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Assessment of Livelihood Capitals among Coastal Fishermen in Thoothukudi, Tamil Nadu

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ABSTRACT

Background: The development of sustainable livelihoods is becoming more challenging for coastal fishing communities owing to economic vulnerability, ecosystem damage and disparities in access to livelihood resources. This research sought to evaluate the livelihood situation of coastal fishermen in Thoothukudi district of Tamil Nadu within a framework of multiple dimensions of livelihoods, as explained by the sustainable livelihood framework (SLF).

Methods: Primary data were collected from 250 fishermen households and analysed using principal component analysis (PCA) based on 25 indicators representing human, social, physical, financial and natural capital to construct a livelihood index. The five-component structure identified *via* PCA explained 85.55% of the total variance and thereby validated the multi-dimensionality of the concept of livelihoods.

Result: The value of the composite livelihood index at 0.50 reveals that fishermen households exhibit a moderately stable yet vulnerable livelihood condition. Among the five livelihood capitals, financial capital had the highest index value of 0.13, showing comparatively stronger financial conditions. However, the lowest index value of 0.08 attributed to natural capital reveals that there is greater ecological pressure leading to resource depletion. Human and physical capital have made moderate contributions (0.10 each) and social capital (0.09) showed relatively poor contribution. As evidenced by the results, there is an imbalance between relatively stronger financial assets and weaker ecological conditions within the livelihood system. The study advocates comprehensive policies on financial security, ecological sustainability, infrastructure, capacity building and institutional development to ensure sustainable coastal livelihoods.

Key words: Coastal fishermen, Principal component analysis (PCA), Socio-economic analysis, Sustainable livelihood.

INTRODUCTION

Fishing is among the key livelihood activities in coastal areas of developing countries, providing employment, income and food security for millions of families (Food and Agriculture Organization of the United Nations, 2020; World Bank *et al*., 2012). Small-scale fisheries play an important role in food security, nutrition, livelihoods and local economic development, particularly where fishing communities remain heavily dependent on fisheries related activities (Food and Agriculture Organization of the United Nations, 2015).

However, fishing communities increasingly face socio-economic and environmental pressures such as climatic variability, over-exploitation of fishery resources, price fluctuations and inadequate institutional support which undermine livelihood security and adaptive capacity (Béné *et al*., 2016). Marine fisheries in Tamil Nadu face increasing challenges from overfishing, habitat degradation, climate change and other anthropogenic pressures, resulting in growing vulnerability of marine fishery resources and threats to the livelihoods of coastal fishing communities (Kanaga *et al*., 2025). Artisanal fishing communities face livelihood challenges arising from seasonal fluctuations, market dynamics, limited access to formal credit and climate-related environmental changes, which affect their income levels and financial stability (Nandy *et al*., 2025). Understanding the structure and distribution of livelihood assets is therefore important for designing interventions that enhance sustainability and resilience.

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Previous studies on fisheries livelihoods have primarily focused on descriptive socio-economic assessments, income analysis, vulnerability studies and regression-based approaches. Evidence from coastal regions such as Puducherry and Karaikal indicates that fisher livelihoods remain moderately developed but unstable due to declining fishery resources, seasonal unemployment and inadequate livelihood diversification (Kumaran *et al*., 2021). Large-scale studies in India have reported low household income, high dependence on fisheries, limited savings and considerable indebtedness among fisher households (Salim *et al*., 2013). Existing literature suggests that livelihood systems are multidimensional, shaped by economic, social, ecological and institutional factors.

Earlier studies have largely focused on the socio-economic conditions, income characteristics, vulnerability and livelihood status of fishing communities (Salim *et al*., 2013; Kumaran *et al*., 2021). Although composite index and PCA-based approaches have been applied in livelihood studies (Pani and Mishra, 2022; Xu *et al*., 2023), empirical evidence examining the relative contribution of human, social, physical, financial and natural capital within a unified livelihood framework remains limited for small-scale marine fisheries. Furthermore, micro-level assessments of livelihood capital structure in fisheries-dependent households of Thoothukudi district are scarce. Therefore, the present study applies a PCA-based Sustainable Livelihood Framework to quantify the contribution of different livelihood capitals and identify structural imbalances affecting the livelihood sustainability of coastal fishermen.

