The Kerala State Higher Education Council

The Chief Minister's NavaKerala Post-Doctoral Fellowship 2021-22
Government of Kerala
Administered by
The Kerala State Higher Education Council (KSHEC)

Order No. KSHEC-A3/344/Govt.Kerala-NKPDF/2022 dated 16/05/2022

Vulnerability, Social Resilience, and Adaptation Strategies against Climate Change:

The Case of Traditional Fisherfolk in Kerala

Submitted by:

Dr Aravindh P

Under the Mentorship of

Dr K Satheesan
Professor
Department of Atmospheric Sciences

Cochin University of Science and Technology
Kochi – 682 016

July 2024

To the Children of the Sea

The Research Team

Post-doctoral Fellow	:	Dr. Aravindh Panikkaveettil, Dept. of Atmospheric Sciences, CUSAT
Mentor	:	Dr. K Satheesan, Professor, Dept. of Atmospheric Sciences, CUSAT
Field Investigators	:	Abhishek K R Akashnath V S Arya C Madanarajan Chandrakumari P Gopika P V Nivedya V S Raj Krishna J Saveri J S Sudev P Sukumaran

Consultant Experts

Dr. S Harikumar,
Professor Emeritus,
Dept. of Applied Economics,
CUSAT

Dr K V Thomas,
Scientist (G) (Retd),
National Centre for Earth Science Studies (NCESS),
Thiruvananthapuram

Dr Johnson Jament,
Research Associate,
School of Global Studies,
University of Sussex

Prof. Siddik Rabiyath,
Assistant Professor,
Department of Economics,
University of Kerala

Dr S Abhilash
Director,
Advanced Centre for Atmospheric Radar Research (ACARR),
CUSAT

Dr M G Manoj,
Scientist (D),
Advanced Centre for Atmospheric Radar Research (ACARR),
CUSAT

FORM 11

Chief Minister's Nava Kerala Post Doctoral Fellowship (CMNPF)

Kerala State Higher Education Council

Undertaking by the CMNPF Fellow

To
The Member Secretary
The Kerala State Higher Education Council
Thiruvananthapuram

Sir

I, Dr Aravindh P, hereby certify that the research proposal titled "***Vulnerability, Social Resilience, and Adaptation Strategies against Climate Change: The Case of Traditional Fisherfolk in Kerala***", completed as part of the Chief Minister's NavaKerala Research fellowship (CMNPF) Year/ Batch/Mode & submitted before the Kerala State Higher Education Council Thiruvananthapuram is my original idea & work and has not been copied/taken verbatim from anyone or from any other sources. I further certify that the final technical report of this research work has been checked for plagiarism through a plagiarism detection tool i.e. **iThenticate** approved by the registering Institution and the contents are original and not copied/taken from any one or many other sources. I am aware of the UGC (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulation 2018. I also declare that there are no plagiarism charges established or pending against me in the last five years. If the funding agency notices any plagiarism or any other discrepancies in the work submitted by me, I would abide by whatsoever action taken against me by KSHEC, as deemed necessary.

Aravindh P, PhD

Dr K Satheesan

Institution Seal

Acknowledgements

I would like to being by expressing sincere gratitude to my mentor, Dr K Satheesan, Professor, Department of Atmospheric Sciences, Cochin University of Science and Technology, whose advice and constant encouragement have helped me complete this piece of research successfully. The freedom granted to me by Dr Satheesan was instrumental to the swift completion of the fieldwork required for the current study. I am also deeply indebted to my Ph.D. supervisor, Dr S Harikumar, Professor Emeritus, Department of Applied Economics, CUSAT, for his advice, encouragement and continued mentorship in making me a better researcher every day.

The seventeen months I spent in the Department of Atmospheric Sciences, CUSAT Lakeside Campus were made easier by the presence of supportive non-teaching and administrative staff. I would like to extend my gratitude to the office personnel and technical staff at the Department of Atmospheric Sciences for their assistance during my tenure as a CMNP Fellow.

I am also highly indebted to the consulting experts who gave their insights while compiling this report. I would like to acknowledge the contributions of Dr K V Thomas, Scientist (G) (Retd), National Centre for Earth Science Studies, Thiruvananthapuram; Dr Johnson Jament, Research Associate, School of Global Studies, University of Sussex; Prof. Siddik Rabiyath, Assistant Professor, Department of Economics, University of Kerala; Dr M G Manoj, Scientist (D), Advanced Centre for Atmospheric Radar Research, CUSAT; and Dr S Abhilash, Director, Advanced Centre for Atmospheric Radar Research, CUSAT, for their suggestions that brought this report to its final format. Their contributions have enriched this report significantly and form the bedrock for further research that I plan to undertake in this field.

I am also deeply indebted to my colleagues at Christ (Deemed to be University), Bangalore, who have been very understanding about my research, and gave me an atmosphere to work in peacefully while balancing official duties as a faculty member. I would like to express my gratitude to Dr Joshy K J, Associate Professor, Department of Economics, Christ (Deemed to be University), and the other faculty including Dr Divya Pradeep, Dr Greeshma Manoj, Dr Rajeshwari U R, Dr Gerard Rassendren, Dr S Subramanian, Dr Mahesh E, Dr Rittu Susan Varkey, Dr Anushree S Panikkassery, Dr Deepa V K, Dr Anjali P K, Prof. Sarathlal P S, and Prof Sankar Varma K C, for their constant encouragement, support, and constructive comments on this research work. I would like to especially point out the contributions of Dr Divya Pradeep for providing me insights into analysing the occupational mobility of the community, and Dr Rajeshwari U R for her inputs in correcting and reviewing the statistical analysis and econometric models used in the current study.

My research work at CUSAT as part of the CMNPF coincided with my participation in the Climate Leadership Programme of Sustera Foundation. I would like to especially thank Mr Sanju Soman, CEO, Sustera Foundation, Mrs Deepa Ananthapadmanabhan, Managing Director, Sustera Foundation, and the Sustera team comprising Souparna, Amjad, Agnus, Sarath, and Roshni for their energy and encouragement, which were crucial in keeping me motivated to complete this research.

I would also like to give a shoutout to my team members in CLP – Jasmine, Najeeha, Sruthi, Reshma, and Farhan – for the wonderful experience we shared. Sustera Foundation also deserves a special mention for the opportunity they gave me in drafting a standard operation procedure to safeguard the mental health of coastal communities who are affected by climate change and extreme weather events in Thiruvananthapuram. I would also like to thank the other climate leaders in CLP-2023, as well as various members of the CLAN-30 Climate Action network, whose ideas and encouragement have acted as the fuel for me to continue with my research in this area.

I am also thankful to the various experts who gave me inputs in improving this research at the two conferences where I presented papers that came out of this report. I would like to thank Dr Chitwan Lalji, Assistant Professor, IIM-Kozhikode, who chaired my presentation at IIM-K in December 2022, and experts at the UNESCO International Conference on Climate Risk, Vulnerability, and Resilience Building, held at the UNESCO Headquarters in in Paris in April 2023, for their critical inputs that helped improve this report.

Covering all nine districts of Kerala and collecting data from a large sample would have been a herculean task if I were to do it alone. I am incredibly thankful to the contributions of my friends and fellow researchers, Sudev P Sukumaran, Arya C Madanarajan, and Nivedya V S from the Department of Applied Economics. CUSAT, who put in the critical effort to lead the data collection aspect of this report by my side. I would also like to acknowledge the contributions of others like Akashnath V S, Gopika P V, and Abhishek K R, along with my mother and partner who participated in the data collection process. Acknowledgements are also due to Mr Raj Krishna J, MA Student, Department of Economics, Christ (Deemed to be University), for his contribution in collecting secondary data in the project.

The core of this report is formed by the data given to me by the 1271 participant households across Kerala. I personally thank everyone who provided me with the data, without which this work would never have been completed. The fieldwork was most arduous in Thiruvananthapuram, and only local level contacts made the task manageable for our team. I am incredibly thankful to Sri Vincent Elias, Parish Member, Our Lady of Good Voyage Church, Vizhinjam, and Fr Manish Peter, Assistant Priest at Our Lady of Good Voyage Church, Vizhinjam, for their assistance with data collection in Vizhinjam. I would also like to thank Fr. Jacob Stellus, Parish Priest, St Mary Magdalene Church, Paruthiyoor, and Dr Sabu Mariadason, NKPDF Fellow, Central

Marine Fisheries Research Institute, Kochi for their assistance with data collection in Pozhiyoor.

During my tenure as a CMNP Fellow, we had built up a network of researchers across Kerala. I would like especially thank Dr Deepa V D, CMNP Fellow, Department of Economics, University of Calicut, for being a constant presence who encouraged me to complete this work on time. I would also like to thank all members of the CMNP Fellows in the community who have stood by each other in times of great adversity.

Finally, I also thank my family members – my partner, mother, siblings, and in-laws – for standing by my side in resolute fashion even during the toughest of times. Their presence gave me the resolve to keep going forward even when institutional hurdles, financial difficulties, and academic egos threatened to derail this piece of research.

Contents

List of Tables

List of Figures

List of Photographs

Form 10

Part A

Project Profile

Form 10

Final Technical Report

Part A. Project Profile

1	Project Title	:	Vulnerability, Social Resilience, and Adaptation Strategies against Climate Change: The Case of Traditional Fisherfolk in Kerala
2	Funding Agency	:	Kerala State Higher Education Council
3	Name of CMNPF Scholar	:	Dr Aravindh P
4	Name and Address of Mentor	:	Dr K Satheesan, Professor, Department of Atmospheric Sciences, Cochin University of Science and Technology Lakeside Campus, Fine Arts Avenue, Kochi – 682016
5	Name of the Institution (Registered)	:	Department of Atmospheric Sciences, Cochin University of Science and Technology
6	Category (Science/Non-Science)	:	Non-Science
7	Domain	:	Economic Studies
8	Specific Area	:	Climate Change and Social Exclusion

Part A. Project Profile (Contd.)

9	Date of commencement of project	:	13/06/2022
10	Date of completion (2-year tenure)	:	13/06/2024
11	Actual date of completion	:	30/11/2023
12	Collaborating Institutions (if any)	:	None

Form 10

Part B

Report Profile

Summary and Objectives

Summary and Objectives

1. Summary of the Project Proposal Stated:

Kerala has been facing the brunt of climate change over the last few years, with extreme climatic events and gradual processes equally responsible for mounting climate concerns in the state. Extreme weather events in recent memory include severe droughts in 2016, torrential rains leading to landslides and floods nearly every year since 2018, and tropical cyclones like Ockhi and Tauktey. The state is also at risk of losing large tracts of coastal land due to sea-level rise if global temperatures accelerate.

Traditional fisherfolk in Kerala's coastal belt are one of the most vulnerable social groups when it comes to climate change. Climate change manifesting itself in the form of severe cyclonic storms and intensified coastal erosion has been wreaking havoc on the livelihoods of the fisherfolk and putting their assets at risk. Recent cyclones in the region have also brought in massive tidal floods and storm surges that erode the coast further and flood the coastal region. For the traditional fisherfolk, climate change represents a total socio-economic catastrophe.

The study seeks to address the concerns of Kerala's coastal communities in the backdrop of climate change. It focuses on plotting future climate changes and assessing the vulnerabilities and adaptive capacities of the coastal communities. The analysis is expected to be carried out in line with the vulnerability framework proposed by IPCC in their assessment reports. The study also proposes to examine issues like migration and displacement of coastal communities due to climate change.

Fashioned as a comprehensive survey of fishing households across Kerala, the study is based on a large-sample survey covering fishing villages in all nine coastal districts of Kerala. The state's entire coastline is projected to be covered in the study, with priority given to households that live along eroding sections of the shoreline. A quarter of all fishing villages in Kerala are identified for the field survey, which is expected to take place over a course of one year, from January to December 2023.

The study looks to examine multiple dimensions related to the livelihood of the state's coastal communities, while also examining the status of coastal protection measures across the 593-km long coastline of Kerala. Areas with inadequate coastal protection measures will be identified and suggestions put forward to improve the situation through sustainable long-term strategies. The study aims to provide a comprehensive document that outlines the major problems faced by Kerala's coastal communities, and give policymakers suggestions to ensure that one of the state's most marginalized communities is not left by the wayside as the world plummets further and further into an uncertain future.

2. Objectives/Expected Outcome of the Project Stated:

The project originally proposed three broad objectives and a set of specific objectives. The three broad objectives put forth in the original proposal are as follows:

1. Examine possible future scenarios of sea level rise and climate change on the Kerala coast
2. Assess the impact of extreme climatic events on the livelihood of fisherfolk
3. Understand the extent of coastal erosion and increasing frequency of cyclones induced migration and displacement among traditional fisherfolk

The specific objectives outlined in the original proposal were as follows:

- ❖ Examine future scenarios of sea level rise, wave climate, and extreme weather events according to CO_2 concentration and sea surface temperatures on the Kerala coast
- ❖ Examine the socio-economic status of traditional fisherfolk in Kerala

- Understand the extent of livelihood disruption faced by fisherfolk due to cyclones
- Understand the nature and extent of coastal erosion in fishing villages
- Assess the nature of migration and livelihood diversification among fisherfolk
- Examine the magnitude of climate change-induced displacement among fisherfolk
- Assess the latent adaptive capabilities of fisherfolk towards climate change
- Examine the existing Government programmes to manage hazard risk in coastal areas and suggest improvements.

3. Deviation from Original Objectives:

Over the course of the project, a few of the initial objectives were abandoned due to time and resource constraints. Objectives including prediction of possible future scenarios was untenable within the short time period of 18 months, and therefore was dropped after consultation with subject experts. The second broad objective pertaining to assessing the impact of natural disasters on livelihood loss was carried forwards, while the third broad objective was also studied using case studies to a limited extent due to data on displacement being difficult to collect from the field.

Among the specific objectives outlined in the initial proposal, a few changes were made, as three of them were dropped. The revised set of objectives are as follows:

- Examine the socio-economic status of traditional fisherfolk in Kerala.
- Understand the extent of livelihood disruption faced by fisherfolk due to cyclones.
- Understand the nature, extent, and impacts of coastal erosion in fishing villages.
- Assess the adaptive capabilities of fisherfolk towards climate change.
- Examine the existing Government programmes to manage hazard risk in coastal areas and suggest improvements.

While the initial proposal gave a vast set of objectives to be completed as part of the project, the constraints of time, money, and personnel meant that the scope of the project was narrowed down to just covering the vulnerability of Kerala's coastal communities, and assessing existing coastal protection measures in the state.

.

Form 10
Part B

Report Profile

Work Methodology and Work Plan

Work Methodology & Research Plan

4.1. Setting of the study

Kerala's coastline of 593 km, spread over nine districts, is vulnerable to large-scale coastal erosion. In recent years, devastating cyclones originating in the Arabian Sea have also laid waste to the state's coastal belt. Yesodhara et al. (2007) have identified coastal erosion, tsunamis, and cyclones as chief natural disasters in Kerala, alongside floods, landslides, and droughts. Recent studies have shown that the Arabian Sea, which was less prone to violent tropical cyclones, has recently warmed up considerably, leading to a massive rise in the number of cyclones on India's West Coast (Deshpande et al. 2021, Murakami, Vecchi and Underwood 2019). Murakami, Sugi and Kitoh (2013) have also predicted that the pattern of tropical cyclones is likely to change in the North Indian Ocean (NIO) region from the Bay of Bengal to the Arabian Sea, especially in the post-monsoon period from October to December.

Kerala's coastline is not uniform throughout its entire length. The state's coastline can be divided into five sediment sub-cells, as followed by NCSCM (2014) and the study by Chenthamilselvan (2019). A sediment sub-cell is defined as "*the length of the coastline and its associated near-shore areas where movement of sediment is largely self-contained*". The stability of a coastline, which is primarily governed by the coastal processes prevailing in the area, is also significantly determined by the sediment budget and transport rate. The five divisions based on sediment sub-cells along the Kerala coastline are as follows:

- Sub-cell I: Kovalam to Thangassery Fishing Harbour
- Sub-cell II: Thangassery fishing harbour to Cochin port
- Sub-cell III: Cochin Port to Moodadi

- Sub-cell IV: Moodadi to Ettikulam
- Sub-cell V: Ettikulam to Manjeshwar

4.2. Sampling Framework

The study uses a multistage stratified random sampling method that identifies the number of fishing villages in each district at the first stage. In the second stage, the number of fishing villages affected by coastal erosion and cyclones is taken and stratified into urban and rural areas. After consultation with other experts including Dr S Harikumar (Professor Emeritus, Department of Applied Economics, CUSAT), and Dr M G Manoj (Scientist (D), ACARR, CUSAT), 5-6 villages affected by erosion were taken, carefully considering the geographical spread of the villages from north to south of the district. Data collection was undertaken between January and October 2023 across the nine districts and was divided into two phases. The first phase covering Thiruvananthapuram, Kollam, Alappuzha, Ernakulam, and Thrissur districts was completed between January and May 2023. Phase – II of the data collection in Malappuram, Kozhikode, Kannur, and Kasaragod was completed between June and October 2023.

Previous primary-level studies including Sangeetha (2011) and Rajeeve (2015) have taken around 10 per cent of fishing villages in each district for sample estimation. The present study follows a similar pattern for identification of villages; however, the present study requires a greater geographical distribution of fishing villages due to the spread of erosion zones along the coastline of each district. Therefore, roughly 20-25% of fishing villages in each district have been covered. The total number of fishing villages estimated to be covered in Kerala is 52, which is 23.6 per cent of all marine fishing villages in Kerala. The study also covers fishing villages in 4 of 101 Local Self-Governing bodies in Kerala, including five out of six municipal corporations.

The state was divided into three zones, each with varying levels of coastal erosion according to Parvathy et al (2022). Since the three zones are different with differing levels and patterns of coastal erosion, a separate sample size was calculated for each. Since each region has more than 10,000 fisherfolk households, a separate sample size of 384 households was chosen. Cochran's formula was employed for sample size estimation given a large population greater than 10,000 households. The equation used is thus:

$$n_0 = \frac{Z^2pq}{e^2}$$

Where,

- e is the desired level of precision (i.e. the margin of error),
- p is the (estimated) proportion of the population that has the attribute in question,
- q is 1 – p.

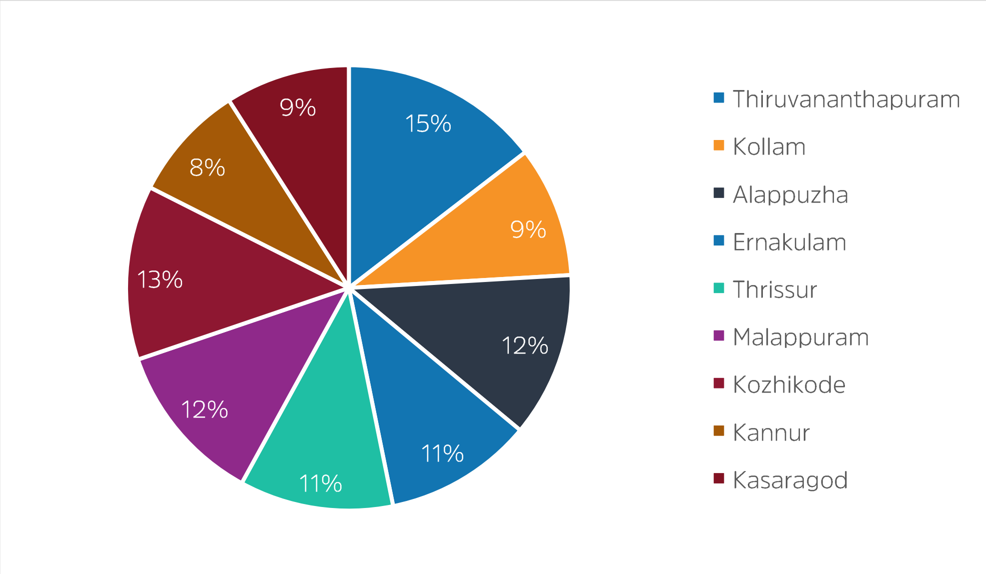
At 95 per cent confidence interval and 5 per cent error, the resultant sample size is

$$n_0 = \frac{\left((1.96)^2(0.5)(0.5)\right)}{(0.05)^2}$$

$$\Rightarrow n_0 = 384.14$$

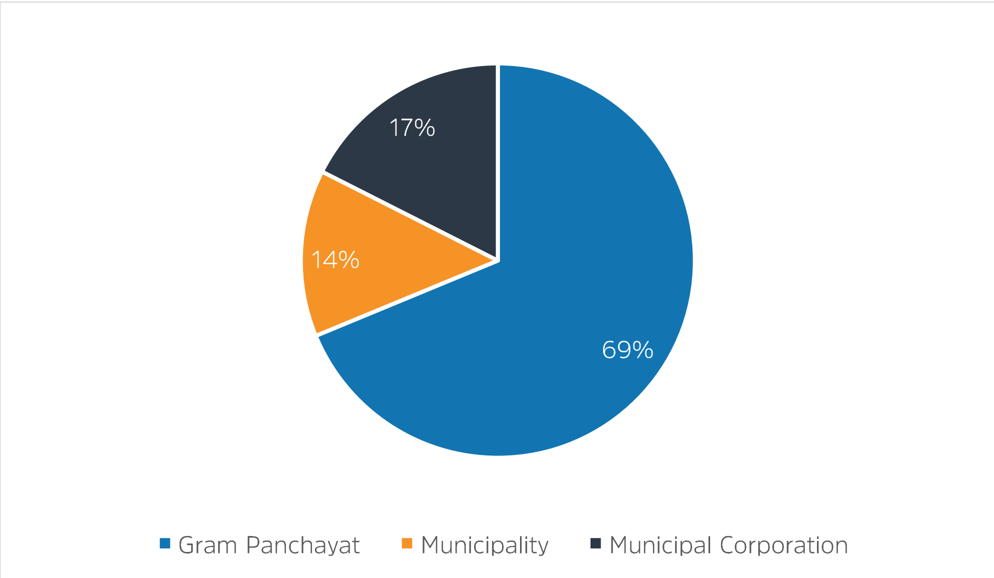
However, the number was exceeded in Southern and Central Kerala due to the higher population of fisherfolk and long coastlines. The total sample size for Southern Kerala is 458, and for Central Kerala it is 429. The estimated sample size for Northern Kerala is fixed at 384 due to the relatively low population in Kannur and Kasaragod districts. The total sample size across the nine districts is thus 1,271 households. Households were selected at random after fetching the list of fisherfolk from the local collectives of fishermen including the parish registers, mosque registers, and the Akhila Kerala Dheevara Sabha. The lottery method was used to identify the households at random and collect data. The spatial distribution of sample households according to the district, is given in figure 1.

Figure 1: Spatial distribution of Fisherfolk by district



Source: Primary Data

Figure 2: Spatial distribution of Fisherfolk by location



Source: Primary Data

Figure 2 shows the spatial distribution of the sample households by rural and urban areas. Slightly more than two-thirds of the sample are taken from rural areas across 31 Gram Panchayats. Of the remaining 397 households that are from urban settings, 44 per cent live in municipalities, while 56 per cent live in the five municipal corporations of Thiruvananthapuram, Kollam, Kochi, Kozhikode, and Kannur. The fishing villages surveyed from each district is given in tables 1, 2, and 3. From the Southern Zone, 19 villages across 12 LSGIs were selected. Urban villages in this zone include three villages in Thiruvananthapuram MC and two villages in Kollam MC.

Table 1: Fishing Villages Selected in Southern Zone

District	LSG	Fishing Village
Thiruvananthapuram	Kulathoor GP	Paruthiyoor
	Thiruvananthapuram MC	Vizhinjam Valiyathura Poonthura
	Chirayinkeezhu GP	Perumathura
Kollam	Anjuthengu GP	Anjuthengu
	Kollam MC	Mundakkal Kollam
	Neendakara GP	Neendakara
	Alappad GP	Vellanathuruth Parayakadavu Srayikad
Alappuzha	Arattupuzha GP	Valiyazheekkal Arattupuzha
	Thrikunnapuzha GP	Thrikunnapuzha
	Purakad GP	Thottappally Purakad
	Mararikulam South GP	Kattoor
	Kadakkarappalli GP	Ottamassery

Source: Primary Data

From the Central Zone, 17 villages across 15 LSGIs were selected. Urban villages in this zone include one village each in Kochi MC, Ponnani Municipality, and Tanur Municipality.

Table 2: Fishing Villages Selected in Central Zone

District	LSG	Fishing Village
Ernakulam	Chellanam GP	Chellanam Maravakad Kannamaly
	Kochi MC	Fort Kochi
	Njarackal GP	Njarackal
	Edavanakkad GP	Edavanakkad
Thrissur	Edavilangu GP	Edavilangu
	Thalikulam GP	Thalikulam
	Vatanappally GP	Vatanappally
	Kadappuram GP	Chettuva
	Punnayurkulam GP	Mandalamkunnu
Malappuram	Perumpadappu GP	Palappetty
	Veliancode GP	Veliancode
	Ponnani Municipality	Puduponnani
	Vettom GP	Paravanna
	Tanur Municipality	Edakadappuram
	Vallikunnu GP	Ariyallur Beach

Source: Primary Data

From the Northern Zone, 20 villages across 16 LSGIs were selected. Urban villages in this zone include two villages each in Thalassery Municipality and Kannur and Kozhikode MCs; and one village each in Koyilandy, Vadakara, Nileswar, and Kasaragod Municipalities.

Table 3: Fishing Villages Selected in Northern Zone

District	LSG	Fishing Village
Kozhikode	Kadalundi GP	Chaliyam
	Kozhikode MC	Beypore Puthiyappa South
	Koyilandy Municipality	Cheriyamangad
	Moodadi GP	Kollam-Moodadi
	Vadakara Municipality	Kuriyadi
	Azhiyur GP	Azhiyur
Kannur	Thalassery Municipality	Kurichiyil Chalil Gopalapetta
	Kannur MC	Thayyil Kannur City
	Mattool GP	Mattool
	Ramanthali GP	Palacode
Kasaragod	Valiyaparamba GP	Padannakadappuram Mavila Kadappuram
	Nileswar Municipality	Thaikadappuram
	Ajanur GP	Ajanur
	Kasaragod Municipality	Kasaba
	Kumbla GP	Koyippady
	Mangalpady GP	Shiriya

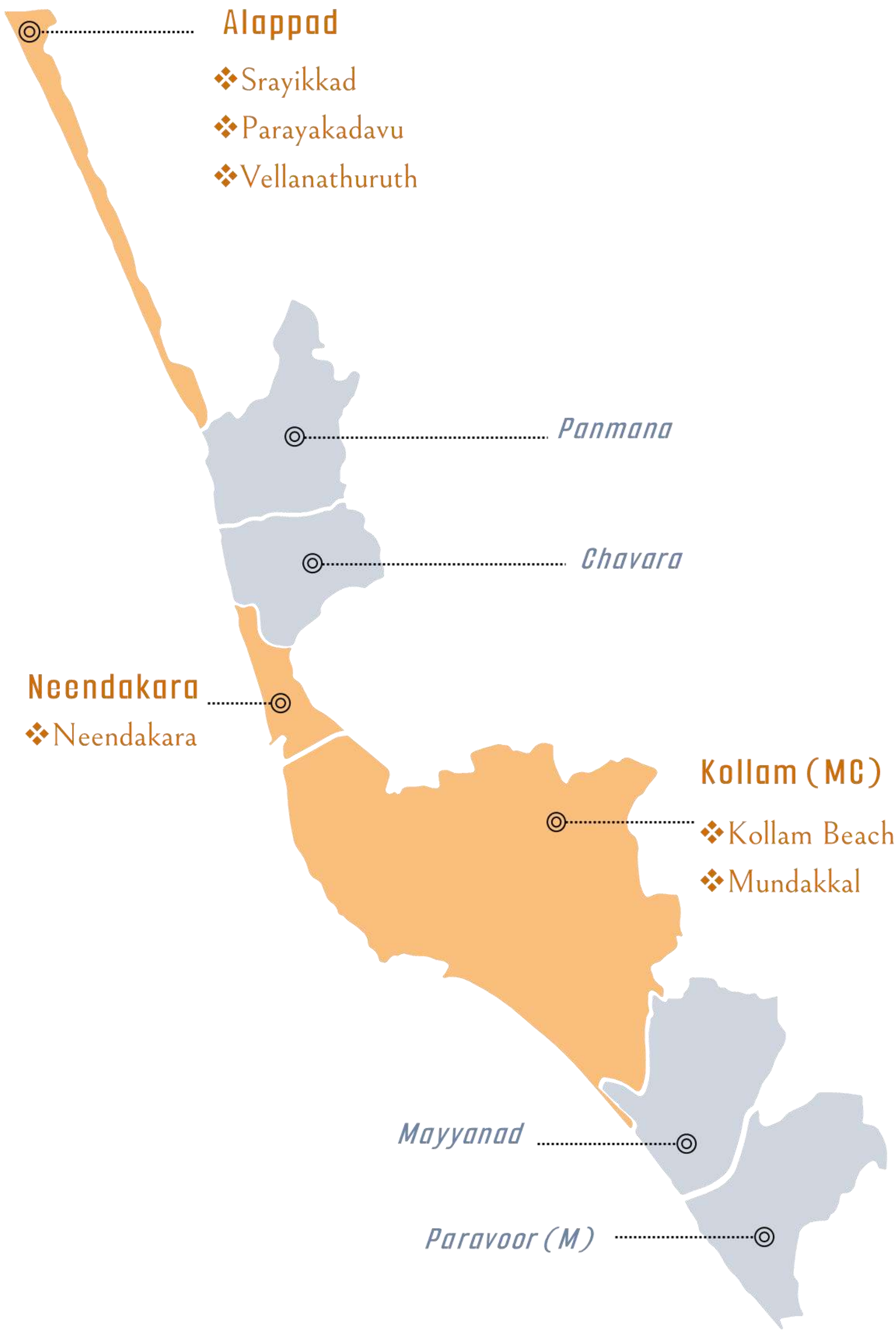
Source: Primary Data

The coastal maps for each district, highlighting the LSGIs and locations surveyed, are given in figures 3 to 11.

