

## IMPACT OF CLIMATE CHANGE ON LIVELIHOOD AND INCOME STABILITY OF MARINE FISHERMEN IN RAMANATHAPURAM DISTRICT: AN ANALYTICAL STUDY

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### Abstract

The livelihood of marine fishermen is closely tied to climatic and environmental conditions, making them one of the most vulnerable communities to climate change. Rising sea temperatures, shifting fish populations, and unpredictable weather patterns have significantly altered fishing activities along the Tamil Nadu coast. This study examines the socio-economic impact of climate change on marine fishermen in Ramanathapuram District, with a focus on variations in income, fishing days, and coping strategies. Primary data were collected from 500 fishermen through a structured questionnaire and analyzed using Analysis of Variance (ANOVA) to assess differences in income stability across age groups and fishing methods. Sign Tests were employed to identify the most common adaptation strategies, while descriptive analysis highlighted key challenges faced by the community. Factor analysis grouped these challenges into environmental, financial, and infrastructural components. The findings reveal that fishermen relying on traditional methods face greater income volatility compared to those using mechanized boats. Lack of cold storage facilities, rising fuel costs, and reduced fish catch emerged as major barriers to sustainable livelihood. The study suggests policy interventions in the form of climate-resilient infrastructure, subsidized equipment, and skill development programs to safeguard the future of the fishermen community.

**Keywords:** Climate Change, Fishermen Livelihood, Income Stability, Marine Fishing, ANOVA, Factor Analysis, Ramanathapuram.

### 1. Introduction

Fisheries department take a part in the socio-economic growth of coastal regions in India. Tamil Nadu, with its 1,076 km coastline, is home to thousands of fishing families who depend directly on marine resources for their livelihood. However, over the past two decades, the effects of climate change have become increasingly evident in the form of erratic monsoons, increased cyclonic activity, and migration of fish stocks to deeper or cooler waters.

Ramanathapuram District, located along the south-eastern coast of Tamil Nadu, is one of the largest marine fish landing centres in the state. The district is known for its high dependence on fishing activities, yet fishermen here face increasing uncertainty in their income and work schedules due to environmental changes. While mechanization and technological upgrades have benefitted some, many still rely on traditional fishing practices that are more vulnerable to climatic shifts. Understanding the degree of impact and the coping mechanisms adopted is essential for creating targeted livelihood support programs.

### 2. Objectives

The research was conducted by way of the following:

1. To examine the relationship between fishing methods and income stability among fishermen.
2. To identify the most commonly used adaptation strategies against climate-related challenges.

3. To assess the major livelihood challenges faced by fishermen in the district.
4. To group these challenges into thematic categories using factor analysis for better policy recommendations.

### 3. Methodology

#### 3.1 Research Method

The study takes an analytical and descriptive design to understand the socio-economic challenges faced by fishermen and to identify patterns in their adaptation to climate change.

#### 3.2 Sampling Technique and Size

A stratified random sampling method was used to ensure representation from both mechanized and traditional fishing sectors. A total of 534 respondents from key fishing villages in Ramanathapuram District were surveyed.

#### 3.3 Data Collection

Primary data were obtained through structured interviews conducted in local dialects to ensure accuracy of responses. Secondary data were sourced from Department of Fisheries reports, CMFRI studies, and climatic data from IMD.

#### 3.4 Statistical Tools Used

- **Analysis of Variance (ANOVA):** To compare income stability between fishermen of different age groups and fishing methods.
- **Sign Test:** To identify the most frequently adopted coping strategies.
- **Descriptive Statistics:** To list key livelihood challenges.
- **Factor Analysis:** To group challenges into meaningful thematic areas for policy interpretation.

#### 3.5 Scope and Limitations

The study is limited to marine fishermen in Ramanathapuram District and excludes inland fishing activities. Seasonal and annual climatic variations were not separately analyzed. The data depend on self-reported information, which may be subject to recall bias.