To address these identified gaps, this study adopted the sustainable livelihoods framework (SLF), conceptually based on Chambers and Conway (1992) sustainable livelihoods approach and operationalized through the DFID (1999) framework. The SLF conceptualizes livelihood sustainability in terms of households' ability to cope with shocks, maintain or enhance their asset base and improve their well-being over time through access to five livelihood capitals: human, social, physical, financial and natural capital (DFID, 1999).

Located in the southeastern coast of Tamil Nadu, the Thoothukudi district is one of the significant centers of marine fisheries in India (Department of Fisheries, Tamil Nadu, 2023) supporting many fishing families dependent on fishing and related activities. High reliance on marine fisheries, seasonal incomes and growing environmental and economic challenges make the selected district suitable for this study. This study addresses the following research questions: (i) what is the overall livelihood status of coastal fishermen in Thoothukudi district? (ii) what is the relative contribution of the five livelihood capitals to the overall livelihood index? (iii) what structural imbalances exist among the livelihood capitals? Therefore, the current research aims to assess the livelihood capitals of coastal fishermen in Thoothukudi district in order to provide a micro-level assessment of livelihood sustainability, quantify the relative contribution of livelihood capitals and identify structural imbalances among livelihood assets affecting coastal fishermen.

MATERIALS AND METHODS

Study area

This research was carried out in selected coastal fishing villages of Thoothukudi district, Tamil Nadu namely Manapad, Alanthalai, Punnaikayal, Singithurai, Kombuthurai and Therespuram. This district lies between 8°19′00″N and 9°20′00″N latitude and 77°40′00″E and 78°10′00″E longitude (District Disaster Management Authority, Thoothukudi, 2024). It is an important part of the ecologically important Gulf of Mannar. With a coastline measuring about 163.5 km, there are extensive marine fishing activities in the region that greatly contribute to the fisheries industry in Tamil Nadu (Department of Fisheries, Tamil Nadu, 2023).

Sampling design

The data for this research were obtained using a multistage sampling approach, where purposive and simple random sampling techniques were used. First, Thoothukudi district was purposefully chosen from the coastal districts of Tamil Nadu with proven marine fishing activities (Department of Fisheries, Tamil Nadu, 2023). Next, a number of coastal villages with marine fishing activities in Thoothukudi district were purposively chosen based on their significance in marine fishing. Finally, 250 active fishermen were selected from the chosen villages using a simple random sampling approach. The selected sample size was adequate for performing PCA, as methodological studies recommend at least 5-10 observations for every variable used in PCA (Hair *et al*., 2010). Since the study included 25 livelihood indicators, the sample size of 250 respondents satisfies the recommended criterion, ensuring adequacy of the PCA results. The field survey and primary data collection for the present study were conducted from September to November 2025 using a structured interview schedule. The 25 indicators are presented in Fig 1.

Selection of indicators

The selection of livelihood indicators in this study was guided by the sustainable livelihood framework (SLF), which was conceptually rooted in the sustainable livelihoods approach of Chambers and Conway (1992) and operationalized through the livelihood capital framework proposed by Scoones (1998). A total of 25 indicators were identified and grouped under five major livelihood capitals, namely human, social, physical, financial and natural capital. The questionnaire was developed based on the Sustainable Livelihood Framework (Chambers and Conway, 1992; DFID, 1999; Scoones, 1998) and indicators commonly used in livelihood and sustainability assessment studies (Singh and