Figure 3: Coastal LSGI Map, Thiruvananthapuram

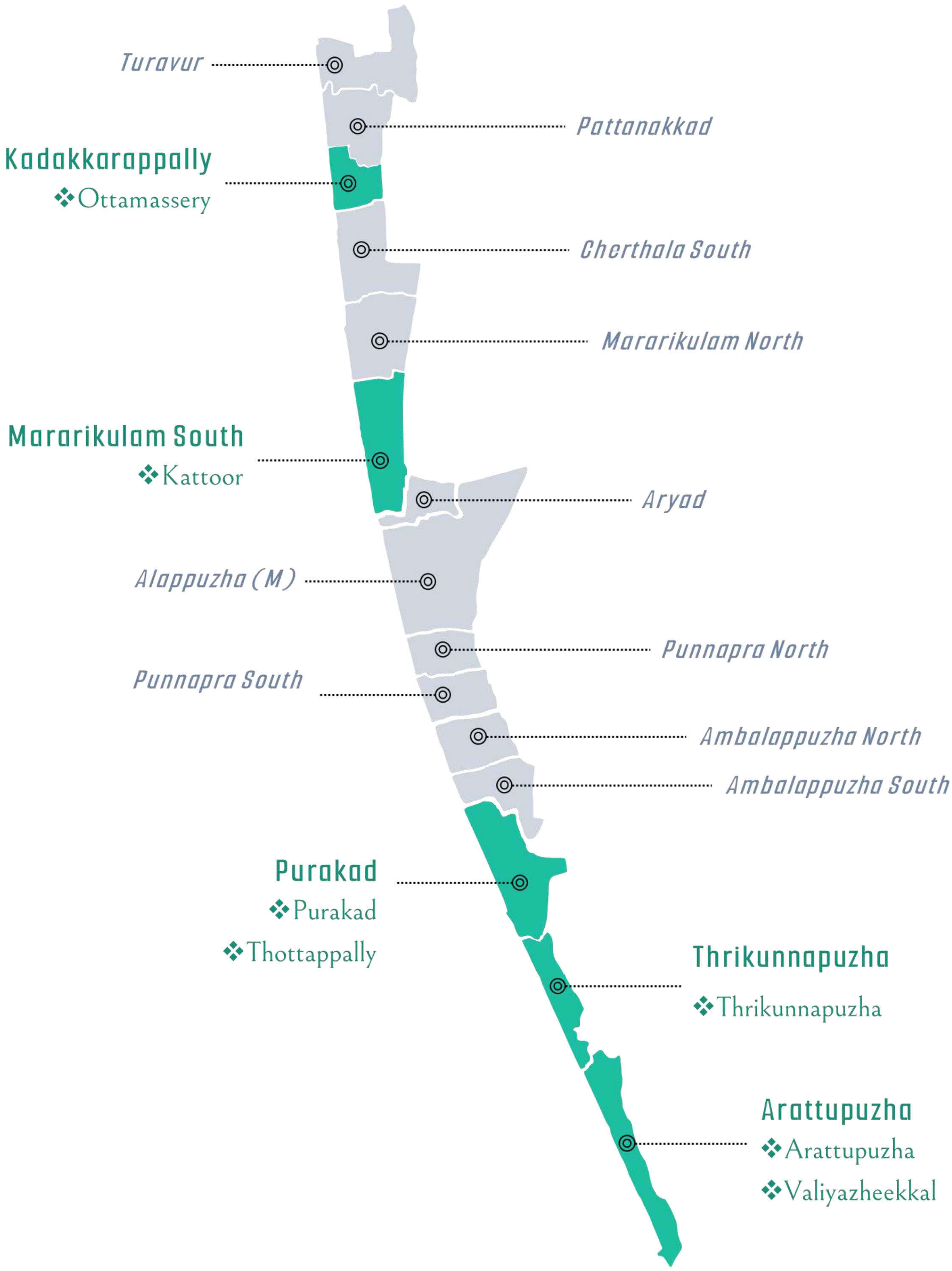
Source: Primary Data

Figure 4: Coastal LSGI Map, Kollam



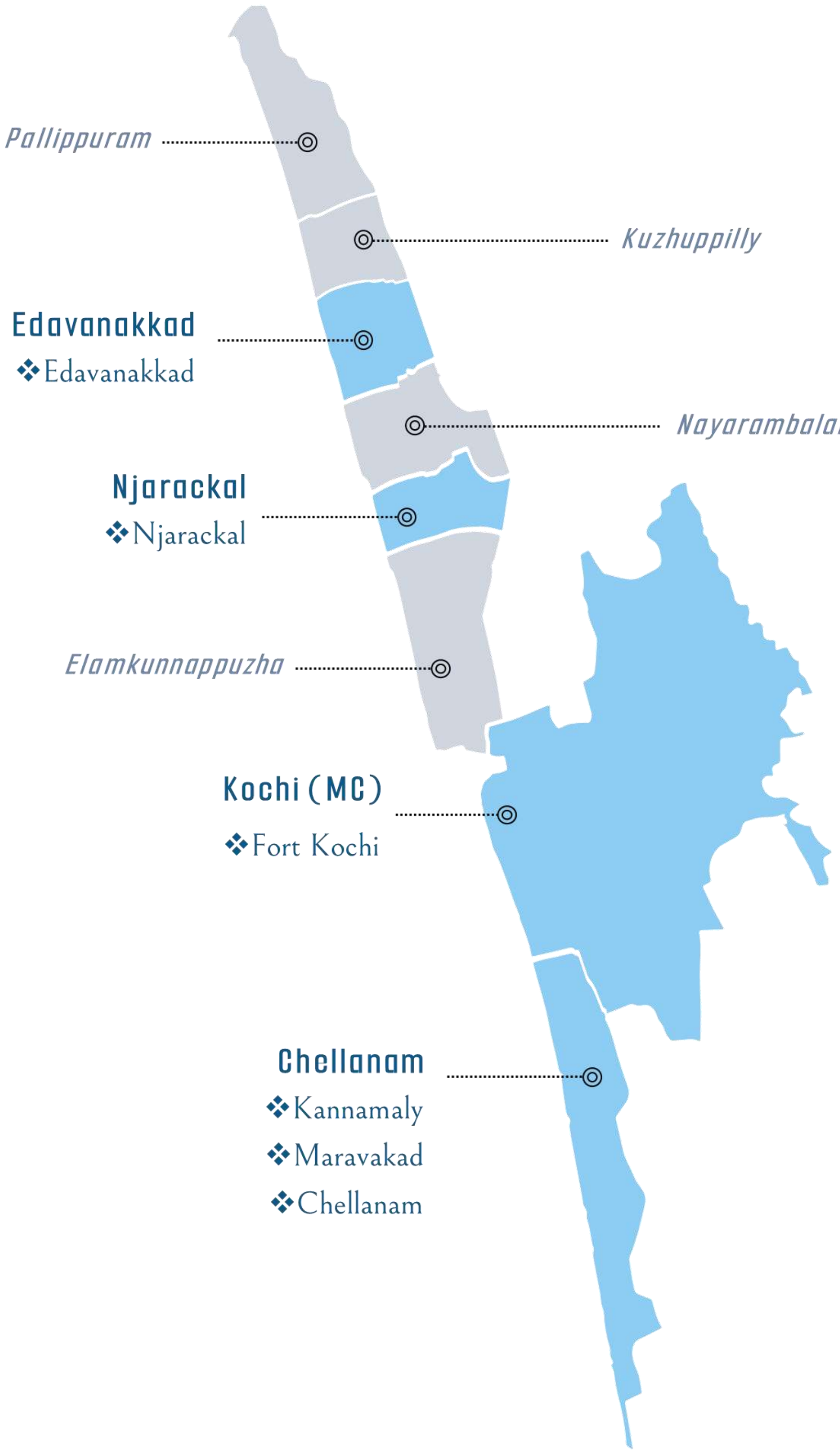
Source: Primary Data

Figure 5: Coastal LSGI Map, Alappuzha



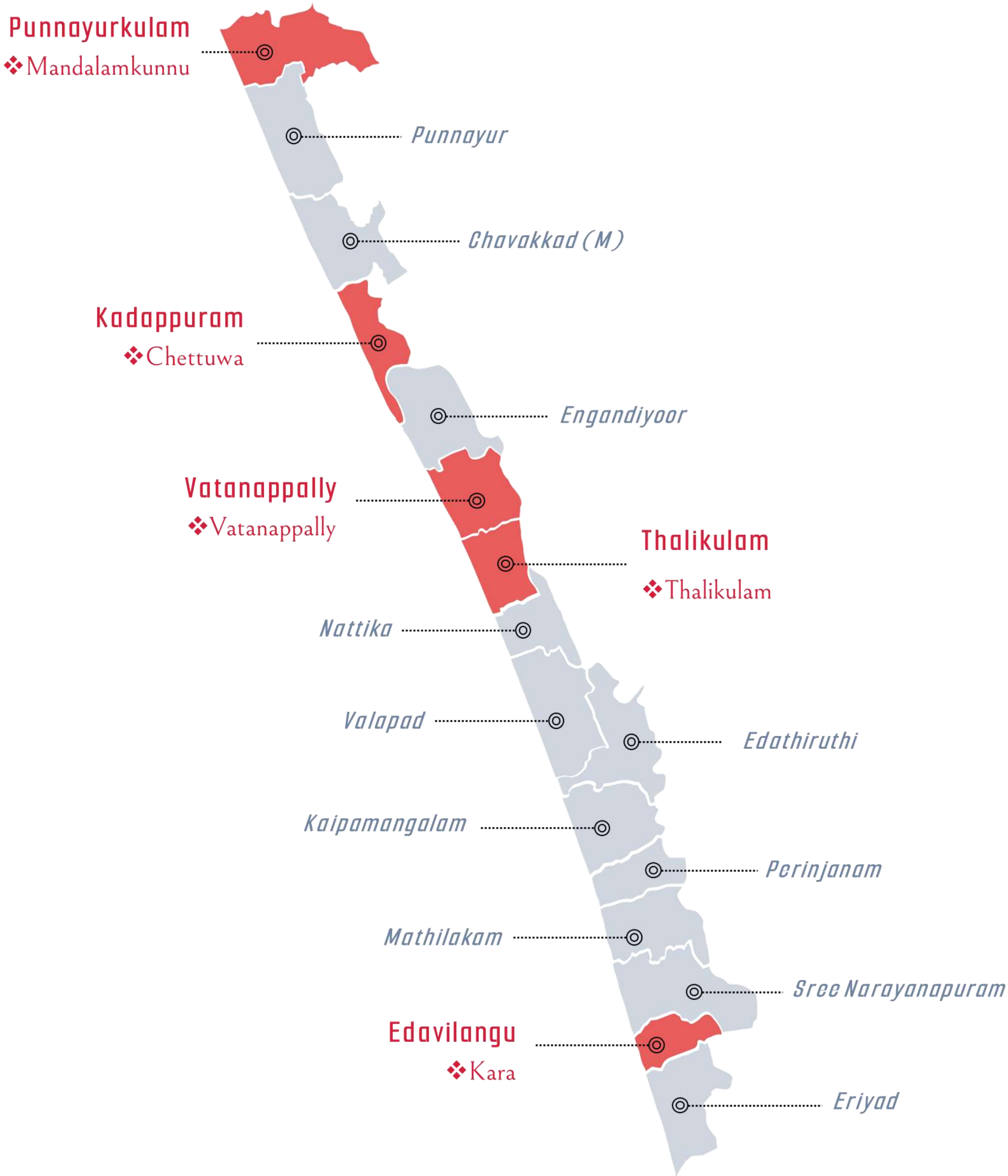
Source: Primary Data

Figure 6: Coastal LSGI Map, Ernakulam



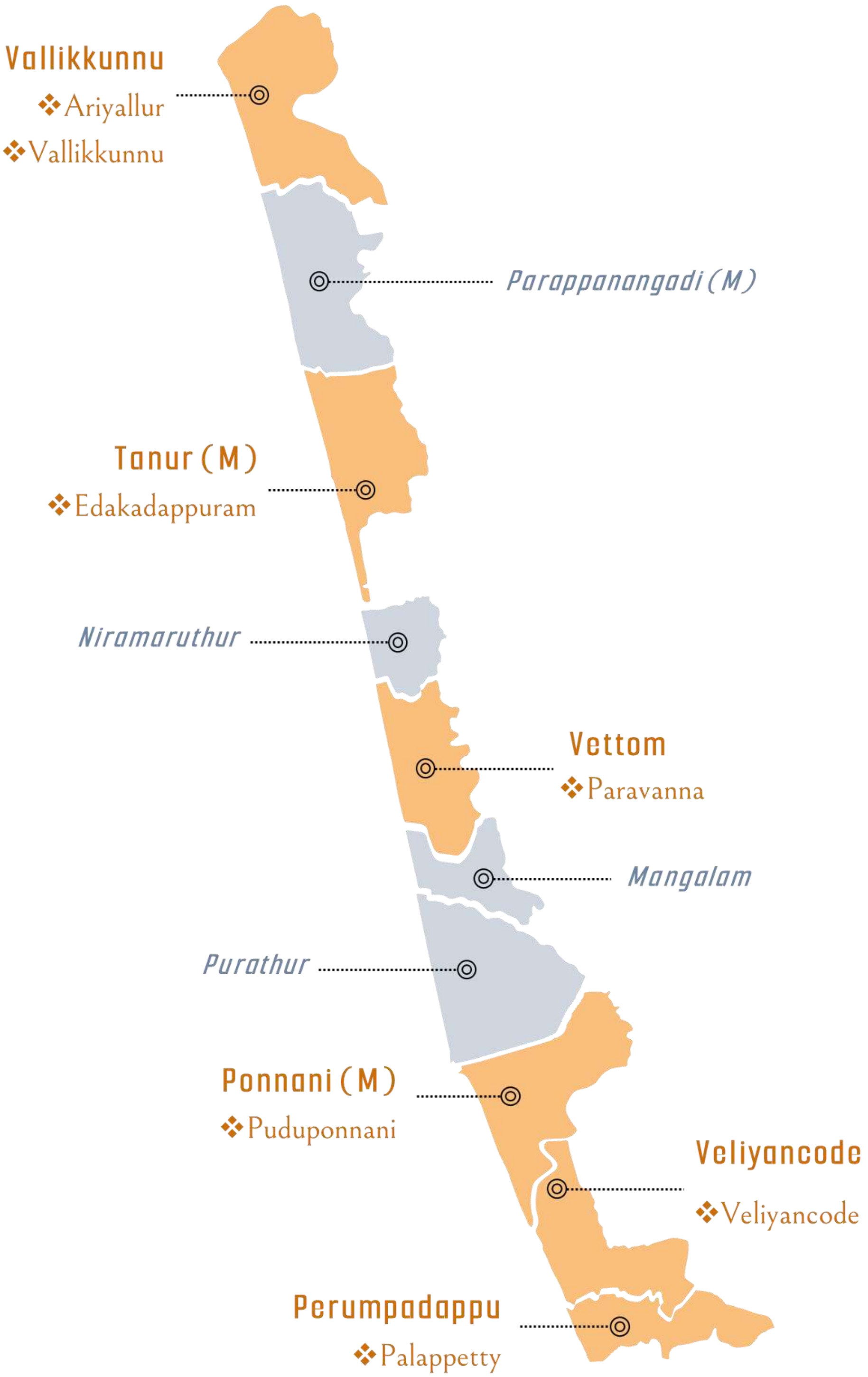
Source: Primary Data

Figure 7: Coastal LSGI Map, Thrissur



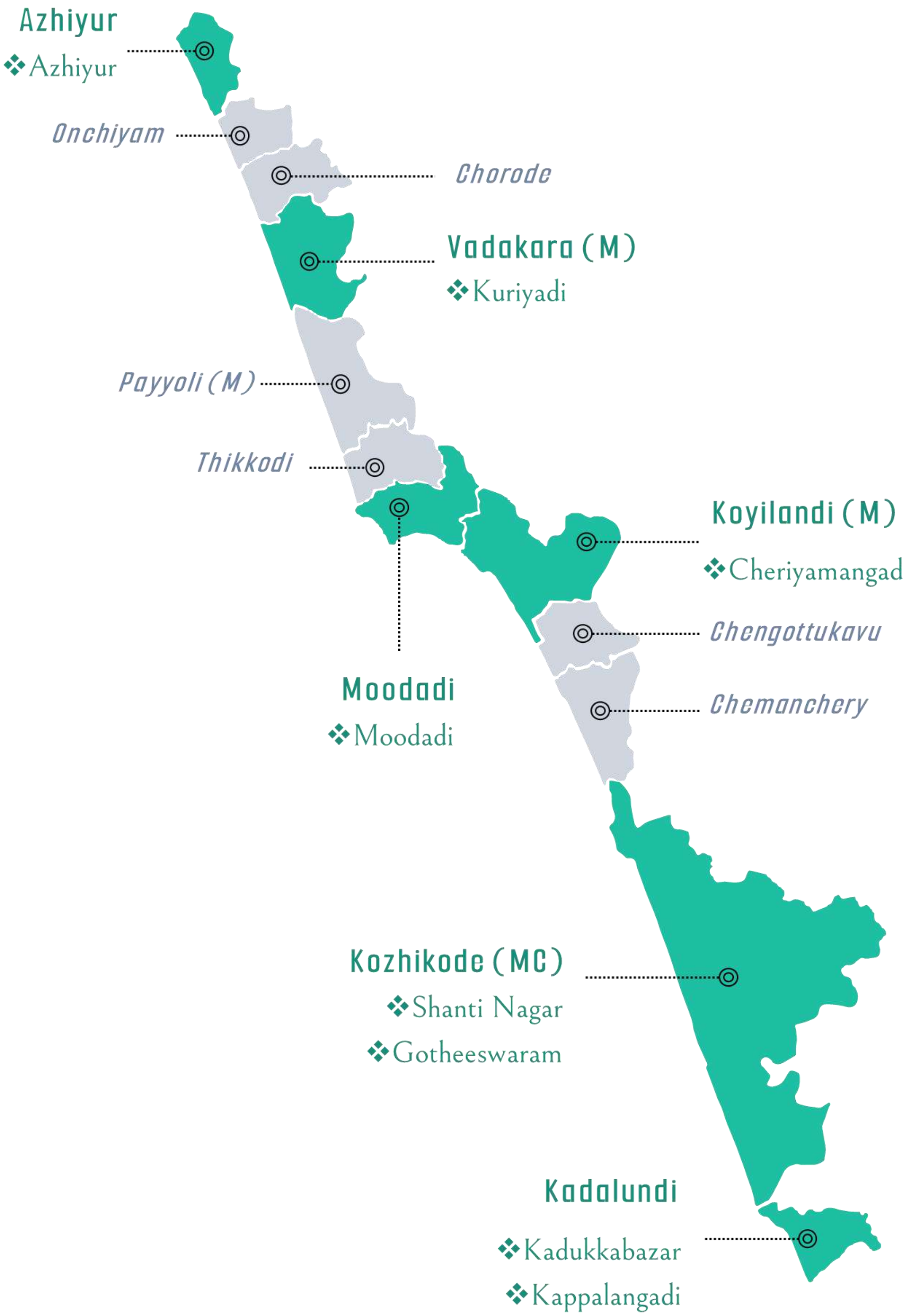
Source: Primary Data

Figure 8: Coastal LSGI Map, Malappuram



Source: Primary Data

Figure 9: Coastal LSGI Map, Kozhikode

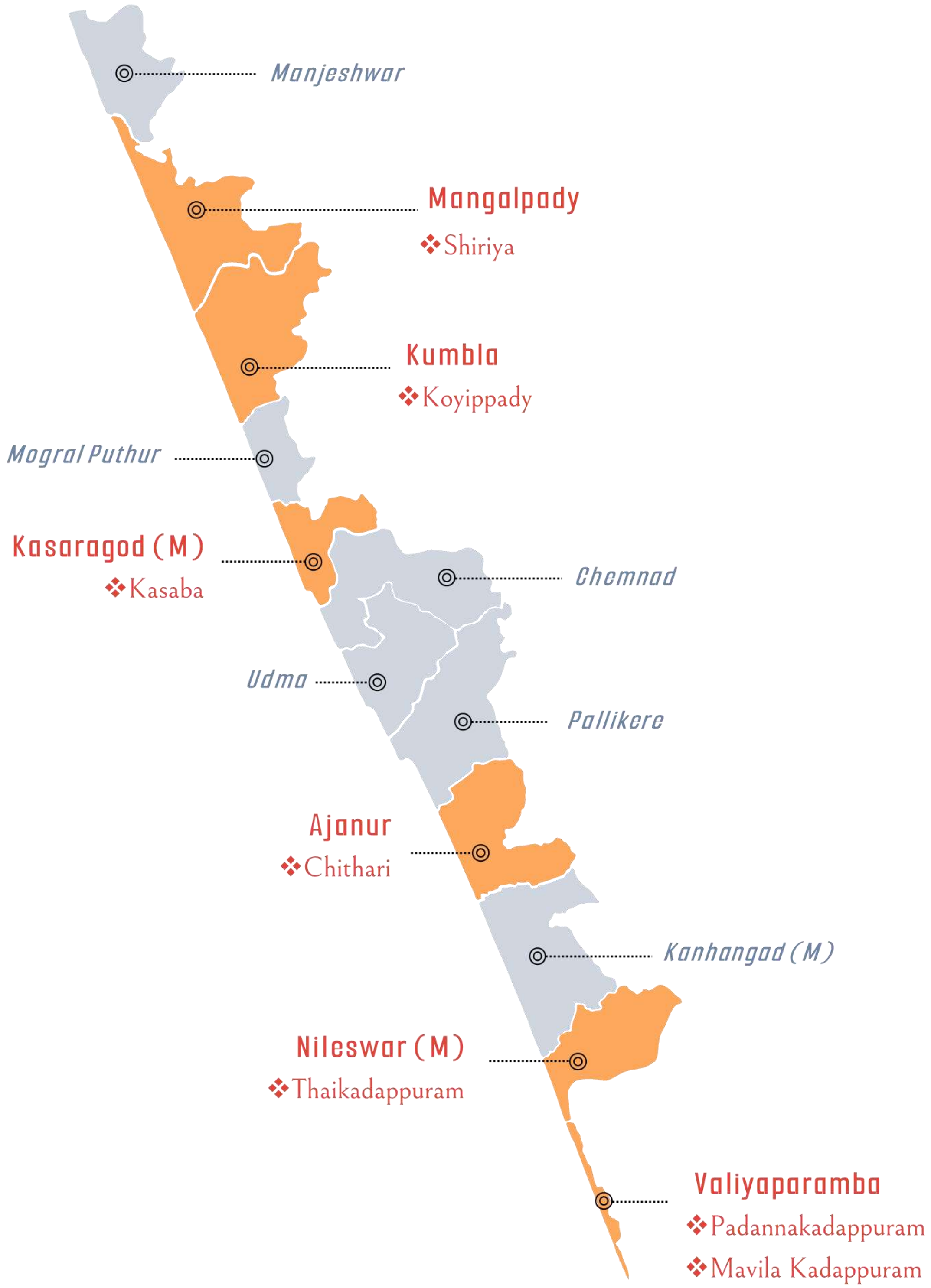


Source: Primary Data

Figure 10: Coastal LSGI Map, Kannur

Source: Primary Data

Figure 11: Coastal LSGI Map, Kasaragod



Source: Primary Data

4.3. Approaches to Climate Change Adaptation

In recent years, how societies react and adapt to disasters has been an area of interest for both scientists and social scientists. There are three principal approaches to assessing adaptation strategies against climate change – the hazards, vulnerability, and resilience approaches. The hazards approach tends to be environmentally deterministic as it emphasises how hazard events are triggered by geological, atmospheric, or other factors (Wisner et al., 2004). It focuses on how disasters are triggered and how they affect human lives without much importance to social systems and human behaviour. Since this approach considers disasters to be removed from human society, it has been termed "deterministic, ahistorical and asocial" by Dekens (2007). The tendency of the hazards approach to look at solutions after a natural hazard has occurred has led to widespread criticism. Lemos (2007), Dekens (2007) and Vogel et al. (2010) have noted that the hazards approach tries to treat a problem with temporary solutions rather than address the underlying factors that put communities at risk in the first place.

The vulnerability framework tries to address this shortcoming of the hazards approach by identifying local communities' issues and reducing those vulnerabilities to help them better cope with natural disasters. Studies employing the vulnerability approach have been used to identify factors that positively or negatively impact the effectiveness of adaptation policies (O'Brien et al. 2007). These include generic factors like education and income, location or hazard-specific factors like knowledge and access to technology, and social capital or networks that households utilise during a crisis.

O'Brien et al. (2007) have observed that vulnerability is often contextual, leading to varying degrees of adaptive capacity among different communities (Smit and Wandel, 2006). Case studies from Bangladesh (Alam and Collins 2004), Tanzania (Paavola 2008) and India (O'Brien et al 2004) show that factors like poverty, gender, and socio-economic inequality are associated with vulnerability in developing countries that deal with natural disasters like cyclones, floods, and droughts. In the specific case of coastal communities affected by cyclones, Alam and Collins (2004) show that vulnerability arising from socio-economic factors is compounded by unplanned habitation along coasts, economic activity in hazardous locations, disrupted social networks and lack of infrastructure to escape from the disaster.

Vulnerability is often measured using indices, such as the Climate Vulnerability Index (CVI) outlined in Pandey and Jha (2012). Pandey and Jha employ the CVI among rural communities in the Lower Himalayas, and the index includes facets such as socio-demographic profile, livelihood strategies, social networks, health and food security, availability of resources, incidence and intensity of natural disasters, and climate variability.

The resilience approach is often used to assess the degree to which a community can absorb and combat the impacts of unanticipated external shocks. The resilience approach focuses on the agency of communities who are affected by natural disasters. It was initially developed by ecologists who placed it in the context of natural systems bouncing back to a state of normality from external shocks (Folke, 2006), but applying it as such to social systems led to short-term and reactionary policies (Davoudi, 2012).

The resilience approach in social science research helps in understanding how negative externalities stimulate latent adaptive capacities of communities and initiate systemic improvements in society (Nelson et al. 2007, Pelling and High 2005). Although the resilience framework may not be enough to explain all dimensions of human behaviour in the face of a disaster, it provides a way to piece together individual perceptions of welfare, impoverishment, and vulnerability to determine their agency. Such agency allows communities to learn, innovate, and constantly reconfigure the social system to better respond to future shocks (Tschakert and

Dietrich 2010, Folke, 2006; Nelson, 2011). Adger (2005) takes the case of coastal communities to illustrate that as a system diversifies its responses to shocks, it gains the ability to better withstand and adapt to externalities. These diversified set of actions include sustainable use of ecosystem functions, diversification of livelihoods, improvement of governance structures and social capital, improved social cohesion, and learning from previous experiences. These views are also echoed by Bahadur, Ibrahim, and Tanner (2013).

4.4. Analytical Framework

The study aims to produce an interdisciplinary framework to assess vulnerability and social resilience of the fisherfolk in Kerala. Multiple studies have attempted to create such frameworks in locations like Canada and Myanmar, but no such study exists for vulnerable coastal populations in an Indian state.

Most studies that employ the vulnerability analysis tend to stick to the IPCC-AR4 model which used the exposure, sensitivity, and adaptive capacity axes to assess vulnerability. Vulnerability assessments are today considered an improvement over traditional climate impact assessments (Soares et al 2012), due to their focus on socio-economic and systemic factors that accentuate the risk faced by communities. They are considered part of a bottom-up approach to climate mitigation and adaptation, with significant focus laid on the capabilities of communities to adapt to changing situations (Fussel and Klein 2006, UNFCCC, 2005). The present study implies vulnerability to be an indicator of possible future harm a system might suffer, in line with Hinkel (2011).

Vulnerability studies for coastal communities that use an integrated approach include Mclaughline et al (2002), McLaughlin and Cooper (2010), Preston et al (2008), King (2001), Greenan (2019), and Kleinosky et al (2007). Other studies on coastal vulnerability that are based primarily on physical or natural factors include Gornitz (1991), Torresan et al (2008), Yohe and Tol (2002), Dwarakish et al (2009), Duriyapong and Nakhapakorn (2011) and Bonetti et al (2013). The latter group of studies completely discount socio-economic variables, while the former group are far more comprehensive frameworks. There are also studies that are based purely on socio-economic variables and not generally applied to coastal contexts, that generally adopt a Social Vulnerability Index. These studies include Cutter et al (2003), O'Brien and Mileti (1992), Handmer et al (1999), and Moss et al (2001). Other vulnerability studies that loosely follow the IPCC framework in an integrated approach include Adger et al (2004) and Brooks et al (2005).

Certain studies that use a vulnerability framework deviant from the IPCC framework include Cinner et al (2018) Peduzzi et al (2001) and Peduzzi et al (2003) who employed an Environmental Vulnerability Index, Sullivan (2002) and Sullivan et al (2003) who used a Climate Vulnerability Index to assess water poverty, Briguglio (2003, 2004) who use a Composite Vulnerability Index in the context of small island countries, and Schröter (2004a, 2004b) who used the vulnerability framework for mainland European countries. One of the biggest highlights of the above studies it that they are all based on macro-level data and calculated at the global or national levels.

Assessing vulnerability at a micro-level is a more recent development in the field. Some prominent studies that utilize a micro-level vulnerability framework include Pandey and Jha (2011) who considered the case of agrarian communities in the Lower Himalaya in India, and Hahn et al (2008) who used it in the African context in Mozambique. Other studies include Thiault et al (2018) in French Polynesia, Cochrane et al (2019) in Madagascar, Huynh et al (2021), Nguyen et al (2017), Can et al (2013) Vietnam, Khan (2021) in Pakistan, Nor Diana et al in Malaysia (2019), Shah et al (2013) in Trinidad, Zhang et al (2019) in China, Ahsan and Warner (2013) in Bangladesh, Etwire et al (2013) and Adu et al (2018) in Ghana, Asfaw et al (2021) in Ethiopia, and Tun Oo et al (2018) in Myanmar. These studies rely in extensive socio-economic surveys among target groups before framing the vulnerability index in line with the

IPCC AR4 framework. The present study follows in the footsteps of the above studies, with Hahn et al (2008) used as the basis to calculate the Livelihood Vulnerability Index, and Khan et al (2021) to calculate a Climate Change Vulnerability Index.

4.5. Ethical Guidelines Followed

The present work of research is an extensive study done across Kerala. Several ethical problems can arise when one works as a researcher in the social sciences. With this realization, ethical guidelines were followed strictly during all stages of data collection during the survey and the qualitative fieldwork. The ethical guidelines pertain to seeking the respondents' consent and following environment-friendly steps in data collection.

4.5.1. Informed Consent Process

Consent of the respondent is an essential part of data collection. The purpose of the research and the nature of the interaction between the researcher and the respondent. The respondent's consent was always sought before collecting data during the field survey. The consent here was primarily oral, with the responses recorded using the data collection device. The households were given information on the various questionnaire sections before the data collection process to maintain transparency. The respondents were given a choice to not answer questions in the survey or to quit the survey altogether if they felt uncomfortable or their privacy compromised in any instance.

4.5.2. Participant Data Confidentiality

In order to safeguard the identities of each respondent in the field survey, no names or contact information was collected. Instead, each respondent was given a household code depending on the panchayat, municipality, or municipal corporation in which they resided. The household code also masks additional data collected from the households, such as sex, education attainment, and age, ensuring that individual families are not easily identified. All the primary data collected as part of the study will be held confidentially in an encrypted folder within the cloud drive of the principal investigator. It will be used only for academic purposes, including this thesis and any research papers based on it, and will not be shared with any third parties at any point in time. The principal investigator will store the primary data in the form of the quantitative dataset, photographs and audio-video recordings for a maximum of three years. It will be summarily destroyed after three years to prevent a data breach of any sort.

4.5.3. Data Collection Tools

It was envisaged that the project would be carried out entirely in a paperless manner. Interview guides and associated documents were stored and used with the help of electronic mobile/tablet devices. For the questionnaire-based field survey, the data collection process was followed using digital tools such as Kobo Toolbox with server-side support provided by the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA). It is a comprehensive, open-source data collection tool operated on Android devices using the Kobo Collect application or Enketo on any modern web browser. The application allows for simultaneous online-offline data collection, thus enabling smooth workflow even in areas with poor or no network coverage. Kobo Toolbox is supported and endorsed by institutions such as Harvard Humanitarian Initiative, UN OCHA, the UN Refugee Agency (UNHCR), the United Nations Development Programme (UNDP), and World Food Programme, among others.

4.6. Working Definitions

The definitions used in the study follow the Marine Fisheries Census 2016, conducted by the Central Marine Fisheries Research Institute (CMFRI, 2016). The definitions are as follows:

- **Fishing Village:**

An assemblage of houses/dwelling place where marine fishermen live, which is recognized by the state fisheries department. A settlement of households which comes under a separate village-panchayat is a Hamlet.

- **Fish Landing Centre:**

  A place or harbour where fishermen land their fishing craft with catch.

- **Household:**

  A household consists of a person or a group of persons, who live together in the same house (pucca/kutcha), share the same housekeeping arrangements and are catered as one. It is important to remember that members of a household are not necessarily related (by blood or marriage) as, for instance, maidservants may form part of household. On the other hand, not all those related in the same house are necessarily members of the same household, two brothers while living in the same house with their wives and children may or may not form separate households depending on their catering arrangements. Thus, in many cases, a house may be broken into separate households (families).

- **Marine Fisherfolk:**

  A person (male/ female/LGBTQ) who is engaged in marine fishing or any other activity associated with marine fishery or both.

- **Traditional Fisherfolk:**

  Those who are fisherfolk by birth and fishing is their ancestral occupation.

- **Fisherfolk Family:**

  A family in which at least one member is engaged in marine fishing or associated activities or both.

- ***Pucca/Kutcha* House:**

  A pucca house is one, which has walls made of burnt bricks, stones (packed with lime or cement), cement concrete, timber etc. and roof made of tiles, galvanised corrugated iron sheets, asbestos cement sheet, reinforced brick concrete, reinforced cement concrete and timber etc. Any structure other than Pucca house is termed as Kutcha house.

- **Non-motorized Craft:**

  Any fishing craft that does not use any kind of machine power for propulsion as well as fishing operation.

- **Mechanized Craft:**

  Any fishing craft with engine permanently fitted to the hull, which uses machine power for both propulsion as well as fishing operation like casting and pulling the net, operating lines, etc., is identified as mechanized craft.

- **Inboard Craft:**

  Any fishing craft that has an engine
  permanently fitted to the hull or central portion of the craft, which is used only for propulsion and not for fishing operation, is identified as Inboard craft.

- **Motorized (Outboard) Craft:**

  Any fishing craft that has an engine fitted temporarily outside the craft, which is used only for propulsion and not for fishing operation, is identified as motorized craft.

4.7. Categories of Schedules

Two schedules were designed to be used in the study. Schedule-I collected household details, while Schedule-II was used to collect individual details.

4.7.1. Schedule – I: Household details

- Respondent Identifiers:
  - Household Code
  - Age
  - Sex

- Location
  - GPS co-ordinates

- Rural/urban status
- Village and LSG body

- Socio-Demographics
  - Religion
  - Caste
  - Poverty line status (ration card)
  - Family size (gender-wise details of adults and children)

- Asset ownership
  - Housing status (own/rental/ancestral/homeless)
  - House type (kutcha/pucca)
  - Land holding (in cents)
  - Electrification status
  - Cooking fuel
  - Vehicles and household durables
  - Gold

- Water and Sanitation
  - Access to potable water
  - Water sources
  - Water shortages
  - Access to toilets

- Consumption
  - Food consumption
  - Fuel expenses
  - Toiletries
  - Utilities (electricity, cooking gas, cable tv and water)
  - Phone and internet
  - Education
  - Healthcare
  - Other miscellaneous expenses

- Saving and indebtedness
  - Saving status
  - Indebtedness status

- Sources of debt
- Purpose of debt
- Average monthly repayment

- Fishing Status
  - Fishing/non-fishing household
  - Nature of fishery
  - Primary fishing strategy
  - Experience with traditional fishing of primary breadwinner
  - Duration of fishing (hours at sea)
  - Duration of fishing (person days per week)
  - Primary channel of marketing

- Ownership of fishing crafts (type and number of crafts owned)
  - Mechanized crafts
  - Motorized traditional crafts
  - Non-motorized traditional crafts

- Ownership of Fishing Gear
  - Engine
  - Fishing nets
  - Hook and line
  - Ice box
  - Other equipment

- Livelihood Diversification
  - Number of individuals in other occupations
  - Nature of occupation
  - Participation in SHGs
  - Economic activity done by SHGs
  - Participation in MNREGS
  - Activity pursued under MNREGS

- Migration status
  - Number of external migrants
  - Migration destination
  - Nature of employment

- Monthly remittances

- Food Security
  - Dependency on subsidized food
  - Access to PDS
  - Incidence of food shortage
  - Receipt of relief kits
  - Subsistence agricultural practices

- Health Status
  - Chronic illnesses
  - Disability
  - Exposure to communicable diseases
  - Nearest health facility
  - Access to health facility

- Social Security & Welfare Schemes
  - Life insurance status
  - Health insurance status
  - Beneficiary of Govt. schemes
  - Social security pension status
  - Receipt of housing assistance under Punargaeham/LIFE Mission

- Social Linkages
  - Gift & receipt of non-monetary aid within community
  - Gift & receipt of monetary aid within community
  - Gift & receipt of aid from social collectives
  - Gift & receipt of aid from SHGs

- Impact of CC on Household
  - Exposure to cyclones
  - Exposure to coastal flooding
  - Loss of work due to adverse weather
  - Death of family member at sea

- Perceptions on Climate Change
  - Change in species landed

- Occurrence of new species
- Disappearance of traditional species
- Decrease in fish landings
- Change of seawater colour
- Increase in sea turbulence
- Increase in sea level
- Increase in sea temperature
- Increase in phytoplankton
- Increase in coastal upwelling
- Increase in humidity
- Increase in distance to fishing ground

- Coastal Management
  - Status of seawall
  - Nature of seawall
  - Flooding despite seawall
  - Coastal afforestation
  - Deployment of tetrapods
  - Perceived change in coastline (eroding/stable/accreting)

4.7.2. Schedule – II: Individual Details

- Age
- Sex
- Relation to head of the household
- Education attainment
- Economic activity
- Marital status
- Migration status
- Non-fishing skills

4.8. Research Plan

The project's timeline was divided into three phases. Phase-I, from June to December 2022 was used as the preparatory phase of the project, where preliminary field visits were undertaken to the nine coastal districts and the survey instrument was designed. Phase I also included collection of secondary data on climate trends, and the formulation of an analytical framework, and the pilot study.

Table 4: Work Timeline

Activity	Month																							
	Phase – I						Phase – II										Phase – III							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Literature Review																								
Secondary Data Collection																								
Tool Preparation																								
Preparatory Fieldwork																								
Rapport Building																								
Data Collection																								
Data Entry and Coding																								
Data Organisation																								
Data Analysis																								
Report Writing																								

S

Source: Primary Data

Phase-II was conducted from January to October 2023 and involved the primary survey of 1271 households across the nine coastal districts. The first part of Phase-II, dubbed Phase-II A, covered the districts from Thiruvananthapuram to Thrissur, and was completed by June 2023. Phase-II B, conducted in the four northern districts of Malappuram, Kozhikode, Kannur, and Kasaragod, was completed between July and October 2023. The data was cleaned, and basic analysis was performed in November 2023, ahead of the submission of the revised first year work report to the KSHEC. Phase-III of the project, which involved the compilation of the present technical report, was done after the fellow resigned from the Chief Minister's Nava Kerala Post-Doctoral Fellowship, between December 2023 and June 2024.

Form 10

Part B

Report Profile

Data Analysis:

Climate Patterns and Coastal Erosion

Climate Patterns and Coastal Erosion

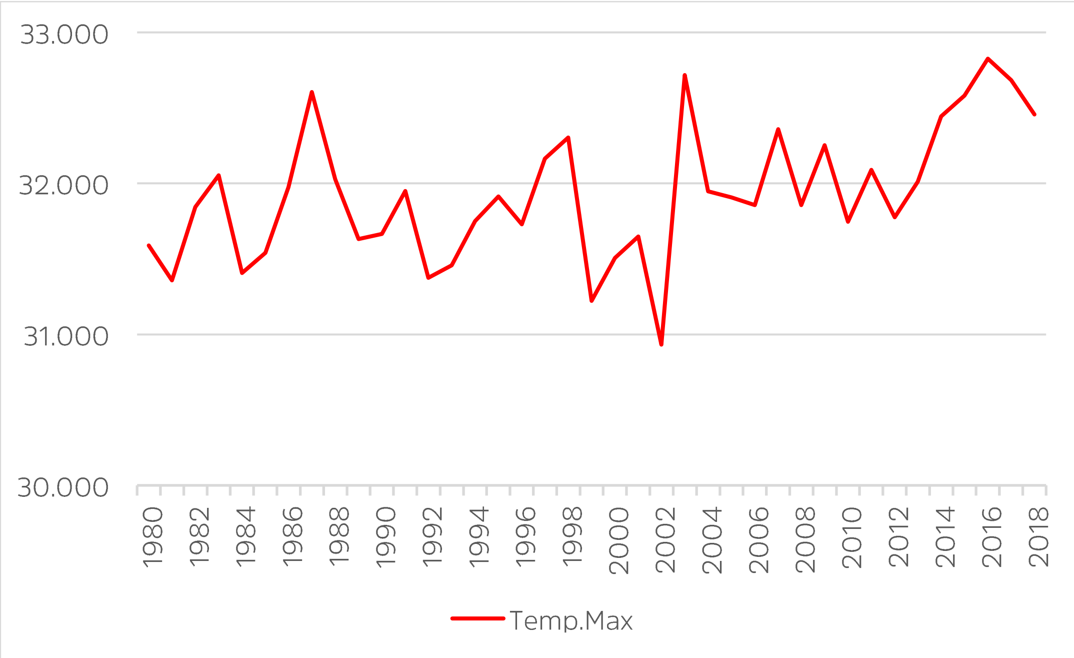
Global weather patterns have been shifting dramatically over the last forty years, and the situation in Kerala is no different. The state has witnessed shifting patterns of the monsoon, increased temperatures, and increasing incidence of extreme weather events, the most damaging of which have been the floods in 2018 (Abraham and Kundapura, 2022). The changing climate has caused several natural disasters in the state, particularly since 2015. These include floods in 2018 and 2019, droughts in 2016 and 2017, heatwaves, extreme precipitation, mini cloudbursts, and landslides.

The current section looks at the overall trend of changing climatic patterns over Kerala for a period from 1981 to 2022. The period of chosen due to availability of accurate data, particularly from geospatial satellites. Climate data from the observatories of the Indian Meteorological Department (IMD) at 12 locations across Kerala have also been analysed to understand the changing pattern of climate. In the case of data collected from the Institute for Climate Change Studies, data from 1901 to 2022 have been used.

5.1. Temperature

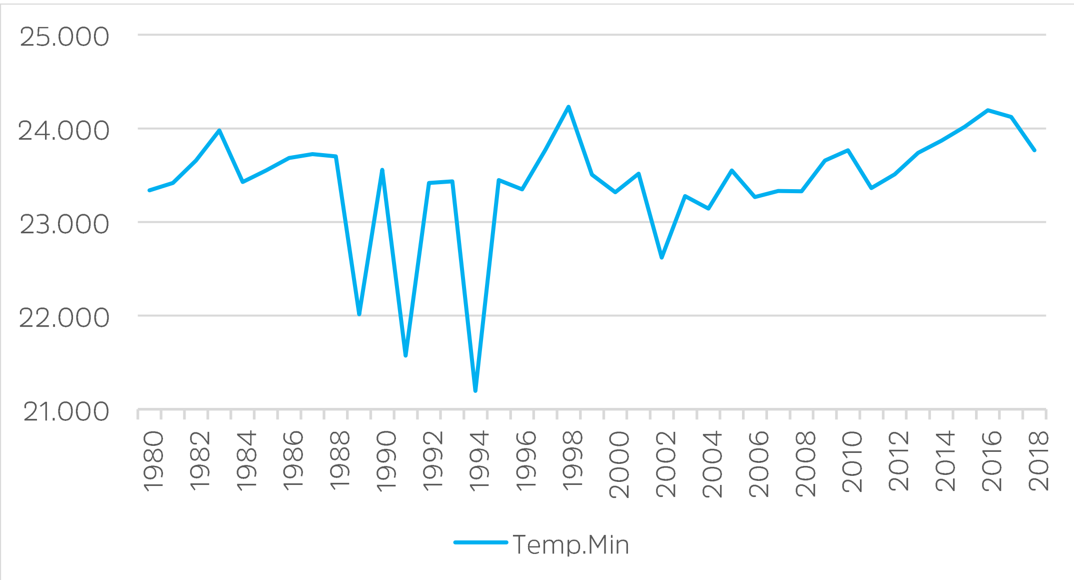
Since 1981, the average daily maximum and minimum temperatures have been rising in Kerala. Figures 12 and 13 represent the rising mean daily maximum and minimum temperatures, respectively. Despite fluctuations at various points during the nearly 40-year period, there is a steady upward trend visible for both daily maximum and minimum temperatures. In terms of instances where temperature anomalies were visible, the trend in Kerala has been rising continuously over the last 122 years.

Figure 12: Mean Daily Maximum Temperature (1980-2018)



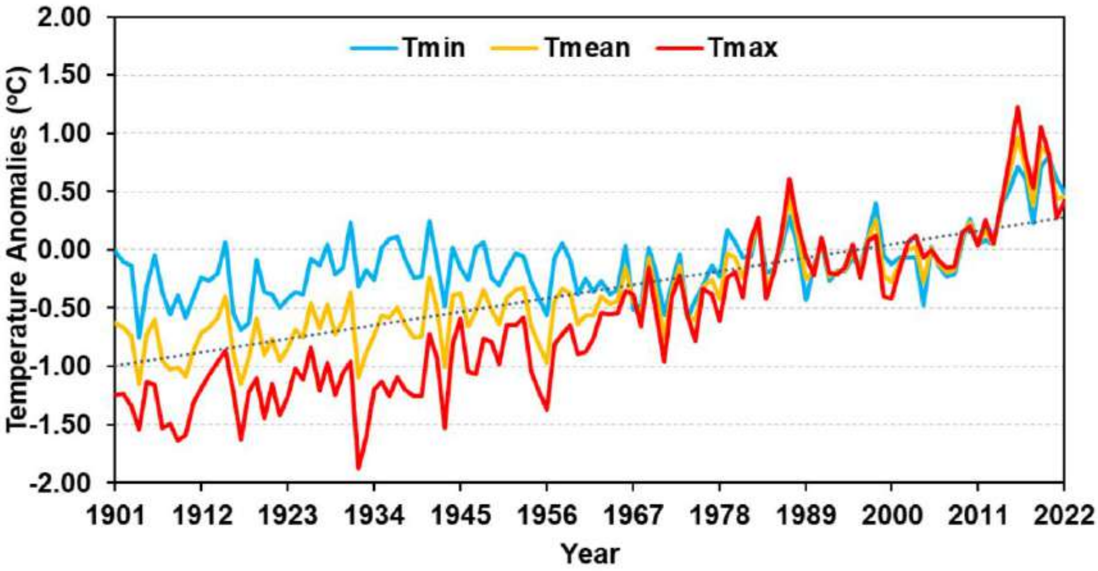
Source: IMD, Pune

Figure 13: Mean Daily Minimum Temperature (1980-2018)



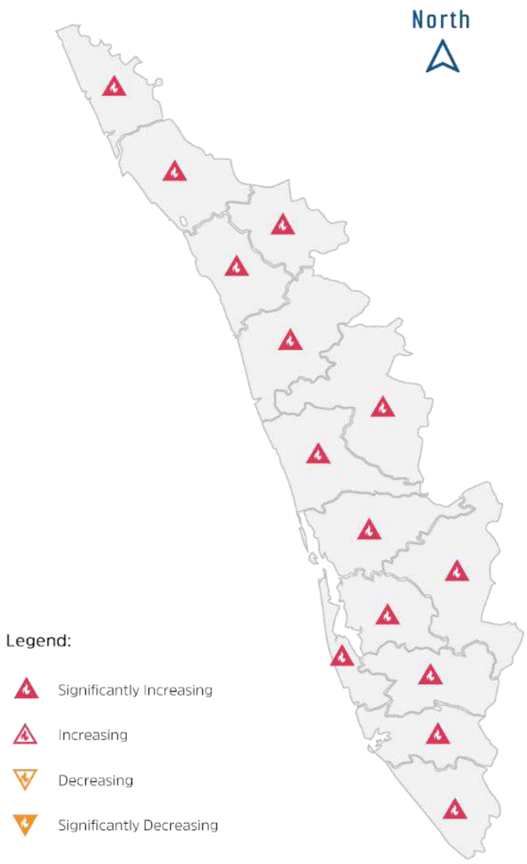
Source: IMD, Pune

Figure 14: Annual Temperature Anomalies Averaged over Kerala (1901-2022)



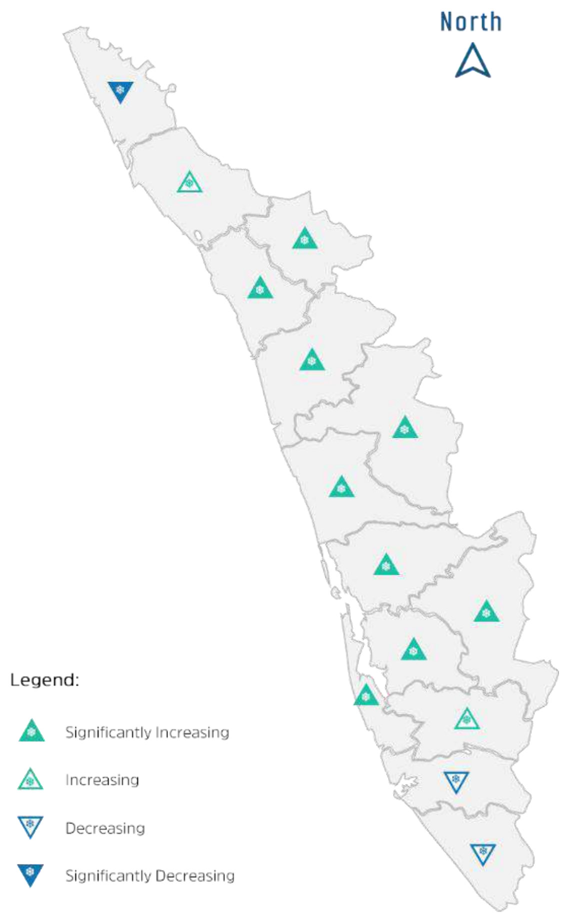
Source: Institute for Climate Change Studies (ICCS), Thiruvananthapuram

Figure 15: Annual Maximum Temperature Trend (1901-2022)



Source: Institute for Climate Change Studies (ICCS), Thiruvananthapuram

Figure 16: Annual Minimum Temperature Trend (1901-2022)



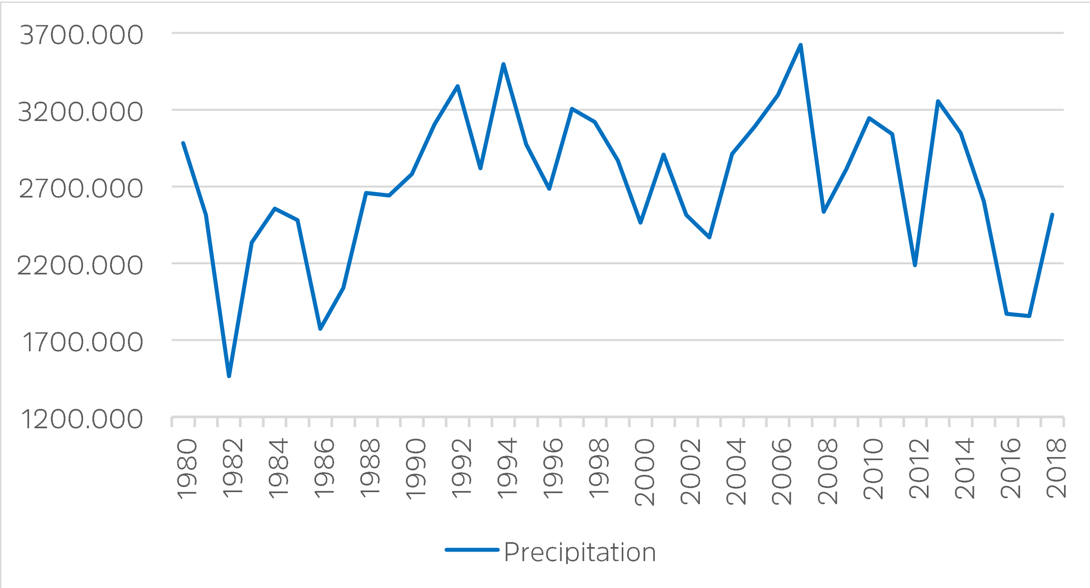
Source: Institute for Climate Change Studies (ICCS), Thiruvananthapuram

Analysing the trend in temperature across the fourteen districts reveals that the daily maximum temperature has risen significantly across the state. In the case of daily minimum temperature, nine districts have seen a significant increase, and two districts have seen a moderate increase. The minimum temperature has declined in only three districts – Thiruvananthapuram, Kollam, and Kasaragod – over a period from 1901 to 2022.

5.2. Rainfall Pattern

In terms of rainfall pattern, annual precipitation in Kerala has been highly erratic since 1980. There have been several fluctuations in the rainfall pattern, with short 4-5 year periods of increasing rainfall being followed by periods of falling precipitation. The data pertaining to deviation from the long period average (LPA) of rainfall in Kerala from 1901 in both the South-West (SWM) and North-East (NEM) Monsoon seasons also shows a highly erratic pattern. The long-period analysis from 1901 to 2022 indicates that across Kerala, the total annual precipitation has been declining. In the case of the NEM season, the declining trend is seen across the board in all districts except Kasaragod, while in the case of the SWM, it has been declining in all districts except Idukki.

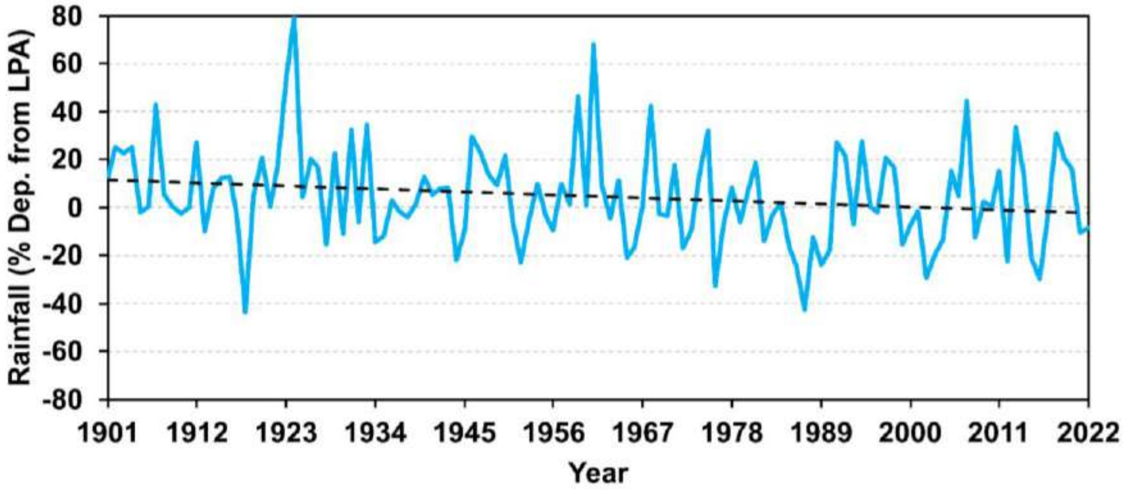
Figure 17: Annual Rainfall in Kerala (1980-2018)



Source: IMD, Pune

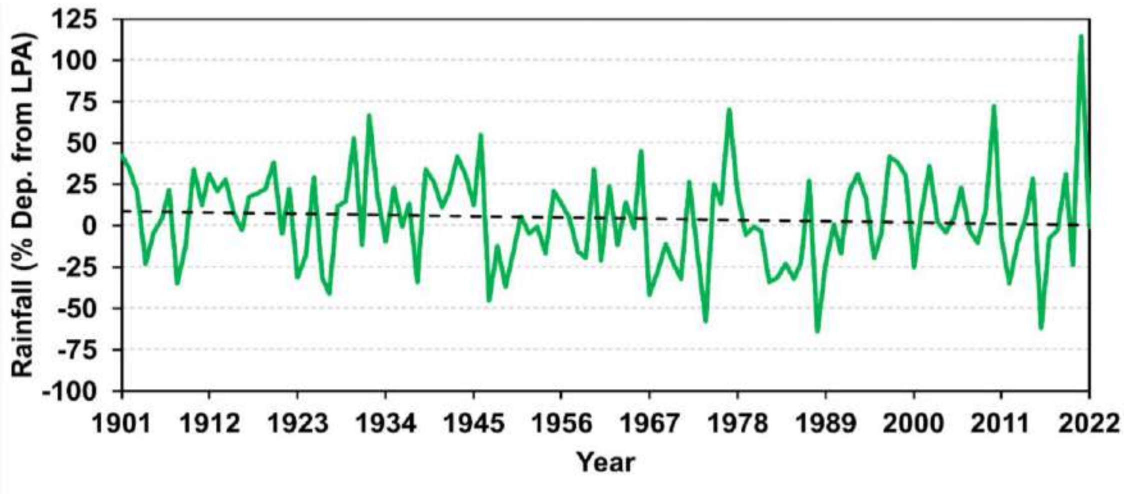
The decrease in rainfall during the SWM is highly significant in Kannur, Wayanad, Malappuram, Palakkad, Alappuzha, and Kollam. The decline is similarly highly significant in Palakkad and Kottayam for the NEM season. While the overall rainfall has declined in Kerala, data indicates that in recent years, the number of episodes with heavy to extremely heavy rainfall have been rising in the state. Figure 2.10 shows the sharp rise in number of incidents of heavy (64.5 – 115.5 mm), very heavy (115.5 – 204.4 mm), and extremely heavy rainfall (>204.4 mm) in Kerala between 2015 and 2021.

Figure 18: Southwest Monsoon Season Rainfall Averaged over Kerala (% Departure from LPA: 1901 – 2022)



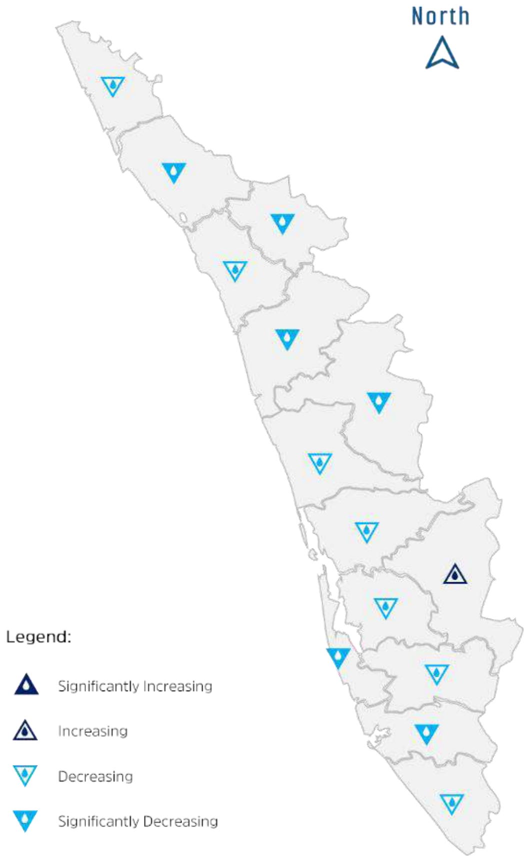
Source: Institute for Climate Change Studies (ICCS), Thiruvananthapuram

Figure 19: Northeast Monsoon Season Rainfall Averaged over Kerala (% Departure from LPA: 1901 – 2022)



Source: Institute for Climate Change Studies (ICCS), Thiruvananthapuram

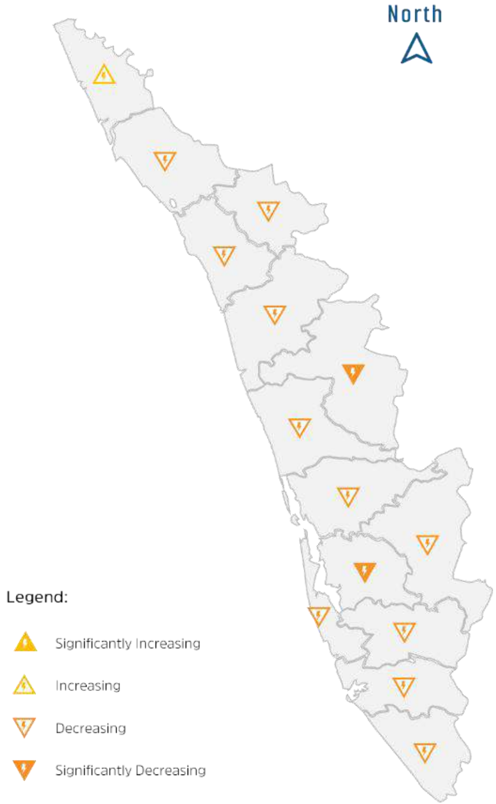
Figure 20: Trends in Southwest Monsoon Rainfall (1901-2022)



Source: Institute for Climate Change Studies (ICCS), Thiruvananthapuram

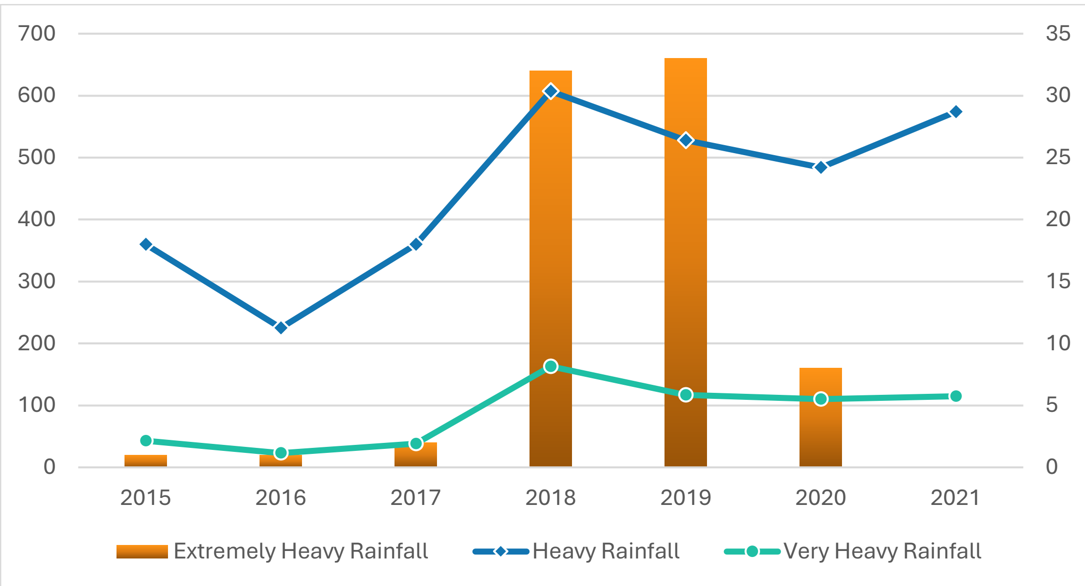
This increasing incidence of heavy rainfall events shows that while overall precipitation might be fluctuating, the rising intensity leaves the state facing the risk of flash floods. It is no surprise that the two years in which Kerala was ravaged by floods – 2018 and 2019 – saw the highest number of heavy, very heavy, and extremely heavy rainfall. The number of extremely heavy rainfall incidents also tend to happen during a short period of time, with August witnessing the highest proportion of such incidents nearly every year.

