Blue Revolution and the Emerging Blue Economy in Telangana Evaluating Policy Outcomes and Institutional Effectiveness

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ABSTRACT

The Blue Revolution in India, launched through the Integrated Development and Management of Fisheries (2015–2020) and expanded under the Pradhan Mantri Matsya Sampada Yojana (PMMSY, 2020–present), has reshaped inland aquaculture as a driver of rural income, food security, and ecological stewardship. Telangana, though a landlocked state, is endowed with extensive inland water resources and a vibrant community of fishers and cooperatives. This study evaluates the policy outcomes and institutional effectiveness of the Blue Revolution and emerging Blue Economy in Telangana over the decade 2014–2024. Using mixed-method evaluation grounded in official data, secondary literature, and institutional mapping, the study traces how policy design, resource mobilization, and convergence strategies between the National Fisheries Development Board (NFDB), the Department of Fisheries (DoF), and state-level agencies have impacted production, employment, gender equity, and environmental sustainability. Findings reveal that fish production rose from 2.68 lakh tons in 2014–15 to over 4.56 lakh tons by 2024, with an estimated value exceeding ₹7,000 crore (NFDB, 2021; Department of Fisheries, 2024). The cooperative base has expanded to include nearly 3 lakh members, and welfare coverage has been enhanced through insurance and credit support. However, persistent gaps exist in cold chain density, traceability, ecological monitoring, and skill development. The paper concludes that Telangana's inland fisheries model, anchored in participatory governance and cross-sectoral convergence, offers a replicable pathway toward a sustainable and inclusive Blue Economy in India.

Keywords: Blue Revolution, Blue Economy, Inland Fisheries, Telangana, PMMSY, NFDB, Mission Kakatiya, IFDS

INTRODUCTION

Background

The concept of the "Blue Revolution" emerged in India as a policy metaphor for the rapid, sustainable, and inclusive growth of fisheries and aquaculture. It was first articulated in the mid-2010s with the launch of the *Integrated Development and Management of Fisheries* scheme by the Department of Animal Husbandry, Dairying, and Fisheries, under the Ministry of Agriculture and Farmers Welfare (Government of India, 2015). The initiative aimed to increase fish production and productivity, strengthen the value chain, and improve post-harvest infrastructure and market access. Subsequently, the *Pradhan Mantri Matsya Sampada Yojana* (PMMSY), launched in 2020, consolidated the Blue Revolution framework into a long-term mission for "sustainable and responsible development of the fisheries sector" (Department of Fisheries, 2020).

While the Blue Revolution originally encompassed marine and coastal ecosystems, its inland dimension has become particularly significant for states like Telangana, which possess extensive networks of reservoirs, tanks, and rivers. Telangana's geographical profile includes more than 77 large, medium, and minor reservoirs and over 24,000 village tanks, covering a water spread area of approximately 5.72 lakh hectares (Department of Fisheries, 2024). These inland resources support a large population of traditional and neo-fishers, estimated at 27.14 lakh individuals organized into nearly 4,000 cooperative societies. The institutional structure supporting this sector is distinctive: the National Fisheries Development Board (NFDB), headquartered in Hyderabad since 2006, functions as both a policy think tank and an implementation hub for central and state schemes (NFDB, 2021).

Table 1. Inland Water Resources and Cooperative Coverage in Telangana (2023–24)

Parameter	Unit	Value	Source
Total water spread area	Lakh ha	5.72	Department of Fisheries, Telangana (2024)
Number of reservoirs	Nos.	77	Department of Fisheries, Telangana (2024)
Number of tanks	Nos.	24,189	Department of Fisheries, Telangana (2024)
Fisher population	Lakhs	27.14	NFDB (2023)
Fisher cooperative societies	Nos.	4,634	NFDB (2023)
Cooperative membership	Nos.	3.04 lakh	NFDB (2023)
Women's cooperatives (approx.)	Nos.	520	Department of Fisheries, Telangana (2024)

Source: Department of Fisheries, Telangana (2024); NFDB (2023); News Meter (2024).

The combination of water resources, cooperative networks, and institutional presence has positioned Telangana as a key site for the expansion of India's Blue Economy. Since state formation in 2014, Telangana's fisheries sector has recorded remarkable growth, doubled its fish production, and witnessed corresponding gains in employment, nutrition, and rural livelihoods (Rao & Reddy, 2022). Yet, this success raises important questions: How effective are the policy instruments driving this growth? What institutional arrangements enable or constrain implementation? And to what extent does the Blue Revolution translate into a genuinely sustainable and inclusive Blue Economy?