Hiremath, 2010; Krishna *et al*., 2020). The selected indicators were chosen based on their relevance to fisheries-dependent livelihoods and their ability to capture the multidimensional nature of livelihood capitals. The draft questionnaire was reviewed by experts in agricultural economics and fisheries to assess its content validity and necessary modifications were incorporated before final data collection. The internal consistency and reliability of the questionnaire were assessed using Cronbach's alpha coefficient. The overall questionnaire comprising 25 livelihood indicators recorded a Cronbach's alpha value of 0.807, indicating good reliability. The alpha values for human capital (0.959), social capital (0.953), physical capital (0.954), financial capital (0.962) and natural capital (0.946) exceeded the recommended threshold of 0.70, confirming excellent internal consistency among the indicators representing each livelihood capital. All indicators were positively scaled, meaning that higher scores reflect positive livelihood conditions. All the indicators were captured on a five-point Likert scale starting from 1 to 5. Since all indicators had a uniformly positive connotation, reverse coding was not required. Likert scaling has gained much acceptance in socio-economic and livelihood research due to its capability of measuring perceptual variations (Likert, 1932; Sullivan and Artino, 2013). Perception-based indicators were used because several livelihood dimensions, including social support, trust, institutional access and resource availability, are inherently subjective and cannot be adequately quantified through objective measures alone. Hence, respondents' perceptions were used to assess livelihood conditions.

Normalization of indicators

To facilitate comparability across indicators, the selected indicators were normalized to a unitless scale ranging from 0 to 1. The Min-max normalization technique was applied in this case which is a practice commonly used in livelihood index construction (Pani and Mishra, 2022). This approach has been adopted in earlier index-based studies, including methods derived from human development index-type frameworks (Saleth and Swaminathan, 1993).

The formula used for normalization of indicators is given below:

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

Where,

Z_{ij} = Normalized value of the i^{th} indicator for the j^{th} respondent.

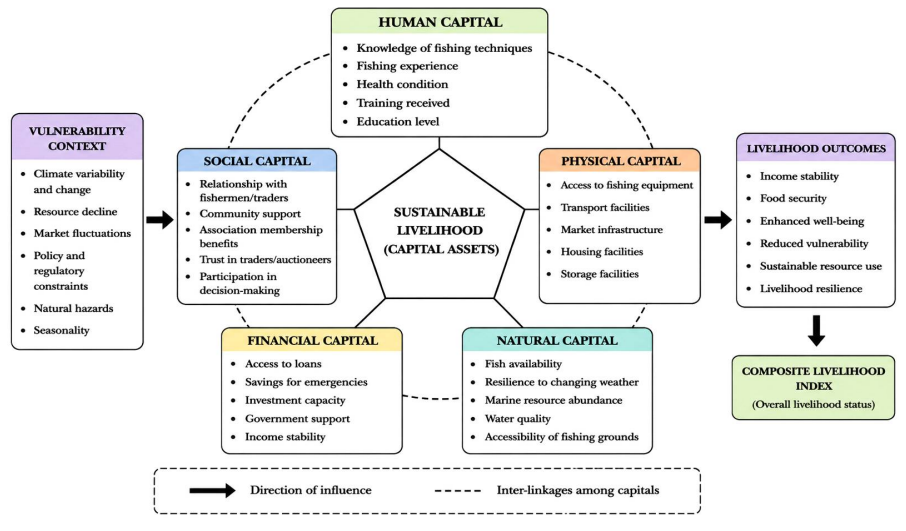
X_{ij} = Original value.

$\min(X_i)$, $\max(X_i)$ = Minimum and maximum values of the i^{th} indicator.

This process ensures that all indices are scaled from 0 to 1, where higher numbers show better livelihood indices.

Principal component analysis (PCA)

The principal component analysis technique was used to reduce the dimensionality of the dataset and estimate the weights of the chosen livelihood indicators by transforming intercorrelated variables into reduced set of linearly uncorrelated components while retaining most of the variance in the original data, making it a widely used technique in composite index construction (OECD and JRC, 2008). PCA was preferred over equal weighting and subjective scoring because it captures the dominant variance structure among indicators. Data adequacy for PCA was tested using kaiser-meyer-olkin (KMO) statistic and Bartlett's Test of Sphericity. The KMO statistic measures sampling adequacy and the relationship between variables, with values above 0.6 considered suitable for PCA (Kaiser, 1974). Bartlett's test of sphericity examines



Source: Author's computation from primary survey data.