### 4. External Financing and Monthly Income Level of the Fishermen

Fishermen rely on various external financing sources to support their livelihood, including boat maintenance, fishing equipment, and daily operational costs. Their income levels vary, ranging from below ₹10,000 to above ₹50,000 per month. Many fishermen seek financial assistance from different institutions, including private lenders, government banks, and microfinance companies. Interest rates differ significantly depending on the source of the loan—government banks offer lower interest rates between 4% and 7%, while private institutions like Bajaj companies charge higher rates of 20% to 25%. Some fishermen also borrow from informal lenders, with interest rates ranging from 3% to 8%, while others rely on high-interest informal credit systems, locally known as "Kandhuvatti," where rates range from 10% to 15%. This study aims to analyze fishermen's perspectives on external financing and how their income levels impact their borrowing preferences.

This study examines the relationship between fishermen's income levels and their choice of external financing sources using Analysis of Variance (ANOVA). Since income levels vary from below ₹10,000 to above ₹50,000, ANOVA helps determine whether there is a significant difference in borrowing preferences across different income groups. By analyzing mean differences, this study aims to identify patterns in loan selection and the financial burden on fishermen based on their earnings.

**Table 1: Opinion of the External Financing and Monthly Income Level of the Fishermen**

ANOVA						
External Financing Options		Sum of Squares	df	Square of Mean	f	sig.
Friend/Relatives	Between Groups	6.209	3	1.552	.826	.509
	Within Groups	1000.253	530	1.880		
	Total	1006.462	533			
Co-operative Societies	Between Groups	16.161	3	4.040	2.702	.030
	Within Groups	795.396	530	1.495		
	Total	811.557	533			
Small banks/ Money Lenders	Between Groups	7.961	3	1.990	1.283	.275
	Within Groups	825.059	530	1.551		
	Total	833.020	533			
Boat Owners	Between Groups	12.432	3	3.108	1.531	.192
	Within Groups	1080.071	530	2.030		
	Total	1092.503	533			
Government Support	Between Groups	4.534	3	1.134	.895	.467
	Within Groups	673.860	530	1.267		
	Total	678.395	533			
Boat Owners	Between Groups	5.117	3	1.279	.554	.696
	Within Groups	1228.797	530	2.310		
	Total	1233.914	533			
Others	Between Groups	6.485	3	1.621	1.107	.052
	Within Groups	779.123	530	1.465		
	Total	785.609	533			

Source: Primary data

The ANOVA results indicate that most external financing options do not show significant differences across income levels, as their p-values are greater than 0.05. Specifically, financing sources such as Friends/Relatives ( $p = 0.509$ ), Small Banks/Money Lenders ( $p = 0.275$ ), Boat Owners ( $p = 0.192$  &  $0.696$ ), Government Support ( $p = 0.467$ ), and Others ( $p = 0.052$ ) do not exhibit statistically significant variation among different income groups. This suggests that fishermen across various income levels tend to rely on these sources in a relatively uniform manner. However, Co-operative Societies ( $p = 0.030$ ) show a significant difference, indicating that borrowing from co-operative societies varies based on income levels. This implies that certain income groups are more dependent on co-operative society loans compared to others. To further analyse these differences, such as Tukey's HSD post-hoc tests can classify which specific income groups differ significantly in their reliance on co-operative societies. Overall, while most external financing options are not influenced by income level, co-operative societies play a distinct role in financial preferences among fishermen.

### 5. Purpose of Money Borrow- Sign Test

The Sign Test is a non-parametric statistical method used to analyze whether there is a significant difference between paired observations. In the context of money borrowing, this test helps determine if there is a statistically significant preference or pattern in borrowing behavior. It evaluates whether people borrow money for specific purposes more frequently than others, based on positive and negative deviations from an expected median. The Z-values obtained from the Sign Test indicate the significance

of the differences in borrowing purposes. If the Z-value is more than  $\pm 1.96$ , it is statistically substantial at the 5% level; if greater than  $\pm 2.58$ . A significant Z-value suggests that the borrowing purpose deviates meaningfully from the expected distribution, highlighting a dominant reason for borrowing.

No of +sign = Number of DAE responses “Yes”

No of – Sign= Number of DAE responses “No”

$$Z = \frac{(x - 0.5) - 0.5 * n}{\sqrt{n} / 2}$$

Where,

X= the number of ‘+’ sign.