Figure 21: Trends in Northeast Monsoon Rainfall (1901-2022)



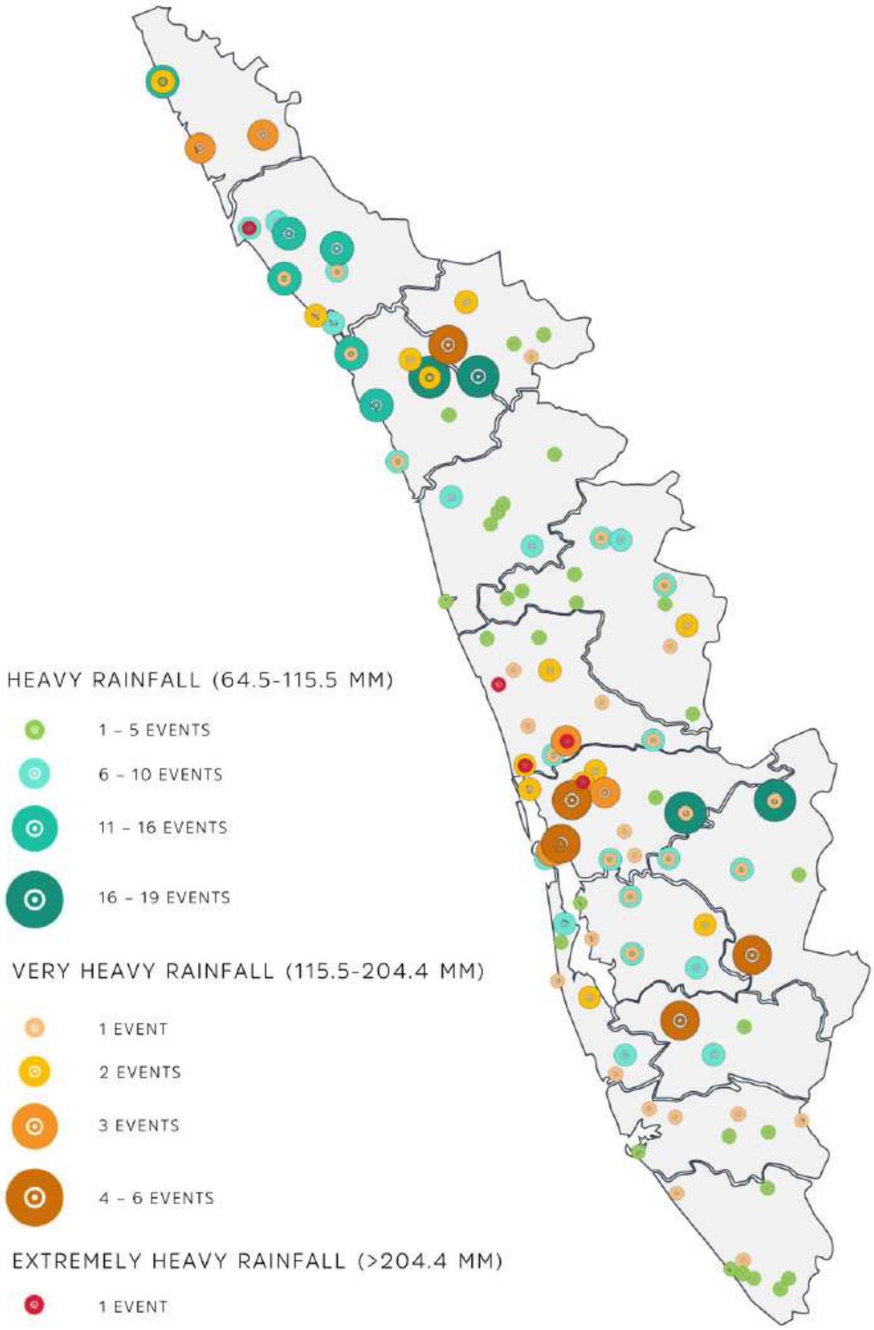
Source: Institute for Climate Change Studies (ICCS), Thiruvananthapuram

Figure 22: Incidence of Heavy Rainfall Events in Kerala (2015-2021)



Source: IMD, Pune

Figure 23: Location of Heavy Rainfall Reporting Stations in 2022

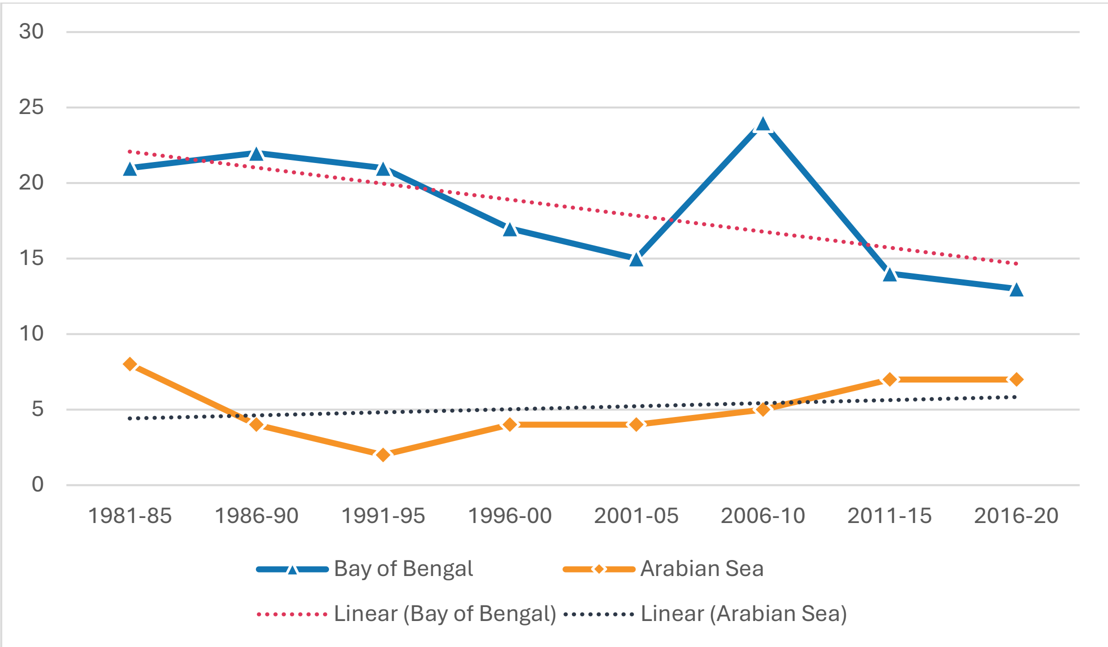


Source: Institute for Climate Change Studies (ICCS), Thiruvananthapuram

5.3. Tropical Cyclones

The changing climate patterns have also reflected in the shifting patterns of cyclones in the North Indian Ocean (NIO) region since the 1980s. The Bay of Bengal (BoB) region has traditionally been considered the more active zone for tropical cyclones, especially those in the class of severe (SCS) to very severe cyclonic storms (VSCS). However, studies have indicated that the Arabian Sea (AS) region has been heating at a rate far exceeding the BoB, leading to rising number of depressions and cyclones in the region.

Figure 24: Incidence of Depressions over the AS and BoB Regions

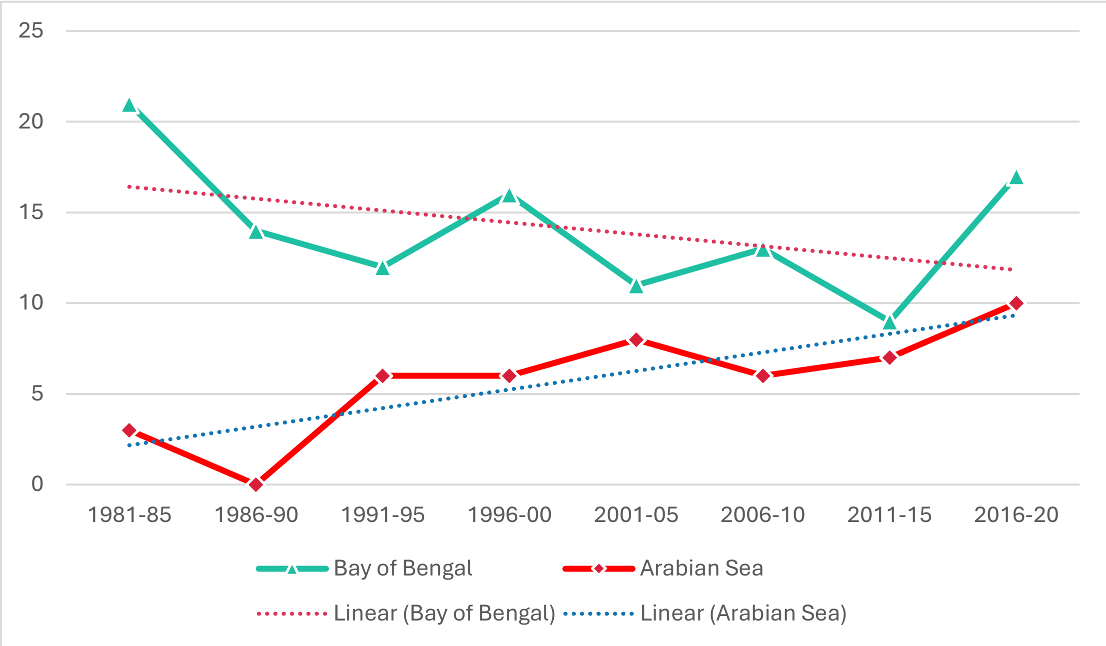


Source: IMD, Pune

Data on depressions and cyclones form the IMD provide empirical backing to this observation. Since 1980, the trend over the BoB region has consistently been declining in the case of depressions in all periods except between 2001 and 2005. The trend in the AS region has consistently risen during this period. In terms of the number of cyclonic storms, the number is on a steady upward trajectory in AS, while the BoB region has seen a fluctuating trend. The overall picture, is that a gradual decline in the BoB combined with a consistent rise in the AS.

This scenario is expected to continue in the future, pacing the way for a definite shift in the pattern of cyclones in the NIO region. Kerala, lying on the west coast of India, is therefore at a greater risk of being affected by tropical cyclones. The increasing incidence of tropical cyclones also influences the rainfall patterns in the state, possible leading to more instances of extremely heavy rainfall, followed by the possibility of flash floods.

Figure 25: Incidence of Cyclonic Storms (CS) and Severe Cyclonic Storms (SCS) over the AS and BoB Regions

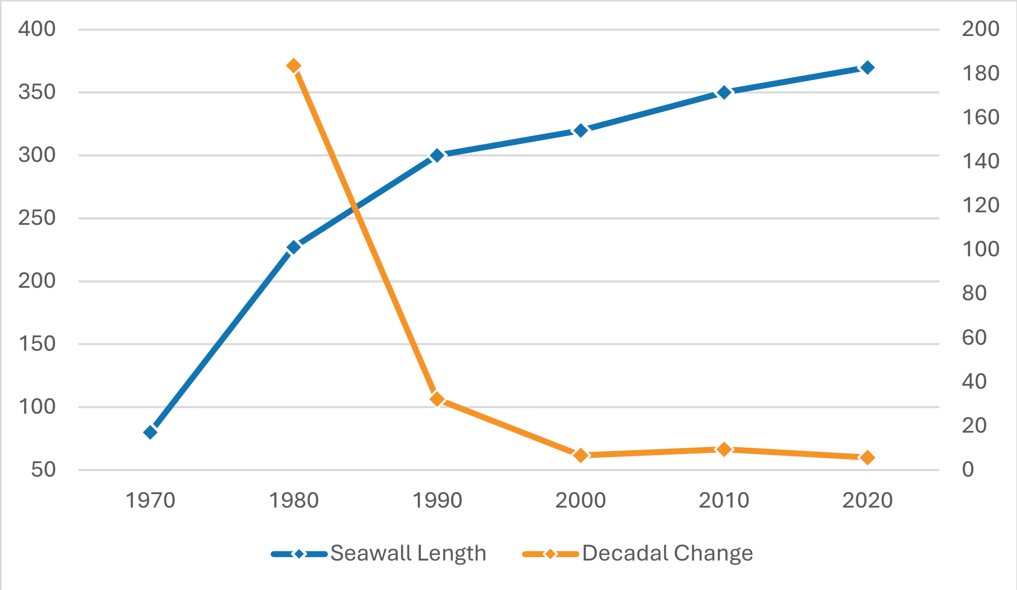


Source: IMD, Pune

5.4. Coastal Erosion

Shorelines are naturally unstable, and subject to changes in the long run. Kerala's coastline has undergone significant changes over the last half a century, as evidenced by Parvathy et al (2023). The latest trends, based on satellite data, indicate that nearly 40 per cent of the coastline is eroding, and another 35 per cent was stable. It must also be noted that erosion is severe in areas where hard structures like seawalls, groynes, and breakwaters have been constructed. Given that more than 60 per cent of the coastline has such hard structures as protective measures, it will not be far-fetched to see the rate of erosion increase in the future.

Figure 26: Increasing Seawall Length in Kerala



Source: Parvathy et al (2023)

The main fallout of human construction along the coastline is severe erosion along the down-drift side of such structures like harbours. Most eroding locations are located immediately north or south of major fishing harbours along the down-drift side. The presence of harbours disrupts the sediment transport, leading to large-scale accretion on the other side. For example, the presence of a harbour at Ponnani has led to significant accretion in Padinjarekkara beach immediately to its north. With the sediment transportation disrupted, the beaches to the south of the harbour in Ponnani Municipality, Veliyancode, Punnayur, Punnayurkulam, Perumpadappu panchayats have been depleted severely and the seafolk have been massively displaced. Figure 2.14 shows the shoreline change along the Kerala coast between two time periods – 1973-98 for the baseline assessment, and 2002-21 for the endline assessment.

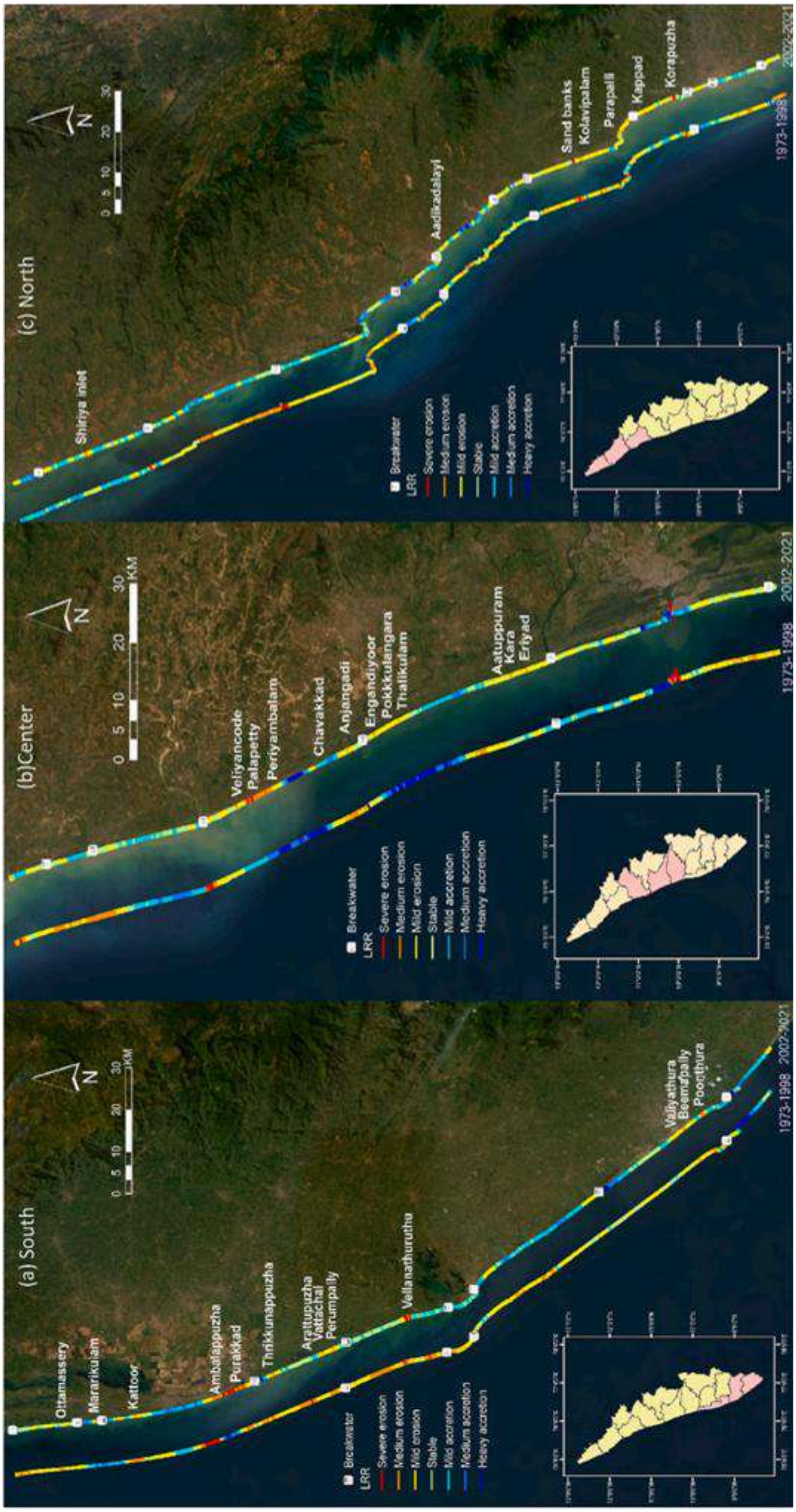
Photograph 1: Slumped and Severely Eroded Seawall, Palappetty

Source: Primary Data

Photograph 2: Wide Accreting Beach, Padinjarekkara

Source: Primary Data

Figure 27: Historical Trend of Shoreline Change in Kerala



Source: Parvathy et al (2023)

Table 5: Prominent Erosion Sites in Kerala – Central & Southern Zones

District	***Site***	***Location***
Thiruvananthapuram	Pozhiyoor	North of Thengapattanam Fishing Harbour, Kanyakumari
	Panathura to Shankhumukham	North of Vizhinjam Fishing Harbour & International Seaport
	Anchuthengu	North of Muthalapozhi Fishing Harbour
Kollam	Iravipuram & Mundakkal	South of Thangassery Fishing Harbour
	Kovilthottam to Valiyazheekkal	North of Neendakara Fishing Harbour, Mineral sand mining site in Chavara & Alappad
Alappuzha	Valiyazheekkal to Ambalapuzha	Between Valiazheekkal Fishing Harbour and Punnapra
	Kattoor	South of Chethi Fishing Harbour
	Ottamassery	North of Arthunkal Fishing Harbour
Ernakulam	Chellanam	North of Chellanam Fishing Harbour
	Fort Kochi	North of Chellanam Fishing Harbour
	Njarackal to Edavanakkad	South of Munambam Fishing Harbour
Thrissur	Kara	North of Munambam Fishing Harbour
	Vadanappally to Chettuva	South and north of Chettuva Fishing Harbour
	Mannalamkunnu	South of Ponnani Fishing Harbour
Malappuram	Palappetty to Ponnani	South of Ponnani Fishing Harbour
	Tanur	South of Tanur Fishing Harbour
	Seddam Beach	South of Parappanangadi Fishing Harbour
	Ariyallur – Vallikunnu	Between Parappanangadi and Beypore Fishing Harbours

Source: Primary Data

Table 6: Prominent Erosion Sites in Kerala – Northern Zone

District	***Site***	***Location***
Kozhikode	Beypore-Chaliyam	Between Parappanangadi and Beypore Fishing Harbours
	Gotheeswaram	North of Beypore Fishing Habour
	Kozhikode Beach	Between Vellayil & Puthiyappa Fishing Harbours
	Kappad to Cheriyamangad	Between Puthiyappa & Koyilandi Fishing harbours
	Kuriyadi-Vadakara	South of Chombala Fishing Harbour
	Azhiyur	South of Mahe Fishing Harbour
Kannur	Thalassery	South of Thalayil Fishing Harbour
	Kannur City	East of Mopla Bay Fishing Harbour
Kasaragod	Shiriya	Shiriya inlet
	Moosodi Beach	South of Manjeswar Fishing Harbour

Source: Primary Data

Table 7: Prominent Accretion Sites in Kerala

District	***Site***	***Location***
Thiruvananthapuram	Poovar to Adimalathura	South of Vizhinjam Fishing Harbour & International Seaport
	Perumathura	South of Muthalapozhi Fishing Harbour
Alappuzha	Ambalapuzha to Kattoor	Between Punnapra and Thumpoly
	Arthunkal	Between Arthunkal and Chethi Fishing Harbours
Ernakulam	Puthuvype	Southern part of Vypeen Island
Thrissur	Perinjanam to Nattika	Between Kaipamangalam and Snehatheeram Beach
	Chavakkad	From Chavakkad Lighthouse to Akalad
Malappuram	Padinjarekkara to Unniyal	Between Ponnani Fishing Harbour and Tanur Puthiya Kadappuram
Kannur	Muzhappilangad	From Dharmadom to Ezhara Beach
	Mattool	From Meenkunnu to Puthiyangadi either side of Madakkara Fishing Harbour
Kasaragod	Valiyaparamba to Nileswar	From Valiyaparamba to Nileswar Thaikadappuram
	Manjeswar to Kanwatheertha	North of Manjeswar Fishing Harbour

Source: Primary Data

During the fieldwork, the findings from the literature were cross-examined, and a list of eroding and accreting stretches were identified. Eroding stretches outstrip accreting zones significantly in Kerala. Prominent eroding and accreting stretches of Kerala's coastline as identified in the field survey are given in tables 5, 6, and 7.

5.5. Hard vs Soft Structures

The total length of seawalls along the Kerala coast has increased by 362.5 per cent between 1970 and 2020 and is only likely to increase further in the coming years. Experts are generally of the opinion that hard structures are not feasible in Kerala going forward. The reference manual on climate change adaptation guidelines for coastal protection and management in India (Black, et al, 2019) calls for a shift from hard to soft structures for coastal protection in Kerala. Soft structures recommended by the experts include beach nourishment, dune management, sand bypassing or backpassing, and beach scraping. Seawalls are considered to be the hardest option available for coastal protection since they involve the use of rocks and concrete. Although seawalls may seem to prevent land erosion, underwater erosion occurs at an accelerated pace at the bottom part of the seawalls.

Climate change is projected to cause sea level rise and increased surge levels, in addition to overall larger waves. In this scenario, seawalls will become increasingly difficult to maintain (Baba and Thomas 1987, Baba et al 1987), while the burial of beaches by these structures causes major environmental impact by preventing the natural adjustments in beach orientation. These natural adjustments are critical to ensuring the stability of a beach, and the process is greatly hindered by the presence of seawalls. Seawalls are also known to subside or collapse in time, leading to greater levels of erosion.

Soft structures are sand-based solutions that are proven to be climate-resilient, although they only been considered very rarely in India. In Kerala, the only instance of a soft solution was the construction of an artificial reef composed of geotextile containers filled with sand. This was implemented at Kovalam in 2010. A comparison between different hard and soft solutions, and their potential applicability in the Kerala context is given in greater detail in the final section on conclusions and recommendations.

Form 10
Part B

Report Profile

Data Analysis

Seafolk in Kerala: an Overview

Seafolk in Kerala: An Overview

The traditional fisherfolk are one of Kerala's three most underprivileged and socially excluded social groups, alongside Dalits and Adivasis. Their situation is highlighted by material depravity, lack of access to resources, and constant combat against nature. The current chapter paints a picture of the traditional fisherfolk of Kerala based on the data collected from the 1271 households across the state's nine coastal districts. The present section deals with the socio-economic and demographic characteristics of the community including religious distribution, age and education attainment and their physical standard of living.

5.6. Traditional Fisherfolk of Kerala in Academic Literature

Very few studies have thus taken place in the state to address the issues coastal communities face and how they use their agency to adapt to the changing climate in the region. Most studies on traditional fisherfolk in Kerala have concentrated on their changing socio-economic status (George and Domi 2002, Sathiadhas 2006, Kelkar-Khambete 2012, Hapke and Ayyankeril 2018), their organisation into self-help groups (Rajeeve and Rajasenan 2015, Vipinkumar et al. 2014, Shyam, Antony and Geetha 2011), or their state of technology (John 2014, Parappurathu et al. 2017, Sabu and Shaijumon 2014). Studies have also been undertaken on the organisation of the fisheries industry in Kerala and its economic aspect in terms of economic feasibility and international trade (Ancy and Raju 2014).

In general the studies have broadly concluded that traditional fisherfolk are one of Kerala's most marginalised communities alongside scheduled castes and tribes (Ramachandran 2018, Oommen and Shyjan 2014, Devika 2017, Kurien 1995). The fisherfolk are economically and socially deprived, located on the bottom rungs of

Kerala's caste hierarchy. They are also educationally backward with a higher than average rate of illiteracy. A clear gender divide was observed between workers in traditional fisheries, and women benefited greatly from the introduction of self-help groups in the sector.

The studies also note that the fisheries sector in Kerala requires modernisation to make the industry more economically sustainable. Modernisation could include mechanisation and better use of information and communication technology. Incorporating ICT into fishing was noted to increase both income and productivity in the fisheries sector. However, the ability of traditional fisherfolk to embrace such innovations remains to be explored in depth.

Only a few studies like Shyam et al. (2014) and Santha (2015) have examined the status of fisherfolk in a climate change scenario. Still, these have been undertaken before tropical cyclones became a common occurrence in the Arabian Sea. Since these studies, the number of violent tropical cyclones in the region has risen significantly. Coastal erosion has also accelerated in Kerala, with incidents from Chellanam in Ernakulam district often highlighting the issues faced by coastal communities. Therefore, a re-examination of the fisherfolks' vulnerability is necessary. Shyam et al. also have not examined the adaptation strategies used by the fisherfolk or the magnitude of climate change-induced displacement among the communities. Studies such as Punya et al. (2021) that have come out in the succeeding years, have mostly focused on the immediate socio-economic fallouts of hazards, and ignored aspects such as vulnerability and resilience.

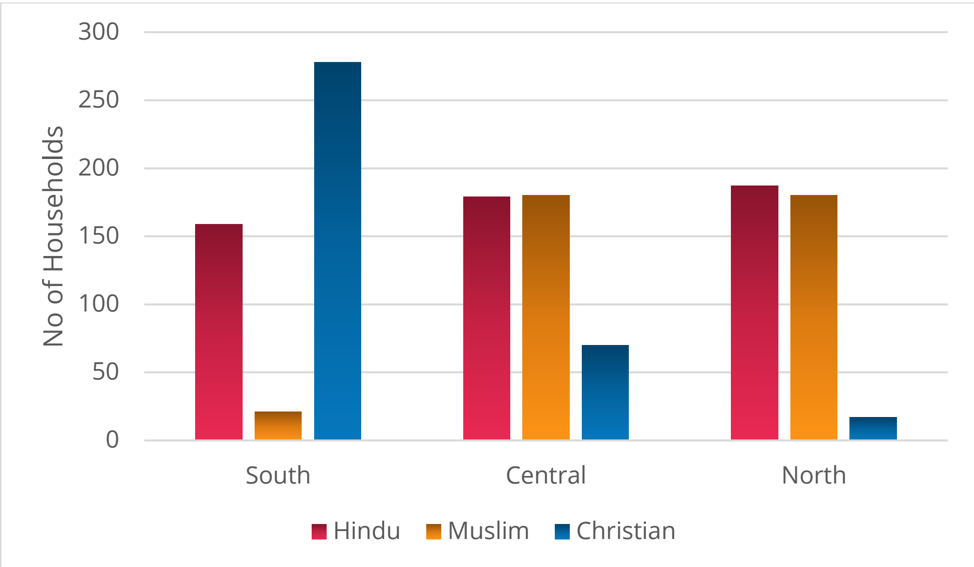
5.7. Religious Distribution

Due to their social exclusion within Hindu society, the fisherfolk in Kerala have historically converted to Christianity and Islam. All three of Kerala's dominant religious dispositions find themselves represented by the traditional fisherfolk. In the sample, Hindus form the largest denomination with 41 per cent adherents, while

Muslims and Christians comprised 30 and 29 per cent respectively of the sample households.

Although Hindus form the largest denomination overall at 41 per cent, they are not the dominant religious group in any region. In Southern Kerala, Christians are the largest group, while in the Central and Northern Zones, the Hindu and Muslim populations are mostly even. The distribution of Christians is fairly negligible in the Northern Zone, and the same is true of Muslim population in the South. This shows that the pattern of religious shift varies across the state, with Christianity finding a larger foothold among fisherfolk in the South, while Islam was the preferred religion in the North.

Figure 28: Religious Distribution of Sample Households

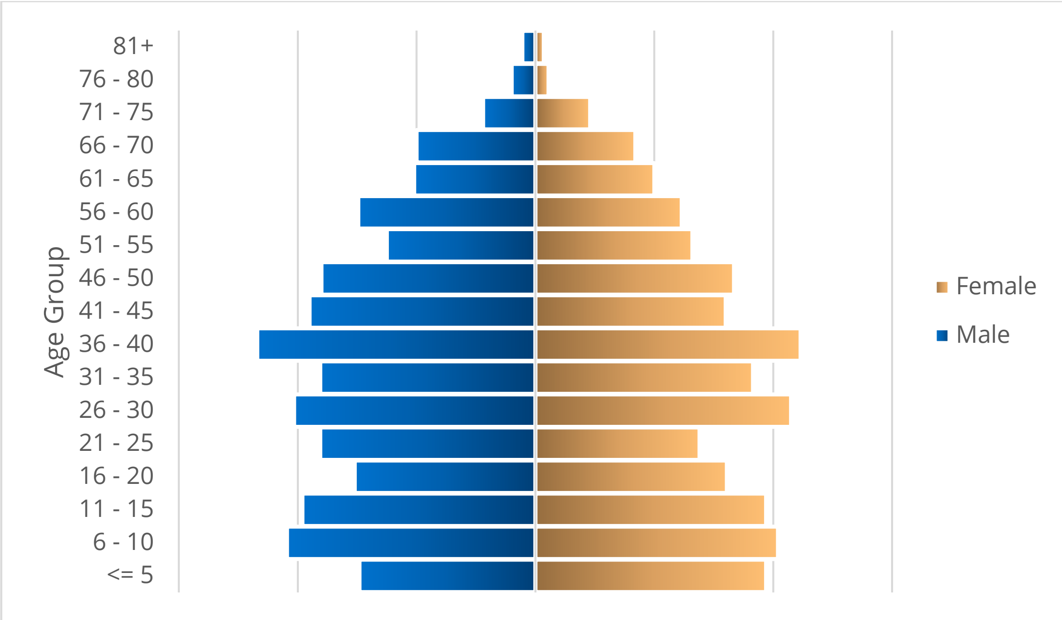


Source: Primary Data

5.8. Demographic Distribution

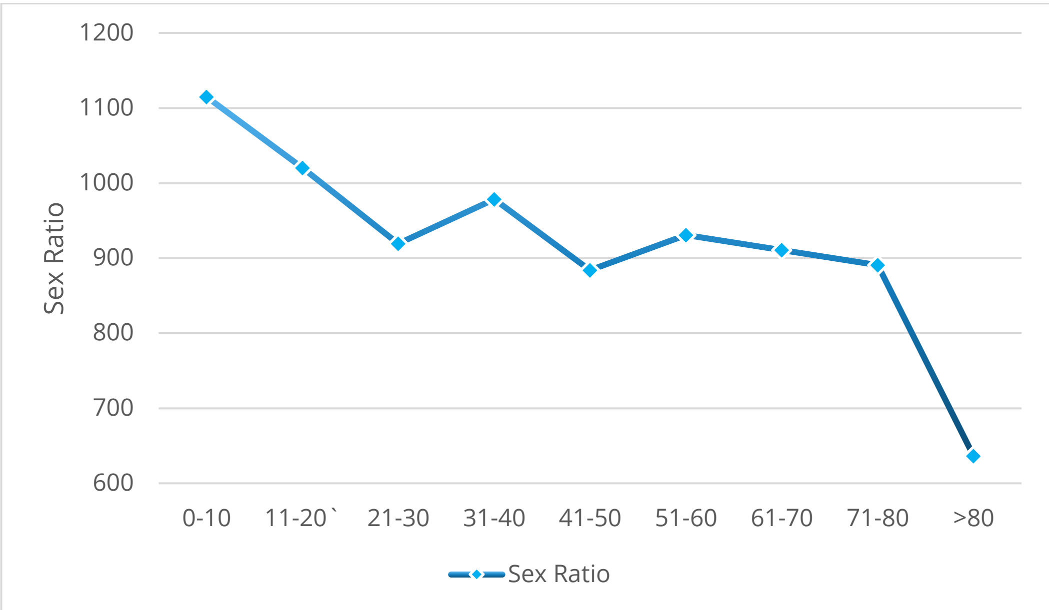
The total number of individuals in the sample was 5353. However, correct data was only reported for 4767 individuals. Data for the remaining 586 individuals was not reported completely by the respondents and therefore was excluded. The population pyramid for the sample is given below in figure 28. The pyramid shows that the population is relatively stable and starting to go into a declining trend.

Figure 29: Distribution of Individuals by Age Group



Source: Primary Data

Figure 30: Age-Specific Sex Ratios

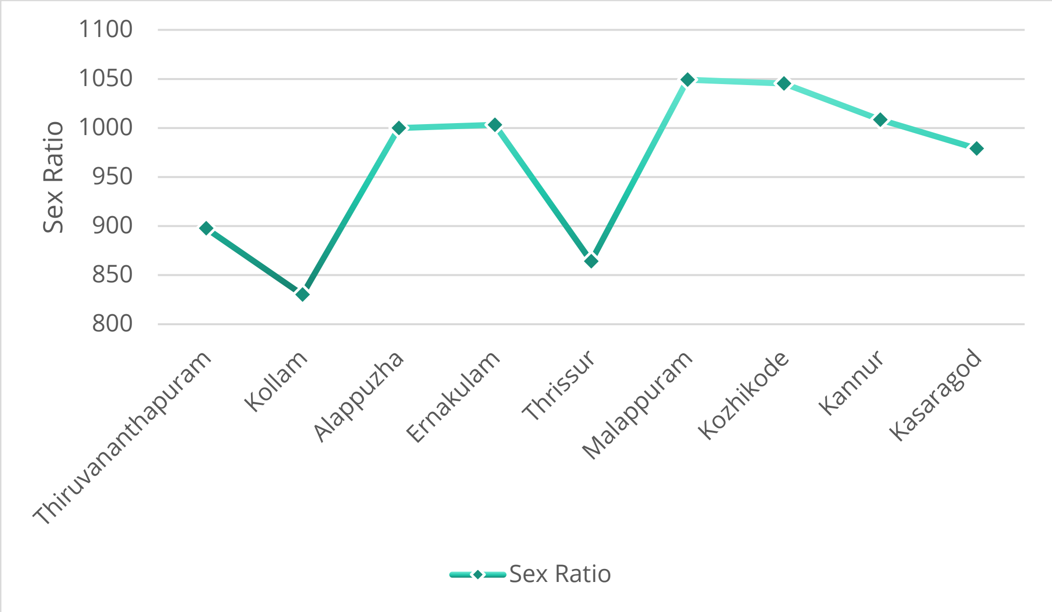


Source: Primary Data

The number of females in the population is greater in the youngest age groups, while it reduces significantly in the older age groups. The overall sex ratio in the sample was 965.7 women per 1000 mem, but the figure differs among age groups. The child sex ratio, in direct contrast to the overall sex ratio, stands at 1246 girls per 1000 boys.

Age-specific sex ratio is lowest in the 80+ age group, followed by the 71-80 age group. The age-specific sex ratios within the sample are given in figure 29.

Figure 31: District-Specific Sex Ratios



Source: Primary Data

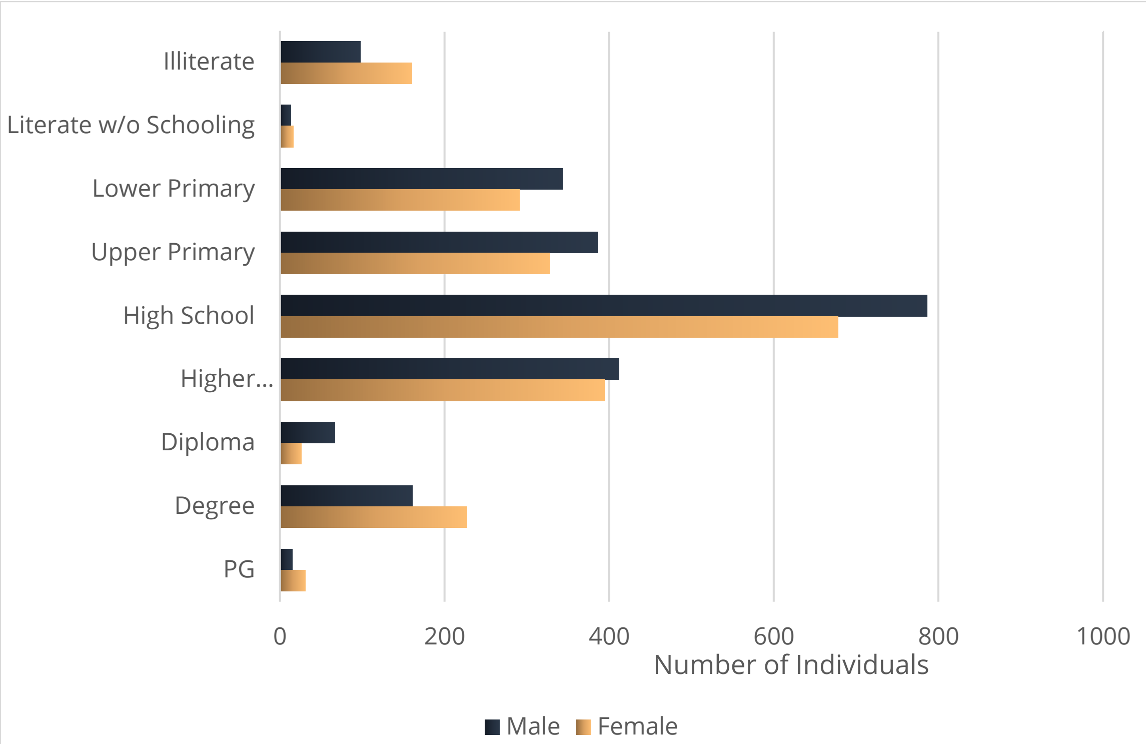
Examining differences in sex ratio at the spatial level reveals that is unfavourable to women only in Thiruvananthapuram, Kollam, and Thrissur. Kollam had the worst sex ratio, while the highest was in Malappuram. The sex ratio was on par in Alappuzha and Ernakulam, while it was favourable in Malappuram, Kozhikode, and Kannur districts.

5.9. Education Attainment

The literacy rate among sample respondents was 95.96 per cent among men, and 93.17 per cent among women. This figure puts the community in line with the statewide figures for Kerala, where the figures are 96.11 per cent and 92.07 per cent respectively for men and women.

Among both men and women, those who had attained high school education were the largest group, followed by those with higher secondary education. Among individuals who had completed schooling, women outnumbered men in terms of graduation and post-graduation. However, men tended to be more enthusiastic in taking up diplomas from polytechnics or ITIs.

Figure 32: Education Attainment among Male and Female Respondents



Source: Primary Data

To assess whether the average education attainment in years differed between men and women in different age groups, a two-way ANOVA was performed. The null hypotheses for the ANOVA are as follows:

H_{0A}: There is no difference in the average education among men and women

H_{0B}: There is no difference in the average education among individuals in different age groups.

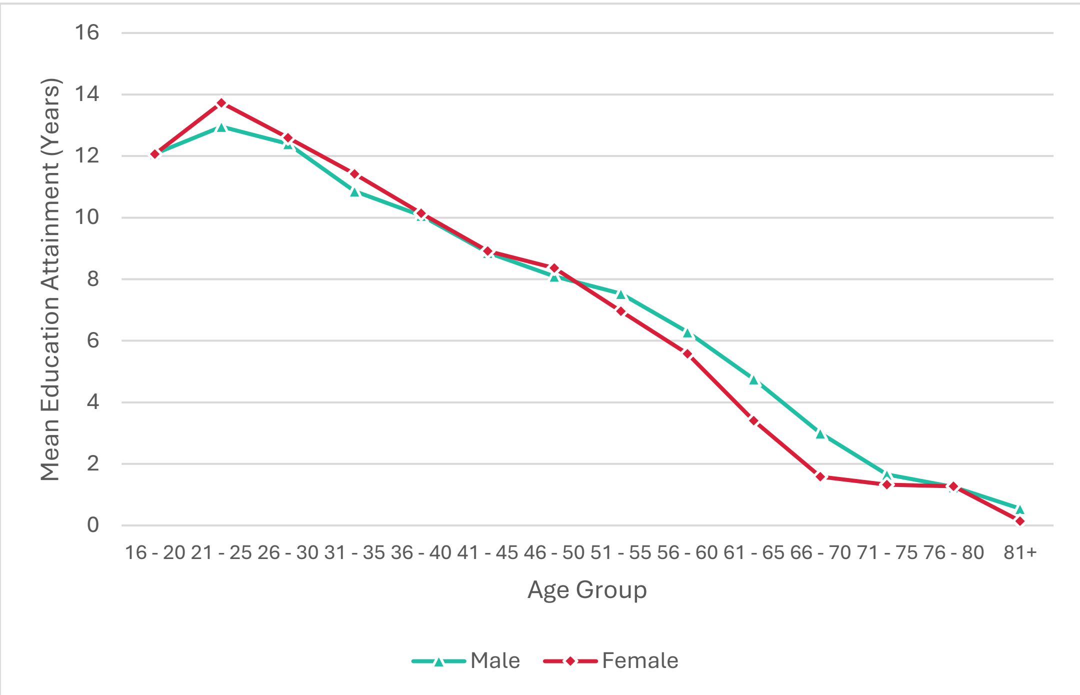
H_{0C}: There is no interaction between sex and age group.

Table 8: Two-way ANOVA (Education Attainment * Age * Sex)

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Corrected Model	54613.969[a]	33	1654.969	286.065	0.000
Intercept	44203.064	1	44203.064	7640.596	0.000
Age_Group_2	54192.235	16	3387.015	585.453	0.000
Sex	7.147	1	7.147	1.235	0.266
Age_Group_2 * Sex	325.923	16	20.370	3.521	0.000
Error	25449.491	4399	5.785		
Total	394737.000	4433			
Corrected Total	80063.460	4432			

Source: Primary Data

Figure 33: ANOVA Scatterplot (Education Attainment * Age * Sex)



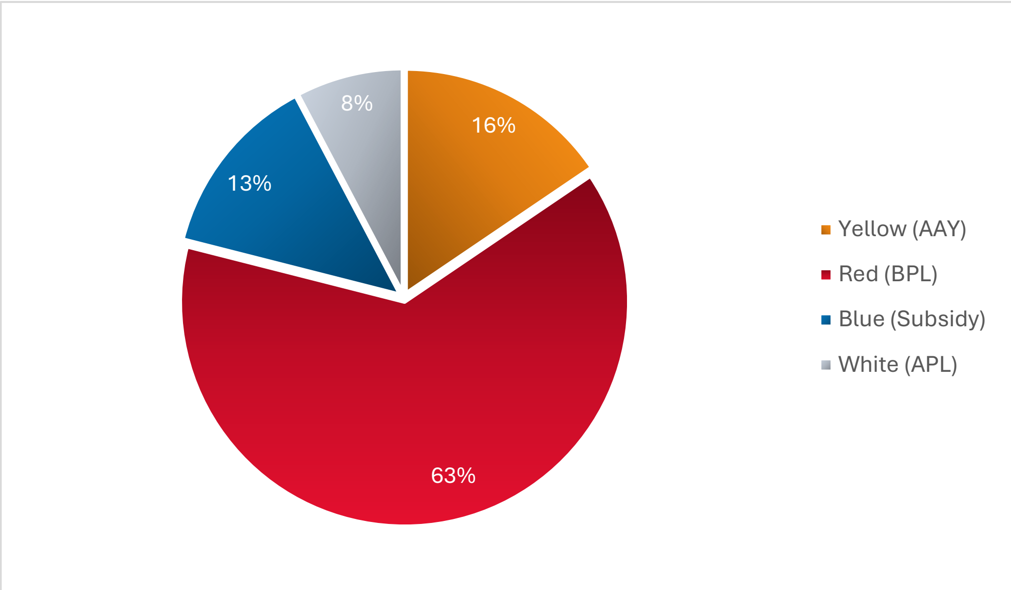
Source: Primary Data

The results of the ANOVA table shows that there is a statistically significant difference between individuals in different age groups. However, there is no statistically significant difference between the education attainment of men and women in the sample. There is also a statistically significant interaction between age and sex of respondents. The relationship between age and education attainment is depicted in the scatter plot of the ANOVA, given in figure 32.

5.10. Physical Amenities

Asset holdings are a critical part of determining the living standard of a household. They also indicate a household's level of poverty and depravity. A significant majority of fisherfolk (79 per cent) in Kerala fall below the poverty line. Of these, 197 households hold a ration card that is classified as Antyodaya Anna Yojana.