Objectives and Scope

This study seeks to evaluate (i) the policy outcomes of the Blue Revolution and PMMSY in Telangana, (ii) the institutional effectiveness of implementing agencies, and (iii) the emerging opportunities and challenges in developing a comprehensive Blue Economy framework for an inland state. The analysis spans the period 2014–2024, covering major interventions under PMMSY, the Integrated Fisheries Development Scheme (IFDS), and convergence initiatives such as Mission Kakatiya. The assessment considers quantitative indicators (production, value, coverage, and infrastructure) and qualitative dimensions (institutional coordination, inclusivity, and sustainability).

Conceptual Framework: From Blue Revolution to Blue Economy

The Blue Revolution primarily aimed at increasing fish production, while the Blue Economy extends the paradigm to include value addition, environmental stewardship, and economic diversification through aquatic resources (World Bank, 2017; FAO, 2022). The Blue Economy concept promotes a balance between economic growth and ecological sustainability, emphasizing responsible resource use, innovation, and circularity (Voyer et al., 2018). In the Indian context, the Ministry of Earth Sciences' *White Paper on the Blue Economy* (2022) highlights inland aquaculture, biodiversity conservation, and renewable energy as key growth domains.

For Telangana, transitioning from a Blue Revolution to a Blue Economy implies a shift from quantitative expansion to qualitative transformation, moving beyond fish production toward integrated value chains, climate-resilient aquaculture, and inclusive governance. This transition also necessitates effective inter-departmental coordination among fisheries, irrigation, rural development, and environment agencies, supported by digital monitoring and research institutions.

Policy Background and Institutional Architecture

Evolution of India's Blue Revolution Policy

The Government of India launched the Blue Revolution: Integrated Development and Management of Fisheries scheme in 2015 as an umbrella framework merging multiple sub-schemes for inland, marine, and aquaculture

development (Government of India, 2015). The vision was to enhance fish production from 10.4 million tons in 2014–15 to 15 million tons by 2020 through integrated resource management, infrastructure development, and capacity building (Department of Fisheries, 2017). Key components included fish seed production, hatchery modernization, cage culture, fish-feed units, cold storage, and insurance coverage for fishers.

Table 2. Growth of Fish and Prawn Production in Telangana (2014–2024)

Year	Fish Production (Lakh Tons)	Prawn Production (Lakh Tons)	Total Production (Lakh Tons)	Value (₹ Crore)
2014–15	2.68	0.20	2.88	3,200
2016–17	3.10	0.25	3.35	4,250
2018–19	3.49	0.30	3.79	5,350
2020–21	3.95	0.35	4.30	6,050
2022–23	4.20	0.36	4.56	6,800
2023–24	4.35	0.38	4.73	7,059

Source: Department of Fisheries, Telangana (2024); NFDB (2023); News Meter (2024).

In 2020, the PMMSY was launched as a central sector–centrally sponsored scheme with an investment outlay of ₹20,050 crore, emphasizing sustainable and inclusive growth (Department of Fisheries, 2020). PMMSY's objectives include (a) doubling fishers' income, (b) reducing post-harvest losses from 20% to 10%, (c) increasing export earnings, and (d) generating employment opportunities for 5.5 million people. The scheme also introduced innovation grants, incubation centers, and dedicated funds for women entrepreneurs, marking a clear shift toward the Blue Economy ethos (FAO, 2022).

Telangana's Institutional Ecosystem

Telangana's fisheries administration is anchored in the Department of Fisheries (DoF), Government of Telangana, supported by NFDB, cooperative societies, and research institutions. The NFDB plays a dual role as a policy arm of the central government and a facilitator for states, managing funds, capacity building, and technology dissemination (NFDB, 2021). The Department of Fisheries implements state-specific programs such as the Integrated Fisheries Development Scheme (IFDS), launched in 2017–18, aimed at infrastructure creation, seed stocking, and market linkages (Telangana DoF, 2024).

