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Understanding climate vulnerability, infrastructure gaps, and social support in coastal fishing communities: a preliminary factor study from Thiruvananthapuram, India

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Abstract: Kerala boasts of the highest quality of life in the country as measured by human development indicators and accounts for the 20% of national fish production .Even though, coastal fishing communities are highly prone to climatic challenges and infrastructural impoverishment that directly effect on their quality of life and livelihood security. Increase of sea surface temperature, sea level rise, ocean acidification, heavy rainfall, extreme events like storms, erosion, flooding, salt water intrusion, cyclones, El Nino and drought are the important climate change indicators that impose threats to the sustainable livelihood of fishing communities which directly affects the infrastructure facilities of the area. This study explores the key dimensions of climate stress/environmental vulnerability, access to basic services, and social security among fishing communities in Thiruvananthapuram, Kerala, India. Primary data were collected using a bilingual structured and semi-structured questionnaire as well as interviews. Using Exploratory Factor Analysis (EFA) with Principal Component Analysis extraction and Varimax rotation, three different but interconnected factors identified as latent challenges hindering the quality of life among fisherman: (1) Environmental Vulnerability, indicates climate related challenges in coastal areas; (2) Social Security, represent the access of government schemes and programs to fishers (3) Basic Amenities, shows the living conditions of fisherman households. The findings revealed that all the three factors are interrelated but stand as a separate threat to the quality of life among fishing communities. The scree plot represents three factor solution made specific that environment vulnerabilities, lack of social support and access to basic amenities together can be the major reason for marginalization of coastal areas. Social support system moderates the intensity of the risk of climate stress and lack of basic living. These findings underscore the significance of inclusive policy framework to enhance the infrastructure to tackle environmental vulnerabilities and social support in vulnerable coastal areas.

Keywords: climate vulnerability; coastal development; fishing communities; infrastructure gaps; social support.

Introduction

A significant portion of fishermen's income comes from natural resources, whose production and distribution are known to be impacted by climate dynamics[1]. Sea level rise, extreme weather, erosion, floods, and other aspects of climate change can cause stress and shocks for coastal fisherman. The productivity of coastal ecosystems, biodiversity, fish stocks, and fish migration pathways are all impacted by climate change in coastal seas. The key climate change indicators that affect fishing communities' ability to sustain themselves are rising sea levels, acidification, heavy rainfall, storms, erosion, flooding, salt water intrusion, cyclones, El Nino, and drought. Because fishing is the only significant source of income for coastal and marine fishermen, they are the group most at risk from

climate change [2]. India boasts an 8000-kilometer coastline that is both heavily populated and extremely productive. The regular cyclones and storms that degrade the local economy and further impact the incomes of many people, including those who live in coastal fishing settlements, make this coastline extremely vulnerable [3]. Even though the fishing industry plays a major role in creating jobs for the poor and boosts local economies, low-income and poverty-stricken fishing areas on coastal belts are particularly vulnerable to these changes [4]. While various government programs aim to enhance resilience, there remains a critical knowledge gap in understanding how infrastructure access and climate stressors collectively influence the quality of life of these communities. This study addresses that gap by employing a data-driven approach using primary data collected field study using both structured and semi structured questionnaire and interview Schedules. Social protection and the fishing industry are strongly related due to common concerns about poverty, food security, better livelihoods, welfare, and environmental sustainability. However, these relationships have not been properly utilized because the majority of social protection mechanisms concentrate on other areas other than fishing sector [5][6]. Existing literature on coastal resilience has explored climate adaptation, livelihood challenges, and disaster risk reduction(e.g.:[7]). However, only few empirical studies have quantitatively modelled the concurrent impact of environment vulnerabilities and infrastructure gap on the quality-of-life dimensions within the fishing populations.

Background

Over a million fishermen live in 222 coastal villages distributed throughout nine of the state's fourteen districts along Kerala's 590-kilometer coastline. Approximately 50,000 vendors in the state make a living from activities related to fishing [7]. Climate change and extreme weather are having a significant negative impact on Kerala's fishing industry, resulting in fewer fishing days, lower catch, and decreased profitability. The Central Marine Fisheries Research Institute (CMFRI) has released research that emphasizes the increasing difficulties that fishermen encounter, such as the susceptibility of fishing nets and gear because of insufficient protective infrastructure [8]. A number of other issues have also been brought on by extreme weather, such as water pollution, coastline erosion, infrastructure degradation, and homestead flooding during high tides. Small-scale fishers with little capacity for adaptation had been disproportionately impacted by these circumstances and their effects. The climate change which creates rising of sea waves and changes in the wave pattern results in the destruction of houses and boats of the fisherman [9]. The marine fishing community in Kerala is cognizant of the changing climate and its substantial impact on the fisheries sector and fishers perceive that deforestation and industrial pollution are the major factors contributing to it. They have also observed alterations in environmental conditions and recognize their implications on fishery resources, livelihoods, and community well-being [10].