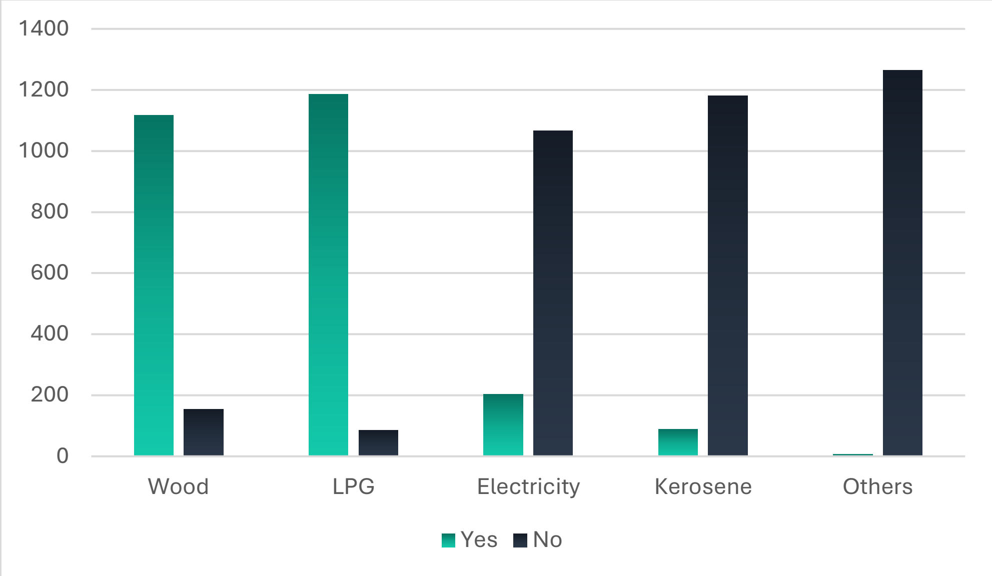
Figure 34: Distribution of Households by Ration Card



Source: Primary Data

When it comes to ownership of physical amenities, it was observed that every household covered under the study had an electrified home. Universal electrification does not however translate into large-scale ownership of consumer durables, or the use of electricity as a cooking fuel. Only about 16 per cent of all surveyed households used electricity as a cooking fuel. LPG was the predominant cooking fuel, used by 93.5 per cent of the households. Wood was also widely used, with 88 per cent of the households reporting that it was one of their cooking fuels.

Figure 35: Usage of Various Cooking Fuels



Source: Primary Data

Table 9: Land Holding across LSGIs

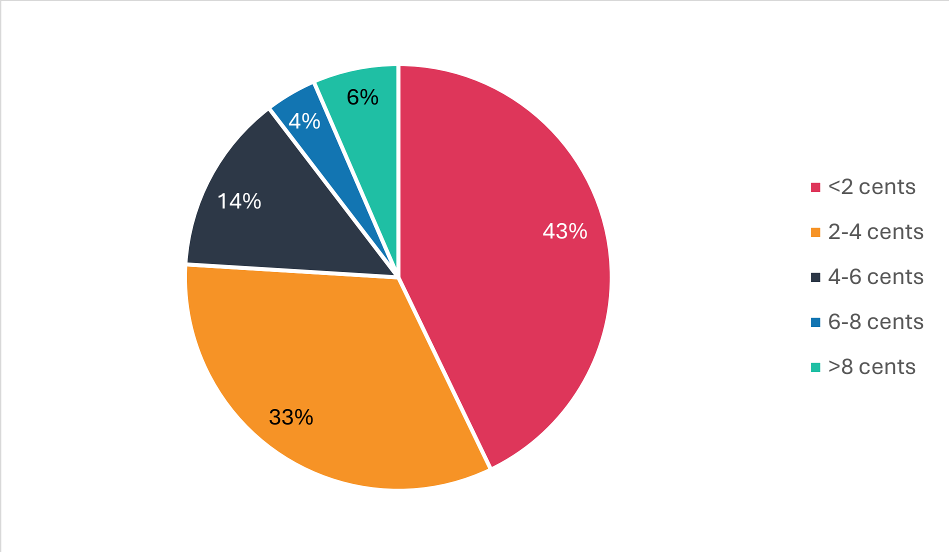
Land Holding	*LSG Category*			*Total*
	Gram Panchayat	*Municipality*	*Corporation*	
<= .00	52	5	32	89
.01 - 2.00	132	32	85	249
2.01 - 4.00	283	49	87	419
4.01 - 6.00	219	48	16	283
6.01 - 8.00	84	24	3	111
8.01 - 10.00	48	10	0	58
10.01+	56	6	0	62
Total	874	174	223	1271

Source: Primary Data

The ownership of houses and household assets is linked to a family's land ownership. The study revealed that 7 per cent of all households in the sample were landless, and that more than 19 per cent has only less than two cents of land. Households having between two and four cents of land comprised one-third of the sample, closely followed by those having between four and six cents of land. The Kerala Land Reforms (Amendment) Act, 1969 stipulates that each household is entitled to possess 10, 5, or

3 cents of land if they live in a Gram Panchayat, Municipality, and Municipal Corporation, respectively. Despite this entitlement, the average land holding was significantly less for fisherfolk across Kerala. The average land holding was 5 cents in Gram Panchayats, 4.7 cents in Municipalities, and 2.3 cents in Corporations.

Figure 36: Ownership of Poṛambōke Land



Source: Primary Data

Approximately 16.7 per cent of all households in the sample were also living in poṛambōke land without any document of land ownership. Among these, 27 per cent households were landless. Of the rest, three-quarters have less than 4 cents of land.

The standard of housing is often considered a reflection of the level of income of a household. The housing standard was measured on a five-point scale based on the quality of material used in the construction and the number of rooms. The levels of housing according to the scale are as follows:

- Kutcha – Mud walls, mud floors and thatched roof
- Poor – Laterite/cement brick walls without plastering, cement or red oxide flooring, tin or asbestos roof
- Good – One or two bedrooms, concrete/tiled roof, brick and mortar walls, tiled/asbestos flooring

- Very good – Two or three bedrooms with attached bathrooms, concrete roof, brick and mortar walls, and tiled/mosaic/marble/granite flooring
- Excellent – Four or more bedrooms with attached bathrooms, concrete roof, brick and mortar walls, and tiled/mosaic/marble/granite flooring

Table 10: Housing Standard of Respondents

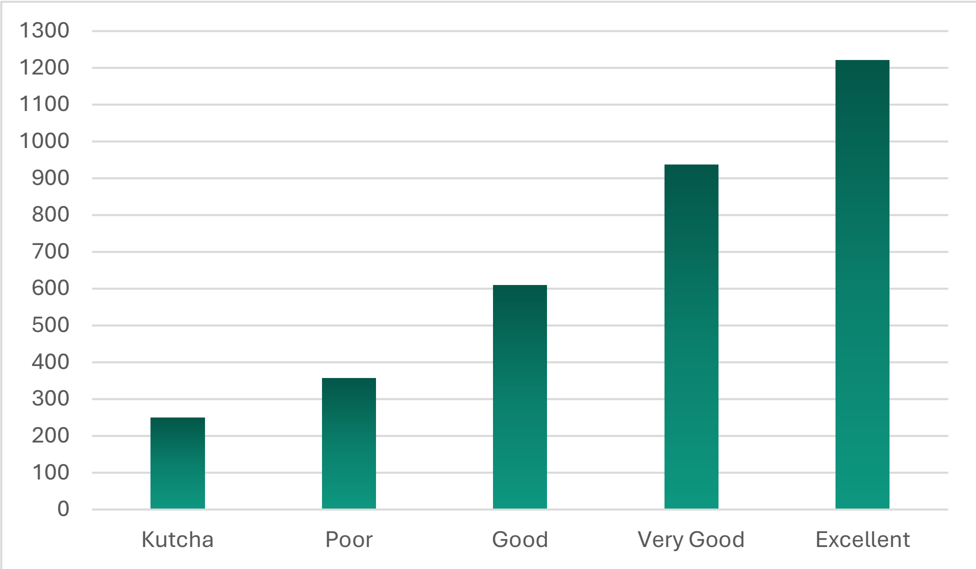
District	*House Type*					*Total*
	Kutcha	*Poor*	*Good*	*Very Good*	*Excellent*	
Thiruvananthapuram	26	119	34	5	1	185
Kollam	11	49	38	19	4	121
Alappuzha	8	36	65	22	21	152
Ernakulam	3	43	69	20	2	137
Thrissur	7	40	86	9	0	142
Malappuram	23	44	74	8	0	149
Kozhikode	6	30	111	14	0	161
Kannur	6	28	52	15	7	108
Kasaragod	0	33	73	9	0	115
Total	*90*	*422*	*602*	*121*	*35*	*1270*

Source: Primary Data

These classifications closely follow the classification of houses into kutcha, semi-pucca and pucca categories, as used by the Kerala State Fisheries Department and the CMFRI. The kutcha category remains the same, while the poor category equates to a semi-pucca status, and the three remaining categories refer to pucca houses.

It is evident from table 3.2 that housing standard of fisherfolk varies remarkably between districts. A significantly higher proportion of households had very good or excellent houses in Alappuzha (28 per cent) and Kannur (20 per cent), while in Thiruvananthapuram, an overwhelming number of households (78 per cent) lived in poor conditions. The situation was also concerning in Kollam and Malappuram districts, where 49.5 and 44 per cent households, respectively, had kutcha or poor houses.

Figure 37: Average Built-up Area

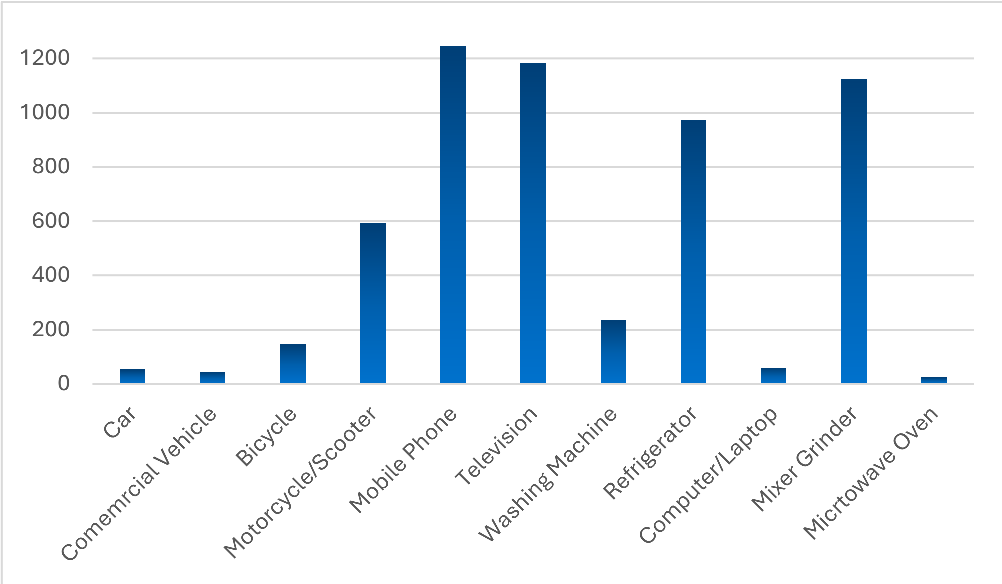


Source: Primary Data

Overall, nearly half of all households in Kerala had good houses, with one-third having poor houses. Twelve per cent of all households lived in very good of excellent dwellings, while the remaining 7 per cent lived in kutcha houses. It is also worth noting that 54 per cent of all households that lived in kutcha houses were in Thiruvananthapuram and Malappuram districts.

In terms of ownership of consumer durables, mobile phones and televisions were near ubiquitous. Mixer grinders and refrigerators were also common, being owned by 88.2 and 76.6 per cent of households respectively. Other household gadgets like washing machines (18.5 per cent) and microwaves (1.9 per cent) had few takers. Vehicular ownership was less than 50 per cent, with only 46.5 per cent of households owning a motorcycle or scooter, and less than 5 per cent owing a car. It was also observed that only about 3.5 per cent of households owned a commercial vehicle.

Figure 38: Ownership of Consumer Durables

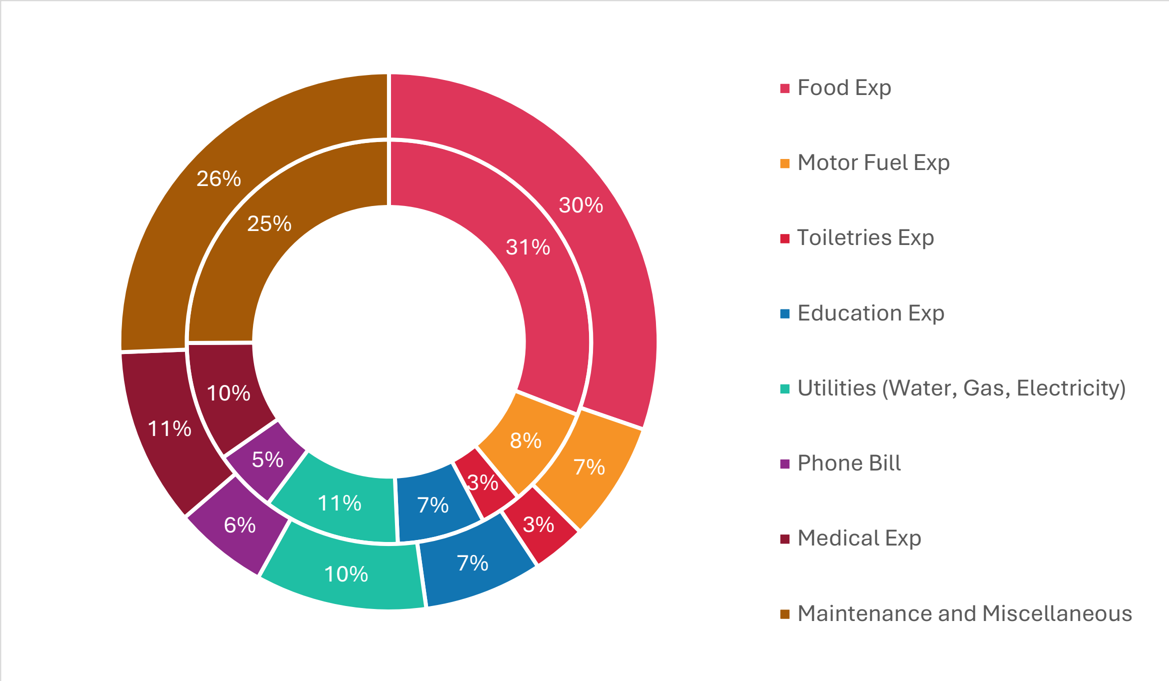


Source: Primary Data

5.11. Expenditure, Savings, and Indebtedness

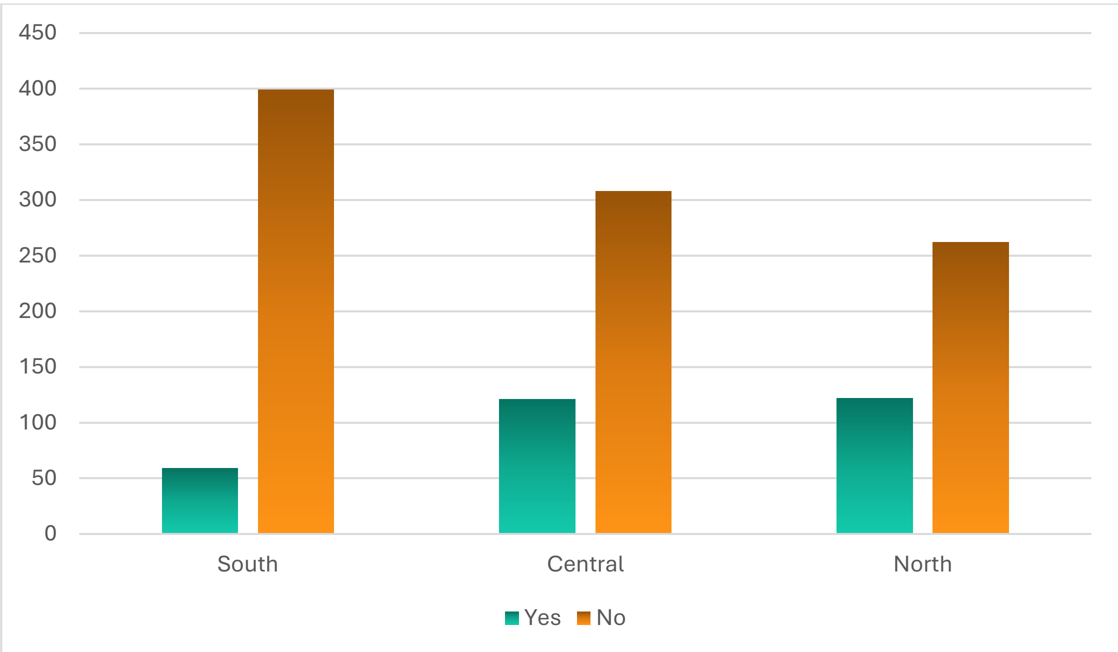
When examining the household expenditure pattern of rural and urban households, it was observed that the figures were not very different. The breakup was fairly similar, with rural households spending slightly more on food, motor fuel, and utility bills. In contrast, urban households has slightly higher expenditure on phone bills, medical expenditure, and the maintenance of households. The rural-urban split is given in figure 3.12, with the inner ring showing the expenditure pattern of rural households, and the outer ring showing expenditure pattern for urban households. Average monthly expenditure was slightly in urban areas, at ₹11,292, while it was ₹10,876 in rural areas.

Figure 39: Monthly Household Expenditure



Source: Primary Data

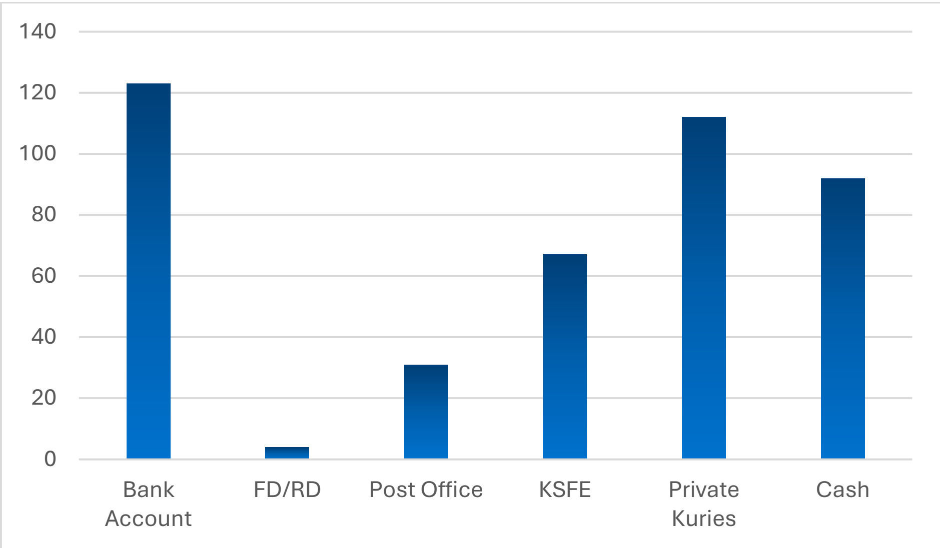
Figure 40: Savings



Source: Primary Data

Among the sample households, savings were not widely seen. Monthly savings were highest in the Northern Zone, where approximately 32 per cent of the households has some sort of savings. The figures were roughly 28 per cent in the Central Zone and 13 per cent In the Southern Zone. Among households that had savings, the most preferred channel was depositing money in a bank account, followed by private chit funds. Cash savings were the third most preferred way of saving money.

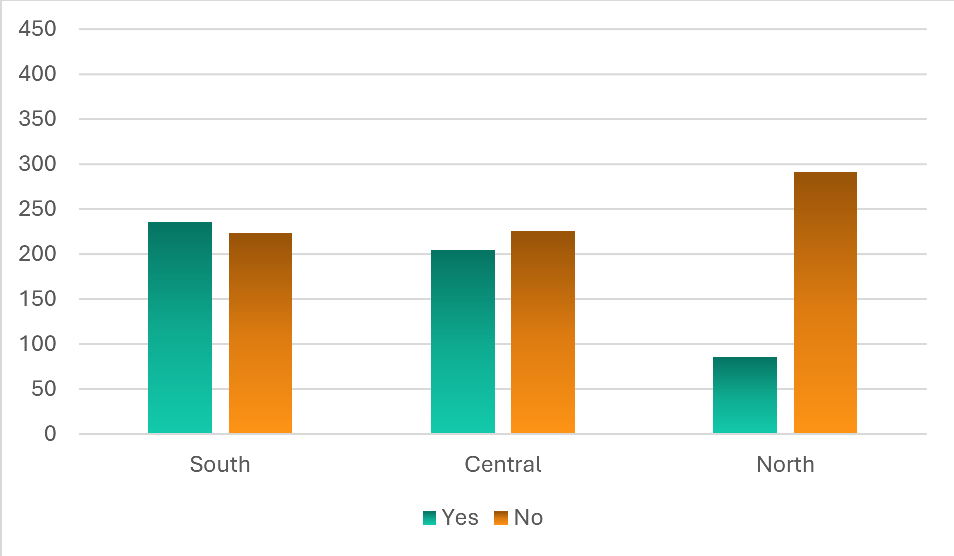
Figure 41: Saving Stream Used



Source: Primary Data

In terms of indebtedness, the burden was seen to be greatest in the Southern Zone, where 51.3 per cent of all households were in debt. In comparison, the figure was 44.7 per cent in the Central Zone, and 22.4 per cent in the Northern Zone. To assess spatial variation in savings and debt burden, one-way ANOVAs were performed, taking null hypotheses that the savings and debt burden did not differ significantly between the nine districts. The results of the ANOVA prove that the null hypothesis may be rejected due to the widely fluctuating nature of average outstanding debt, as well as monthly savings between households in different districts.

Figure 42: Indebtedness



Source: Primary Data

Table 11: One-Way ANOVA (Monthly Savings * District)

	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	315891890.01	8	39486486.251	5.154	0.000
Within Groups	9667828947.91	1262	7660720.244		
Total	9983720837.92	1270			

Source: Primary Data

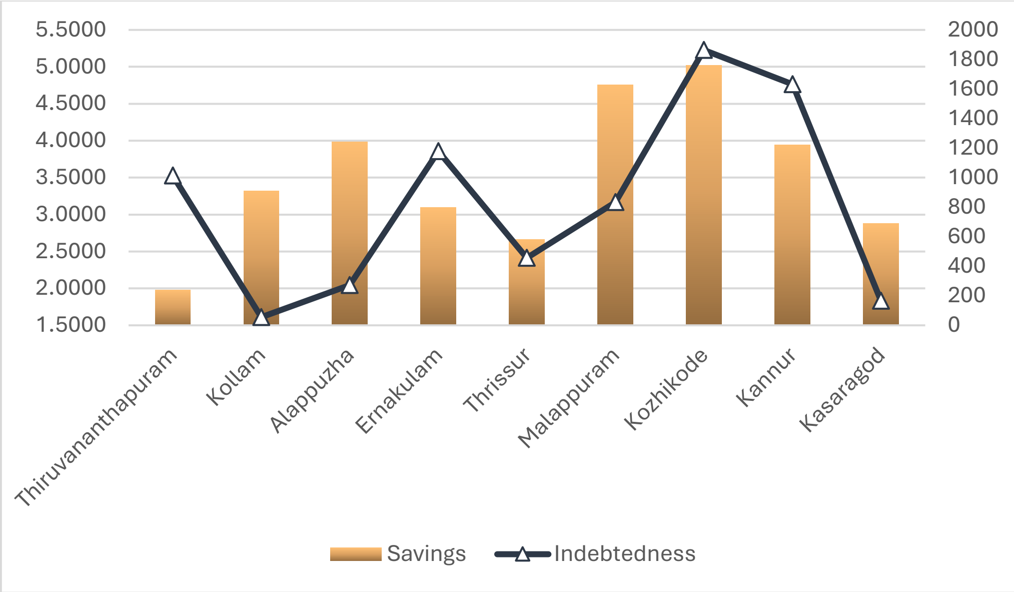
Table 12: One-Way ANOVA (Current Debt * District)

	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	589.244	8	73.655	6.169	0.000
Within Groups	6327.745	530	11.939		
Total	6916.989	538			

Source: Primary Data

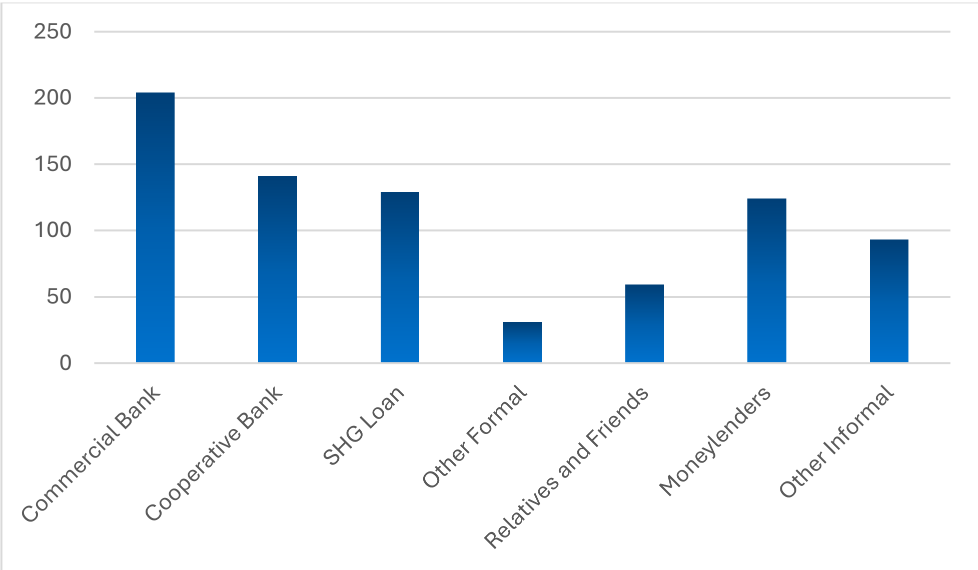
The ANOVA scatter plot given in figure 3.16 shows that households in Kozhikode and Kannur had significantly higher debt burden when compared to their counterparts in districts like Kollam, Alappuzha, Thrissur, or Kasaragod. Debt burden was lowest in Kollam, averaging slightly above ₹1.5 lakhs, while in Kozhikode, it was above ₹5 lakhs.

Figure 43: Indebtedness in Lakh Rupees by District



Source: Primary Data

Figure 44: Source of Debt

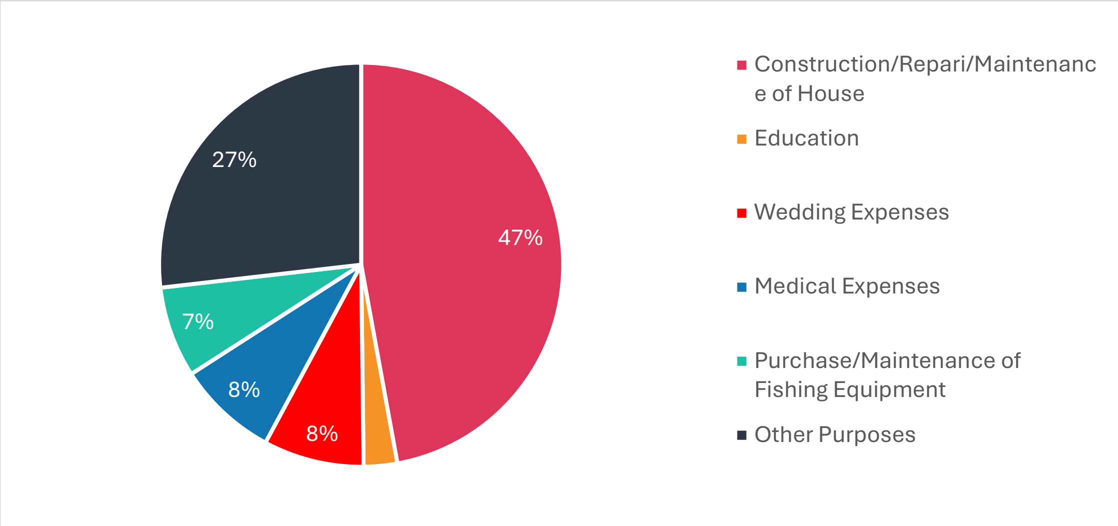


Source: Primary Data

Examining the source of debt reveals that institutional lenders were the most preferred option for the seafolk. The most preferred options were commercial and co-operative banks, as well as loans from SHGs like Kudumbashree. Among informal sources, only around 9.75 per cent depended on moneylenders for their credit needs.

Borrowings were largely used for the construction, repair, or maintenance of houses, followed by miscellaneous purposes.

Figure 45: Primary Purpose of Borrowing



Source: Primary Data

Table 13: Correlation between Consumption, Savings, and Indebtedness

		Total Consumption	*Savings*	*Current Debt in Lakh Rs*
Total Consumption	Pearson Correlation	1	.451**	.384**
	Sig. (2-tailed)		0.000	0.000
	N	1271	1271	539
Savings	Pearson Correlation	.451**	1	.310**
	Sig. (2-tailed)	0.000		0.000
	N	1271	1271	539
Current Debt in Lakh Rs	Pearson Correlation	.384**	.310**	1
	Sig. (2-tailed)	0.000	0.000	
	N	539	539	539

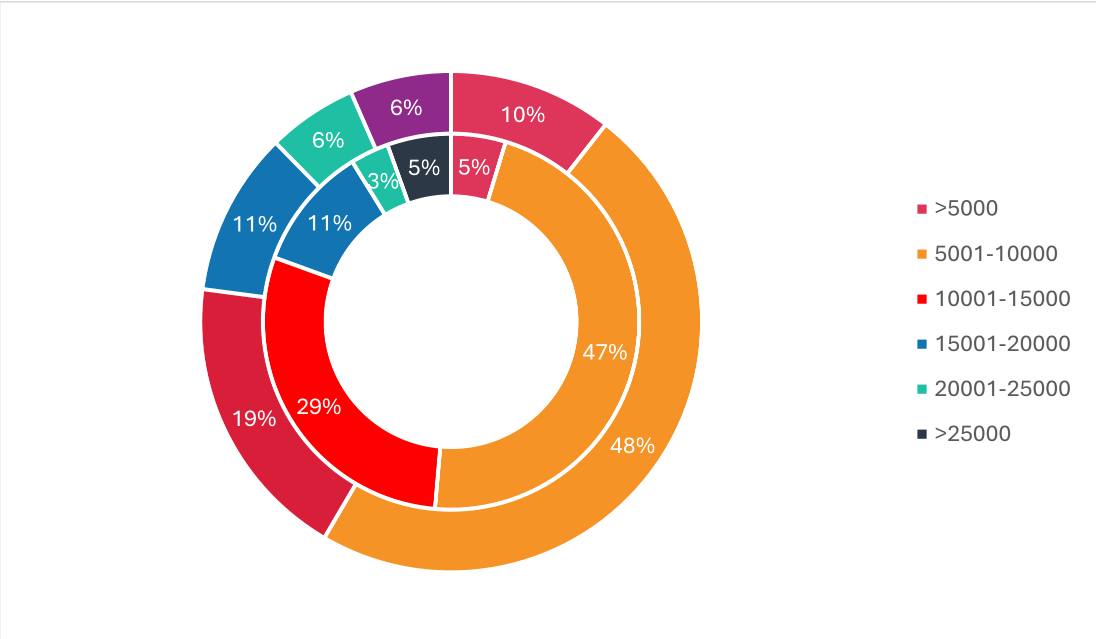
Source: Primary Data

To analyse whether there was a relationship between consumption, savings, and indebtedness, a correlation was undertaken. The results of the correlation analysis, given below in table 3.6, show that households who spent more also tended to save at a higher rate, while also accruing higher debt burden.

5.12. Income Estimation

Since it is difficult to ascertain the actual income levels of a household based on the recollection of the respondent, income was computed as the sum of monthly consumption, loan repayment, and savings of a household. Figure 3.19 depicts the differences in distribution of households according to their monthly income class for rural and urban areas. Rural households are depicted in the inner ring, while the outer ring represents urban households.

Figure 46: Distribution of Households based on Computed Income in Rupees



Source: Primary Data

The proportion of households having a monthly income less than ₹10,000 was higher by percentage points among urban households. Urban areas also had a slightly higher proportion of households having a monthly income more than ₹20,000. An examination of distribution of income among sample households shows that in the Southern Zone, more than 28 per cent of households fell in the bottom quintile, while the corresponding figures were 17 per cent and 13.8 per cent in the Central and Northern Zones respectively. In the Central Zone, the fourth quintile had the higher share of households, at about 24.7 per cent, while in the Northern Zone, the concentration was highest in the third quintile (23.7 per cent). These figures are given below in table 3.7.

Table 14: Households in each Income Quintile by Region

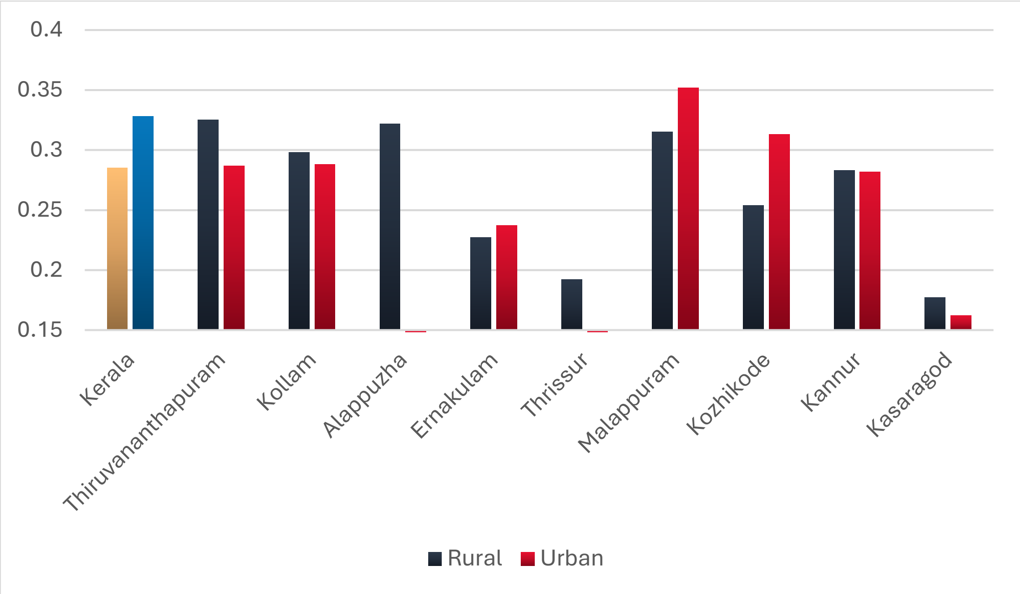
Income Quintile	*Region*			*Total*	*Average Income*
	South	*Central*	*North*		
Q1	130	73	53	256	5,349
Q2	88	90	82	260	7,609
Q3	74	86	91	251	9,725
Q4	68	106	78	252	12,919
Q5	98	74	80	252	23,078
Total	*458*	*429*	*384*	*1271*	*11,691*

Source: Primary Data

To further examine the level of income inequality, the Gini coefficient was calculated for urban and rural areas in the nine districts. In Alappuzha and Thrissur, the sample only had rural households. The overall figures for Kerala show that income inequality is greater in urban areas, as depicted in figure 3.19. The Gini coefficient for urban households is 0.328 compared to 0.285 for rural households. Overall, Kasaragod and Thrissur districts have the lowest income inequality, as evidenced by Gini coefficient values less than. Rural Kasaragod has the lowest value at 0.162, while Urban Kasaragod has 0.177. The highest income inequality was observed among urban households in Malappuram, followed by households in Alappuzha. Districts like Malappuram, Alappuzha, and Thiruvananthapuram had a relatively higher level of income inequality.

Income inequality was higher in the urban areas in Ernakulam, Kozhikode, and Malappuram districts. In Thiruvananthapuram, Kollam, and Kasaragod, the inequality was greater in rural areas. In Kannur, the income inequality was roughly even in both urban and rural areas. The comparatively higher level of income inequality in Malappuram, Kozhikode, and Kannur districts is likely due to the presence of households that receive remittances, allowing them to have a higher level of income. However, there is also a considerable number of households that live on low income levels in these areas. The income inequality was lowest in Kasaragod and Thrissur districts, where most households maintained a fairly equal standard of living.

Figure 47: Rural-Urban Income Inequality by District (Gini Co-efficient)



Source: Primary Data

Overall, it can be said that coastal communities in Kerala suffer from significant material deprivation, with low incomes and poor levels of asset ownership. Savings are also generally paltry, while there is high indebtedness for a significant section of the sample respondents. Land constraints were another major issue faced by the community, with almost one fifth of respondents either being landless or living in poṛambōke land illegally. The material deprivation faced by the community has significant meaning when placed intso the context of climate change, as rising sea levels and increasing number of natural disasters force more and more households into migrating away from the coastal regions of Kerala.

This page is intentionally left blank

Form 10
Part B

Report Profile

Data Analysis

Livelihood Shift as Adaptation

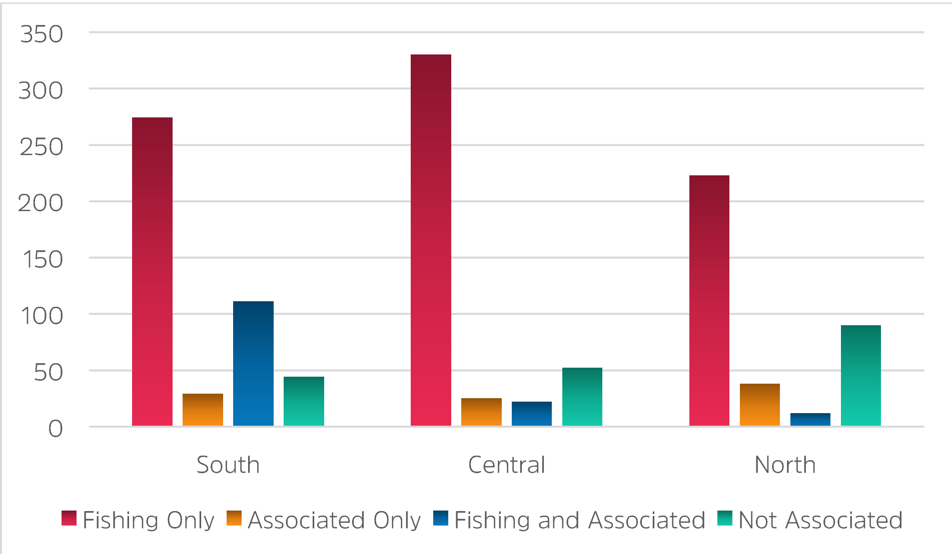
Livelihood Shift as Adaptation

Adaptive capacity is the first of the three pillars in the livelihood vulnerability framework. Among the traditional seafolk of Kerala, the most prominent adaptation strategy is a shift in the occupational status of community members away from fishing. The current chapter examines the occupational status of the coastal communities in the state, including a livelihood shift away from fishing, migration status, and participation in self-help groups.

5.13. Fishing Status

In the sample, only about 15 per cent of households reported that they had completely moved away from the fisheries sector for their livelihood. The total number of households that had active fishermen was 985, implying that 77.5 per cent of sample households were dependent on active fishing for their livelihood.

Figure 48: Fishing Status of Sample Households



Source: Primary Data

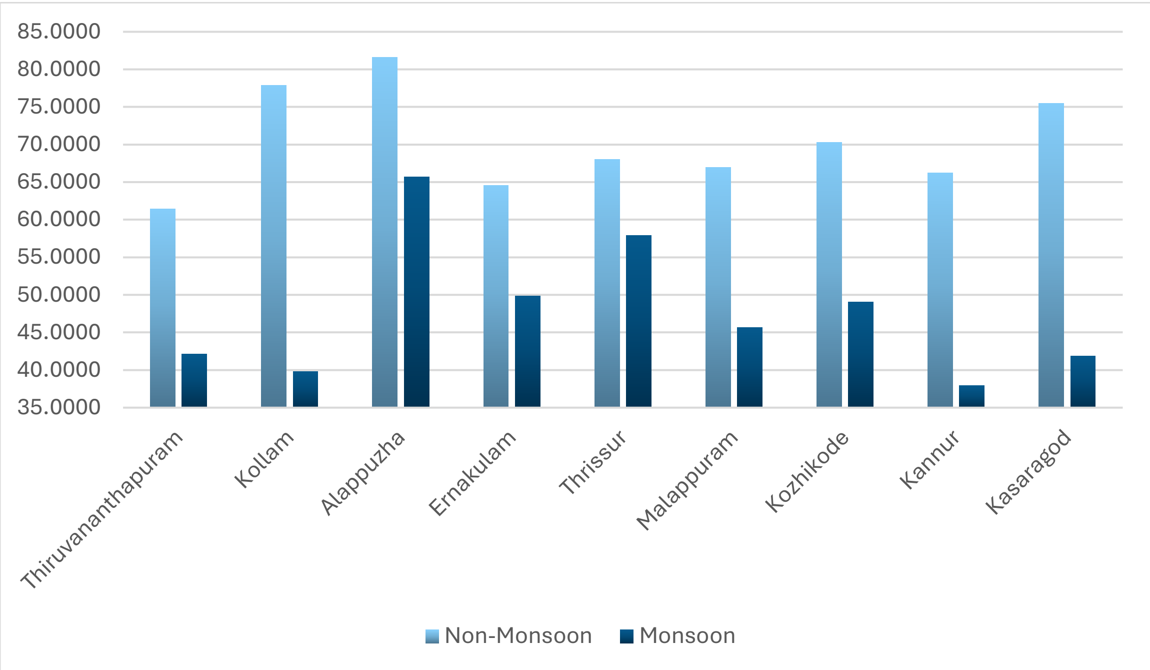
Among the 985 fishing households, however, only about 30 per cent had fishing craft of their own. Seventy per cent were working as labourers in other crafts. Among respondents who owned boats, 90 per cent owned traditional vessels, and more than half of those were non-motorized ones. Traditional vessels were predominantly motorized in the Northern Zone, and less so in the Central Zone.

Table 15: Ownership of Fishing Craft

Fishing Craft	Region			Total
	South	Central	North	
Non-motorized	54	69	17	140
Outboard	42	31	52	125
Inboard	7	5	2	14
Mechanized	0	16	0	16
Total	103	121	71	295

Source: Primary Data

Figure 49: Weekly Working Hours (Monsoon vs Non-Monsoon)

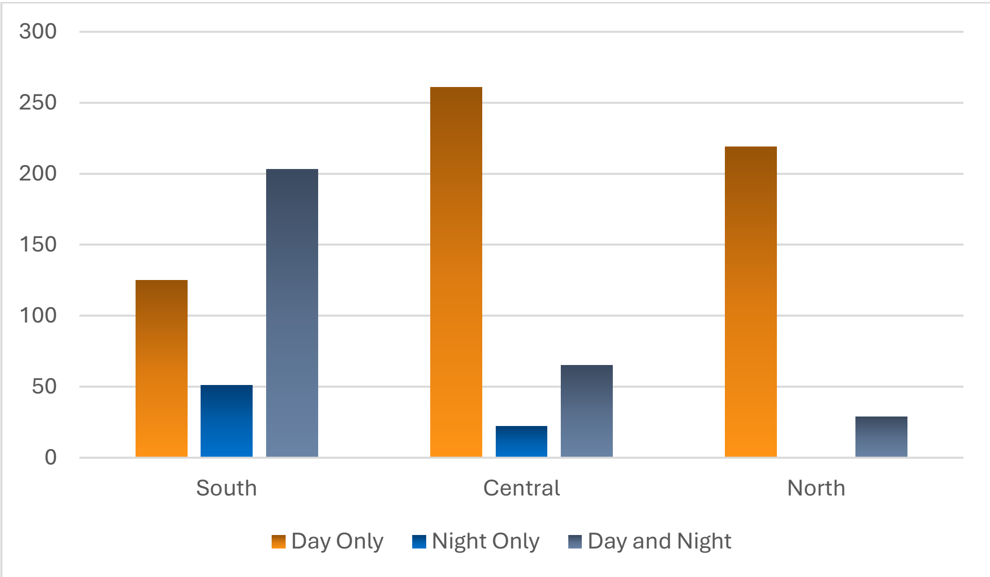


Source: Primary Data

The weekly working hours of fishermen in each district was computed based on the average number of days spent at sea per week and the number of hours spent at sea per seagoing day. The number of days spent per week was multiplied by the duration spent at sea each day to calculate weekly working hours.

The results given in figure 4.2 indicate that fishermen generally spend more time at sea during the calm, non-Monsoon season, with those in Alappuzha and Kollam spending the most time in their traditional occupation. In most districts, the difference between weekly time spent at sea varies significantly between Monsoon and non-Monsoon periods, except in Alappuzha and Thrissur. During the Monsoon season, the fishermen in Alappuzha and Thrissur were found to be the most active.

Figure 50: Fishing Timing

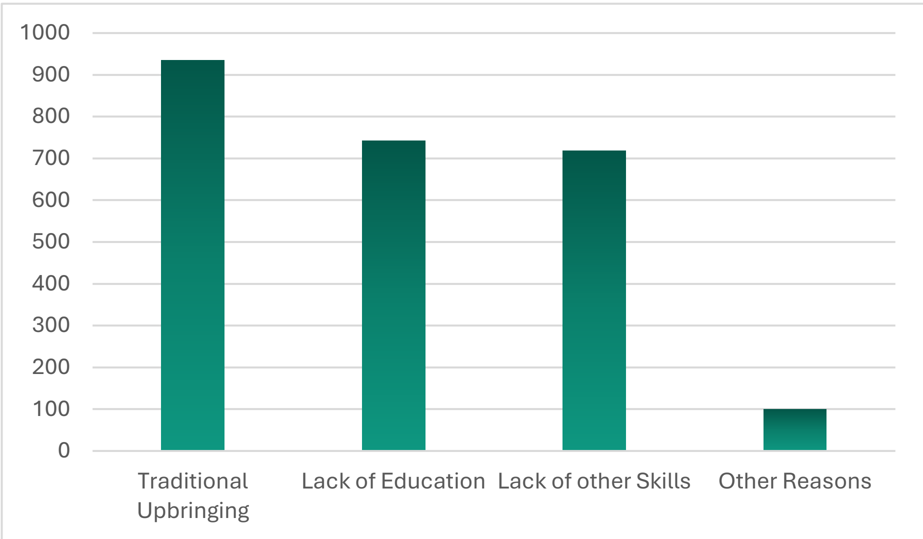


Source: Primary Data

In terms of fishing patterns, fishermen in Southern Kerala gave higher preference to fishing at night. Fishermen in Central and Northern Kerala largely preferred daytime fishing activity. Daytime fishing generally starts at around 4-5 am and usually gets complete within 12 hours, while nighttime fishing starts usually at around 6 pm with the fishermen returning early the next morning with their catch.

