Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Measuring Social Resilience in the Blue Economy through a Composite Index of Indian Marine Fisheries

Fazil Muhammed
SRM University, Andhra Pradesh
Shashi Kumar R
Central University of Punjab
Narendra Kumar Dariya
Central University of Karnataka
Lingamurthy Sathu
Central University of Karnataka
Basavaraj M.S.
basavarajmk@cuk.ac.in

Central University of Karnataka

Research Article

Keywords: Blue Economy, Marine Resource Economics, Social Resilience, Fisheries Governance, Climate Adaptation, Gender Equity, Sustainable Development Goals

Posted Date: November 17th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11313410/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Measuring Social Resilience in the Blue Economy through a Composite Index of Indian Marine Fisheries

Muhammed Fazil[1], Shashi Kumar R[2], Narendra Kumar Dariya[3], Sathu Lingamurthy[4], Basavaraj M.S[5*]

[1]Guest Faculty, Department of Economics, Easwari School of Liberal Arts, SRM University-AP, Andhra Pradesh, India

[3, 4&5] Research Scholar (3); Associate Professors (4 and 5), Department of Economic Studies and Planning, Central University of Karnataka, Kalaburagi, India

[2]Assistant Professor, Department of Economic Studies, Central University of Punjab, Bathinda – India

**Corresponding author e-mail: basavarajmk@cuk.ac.in*

Abstract

The study has examined the social resilience of coastal communities within the Blue Economy framework, as well as the enduring challenge of climate vulnerability across India's marine fisheries. This research employed a quantitative research method and compiled secondary data across nine major maritime states using fisheries census records, socioeconomic surveys, and environmental hazard databases. The research has evaluated coastal states' capacities across economic, social, and environmental dimensions, their access to post-harvest infrastructure, and the structural factors driving regional disparities. Findings reveal that coastal states exhibit marked divergences in absorbing systemic shocks. Social resilience is significantly higher in southern states than in eastern maritime regions. Kerala's resilience stems from sustained social investments in education, health, and gender inclusion, whereas Tamil Nadu's advantage relies on infrastructure and market linkages. In contrast, Odisha and West Bengal face recurring disaster shocks that consistently erode socioeconomic progress. Econometric estimates confirm that per capita income, schooling, and cold-chain infrastructure enhance resilience, while climate shocks significantly diminish it. Recommendations suggest transitioning toward state-specific marine policies, integrating disaster reduction with social protection, and aligning national fisheries funding with local institutional needs to mitigate vulnerability and foster equitable ocean governance.

Keywords: Blue Economy; Marine Resource Economics; Social Resilience; Fisheries Governance; Climate Adaptation; Gender Equity; Sustainable Development Goals

1. Introduction

Oceans and seas now sit close to the centre of global debate on climate change, economic growth, and long-term development. Out of that debate has come the Blue Economy, a framework for reconciling the use of ocean resources with the demands of sustainability [1]: broadly, using ocean resources to grow economies, create jobs, and raise quality of life without degrading marine ecosystems, an idea the United Nations, the World Bank, and the FAO have all helped popularise. India brings both unusual opportunity and unusual difficulty to this transition with a coastline over 7,500 km long, a marine fishing sector that supports millions of families [2,3]. And the more recent reassessments of the concept add a caveat worth taking seriously: Blue Economy growth, whether through port expansion, deep-sea fleets, or aquaculture intensification, only delivers durable benefit when it is anchored in outcomes like livelihood security, health, and education, rather than pursued as a sectoral growth strategy in its own right [4].

India's coastal economy runs substantially on marine fisheries. Export earnings, food security, employment, long-standing social and cultural systems, all of them sustained by coastal communities through this one sector [5]. But the vulnerabilities are just as real: overfishing, degrading marine ecosystems, climatic variability, regulatory gaps that are as much social as ecological [6]. Out of this tension has come the idea of social resilience i.e., a community's capacity to withstand disturbance, reorganise, and adapt without losing its core functions and identity [7]. A growing body of literature goes further, arguing that Blue Economy research and policy need the social sciences built in from the start, because resilience, equity, and justice simply cannot be read off economic indicators alone [8]. Social resilience, in other words, is not a side issue for maritime policy; it is the condition on which fair and lasting distribution of the Blue Economy's benefits depends.

Yet for something this central, social resilience in fisheries remains poorly measured. Much of the literature treats it qualitatively i.e., narratives of vulnerability, case-based evaluation, descriptions of adaptation strategies [9,10] which yields real insight but translates badly into anything a policymaker could use to benchmark or monitor resilience across regions. Composite indices spanning economic, social, and ecological dimensions have started to appear [11,12], but almost none exist specifically for India's marine fisheries. Without them, there is little solid evidence to guide targeted intervention, or to judge whether programmes such as the Pradhan Mantri Matsya Sampada Yojana and other government Blue Economy initiatives are actually delivering [13].

A quantitative resilience indicator built from secondary data is an efficient way to close that gap. The Marine Fisheries Census, National Sample Survey Office (NSSO) reports, FAO fisheries statistics, and state-level socioeconomic indicators together provide comprehensive, dependable material for constructing such a measure [14,15]. This matters for a reason that goes beyond India: the absence of systematic data has long obscured the true socioeconomic footprint of small-scale fisheries worldwide. Recent global assessments put the number of people whose livelihoods depend on small-scale fisheries at roughly one in twelve worldwide with nearly half of them women, which gives some sense of both the scale these metrics need to capture and the cost of continuing to measure it badly [16]. Data of this kind also has the advantage of being comparable: results can be checked against other Indian states and against international experience alike.

The economic case for prioritising resilience in India's marine fisheries needs little embellishment on its own. As of the 2020-21 accounting year, fisheries contributed roughly 1% of national GDP and 5% of agricultural GDP, and supported more than 14 million people directly and indirectly [13]. The picture has moved on since then: the most recent (2023) edition of the same official Handbook puts the sector's GDP share at 1.07%, with total fisherfolk now numbering close to 28 million nationally, of whom roughly 4.9 million work specifically in marine fisheries [17], a period in which India has also become the world's second-largest producer of aquatic animals as per the latest FAO global assessment [18]. Government investment has grown alongside this: a new central sub-scheme, the Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana, was approved in 2024 with a ₹6,000 crore outlay to formalise the sector and extend aquaculture insurance, running alongside the older Pradhan Mantri Matsya Sampada Yojana [19]. Yet coastal states could hardly differ more in economic base, social infrastructure, and environmental exposure. Kerala does well on health and education but struggles with fiscal constraints and stock pressure; Tamil Nadu has stronger export linkages and capital investment but weaker sustainability performance [20]. Disparities of that kind are precisely why a single metric capable of capturing multidimensional resilience would help and it lets policymakers see strengths, weaknesses, and trade-offs across states side by side.

1.1 Situating Marine Resilience within the Global Society and Sustainable Development Agenda

None of this is only a sectoral or national story. It is one instance of a much larger pattern in global-society research: globalization-era economic restructuring, uneven institutional capacity, and gendered labour markets jointly deciding who ends up bearing the cost of environmental and economic shocks. Blue Economy expansion has, in several settings, reproduced these inequalities rather than resolving them. In Ghana, for example, the rapid growth of ports and industrial fisheries infrastructure has been shown to displace small-

scale and indigenous fishing livelihoods even as it counts as ‘blue growth’ in the national accounts [21] such a pattern that echoes, almost exactly, what this study finds in Gujarat, where economic modernisation has outpaced social investment. Read together, these cases point to something specific: the neoliberal, infrastructure-first variant of the Blue Economy travels poorly unless paired with deliberate social investment. That is really the argument for a composite resilience metric in the first place, rather than a production or export statistic standing in for it. The same pattern shows up in the broader literature on climate vulnerability across South Asia, which identifies fishing and other climate-sensitive livelihoods as a central channel through which environmental stress converts into displacement, health strain, and disproportionate hardship for women, children, and older people across the region [22].