Fig 1: Sustainable livelihood framework of coastal fishermen in Thoothukudi district.

whether the correlation matrix significantly differs from an identity matrix, checking whether sufficient correlations exist among variables for PCA (Bartlett, 1954). As per Kaiser's recommendation, the factors with eigenvalue > 1 were chosen (Kaiser, 1960). For further increasing the clarity of the obtained factor loadings, varimax rotation has been used (Kaiser, 1958).

Determination of weights

Weights of selected variables were calculated based on results obtained using principal component analysis (PCA). Indicators having higher values of factor loadings and larger eigenvalues were assigned greater weights, as they contributed more to the variability of the entire data set. PCA-based weights were used in lieu of equal weights in constructing an index, since this method takes into account relative importance of indicators based on variability of data. The weights for each indicator were derived from the absolute value of the factor loading and the eigenvalue corresponding to each retained principal component. The derived weights were then normalized such that the total weight equalled one, ensuring comparability and proportionality of each indicator.

Accordingly, the weight of each indicator is given by:

$$W_i = \frac{|L_{ij}| \times E_j}{\sum_{i=1}^{n} (|L_{ij}| \times E_j)}$$

Where,
W_i = Weight of the i^{th} indicator.
L_i = Factor loading of the i^{th} indicator.
E_j = Eigenvalue of the j^{th} component.
n = Total number of indicators.

Construction of livelihood index

Livelihood Index was developed based on the normalized scores of selected indicators and their corresponding PCA derived weights. For each fisherman, the normalized score of each indicator was multiplied by the corresponding weight and summed to get the index score.

Capital-wise index

Capital-wise indices were calculated by adding the weighted normalized score of indicators within each livelihood capital. The indices reflect the state of each livelihood capital per fisherman. The formula used for calculating the capital-wise index is given below:

$$CI_j = \sum_{i=1}^{n} (W_i \times Z_{ij})$$

Composite livelihood index

Composite livelihood index was developed by adding all five livelihood capital indices.

$$LI_j = \sum_{k=1}^{5} CI_{kj}$$

Where,
CI_j = Capital index for j^{th} respondent.
LI_j = Composite livelihood index.
W_i = Weight of indicator.
Z_{ij} = Normalized value.
CI_{kj} = Index of each capital.

RESULTS AND DISCUSSION

Descriptive statistics of livelihood indicators

The descriptive statistics (Table 1) show variations in the distribution of the livelihood resources within the five capitals. Among the human capital elements, training provided (Mean = 3.16) and the health status (Mean = 3.04) recorded relatively high mean scores, while education recorded a comparatively lower mean score (Mean = 2.98). In social capital, decision-making (Mean = 3.09) and community support (Mean = 3.044) exhibit relatively high scores, while relationship with fishermen/traders is relatively low (Mean = 2.75). As for physical capital, housing and storage facilities have relatively higher scores (Mean = 3.11 and 3.03 respectively). Whereas transport facilities (Mean = 2.89) imply infrastructure constraints in terms of market movement. Difficulties in accessing transportation can adversely affect fisheries livelihoods by increasing post-harvest losses, limiting market access and reducing household income (Diei-Ouadi and Mgawe, 2011). Concerning financial capital, the value of income stability (Mean = 3.08) and investment opportunities (Mean = 3.08) show a relatively moderate level of financial viability. Nonetheless, low averages of savings (Mean = 2.92) and government help (Mean = 2.97) signify weak financial resilience. Among the natural capital indicators, resilience against changes in weather (Mean = 3.37) and water quality (Mean = 3.33) recorded higher mean values, implying that the fishermen's operations have some level of stability under variable climatic conditions. On the other hand, fish availability (Mean = 2.84) and marine resource availability (Mean = 2.89) recorded lower values. Accessibility of fishing grounds recorded a mean value of 3.12.