At the grassroots level, approximately 4,634 cooperative societies with 3.04 lakh registered members manage reservoirs, tanks, and community ponds. These societies serve as vehicles for collective resource management, welfare delivery, and credit linkage. The State Institute of Fisheries Technology (SIFT) at Medchal and the Inland Fisheries Training Centre (IFTC) at Hanumakonda act as centers of excellence for technical training, quality assurance, and entrepreneurship (Reddy, 2023). Importantly, Telangana's fisheries development has benefitted from proximity to NFDB's national headquarters in Hyderabad. This has facilitated smoother coordination, data sharing, and access to funding under central schemes. The synergy between state and national institutions exemplifies multilevel governance, an essential attribute of successful Blue Economy models (Voyer et al., 2018).

Convergence and the Role of Mission Kakatiya

A distinctive feature of Telangana's policy environment is the convergence between fisheries and water resource management programs, particularly *Mission Kakatiya*, a flagship initiative launched in 2015 to restore and rejuvenate 46,531 village tanks (Government of Telangana, 2016). The program's objectives, desiltation,

strengthening bunds, and improving water storage have direct spillover effects on inland fisheries productivity. Studies by the Centre for Economic and Social Studies (CESS, 2021) found that restored tanks under Mission Kakatiya recorded higher water retention, improved soil fertility through silt application, and enhanced livelihoods through fisheries and allied activities.

Table 5. Environmental Impact Indicators of Mission Kakatiya and Fisheries Convergence

Parameter	Baseline (2014)	Post-Intervention (2023)	% Improvement	Source
Average tank water retention (months/year)	4.5	6.0	+33%	Gumma et al. (2023)
Groundwater recharge (m/year)	0.45	0.60	+25%	CESS (2021)
Fish seed survival rate (%)	62	80	+18 p.p.	DoF (2024)
Silt reused in agriculture (tons)	–	35 lakh	–	Government of Telangana (2016)
Tank productivity (kg/ha)	450	750	+66%	NFDB (2023)

The integration of tank restoration with fish seed stocking under PMMSY and IFDS has produced notable ecological and economic outcomes. Improved water quality and extended hydroperiods have led to higher fish survival rates, while reduced input costs in agriculture (through silt use) have strengthened cross-sectoral sustainability (Gumma et al., 2023). This model demonstrates how ecosystem restoration can serve as a foundation for a resilient Blue Economy.

Funding and Financial Mechanisms

Under PMMSY, central and state governments share funding responsibilities in a 60:40 ratio for general states, with higher ratios for northeastern and Himalayan states. Telangana's cumulative allocation under PMMSY from 2020–21 to 2023–24 is estimated at ₹1,120 crore, covering infrastructure, welfare, and entrepreneurship (Department of Fisheries, 2024). Additionally, the IFDS has mobilized nearly ₹1,800 crore since its inception, channeling resources into hatcheries, retail infrastructure, and processing facilities.

Table 3. Physical Achievements under PMMSY and IFDS (2015–2024)

Component	Units Created / Distributed	Remarks
Fish seed supplied	344.61 crore	100% grant support
Prawn juveniles stocked	19.57 crore	Reservoirs and tanks
Hatcheries established	21	Private and cooperative sectors
Cage aquaculture units	650	Major reservoirs
RAS/Biofloc clusters	11 (5 large, 6 medium)	Intensive aquaculture
Fish ponds developed	400 ha	IFDS-supported
Mobile fish outlets	185	Women entrepreneurs
Insulated vehicles	20	Fish transport

Ice plants and feed mills	15	Processing and cold chain
Training participants	27,000	SIFT and IFTC programs

Source: NFDB (2023); Department of Fisheries, Telangana (2024).

Financial inclusion has been strengthened through cooperative credit, Kisan Credit Cards (KCC) for farmers, and insurance schemes offering ₹5 lakh coverage for accidental death and ₹2.5 lakh for partial disability (NFDB, 2021). Start-up incubation and youth entrepreneurship are supported through NFDB's Innovation Challenges and Women Entrepreneurship platforms launched in Hyderabad (NFDB, 2022).

Institutional Effectiveness Indicators

Institutional effectiveness in the Blue Revolution framework can be assessed across four dimensions:

1. **Coverage and Targeting:** The extent to which beneficiaries, particularly marginalized fishers and women, are included.

2. **Coordination:** The degree of alignment between national (NFDB/PMMSY) and state (DoF/IFDS) structures.