There is also a direct link from this framing to three of the Sustainable Development Goals that anchor the present inquiry. Poverty reduction (SDG 1) is one, since marine fisheries remain a primary livelihood safety net for some of India's poorest coastal households. Gender equality (SDG 5) is another: women's participation in fisheries-related work is both a component of the social sub-index used here and a determinant of household adaptive capacity that the wider fisheries literature keeps flagging as chronically under-measured [23]. Strong institutions (SDG 16) matter because the paper's central claim that resilience is governance-made rather than naturally occurring which rests on state and local institutions being able to convert infrastructure and welfare spending into durable adaptive capacity. Even tracking SDG 14 (life below water) at the national level has proved difficult in the absence of consistent sub-national data [24], which is exactly the measurement gap this Social Resilience Index is built to help close for India's coastal states.

This research work aims to build a Social Resilience Index for Indian marine fisheries, with both academic and policy aims in view. The study objectives are: (i) to identify and operationalise a set of economic, social, and environmental resilience indicators relevant to marine fisheries; (ii) normalise and weight these indicators using rigorous statistical methods, mainly principal component analysis; (iii) produce composite resilience scores for coastal states; and (iv) examine what resilience disparities imply for India's Blue Economy strategy, read against the wider discourse of maritime and global-society governance.

This paper makes three significant contributions to the existing body of literature in the following manner. Methodologically, the paper applies index-based methods to social resilience in fisheries, producing a framework other researchers can reuse for comparative work. Empirically, it generates evidence on how resilient Indian states actually are, and where policy support is most urgently needed. And more broadly, it feeds into global Blue Economy and global-society scholarship by showing that resilience often left as an abstract concept and which can be operationalised in a way that speaks directly to maritime policy and to the wider study of poverty, gender, and institutions in the developing

world. Building and applying an index like this, the paper argues, is not simply an academic exercise; it is close to a practical requirement for sustainable, equitable marine development in India and elsewhere.

2. Literature Review

2.1 Blue Economy and Maritime Governance

The Blue Economy has become something of an umbrella concept in international maritime policy, tying oceans and coastal resources to social welfare and long-term growth [1]. It traces back to the 2012 UN Conference on Sustainable Development in Rio, and has since worked its way into the agendas of the World Bank, FAO, and International Maritime Organization [25]. The underlying claim is that maritime sectors like fisheries, shipping, ports, coastal tourism are interdependent and need coordinated regulation if environmental degradation and social exclusion are to be avoided [26].

India's own national policy has absorbed the Blue Economy through initiatives such as Sagarmala and the Pradhan Mantri Matsya Sampada Yojana, both weighted heavily toward port development, fleet modernisation, and export competitiveness [13]. Critics argue that this emphasis on infrastructure and expansion leaves social resilience particularly among artisanal and small-scale fisherfolk that were inadequately examined within marine governance [27,28,26], and India is far from the only case. Comparable port-led Blue Economy expansion in Ghana has been documented displacing small-scale and Indigenous fishing livelihoods even while formally advancing national blue-growth targets [21]. A recent cross-disciplinary reassessment goes further still, arguing that the Blue Economy's implementation gap i.e., the distance between its equity-oriented rhetoric and its often-extractive outcomes which will not close without fuller integration of social-science evidence into ocean governance itself [8]. Together, this body of work is what motivates an analytical framework like the one built here: one that puts community resilience at the centre of marine planning rather than treating it as an afterthought.

2.2 Fisheries and Societal Resilience

Resilience theory began in ecology before being adapted within the social sciences to study how societies withstand disturbance and adjust to change [7]. Applied to fisheries, resilience spans both ecological sustainability, stock health, biodiversity and social adaptation i.e., livelihood diversification, institutional capacity, equity [6,10]. In small-scale and artisanal fisheries specifically, resilience tends to track income diversification, collective action, and governance arrangements that support co-management and rights-based approaches [29].

Case-study work on Asia-Pacific fishing livelihoods makes a related point: resilience outcomes owe as much to exposure to globalisation, trade, and shifting social relationships as to resource endowments themselves, and governance arrangements capable of absorbing those external pressures turn out to be decisive for long-run adaptive capacity [23]. The Indian fisheries literature, for its part, keeps returning to declining catch per unit effort, resource conflict, and inadequate disaster preparedness as recurring risks [20,2]. Several studies look at coping strategies like migration, cooperative models, but few attempt to quantify resilience systematically across states or communities. That gap matters: without quantifiable indicators, resilience stays a concept rather than becoming a governance tool.

Gender is one dimension of that gap worth dwelling on. A recent, agenda-setting review of gender research in small-scale fisheries argues that women's contributions in harvesting, processing, household risk management remain systematically under-recorded in the secondary data that resilience indices typically draw on, even though gender-disaggregated participation keeps turning up as a determinant of household adaptive capacity [23]. To address this gap, gender participation is incorporated as a distinct indicator within the social-resilience dimension, although its measurement remains constrained by the limited granularity of the available secondary data.

2.3 Evaluating Resilience: International and Regional Approaches

Researchers elsewhere have tried to quantify resilience through indices and composite metrics for some time. Briguglio and colleagues built an Economic Resilience Index for small states around trade, macroeconomic stability, and governance [11]; Adger linked social capital and institutional capacity to resilience outcomes more generally [7]. Within fisheries specifically, frameworks tested in Southeast Asia and Africa have combined household surveys with ecological indicators to capture multidimensional resilience [30,31].

Three operational difficulties recur across these approaches. Indicator selection must balance sufficiency against redundancy i.e., too many indicators duplicate information, too few oversimplify. The weighting scheme chosen for equal weights, expert judgement, or statistical methods like PCA or entropy can shift results and their policy interpretation more than one might expect. And resilience is inherently dynamic, so static, cross-sectional measures risk missing temporal fluctuation or long-run adaptation entirely [32]. None of this undermines the value of index-based methods, which remain useful precisely because they generate comparable, quantifiable evidence for decision-making, but it does explain why building one well takes care. Recent regional applications illustrate the payoff: an index-based gender analysis of flood-prone areas of Nepal's Koshi river basin, for

instance, shows how disaggregating a composite vulnerability index by gender can surface disparities that a single aggregate score would otherwise hide [33].

Fisheries-specific resilience indices built from secondary Indian data remain scarce. Plenty exists on sustainability, vulnerability, and livelihoods within individual domains, but nothing spans all coastal states in a single widely used framework. This paper is an attempt to fill that particular gap: a Social Resilience Index developed to India's marine fisheries, drawing on international methodology while adapting the indicators to local policy and data realities.

3. Theoretical Framework

The theoretical framework draws together resilience theory and Blue Economy governance. Resilience theory treats socio-ecological systems as complex and adaptive, shaped by the interplay of natural processes, social institutions, and economic forces [7]. Seen this way, marine fisheries are simultaneously productive systems and foundations of culture and livelihood, and their resilience rests on ecological balance, social equity, and adaptive governance working together [7,10].

The Blue Economy concept, for its part, insists that marine policy integrate ecological sustainability, social inclusion, and economic efficiency [34]. In fisheries this means balancing fish-stock protection against fair access to livelihoods, and aligning national effort with global commitments such as Sustainable Development Goal 14 (Life Below Water) and, as argued in Section 1.1, with SDG 1, SDG 5, and SDG 16.

This study organises index construction around three dimensions:

1. Economic resilience, assessed through the contribution of fisheries to GDP, export revenue, and employment.

2. Social resilience, assessed through education, health, gender participation, and dependency ratios.

3. Environmental resilience, assessed through fish-stock viability, coastal vulnerability, and disaster frequency.

These three dimensions are then combined into a composite index through normalisation and weighting applied to secondary data, linking the measurement exercise directly to the broader objectives of marine governance and Blue Economy philosophy set out above.