Kaiser-meyer-olkin (KMO) and bartlett's test interpretation

The KMO measure of sampling adequacy and the bartlett test of sphericity (Table 2) were used in order to determine whether the data were appropriate for factor analysis. A KMO value of 0.856 exceeded the suggested minimum of 0.60, implying adequate sampling and sufficient shared variance among variables. Bartlett's Test of Sphericity was significant at $p<0.01$ (χ^2 = 6918.291), rejecting the null hypothesis that the correlation matrix is an identity matrix. These results indicate that the selected livelihood indicators were appropriate for PCA.

Component extraction and variance contribution

PCA produced five components with eigenvalues greater than one according to the Kaiser criterion. The eigenvalues for these components (5.048, 4.508, 4.491, 3.799 and

Table 1: Descriptive Statistics of selected livelihood indicators.

Component	Indicator	Mean	Standard deviation
Human	Knowledge of fishing techniques	3.09	0.86
	Fishing experience	3.03	0.84
	Health condition	3.04	1.02
	Training received	3.16	0.91
	Education level	2.98	0.85
Social	Relationship with fishermen/traders	2.75	0.78
	Community support	3.04	0.76
	Association membership benefits	2.99	0.87
	Trust in traders/auctioneers	2.97	0.83
	Participation in decision-making	3.09	0.81
Physical	Access to fishing equipment	2.94	0.92
	Transport facilities	2.89	0.76
	Market infrastructure	3	0.79
	Housing facilities	3.11	0.82
	Storage facilities	3.03	0.83
Financial	Access to loans	3.02	0.82
	Savings for emergencies	2.92	0.85
	Investment capacity	3.08	0.87
	Government support	2.96	0.85
	Income stability	3.08	0.83
Natural	Fish availability	2.83	0.76
	Resilience to changing weather	3.37	0.81
	Marine resource abundance	2.89	0.74
	Water quality	3.33	0.77
	Accessibility of fishing grounds	3.12	0.71

Source: Author's computation from primary data.

Table 2: KMO and bartlett's test results for assessing the suitability of PCA.

Test	Value
Kaiser-meyer-olkin (KMO) measure	0.856
Bartlett's test chi-square	6918.291
Degrees of freedom (df)	300
Significance level (p-value)	0.000

Source: Author's computation from primary data.

3.541) explained 20.194%, 18.031%, 17.966%, 15.197% and 14.162% of the total variance respectively. All the five components together account for 85.550% of the variance within the dataset. Eigenvalues, percentage variance explained and cumulative variance for each component are presented in Table 3 and Fig 2.

The rotated component matrix showed a clear grouping pattern of indicators across the five livelihood capitals. Financial capital indicators loaded highly in component 1 (0.917-0.946), human capital indicators in component 2 (0.917-0.936), physical capital indicators in component 3 (0.912-0.925), social capital indicators in component 4 (0.901-0.933) and natural capital indicators in component 5 (0.884-0.923). No significant cross-loadings were observed between the retained components, indicating a clear separation between the dimensions. The factor loadings for each indicator in all the five components are shown in Table 4.

Weights of livelihood indicators derived from PCA

The weights of the livelihood indicators were calculated from PCA factor loadings and eigenvalues so that indicators with comparatively higher contribution to the explained variance received relatively higher weights in the composite index. The results revealed that the indicators of financial capital had relatively higher weights, indicating greater contribution to the total variance structure. Human and physical capital indicators were also weighted considerably, while social capital variables contributed modestly and natural capital received relatively lower weights.

Capital-wise and composite livelihood index

The capital-based and composite livelihood indices were determined by multiplying the normalized scores of the indicators using PCA weights. The scores obtained are shown in Table 5 and Fig 3. The livelihood index of 0.50 shows a moderate livelihood status among the fishermen households. Among the five livelihood capitals, financial capital showed the highest index value of 0.13, followed by human capital and physical capital with index values of