3. **Capacity:** Availability of training, extension, and monitoring systems.

4. **Sustainability:** Integration of ecological, economic, and social goals.

Telangana's record on these dimensions appears strong. Cooperative coverage reaches nearly all major reservoirs, NFDB's proximity ensures regular monitoring, and Mission Kakatiya provides environmental synergy. However, institutional reviews indicate a continued need for cross-departmental digital integration, improved data collection, and formal impact evaluation mechanisms (Rao, 2023).

METHODOLOGY

Research Design

This study employs a mixed-methods approach, combining descriptive statistical analysis with institutional and policy evaluation. Quantitative data are drawn from secondary sources, annual reports of the Department of Fisheries (Government of Telangana, 2024), NFDB progress notes (NFDB, 2021, 2023), the *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) dashboard (Department of Fisheries, 2024), and the Reserve Bank of India's *Handbook of Statistics on the Indian Economy* (RBI, 2023). Qualitative insights are synthesized from peer-reviewed studies (Gumma et al., 2023; Rao & Reddy, 2022), government evaluation reports (CESS, 2021), and interviews published in newspapers and public domain policy dialogues.

Data were triangulated to construct a coherent results chain linking **inputs → outputs → outcomes → impacts**. Particular attention was given to identifying convergence effects among flagship programmes, Mission Kakatiya, PMMSY, and the Integrated Fisheries Development Scheme (IFDS), and to tracing the flow of benefits across gender and social groups.

Evaluation Framework

The analysis adopts a **Results-Based Management (RBM)** framework. Indicators were grouped as follows:

1. **Input indicators**: budget allocation, physical resources (reservoirs, tanks, hatcheries), and training facilities.

2. **Output indicators**: seed stocking, infrastructure built, mobile outlets distributed, and number of beneficiaries.

3. **Outcome indicators**: fish production (tons), income per fisher household, employment generation, and women's participation.

4. **Impact indicators**: ecological sustainability, institutional capacity, and integration into the emerging Blue Economy value chain.

Where longitudinal data were incomplete, averages and growth rates were estimated using compound annual growth rate (CAGR) formulas to assess trends over 2014–2024.

Limitations

The study relies on secondary data, and time-series gaps persist because official dashboards are updated at variable intervals. Nevertheless, triangulation across multiple credible sources enhances reliability (Bryman, 2016). The research focuses on Telangana; findings may not be generalizable to marine states, though they provide valuable lessons for inland economies.

Results: Outputs and Outcomes in Telangana

Resource Base and Community Structure

Telangana possesses one of India's richest inland water systems. The state's 5.72 lakh ha water-spread area, comprising 77 large/medium reservoirs and 24,189 tanks, supports an estimated 27.14 lakh fisher population (Government of Telangana, 2024). Nearly 4,600 cooperative societies organize fishers, and around 3 lakh members actively participate in collective management (NFDB, 2021).

These cooperatives are key intermediaries between state agencies and local communities, facilitating stocking, revenue collection, and benefit transfer. Field studies (Reddy, 2023) show that cooperatives with training exposure under the State Institute of Fisheries Technology (SIFT) exhibit higher productivity and compliance with sustainable harvesting norms.

Growth in Fish Production and Economic Value

Fish production in Telangana has risen from 2.68 lakh tons in 2014–15 to 4.56 lakh tons in 2023–24, reflecting a CAGR of approximately 6.7 percent (NFDB, 2023; News Meter, 2024). The gross value of output increased from ₹3,200 crore to ₹7,059 crore in the same period, driven largely by enhanced seed stocking, adoption of biofloc and recirculatory aquaculture systems (RAS), and expanded market access (Department of Fisheries, 2024).

These gains correspond with a national upsurge; India's fish production crossed 16.2 million tons in 2021–22 (FAO, 2022). Telangana contributes roughly 2.8 percent of India's total output, ranking among the top inland states (Rao & Reddy, 2022).

Infrastructure Development and Technology Adoption

Between 2015 and 2024, Telangana implemented several infrastructure projects under PMMSY and IFDS:

- **Seed Stocking:** 344.61 crore fish seed and 19.57 crore prawn juveniles supplied to reservoirs and tanks.

- **Aquaculture Systems:** 650 cage units installed in major reservoirs; five large and six medium RAS/biofloc clusters commissioned.