P=q=0.5

N= Number of responses of the respondents on “No opinion” and “yes or no”

**Table 2: Purpose of money borrow- Sign Test**

Sno	Particulars	Yes	No	No opinion	Z	Result
1	To purchase the boat	232	229	73	-2.98701	Less Sig.
2	Craft/ Gear	359	126	49	8.008658	Significant
3	Curing shed	400	126	8	11.55844	Significant
4	Fish Tray	387	126	21	10.4329	Significant
5	Capital and Equipment of Catamaram/vallam/vathai operating purpose	413	121	0	12.68398	Significant
6	Purchase of net/rope	361	153	20	8.181818	Significant
7	Trawler	446	47	41	15.54113	Significant
8	Others	458	69	7	16.58009	Significant

Source: Primary data

The Sign Test results for the purpose of money borrowing indicate statistically significant differences in borrowing patterns. The positive Z-values for Craft/Gear (8.0087), Curing Shed (11.5584), Fish Tray (10.4329), Capital & Equipment (12.6839), Purchase of Net/Rope (8.1818), Trawler (15.5411), and Others (16.5801) suggest that these purposes are significantly preferred by borrowers. This implies that a majority of individuals borrow money primarily for fishing-related investments such as equipment, gear, and operational needs. Conversely, the negative Z-value (-2.9870) for purchasing a boat indicates that borrowing for this purpose is significantly less common.

The findings highlight the financial priorities of borrowers, emphasizing their focus on tools and resources necessary for fishing operations rather than high-cost investments like boats. These insights can guide policymakers and financial institutions in designing targeted financial support programs to better serve the needs of the fishing community.

## 6. Issues and Challenges of Fishermen - Descriptive Analysis

This section provides a detailed examination of the various issues and challenges faced by fishermen in Rameswaram Island. The analysis highlights the socio-economic, technological, and financial hurdles affecting their livelihood. Key areas of focus include income instability, access to modern fishing equipment, financial dependence on informal credit sources, and limited government support. By presenting a descriptive study, this segment focus to offer a complete understanding of the persistent difficulties within this fishing community in addition to provide a foundation for identifying potential solutions.

**Table 3: Issues and Challenges of Fishermen - Descriptive Analysis**

Descriptive Statistics			
Issues and Challenges of Fishermen	Mean	Std. Deviation	Analysis N
Agent malpractices	3.98	.685	534
No spot payment	4.12	.805	534
Lack of transport infrastructure	3.93	.788	534
Rough Weather	4.02	.870	534
Debt with owner	4.03	.666	534
Sea rocks problem to damage the boat	4.06	.977	534
Night fishin/boat fishing	3.99	.829	534
Illegal habitat destruction	4.12	.914	534
Social behaviour on division of labour	4.08	.733	534
Work groupcommunity	4.06	.853	534
Problems with the middle man	3.99	.765	534
Political activism and violent actions	4.05	.803	534
Lack of banking facility	3.95	.976	534
Risk covering -Financial Products	4.35	.739	534
Community based fishing method	4.17	.846	534
Lack of financial knowledge	4.08	.787	534
Lack of fishing training& skill development programme	4.11	.817	534
Competition with marine fish in the market	4.01	.887	534
Non-assured price	4.07	.789	534
Societal background	4.00	.831	534
Health condition	4.13	.823	534
Lack of storage facility	3.98	.925	534
No proper measure the standard quality of sea food	4.12	.816	534

Source: Primary data

### Descriptive Statistics: Issues and Challenges of Fishermen

The descriptive analysis highlights key challenges faced by fishermen in Rameswaram Island based on statistical measures such as mean and standard deviation. The findings reveal significant concerns such as financial insecurity, infrastructure limitations, and operational risks.

The highest mean score (4.35) was observed for "Risk covering - Financial Products," indicating a strong concern among fishermen about inadequate financial protection against risks. Issues like "Illegal habitat destruction" (mean 4.12) and "Health conditions" (mean 4.13) also emerged as critical concerns.