Among the factors that prompted a fisherman to choose fishing as his primary occupation, the most prevalent one was the traditional upbringing. More than three quarters of fishermen reported that the growing up seeing their forefathers at sea, and hearing stories of their community prompted them to take up fishing as a means of livelihood. These people are of the opinion that even if they get no other employment, they can still venture out into the sea and earn their daily bread. The two other factors that significantly affected people's choices were a lack of education or other skills.

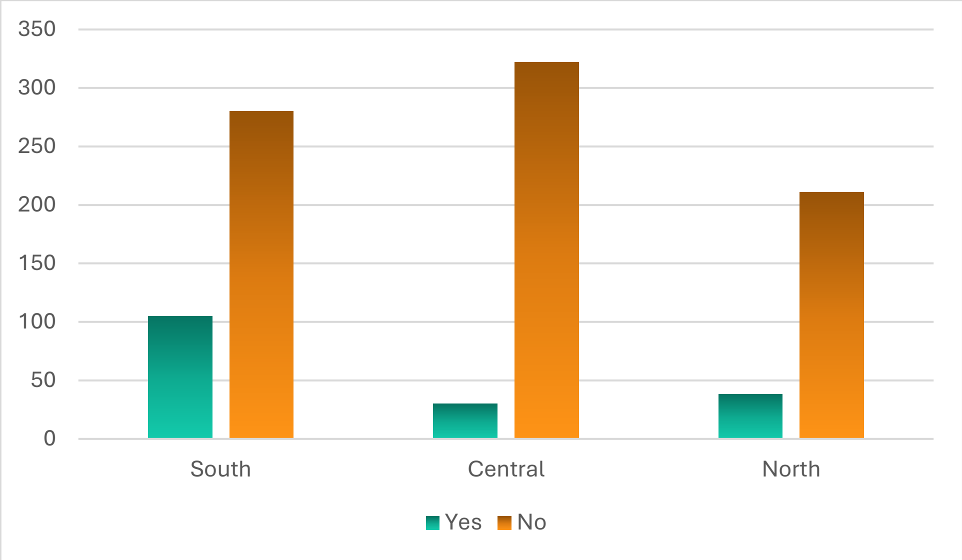
Figure 51: Reason for Choosing Fishing



Source: Primary Data

The practicing fishermen were asked whether they were willing to shift from fishing in the future, and an overwhelming majority refused to entertain that thought. Fishing is considered the lifeblood of the community, and giving it up was considered a departure from their identity. The fishermen who said that they would not abandon the traditional occupation spoke with much fondness about their life that is connected with the sea. Even those who were willing to shift were only willing to do so because they feared that climate change would make it impossible to carry on the traditional occupation, and that they would eventually be supplanted from the seashore due to rehabilitation programmes.

Figure 52: Willingness to Shift

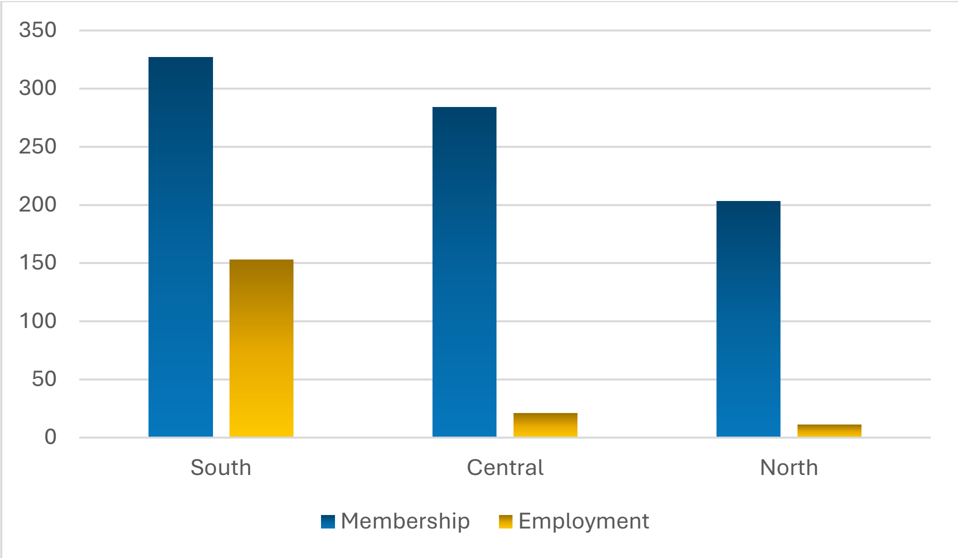


Source: Primary Data

5.14. SHGs and MGNREGS

In the sample, only about 14.5 per cent households reported that they had some sort of gainful employment through self-help groups. The proportion of households that has employment through SHGs was far shorter than the number of households that had at least one member in them. The gap between membership and employment in SHGs was smallest in Southern Kerala, where 71.3 per cent of households had at least one individual who was a member in an SHG, and 33 per cent found employment through this route. In the Central and Northern Zones, the gap was far greater. In Central Kerala, 66 per cent of households had membership while only 5 per cent found employment. In the North, the situation was equally worse, with only 53 per cent having membership and only 2.9 per cent finding employment. Among households that had members who found employment through SHGs, the largest proportion were employed in seafood manufacturing units. More than three-quarters were employed in these units. Manufacturing focused on products other than fisheries and agriculture was a distant second, and agro-based manufacturing industries employed the least.

Figure 53: SHG Membership and Employment



Source: Primary Data

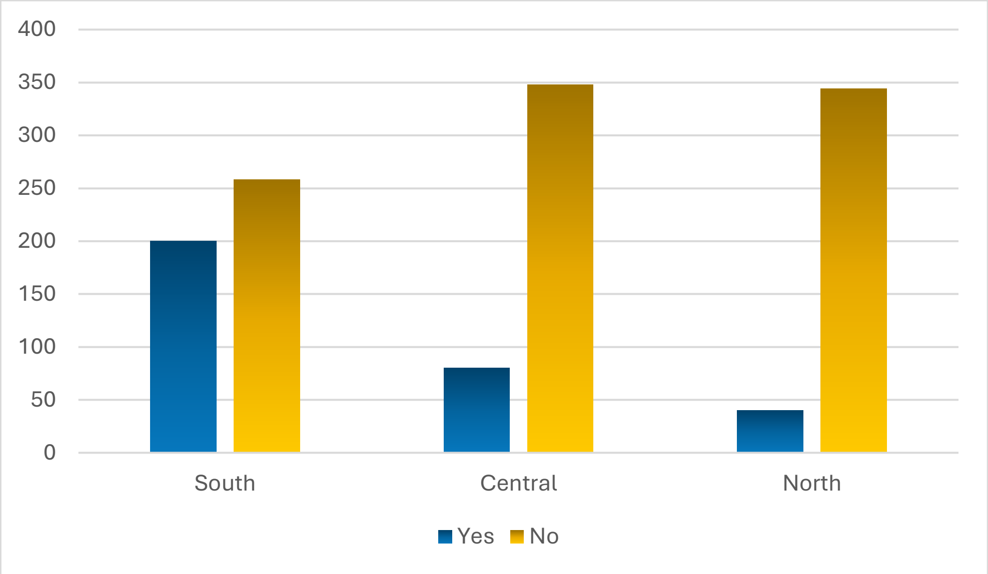
Table 16: Employment Through SHGs by Region

SHG Activity	Region			Total
	South	Central	North	
Agriculture	8	0	0	8
Manufacturing (Seafood)	122	20	2	144
Manufacturing (Agro-based)	1	0	0	1
Manufacturing (Others)	19	1	0	20
Service Sector	3	0	9	12
Total	153	21	11	185

Source: Primary Data

The Mahatma Gandhi National Rural Employment Guarantee Scheme and Ayyankali Urban Employment Guarantee Scheme are both aimed at augmenting livelihoods by providing 100 days of guaranteed employment to beneficiaries. The uptake of these income-augmenting schemes varied significantly between different regions of Kerala's coastal belt. In all three regions, the number of households who were nonbeneficiaries outnumbered the number of beneficiaries, although the gap was narrowest in the South. Almost 44 per cent of fishing households in Southern Kerala had at least one member employed under MGNREGS or AUEGS. This number is significantly higher than in Central Kerala (18.6 per cent) and Northern Kerala (10.4 per cent).

Figure 54: Employment under MGNREGS/AUEGS



Source: Primary Data

Table 17: Activity Under MGNREGS/AUEGS

Activity	Region			Total
	South	Central	North	
Construction of communal assets	61	44	28	133
Construction of individual assets	2	1	1	4
Cleaning work	131	35	11	177
Other activities	6	0	0	6
Total	200	80	40	320

Source: Primary Data

Examining the activity undertaken by individuals employed under MGNREGS or AUEGS shows that cleaning work was the most commonly undertaken work in the Southern Zone. In the Central and Northern Zones, however, construction of communal assets including roads and canals were the most common activity assigned under the schemes. To assess how effective the schemes were in terms of employment generation, a one-way ANOVA was performed with the following null hypothesis:

H_0: There is no significant difference in the average number of employment days generated under the employment guarantee schemes in different districts.

Table 18: One-Way ANOVA (MGNREGS Days * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	51817.607	8	6477.201	9.384	0.000
Within Groups	214663.065	311	690.235		
Total	266480.672	319			

Source: Primary Data

Figure 55: Effectiveness of MGNREGS/AUEGS by District

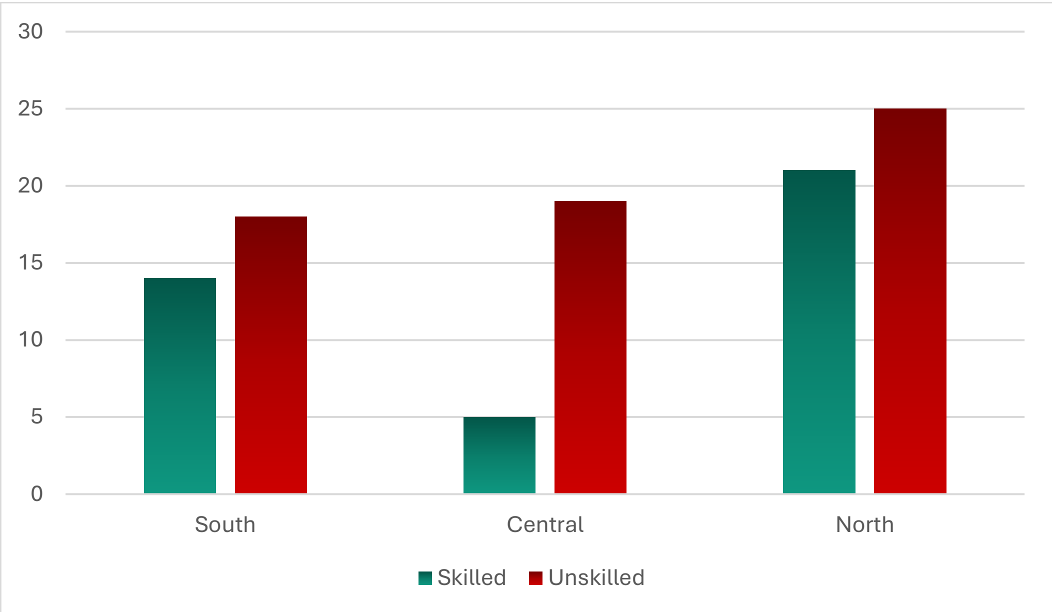
Source: Primary Data

The ANOVA test revealed that the null hypothesis may be rejected, with the number of employment days generated varying significantly between the nine coastal districts. Thrissur, Ernakulam, and Thiruvananthapuram showed the best performance, while Kannur, Kollam, and Kasaragod were the worst. Overall, the schemes were more effectively implemented in the districts of Central Kerala.

5.15. Alternate Livelihoods

Only about 8 per cent of sample households had at least one migrant whose remittances supported the family economically. Of these 102 households, the vast majority (93 per cent) were migrants to the Middle East, and only seven households had a migrant member working in Europe or other regions. The migration of skilled and unskilled workers, however, differed between the regions. Migrants from Central Kerala tended to predominantly be unskilled workers. While unskilled workers outnumbered skilled migrants In the Southern and Northern Zones too, the gap between the two categories was far narrower.

Figure 56: Migration Pattern



Source: Primary Data

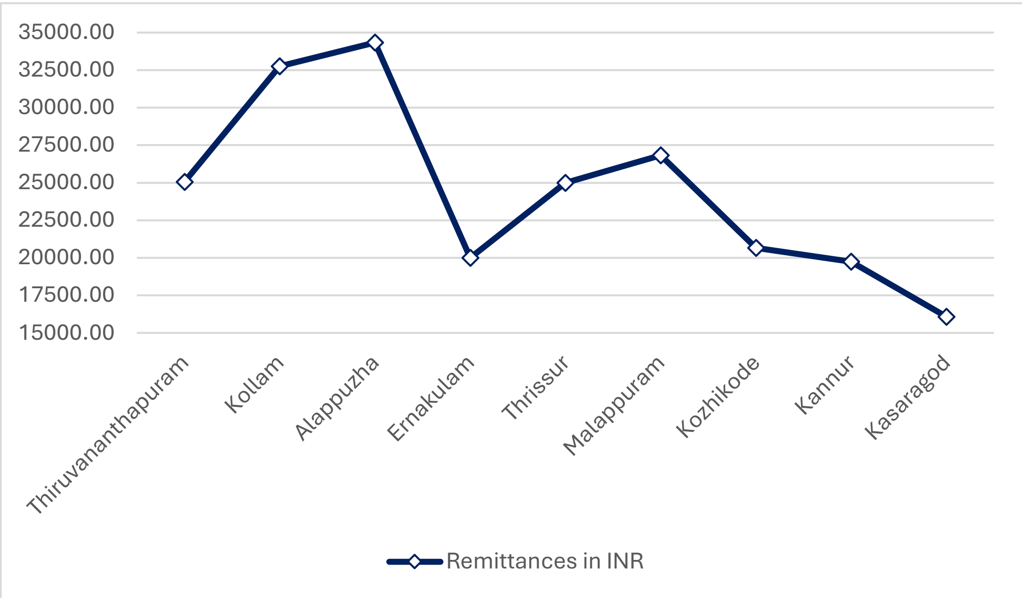
To assess the impact of external migration on fishing households, a one-way ANOVA was performed assuming a null hypothesis that monthly remittances were identical between the districts. The results of the test, given in table 4.5, however, show that the null hypothesis may be rejected. There is a significant gap in the average remittances received by fishing households in various districts, with those in Alappuzha and Kollam receiving the highest amounts. Households in Kasaragod, Kannus, and Ernakulam received the lowest in terms of monthly remittances.

Table 19: One-Way ANOVA (Remittances * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3598646450.771	8	449830806.346	4.022	0.000
Within Groups	9172150252.525	82	111855490.884		
Total	12770796703.297	90			

Source: Primary Data

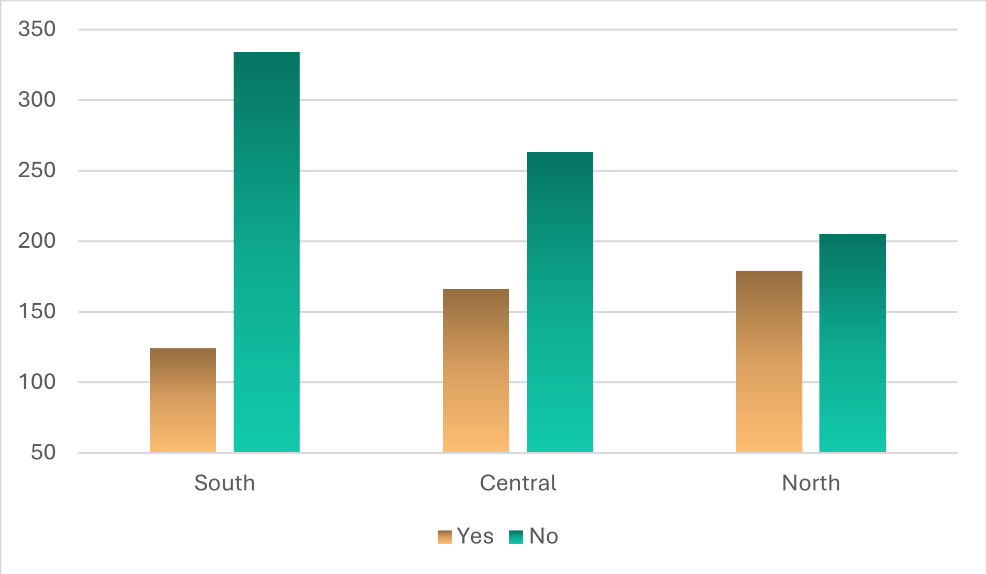
Figure 57: Average Self-Reported Remittances by District



Source: Primary Data

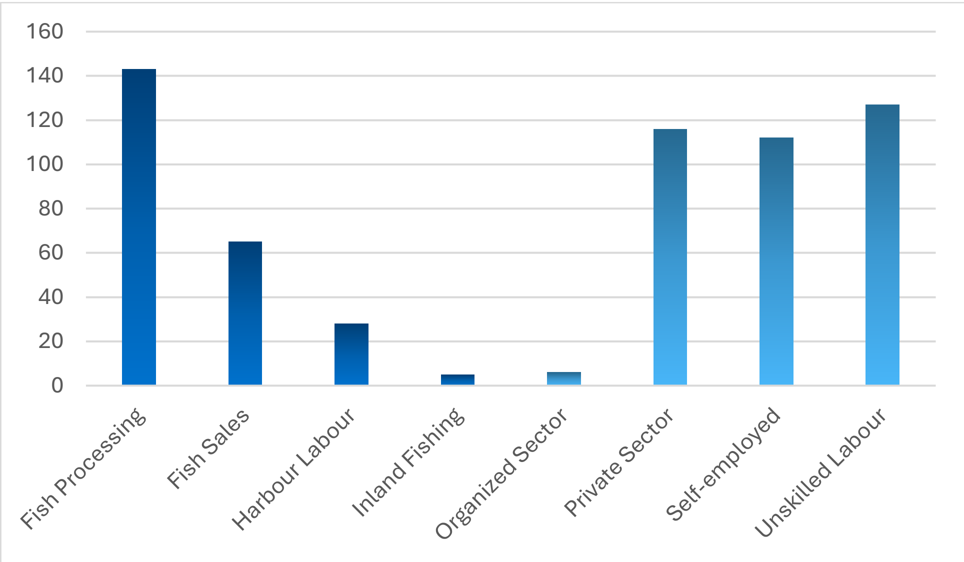
In all three regions, households entirely dependent on fishing outnumbered those who had at least one other source of income. The pattern was, however, different between the regions, with the widest gap seen in Southern Kerala, and the narrowest in the Northern Zone. More than 46 per cent of households in Northern Kerala had at least one member who had an alternative employment, compared to just 27 per cent in Southern Kerala. In the Central Zone, nearly 39 per cent had an alternative employment.

Figure 58: Alternate Employment



Source: Primary Data

Figure 59: Alternate Employment Avenues



Source: Primary Data

In terms of the avenues of alternative employment, fish processing and unskilled casual labour were the most preferred. There were 241 households had members who found alternate employment within the fisheries sector, while 361 had employment outside fisheries. Even so, only 6 out of 1271 households had a government servant, indicating that the community members were finding ti difficult to gain employment in the organized sector. Even in the private sector, only about 9 per cent of all sample households had at least one member finding employment.

Table 20: One-Way ANOVA (Alternate Income * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4522968746.312	8	565371093.289	5.325	0.000
Within Groups	63487215833.589	598	106165912.765		
Total	68010184579.901	606			

Source: Primary Data

Figure 60: Average Self-Reported Alternate Income by District

Source: Primary Data

The variation in monthly income from alternate employment across the districts was measured using a one-way ANOVA with a null hypothesis that the variation was not significant. The results of the ANOVA lead to the rejection of this null hypothesis, with income from alternate employment varying widely between the nine districts. Households in Alappuzha, Ernakulam, and Kozhikode had the highest income from alternative sources, with Thiruvananthapuram, Kasaragod, and Malappuram having the lowest.

5.16. Shifting from Fisheries

Although most traditional fisherfolk were hesitant to leave behind their traditional livelihood, there were several households that had entirely moved away from the fisheries sector as a way of adapting to the changing situation. Fisheries was considered by these households to be a career path that paid low dividends. These households also viewed the shift as a pointer towards the future, as they fear climate change will make it impossible to continue with the traditional occupation in the coming decades.

To assess the impact of different factors on this decision to move away from fisheries, a binary logit regression was performed. The model uses dependency on fisheries as the dependent variable, with independent variables being age and sex of the head of the household, household size, housing status, income and poverty line status, location of the household, indebtedness, presence of alternate income sources and remittances, and the impact of natural disasters. The variables are explained in detail in table 4.7.

The logit estimates are given in table 4.8. The model had a McFadden R^2 value of 0.2424, indicating a good enough fit. The regression analysis shows that of the thirteen independent variables considered for the model, the only ones found to not be significant were the poverty line status of the household, and their location. Among the significant variables, distance form the sea, monthly consumption, and damage from storm surges and coastal flooding were significant at the 95 per cent confidence level, while the remaining variables were significant at the 99 per cent confidence level.

Table 21: Descriptions of Variables Used for Livelihood Shift Model

Variable	Description
	Dependent Variable
Fisheries Dependency	Dummy variable for a household's dependency on fisheries for income. It takes the value of '1' if at least one family member practices fishing as a source of livelihood and '0' if s/he does not.
	Independent Variable
Age	Age of the head of household in years
HH Size	Household size in number of family members
Area	Built-up area of the house in sq. ft
Consumption	Monthly household consumption in '000 INR
Sea Distance	Distance from the High Tide Line (HTL) to the homestead in meters
Sex	Dummy variable for sex of the head of the household. =1 if Female, otherwise 0. (Reference Group: Male)
Rural	Dummy variable for location. =1 if Rural, otherwise 0. (Reference Group): Urban
APL	Dummy variable for poverty line status. =1 if APL, otherwise 0. (Reference Group): BPL
Debt	Dummy variable for indebtedness status. =1 if household has outstanding debt, otherwise 0. (Reference Group): No debt
Alt Employed	Dummy variable for alternate employment outside fisheries. =1 if at least one family member has an alternate source of income, otherwise 0. (Reference Group): Fisheries_bin
Migrant	Dummy variable for migration status. =1 if at least one family member is a migrant who send remittances, otherwise 0. (Reference Group): Non-migrant
Cyclones	Dummy variable for cyclone damage. =1 if household has suffered losses due to cyclones in the past six years, otherwise 0. (Reference Group): Cyclone_nil
Storm Surge	Dummy variable for damage from coastal flooding and storm surges. =1 if household has suffered losses due to coastal flooding and storm surges in the past six years, otherwise 0. (Reference Group): Storm_Surges_nil

Source: Primary Data

Table 22: Logit estimates for Determinants of Livelihood Shift

Fisheries Dependency	Coefficient	Std. err.	z	P>z	Odds Ratio	Marginal Effect at Mean
_cons	1.6064	0.4993	3.220	0.001	4.9849	
Age	0.0016	0.0049	0.330	0.742	1.0016	0.0002
HHSize***	0.4160	0.0634	6.570	0.000	1.5159	0.0540
Builtup***	-0.0018	0.0003	-5.470	0.000	-0.9982	-0.0002
Cons_000**	0.0364	0.0146	2.490	0.013	1.0371	0.0047
Sea_Dist**	0.0052	0.0022	2.340	0.019	1.0052	0.0006
Sex***	-1.2524	0.1921	-6.520	0.000	0.2858	-0.1626
Rural	0.1024	0.1856	0.550	0.581	1.1078	0.0135
APL_Bin	-0.0050	0.2046	-0.020	0.981	0.9950	-0.0006
Debt_Bin***	0.6417	0.1851	3.470	0.001	1.8998	0.0806
Other_Employment _Bin***	-1.9190	0.1766	-10.870	0.000	0.1467	-0.2959
Migrant_Bin***	-1.5232	0.2912	-5.230	0.000	0.2180	-0.2855
Cyclones***	1.0083	0.2390	4.220	0.000	2.7409	0.1580
Storm_Surge**	-0.4102	0.2095	-1.960	0.050	0.6635	-0.0527

McFadden R^2	*0.2424*	*McFadden Adjusted R^2*	*0.2213*
Likelihood Ratio Test (χ2)	*321.287*	*p-value (χ2)*	*0.000*
Pearson χ2	*1336.07*	*p-value (χ2)*	*0.0253*

Source: Primary Data

Among the significant variables, household size, monthly consumption expenditure, distance from the sea, indebtedness, and impact from cyclones had a positive relationship with the dependent variable. Among these positive factors, the highest impact was from the impact of cyclones, with an affected household being 15.8 per cent more likely to practice fishing. This result is likely due to more fishing households being affected by cyclones in recent years. Larger households also had a 5.4 greater probability of sticking to fishing.

Among the significant negative factors, the two most significant variables were the presence of alternate income sources and presence of remittances. A household that had at least one member working in an occupation other than fishing was 29.6 per cent more likely to drop out of fisheries, while having at least one migrant increased the likelihood of dropout by 28.55 per cent. Female headed households were also less likely to be dependent on fisheries, with the probability of abandonment rising by 16.3 per cent in the case of these households.

Two variables that need to be examined in tandem with each other are distance to the sea and damage from storm surges and coastal flooding. Households living nearer to the high tide line (HTL) were at greater risk of suffering from the impact of storm surges or coastal flooding. According to the model, these households were 5.3 per cent more likely to abandon fisheries as a way of livelihood. Distance to the sea, on the other hand, is positively linked to a household's chances of being dependent on fishing as their primary source of livelihood. Households living further away from the sea are far less likely to lose their homesteads and livelihoods to the sea, further corroborating the results of the model. A further explanation of these trends will be made in chapter seven, where the impact of these variables is examined in greater detail.

Form 10
Part B

Report Profile

Data Analysis

Sensitivity and Resilience

Sensitivity and Resilience

The current chapter deals with second axis of the IPCC's vulnerability analysis – sensitivity. Sensitivity is measured based on factors such as access to food, water and healthcare. The chapter also examines resilience of the community in terms of access to governmental schemes and intra-community linkages.

5.17. Access to Food

All but two households in the sample bought food from ration shops using their ration cards. In fact, 31.5% of all households in the sample completely depended upon the public distribution system for food grains, sugar and kerosene. More than 36% of households were dependent upon the PDS for food grains, but they also purchased food from the open market as well as Supplyco or the Maveli stores. The smallest group that we saw in the sample were the households that had purchased only from the PDS and the open market. The last category comprises almost 9.5% of the sample households.

Table 23: Primary Source of Foodgrains, Pulses and Sugar by Region

Food Source	Region			Total
	South	Central	North	
PDS Only	228	171	1	400
PDS + Supplyco/Maveli Stores	76	76	139	291
PDS + Open Market	81	22	17	120
All three	71	160	227	458
Total	456	429	384	1269

Source: Primary Data

Examining the primary source of food grains, pulses, and sugar, in terms of the ration card that was held by the households revealed that among households that had the yellow relation cards under the Anthyodaya Anna Yojana scheme, 42 per cent were dependent upon the PDS system entirely. Among households that had the BPL ration card, this figure was exceeded by households that purchased food from the PDS outlets as well as Open market and supply Co or Maveli stores. Among the households that were above the poverty line, the prevalent tendency was to purchase items from all three outlets, with a lowered dependency on the PDS.

Table 24: Primary Source of Foodgrains, Pulses and Sugar by Ration Card

Food Source	Ration Card				Total
	Yellow (AAY)	Red (BPL)	Blue (Priority)	White (General)	
PDS Only	83	237	61	19	400
PDS + Supplyco/Maveli Stores	58	204	24	5	291
PDS + Open Market	22	70	14	14	120
All three	34	294	70	60	458
Total	197	805	169	98	1269

Source: Primary Data

Table 25: Food Inadequacy

District	Food Inadequacy		Total
	Yes	No	
Thiruvananthapuram	120	65	185
Kollam	34	87	121
Alappuzha	5	147	152
Ernakulam	1	136	137
Thrissur	0	142	142
Malappuram	11	139	150
Kozhikode	7	154	161
Kannur	13	95	108
Kasaragod	5	110	115
Total	232	1039	1271

Source: Primary Data

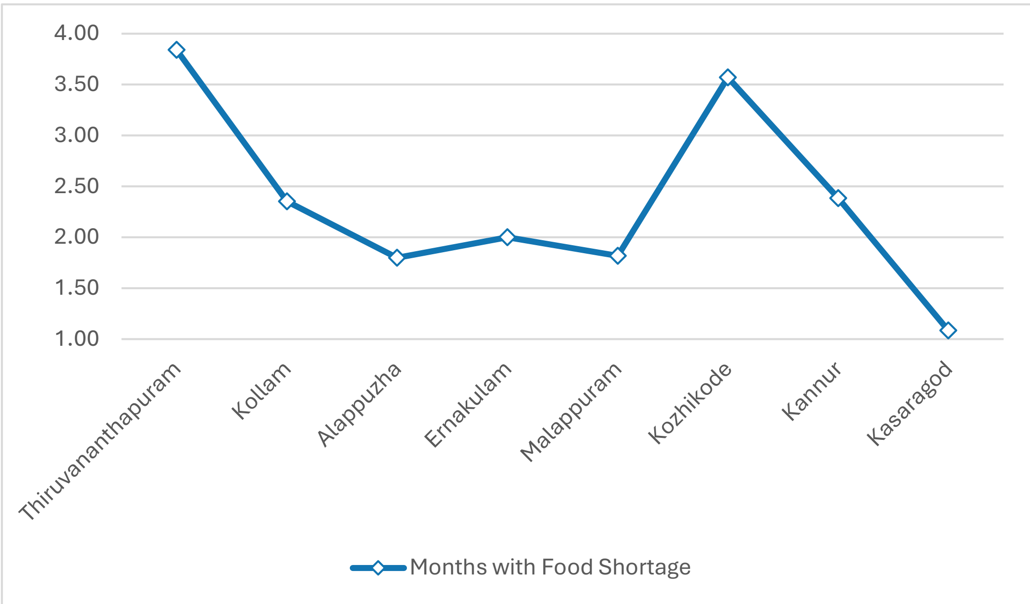
The prevalence of hunger among households was also examined as part of this study. Food inadequacy was defined as a situation in which at least one member of the household stayed hungry for at least one month in the preceding year. Table 5.3 reveals that the situation was the worst in Thiruvananthapuram district, where more than 60% of households faced food inadequacy for at least one family member. The number was very low in northern Kerala and in central Kerala, especially in Ernakulam and Thrissur districts. At roughly 28.1 per cent, Kollam district had a slightly figure for food inadequacy compared to the other districts, although the figure was still dwarfed significantly by the percentage of hungry households in Thiruvananthapuram.

Table 26: One-way ANOVA (Food Inadequacy * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	216.909	7	30.987	12.304	0.000
Within Groups	518.792	206	2.518		
Total	735.701	213			

Source: Primary Data

Figure 61: Intensity of Hunger by Districts



Source: Primary Data

The intensity of hunger was examined by using a one-way ANOVA. The figure taken was the average number of months in which a household faced food inadequacy. The result of the ANOVA given in Table 5.4 reveals that the null hypothesis, which assumes that there is no significant difference in the in the food inadequacy between the districts, may be rejected. The scatter plot given in figure 5.1 indicates that the highest prevalence of hunger was highest in Thiruvananthapuram and Kozhikode districts, while it was lowest in Kasaragod. The data reveals that households that faced hunger in Thiruvananthapuram and Kozhikode had to suffer the situation for 3.5 months or more, while the figure was slightly above one month in Kasaragod.

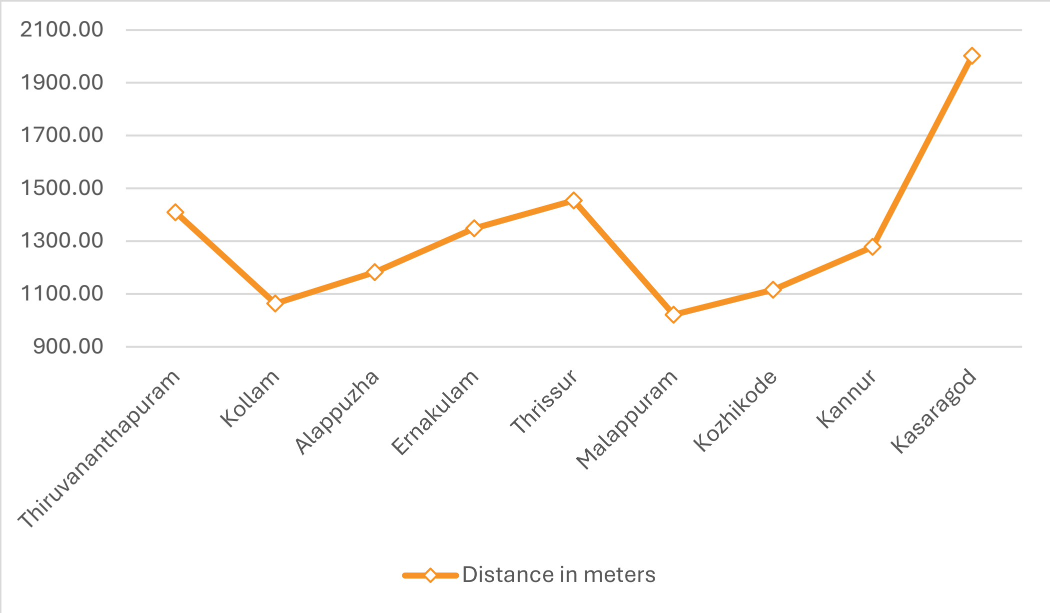
A one-way ANOVA was also performed to examine whether the average distance to a ration shop varied significantly between the 9 coastal districts. The results of these of this ANOVA shows that there is a significant difference between the average distance from a household to a PDS outlet in the nine districts. The distance was lowest in Malappuram and Kollam and highest in Kasargod district. The distance broadly stayed within a range of 900 to 1500 meters in all eight districts except Kasaragod. Kasaragod the distance to a ration shop was almost 2 kilometres on average from every household. This distance may be due to the significantly greater distance that households in Valiyapramba panchayat had to travel to access a PDS outlet. The panchayat is located along a narrow strip of land between the Kavvayi backwaters and the Arabian Sea, with households often travelling for more than six kilometres to access the PDS outlet. The data is portrayed in the ANOVA scatter plot, which leads to a conclusion that the null hypothesis, which assumes that the average distance duration shock is not significantly different between the 9 districts, may be handily rejected.

Table 27: One-way ANOVA (Distance to PDS * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	88572769.719	8	11071596.215	15.948	0.000
Within Groups	876115153.586	1262	694227.538		
Total	964687923.304	1270			

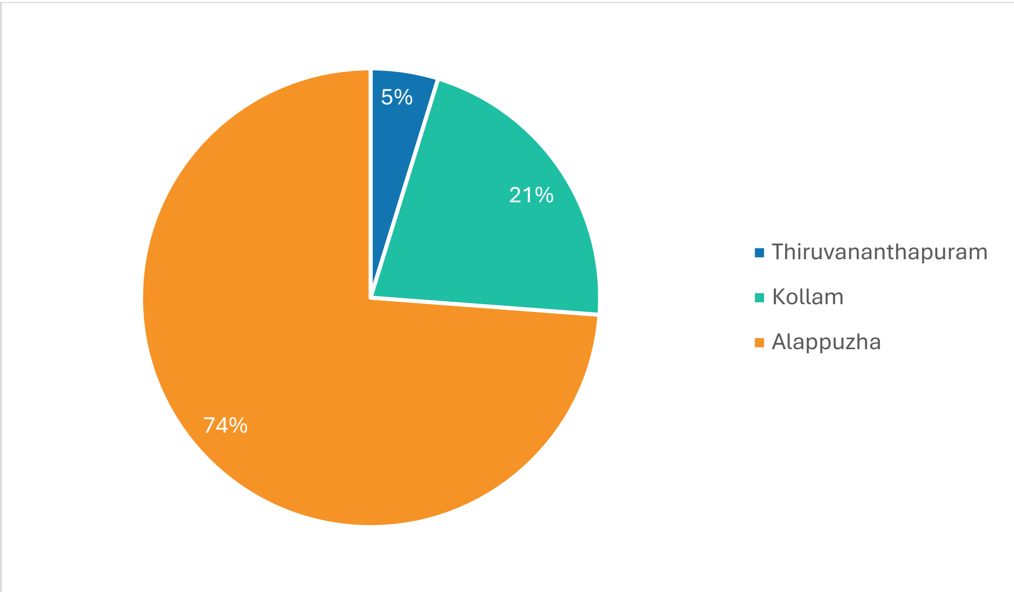
Source: Primary Data

Figure 62: Distance to Ration Shop



Source: Primary Data

Figure 63: Cultivation of Vegetables



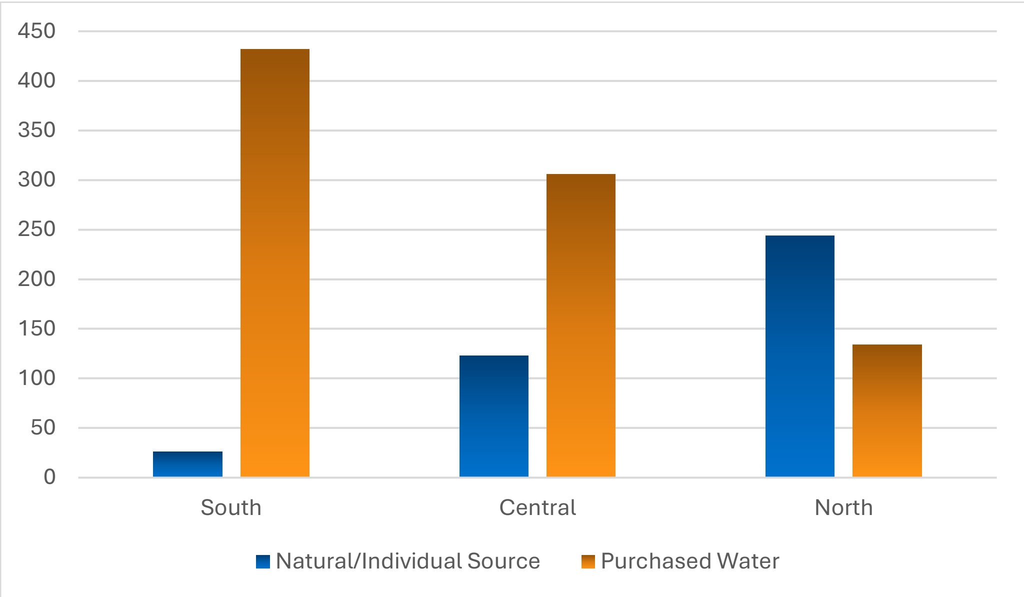
Source: Primary Data

Subsistence agriculture was practiced only by approximately 3 per cent of all respondent households. It was seen only in the Southern Zone, and only vegetables were cultivated by households in this manner. Most of these households were in Alappuzha district.

5.18. Water and Sanitation

When it comes to access to water and sanitation, the variables considered included the source of natural water, the instances of water shortage, the distance to water source as well as the availability of toilets and the number of toilets per household.

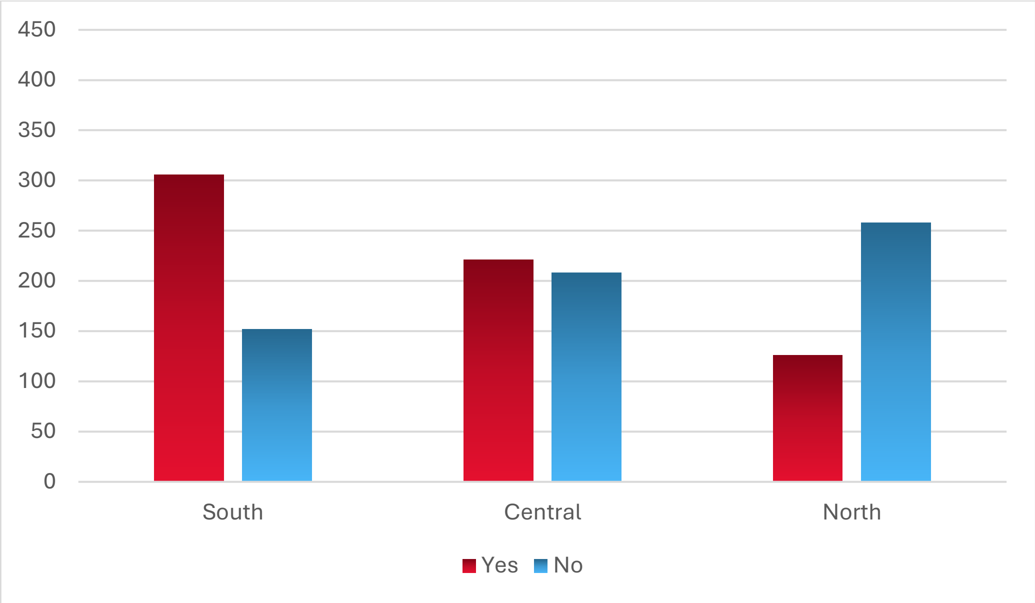
Figure 64: Source of Water



Source: Primary Data

The first variable among these is the source of drinking water for the households. In both the southern and central zones, the number of households which had to purchase potable water outnumber the number of households that had access to a natural or individual water source. The gap was extremely wide in the case of Southern Kerala, where less than 30 households had individual or natural sources of water for the household and more than 95 per cent had to purchase water from outside. In central Kerala, the gap was narrower, while in Northern Kerala, the number of households have had natural or individual sources of water outstripped the number of households had to purchase drinking water for themselves. The habit of using rainwater harvesting systems was also seen only among the fishing households in northern Kerala. The practice was alien to households in Southern and Central parts of the state.

Figure 65: Water Shortages



Source: Primary Data

In both Southern and Central Kerala, the number of households who faced water shortages outnumber the ones who did not face such shortages. The number of households who face water shortages was only marginally higher than the number of households that did not face shortages in the central part of the state. This gap was much narrower when compared to Southern Kerala, where nearly two-thirds of all households faced water conflicts. In northern Kerala, the situation was nearly the opposite to the South, with households that did not face water shortages being the majority. This could likely be due to the number of larger number of households who had access to individual water sources in the region.

To assess whether the number of days per week with water shortage varied between the different districts a one-way ANOVA was undertaken. The results of the ANOVA, given in table 5.4, indicate that the intensity of water shortage varied widely between the districts. The highest figure was in Trivandrum district, where water supply was disrupted on an average of 4.5 days per week. Ernakulam had the second highest figure for water conflicts Weekly water shortage figures the lower scores in Malappuram, Kollam, and Kozhikode districts. The variation is given in the ANOVA scatter plot in figure 5.6.

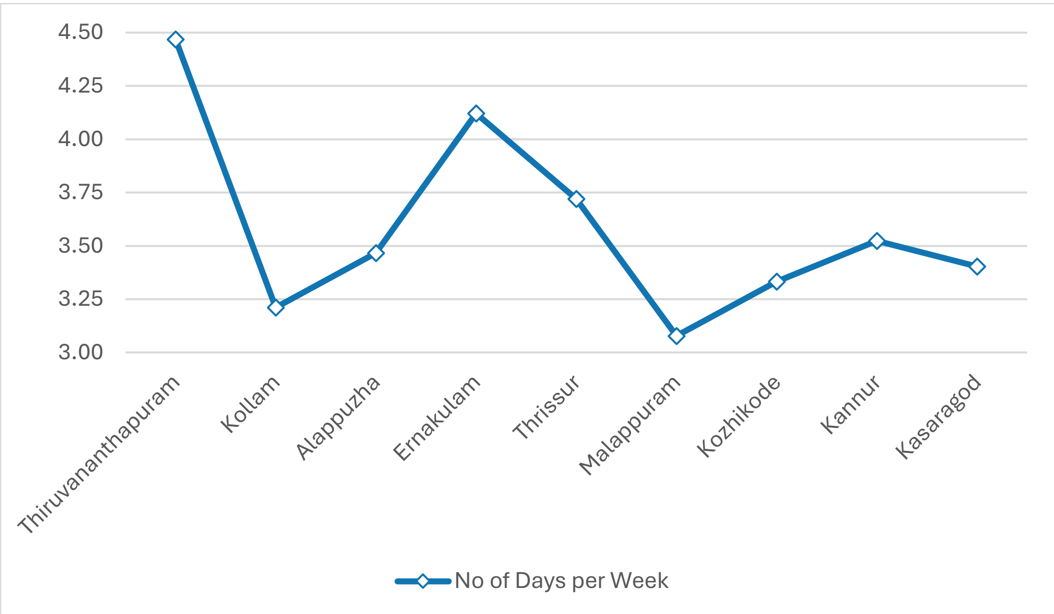
Table 28: One-way ANOVA (Water Shortages * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	155.070	8	19.384	14.759	0.000
Within Groups	840.523	640	1.313		
Total	995.593	648			

Source: Primary Data

Drinking water shortages in Thiruvananthapuram, Ernakulam, and Thrissur are a major issue and it needs to be addressed immediately by the administration. The presence of saline water in wells leads to shortages in potable water, and a lack of space in homesteads in these districts limits the feasibility of rainwater harvesting.