In 454 operations off the coast of Kerala in 2012, maritime services saved 3046 fishermen; however, another 44-fisherman died and 11 disappeared. Seventy-five percent of the 643 fishing boat incidents that occurred in three south Indian coastal areas between 2011 and 2016 involved small motorized boats [11]. Ockhi caused the deaths of at least 102 fishermen from Kerala and the nearby state of Tamil Nadu, while 263 fishermen who went missing at sea were later pronounced dead. The loss of 4591 fishing boats caused disruptions to coastal livelihoods [12].

Fisherman in Thiruvananthapuram, Kerala- An Overview

The state of Kerala in the southwest of India has nine coastal districts. According to the Marine Fisheries Census 2010 by CMFRI (Central Marine Fisheries Research Institute), there are 222 marine fishing villages, with the maximum number (42) in the Thiruvananthapuram district. Thiruvananthapuram is home to 51 of the 187 fish landing centers in total. With a population of 6,10,165, the state has about 1,18,937 fishermen’s households. Thiruvananthapuram is home to the greatest number of families (33,340), making up 24% of the state's total fisher population. Approximately 46% of fishermen are active fisherman, whereas 98% of fishermen's households are traditional fishermen. 54,407 fishermen are involved in fishing-related activities, including manual labor (27%), marketing (38%), and other activities (35%). Thiruvananthapuram has the highest percentage of fishermen engaging in fishing-related activities (39%), while the district is home to the bulk of those active in fish marketing (58%). Small-scale fisheries, which generate a significant portion of the state's revenue, are the foundation of the majority of fishing communities in the district [13]. Major share (84%) of those who engaged in marketing of fish belonged to the three districts i.e., Thiruvananthapuram (58%), Kasargod (16%) and Kollam (10%).

Major Objectives

The present study may evaluate underlying dimensions of climate challenges and infrastructure issues faced by fishing communities and how do these dimensions impact their perceived or actual quality of life

- To identify and explore the underlying dimensions of climate vulnerability, infrastructure access, and social support experienced by coastal fishing communities in Kerala.
- To use exploratory factor analysis (EFA) to determine how key environmental and social challenges group into latent constructs affecting community well-being.
- To understand the role of perceived social support as a distinct factor in reducing the negative effects of climate and infrastructure problems on people's lives.

Materials and Methods

Since Thiruvananthapuram District contains 42 fishing communities, multi-stage random sampling was used to identify the fishing village for conducting data collection. The district's large concentration of sea fishermen led to the selection of Anchutheng village. Structured and semi-structured questionnaires in both Malayalam and English were used to survey 100 fishing households. In order to include respondents who were most reliant on marine fishing, purposive sampling was used. Focus groups, interviews, and quantitative questions were all used in the data collection process. Triangulation method was used to reduce the internal biases from verbal and textual data; answers were cross-verified and validated through focus group discussion and observation throughout data collection. The institutional ethics committee granted ethical clearance to collect data which includes human beings, and all participants gave their informed consent verbally. Bias mitigation measures included careful translation of questions, culturally appropriate phrasing, and respondent debriefing. All the analyses were conducted using IBM SPSS Version 25.

Study Area

The present study was conducted among the fishing communities of Anchutheng, Thiruvananthapuram, Kerala. Anchutheng has the highest number of active fishermen in the district. Because of their high reliance on marine resources, these communities are socially and economically marginalized and also faces environmental degradation. Because of its extreme susceptibility to cyclones, tidal surges, and sea erosion, this coastal area is a suitable location for investigating the relationship between social well-being and climatic vulnerability. The study population comprised active adult fisherman whose income mainly depended on fishing.

Study Design

In order to understand the underlying factors that influence the quality-of-life among fishing communities in coastal areas of Anchutheng, Kerala, the current study used a **quantitative exploratory design**. Using Exploratory Factor Analysis (EFA) as the main statistical technique, the study sought to determine the relationships between climate-related stresses, infrastructure access, and social support networks.