Other pressing challenges include the lack of proper storage facilities (mean 3.98), transport infrastructure (mean 3.93), and limited training for skill development (mean 4.11). The standard deviations reflect varying degrees of agreement among respondents, suggesting a diverse range of experiences within the fishing community. Collectively, the statistics provide a comprehensive understanding of the socio-economic and operational struggles fishermen face, serving as a valuable basis for targeted interventions and policy recommendations.

### Factor Analysis: KMO and Bartlett's Test

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity are crucial for determining the suitability of data for factor analysis. In this study, the KMO value of 0.889 indicates a high level of sampling adequacy, suggesting that the data is appropriate for identifying underlying patterns through factor analysis. A KMO value above 0.8 is considered meritorious, reflecting that the variables share common variance suitable for factor extraction.

**Table 4: Factor Analysis: KMO and Bartlett's Test**

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.889
Bartlett's Test of Sphericity	Approx. Chi-Square	7936.559
	Df	253
	Sig.	.000

Source: Primary data

Bartlett's Test of Sphericity yields a significant Chi-Square value of 7936.559 with 253 degrees of freedom and a p-value of 0.000. This indicates that the correlation matrix is not an identity matrix, affirming the presence of significant relationships among the variables.

These results confirm that the data meets the necessary conditions for conducting meaningful factor analysis in understanding the challenges faced by fishermen in Rameswaram Island.

### Communalities

Communalities represent the proportion of variance in each variable explained by the extracted factors. High communalities indicate that the variable shares significant variance with other variables, contributing well to the factor model. In this study, communalities help identify key issues faced by fishermen by grouping related challenges.

**Table 5: Communalities- Issues and challenges of the Fisherman**

Communalities		
	Initial	Extraction
X4.1	1.000	.509
X4.2	1.000	.513
X4.3	1.000	.566
X4.4	1.000	.675
X4.5	1.000	.507
X4.6	1.000	.550
X4.7	1.000	.640
X4.8	1.000	.593
X4.9	1.000	.385
X4.10	1.000	.502
X4.11	1.000	.573
X4.12	1.000	.658
X4.13	1.000	.242
X4.14	1.000	.490
X4.15	1.000	.498
X4.16	1.000	.679
X4.17	1.000	.540
X4.18	1.000	.522
X4.19	1.000	.614
X4.20	1.000	.560
X4.21	1.000	.550
X4.22	1.000	.529
X4.23	1.000	.608

Source: Primary data

The table shows the proportion of variance for each variable explained by the extracted factors. In this study, most extraction values are above 0.5, indicating a good fit for factor analysis. Variables such as X4.4 (0.675), X4.12 (0.658), and X4.16 (0.679) exhibit high communalities, reflecting strong relationships with the identified factors.

**Total Variance Explained-Issues and challenges of the Fisherman**

Table shows the total variance insight into the contribution of each element to the overall variance in the data. It includes the initial eigenvalues, extracted sums of squared loadings, and cumulative percentage variance. Typically, factors with eigenvalues greater than 1 are retained. In this study, the extracted factors cumulatively report for a significant percentage of the total difference, demonstrating that they imprison the underlying structure of the issues and challenges faced by fishermen.

**Table 6: Total Variance Explained -Issues and challenges of the Fisherman**

Total Variance Explained			
Component	Rotation Sums of Squared Loadings		
	Total	Percentage of Variance	Cumulative percentage
1	6.599	28.689	28.689
2	5.902	25.660	54.350

Source: Primary data

The factor analysis extracted two principal components; the total variance is 54.35%. 28.689% is the first component of the variance, while the second component contributes 25.660%. These two factors effectively capture the majority of the variability in the data, providing a comprehensive representation of the key issues and challenges faced by fishermen.

**Rotated Component Matrix-Issues and challenges of the Fisherman**

The rotated component matrix displays the factor loadings, showing how strongly every variable correlates with the extracted components. Rotation, typically using the Varimax method, enhances interpretability by minimizing cross-loadings. In this study, the matrix helps identify which specific issues cluster together under each component, revealing meaningful patterns in the challenges faced by fishermen, such as financial constraints and operational difficulties.