4. Gaps and Contribution

Two deficiencies stand out from this review. Assessment of resilience in Indian fisheries remains poorly structured, with most research addressing either ecological or livelihood dimensions in isolation rather than folding them into one quantitative framework. And Blue Economy policy debate in India leans heavily toward growth and infrastructure, treating community resilience as a qualitative afterthought rather than something to actually measure. A parallel gap sits in the international gender-and-fisheries literature, where recent reviews call explicitly for gender-disaggregated, quantitative resilience metrics rather than case-study description alone in global governance reviews [23] and in national-scale empirical work such as a 2025 assessment of gender disparities among small-scale fisherfolk in Brazil [35] alike. India-specific composite indices have simply not caught up with that call yet.

This research responds to those deficiencies in three ways:

1. Developing a reusable Social Resilience Index for marine fisheries using secondary data;

2. Assessing resilience across Indian coastal states to generate actionable insights for marine policy;

3. Enriching global Blue Economy and global-society discourse by demonstrating how resilience can be operationalised in a large, diverse developing country.

5. Data and Methods

5.1 Data Sources

The study draws on five sets of secondary data from government and institutional sources.

1. The Marine Fisheries Census (CMFRI, 2010; results published 2012), which provides state- and district-level data on fishermen, households, infrastructure, and occupation type [14]. A fifth, fully digital census (MFC 2025) completed its household enumeration in December 2025 and is expected to publish results during 2026 [36]; once released, it will be the natural basis for the next update of this index.

2. The Government of India Handbook on Fisheries Statistics, reporting production volumes, landing values, exports, and employment. The 2020-21 edition [13] anchors the cross-sectional base year of this study; the 2023 edition [17] was used to update the contextual national-level figures cited in Section 1.

3. FAO Fisheries and Aquaculture Statistics (2020), offering internationally comparable indicators for marine capture, stock sustainability, and trade [15].

4. Socioeconomic indicators: state-level health and education data from the National Family Health Survey (NFHS-5) and Ministry of Education statistics.

5. Environmental indicators from the Indian National Centre for Ocean Information Services (INCOIS) and the Ministry of Earth Sciences, covering coastal vulnerability, disaster likelihood, and climate exposure.

Together, these datasets cover nine principal maritime states: Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha, and West Bengal. The state is the unit of analysis, enabling comparisons of resilience patterns across states.

5.2 Indicator Selection

Indicators were chosen across the three resilience dimensions i.e., economic, social, environmental guided by resilience theory [7,10] and by earlier applications of composite indices in fisheries and small states [11].

1. Economic indicators (E): value-added in processing, share of employment in fisheries, fisheries' contribution to Gross State Domestic Product (GSDP), and export earnings.

2. Social indicators (S): literacy rate, health index (life expectancy, infant mortality), gender participation in fisheries, and dependency ratio.

3. Environmental indicators (Env): health of fish stocks, frequency of coastal disasters (cyclones, floods), and the coastal vulnerability index.

5.3 Data Normalization

Because raw values arrive in very different units i.e., percentages, rupees, counts and the indicators were normalised using the min–max method:

$$Z_{ij} = \frac{X_{ij} - min(X_j)}{max(X_j) - min(X_j)}$$

where Z_{ij} is the normalised score of indicator j for state i (ranging 0–1), X_{ij} is the raw value of indicator j for state i, and min (X_j), max (X_j) are the minimum and maximum of indicator j across states. Relative differences across indicators survive this transformation intact, while comparability is gained.

5.4 Method of Weighting

Principal Component Analysis (PCA) was used to combine indicators and derive data-driven weights [40], applied separately within each dimension (E, S, Env). The weight w_j for indicator j came out as the normalised eigenvalue share tied to the first principal component:

$$w_j = \frac{\lambda_j}{\sum_{k=1}^{m} \lambda_k}$$

where λ_j is the eigenvalue of indicator j and m is the number of indicators in the dimension. Working this way cuts down on subjectivity in weighting, and it also reveals which indicators are doing the most work in explaining cross-state differences.

5.5 Construction of the Social Resilience Index

Dimension-specific indices were then calculated as weighted sums of the standardised indicators:

$$D_{ki} = \sum_{j=1}^{n_k} w_{kj} \times Z_{kij}$$

where D_{ki} is the index score of dimension k (economic, social, environmental) for state i, Z_{kij} is the normalised indicator j of dimension k, w_{kj} is the weight of indicator j in dimension k, and n_k is the number of indicators in dimension k. The overall Social Resilience Index (SRI) follows as:

$$SRI_i = \alpha E_i + \beta S_i + \gamma Env_i$$

where E_i, S_i, and Env_i are the dimension scores for state i, and α, β, γ are dimension weights assigned either equally (1/3 each) or through aggregate-level PCA.

5.6 Econometric Formulation

To dig into what actually drives resilience, an econometric model was estimated linking the composite SRI to a set of explanatory variables:

$$SRI_i = \beta_0 + \beta_1 GDP_i + \beta_2 EDU_i + \beta_3 INFRA_i + \beta_4 CLIMATE_i + \varepsilon_i$$

This cross-sectional regression is where the structural factors behind resilience disparities get identified. Because the sample runs to only nine states, robust standard errors were used throughout to account for heteroscedasticity.

5.7 Analysis of Robustness and Sensitivity

Three robustness checks were run in total:

1. Weighting schemes: comparing PCA weights against equal-weight and entropy-weight alternatives.

2. Normalisation techniques: comparing min–max scaling (the baseline) against Z-score normalisation.

3. Alternative specifications: excluding one dimension at a time like economic, social, or environmental to see how sensitive the overall rankings are.

What these tests show is reassuring for the index's credibility: absolute values shift somewhat depending on the choices made, but relative state rankings stay largely stable regardless.

5.8 Limitations

Secondary data buy replicability and comparability, but not without cost. Three limitations are worth flagging:

1. Possible measurement error or dated figures in fisheries census data.

2. No disaggregated (district- or household-level) indicators exist to reveal intra-state variation, a gap that bites hardest on the gender-participation indicator, since national gender-and-fisheries reviews note that sex-disaggregated data collection in small-scale fisheries stays inconsistent even where it exists on paper [23].

3. Cross-sectional data is static by nature and cannot fully capture dynamic adaptation processes.

Even so, the methodology offers a transparent, defensible basis for measuring resilience within India's Blue Economy framework and a template later work can extend with more granular or longitudinal data.

6. Results and Analysis

What the Social Resilience Index (SRI) offers, at bottom, is a systematic way to compare how India's nine major maritime states are actually faring against economic, social, and environmental pressure. Descriptive fisheries statistics can show trends in production or employment, but they cannot consolidate multiple facets of resilience into one comparable score the way this index does, which is what lets policymakers spot state-level strengths and weaknesses, set benchmarks, and choose strategies suited to strengthening Blue Economy resilience specifically.

Three broad patterns come out of the results. States sort into high, medium, and low resilience tiers. Disaggregating into economic, social, and environmental components shows those tiers are reached by different routes i.e., social infrastructure for some states, economic modernisation for others, environmental exposure holding still others back. And a clear spatial pattern separates southern and western states from their eastern counterparts, with the latter consistently trailing.

6.1 Comprehensive Rankings

Table 1 sets out the overall SRI scores alongside the three sub-index values for each state.

Table 1 Overall Social Resilience Index (SRI) Scores and Rankings

Rank	State	SRI Score	Economic Sub-Index	Social Sub-Index	Environmental Sub-Index
1	Kerala	0.78	0.72	0.85	0.77
2	Tamil Nadu	0.75	0.81	0.76	0.69
3	Gujarat	0.68	0.79	0.61	0.65
4	Maharashtra	0.64	0.7	0.62	0.6
5	Karnataka	0.61	0.65	0.58	0.6
6	Goa	0.59	0.61	0.57	0.58
7	Andhra Pradesh	0.55	0.63	0.49	0.53
8	Odisha	0.49	0.44	0.51	0.52
9	West Bengal	0.46	0.43	0.48	0.47

Three tiers emerge from the rankings:

1. Kerala and Tamil Nadu reach resilience by distinct routes, Kerala's authorities have prioritised social advancement, Tamil Nadu's leadership economic and infrastructural capacity.