- **Pond Construction:** Over 400 ha of new ponds developed for community and private culture.

- **Hatcheries:** 21 modern hatcheries established with capacity for quality brood stock.

- **Market Infrastructure:** 185 mobile and stationary retail outlets, 20 insulated vehicles, and a statewide branding campaign under "Telangana Chepalu."

- **Cold Chain Facilities:** ice plants, chilling centres, and feed mills set up in Mahabubnagar, Karimnagar, and Khammam districts (NFDB, 2021).

Such investments have improved post-harvest handling and reduced spoilage losses from 22 percent to about 12 percent (Department of Fisheries, 2024). Adoption of RAS and biofloc technologies has boosted productivity per unit area by 30–40 percent while optimizing water use (Reddy, 2023).

Employment and Livelihood Outcomes

The fisheries sector now provides direct and indirect employment to about 5.3 lakh people, up from 3.8 lakh in 2014 (NFDB, 2023). The average annual income per active fisher rose from ₹72,000 to ₹1.45 lakh between 2015 and 2023 (Department of Fisheries, 2024). Women constitute approximately 28 percent of the workforce, concentrated in marketing and processing segments (FAO, 2022). The introduction of mobile fish outlets has enabled over 1,500 women entrepreneurs to enter the value chain through PMMSY grants and subsidized loans (NFDB, 2022).

Table 4. Employment and Income in the Fisheries Sector (2014–2024)

Indicator	2014–15	2023–24	% Change
Direct employment (persons)	3.8 lakh	5.3 lakh	+39%
Indirect employment	1.5 lakh	2.2 lakh	+46%
Average annual income per fisher (₹)	72,000	1,45,000	+101%
Women employed (%)	18	28	+10 p.p.
Fisher households covered by insurance	1.2 lakh	3.36 lakh	+180%

Source: Department of Fisheries (2024); NFDB (2023); CESS (2021).

Self-Help Groups (SHGs) supported under the National Rural Livelihood Mission (NRLM) have diversified into ancillary activities such as fish pickling, drying, and ready-to-cook (RTC) product manufacture (Kumari & Rao, 2022). These developments underscore how fisheries are emerging as a pillar of Telangana's rural non-farm economy.

Welfare and Risk Protection

PMMSY's insurance component enhanced risk protection. By 2024, around 3.36 lakh active fishers were covered under group insurance schemes, with increased benefits of ₹5 lakh for accidental death and ₹2.5 lakh for partial disability (NFDB, 2021). The integration of Kisan Credit Cards (KCC) for farmers further improved liquidity for working capital needs (RBI, 2023).

Welfare programs such as housing grants, educational scholarships, and old-age pensions have been extended to registered members of cooperative societies. Evaluations by the Centre for Good Governance (2022) report a decline in distress migration among traditional fishers in districts like Nalgonda and Warangal.

Environmental and Hydrological Outcomes

Mission Kakatiya's restoration of over 45,000 tanks has significantly improved water availability for fisheries. Research by Gumma et al. (2023) demonstrates that tank rehabilitation increased groundwater recharge by 25–30 percent and prolonged the hydroperiod by two months in semi-arid zones. This ecological improvement

boosted fish seed survival and reduced mortality rates. Moreover, desilted nutrient-rich soils applied to agricultural fields enhanced soil organic carbon and created a positive feedback loop between agriculture and fisheries (CESS, 2021).

However, rapid aquaculture expansion poses environmental risks. Unregulated feed use, effluent disposal, and over-stocking can lead to eutrophication and disease outbreaks. The Department of Fisheries has issued biosecurity guidelines and banned invasive species such as African catfish, but enforcement remains a challenge (Rao, 2023).

DISCUSSION: INSTITUTIONAL EFFECTIVENESS AND POLICY COHERENCE

Multilevel Governance and Coordination

Telangana's fisheries governance exemplifies effective multilevel coordination between the centre and state. The co-location of NFDB in Hyderabad has facilitated timely fund release and technical support. Regular joint review meetings between NFDB, the Department of Fisheries, and district officials ensure alignment of targets and avoid duplication (Department of Fisheries, 2024). Such institutional synergy is a key determinant of Telangana's above-average implementation rates under PMMSY (Voyer et al., 2018).

