policy interventions and investment in human capital, India's Fisheries Sector is moving towards sustainable growth and development.

12.0 LIMITATIONS

1. The model is based only macro level secondary data
2. It relies on quantitative inputs but ignores qualitative variables such as attitudes, education level of beneficiaries which may affect the models.
3. Covid year is an outlier and lockdowns may have impacted data

13.0 REFERENCES

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14.0 APPENDIX

Appendix A:

TABLE 1: Output – Total, Marine Production, Inland Aquaculture And Export Earnings (2014-2023)

Year	Total Production (MT)	Marine Production (MT)	Inland Aquaculture (MT)	Export Earnings (₹ Crore)
2014	10.26	3.44	6.82	33,441
2015	10.79	3.50	7.29	30,500
2016	11.41	3.63	7.78	33,400
2017	12.60	3.69	8.91	37,870
2018	13.75	3.71	10.04	46,589
2019	14.16	3.73	10.43	46,850
2020	14.16	4.12	10.04	43,717
2021	15.00	4.30	10.70	57,100
2022	15.96	4.40	11.56	57,986
2023	16.25	4.50	11.75	63,969

Year	Inland Aquaculture (MT)	Export Earnings (₹ Cr)	Statistic	Value
2014	6.82	33441	R ²	0.896
2015	7.29	30500	Adjusted R ²	0.883
2016	7.78	33400	F-statistic	69.06
2017	8.91	37870	Prob(F)	0.00003
2018	10.04	46589		
2019	10.43	46850		
2020	10.04	43717		
2021	10.70	57100		
2022	11.56	57986		
2023	11.75	63969		

Source: PIB factsheet, CMFRI annual reports and MPEDA release.

TABLE 2: Compound Annual Growth Rate:

Source: Calculated based on data in Table 1

Sector	CAGR (2014–2023)	Interpretation
Marine Fisheries	3.03%	Medium growth

<u>Sector</u>	<u>CAGR (2014–2023)</u>	<u>Interpretation</u>
<u>Inland Aquaculture</u>	6.23%	<u>High and Rapid growth</u>
<u>Export Earnings</u>	7.47%	<u>Rapid Growth</u>

TABLE 3: Marine Dependency Ratio is calculated as the ratio of marine production to total production

<u>YEAR</u>	<u>MARINE DEPENDENCY</u>	<u>YEAR</u>	<u>MARINE DEPENDENCY</u>	<u>YEAR</u>	<u>MARINE DEPENDENCY</u>
2014	0.335	2018	0.270	2022	0.276
2015	0.324	2019	0.263	2023	0.277
2016	0.318	2020	0.291		
2017	0.293	2021	0.287		