Data collection and Sample

A bilingual (Malayalam and English) questionnaire that include sociodemographic information, standard of living, health and education, challenges faced by fisherman to achieve quality of life was used to gather primary data. In addition to Focus Group Discussions (FGD), the researcher conducted household interviews with fisherman from Anchutheng Fishing Village and the nearby Muthalapozhi Fishing Harbour to learn about the different challenges they face due to climate change and how it affects their quality of life. The study focused on three key domains :

EV1: Perceived severity of Environmental Vulnerability /climate stress (e.g., plastic waste, erosion)

BA1: Access to basic infrastructure/Living conditions(e.g., Sanitation facilities)

SS1: Access to social support or Security(e.g. insurance)

Sample size

To ensure the credibility , reliability of data and representation of active fisherman, sample size of 100 respondents was selected purposively for quantitative study. The population of Anchutheng fishing village is highly concentrated on marine fishing ensures the homogeneity of the respondents. It covered various age groups, different household sizes and type of fishing job allowing proper field study. The study included three main quantitative variables, with a sample of 100, it was statistically sufficient for factor extraction and interpretation.

For the Qualitative data, 30 participants (comprising fishers, fish vendors, and community leaders) were selected using purposive sampling to understand diverse perspectives on climate stress, infrastructure access, and social support. This allowed an in-depth understanding of the lived experiences of fisherman by interviews and focus group discussions untill achieving data saturation.

Inclusion criteria

- Adult members of fishing households primarily dependent on fishing sector.
- Residents of Anchutheng village for ≥10 years.

Ethical procedure

Informed consent was obtained from the respondents verbally by assuring confidentiality.

Table 1: Variables Used in the Study

No.	Category	Description
1	**Socio-Demographic**	Age, gender, and education level
2	**Housing & Assets**	Family size, boat/house ownership
3	**Basic Amenities(BA1)**	Access to sanitation, water, electricity, etc.
4	**Support Systems(SS1)**	Child education, insurance, govt support, safety equipment
5	**Environmental vulnerabilities(EV1)**	Plastic waste, sea erosion, fish availability, sea level rise

Source: Primary Survey Data, 2025.

Data Analysis

All the data collected were analyzed using **IBM SPSS Version 22**

Exploratory Factor Analysis (EFA)

An EFA(Exploratory Factor Analysis) was conducted to understand the unacknowledged factors that underlie the observed variables. The extraction method was **Principal Component Analysis (PCA)** with **Varimax rotation.** The various steps included in the Exploratory Factor Analysis (EFA) are the following:

1. **Suitability testing**

o Kaiser–Meyer–Olkin (KMO) and Bartlett's Test of Sphericity confirmed data adequacy for factor analysis (KMO > 0.6, $p < 0.05$).

2. **Extraction method**

o Principal Component Analysis (PCA) was used to extract factors.

3. **Rotation**

o Varimax rotation (orthogonal) was applied to enhance interpretability of factor loadings.

4. **Factor retention criteria**

o Eigenvalue > 1.0

o Factor loadings ≥ 0.60

o Minimal cross-loading across factors

Scree plot used to confirm the optimal number of factors

Results and Discussion

Using **Principal Component Analysis (PCA)** with **Varimax rotation**, three factors with **eigenvalues greater than 1** were extracted, accounting for a **cumulative variance of 100%**. The percentage of variance explained by each factor was **38.97%, 33.25%, and 27.78%**, respectively.

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Table 2: Rotated Component Matrix[a]

Variables	Component		
	Factor 1 Environmental Vulnerability	Factor 2 Social Security	Factor 3 Access to Basic Amenities
BA1-Access to Basic Amenities	.064	-.054	**.996**
EV1-Environmental vulnerability	**.998**	.001	.064
SS1-Social Security	.001	**.999**	-.054

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 4 iterations.
Source: Primary Survey Data, Anchutheng Fishing Village, Thiruvananthapuram District, Kerala (2025). *Computed using SPSS (Version 25).*

Interpretation of Factors

The rotated component matrix revealed three conceptually meaningful and statistically varied factors:

Factor 1: Environmental Vulnerability

This factor captured the **perceived impact of environmental challenges and vulnerability**(e.g., coastal erosion, flooding, and sea-level rise) faced by the fishing communities. Environmental threats are the most common perceived problem among respondents, according to the extremely high loading of environmental vulnerability (0.998). It also represents negative influences on the stability of the coastal belt's environment which comes from the outside due to rapid urbanisation where security of fisherman livelihoods is compromised.