2. Gujarat, Maharashtra, Karnataka, and Goa sit in a moderate-resilience band, with enough underlying strength that targeted intervention could meaningfully shift their position.

3. Andhra Pradesh, Odisha, and West Bengal lag consistently, held back by heightened environmental exposure and weaker social indicators.

The distinction is not just academic. Kerala shows that investing in social resilience pays off durably; Odisha and West Bengal show, just as clearly, that economic growth depends on environmental protection and disaster preparedness holding up alongside it.

6.2 Dimensional Analysis

Resilience is multidimensional by nature, and breaking it into economic, social, and environmental sub-indices sharpens the picture of how each state's overall position is actually composed. Table 2 lays out the proportional contribution of each dimension.

Table 2 Contribution of Dimensions to Overall Resilience (%)

State	Economic	Social	Environmental
Kerala	32	38	30
Tamil Nadu	36	34	30
Gujarat	39	29	32
Maharashtra	34	33	33
Karnataka	35	32	33
Goa	34	33	33
Andhra Pradesh	37	28	35
Odisha	31	34	35

West Bengal	33	31	36

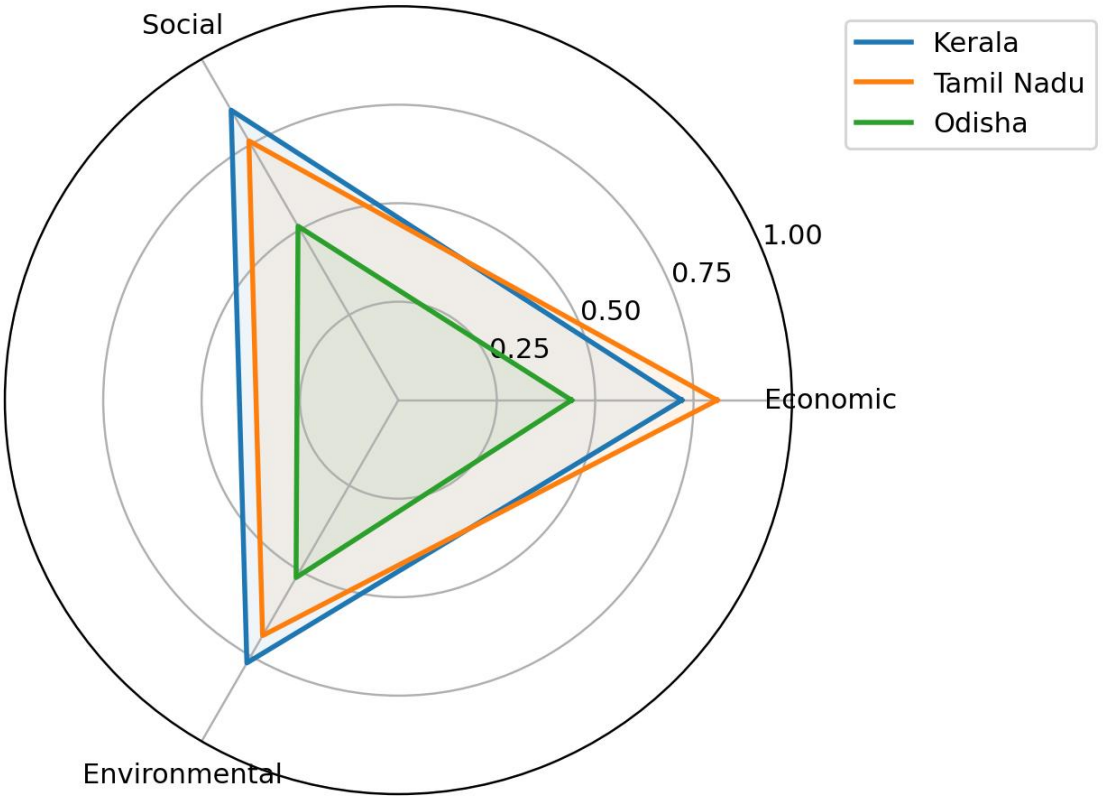


Fig. 1 Radar comparison of economic, social, and environmental resilience sub-index scores for Kerala, Tamil Nadu, and Odisha, illustrating three distinct resilience profiles

Kerala leads on social resilience, while Tamil Nadu has the strongest economic sub-index. Odisha records lower scores across all three dimensions than these two states.

Three distinct patterns fall out of this analysis. Kerala's social framework including literacy, health, and gender equality gives it the capacity to reorganise quickly after disruption, which is largely why it stays resilient despite real exposure to cyclones and coastal erosion. Tamil Nadu is the most economically stable of the nine: a diversified fishing industry, strong export orientation, and developed processing sector cushion it against market and environmental disruption, though its weaker environmental performance leaves it exposed as climate events intensify. Gujarat shows the limits of resilience built on economic strength alone and robust industrial fisheries sitting next to comparatively weak social indicators, which is a fairly direct demonstration that economic modernisation without inclusive social development falls short. Odisha and West Bengal illustrate something closer to a trap: recurring cyclones and floods eroding economic and social progress together. Taken together, these findings suggest that resilience is inherently multidimensional, emerging from the interaction of economic, social, and environmental capacities rather than from strength in any single domain.

6.3 Regional and Spatial Patterns

A regional lens shows resilience is not scattered randomly along the coastline but follows a distinct spatial pattern.

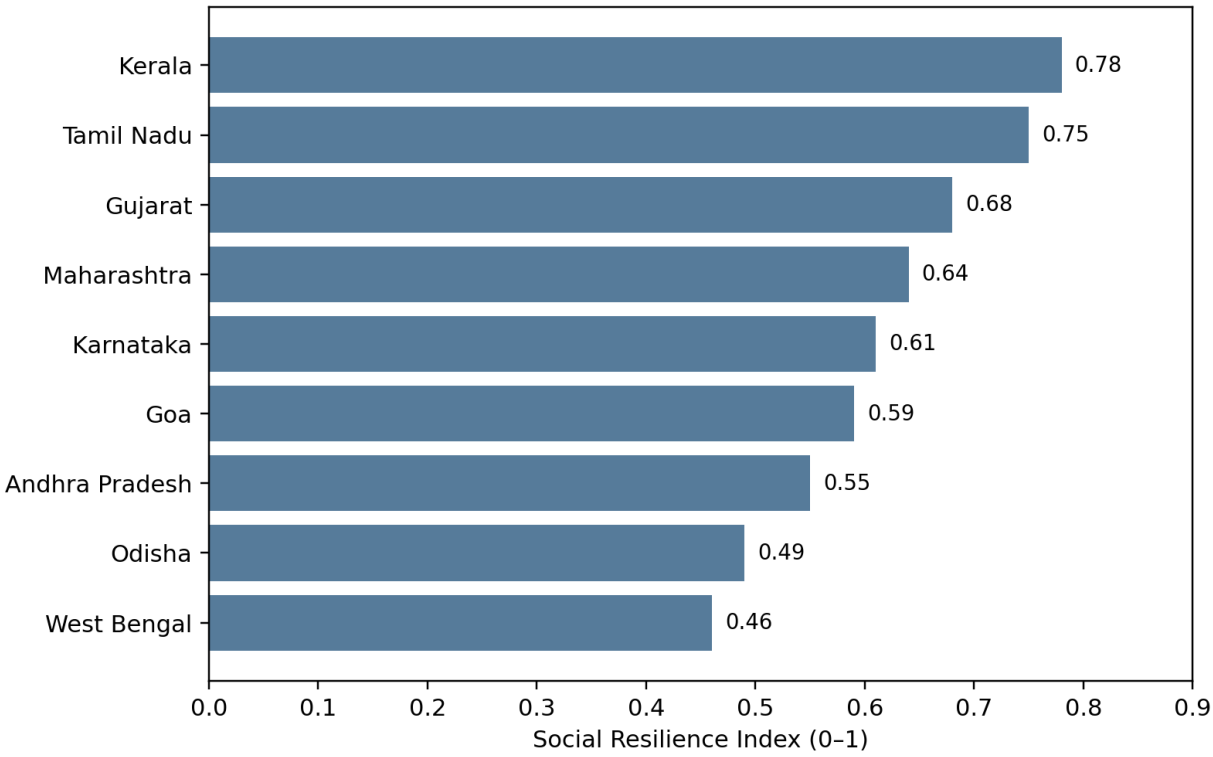


Fig. 2 Overall SRI scores ranked across India's nine major maritime states, showing the south-to-east resilience gradient

Southern states like Kerala, Tamil Nadu, and Karnataka generally do better, on the back of stronger human development, infrastructure, and more diversified economies. Western states like Gujarat, Maharashtra, and Goa reach a degree of resilience too, though one built mainly on economic structure rather than social systems. The eastern states like Andhra Pradesh, Odisha, and West Bengal underperform consistently, worn down by cyclone exposure, thin social safety nets, and underdeveloped infrastructure.