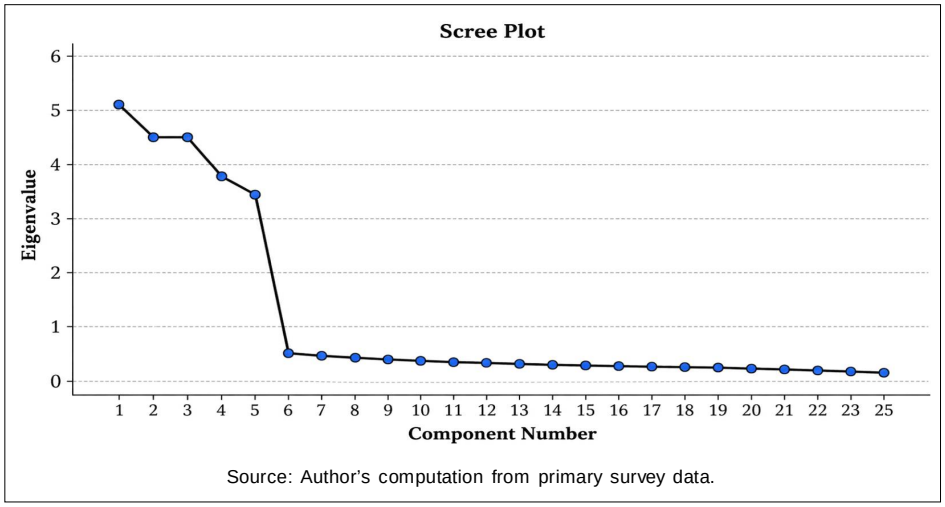
0.10 each. Social capital recorded an index value of 0.09, while natural capital showed the lowest index of 0.08.

In this study, insights into the multidimensional livelihood situation of coastal fishers are obtained through an analysis of the relative importance of human capital, social capital, physical capital, financial capital and natural capital to livelihood sustainability. The composite livelihood index score of 0.50 depicts a moderate yet vulnerable livelihood status, suggesting that although fishers are not critically deprived, they are not fully resilient. This is consistent with findings from Indian coastal fisheries studies and broader small-scale fisheries literature,

Table 3: Variance explained by retained principal components.

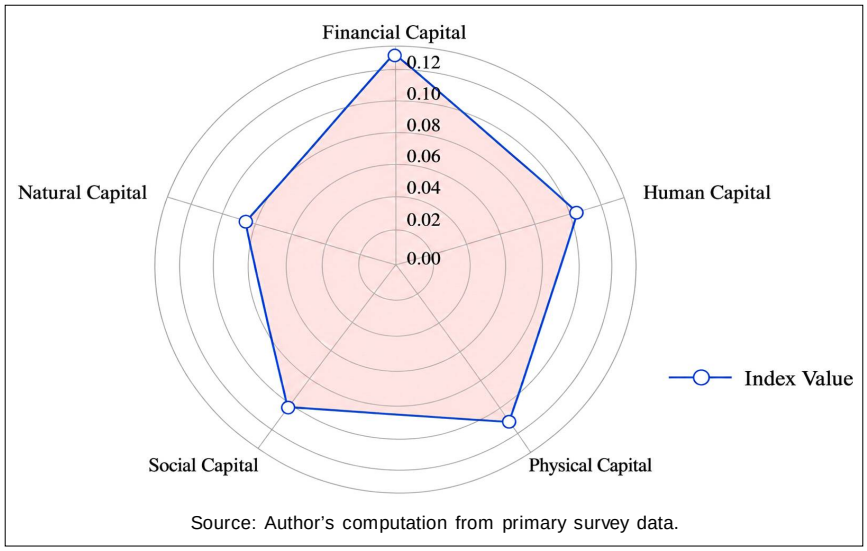
Component	Eigenvalue	% of variance	Cumulative %
1	5.048	20.194	20.194
2	4.508	18.031	38.225
3	4.491	17.966	56.191
4	3.799	15.197	71.388
5	3.541	14.162	85.550

Source: Author's computation from primary data.



Source: Author's computation from primary survey data.

Fig 2: Scree plot of retained principal components from PCA.



Source: Author's computation from primary survey data.

Fig 3: Capital-wise distribution of livelihood index values among coastal fishermen.

wherein livelihood systems remain highly dependent on fishing-based activities while facing environmental, market and institutional vulnerabilities (Béné, 2009; Kumaran *et al*., 2021).