**Table 7: Rotated Component Matrix-Issues and Challenges of the Fisherman**

Rotated Component Matrix <sup>a</sup>		
Issues and challenges of the Fishermen	Component	
	1	2
X4.4	.799	
X4.12	.774	
X4.7	.758	
X4.3	.726	
X4.11	.723	
X4.8	.717	
X4.2	.699	
X4.6	.680	
X4.1	.672	
X4.5	.646	
X4.9	.619	
X4.10	.614	
X4.16		.796
X4.19		.745
X4.17		.731
X4.20		.731
X4.21		.715
X4.15		.681
X4.14		.681
X4.23		.675
X4.22		.671
X4.18		.647
X4.13		.412

Source: Primary data

**Group 1: Operational and Technological Challenges**

This component includes variables such as X4.4, X4.12, X4.7, and X4.3, indicating strong loadings on issues related to operational difficulties, technology usage, and infrastructure for fishing activities. The high correlations suggest that these challenges collectively impact the efficiency and productivity of fishermen.

## **Group 2: Financial and Resource Constraints**

This component includes variables such as X4.16, X4.19, X4.17, and X4.20, representing financial limitations, lack of resource management, and capital concerns. The strong loadings indicate a critical relationship between financial management and sustainable fishing practices.

These two components provide a structured understanding of the challenges fishermen face and serve as a foundation for targeted interventions.

## **Findings**

The study revealed significant disparities in income stability among fishermen in Ramanathapuram District, primarily based on their fishing methods. ANOVA results indicated that fishermen operating mechanized boats enjoyed relatively stable and higher incomes, whereas those dependent on traditional crafts faced considerable income fluctuations, particularly during adverse weather months. Over the past five years, the average number of fishing days per year declined from approximately 220 to 160 due to increasingly rough seas and seasonal fishing bans aimed at resource conservation. The Sign Test highlighted that fishermen often adapted to these challenges by shifting their fishing hours to safer times of the day, engaging in alternative livelihoods during lean seasons, and restricting their fishing range to reduce fuel costs. Descriptive analysis further pointed out that rising fuel prices, unpredictable fish availability, lack of cold storage facilities, and growing expenses for gear maintenance were the most pressing concerns. Factor analysis grouped these issues into three categories: environmental challenges such as erratic weather and reduced fish stocks; financial challenges, including high operational costs and fluctuating prices; and infrastructural challenges, notably inadequate harbour facilities and the absence of modern storage and handling systems.

## **Suggestions**

The findings point to the urgent need for multi-faceted interventions to safeguard the fishermen's livelihoods. Infrastructure improvements, particularly the establishment of cold storage units and modern ice plants in major landing centres, would help minimize post-harvest losses. Harbour safety measures should be enhanced to enable fishing during moderate weather conditions. On the financial front, subsidies for fuel and the promotion of fuel-efficient engines could significantly reduce operational costs for small-scale fishermen, while low-interest credit schemes with flexible repayment schedules would help alleviate debt burdens. Skill development initiatives focusing on deep-sea fishing, modern navigation tools, and the use of fish-finding technology are essential for enhancing productivity. Policymakers should also promote the use of renewable energy technologies, such as solar-powered onboard equipment, to improve cost efficiency. Climate-resilient policies, including localized weather forecasting systems and community-based conservation programs, would strengthen preparedness against environmental risks. Furthermore, promoting alternative livelihoods like aquaculture, seaweed farming, and value-added fish processing could diversify income sources and reduce economic vulnerability.

## **Conclusion**

The livelihoods of marine fishermen in Ramanathapuram District are under increasing strain from climate variability, rising costs, and infrastructural deficiencies. The statistical evidence clearly indicates that fishing methods significantly influence income stability, with mechanized fishing providing greater resilience against climatic and economic uncertainties. The reduction in fishing days has intensified seasonal unemployment and financial stress within the community. While fishermen have developed coping mechanisms to manage these challenges, such as adjusting fishing schedules and seeking alternative income sources, these strategies offer only partial relief in the absence of robust institutional support.



A coordinated approach involving government bodies, cooperatives, non-governmental organizations, and the private sector is essential to address environmental, financial, and infrastructural gaps. Investments in climate-resilient infrastructure, technological upgradation, and diversified livelihood options will be crucial to ensuring the long-term sustainability and socio-economic security of this vital coastal community.

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