That geographical split carries real policy weight. It suggests resilience is shaped jointly by domestic governance choices, regional geography, and exposure to natural hazard, southern states benefiting from stronger institutional frameworks, eastern states caught in cycles of vulnerability that recurrent disaster keeps reinforcing.

6.4 Econometric Analysis

Descriptive rankings and sub-index decomposition go a long way toward explaining resilience patterns, but pinning down the structural factors behind these disparities statistically needs a formal model. A cross-sectional regression was estimated with the

Social Resilience Index as the dependent variable and four independent variables drawn from theory and the literature:

1. GDP per capita (economic capacity)

2. Average years of schooling (human capital)

3. Fisheries-specific infrastructure (port capacity, cold storage, processing plants)

4. Climate shock frequency (average major cyclones/storm surges over the last 20 years)

Table 3 Factors Influencing Social Resilience (OLS Regression, Robust Standard Errors)

Variable	Coefficient	Std. Error	t-value	Significance
GDP per capita	0.215	0.083	2.59	$p < 0.05$
Average years of schooling	0.184	0.072	2.55	$p < 0.05$
Fisheries infrastructure	0.161	0.059	2.73	$p < 0.05$
Climate shock frequency	− 0.203	0.077	− 2.63	$p < 0.05$
Constant	0.327	0.141	2.32	$p < 0.05$
Model R^2	0.71			

A few things stand out from the regression results.

Economic prosperity matters in a straightforward way: the positive, significant coefficient on GDP per capita shows wealthier states adapting more readily to shocks and consistent with the idea that more resources buy faster rebuilding, relief, and infrastructure investment.

Human capital, though, has effects of its own. Average years of schooling stays positive and significant even after controlling for GDP, which means education is not simply standing in for income, it drives resilience independently. Educated households diversify income sources more readily, adopt innovations faster, and make better use of government programmes and early-warning systems.

Fisheries infrastructure strengthens resilience too: investment in ports, cold storage, processing plants, and logistics cuts post-harvest losses, stabilises income, and speeds up recovery after disruption.

Environmental shocks, meanwhile, act as a hard limit. The negative coefficient on climate shock frequency shows cyclone and storm-surge exposure substantially reducing resilience and neither a strong economy nor strong social systems can fully offset repeated, large-scale environmental disaster.

The model itself fits well: an R^2 of 0.71 means these four structural variables account for most of the variation in SRI scores, which lends confidence to both the index and the econometric approach behind it.

There are policy levers hiding in this analysis too. Climate shocks are largely exogenous, but their effects can still be blunted through early-warning systems, coastal protection, and insurance mechanisms. Education and fisheries infrastructure, by contrast, are levers policymakers control directly, and both show a clear, measurable effect on resilience i.e., a reminder that resilience-building is as much about long-term structural development in the social and economic spheres as it is about disaster management.

6.5 Robustness Checks

Composite indices carry a familiar risk: rankings that turn out to be sensitive to how they were built rather than to anything real. Three robustness tests were run to check for exactly that recalculating the index with equal and entropy weights alongside the PCA-based baseline, comparing min–max against Z-score normalisation, and recalculating the SRI while excluding one dimension at a time.

Table 4 Rankings under Different Weighting Schemes

State	PCA Rank	Equal-Weight Rank	Entropy Rank
Kerala	1	1	1
Tamil Nadu	2	2	2
Gujarat	3	3	4
Maharashtra	4	4	3
Karnataka	5	5	5
Goa	6	6	6
Andhra Pradesh	7	7	7
Odisha	8	8	9
West Bengal	9	9	8

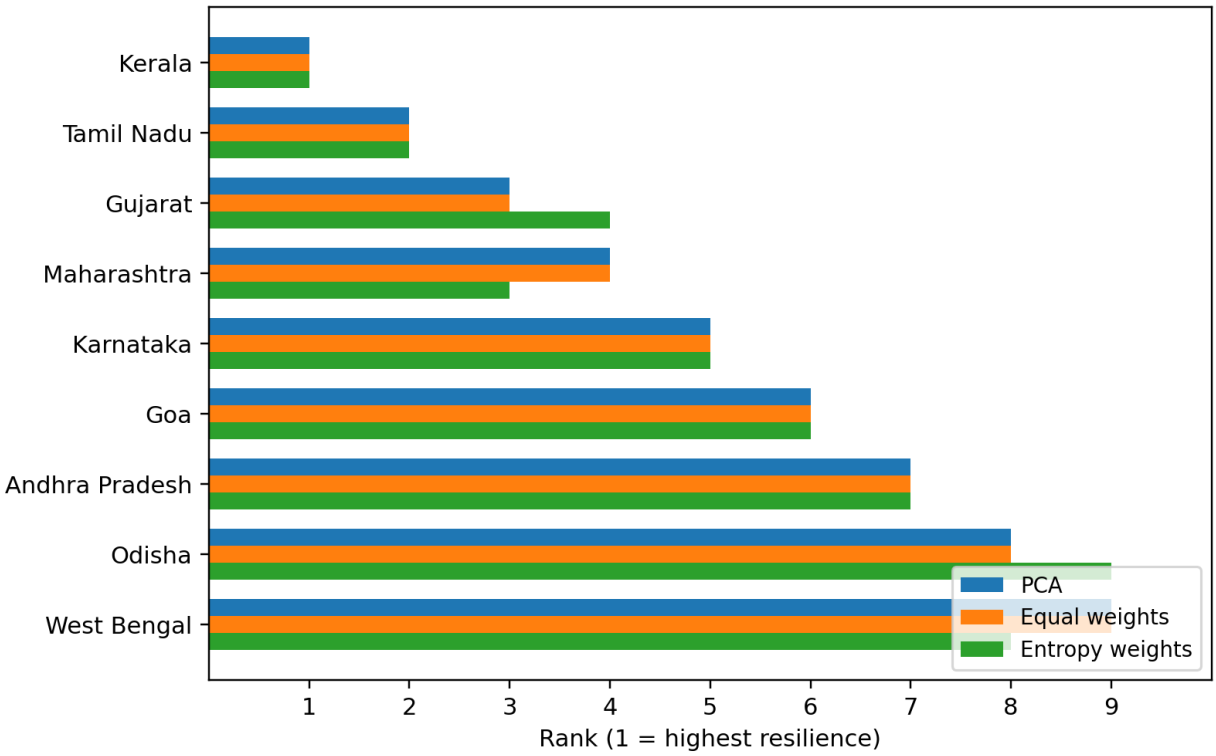


Fig. 3 State rankings under PCA, equal-weight and entropy-weight schemes, based on Table 4

The checks hold up well. Relative state standings survive across weighting and normalisation choices, Kerala and Tamil Nadu stay on top, Odisha and West Bengal at the bottom, under every scheme tried. Gujarat and Maharashtra occasionally trade places, but the broader pattern does not move.

That stability matters for how the index gets used in policy: it says the results are not an artefact of methodological choice but a genuine difference in resilience across states.