Inclusivity and Social Equity

The Blue Revolution in Telangana has demonstrated strong inclusion outcomes. Cooperative membership of Scheduled Caste and Scheduled Tribe fishers has grown by nearly 40 percent since 2015 (Department of Fisheries, 2024). Targeted training and subsidy support for women have enhanced their representation in marketing and retailing. Studies show that women entrepreneurs running mobile outlets achieve average monthly profits of ₹18,000–22,000 (Reddy, 2023). Yet, female ownership in production-level assets remains below 10 percent, indicating the need for gender-responsive credit mechanisms and cooperative leadership quotas (Kumari & Rao, 2022).

Financial and Market Linkages

The expansion of fish production has outpaced post-harvest and marketing infrastructure. Despite new facilities, cold-chain density remains insufficient; only about 60 percent of fish markets are served by modern ice plants (NFDB, 2023). Seasonal price volatility persists because of supply gluts after stocking cycles and a lack of storage capacity. Policy analysts recommend developing district-level cold rooms and value-addition clusters to smooth market fluctuations (FAO, 2022; World Bank, 2017).

Digital solutions, such as QR-coded traceability systems and online market platforms, are beginning to emerge. Pilot projects under NFDB's "Fish Track" initiative in Hyderabad link farmers, wholesalers, and consumers through real-time price data (NFDB, 2023). Such digitalization is central to transitioning toward a fully networked Blue Economy.

Environmental Governance and Sustainability

The Blue Economy emphasizes ecological stewardship. Telangana's approach combines regulatory and community-based mechanisms. Reservoir management plans specify stocking densities and closed seasons; district committees enforce mesh-size regulations. However, the capacity for continuous monitoring of water quality and disease outbreaks remains limited. Adopting IoT-based sensors and satellite data for water quality assessment could significantly improve resilience (Gumma et al., 2023).

Environmental sustainability also demands integration of aquaculture with catchment management. Integrated Multi-Trophic Aquaculture (IMTA) pilots, combining fish, prawn, and macrophyte cultures, are under consideration to reduce nutrient loads and promote circular economy principles (FAO, 2022).

Human Capital and Skill Development

The State Institute of Fisheries Technology (Medchal) and Inland Fisheries Training Centre (Hanumakonda) have trained over 25,000 fishers and entrepreneurs since 2015 (Department of Fisheries, 2024). Curricula cover aquaculture management, biosecurity, feed formulation, and quality assurance. Nonetheless, a mismatch exists between training supply and emerging skill demand in areas like digital traceability and export standards (Reddy, 2023). Integrating fisheries training with polytechnic and agri-business courses under the Telangana State Council for Higher Education could bridge this gap.

Institutional Effectiveness Metrics

Framework for Evaluation

Institutional effectiveness in the fisheries sector can be evaluated across four functional pillars—**governance and coordination**, **capacity and infrastructure**, **financial inclusion and delivery**, and **monitoring and sustainability** (Rao & Reddy, 2022). Each pillar corresponds to specific indicators used in this assessment. The analysis draws upon RBM methodology to link program inputs with measurable outcomes.

Governance and Coordination

Telangana's fisheries governance model is distinguished by strong inter-departmental coordination. The Department of Fisheries functions as the nodal agency, but close alignment with NFDB, the Department of Rural Development, and the Irrigation & Command Area Development Department has been critical to success. Joint task forces meet quarterly to review PMMSY progress and coordinate stocking schedules with Mission Kakatiya tank restorations (Department of Fisheries, 2024).

This governance model has also benefited from digital tools such as the Fisheries Management Information System (FMIS), which tracks fish seed distribution, insurance enrollment, and cooperative performance. NFDB's *National Fisheries Digital Platform*, headquartered in Hyderabad, has improved transparency and data availability (NFDB, 2023).

From a policy perspective, Telangana's alignment between state and central agencies embodies what scholars term *multi-scalar coherence*, the synchronization of national funding with state-level planning and local execution (Voyer et al., 2018). The state's implementation rate under PMMSY averaged 93 percent during 2020–23, compared with the national mean of 78 percent (FAO, 2022). This indicates high institutional absorption capacity and administrative efficiency.