Factor 2: Social Support/Security

Insurance, government assistance, and welfare programs are examples of the institutional and community-level support that the fishing population has access to. The high loading of *Social Security (0.999)* indicates that fisherman view these mechanisms as a different kind of security apart from challenges posed by climate change or living conditions. This can be seen with other research highlighting the protective function of welfare programs in boosting small-scale fishermen's resilience.

Factor 3: Basic Amenities

Access to Basic Amenities (0.996) defined the third factor, suggesting that infrastructure elements-like having access to electricity, drinkable water, and sanitary facilities form a separate part of well-being. Respondents were able to distinguish between other social or environmental challenges and quality-of-life measures connected to infrastructure.

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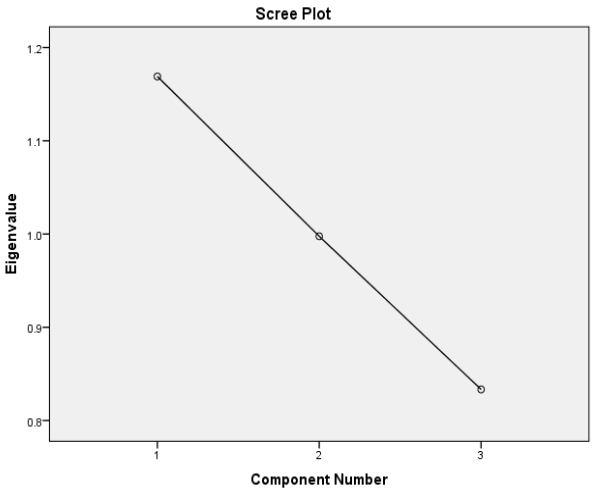
Figure 1. Scree Plot of Extracted Components



Source: Primary data computed using SPSS

The scree plot (Figure 1) shows a steady decline in eigenvalues, with three components exceeding the maximum value of 1. The scree plot supports a three-factor model, which showed a distinct elbow shape following the third component. This pattern shows that the data structure is best represented by a three-factor solution. Each of the three factors- environmental vulnerabilities, social security, and basic amenities or living conditions represents a different aspect of the fishermen's experiences, indicating the fact that respondents understand these as distinct but equally important factors which plays a major role in deciding their overall quality of life in coastal areas.

The analysis identifies **three independent domains** affecting the well-being of coastal fishers:

Factor 1- Environmental Vulnerabilities– it captures the intensity of climate challenges fisherman faces due to various issues such as sea erosion, floods, availability of fish and sea pollution.

Factor 2- Social Support- it refers to the various governmental schemes and programs to support coastal fishing communities like insurance, old age pension, financial aid for building houses etc.

Factor 3- Basic Amenities – it refers to the living condition of the fisherman such as shelter, electricity, drinkable water etc. which affects their quality of life.

The separation of these three factors represents that fishermen perceive these factors as distinct yet equally critical. All the factors and interdependent but stand as unique factor responsible for the Quality of life among fishing communities. Environmental stress represents external vulnerability, infrastructure reflects internal coping capacity, and social support acts as a mediating or buffering factor. Lack of all these factors are the major reasons for backwardness and marginalization of the fishing communities.

Discussion

The Exploratory factor Analysis findings revealed that there are three key dimensions affecting the quality of life among fishing communities namely**: access to basic amenities, social security, and environmental vulnerability**. Each one is a crucial component of coastal ecosystems' livelihood resilience. **Environmental vulnerability** considers as one of the most important factors influences the wellbeing of coastal communities. It reflects the fact that the risks brought by environmental vulnerabilities are having enduring influence on the life of fisherman. The findings by Jacob (2022) and CMFRI (2025) regarding the influence of marine fishing in the national economy and increasing severity of climate threats due to lack of infrastructure in Kerala's coastal areas are authenticated by the actual findings from the study. The findings including loss of fishing days, coastal erosion and livelihood challenges are supported through the previous literatures. The government support and initiatives to improve the welfare of fishing communities are important to be considered is evident from the findings that **social support** stand as an independent factor. In line with

Thorpe et al. (2006), Funding for different schemes such as old age pensions, insurance, and community-based programmes that helps fisherman during rough seasons serve as buffers that lessen livelihood shocks. The literature suggests that most of the government schemes are concentrated on other sectors other than fishing sector. The result indicated that some fishermen are even unaware of basic community enhancement programmes initiated by the government and they are being neglected due to these circumstances. Another distinctive factor which affects the quality of life among fishermen is their living or **basic amenities.** The living conditions or the basic amenities are the physical infrastructure that are essential for the coastal communities to sustain their livelihood and comprises of the necessary facilities that lead to their quality of life. The living condition not only plays a major role in tackling the risks caused by natural calamities in coastal areas but also as a protective shield. The Lack of proper infrastructure can lead to utmost vulnerability for the fisherman during climate changes. They are forced to move from one place to another as victims of natural calamities. These three components together highlight a layered understanding of vulnerability and adaptation. Environmental and infrastructural challenges represent structural constraints, while social support acts as a mediating factor capable of mitigating some of their negative impacts.