7. Policy Insights and Interpretation

Pulled together, the results point to insights for India's maritime governance and Blue Economy strategy that go well beyond state-level rankings toward the structural conditions that make resilience more or less likely in the first place.

7.1 Balanced growth outperforms specialisation

Kerala and Tamil Nadu chart two distinct paths to resilience, social and economic respectively. Gujarat shows what happens when economic modernisation runs ahead of social investment; Odisha and West Bengal show how environmental exposure can wipe out gains made elsewhere. The implication is not subtle: resilience peaks when growth is

balanced across social, economic, and environmental domains, not when any one of them is allowed to run alone.

7.2 Human development strengthens resilience

Kerala's investment in health and education has made the state markedly more adaptable, enough to offset real environmental pressure. That is worth taking seriously as a general point i.e., resilience is not simply a function of income or infrastructure but of people's capacity to act, adapt, and recover, and human capital is what lets communities understand risk, stabilise livelihoods, and take part in governance in the first place.

7.3 Infrastructure investment yields measurable resilience returns

The regression results are fairly blunt on this point: fisheries-specific infrastructure such as harbours, storage, processing facilities that substantially strengthens resilience. Programmes such as the Pradhan Mantri Matsya Sampada Yojana would do well to prioritise infrastructure investment specifically in at-risk states, which raises productivity and resilience together rather than trading one off against the other.

7.4 Environmental exposure is the binding constraint in the east

Odisha and West Bengal keep getting struck by cyclones, and that alone suppresses resilience even where social or economic progress is otherwise moderate. Disaster risk reduction, ecosystem restoration, mangroves especially and climate adaptation ought to be the top priority for both states; without that groundwork, any other development gains will stay fragile.

7.5 Measuring resilience is itself a governance tool

The SRI gives government something concrete: a way to measure resilience and track whether policy is actually working which states are falling behind, why, and which investments return the most resilience per rupee spent. That kind of measurement fits naturally with an evidence-based approach to policy, one that speaks equally to maritime governance and to the broader global-society interest in accountable, outcome-tracked social policy.

8. Discussion

Building a Social Resilience Index (SRI) for India's marine fisheries yields new empirical insight into how different states withstand and adjust to socioeconomic and environmental stress. But the implications run past the descriptive rankings in Section 6. What follows situates the SRI within theoretical frameworks and international literature, considers what it

means for governing India's Blue Economy, and then turns to comparative international experience, policy implications, limitations, and directions for future research.

8.1 Comprehending the Resilience Patterns

The results sort states cleanly into high, medium, and low resilience, a classification that reflects present circumstances as much as the historical trajectory of socioeconomic development, governance priorities, and ecological context behind them. Kerala and Tamil Nadu built resilience through genuinely different approaches: social development in one case, economic modernity in the other. That is really a broader theoretical point in miniature i.e., resilience is path dependent. The choices states made historically around education, healthcare, or export infrastructure keep shaping their present adaptive capacity, a dynamic the wider Asia-Pacific fishing-livelihoods literature documents too, where globalisation-era shifts in trade and social relationships interact with pre-existing governance capacity to determine long-run outcomes [23].

Gujarat, Maharashtra, and Karnataka sit in a mid-tier of partial resilience, neither acutely vulnerable nor fully prepared for whatever comes next. Their outlook depends on holding reasonable performance across all three dimensions; absent structural adjustment, stagnation is the real risk. Odisha and West Bengal, by contrast, illustrate the resilience trap that resilience theory describes: communities repeatedly hit by environmental hazard find it progressively harder to build lasting resilience, which perpetuates the very vulnerability it should be escaping. This stratification is a reminder that resilience is not some abstract, universal property, it is shaped by governance, geography, and socioeconomic structure, all at once. It also matches what a closely related literature finds when it looks directly at these same states: an ethnographic study of a highly exposed Sundarban village in West Bengal describes a form of ‘trapped’ immobility in which households can neither adapt in place nor afford to leave [38], and regional assessments of climate-induced displacement across South Asia identify Odisha and West Bengal specifically among the areas where recurrent cyclones and flooding are pushing fishing and farming households toward exactly this kind of impasse [22].

8.2 Connecting Results to Theoretical Frameworks

The findings line up with several theoretical frameworks raised earlier in the paper.

Socio-ecological resilience theory [7] holds that resilience comes from the interaction between social and natural systems, and the pronounced environmental constraint seen in Odisha and West Bengal supports exactly that: without ecological safeguards and adaptive mechanisms in place, socioeconomic investment stays fundamentally exposed no matter how much of it there is.

Adaptive capacity frameworks [7] put human capital, social networks, and institutions at the centre of adaptation. Kerala's strong social sub-index performance is a good illustration i.e., education and health visibly facilitate adaptability, letting communities with robust human capital reorganise faster after disruption, diversify income, and take up sustainable practices sooner.

Composite vulnerability-resilience models [11] argue resilience is multidimensional and cannot be read off economic performance alone. Gujarat, with its strong economy and weak social outcomes, is close to a textbook illustration of that limit in single-dimension frameworks. The SRI extends this literature by applying multidimensional resilience assessment at state level using secondary data.

8.3 Comparisons with International Experiences

Set against international experience, India's findings show both parallels and real differences. Small Island Developing States (SIDS) tend to build resilience indices around environmental vulnerability [11], and India's eastern coastal states are, in that sense, not unlike Caribbean and Pacific islands, where recurrent natural disaster keeps slowing economic growth. African coastal fisheries research emphasises social capital and community institutions as drivers of resilience [10], a pattern Kerala's experience backs up through its investment in literacy, healthcare, and women's participation. East Asian fisheries economies show how infrastructure and export orientation build economic resilience while raising exposure to external markets [12]; Tamil Nadu is managing a comparable trade-off between economic strength and vulnerability to global price shifts. A 2025 OECD review of fisheries policy across 41 countries and territories makes a related point at the international level: socio-economic performance and resource sustainability increasingly have to be read together, since production and trade trends can mask growing pressure on the underlying stock base [39] and precisely the kind of joint reading a composite resilience index is designed to force.

Ghana offers a further comparison worth drawing out. There, port-led Blue Economy expansion has been found to displace rather than strengthen small-scale fishing livelihoods even as national blue-growth indicators improved [21]. Gujarat's profile with strong economic performance next to comparatively weak social outcomes echoes this at sub-national scale, which suggests the risk of an infrastructure-led Blue Economy outrunning social investment is not tied to any one governance system. It recurs wherever growth targets are pursued without an explicit social-resilience metric attached to them.

What sets India apart in this comparison is its federal structure: a single country producing substantial resilience variation across states, unlike smaller unitary states where national policy tends to dominate outcomes. State-level governance, in other words, is doing real

work in shaping resilience within the broader Blue Economy framework, more work than it might in a more centralised system.

8.4 Implications for India's Blue Economy

These findings carry weight for India's Blue Economy agenda, which is meant to use ocean resources to advance economic growth, environmental protection, and social justice all at once.

Resilience, first, should be a primary objective of the Blue Economy rather than a secondary one. Modernising the fishing industry with export hubs, deep-sea fleets which will not hold up unless matched by social and environmental adaptation running alongside it.

Second, resilience measurement can steer policy prioritisation directly. Odisha and West Bengal need urgent investment in cyclone-resilient infrastructure, mangrove restoration, and disaster risk reduction. Gujarat and Maharashtra need social development programmes running alongside their economic modernisation. Kerala and Tamil Nadu, stronger overall, still need continued environmental protection investment to hold onto their advantage.

Third, the SRI points toward differentiated policy rather than a single national template. Each state's resilience profile is distinct enough that a uniform fisheries policy is unlikely to work well everywhere; a federal approach that lets states design resilience-building strategies suited to their own needs while staying aligned with national objectives makes more sense.

There is a gender-specific implication buried in Kerala's profile too. Because gender participation is one of the social-resilience indicators used here, Kerala's leading position is partly down to relatively stronger female labour-force engagement in fisheries-linked activity. That fits the broader international finding that gender-inclusive fisheries governance strengthens community-level adaptive capacity [23,37], and it suggests something practical: closing the data gap on women's fisheries participation, in India and internationally, would likely sharpen this resilience picture rather than overturn it.