Figure 66: No of Days with Water Shortage per Week



Source: Primary Data

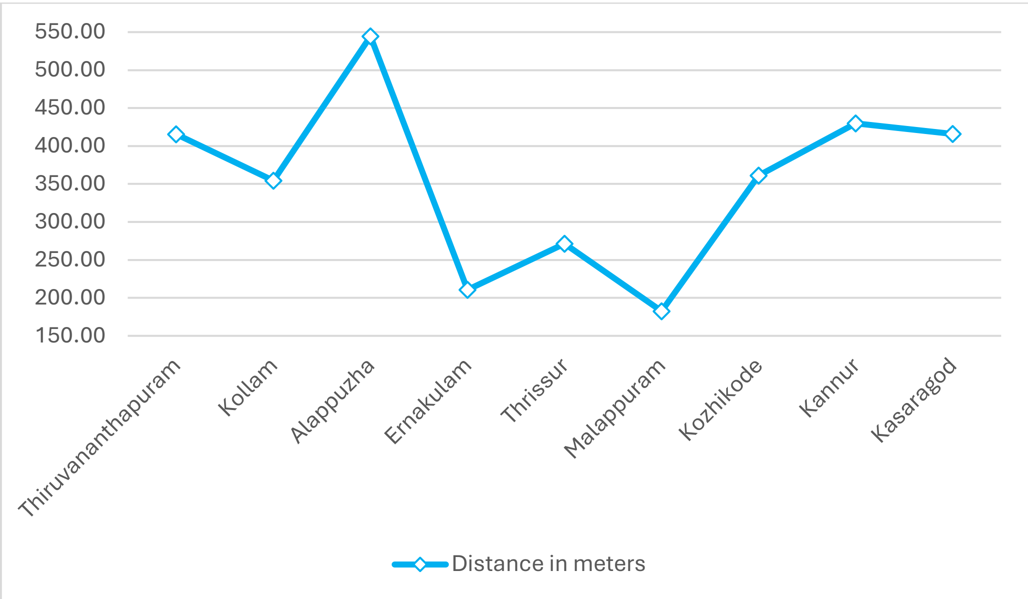
The average distance that an individual must travel to reach the nearest source of potable water was also considered as part of the study. A one-way ANOVA was undertaken to assess whether the distance to water source varied significantly between the nine coastal districts. The results given in table 5.7 show that the distance is significantly different between the districts. The longest distance to water source was seen in Alappuzha, where an individual had to travel approximately 550 meters to reach the nearest source of freshwater. The lowest distance was seen in Malappuram, Ernakulam, and Thrissur.

Table 29: One-way ANOVA (Distance to Water Source * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8276239.586	8	1034529.948	9.426	0.000
Within Groups	70243071.662	640	109754.799		
Total	78519311.248	648			

Source: Primary Data

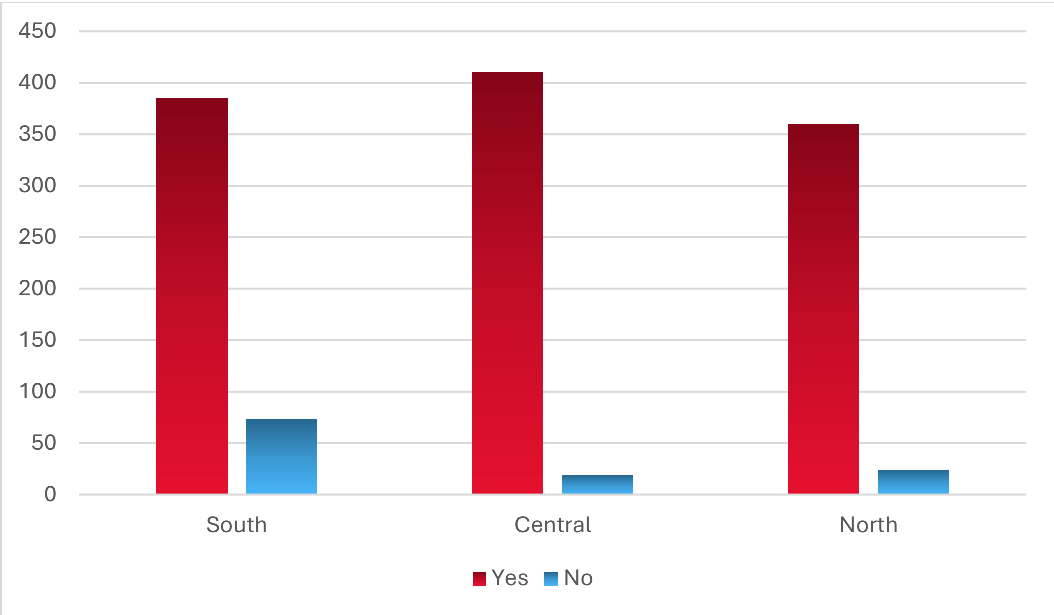
Figure 67: Distance to Water Source



Source: Primary Data

The ANOVA scatter plot given in figure 5.7 shows that in central Kerala, the distance to a water source is considerably less than that in other parts of the state. Even in southern Kerala, the distance to water source in Trivandrum and column is less than that of the distance to water in the northern districts. This shows that overall, central Kerala has the lowest distance to freshwater, while the situation was overall worst in the Northern Zone.

Figure 68: Availability of Toilets



Source: Primary Data

With regard to the availability of toilets, most households across Kerala had toilets of their own. The lack of sanitation was a major problem only in the Southern Zone, especially in Thiruvananthapuram district. In the Central and Northern zones, the availability of toilets was a non-issue in most cases and the proportion of households that did not have a functional toilet was miniscule in these districts. In Southern Kerala, close to 16 per cent of surveyed households did not have a functional toilet, and the seafolk had to either rely on open defecation or use of unhygienic public toilets. In Central and Northern Kerala, the corresponding numbers were only 4.4 and 6.25 per cent respectively. Overall, 9.1 per cent of all sample households lacked proper sanitation, despite Kerala being considered India's first open defecation-free state.

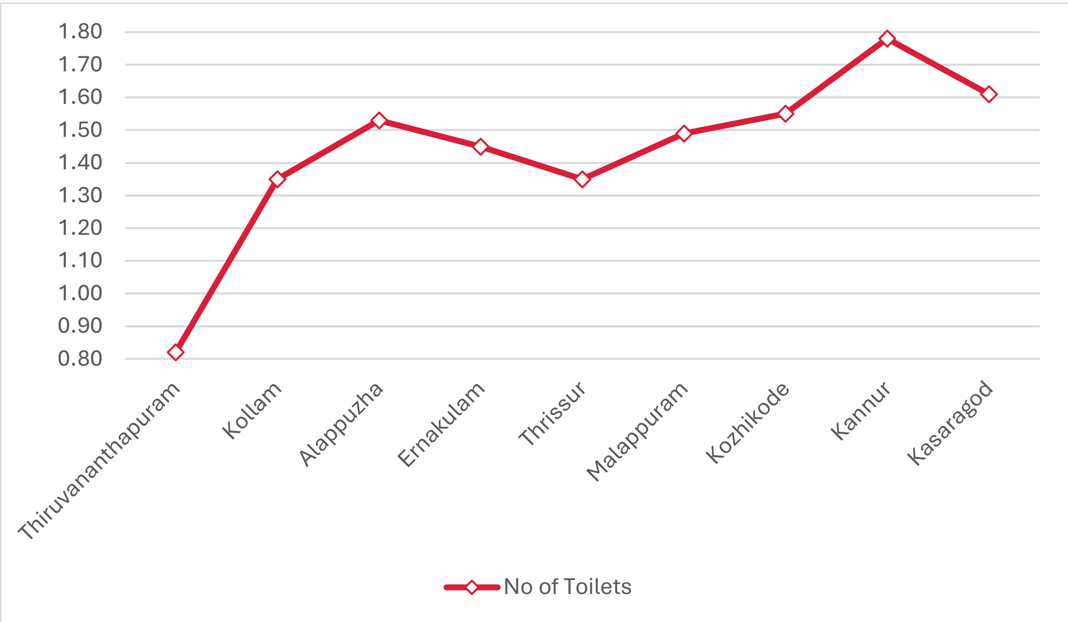
To assess whether the number of toilets available per household differed between different districts, a one-way ANOVA was performed, assuming that the difference was insignificant. The results of the ANOVA, however, facilitate the rejection of this null hypothesis, with households in Northern Kerala having better sanitation facilities than their counterparts in the South. Thiruvananthapuram is the worst-performing district, while the best scenario was in Kannur.

Table 30: One-way ANOVA (Number of Toilets * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	92.308	8	11.538	0.556	0.000
Within Groups	708.394	1262	0.561		
Total	900.702	1270			

Source: Primary Data

Figure 69: No of Toilets per Household

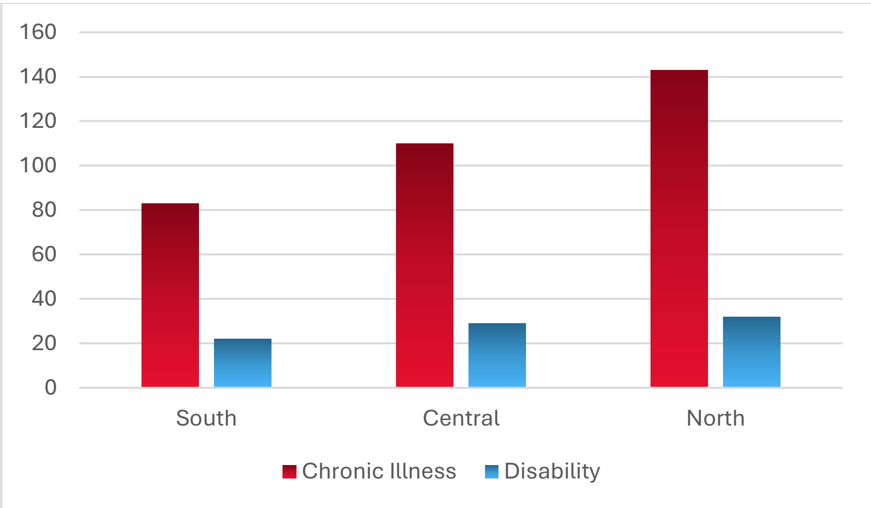


Source: Primary Data

5.19. Health Status and Access to Healthcare

One of the key factors that defines the sensitivity of a community towards climate change is its health status. The study considered the number of households in each region that had at least one member who suffered from a chronic illness, as well as number of households that had at least one disabled member. The numbers, shown in figure 5.10, shows that the proportion is highest in the Northern Zone, and least in Southern Kerala. More than one-third of all households in Northern Kerala had one member who suffered from a chronic illness, while the numbers were only about 25 per cent in Central Kerala, and roughly 18 per cent in Southern Kerala.

Figure 70: Chronic Illness and Disability



Source: Primary Data

Table 31: Nearest Health Facility

The nearest clinic/hospital	Region			Total
	South	Central	North	
Primary Health Centre (PHC)	264	208	104	576
Family/Community Health Centre (FHC/CHC)	122	31	79	232
Taluk Hospital	35	40	64	139
District hospital/General hospital	19	71	102	192
Government medical college	5	0	0	5
Private hospital	13	79	35	127
Total	458	429	384	1271

Source: Primary Data

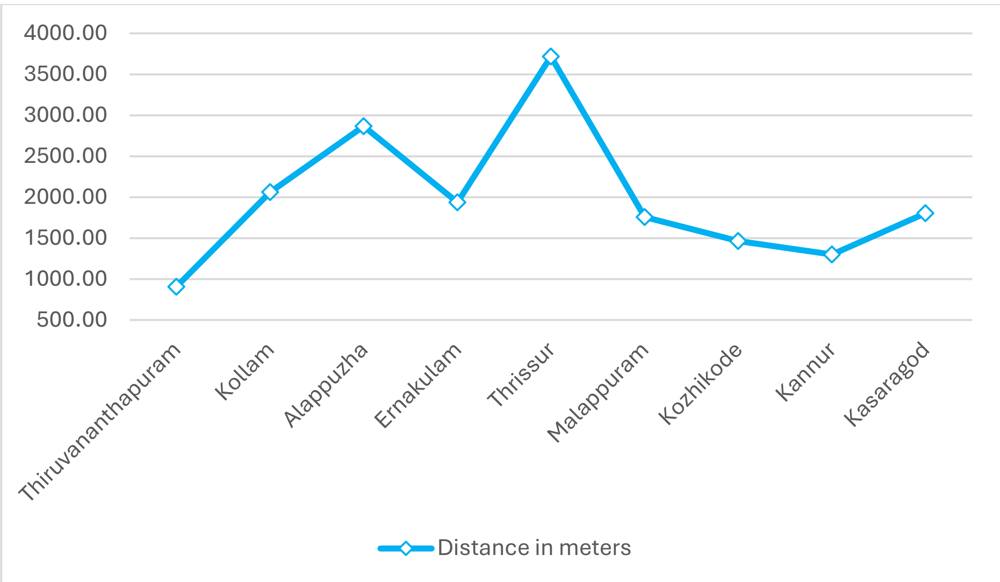
In terms of access to health facilities, the data revealed that the first point of contact for more than 63 per cent of all households was a primary health centre or family health centre. The strength of Kerala's health infrastructure meant that households had access to health practitioners at affordable costs within a short distance. The distance was, on average, less than two kilometres in all districts except Kollam, Alappuzha, and Thrissur. Households in Thiruvananthapuram had the highest proximity to healthcare facilities, at about roughly a kilometre, while those in Thrissur had to travel the furthest. The distance to nearest healthcare facility is significantly different between the nine districts, as evident from the one-way ANOVA depicted in Table 5.6 and figure 5.11.

Table 32: One-way ANOVA (Distance to Nearest Health Facility * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	865021354.288	8	108127669.286	118.306	0.000
Within Groups	1153421498.584	1262	913963.153		
Total	2018442852.872	1270			

Source: Primary Data

Figure 71: Distance to Nearest Health Facility



Source: Primary Data

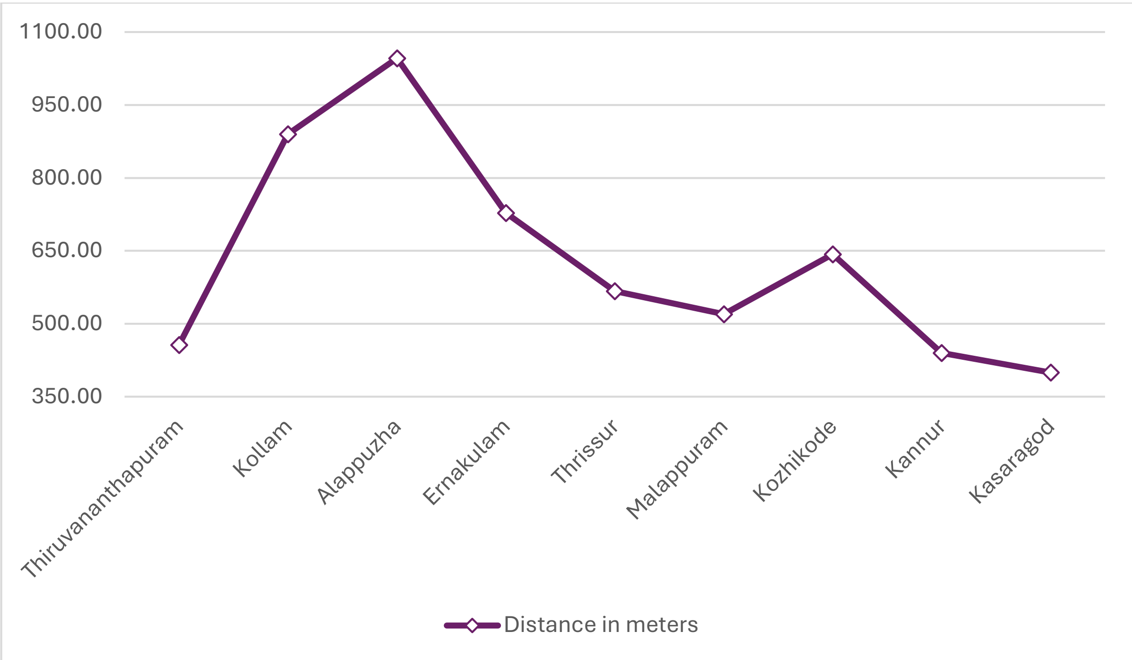
In terms of average monthly expenditure on healthcare, we can see that a statistically significant difference exists between the nine districts. The results of the one-way ANOVA in table 5.7 indicate that the null hypothesis which assumes no significant difference may be rejected. The scatterplot of points in figure 5.12 shows that health expenditure is significantly higher in Alappuzha and Kollam districts, while it was lowest in Kasaragod, Kannur, and Thiruvananthapuram districts.

Table 33: One-way ANOVA (Average Monthly Health Expenditure * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	53779770.197	8	6722471.275	2.568	0.009
Within Groups	3303018656.239	1262	2617288.951		
Total	3356798426.436	1270			

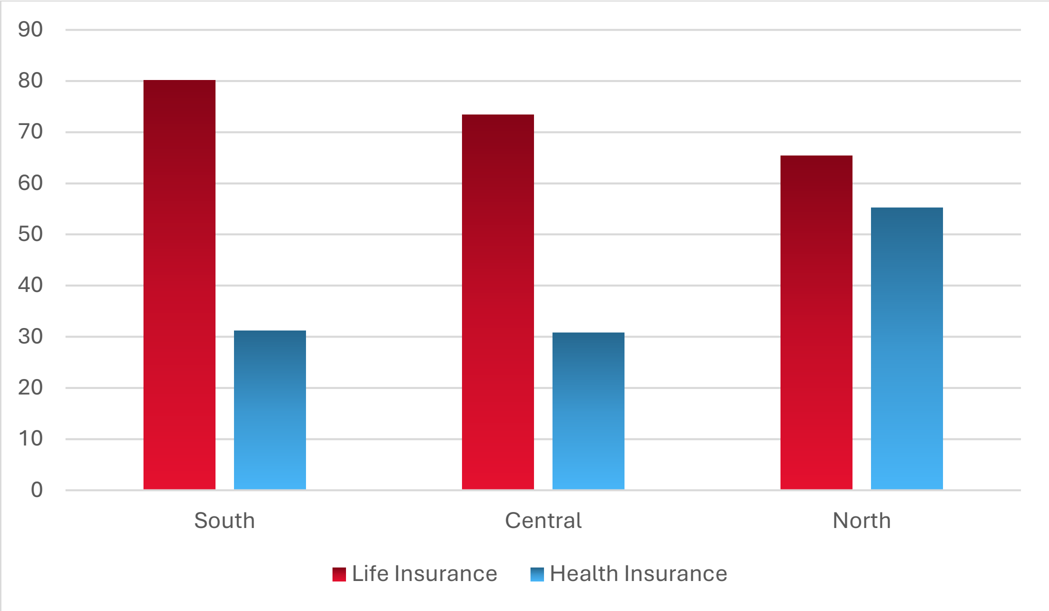
Source: Primary Data

Figure 72: Average Monthly Health Expenditure



Source: Primary Data

Figure 73: Percentage of Households with Life or Health Insurance



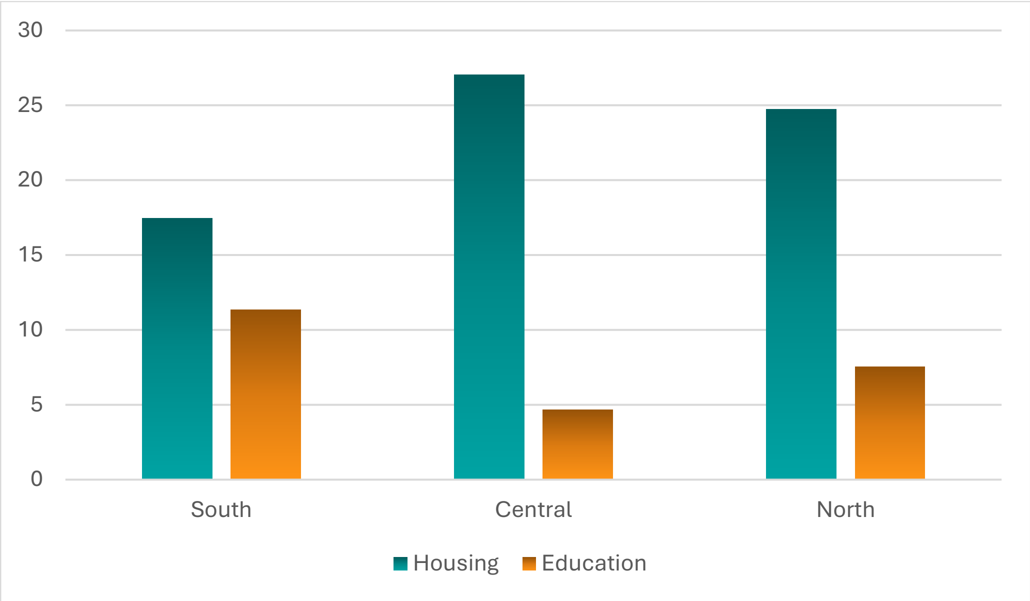
Source: Primary Data

While most households in the study had quick access to medical care, the coverage of health insurance was found to be severely lacking. Northern Kerala had the highest proportion of households with health insurance, as well as the lowest proportion where the head of the household had a valid life insurance against them. Households in the Southern Zone tended to be more inclined towards insuring their lives to ensure that household would survive even if the head were to meet with a tragic fate.

5.20. Govt Schemes

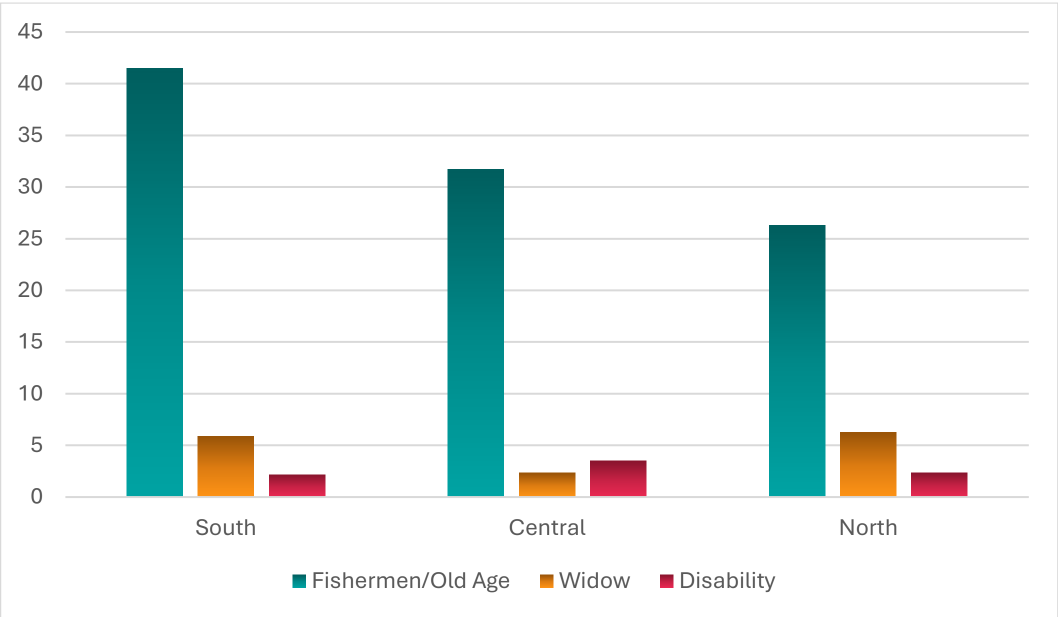
The uptake of government schemes was also quite lacking among the seafolk across Kerala, especially in Southern Kerala. Two thrust areas of the State's welfare measures for the seafolk are housing and education. In the South, less than one-fifth of all households had received assistance from the Government to build their houses. This pales in comparison to the figures for Central and Northern Kerala, which are at about 27 and 25 per cent, respectively. In terms of education schemes, however, households in the South showed a greater affinity, although the number was only about a paltry 12 per cent. This figure was still greater than in other two zones, where the figures are roughly 8 per cent (North) and 5 per cent (Central).

Figure 74: Percentage of Households that received Housing or Educational Assistance



Source: Primary Data

Figure 75: Percentage of Households that received Social Security Pensions



Source: Primary Data

The above situation, however, does not reflect in the receipt of welfare pensions from the Government. In Southern Kerala, nearly half of all households received either fisherman/old age pension, widow pension, or disability pension. The numbers in the Central and Northern Zones were only approximately 38 and 34 per cent respectively. The above trend shows that although the number of households that received housing assistance from the Government was lowest in Southern Kerala, they enjoyed greater support in the form of educational assistance and social security pensions.

The fishing households were asked to rate their satisfaction with the existing Government schemes on a scale of 1 to 5, with 1 representing high dissatisfaction and 5 representing high satisfaction. The reaction to this question was overwhelmingly negative across the board, with only about 0.5 per cent of all respondent households expressing a high level of satisfaction with existing Government schemes.

Table 34: Satisfaction with Govt Schemes for Fisherfolk

Scheme satisfaction	Region			Total
	South	Central	North	
Highly Dissatisfied	165	161	261	587
Dissatisfied	181	163	71	415
Neutral	75	69	52	196
Satisfied	30	36	0	66
Highly Satisfied	7	0	0	7
Total	458	429	384	1271

Source: Primary Data

The greatest level of dissatisfaction was seen in the Northern Zone, where close to 86.5 per cent of households expressed a view that the Government’s policies had to improve drastically. No household in the Northern districts expressed satisfaction with the Government schemes, and this was in contrast to the situation in the rest of the state. In Central and Southern Kerala, roughly eight per cent of households expressed some level of satisfaction.

The dissatisfaction of the community mostly stemmed from a feeling of being left behind in terms of development, and the haphazard nature of governmental activities happening in the coastal regions. The cases of shabby government-sponsored houses and flats were found to significantly affect the people's opinion. The negative opinion was further exacerbated by the perceived lack of compensation under the Punargaeham scheme of the Government of Kerala, which sets aside Rs. 10 lakhs for each household to relocate from within 50 meters of the High Tide Line in their region.

There was a great concern that the amount of uniform throughout Kerala without considering the local differences in the price of land. The seafolk felt that it was impossible to relocate from their current spaces without going into a debt trap if they chose to move into independent houses. Moving into Government-constructed flats was also a choice the communities resisted, since there was a dominant opinion that flats remove the community's connection to the sea. The experience of households who moved into flats at Thalassery and Ponnani, who ended up without proper access to drinking water or sanitation facilities, also acted as a major deterrent for the community.

5.20.1. Case I: The Government Flats at Ponnani

Located right next to the Ponnani fishing harbour, the government-constructed flats are currently home to around 130 fishing families who moved in from areas such as Puduponnani and Veliancode. The flats, constructed by the Uralungal Labour Contract Cooperative Society (ULCCS) were noted to be cramped and without adequate sanitation facilities. The entire plot was overgrown with snakes and had no proper road access. There was also a lack of street lighting in the area. While the buildings seem to be well-constructed from the outside, the story inside is entirely different.

Photograph 3: Punargaeham Project, Ponnani

Source: Primary Data

Every flat is roughly around 400-500 sq. ft in size, which was termed inadequate by many residents who had large families. Each flat comprises two small bedrooms, a living room, a kitchen, and one common bathroom. The bathroom was often a congested space located in the middle of the flat. The residents also complained that they had no way of cooking food using firewood, which they did earlier in their independent houses. The residents also were not given any proof of residence by the Government since moving into the flats, and they also lack any land holding since the land is Government property.

The residents were exasperated when asked to speak about their current state and responded that they would have never moved into the flats if they knew that the situation was going to worse than living on an eroding beach. The biggest issue in Ponnani was the lack of adequate sanitation, as four to eight households shared a common septic tank that would burst open every 5-6 days, leaking human waste right at the footsteps of the buildings.

Photograph 4: Punargaeham Project, Ponnani

Source: Primary Data

There was also a conflict reported with the Municipality and Kerala Water Authority regarding water supply to the buildings. The lack of proper sanitation forces men and women to either depend on the public toilets in the harbour or engage in open defecation for their primary needs. The residents were crestfallen that authorities turned a blind eye when they were approached for solutions. To sum up the situation in the words an octogenarian resident,

> "*My son, if we knew that we would have to live in a hellish condition like this, we would have never given up our lives by the sea. We are cut off from the sea here and are grovelling in a situation where children and women have to brave snakes if they want to empty their bowels. We are deprived of a decent living here, and we would rather die being consumed by the sea than live in such inhumane conditions.*"

Photograph 5: Water Tank, Punargaeham Project, Ponnani

Source: Primary Data

5.20.2. Case II: The Government Flats at Thalassery

The flats at Pettippalam on the fringes of Thalassery municipality are located along the old National Highway 66 just south of the Thalai fishing harbour. The number of flats here was less than that at Ponnani, and these were also constructed several years before. The situation in Thalassery was very similar to the one at Ponnani, with households staying in small, cramped accommodation without proper sanitation facilities. Drinking water was also a major issue in this location. The issue in Thalassery extended beyond just poor sanitation, as the flats are also located on a severely eroding coastline, sandwiched between an eroding seawall and the national highway. Rough waves during the monsoon season were noted to regularly inundate the area, forcing the households to shift to relief camps.

Photograph 6: Decrepit Flats at Pettippalam, Thalassery

Source: Primary Data

There were only about 20 families living these flats which were in a decrepit condition. The flats had structural frailties coming to the fore, windows and door frames suffering damage, and an overall lack of maintenance visible throughout. At Thalassery too, there was visible range among the fishing community, many of whom felt that they were being ignored by the authorities including the Municipality and elected representatives. The lack of proper plumbing and sanitation had even led to households living in the upper storeys installing pipes that discharged wastewater from bathrooms and kitchens directly into the sea.

Photograph 7: Decrepit Flats at Pettippalam, Thalassery

Source: Primary Data

The situation at Pettippalam was such that other fishing communities in Kannur and Kozhikode districts highlighted it as an example of Government apathy and therefore a major reason to not trust rehabilitation projects such as Punargaeham. The case of the fishing community at Pettippalam stands as a stark reminder of the policies of successive Governments in Kerala who have not adequately addressed the issues faced by coastal communities.

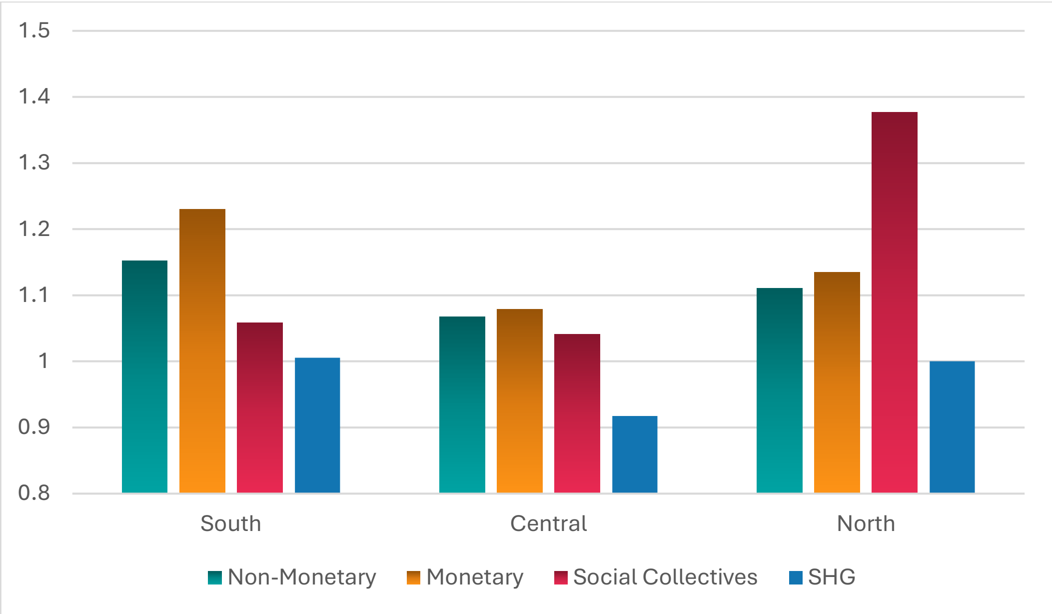
Photograph 8: Proximity of Flats at Pettippalam to the Seawall

Source: Primary Data

5.21. Social Networks

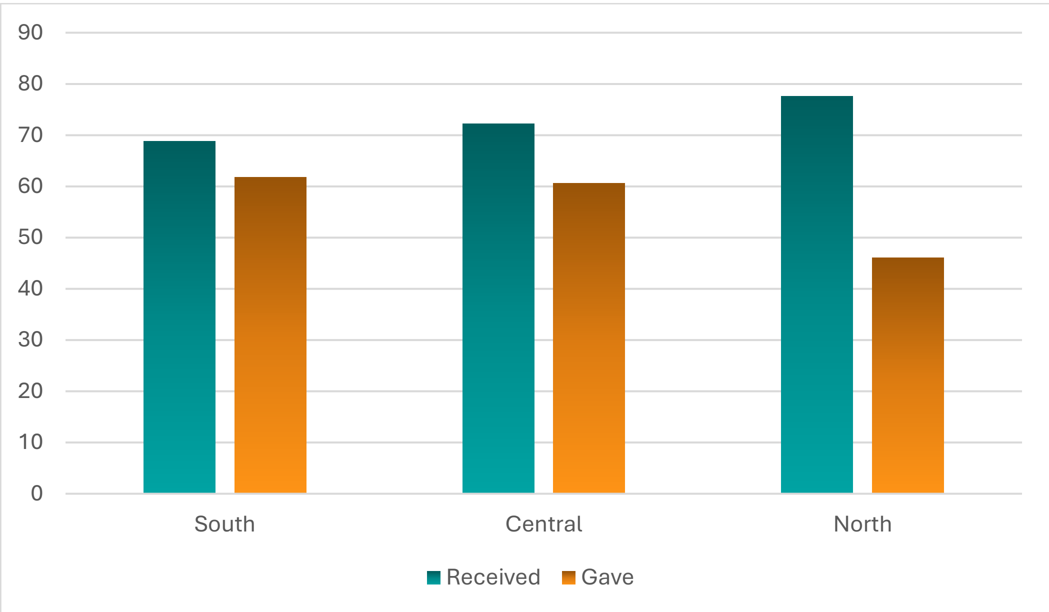
The strength of intra-community social networks among the fisherfolk was assessed based on a receive-to-give ratio (R-G Ratio). The ratio is defined as the number of households in a community who received some sort of assistance from within to the number of households who helped their fellow members. The assistance was measured across four dimensions – non-monetary help including looking children and elderly, monetary support, help through donations via social collective, and support through the Kudumbashree network. The recall period for this assistance was the last 365 days.

Figure 76: Receive to Give Ratio



Source: Primary Data

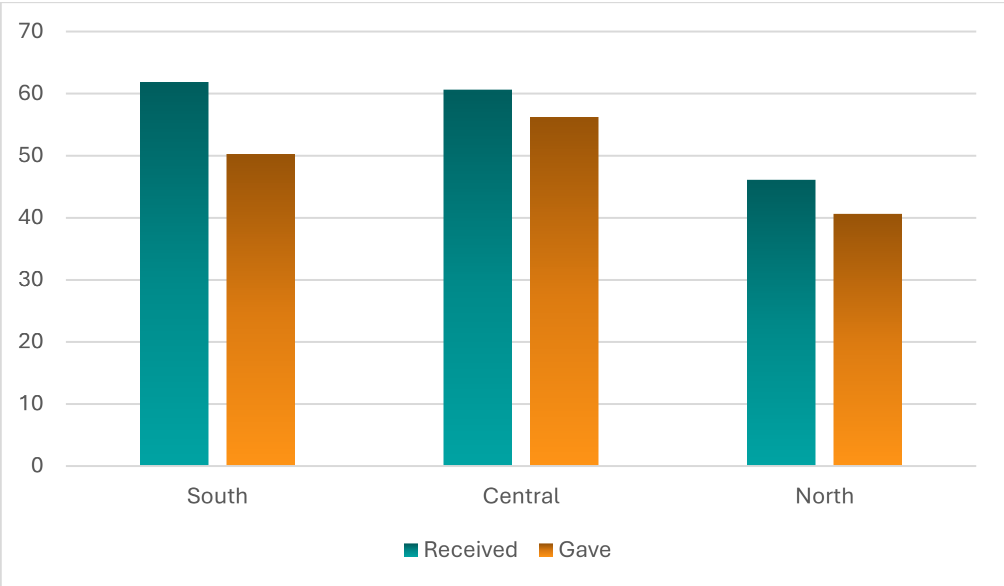
Figure 77: Percentage of Households that Received and Gave Non-monetary Help



Source: Primary Data

An analysis of the R-G Ratio in the three regions reveals that intra-community networks were relatively weaker in the Northern Zone. In terms of both monetary and non-monetary help, households in the Southern and Central Zones were more active in responding to their community's needs. In terms of non-monetary help, the situation was almost identical in these regions, but in the case of monetary assistance, households in Central Kerala were observed to have a slightly stronger network.

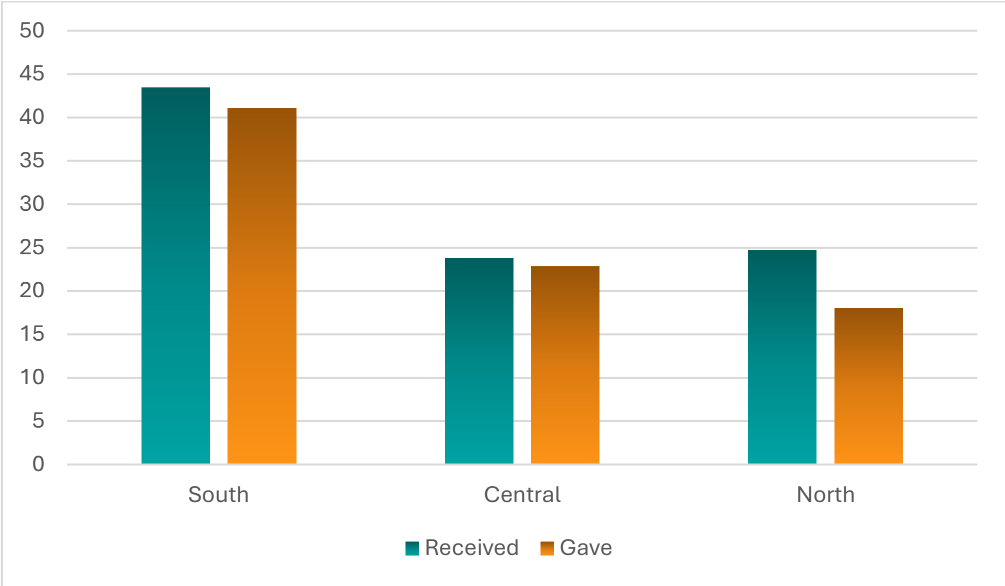
Figure 78: Percentage of Households that Received and Gave Monetary Help



Source: Primary Data

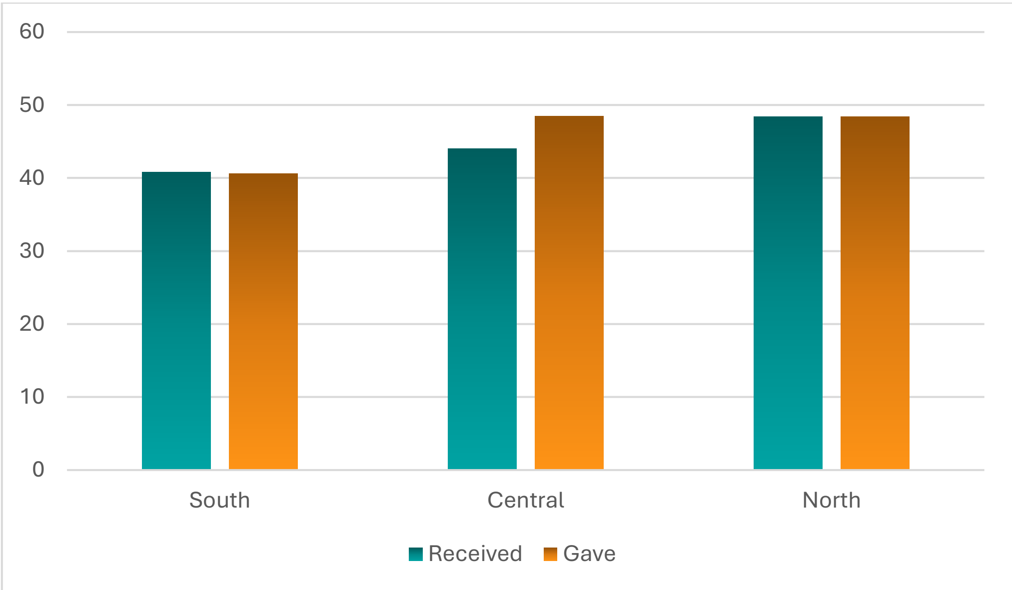
In the case of help received or given through social organizations, the situation in Southern Kerala was far better than the other parts of the state. Social organizations considered in the present study included social collectives, religious organizations, and caste-based organizations. While less than one-fourth of households used these organizations to support their community in Central and Northern Kerala, the South saw more than 40 per cent of households utilizing these channels to support each other. The Church plays a major role in ensuring this angle in Southern Kerala, where priests were observed to hold a significant sway over the community.

Figure 79: Percentage of Households that Received and Gave help through Collectives



Source: Primary Data

Figure 80: Percentage of Households that Received and Gave Help through SHGs



Source: Primary Data

Self Help Groups like the Kudumbashree were also observed to play a vital role in fostering intra-community linkages across Kerala among the seafolk. The R-G ratio in this category was almost unity across the board, with the networks being strongest in Northern Kerala and weakest in the Southern Zone. Curiously, in Central Kerala, more women who were a part of Kudumbashree had given out assistance than receive it themselves, indicating a strong sense of comradeship among the community members.

5.22. Summing Up

An analysis of the sensitivity of seafolk in Kerala towards climate change shows that the situation was concerning in Southern Kerala, especially in Thiruvananthapuram district. Aspects including food security, access to drinking water, and sanitation require urgent and constructive action in Thiruvananthapuram. While the health status of the community was not as alarming, especially with a good degree of access to medical facilities, more awareness needs to be spread about Government-sponsored health insurance schemes. The lack of awareness of these schemes was most evident in Northern Kerala, especially in Kannur and Kasaragod districts.

Ensuring that marginalized sections of society get access to basic facilities helps reduce their susceptibility of being impacted negatively by climate change and natural disasters. The community members were generally well-informed about the state of affairs across Kerala’s coastline, and there was a general perception that the administration’s work was underwhelming. Public anger towards the Government and its machinery was overwhelming, and the deep distrust spilled over into scepticism regarding the Government’s plans to rehabilitate the community. The poor work done in the rehabilitation exercise, as well as a concern about being pushed into a debt trap due to insufficient state support had induced a sense of state apathy among the seafolk. It is imperative that the State takes the concerns of the community into consideration while drafting policies to better their lives. Addressing the massive erosion of trust that the seafolk have can be considered the chief priority, especially given the level of sensitivity that the community has towards natural disasters and climate change in Kerala today.

Form 10
Part B

Report Profile

Data Analysis

Exposure to Disasters

Exposure to Disasters

It has been empirically established that Kerala's coastline is highly vulnerable to severe cyclones and sea-level rise, with the shoreline eroding massively in large stretches. In this situation, the coastal communities are increasingly exposed to damages caused by natural disasters. The current section examines the level of exposure that coastal communities in Kerala have towards natural disasters, focusing on cyclones, storm surges, and extreme rainfall events during the Monsoon.

5.23. Distance to the High Tide Line

The High Tide Line (HTL) is defined as the line on the land upto which the highest water line reaches during the spring tide (MoEF, 2001). Households living within fifty meters of the HTL have been identified as being vulnerable to coastal disasters by the Government of Kerala, and therefore been earmarked for rehabilitation in the state.

Table 35: Distance to the High Tide Line by Region

Distance to High Tide Line	Region			Total
	South	Central	North	
<= 25	265	156	143	564
26 – 50	122	117	80	319
51 – 75	30	45	43	118
76 – 100	33	40	70	143
101 – 125	4	12	29	45
126 – 150	4	29	12	45
151+	0	30	7	37
Total	458	429	384	1271

Source: Primary Data

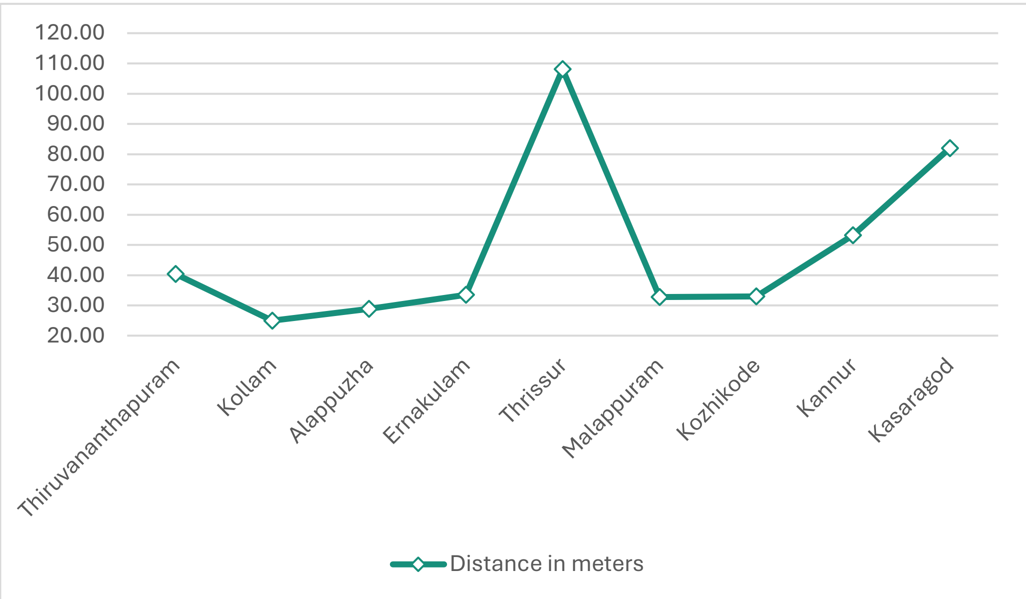
Among sample households, roughly 69 per cent were living in this zone, where they have been asked to relocate by the Government. Almost 64 per cent of these households who lived within fifty meters of the HTL, however, lived in close proximity to sea, with their homesteads located within 25 meters of the HTL. Only about ten per cent of sample households lived at a distance of more than 100 meters from the HTL, where they were safe from cyclones and storm surges/coastal flooding. A significant proportion of these households (56 per cent) were in Central Kerala, particularly in Thrissur district. Even in panchayats like Punnayurkulam and Thalikulam where the coastline were eroding, the households lived a considerable distance inland, thereby reducing their exposure to natural disasters.