Capacity and Infrastructure

Capacity building extends beyond physical infrastructure to encompass human resource development and knowledge diffusion. Between 2015 and 2024, over 27,000 fishers were trained in hatchery management, feed formulation, and quality assurance through SIFT and IFTC (Reddy, 2023). Mobile training units reach remote tank clusters, and e-learning modules on biofloc systems were introduced during the COVID-19 pandemic. In infrastructure terms, the IFDS and PMMSY together facilitated the construction of 14 fish seed farms, 21 hatcheries, and 400 ha of new ponds. Districts such as Khammam and Mahabubnagar emerged as aquaculture hubs. The presence of solar-powered aeration systems and automated feeders demonstrates technological upgrading consistent with global Blue Economy standards (World Bank, 2017).

Table 6. Financial Allocations and Disbursements under PMMSY and IFDS (₹ crore)

Year	PMMSY Allocation	PMMSY Expenditure	IFDS Allocation	IFDS Expenditure	Utilization (%)
2017–18	–	–	280	260	93

2018–19	–	–	300	290	97
2019–20	180	160	330	310	95
2020–21	220	205	310	295	94
2021–22	250	235	285	275	96
2022–23	270	250	295	282	95
2023–24	300	278	320	305	94

Source: Department of Fisheries, Telangana (2024); NFDB (2023).

Financial Inclusion and Delivery

Institutional finance is a decisive factor for sustainability. Telangana's integration of Kisan Credit Cards for fishers under PMMSY expanded formal credit access to 1.2 lakh households by 2023 (RBI, 2023). The state introduced the Fisheries Credit Guarantee Fund, enabling small entrepreneurs to borrow without collateral. Cooperative societies act as micro-finance intermediaries, collecting user charges and revolving funds for maintenance. Women's SHGs increasingly participate in processing and retailing activities with financial support under PMMSY's *Beneficiary-Oriented Activities* (NFDB, 2022). These mechanisms align with global recommendations for inclusive Blue Economy financing (FAO, 2022).

Monitoring, Evaluation, and Data Systems

A major institutional innovation is the establishment of a real-time fisheries dashboard integrating GIS mapping, production logs, and welfare data. District officers upload monthly data on stocking density, yield, and mortality. This digital infrastructure enhances accountability and allows evidence-based policymaking. However, independent third-party evaluations remain infrequent. Introducing external audits and randomized impact assessments every three years would strengthen credibility (Bryman, 2016).

Gender, Youth, and Social Inclusion

Women in the Blue Economy

Women's roles have expanded from traditional post-harvest labor to entrepreneurship. Under PMMSY, women receive up to 60 percent financial assistance for units such as cold-storage facilities, fish retail kiosks, and processing centers (Department of Fisheries, 2024). In Telangana, more than 1,500 women operate mobile fish outlets; around 220 manage small processing units producing dried and pickled fish products (NFDB, 2022).

The success of these ventures stems from integrated training and micro-credit support. Yet challenges remain, particularly in property rights, asset ownership, and leadership roles within cooperatives. Institutional frameworks must evolve to ensure women's representation on cooperative boards and decision-making committees (Kumari & Rao, 2022).

Youth and Innovation

Youth participation is essential for modernization. NFDB's *Fisheries Start-up Challenge* launched in Hyderabad in 2022, incubated over 20 start-ups in digital aquaculture, feed technology, and e-commerce logistics (NFDB, 2023). Telangana's Department of Fisheries collaborates with the State Innovation Cell to mentor these enterprises. Entrepreneurial youth clusters in Karimnagar and Warangal districts are experimenting with IoT-based water-quality sensors and solar-powered cold boxes, aligning with the state's green energy policy (Rao, 2023). Such innovation enhances sustainability while attracting skilled graduates into aquaculture.

Environmental Sustainability and Climate Resilience

Ecological Context

Climate variability threatens inland water systems through erratic rainfall, temperature fluctuations, and eutrophication. The restoration of tanks under Mission Kakatiya has improved adaptive capacity by increasing water-holding capacity and stabilizing hydrological cycles (Gumma et al., 2023). Nevertheless, intensive aquaculture poses risks. The adoption of biofloc and RAS systems requires rigorous effluent management. Studies show that nutrient-rich discharge from ponds can raise nitrogen levels in surrounding water bodies (FAO, 2022). The Department of Fisheries issued *Effluent Treatment Guidelines 2022*, mandating sedimentation tanks and periodic monitoring.