The PCA and composite livelihood index indicate that financial capital is the relatively strongest livelihood dimension. This reflects better performance in income stability, access to credit, savings and investment capability among the sampled fishermen. Similar observations were reported by Nandy *et al*. (2025), who highlighted income diversification, access to credit, microfinance and insurance as important factors enhancing the economic stability of artisanal fishers. Human capital also emerged as an important determinant through fishing experience, occupational knowledge, training and general health status, although low educational attainment suggests adaptation may remain experienced-based rather than institutional or technological. These findings are consistent

Table 4: Rotated component matrix showing factor loadings of livelihood indicators.

Indicator	Component 1	Component 2	Component 3	Component 4	Component 5
Access to loans	0.946	-	-	-	-
Government support	0.932	-	-	-	-
Income stability	0.931	-	-	-	-
Investment capacity	0.925	-	-	-	-
Savings for emergencies	0.917	-	-	-	-
Health condition	-	0.936	-	-	-
Education level	-	0.933	-	-	-
Fishing experience	-	0.931	-	-	-
Training received	-	0.919	-	-	-
Knowledge of fishing techniques	-	0.917	-	-	-
Market infrastructure	-	-	0.925	-	-
Storage facilities	-	-	0.921	-	-
Access to fishing equipment	-	-	0.920	-	-
Housing facilities	-	-	0.914	-	-
Transport facilities	-	-	0.912	-	-
Participation in decision-making	-	-	-	0.933	-
Trust in traders/auctioneers	-	-	-	0.923	-
Relationship with fishermen/traders	-	-	-	0.912	-
Association membership benefits	-	-	-	0.912	-
Community support	-	-	-	0.901	-
Fish availability	-	-	-	-	0.923
Resilience to changing weather	-	-	-	-	0.910
Marine resource abundance	-	-	-	-	0.907
Water quality	-	-	-	-	0.907
Accessibility of fishing grounds	-	-	-	-	0.884

Source: Author's computation from primary data.

Table 5: Capital-wise and composite livelihood indices.

Capital	Index value	Interpretation
Financial	0.13	Highest contributing livelihood dimension, indicating strong dependence on income, credit access and financial stability.
Human	0.10	Moderate livelihood support through skills, health condition, education and fishing experience.
Physical	0.10	Moderate infrastructural support through housing, equipment access, storage and market facilities.
Social	0.09	Relatively weaker institutional participation and market relationships despite community solidarity.
Natural	0.08	Weakest livelihood dimension, reflecting ecological pressure and resource-related constraints.
Composite livelihood index	0.50	Indicates a moderate but vulnerable livelihood condition among coastal fishermen.

Source: Author's computation from primary data.

with previous studies which reported that fishing experience plays an important role in enhancing fishers' knowledge regarding fish diversity and conservation. Jamoh *et al*. (2024) found that fishers with greater fishing experience possessed significantly higher levels of knowledge regarding fish diversity and conservation. Physical capital indicates average access to infrastructure, particularly housing and storage, but weaker transport and market access. The need for immediate selling in the study area due to the presence of auction-based sales limits the need of post-harvest handling, storage and value addition. Social capital depicts a mixed livelihood situation. Although community involvement in the decision-making process remains high, poor relations with traders and intermediaries show an imbalanced power structure within the fisheries value chain. These findings align with the literature highlighting the importance of social cohesion, trust and collective support system in strengthening resource-based livelihoods (Xu *et al*., 2023; Pretty, 2003). Natural capital had the lowest index value, suggesting environmental stress in the fishing ecosystem. The relatively low value of natural capital observed in the present study may be associated with declining fish availability, environmental degradation and increasing pressure on marine resources. Similar findings were reported by Kanaga *et al*. (2025), who identified overfishing, habitat degradation, declining catch per unit effort and resource-sharing conflicts as important contributors to marine resource vulnerability in the Gulf of Mannar region. Despite greater reliance on monetary resources, natural capital remained the weakest livelihood category, suggesting ecological constraints within the livelihood system.