Table 36: One-way ANOVA (Average Distance to HTL * District)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	878623.553	8	109827.944	96.625	0.000
Within Groups	1432164.887	1260	1136.639		
Total	2310788.440	1268			

Source: Primary Data

Figure 81: Average Distance to HTL in meters



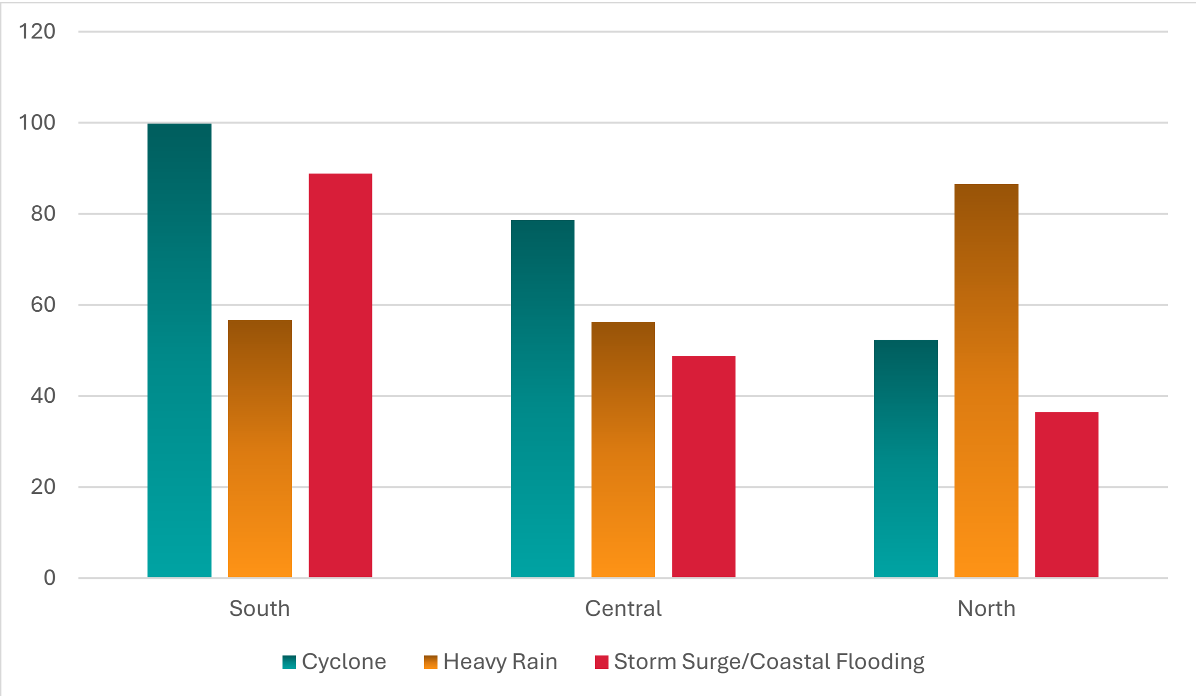
Source: Primary Data

The average distance to HTL from the homestead was tested for a significant difference between the districts with a one-way ANOVA, whose results are given in table 6.2. The results of the test lead to the rejection of the null hypothesis that there is no significant difference in the distance from the homestead to HTL in the nine districts. The scatterplot given in figure 6.1 shows that the distance was greatest in Thrissur, Kasaragod, and Kannur districts, and lowest in Kollam, Alappuzha, and Ernakulam. Households in Thrissur and Kasaragod exhibited the lowest level of exposure to natural disasters in the study courtesy of this increased distance.

5.24. Impact of Disasters

The High Tide Line (HTL) is defined as the line on the land upto which the highest water line reaches during the spring tide (MoEF, 2001). Households living within fifty meters of the HTL have been identified as being vulnerable to coastal disasters by the Government of Kerala, and therefore been earmarked for rehabilitation in the state. In terms of suffering damage to housing, household assets, and fishing assets, three extreme events were considered – cyclones, extreme precipitation, and storm surges/coastal flooding.

Figure 82: Percentage of Households that suffered damages due to Natural Disasters



Source: Primary Data

The patterns are quite distinct in all three zones, with households in Southern Kerala being more affected by cyclones and storm surges, while in the North, extreme rainfall had more of a negative impact. Cyclones and Storm surges were least in the North. In Central Kerala, the situation was something of a middle ground, with cyclones being the most damaging extreme event. The one with least impact was coastal flooding and storm surges, which affected less than half of all households.

Table 37: Descriptions of Variables Used for Hazard Model

Variable	Description
	Dependent Variable
Flood Damage	Dummy variable indicating whether a household has suffered considerable loss of property due to coastal flooding. It takes the value of '1' if yes, and '0' otherwise.
Cyclone Damage	Dummy variable indicating whether a household has suffered considerable loss of property due to tropical cyclones. It takes the value of '1' if yes, and '0' otherwise.
	Independent Variable
Sea Distance	Distance from the High Tide Line (HTL) to the homestead in meters
Erosion	Dummy variable indicating the shoreline status. =1 if eroding, otherwise 0. (Reference Group: Stable/Accreting)
Vanilla Coast	Dummy variable indicating the absence of coastal protection measures. =1 if Yes, otherwise 0. (Reference Group: No)
Seawall Status	Dummy variable for a dysfunctional seawall. =1 if the seawall is eroded with wave overtopping, otherwise 0. (Reference Group: Perfect Seawall)
Afforestation	Dummy variable for coastal afforestation. =1 if afforestation activities have been undertaken, otherwise 0. (Reference Group: No Afforestation)
Sandbags	Dummy variable for presence of sandbags. =1 if sandbags have been used for coastal protection, otherwise 0. (Reference Group: No sandbags)
Downdrift	Dummy variable for location of the household. =1 if the fishing village is located downdrift of a harbour, otherwise 0. (Reference Group: Updrift)

Source: Primary Data

The model in table 6.3 uses four variables to explain likelihood of a household suffering economic loss due to a climate disaster, which in this case can either be a cyclone or a storm surge/coastal flood. Table 6.3 gives a description of the variables used, and table 6.4 shows the results of the logit regression that was performed.

The results of the regression show that in the case of coastal flooding, distance to the sea and afforestation were found to have a significant negative relationship with the probability of economic loss due to the disaster. The most significant variables in the model were the functional nature of the seawall, and the presence of a erosion. A household living on an eroding coast was 29.3 per cent more likely to suffer economic loss due to the disaster, and these odds rise to almost 35 per cent if the area has a seawall that lacks maintenance. Afforestation was seen to reduce the disaster risk by 20 per cent, although it has not always been carried out across the state.

Table 38: Logit Estimates for Determinants of Hazard-related Damage

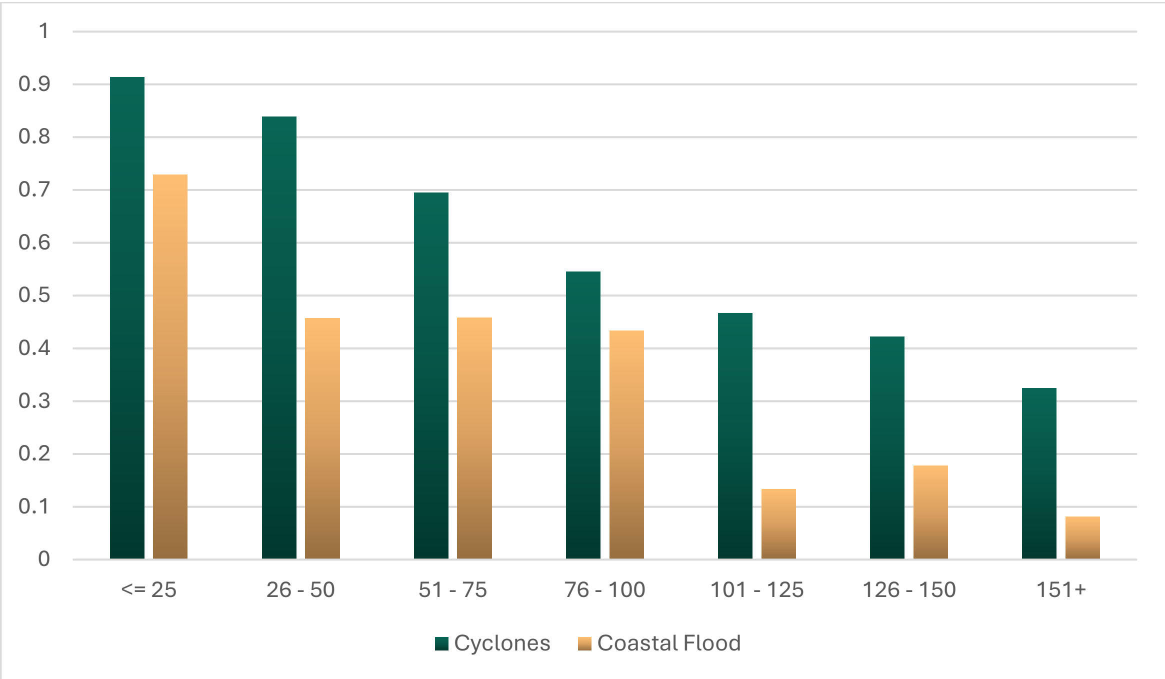
	Tidal Flooding			Cyclones		
	Coefficient	p-Value	Marginal Effect	Coefficient	p-Value	Marginal Effect
_cons	-1.285	0.000	-	1.243	0.000	-
Sea Distance	-0.016	0.000	-0.004	-0.017	0.000	-0.002
Erosion	0.650	0.000	0.161	1.496	0.000	0.194
Vanilla Coast	0.317	0.245	0.077	-0.811	0.007	-0.119
Seawall Status	1.598	0.000	0.367	0.505	0.011	0.066
Afforestation	-0.947	0.000	-0.230	-1.693	0.000	-0.296
Sandbags	0.721	0.006	0.169	2.184	0.000	0.139
Downdrift	1.221	0.000	0.289	0.453	0.067	0.050
McFadden R^2		0.247			0.287	

Source: Primary Data

In the case of economic loss due to cyclones, all variables except for erosion were significant, with distance to sea, vanilla coast, and afforestation having negative relationship. Afforestation was seen to reduce the impact of cyclones by almost 27 per cent, while living on a virgin coast reduced the impact by about 6 per cent.

Households living in areas with dysfunctional seawalls were 7.3 per cent more likely to suffer economic loss due to cyclones, while areas that had sandbags as a key coastal protection measure were almost twice as likely to be affected by cyclones, at slightly less than 14 per cent. Sandbags were noted to be ineffective in reducing damage from coastal flooding as well, showing that they are a strategy that should be moved on from.

Figure 83: Hazard Risk and Distance to HTL



Source: Primary Data

Figure 6.3 shows that living further inland significantly reduced the risk of households being affected by cyclones and storm surges. While almost 90 per cent of households living within 25 meters of the HTL suffered damage due to cyclones, the proportion kept falling drastically, to just over 30 per cent for those living more than 150 meters inland. In the case of storm surges/coastal flooding, A similar drop-off was observed where the figure fell from more than 70 per cent to about 8 per cent for these same categories.

Table 39: Seawall Protection Status

Seawall Status	Region			Total
	South	Central	North	
No Seawall	58	17	19	94
Perfect Condition	20	109	51	180
Slightly Eroded	24	37	80	141
Moderately Eroded	137	101	169	407
Severely Eroded	219	165	65	449
Total	458	429	384	1271

Source: Primary Data

Examining the status of coastal protection measures reveals that the highest number of households that lived on a virgin coast was in the Southern Zone. Among households that lived in areas with a seawall, only 15 per cent had a seawall in perfect condition protecting them against natural disasters. Close to 38 per cent of households that lived in areas with a seawall had one that was severely eroded, while another 34.5 per cent stated that their seawall was moderately eroded. In these situations, wave overtopping was a common occurrence, leading to severe coastal floods.

In several locations, erosion was observed to be greater in the downdrift area of a harbour or breakwater. A two-way ANOVA was performed to test whether this phenomenon happened across Kerala. The ANOVA has the following null hypotheses:

H_{0A}: There is no difference in perceived erosion rate between the up-drift down-drift sides of a harbour

H_{0B}: There is no difference in perceived erosion rate across districts

H_{0C}: There is no interaction location of settlement vis-à-vis a harbour and district

The analysis of the ANOVA test shows that there is a significant difference between the erosion rates in different districts, although the difference in erosion between villages located up-drift or down-drift of a harbour is not significantly different at the

95% confidence level. The difference between locations was widest in Malappuram, and narrowest in Alappuzha. The trend of erosion affecting down-drift regions significantly more is visible in the Northern Zone.

Only in three districts – Kollam, Ernakulam, and Thrissur – is erosion greater in areas up-drift of a harbour. The gap is widest in Kollam, where large-scale erosion north of Neendakara is primarily due to mineral sand mining rather than blockage of sediment transport. The erosion here is significantly greater than the erosion caused by harbours in other parts of Kollam that lie down-drift of the Neendakara and Thanagassery harbours.

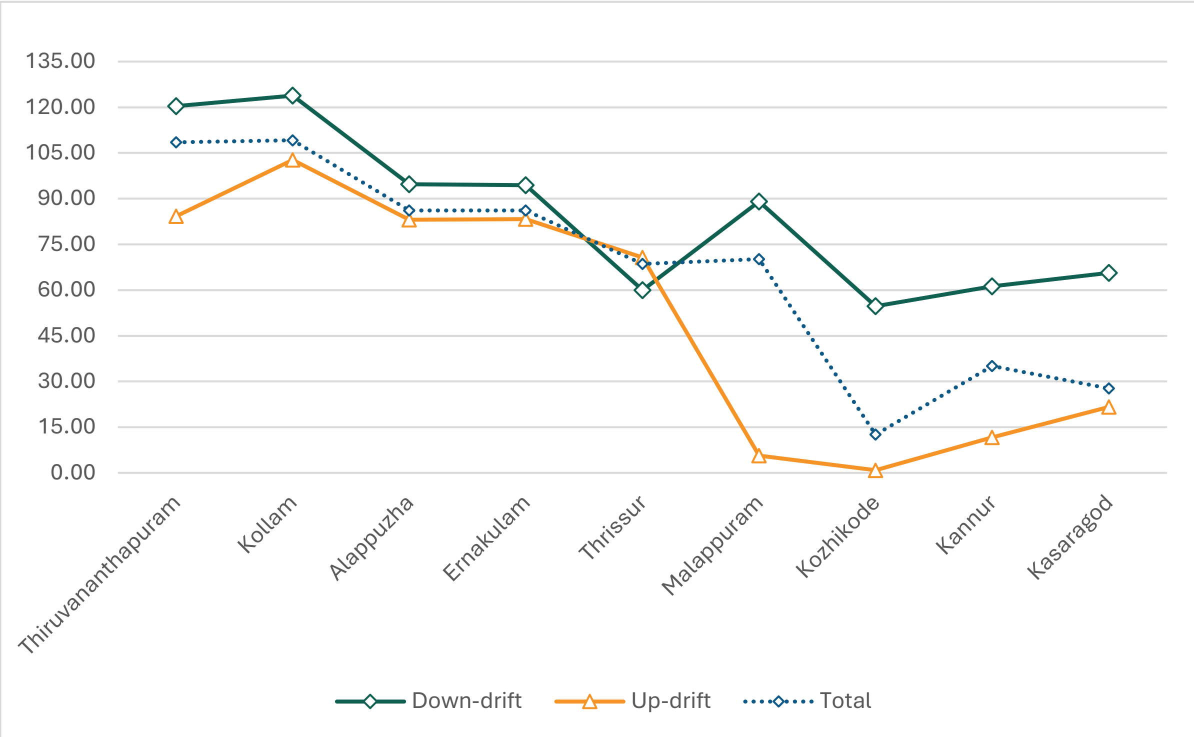
Table 40: Two-Way ANOVA (Perceived Erosion Rate * Village Location * District)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1831777.583	17	107751.623	33.871	0.000
Intercept	4136698.821	1	4136698.821	1300.348	0.000
District	851940.590	8	106492.574	33.475	0.000
Location	246969.836	1	246969.836	77.634	0.000
District*Location	160142.464	8	20017.808	6.292	0.000
Error	3986072.855	1253	3181.223		
Total	11833805.000	1271			
Corrected Total	5817850.437	1270			

Source: Primary Data

In Ernakulam and Thrissur, erosion is prevalent in parts without the presence of harbour. These areas include the stretch from Njarackal to Edavanakkad in Ernakulam, and the stretch from Thalikulam to Chettuva in Thrissur. The northernmost parts of Thrissur districts, in Punnayur and Punnayurkulam panchayats, are located down-drift of Ponnani harbour, but the erosion rate in these areas is less than the erosion from Thalikulam to Chettuva. In Ernakulam, the erosion from Njarackal to Edavanakad exceeds the erosion from Chellanam to Fort Kochi, which can be attributed to the presence of the fishing harbour at Chellanam.

Figure 84: ANOVA Scatter Plot (Perceived Erosion Rate * Village Location * District)



Source: Primary Data

5.25. Work Loss and Deaths at Sea

One of the biggest impact of disasters on the seafolk is a direct loss of employment as rough weather prevents fishing in the seas. In terms of workdays lost in the last one year, the situation was quite different across the three zones. The loss of workdays was least in the Southern Zone, where only about 84 per cent of respondents said that they abstained from fishing due to adverse weather conditions. In the Central and Northern Zones, the corresponding figures were 89 and 96 per cent respectively.

Table 41: Workdays Lost

Region	Workdays Lost		Total
	Yes	No	
South	324	61	385
Central	317	35	352
North	237	11	248
Total	878	107	985

Source: Primary Data

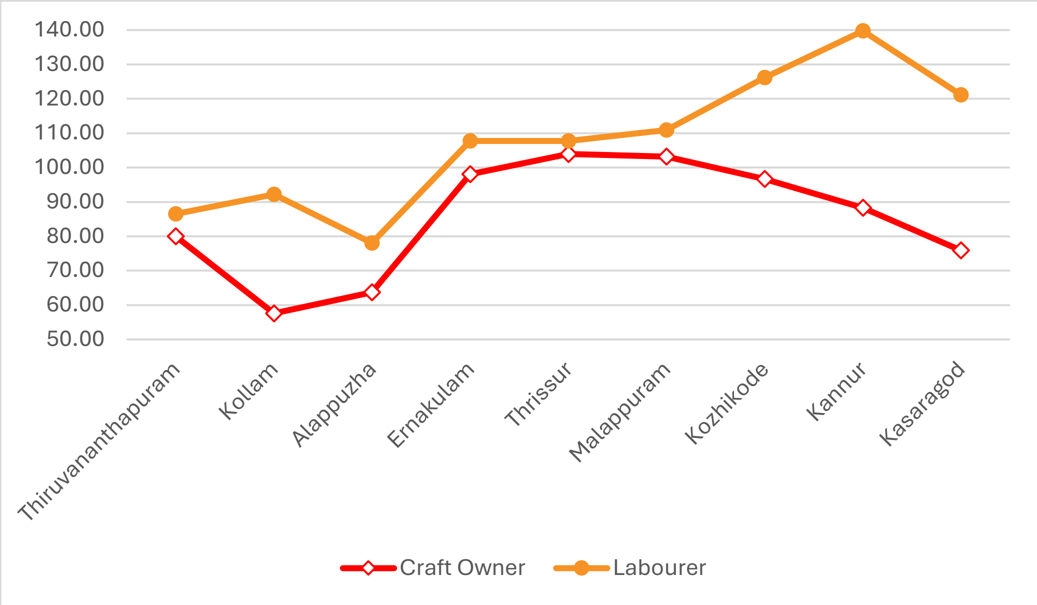
To assess whether work loss due to inclement weather differed between districts and craft ownership status of the seafolk, a two-way ANOVA was performed. The results of the ANOVA, given in table 6.8, show that there is a significant difference in the work loss suffered by seafolk across Kerala, with the figure lowest in Alappuzha and highest in Kannur. Across the nine districts, seafolk who owned a craft went out into the sea more often since they had the option to engage in fishing out of their own volition. Labourers, however, did not have this freedom and suffered work loss whenever the boat owners refused to engage in fishing. The gap between labourers and craft owners was highest in Kannur and lowest in Thrissur.

Table 42: Two-Way ANOVA (Work Loss * Craft Ownership * District)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	317816.679a	17	18695.099	15.133	0.000
Intercept	5980964.769	1	5980964.769	4841.421	0.000
District	152377.042	8	19047.130	15.418	0.000
Fishing_Vessel_Bin	81369.373	1	81369.373	65.866	0.000
District * Fishing_Vessel_Bin	46198.585	8	5774.823	4.675	0.000
Error	1059950.731	858	1235.374		
Total	10082455.000	876			
Corrected Total	1377767.410	875			

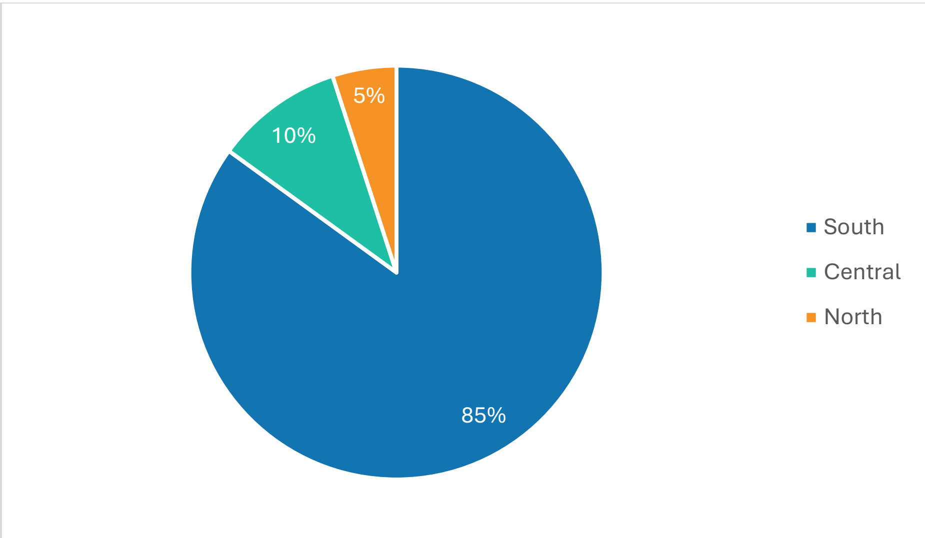
Source: Primary Data

Figure 85: ANOVA Scatter Plot (Work Loss * Craft Ownership * District)



Source: Primary Data

Figure 86: Death at Sea



Source: Primary Data

Regular warnings are given to fishermen in times of inclement weather, and most stick to these warnings and abstain from going to sea. However, there were several individuals who still ventured out into the sea despite the warnings due to economic and cultural factors. In terms of death at sea, the figures represent a stark difference between the three regions in Kerala. Of the forty households who reported at least one death at sea due to rough weather, 34 were in Southern Kerala, indicating that the seafolk are bigger risk-takers. A greater inclination to venture into the sea braving the elements can be considered to have contributed to more deaths in the South.

The seafolk were asked to state their perception about changes in various aspects of the sea in the context of warming and climate change. For all phenomena except warming of the sea and sea level rise, the responses were overwhelmingly in agreement with the given statement. Some of the most striking observations are regarding decline in catch, where close to 66 per cent strongly agreed that the phenomenon was happening on the Kerala coast. An increase in coastal erosion also was a phenomenon that almost 58 per cent of respondents strongly felt. Almost 55 per cent of respondents also strongly resonated with a view that upwelling had increased in their region.

Table 43: Climate Change Perception

	No Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Disappearance of common fish	56	2	28	59	360	481	930
Decline in catch	57	4	27	51	237	610	929
Sea Level Rise	62	3	84	126	324	387	924
Sea Temperature Rise	64	9	82	98	334	399	922
Turbulence Rise	62	4	33	60	396	431	924
Upwelling Rise	63	0	31	61	325	506	923
Erosion Rise	59	18	61	89	214	545	927
Humidity Rise	60	6	19	51	352	498	926

Source: Primary Data

The two phenomena that did resonate as much among respondents were, as mentioned earlier, sea level rise and warming of the ocean. For both statements, slightly over 9 per cent of all respondents disagreed to some degree. However, in the number of respondents who were unaware about the situation, the numbers differed, as more than 13 per were neutral to an observation of sea level rise, with the corresponding figure for rise in ocean temperatures being only above 10 per cent.

5.26. Summing Up

Summing the exposure of seafolk to climate change reveals that proximity to the sea plays a crucial role in determining the level of economic loss suffered by the families. The presence of erosion on the coast was also observed to play a major role in exposing the households to the vagaries of nature. Among various coastal protection measures, having a functional seawall and a practice of coastal afforestation were observed to give a positive effect. Leaving a seawall abandoned without any maintenance leads to its degradation, which significantly increases the disaster risk of seafolk. The deployment of sandbags or geobags were seen to have no positive effect on the disaster risk of a household, indicating that it is a wasteful exercise overall.

Households in Southern Kerala tended to be exposed to natural disasters to a far greater degree when compared to their counterparts in Central or Northern Kerala. In terms of work loss, however, the observations were in the opposite direction, with fishermen in the South showing an increased willingness to venture into the sea despite inclement weather. Individuals who owned fishing crafts were also more likely to take the risk in times of rough weather. The increased risk-taking nature of seafolk in Southern Kerala could also be attributed to the higher number of deaths at sea in the region due to being caught up in rough weather.

In terms of various phenomena commonly associated with climate change, most seafolk concurred with the statements given to them in the questionnaire.

Phenomena like rise in coastal upwelling and coastal erosion, as well as a reduction in fish catch, particularly strongly with the community. The same level of agreement, was, however, not observed in the case of sea level rise and rise in ocean temperatures. The findings in this chapter indicate that there are regional variations in the exposure to extreme weather events across the Kerala coast, and that households in Southern Kerala were greater risk takers when it came to their livelihood. The community is also largely aware of the effects of climate change and observe these changes in their everyday lives.

Form 10

Part B

Report Profile

Data Analysis

Estimating Vulnerability

Estimating Vulnerability

Estimating the vulnerability involves calculating the values for the six sub-components, and the three primary axes. The current chapter involves computing the livelihood vulnerability of the seafolk in the nine districts and making an inter-district comparison. Literature shows that multiple forms of indices can be used to ascertain the vulnerability, including the Livelihood Vulnerability Index (LVI) (Hahn et al. 2009), Climate Vulnerability Index (CVI) (Pandey and Jha, 2011), Flood Vulnerability Index (FVI) (Balica & Wright, 2009, Balica & Wright, 2010, Balica et al., 2009), Socio-economic Vulnerability Index (SVI), and Water Poverty Index (WPI), and Climate Change Vulnerability Index (CCVI).

Among these, the present study only considers the LVI, modified to align itself with the IPCC framework, and the CCVI. The LVI has been widely used in the contexts of developing and least developed countries to assess the vulnerability of communities to climate change. The index is thus well suited to assess the vulnerability of the seafolk to climate change in Kerala. The CCVI is also a widely used tool at the district and state levels to assess the vulnerability of communities It is used in the present study as a way to corroborate the findings for the LVI and to solidify the findings from the study.

5.27. Framing the Indices

The study follows the IPCC framework for livelihood vulnerability assessment. While the IPCC framework can be used to assess vulnerability along several indices, the current study adopts two indices to assess vulnerability to climate change. The first index is the Livelihood Vulnerability Index (LVI) from Hahn et al (2009), and the second index is the Climate Change Vulnerability Index (CCVI) proposed by the Connecticut

Institute for Resilience and Climate Adaptation and used by Khan et al. (2021) to assess climate vulnerability of farming communities in Pakistan.

Both methods have three components – exposure, sensitivity, and adaptive capacity, which are further composed of six sub-components. Exposure is measured as a function of climate change and exposure to natural disasters. Sensitivity comprises the factors of health status and access to food water. Adaptive capacity has three sub-components – socio-economics profile, livelihood diversification, and social networks. For some of the sub-components, an index value was calculated using the following formula:

$$Index_{sv} = \frac{S_v - S_{min}}{S_{max} - S_{min}}$$

Where,

- S_v is the sub-component or indicator value for v^{th} village/community
- S_{max} and S_{min} are the maximum and minimum values of the sub-component

Post standardization, each major component was computed using the following formula:

$$M_v = \frac{\sum_{i=1}^{n} Index_{svi}}{n}$$

Where,

- M_v is a major component of the LVI
- $Index_{svi}$ is the i^{th} sub-component value, belonging to the major component M_v for the v^{th} village or community
- n is the number of sub-components in the major component

The six major components were then aggregated into the three dimensions in line with the IPCC classification:

$$Exp = \frac{W_{e1}NCV}{W_{e1}}$$

$$Sen = \frac{W_{s1}H + W_{s2}F + \ W_{s3}WS}{W_{s1} + W_{s2} + W_{s3}}$$

$$AC = \frac{W_{a1}SE + W_{a2}LS + W_{a3}SN}{W_{a1} + W_{a2} + W_{a3}}$$

The Livelihood Vulnerability Index (LVI_{IPCC}) is defined by the following formula:

$$LVI_{IPCC} = (Exp - AC) * Sen$$

LVI_{IPCC} is measured on a scale from -1 to +1, where -1 represents the lowest level of vulnerability, and +1 the highest. The Climate Change Vulnerability Index (CCVI) is defined by the following formula, and ranges from 0 to 1, with 0 being the lowest level and 1 being the highest level of vulnerability:

$$CCVI = (Exp + Sen) - AC$$

The indices consist of a total of 41 sub-components spread across seven key dimensions, which are further aggregated into the three axes of exposure, sensitivity, and adaptive capacity. The breakup and descriptions of each of the sub-components is given below in tables 7.1 to 7.3.

Under adaptive capacity, the 19 variables are divided into three dimensions – socio-economic status and social networks each having 7 sub-components, and livelihood diversification having 5 sub-components. There 12 sub-components under the sensitivity axis, which are divided into three dimensions – health, food, water & sanitation – with each having four variables.

Table 44: Variables (Adaptive Capacity)

Variable	*Description*
Socio-Economic Status	
Family Dependency Index	Ratio derived on population up to 15 and above 65 years to the population aged between 16 and 64
House-type Diversity Index	Percentage of households that have a *pucca* house
Vehicle Index	Percentage of households that have a vehicle of their own
Family Decision Index	Percentage of households where the head is a literate male
Poverty Line Index	Percentage of households categorized as above poverty line
Debt-free Index	Percentage of households that have no debt burden
Consumption Index (MCI)	Average monthly consumption expenditure of households
Livelihood Diversification	
Job Diversification Index	Percentage of households that have an income source in addition to fishing
MNREGS Index	Percentage of households that have additional income from the MNREGS Scheme
SHG Job Index	Percentage of households that have additional income from SHG-based activities
Migration Index	Percentage of households in which at least one member is a migrant
Abandonment Index	Percentage of households that have abandoned fishing as a livelihood strategy
Social Networks	
Non-Monetary RG Ratio	Ratio of households that have received non-monetary help to those who have given non-monetary help to community members
Monetary RG Ratio	Ratio of households that have received monetary help to those who have given monetary help to community members
Collective RG Ratio	Ratio of households that have received help from social collectives to those who have given help to others as part of social collectives
SHG RG Ratio	Ratio of households that have received help through SHGs to those who have given help to others through SHGs
SHG Membership Index	Percentage of households that have membership in Self Help Groups
Social Security Index	Percentage of households that have at least one member who receives social security pensions
Assistance Index	Percent of households that received any assistance from the Government

Source: Hahn et al (2009), Primary Data

Table 45: Variables (Sensitivity)

Variable	*Description*
	Food
Subsidy Dependency Index	Percentage of households wholly dependent on PDS and subsidized outlets for foodgrains, pulses, and condiments
PDS Distance Index (RDI)	Average distance to the nearest PDS outlet in meters
Hunger Index	Percentage of households that reported food shortages for at least one month in the last year
Free Ration Index	Percentage of households that received free ration from the Government
	Water & Sanitation
Water Scarcity Index	Percentage of households that reported water shortages
Water Distance Index (WDI)	Average distance to the nearest source of potable water in meters
Lack of Access Index	Percentage of households that did not have an individual water source and therefore purchased drinking water
Sanitation Index	Percentage of households that did not have a functioning toilet
	Health Status
Chronic Illness Index	Percentage of households that had at least one member who was chronically ill
Disability Index	Percentage of households that had at least one disabled member
No Insurance Index	Percentage of households that did not have health insurance of any kind
Hospital Distance Index (HDI)	Average distance to the nearest health facility in meters

Source: Hahn et al (2009), Primary Data

The exposure axis has ten variables, including variations in climate, incidence of natural disasters, and impacts of climate change on livelihoods.

Table 46: Variables (Exposure)

Variable	*Description*
Cyclone damage index	Percentage of households that have suffered damages due to cyclones
Coastal flooding damage index	Percentage of households that have suffered damages due to coastal flooding and storm surges
Sea Distance Index (SDI)	Average distance to the High Tide Line (HTL)
Mortality Index	Percentage of households that reported a death due to disasters in the last year
Livelihood Disruption Index	Percentage of households that saw their livelihoods disrupted by inclement weather
Eroded Coastal Protection Index	Percentage of households that lived in areas with severely eroded seawalls
Harbour Erosion Index	Percentage of households that were affected by coastal flooding due to being downdrift of harbours
Maximum Temperature Index	Standard deviation of the average daily maximum temperature by month between 1981 and 2020 for the district
Minimum Temperature Index	Standard deviation of the average daily minimum temperature by month between 1981 and 2020 for the district
Precipitation Index	Standard deviation of the monthly precipitation between 1981 and 2020 for the district

Source: Hahn et al (2009), Primary Data

5.28. Aggregating the Index

5.28.1. Southern Kerala

The results show that in Southern Kerala, Thiruvananthapuram district had the highest level of exposure and sensitivity, while also having the lowest adaptive capacity. Factors that spiked sensitivity included the prevalence of inadequate nutrition, higher dependency on subsidized food, severe water scarcity, and a situation where more than a third of all households lacked access to toilets. The households also lived closer to the sea, therefore increasing their level of exposure to cyclones and storm surges. Although the value for the health subcomponent was best in Thiruvananthapuram, the district lagged the other two severely across the other indices.

Table 47: Components of Adaptive Capacity – Southern Zone

Sl. No	*Indicator*	*Thiruvananthapuram*	*Kollam*	*Alappuzha*
1	Family Dependency Index	0.4883	0.3480	0.4714
2	House type Diversity Index	0.2162	0.5041	0.7105
3	Vehicle Index	0.1730	0.5455	0.7566
4	Family Decision Index	0.8054	0.7273	0.8750
5	Poverty Line Index	0.1676	0.1901	0.2171
6	Debt-free Index	0.4973	0.5785	0.4013
7	Consumption Index	0.2006	0.2959	0.1937
	Socio-Economic Status	***0.3640***	***0.4556***	***0.5179***
1	Job Diversification Index	0.1405	0.3306	0.3816
2	MNREGS Index	0.1622	0.5702	0.6579
3	SHG Job Index	0.1189	0.4793	0.4803
4	Migration Index	0.0486	0.0661	0.0987
5	Abandonment Index	0.0486	0.0992	0.1382
	Livelihood Diversification	***0.1038***	***0.3091***	***0.3513***
1	Non-monetary RG	0.4288	0.4408	0.3925
2	Monetary RG	0.4955	0.4159	0.3706
3	Collective RG	0.3677	0.3691	0.3531
4	SHG RG	0.3555	0.3295	0.3534
5	SHG Membership	0.5730	0.7273	0.8750
6	Social Security Index	0.4324	0.4876	0.4868
7	Assistance Index	0.1405	0.4050	0.2303
	Social Networks	***0.3991***	***0.4536***	***0.4374***
	Adaptive Capacity	***0.3085***	***0.4163***	***0.4444***

Source: Primary Data

On the other hand, Alappuzha had a significantly higher adaptive capacity due to the households being wealthier in general and having backup options for household income. Households in Alappuzha were also less exposed to disasters, while having the lowest level of sensitivity among the three Southern districts. The situation in Kollam is something of a middle ground to Alappuzha and Thiruvananthapuram, although the index values are closer towards the situation in Alappuzha across the board.

Table 48: Components of Sensitivity – Southern Zone

Sl. No	*Indicator*	*Thiruvananthapuram*	*Kollam*	*Alappuzha*
1	Chronic Illness Index	0.1568	0.2231	0.1776
2	Disability Index	0.0324	0.0579	0.0592
3	No Insurance Index	0.7730	0.7190	0.5724
4	Hospital Distance Index	0.2069	0.3467	0.4149
	Health	***0.2923***	***0.3367***	***0.3060***
1	PDS Dependency Index	0.7189	0.6033	0.6645
2	PDS Distance Index	0.2848	0.1628	0.2079
3	Hunger Index	0.6486	0.2810	0.0329
4	Free Ration Index	0.2054	0.1983	0.1053
	Food	***0.4644***	***0.3114***	***0.2526***
1	No Toilet Index	0.3405	0.0744	0.0066
2	Water Scarcity Index	0.7622	0.5868	0.6184
3	WDI	0.2254	0.1059	0.1852
4	No Individual Access	0.9838	0.9835	0.8618
	Water & Sanitation	***0.5780***	***0.4376***	***0.4180***
	Sensitivity	***0.4449***	***0.3619***	***0.3256***

Source: Primary Data

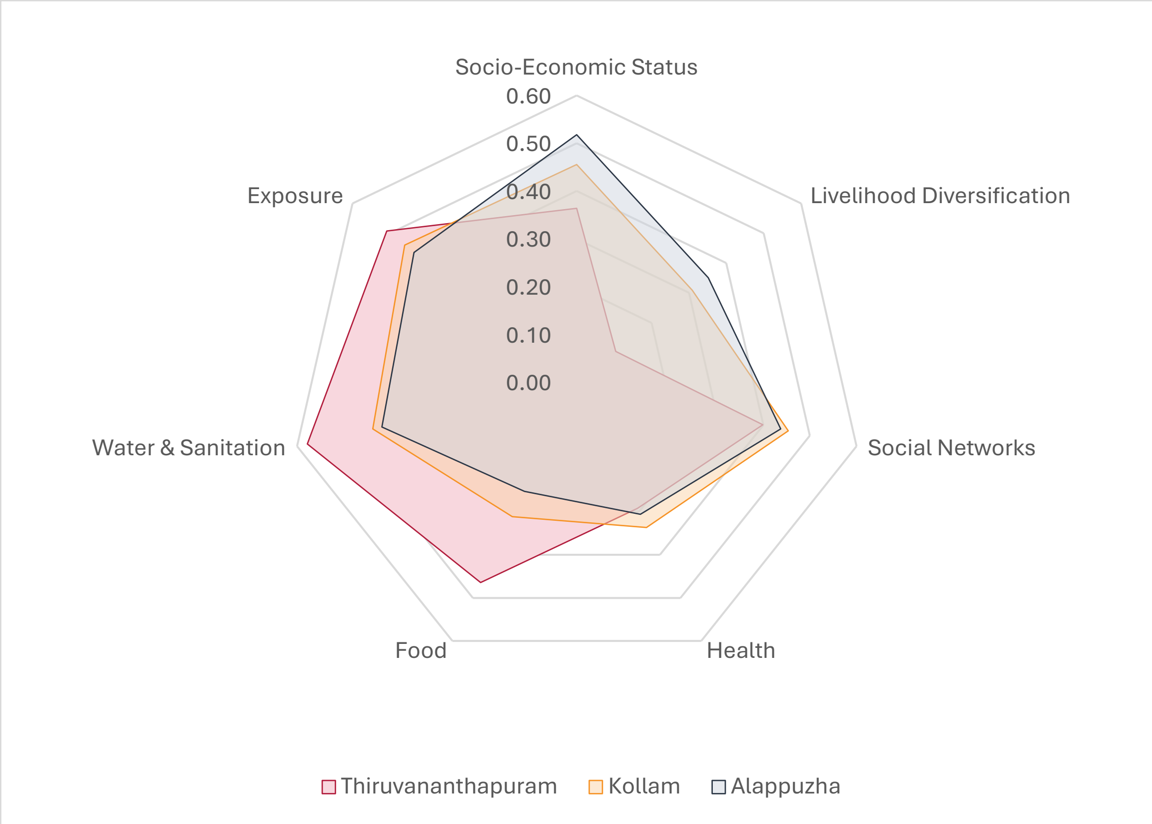
Table 49: Components of Exposure – Southern Zone

Sl. No	*Indicator*	*Thiruvananthapuram*	*Kollam*	*Alappuzha*
1	Cyclone Damage Index	1.0000	0.9917	1.0000
2	Flood Damage Index	0.9027	0.7025	0.5921
3	Sea Distance Index	0.2150	0.1438	0.1852
4	Mortality Index	0.1189	0.0579	0.0329
5	Livelihood Disruption	0.7189	0.6033	0.5592
6	Severely Eroded Coastal Protection	0.3946	0.4380	0.6118
7	Harbour Erosion	0.6703	0.3058	0.2632
8	T Max SD	0.5100	0.5750	0.5000
9	T Min SD	0.5900	0.6400	0.5800
10	TR SD	0.4600	0.4400	0.4450
	Exposure	***0.5580***	***0.4898***	***0.4769***

Source: Primary Data

Among the three districts, Kollam had the least cases of water conflict, while also having better social networks than Alappuzha. However, the terms of livelihood diversification, socio-economic status, and health status, the district lagged behind Alappuzha. An overall comparison of the seven dimensions for Southern Kerala is given in Figure 7.1.

Figure 87: Vulnerability Index Components – South Zone



Source: Primary Data

5.28.2. Central Kerala

Moving northwards to Central Kerala paints a different picture overall, where neither district performs absolutely better or worse than the others. Overall, Ernakulam has the best situation, with the highest adaptive capacity, and staying in the middle ground for sensitivity and exposure. Thrissur, on the other hand, had the lowest exposure but highest sensitivity, while Malappuram had the lowest level of sensitivity but the highest level of exposure to natural disasters. Malappuram also had the lowest level of adaptive capacity, making it the most vulnerable of the three central districts.

Table 50: Components of Adaptive Capacity – Central Zone

Sl. No	*Indicator*	*Ernakulam*	*Thrissur*	*Malappuram*
1	Family Dependency Index	0.5651	0.2713	0.5691
2	House type Diversity Index	0.6642	0.6690	0.5467
3	Vehicle Index	0.3869	0.6408	0.4133
4	Family Decision Index	0.6642	0.8873	0.7933
5	Poverty Line Index	0.3796	0.2113	0.1333
6	Debt-free Index	0.4234	0.5493	0.5933
7	Consumption Index	0.2990	0.2880	0.1549
	Socio-Economic Status	***0.4832***	***0.5024***	***0.4577***
1	Job Diversification Index	0.3139	0.3239	0.5133
2	MNREGS Index	0.3942	0.0563	0.1133
3	SHG Job Index	0.1460	0.0000	0.0067
4	Migration Index	0.0073	0.0845	0.0738
5	Abandonment Index	0.0365	0.0775	0.2400
	Livelihood Diversification	***0.1796***	***0.1085***	***0.1894***
1	Non-monetary RG	0.4014	0.4107	0.4177
2	Monetary RG	0.3674	0.4554	0.4466
3	Collective RG	0.3844	0.3967	0.3422
4	SHG RG	0.3542	0.3663	0.3416
5	SHG Membership	0.8175	0.6408	0.5400
6	Social Security Index	0.4526	0.3028	0.3133
7	Assistance Index	0.7372	0.2183	0.2600
	Social Networks	***0.5021***	***0.3987***	***0.3802***
	Adaptive Capacity	***0.4103***	***0.3605***	***0.3586***

Source: Primary Data

Delving deeper into each index reveals that Thrissur districts had the lowest level of exposure owing to the greater distance between homesteads and the HTL. Households in Malappuram, especially in the Southern part of the district, lived precariously close to the sea, increasing their exposure to storm surges and cyclones. A similar situation was also seen in Ernakulam, especially in Njarackal and

Edavanakkad. In terms of sensitivity, Thrissur performed the worst mostly due to a significantly higher level of water conflicts and a greater dependence on subsidized food. Malappuram was the best placed of the three districts in the sensitivity index mostly due to the better performance in the food index.