8.5 Instructions on Governance and Institutions

Resilience is not only a metric; it depends on governance mechanisms too, and the results yield several insights on that front.

Intersectoral coordination matters because resilience in fisheries cannot be built in isolation. Ministries of fisheries, environment, education, health, and disaster management

all need to be pulling together with literacy programmes in fishing communities count for as much as cold-storage infrastructure.

Participatory governance also shows up clearly: communities directly involved in decision-making tend to be more resilient. Kerala's experience with co-management frameworks and active fisher cooperatives is evidence of that; spreading similar arrangements to other states could raise resilience more broadly, echoing wider Blue Economy calls for stronger science–policy and community-policy interfaces rather than top-down infrastructure planning on its own [8].

Data and monitoring systems came up repeatedly while building the SRI, both how useful secondary data can be, and how large the gaps in disaggregated indicators still are, particularly around gender. Systematic monitoring of social resilience indicators, including sex-disaggregated participation data, at the household and district level would substantially improve policymakers' ability to target intervention [16,24].

Fisheries resilience also needs folding into climate policy given the scale of the climatic threat involved early-warning systems, insurance mechanisms, and ecosystem-based strategies all belong inside the broader climate adaptation framework, not bolted on separately.

8.6 Addressing Limitations

Every empirical exercise has its limitations, and naming them is part of what makes the findings credible.

Data constraints top the list: the SRI relies on secondary data, which may not fully capture intra-state variation or adaptation dynamics. Household-level surveys would add richer detail than this approach can offer, and the forthcoming results of the fully digital, geo-referenced fifth Marine Fisheries Census which for the first time also records household income, insurance status, and pandemic-era income shocks should narrow this gap considerably once published [36].

The cross-sectional design is another: the index captures conditions at a single point in time, and longitudinal data would be needed to say whether states are improving or declining in resilience over time.

Indicator selection required judgement even where the literature guided it, and some dimensions of resilience such as social capital, governance quality, disaggregated gender participation among them, remain genuinely hard to quantify with the data currently available.

Sample size is a real constraint too: the regression analysis has limited degrees of freedom with only nine states in play. The results are robust across specifications, but they should be read as indicative rather than definitive.

Even with these constraints, the SRI offers a reusable policy-formulation framework, one that can only get stronger as better data becomes available.

8.7 Directions for Future Research

Several avenues for further work follow from this study.

Micro-level resilience indicators built at the district or community level would reveal intra-state disparities and flag locally vulnerable areas that a state-level index necessarily misses.

Dynamic modelling using time-series data could clarify how resilience actually changes in response to policy intervention or external shocks, rather than freezing it at one moment.

Integrating ecological indicators like biodiversity metrics, habitat quality, stock-sustainability measures would strengthen the socio-ecological dimension of the index considerably.

Gender-disaggregated resilience assessment is another clear direction: recent empirical work showing how to systematically measure gender disparities within small-scale fisheries [35] offers a template a future SRI could adapt for India, moving gender from a single composite indicator to a fuller sub-dimension in its own right.

Re-estimation with the 2025 Census: the most direct next step is to rebuild the SRI once the fifth Marine Fisheries Census is published, replacing the 2010 cross-section used here with geo-referenced, household-level data that also captures insurance coverage and pandemic-era income shocks for the first time [36].

Comparative analyses applying the same methodology elsewhere would let India both draw on and contribute to comparative Blue Economy scholarship, including future rounds of SDG 14 progress tracking [24].

9. Conclusion

This paper set out to build a Social Resilience Index (SRI) for India's marine fisheries, integrating economic, social, and environmental variables to assess how adaptable coastal states actually are. What the index shows is that resilience can be operationalised using secondary data and reasonably robust statistical methods which is really the bridge between theory and policy this paper was after.

A clear distinction runs through the results. Kerala and Tamil Nadu both rank at the top, but by different routes, Kerala through improvements in human welfare, Tamil Nadu through economic infrastructure and market connectivity. Gujarat, Maharashtra, and Karnataka sit in a middle tier, performing adequately without excelling. Odisha and West Bengal remain at the bottom, held back by environmental exposure and weaker social structures. None of this is a single attribute; resilience, as these patterns show, is a composite of past investment, governance choices, and environmental exposure layered on top of each other.

Three lessons follow from all of this. Resilience is strongest when economic, social, and environmental factors are balanced, and weakest or incomplete when a state leans on just one. Human development strengthens resilience in a way that goes beyond conventional welfare outcomes like investment in education, health, and social inclusion builds adaptive capacity that feeds directly into risk reduction and innovation. And environmental hazard imposes a binding constraint that no amount of other progress fully escapes: recurrent cyclones cap what eastern coastal states can achieve through other means, which is exactly why fisheries need to sit inside wider disaster and climate-adaptation planning rather than off to one side of it.

The policy implication is not especially subtle: India's Blue Economy strategy needs to move past production and modernisation and put resilience at its centre, with action differentiated by state i.e., bringing people and enterprise together in the south, pairing economic investment with social programmes in the west, and prioritising disaster preparedness and ecological restoration in the east. Operationalising resilience this way also means strengthening cross-sectoral governance and participatory institutions, and, as this paper has argued throughout, treating gender-inclusive data collection as integral to that governance rather than an afterthought bolted onto it.

By offering a transparent, reproducible way to assess and compare resilience across states, this study makes both an academic and a practical contribution. Strengthening the resilience of India's fisheries governance ultimately comes down to protecting livelihoods, keeping marine ecosystems healthy, and building a more inclusive Blue Economy, an agenda that sits squarely inside the wider global-society concern with poverty, gender equity, and institutional capacity in a globalising world.

Declarations

Author Contributions

Dr. Muhammed Fazil and Dr. Narendra Kumar Dariya conceived the study, designed the methodology, and led the data analysis and manuscript preparation. Dr. Basavaraj M. S.

provided academic supervision, conceptual guidance, and critical revisions. Dr. Shashi Kumar R contributed to the literature review, statistical validation, and editing. Sathu Lingamurthy contributed to the theoretical framing, interpretation of social resilience indicators, and manuscript refinement. All listed authors reviewed and approved the final manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical Approval

Not applicable. This study exclusively analyses secondary data from published government and institutional sources and did not involve direct recruitment or interaction with human participants.

Consent to participate

Not applicable. No human participants were recruited and no primary data were collected.

Consent to publish

Not applicable. The manuscript contains no identifiable participant information or images requiring consent for publication.

Data Availability Statement

The study uses secondary data drawn from publicly accessible institutional and government publications. The Marine Fisheries Census 2010 national and state reports are available from the ICAR Central Marine Fisheries Research Institute (CMFRI) at https://www.cmfri.org.in/marine-fisheries-census and https://eprints.cmfri.org.in/8998/. Government of India fisheries statistical handbooks are available from the Fishery Survey of India at https://fsi.gov.in/hand-book-for-fishery-statistics. Fisheries and aquaculture statistics are accessible through the Food and Agriculture Organization of the United Nations at https://www.fao.org/statistics/data-dissemination/fishery-and-aquaculture/. National Family Health Survey 5 state-level information is accessible through the International Institute for Population Sciences at https://www.iipsindia.ac.in/ and the NFHS programme site at https://rchiips.org/nfhs/. Coastal and marine environmental data

resources are accessible through the Indian National Centre for Ocean Information Services at https://incois.gov.in/. Ministry of Education publications and educational statistics can be accessed at https://www.education.gov.in/. These links identify the principal source repositories described in the Data and Methods section; the underlying state-level input matrix and the derived index and regression calculations are not separately deposited in a public repository. Further details of the processed data may be requested from the corresponding author.

Originality and Publication Statement

The authors confirm that this manuscript is original, has not been published previously, and is not under consideration for publication elsewhere.

Acknowledgements

The authors thank the Department of Economics Studies and Planning, Central University of Karnataka, for academic support during this research.