Climate-Resilient Technologies

Technological innovation supports resilience. Solar aerators and energy-efficient pumps reduce operational costs and greenhouse gas emissions. Recirculatory Aquaculture Systems (RAS) enable year-round production with minimal water exchange, aligning with global best practices (World Bank, 2017). The introduction of *climate-tolerant fish strains* such as Jayanti Rohu and Amur Carp increases productivity while reducing mortality under high-temperature conditions (NFDB, 2023). Integrating these innovations into training curricula enhances long-term adaptability.

Integrated Multi-Trophic Aquaculture (IMTA)

IMTA pilots are underway in select reservoirs combining fish, prawns, and aquatic plants. This system utilizes waste from one species as input for another, thereby minimizing pollution and improving nutrient cycling (FAO, 2022). If scaled, IMTA could transform Telangana's inland aquaculture into a circular Blue Economy model consistent with the United Nations Sustainable Development Goals (UN, 2021).

Roadmap for Telangana's Blue Economy 2.0

Value-Chain Modernization

To sustain growth, Telangana must shift from a production-centric to a value-chain-centric model. Establishing Aquaculture Value Hubs around major reservoirs would cluster hatcheries, feed mills, processing plants, and logistics services. Such hubs could operate under public–private partnerships, ensuring economies of scale (Reddy, 2023). Developing cold-chain networks, district pack houses, refrigerated trucks, and retail freezers would reduce post-harvest losses below 8 percent. Implementing QR-code-based traceability aligned with FSSAI standards can open export opportunities.

Policy and Regulatory Reforms

The Blue Economy demands updated regulatory frameworks. Telangana could adopt a State Aquaculture Policy integrating environmental clearances, water leasing, and cooperative governance. Simplifying license procedures through single-window digital platforms will encourage formalization (Department of Fisheries, 2024). Introducing *Performance-Based Incentives* for cooperatives that achieve sustainability benchmarks, such as low feed-conversion ratios and zero-effluent discharge, can institutionalize responsible aquaculture (FAO, 2022).

Financing the Transition

Expanding credit access is vital. Establishing a Blue Economy Fund blending state resources, NABARD refinance, and CSR capital could finance infrastructure and climate-resilient innovations. Micro-insurance products for disease and crop failure would complement the existing accident insurance. Encouraging private investment through viability-gap funding and interest subvention can catalyze processing and export ventures. Global development agencies like the World Bank (2017) and FAO (2022) emphasize leveraging blended finance to scale sustainable aquaculture.

Data-Driven Governance

Digitization is central to efficiency. The Fisheries Dashboard should evolve into an Open-Access Data Portal linking production statistics, market prices, and environmental parameters. Integration with satellite-based monitoring will enable predictive analytics for disease outbreaks and climate anomalies (Gumma et al., 2023).

Creating an Annual Blue Economy Report for Telangana would institutionalize data transparency and attract investor confidence.

Education, Research, and Innovation

Partnerships with universities such as Professor Jayashankar Telangana State Agricultural University and Osmania University could establish a *Centre for Blue Economy Research*. Focus areas would include climate economics, aquaculture AI, and ecosystem services valuation.

Embedding entrepreneurship modules within fisheries curricula would nurture the next generation of *aqua-preneurs* (Reddy, 2023). International collaboration with FAO and ASEAN institutions could bring technical expertise and market linkages.

CONCLUSION

Telangana's experience demonstrates how a landlocked state can harness inland water resources and institutional innovation to operationalize India's Blue Revolution and transition toward a comprehensive Blue Economy. Over the past decade, fish production nearly doubled, cooperative membership expanded, and welfare coverage deepened. The integration of Mission Kakatiya with PMMSY and IFDS exemplifies effective cross-sectoral synergy that enhances both ecological sustainability and livelihood security.

However, the next phase requires qualitative transformation: strengthening post-harvest infrastructure, institutionalizing environmental safeguards, deepening women's participation, and embedding digital traceability. A *Blue Economy 2.0* for Telangana should rest on four pillars: standards, sustainability, social inclusion, and science-based governance. As India charts its *Viksit Bharat 2047* vision, Telangana's model offers a microcosm of inclusive aquatic growth, anchored in local ecosystems yet connected to global value chains. With NFDB's institutional leadership and the state's proactive governance, Telangana can emerge as a national and global exemplar of an inland, equitable, and climate-resilient Blue Economy.

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