Existing literature in line with Jacob(2022)on coastal resilience has explored climate adaptation, livelihood challenges, and disaster risk reduction. However, only few empirical studies have quantitatively modelled the concurrent impact of environment vulnerabilities and infrastructure gap on the quality-of-life dimensions within the fishing populations. The current study helps to fill this gap by providing a quantitative model to understand the interrelationship between economic vulnerabilities, basic amenities and social support as three distinct factors which determine the quality of life among the fishing communities.

The three-factor solution emphasizes how physical infrastructure and access to welfare mechanisms are interwoven with climate vulnerability, which is not an isolated phenomenon. This result is connecting with earlier research studies showing that coexisting advancements in the field of social protection and infrastructure access to the fishing communities are necessary for coastal resilience. Furthermore, all three factors contribute similarly to the explanation of livelihood situations, as indicated by the equal distribution of explained variance (about 33% each). The findings highlight the importance of a local policy intervention which emphasizes the development of coastal communities to improve their standard of living by advancing infrastructure facilities, environmental management system, coastal resilient programs and equitable welfare schemes. To validate this structure, future studies should use confirmatory factor analysis (CFA) and increase the number of observed variables.

Implications

The findings lead to the inclusive policy framework address all three domains all together:

- Enhancing climate-resilient infrastructure and coastal protection by ensuring financial assistance to the fisherman for the damages caused by environmental challenges
- Ensuring that insurance and welfare benefits are distributed fairly and up to time.
- Ensuring a better living conditions for the fishing communities where they are accessible to all the basic amenities.

Limitations

This factor analysis was based on only three variables, limiting generalizability. Future studies should include more items per domain to improve factor robustness. Also, self-reported perceptions may carry bias. Still, this pilot analysis offers a useful framework for future, larger-scale models

Conclusion

This study examined the major challenges faced by fishing communities in coastal areas by focusing on climate-related vulnerabilities, basic infrastructure access, and social support and the results showed that all the three are interconnected and are influencing the quality of life among fishing communities of Thiruvananthapuram, Kerala. Using the Exploratory Factor Analysis, it identified that all the factors are interconnected but stays as separate challenge for the communities' resilience. Environmental and infrastructural issues are closely linked and represent a combined source of vulnerability, while social support operates as a separate and potentially protective factor. Livelihood instability is intensified by environmental stressors including cyclones such as Ockhi, harsh weather conditions, lack of necessary safety equipment and coastal erosion, and vulnerability is increased by a lack of access to essential services, shelter, drinking water and sanitary facilities. On the other hand, strong social support networks, like insurance plans and disaster relief, serve as safeguards but the findings show that majority of the people are neither unaware nor benefitting from the social support systems. Also lack of infrastructure facilities including a proper harbour for the fishing people in Anchutheng village worsen the situation. Muthalapozhi harbour

(Thiruvananthapuram), where most of the fisherman from Anchutheng goes for fishing is still facing allegations related to the safety of the harbour. The results underscore the importance of addressing both physical and social dimensions of well-being in policy interventions. Strengthening physical infrastructure such as access to pure drinking water for each house, hygienic sanitation facilities along with step up the social support systems including government aids and insurance can considerably improve the resilience in the coastal areas. It is important to ensure that the social support systems provided by the government is distributed equally and all the people of coastal area are getting the fruit out of it. In conclusion, to improve the sustainability and resilience of the coastal fishing communities of Kerala, a localised policy framework consists of climate management resilience, infrastructure facilities to mitigate the risks and welfare programs supporting fishermen should be implemented. To mitigate internal biases of the qualitative data and derive conclusions from them, different strategies were used to validate the data while data collection and analysis. The complete study was carried out using the local language(Malayalam) to extract the lived experiences of the fisherman and were later translated to and cross verified for consistency. Triangulation between interview data, focus group discussions, and field observations was used to verify recurring themes and avoid researcher subjectivity. Through this approach, qualitative insights were systematically compared with quantitative findings, allowing for credible and contextually grounded conclusions.

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