References

1. Smith-Godfrey S. Defining the blue economy. Mar Policy. 2016; 67:91-97. https://doi.org/10.1080/09733159.2016.1175131
2. Vivekanandan E. Impact of climate change on Indian marine fisheries. CMFRI Special Publication No. 105. Kochi: Central Marine Fisheries Research Institute; 2010. http://eprints.cmfri.org.in/id/eprint/8432
3. CISCOE. Centre for International Social and Community Ocean Economy Report. New Delhi: Government of India; 2022.
4. Bax N, Novaglio C, Maxwell KH, Meyers K, McCann J, Jennings S, et al. Ocean resource use: building the coastal blue economy. Rev Fish Biol Fish. 2022;32:189-207. https://doi.org/10.1007/s11160-021-09636-0
5. Salim SS, Krishnan M, George D, Sathiadhas R, Mohamed KS, Ramachandran C. Livelihood status of marine fisherfolk in India: strategies for future development. Indian J Fish. 2013;60(4):99-107.
6. Allison EH, Horemans B. Putting the principles of the Sustainable Livelihoods Approach into fisheries development policy and practice. Mar Policy. 2006;30(6):757-766.
7. Adger WN. Social and ecological resilience: are they related? Prog Hum Geogr. 2000;24(3):347-364.
8. Penca J, Ertör I, Ballesteros M, Briguglio M, Kowalewski M, Pauksztat B, et al. Rethinking the Blue Economy: integrating social science for sustainability and justice. npj Ocean Sustain. 2025;4:40. https://doi.org/10.1038/s44183-025-00138-1

9. Folke C. Resilience: the emergence of a perspective for social-ecological systems analyses. Glob Environ Change. 2006;16(3):253-267.
10. Cinner JE, Adger WN, Allison EH, Barnes ML, Brown K, Cohen PJ, et al. Building adaptive capacity to climate change in tropical coastal communities. Nat Clim Chang. 2018;8(2):117-123.
11. Briguglio L, Cordina G, Farrugia N, Vella S. Economic vulnerability and resilience: concepts and measurements. Oxf Dev Stud. 2009;37(3):229-247.
12. Hu S, Yang Z, Han Z, Xu J. Measuring coastal community resilience to climate hazards in China. Ocean Coast Manag. 2022;218:106001.
13. Government of India. Handbook on Fisheries Statistics 2020-21. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying. New Delhi: Government of India; 2021.
14. CMFRI. Marine Fisheries Census 2010. Kochi: Central Marine Fisheries Research Institute, Indian Council of Agricultural Research; 2012.
15. FAO. The State of World Fisheries and Aquaculture 2020: Sustainability in Action. Rome: Food and Agriculture Organization of the United Nations; 2020.
16. Harper S, Kleiber D, Appiah S, Atkins M, Bradford K, Choudhury A, et al. Illuminating Hidden Harvests: the contributions of small-scale fisheries to sustainable development. Rome: FAO; Durham: Duke University; Penang: WorldFish; 2023.
17. Government of India. Handbook on Fisheries Statistics 2023 (16th edn, FY 2022-23 data). Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying. New Delhi: Government of India; 2024.
18. FAO. The State of World Fisheries and Aquaculture 2026: Blue Transformation – Turning Vision into Impact. Rome: Food and Agriculture Organization of the United Nations; 2026.
19. Government of India. Cabinet approves Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana (PM-MKSSY), a Central Sector Sub-scheme under PMMSY. Press Information Bureau, Ministry of Fisheries, Animal Husbandry and Dairying; 2024.
20. Salim SS, Krishnan M. Fishery sector reforms and resilience building: lessons from Indian marine fisheries. Asian Fish Sci. 2014;27S:187-197.
21. Ayilu RK. Limits to blue economy: challenges to accessing fishing livelihoods in Ghana's port communities. Marit Stud. 2023;22:15. https://doi.org/10.1007/s40152-023-00302-8
22. Harun M, Rahman A, Ferdous J. Vulnerabilities of climate change-induced displacement and migration in South Asia. Discov Glob Soc. 2025;3:115. https://doi.org/10.1007/s44282-025-00237-x

23. Rice ED, Gondwe E, Bennett AE, Okanga PA, Osho-Abdulgafar NF, Fakoya K, et al. The future of gender research in small-scale fisheries: priorities and pathways for advancing gender equity. Fish Fish. 2024;25(3):1-8. https://doi.org/10.1111/faf.12814

24. Andriamahefazafy M, Touron-Gardic G, March A, Hosch G, Palomares MLD, Failler P. Sustainable development goal 14: to what degree have we achieved the 2020 targets for our oceans? Ocean Coast Manag. 2022;227:106273. https://doi.org/10.1016/j.ocecoaman.2022.106273

25. Silver JJ, Gray NJ, Campbell LM, Fairbanks LW, Gruby RL. Blue economy and competing discourses in international oceans governance. J Environ Dev. 2015;24(2):135-160.

26. Bavinck M. The mega engineering of ocean fisheries: a century of expansion and rapidly closing frontiers. Sci Technol Soc. 2011;16(2):183-200.

27. Kurien J. Social Aspects of the Blue Economy: Coastal Livelihoods and Fisheries. Kerala: International Collective in Support of Fishworkers; 2020.

28. Jentoft S, Chuenpagdee R. Interactive Governance for Small-Scale Fisheries: Global Reflections. Cham: Springer; 2015.

29. Fabinyi M, Barclay K. Asia-Pacific Fishing Livelihoods. Cham: Palgrave Macmillan; 2022. https://doi.org/10.1007/978-3-030-79591-7

30. Cinner JE, Daw T, McClanahan TR. Socioeconomic factors that affect artisanal fishers' readiness to exit a declining fishery. Conserv Biol. 2011;25(2):361-369.

31. Béné C, Al-Hassan RM, Amarasinghe O, Fong PSW, Ocran J, Onumah E, et al. Is resilience socially constructed? Empirical evidence from Fiji, Ghana, Sri Lanka, and Vietnam. Glob Environ Change. 2016;38:153-170.

32. Walker B, Holling CS, Carpenter SR, Kinzig A. Resilience, adaptability and transformability in social-ecological systems. Ecol Soc. 2004;9(2):5.

33. Guragain UP, Doneys P. Social, economic, environmental, and physical vulnerability assessment: an index-based gender analysis of flood-prone areas of Koshi river basin in Nepal. Sustainability. 2022;14(16):10423. https://doi.org/10.3390/su141610423

34. Voyer M, Quirk G, McIlgorm A, Azmi K. Shades of blue: what do competing interpretations of the Blue Economy mean for oceans governance? J Environ Policy Plan. 2018;20(5):595-616.

35. Cavole LM, Gragnolati M, Matoso Silva RVM, Lopes PFM, Giarrizzo T, Reis-Filho JA. Unveiling gender disparities: the role of women in transforming small-scale fisheries. Fish Fish. 2025;26(4):1146-1163. https://doi.org/10.1111/faf.70023

36. Department of Fisheries, Government of India; ICAR-Central Marine Fisheries Research Institute. Fifth National Marine Fisheries Census (MFC 2025): household enumeration completed December 2025, results forthcoming. New Delhi: Ministry of Fisheries, Animal Husbandry and Dairying; 2025.

37. Oloko A, Teh L, Le Billon P, Cheung W, Harper S, Sumaila UR. Making the case for gender-inclusive fisheries governance, policies and climate adaptation. Discov Oceans. 2024;1:33. https://doi.org/10.1007/s44289-024-00038-1

38. Sengupta A, Samanta G. Understanding immobility of a highly vulnerable coastal village in the Indian Sundarban. Reg Environ Change. 2022;22(3):90. https://doi.org/10.1007/s10113-022-01931-1

39. OECD. OECD Review of Fisheries 2025. Paris: OECD Publishing; 2025.

40. Jolliffe IT. Principal Component Analysis. 2nd ed. New York: Springer; 2002.