The PCA results indicate that the observed indicator structure aligns with the conceptual dimensions of the Sustainable Livelihood Framework. The high cumulative variance explained by the extracted components suggests that the selected indicators adequately capture livelihood variability among respondents. Similar multidimensional livelihood structures have been identified in PCA-based sustainable livelihood studies, where ecological, social and economic dimensions emerged as distinct but interrelated components of livelihood security (Pani and Mishra, 2022).

A major strength of this study is the application of the Sustainable Livelihood Framework combined with a PCA-based weighting approach, which enables an objective assessment of the contribution of different livelihood capitals. However, some limitations should be acknowledged. First, the cross-sectional design captures livelihood conditions at a single point in time and may not reflect seasonal or long-term changes. Second, the findings are specific to the selected coastal villages of Thoothukudi district and may not be fully generalizable to other fishing communities. Third, although perception-based Likert scale indicators are widely used in livelihood research, subjective responses may introduce bias. In addition, PCA-derived weights represent statistical relationships among indicators and should not be interpreted as causal relationships. The weights may also vary across locations and datasets.

The findings suggest that improving fisher livelihoods requires a multidimensional policy approach targeting all five livelihood capitals. Human capital can be strengthened through fisheries training, skill development and entrepreneurship programmes. Social capital may be enhanced through stronger fisher cooperatives and community-based organizations that improve collective bargaining and institutional participation. Physical capital requires continued investment in fish landing centres, cold storage facilities, transportation and market infrastructure under schemes such as the Pradhan Mantri Matsya Sampada Yojana (PMMSY) and Fisheries and Aquaculture Infrastructure Development Fund (FIDF). Financial capital can be improved through greater access to institutional credit, fisheries insurance and Kisan Credit Card facilities, while natural capital requires sustainable resource management, responsible fishing practices, mariculture and conservation initiatives to ensure long-term ecological sustainability. Collectively, these interventions can improve livelihood resilience and support sustainable development of coastal fishing communities in Thoothukudi district.

Future studies may adopt longitudinal designs to capture livelihood dynamics over time, incorporate objective ecological and economic indicators alongside perception-based measures and undertake comparative assessments across multiple coastal regions to improve external validity and provide a broader understanding of livelihood sustainability in fisheries-dependent communities.

CONCLUSION

This study assessed the livelihood status of coastal fishermen in Thoothukudi district using the sustainable livelihood framework (SLF) and a PCA-based composite livelihood index comprising human, social, physical, financial and natural capital. The PCA identified five components explaining 85.55% of the total variance, while the composite livelihood index of 0.50 indicated a moderate but vulnerable livelihood condition among fishing households. The findings revealed an imbalance among livelihood capitals. Financial capital emerged as the strongest dimension (0.13), reflecting the importance of income, credit access, savings and investment opportunities. In contrast, natural capital recorded the lowest index value (0.08), indicating ecological pressures and declining resource availability. Human and physical capitals contributed moderately through skills, health, infrastructure and production assets, while social capital remained relatively weak due to limited institutional participation and collective support. The results suggest that improving fisher livelihoods requires a multidimensional policy approach. Efforts should focus on strengthening

financial resilience through better access to credit and institutional support, promoting sustainable fisheries resource management and conservation, enhancing education and skill development, improving infrastructure and market access and strengthening fisher organizations and community participation. Future studies may adopt longitudinal approaches, include objective ecological and economic indicators and undertake comparative assessments across coastal regions to better understand livelihood dynamics. Overall, sustainable livelihood development among coastal fishing communities requires balanced attention to economic, ecological, social, institutional and infrastructural dimensions.

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Disclaimers

The opinions, interpretations and conclusions presented in this article are those of the authors and do not necessarily reflect the views of their affiliated institutions. The authors are solely responsible for the accuracy and integrity of the information provided.

Informed consent

Informed consent was obtained from all respondents prior to data collection. Participation in the survey was voluntary and respondents were informed about the purpose of the study and assured of the confidentiality of the information provided.

Conflict of interest

The authors declare that they have no conflict of interest regarding the publication of this article.

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