Table 51: Components of Sensitivity – Central Zone

Sl. No.	*Indicator*	*Ernakulam*	*Thrissur*	*Malappuram*
1	Chronic Illness Index	0.2336	0.2324	0.3000
2	Disability Index	0.0730	0.0352	0.0933
3	No Insurance Index	0.6861	0.6831	0.7133
4	Hospital Distance Index	0.2817	0.3716	0.5011
	Health	***0.3186***	***0.3306***	***0.4019***
1	PDS Dependency Index	0.7445	0.7465	0.2667
2	PDS Distance Index	0.2175	0.2843	0.1717
3	Hunger Index	0.0073	0.0000	0.0733
4	Free Ration Index	0.2190	0.1972	0.1067
	Food	***0.2971***	***0.3070***	***0.1546***
1	No Toilet Index	0.1241	0.0070	0.0067
2	Water Scarcity Index	0.4234	0.6056	0.5133
3	WDI	0.1845	0.6860	0.1649
4	No Individual Access	0.8978	0.7746	0.4867
	Water & Sanitation	***0.4074***	***0.5183***	***0.2929***
	Sensitivity	***0.3410***	***0.3853***	***0.2831***

Source: Primary Data

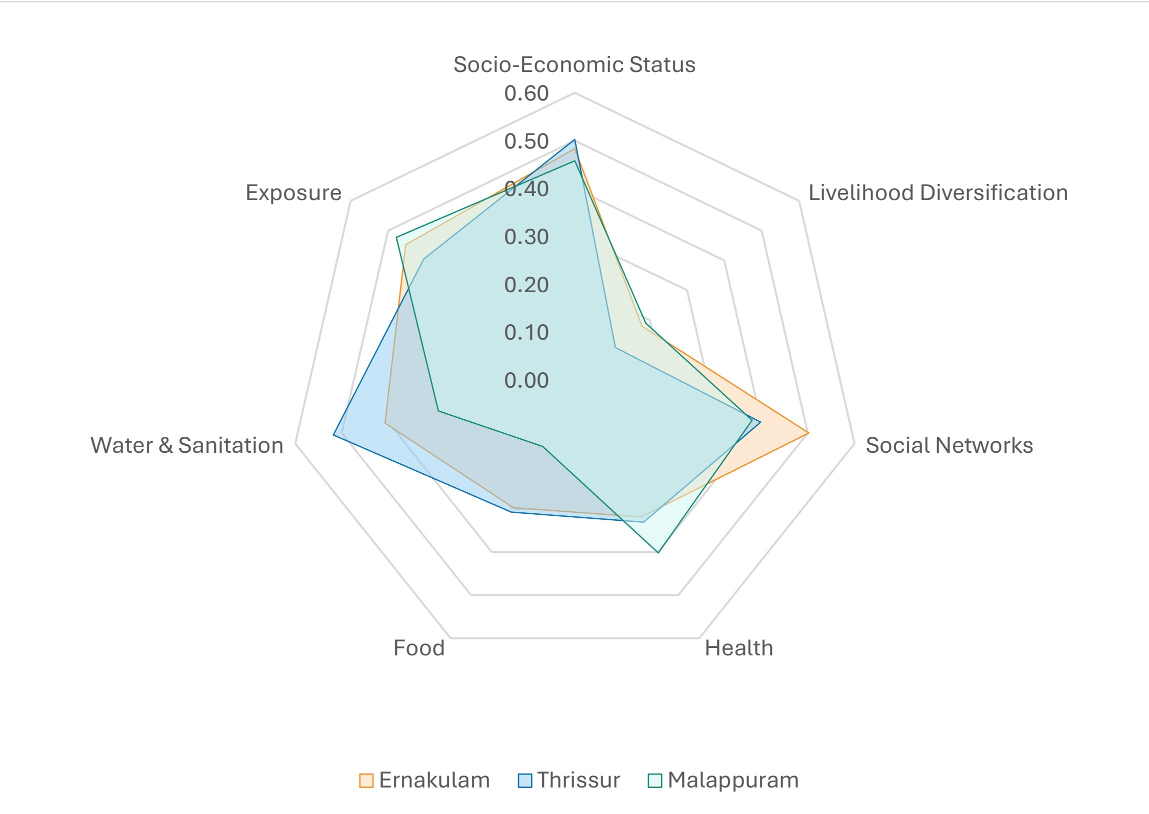
When it came to adaptive capacity, Ernakulam district had the highest score particularly owing to a far superior and robust social network that existed amongst the community. In Ernakulam, the number of households who had taken assistance from the Government was significantly higher than the other two districts, while a significantly larger number of households also enjoyed the benefits of social security measures instituted by the Central and State Governments.

Table 52: Components of Exposure – Central Zone

Sl. No	*Indicator*	*Ernakulam*	*Thrissur*	*Malappuram*
1	Cyclone Damage Index	0.7883	0.6268	0.9333
2	Flood Damage Index	0.6715	0.3873	0.6667
3	Sea Distance Index	0.2407	0.2624	0.2393
4	Mortality Index	0.0000	0.0282	0.0000
5	Livelihood Disruption	0.7445	0.7254	0.7267
6	Severely Eroded Coastal Protection	0.2263	0.2465	0.6600
7	Harbour Erosion	0.2555	0.1972	0.7733
8	T Max SD	0.6800	0.6650	0.6450
9	T Min SD	0.7100	0.6950	0.5700
10	TR SD	0.5100	0.5550	0.5250
	Exposure	***0.4827***	***0.4389***	***0.5739***

Source: Primary Data

Figure 88: Vulnerability Index Components – Central Zone



Source: Primary Data

Although the ground reality differed quite a bit across the three districts in the Central Zone, Malappuram was overall the worst district, while Ernakulam was the best performing one, with Thrissur occupying the middle ground. An overall representation of the seven dimensions of vulnerability for Central Kerala is given in Figure 7.2.

5.28.3. Northern Kerala

Among the three zones, the Northern Zone was comparatively the least exposed to natural disasters, while also showing an overall lower level of sensitivity. There was very little separating the three northern districts of Kozhikode, Kannur, and Kasaragod across the various dimensions of the vulnerability index. Amongst the three, Kozhikode had a marginally higher level of exposure, although this was mostly offset due to the sensitivity being lowest in the Northern Zone. Kasaragod had the highest score for adaptive capacity, while also displaying the lowest level of exposure, making it the least vulnerable of the three districts in the zone. Kozhikode had the lowest level of sensitivity primarily due to fewer instances of water conflict and better food security experienced by the households.

In terms of adaptive capacity, the Northern districts quite similar to Ernakulam, Alappuzha, and Kollam. What helps the three Northern districts stand out from the rest of the state is the significantly lower level of exposure to hazards, with a significantly less proportion of households being affected by natural disasters. The households in Kannur and Kasaragod especially lived further inland, reducing their exposure to disasters. The proportion of households who faced a disruption in fishing due to bad weather was also far less in the North. The level of sensitivity was also low in the Northern zone due to fewer water conflicts, lesser dependence of subsidized food sources, and lower levels of food inadequacy.

Table 53: Components of Adaptive Capacity – Northern Zone

Sl. No	Indicator	Kozhikode	Kannur	Kasaragod
1	Family Dependency Index	0.4740	0.5867	0.5260
2	House type Diversity Index	0.7764	0.6852	0.7130
3	Vehicle Index	0.5031	0.5370	0.4435
4	Family Decision Index	0.7950	0.9352	0.8348
5	Poverty Line Index	0.2236	0.3519	0.2000
6	Debt-free Index	0.7640	0.7778	0.7913
7	Consumption Index	0.2539	0.2326	0.3509
	Socio-Economic Status	***0.5414***	***0.5866***	***0.5514***
1	Job Diversification Index	0.4845	0.3889	0.5130
2	MNREGS Index	0.1242	0.0370	0.1391
3	SHG Job Index	0.0186	0.0278	0.0435
4	Migration Index	0.0683	0.2037	0.1150
5	Abandonment Index	0.2484	0.2778	0.3478
	Livelihood Diversification	***0.1888***	***0.1870***	***0.2317***
1	Non-monetary RG	0.3892	0.3827	0.4406
2	Monetary RG	0.4555	0.3302	0.4899
3	Collective RG	0.4120	0.3426	0.4579
4	SHG RG	0.3449	0.3330	0.3333
5	SHG Membership	0.5342	0.4815	0.5652
6	Social Security Index	0.3043	0.3704	0.3043
7	Assistance Index	0.3975	0.1204	0.3739
	Social Networks	***0.4054***	***0.3372***	***0.4236***
	Adaptive Capacity	***0.3985***	***0.3896***	***0.4202***

Source: Primary Data

Overall, the Northern districts of Kerala had comparatively the lowest levels of exposure and sensitivity, while also having decent levels of adaptive capacity, thus placing them much lower in terms of overall vulnerability. It could be said seafolk in Northern Kerala are better equipped to deal with climate change than their counterparts in Southern and Central Kerala. The overall picture for the seven dimensions in Northern Kerala is given in Figure 7.3.

Table 54: Components of Sensitivity – Northern Zone

Sl. No	Indicator	Kozhikode	Kannur	Kasaragod
1	Chronic Illness Index	0.4348	0.3519	0.3043
2	Disability Index	0.1553	0.0463	0.0174
3	No Insurance Index	0.4286	0.4074	0.5130
4	Hospital Distance Index	0.3926	0.4668	0.2602
	Health	***0.3528***	***0.3181***	***0.2737***
1	PDS Dependency Index	0.3665	0.2870	0.4000
2	PDS Distance Index	0.1438	0.3731	0.2714
3	Hunger Index	0.0435	0.1204	0.0435
4	Free Ration Index	0.1553	0.0833	0.0957
	Food	***0.1772***	***0.2160***	***0.2026***
1	No Toilet Index	0.0807	0.1389	0.0000
2	Water Scarcity Index	0.1677	0.3889	0.4957
3	WDI	0.1865	0.3280	0.3852
4	No Individual Access	0.2671	0.3426	0.4696
	Water & Sanitation	***0.1755***	***0.2996***	***0.3376***
	Sensitivity	***0.2352***	***0.2779***	***0.2713***

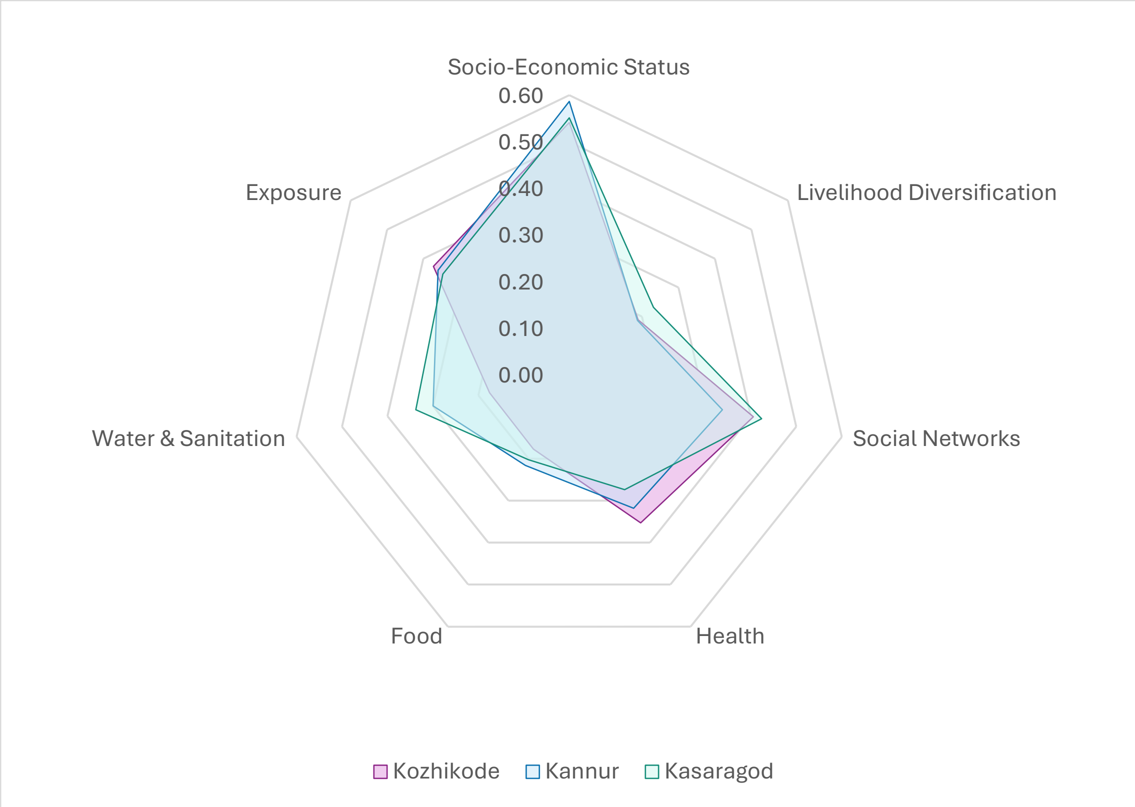
Source: Primary Data

Table 55: Components of Exposure – Northern Zone

Sl. No	Indicator	Kozhikode	Kannur	Kasaragod
1	Cyclone Damage Index	0.6025	0.5000	0.4348
2	Flood Damage Index	0.4037	0.4167	0.2609
3	Sea Distance Index	0.2015	0.2861	0.2674
4	Mortality Index	0.0062	0.0278	0.0000
5	Livelihood Disruption	0.5093	0.4907	0.4000
6	Severely Eroded Coastal Protection	0.2484	0.1667	0.0609
7	Harbour Erosion	0.2174	0.4722	0.1391
8	T Max SD	0.6100	0.5350	0.4600
9	T Min SD	0.3800	0.5000	0.2550
10	TR SD	0.3700	0.2750	0.3000
	Exposure	***0.3549***	***0.2850***	***0.2578***

Source: Primary Data

Figure 89: Vulnerability Index Components – North Zone



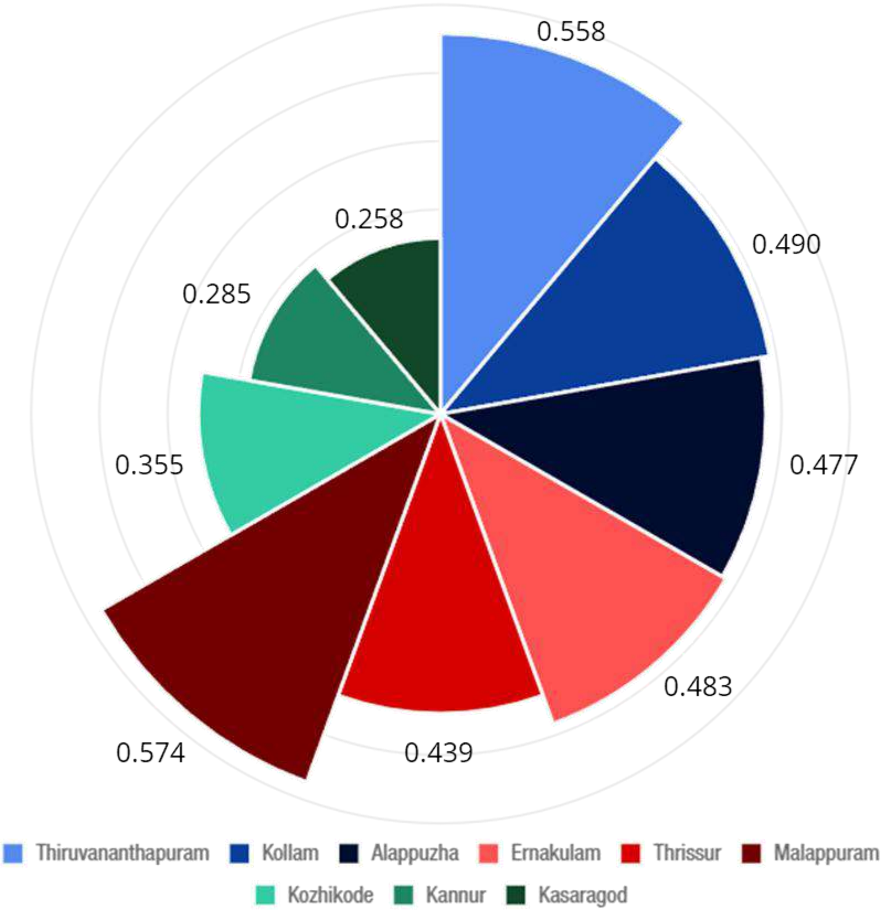
Source: Primary Data

5.29. Calculating Vulnerability

Calculating the LVI_{IPCC} and CCVI involves taking the final values for exposure, sensitivity, and adaptive capacity and applying them to the appropriate formulae. A breakdown of the three major axes by district is represented by using Nightingale-Rose charts, given in figures 7.4 to 7.6. Each chart represents the level of exposure, sensitivity, and adaptive capacity of households in the nine districts, with the size of the slice showing the extent of each index value for the respective districts.

Comparing the exposure levels of seafolk across Kerala reveals that the Malappuram has the highest score followed by Thiruvananthapuram and Kollam. Overall, the scores were highest in the South and lowest in the North. None of the northern districts had an exposure value greater than 0.4, which indicates that this zone was relatively safer for the seafolk. Kasaragod, Kannur, and Kozhikode are undoubtedly the least exposed to natural disasters in Kerala.

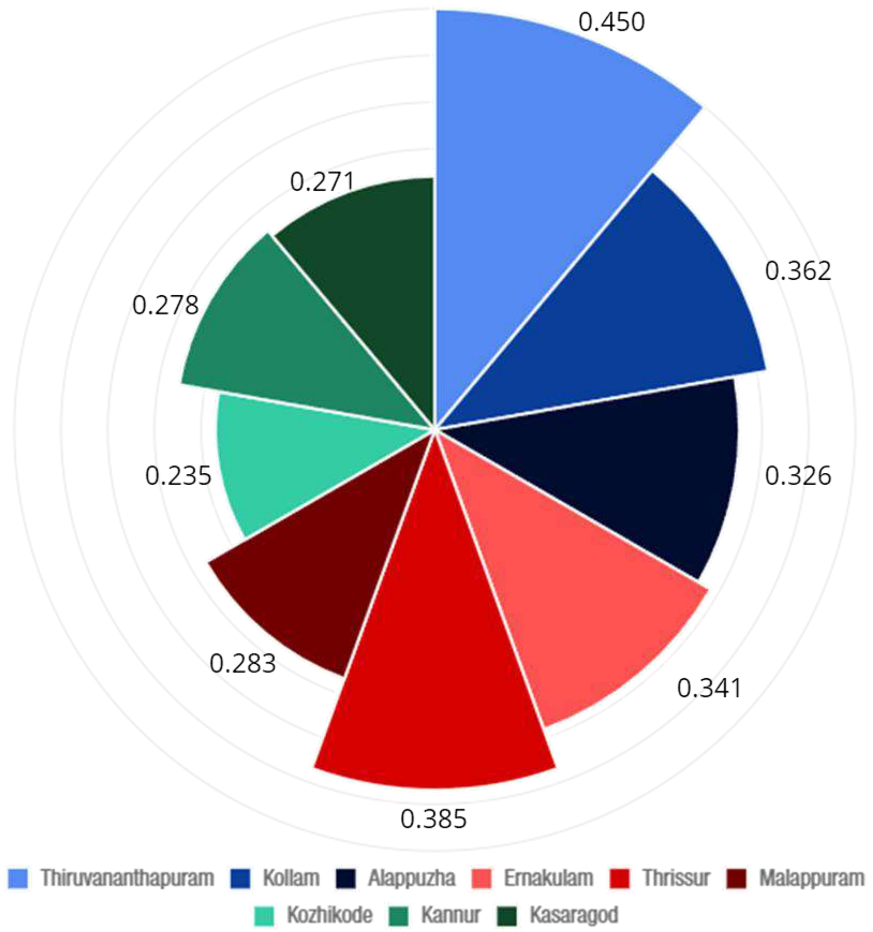
Figure 90: Exposure Index



Source: Primary Data

The scores for sensitivity range between 0.23 and 0.45, with Thiruvananthapuram, Thrissur, and Kollam having the highest scores. All three districts have severe water conflicts, and in the case of Thiruvananthapuram, food inadequacy and poor sanitation to compound to situation. The lowest sensitivity levels were seen in the three Northern districts, with Kozhikode displaying the lowest value at 0.235. Malappuram also had a sensitivity score below the state average of 0.327 to go along with the other Northern districts.

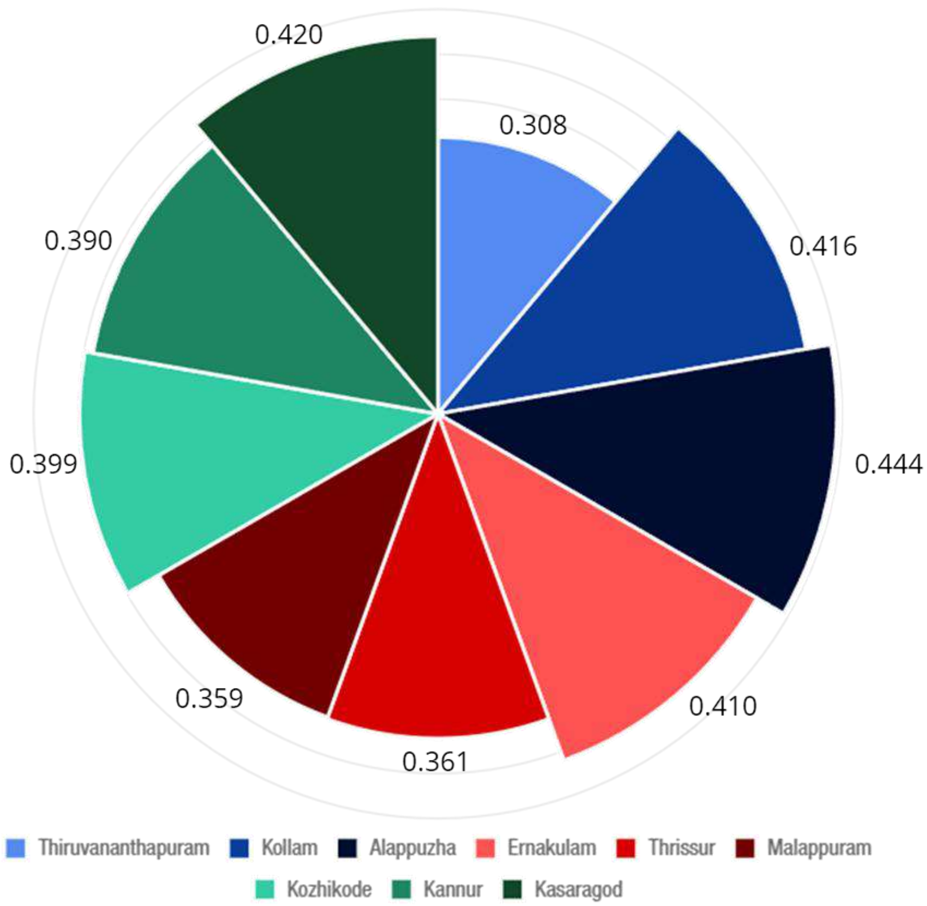
Figure 91: Sensitivity Index



Source: Primary Data

In terms of adaptive capacity, Alappuzha, Kasaragod, and Kollam were the best placed districts, while Thiruvananthapuram, Malappuram, and Thrissur were the worst placed. The former three districts had a greater level of livelihood diversification, as well as stronger community networks, and an overall better standard of living. The latter three districts are particularly hamstrung by the relative immobility of labour and weaker social linkages, with the situation in Thiruvananthapuram made worse by the poor material condition of households.

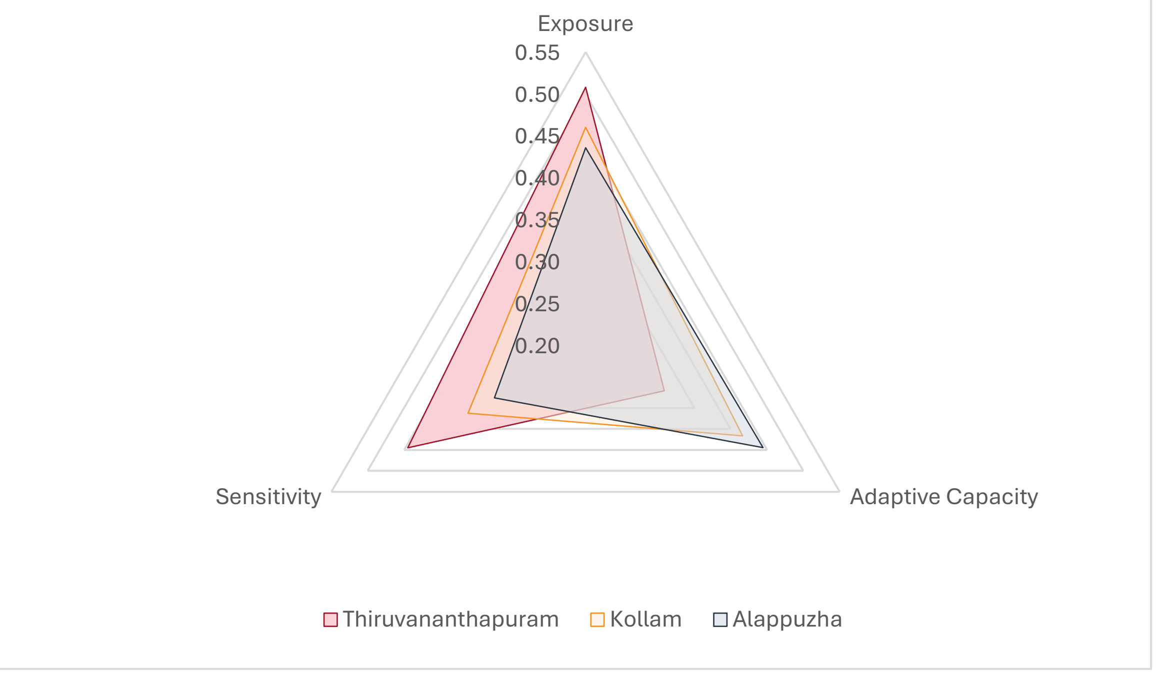
Figure 92: Adaptive Capacity Index



Source: Primary Data

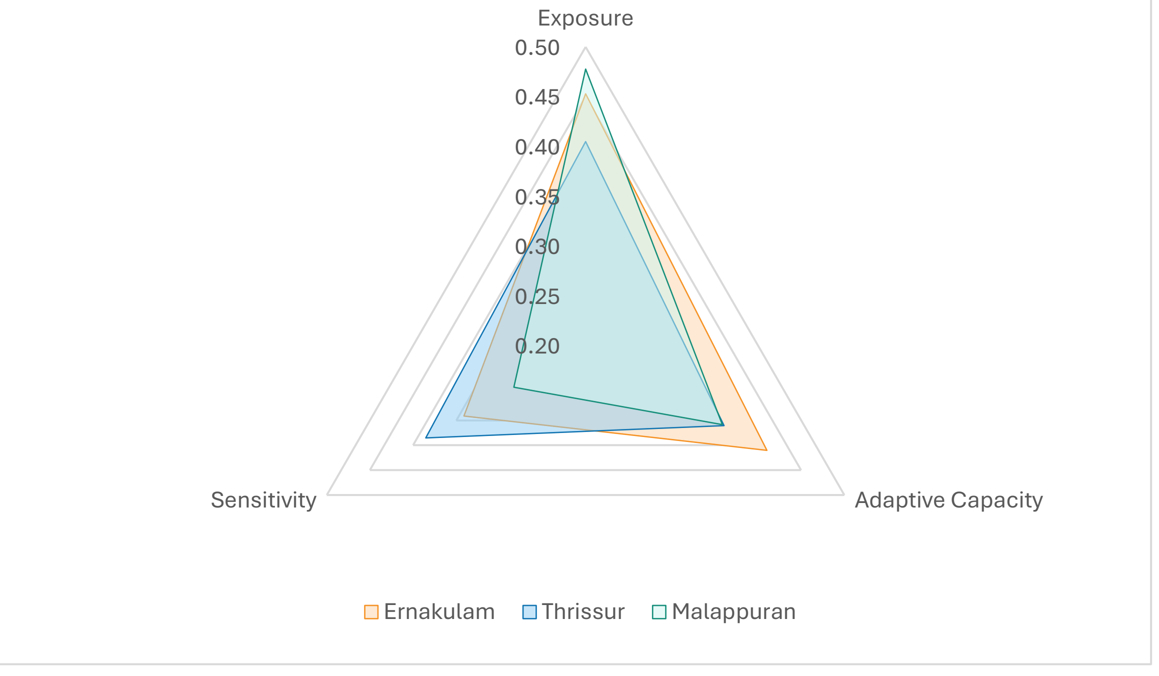
A comparison of the levels of exposure, sensitivity, and adaptive capacity of each district within a region is being depicted with the help of vulnerability triangles, in figures 7.7 to 7.9. The vulnerability triangle shows the distribution of the index values for the three axes of the CCVI and LVI_{IPCC} across the nine districts. The vulnerability triangle is a key component of the vulnerability analysis and helps condense the situation for each comparison between the districts in each region. Figure 7.7. shows Thiruvananthapuram has the highest level of exposure and sensitivity, combined with the lowest adaptive capacity in South Kerala, thereby making it the most vulnerable district of the three. On the contrary, Alappuzha with the highest adaptive capacity and lowest exposure and sensitivity becomes the least vulnerable district in the Southern Zone.

Figure 93: Vulnerability Triangle – South Zone



Source: Primary Data

Figure 94: Vulnerability Triangle – Central Zone

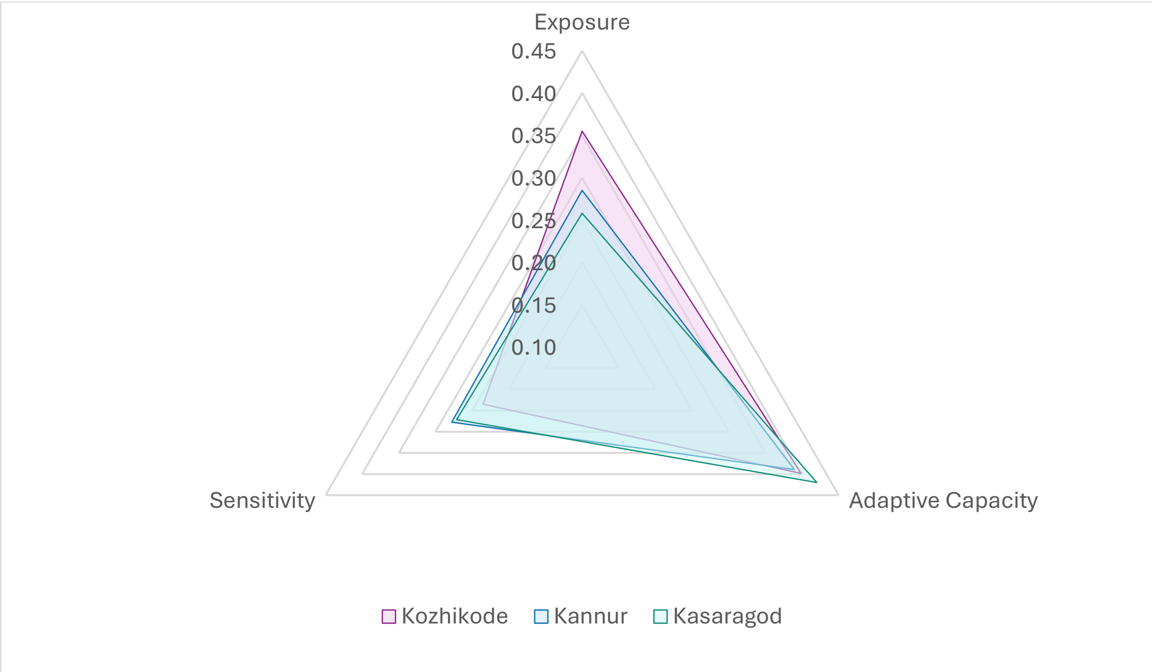


Source: Primary Data

Examining the vulnerability triangle for Central Kerala shows Malappuram as the most vulnerable, courtesy of the highest exposure score, and lowest adaptive capacity, despite having the lowest sensitivity. Ernakulam has the lowest overall level of vulnerability due to the high adaptive capacity of the community, combined with middle of the road values for sensitivity and exposure. Households in Thrissur have by far the lowest score for exposure among the three districts in Central Kerala, but also the highest level of sensitivity, which raises the overall level of vulnerability for the community.

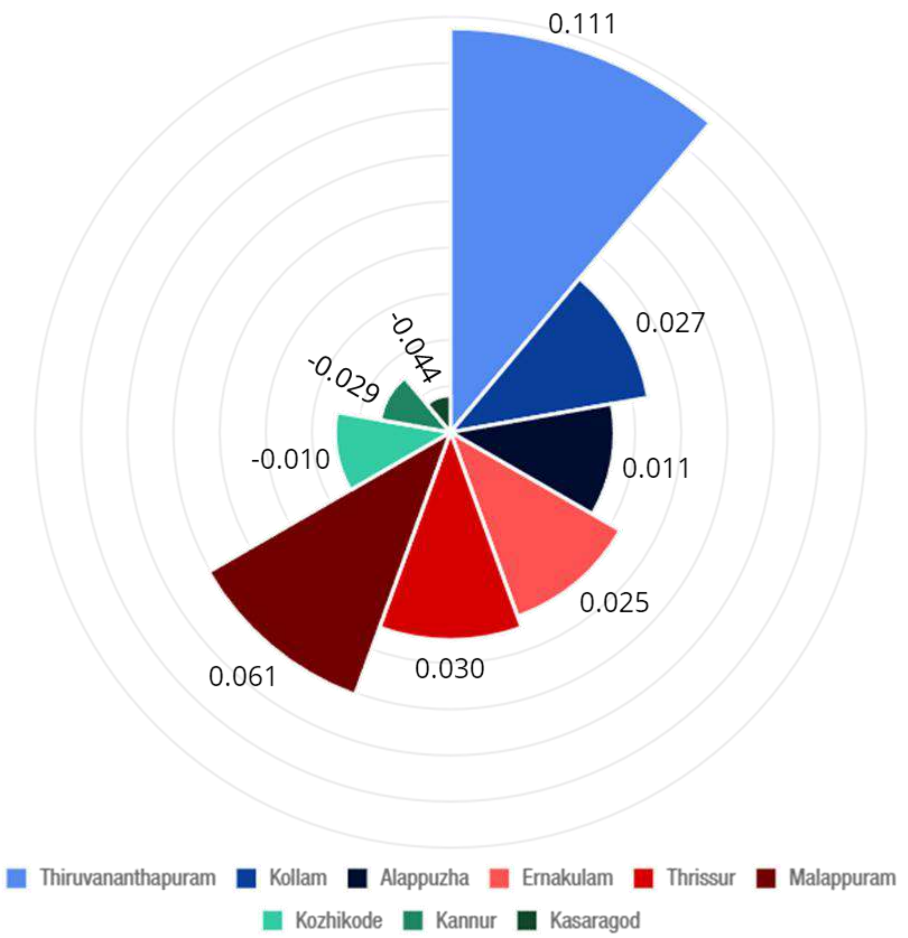
In the Northern Zone, the values for all three districts are quite close across the board. The differentiating factors that make Kasaragod the least vulnerable are the marginally lower scores for exposure and sensitivity, and the highest value for adaptive capacity. Despite having the lowest level of sensitivity, households in Kozhikode ended up having the overall highest vulnerability due to their increased level of exposure to hazards, and comparatively lower adaptive capacity.

Figure 95: Vulnerability Triangle – North Zone



Source: Primary Data

Figure 96: Livelihood Vulnerability Index – IPCC

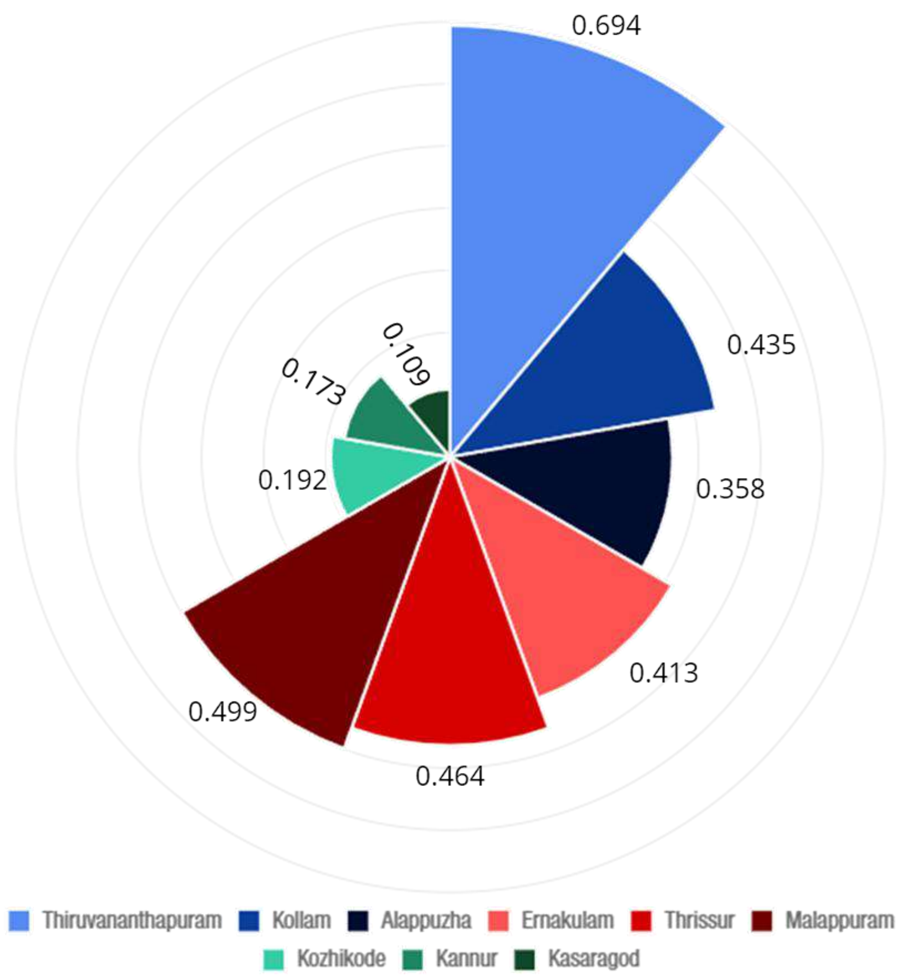


Source: Primary Data

Condensing the situation into a statewide comparison shows that the most vulnerable districts in Kerala were Thiruvananthapuram, Malappuram, and Thrissur. The comparisons for both LVI_{IPCC} and CCVI are given with the help of Nightingale-Rose diagrams in figures 7.10 and 7.11. The patterns are similar between both the indices. The value for LVI_{IPCC} ranges between -0.044 in Kasaragod to 0.111 in Thiruvananthapuram. LVI_{IPCC} ranges from -1 to +1, with the districts having a value less than zero considered less vulnerable. All three Northern districts have the LVI_{IPCC} less than 0, indicating that communities there are far less vulnerable than their counterparts in the rest of the state. Among the remaining districts, Alappuzha had the lowest index value, just above zero.

The value of CCVI ranges from 0 to 1. It can be seen from figure 7.11 that the values for the nine districts ranges from 0.1 to 0.69, with Thiruvananthapuram being most vulnerable and Kasaragod being least vulnerable. The trends are in line with the results of the LVI_{IPCC}, Thiruvananthapuram can be considered to have a high level of vulnerability, while the three Northern districts have a low level of vulnerability. The districts from Malappuram to Kollam have a moderate level of vulnerability.

Figure 97: Climate Change Vulnerability Index



Source: Primary Data

The vulnerability analysis for Kerala's coastal districts thus shows that the most vulnerable communities live in the Central and Southern parts of the state, with the Northern districts being relatively lower on the vulnerability scale. A lower incidence of natural disasters, fewer water conflicts, better food security, and having alternate livelihood strategies were key to the improved status of the fishing communities in Northern Kerala. In the Central and Southern districts, the situation varied significantly, especially with regard to livelihood diversification, food security, water availability, and sanitation. The extreme sensitivity of the communities is the key factor that drove Thiruvananthapuram to the highest vulnerability score. Exposure to natural disasters was also a key factor in the rest of the state, except for Thrissur district, where the communities tended to live further inland, reducing their exposure to hazards.

5.30. Wrapping Up

Initiatives to reduce households' vulnerability to climate change and its implications must be paramount when the government makes its developmental plans. The problems faced by the seafolk are diverse in each district of Kerala, and localized plans need to be drawn up to address the specific factors that raise the community's vulnerability in a given region. These could include steps to replenish beaches, strengthen coastal protection measures where necessary, rehabilitate the communities that face the greatest risk, increase their access to food, water, and sanitation, and ensure that the community members attain a greater level of skill that enables them to transition to alternate livelihoods in the event of forced displacement in the future. These possibilities are discussed further and in greater detail in the concluding chapter.

Form 10

Part B

Report Profile

Conclusions and Scope for Future Research

Conclusions & Recommendations

The study provides a comprehensive analysis of the livelihood vulnerability of Kerala's seafolk, covering the communities in all nine coastal districts of the state. Based on the vulnerability analysis, consultations with experts in the field, interactions with LSGI representatives, and the researcher's own field experiences interacting with the seafolk, a set of policy suggestions have also been drawn up regarding specific areas.

6.1 Key Findings

The key findings of the study are as follows:

- The seafolk remain an underprivileged community in Kerala irrespective of their geographic location. The community continues to suffer from centuries of socio-economic exclusion, which has impacted education attainment and labour mobility.
- Although problems are generally similar across the board, the intensity of the issues varies widely between districts, and between different parts within a district.
- The levels of poverty among the seafolk is high. Income from fisheries is low, and there is significant indebtedness among households. Households spend a considerable amount of money recovering from the impacts of extreme weather events. Saving levels are also generally low, as is the ownership of consumer durables.
- A significant proportion of households are directly dependent on fisheries for their livelihood. There is a slow shift away from fisheries, although it is seen more widely in the Northern parts of Kerala. Limited labour mobility, however, means that

those who do eventually shift away from fisheries largely end up becoming unskilled manual labourers in the informal sector.

- There are major problems in terms of food security, water availability, and sanitation, which require immediate attention of the State. Thiruvananthapuram district, in particular, suffers greatly in these respects, with almost two-thirds of all sample households facing the prospect of food inadequacy. More than one-third of households in the districts also lack access to drinking water and sanitation facilities.
- The households, especially in Southern and Central Kerala, are more exposed to natural disasters like cyclones and tidal floods. Households who live closer to the HTL are more prone to being affected by extreme weather events. Hard structures along the coast, such as harbours and breakwaters, also have a detrimental effect, exacerbating coastal erosion and the impact of extreme weather events.

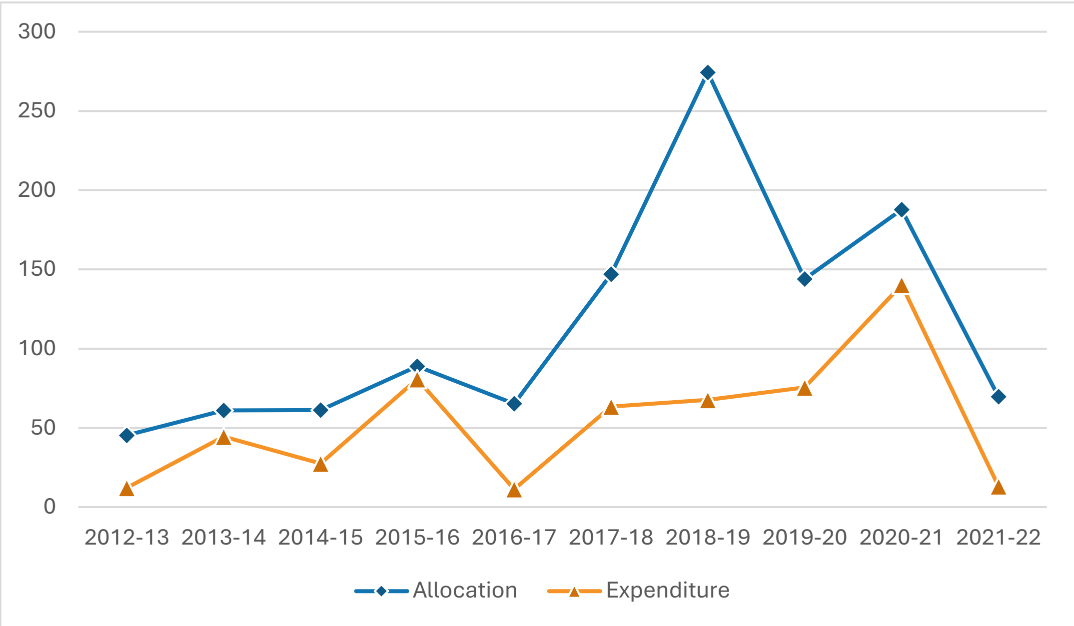
6.2. Addressing Specific Issues

There is considerable anger amongst the community against the administrative machinery at both the State and Union Governments. Interactions with various stakeholders helped identify major areas of concern that require a systematic intervention of the State's administrative machinery. These issues are discussed at length in this section, starting from the fundamental problem of social exclusion and its impact on the community's educational attainment and labour mobility.

6.2.1. The Education Situation

The seafolk in Kerala have been subject to widespread social marginalization, with its roots lying deep in the bedrock of caste. The education attainment is generally poor among the community, although literacy levels have improved in recent times. Experts and community members in the interactions spoke of a need for greater public investment in education in the coastal belt. There was a general feel that the number of fisheries schools in Kerala was less than the number required for a community as large as the seafolk. The Fisheries Department of the Government of Kerala runs ten Fisheries Technical High Schools in the State, which may be considered inadequate given the sheer size of the community. There is also a fact that Government and aided schools in the coastal regions are ignored in terms of infrastructure development, and lag behind schools located in more mainstream areas.

Figure 98: Allocation and Expenditure of Public Funds on Education of Seafolk in Kerala, 12th and 13th FYPs in Lakh Rupees



Source: Sulekha Portal, LSGI Department, GoK

In terms of public spending on education for children belonging to the seafolk, the track record of Kerala's LSG institutions is sub-par. Compared to the expenditure on improving the education of Dalit and Adivasi students, the spending is paltry for the seafolk. The most prominent reason for this is likely the fact that dedicated funds are available for Dalit and Adivasi students in the form of SC Plan (SCP) and Tribal Sub-Plan (TSP) funds, while no such funds exist for the seafolk. The highest expenditure on education of the seafolk in Kerala during the 12th and 13th Five Year Plans (FYP) was roughly Rs. 1.4 Crores in 2020-21. Figure 100 shows that in no year has expenditure matched actual layout of funds, although the gap was quite low in 2013-14 and 2015-16. The gap between allocation and expenditure was highest in 2018-19, where only about Rs. 67 lakhs was spent despite an outlay of close to Rs. 2.75 crores across all the coastal districts. A detailed district-wise breakup of allocation and expenditure is given in tables 58 and 59.

Table 56: Allocation for Fisherfolk (in Lakh Rs.)

District	***12-13***	***13-14***	***14-15***	***15-16***	***16-17***	***17-18***	***18-19***	***19-20***	***20-21***	***21-22***
Thiruvananthapuram	15.00	0.94	-	15.00	-	10.00	-	-	31.35	-
Kollam	-	-	-	-	-	-	10.00	-	-	-
Alappuzha	1.78	0.92	0.92	-	5.00	10.00	15.00	20.44	20.31	29.87
Ernakulam	-	5.00	10.00	5.00	5.31	10.00	10.00	15.42	10.50	-
Thrissur	10.38	12.03	14.40	24.00	14.00	24.00	7.00	6.10	15.00	10.00
Malappuram	-	-	5.00	10.00	-	14.06	-	-	-	-
Kozhikode	-	8.15	-	-	-	7.48	-	-	-	-
Kannur	10.66	9.62	12.44	20.80	21.00	12.00	10.00	25.84	34.47	8.00
Kasaragod	7.50	24.37	18.50	14.14	20.00	59.55	222.4	76.11	76.11	21.89

Source: Sulekha Portal, LSGI Department, GoK

Table 57: Expenditure for Fisherfolk (in Lakh Rs.)

District	***12-13***	***13-14***	***14-15***	***15-16***	***16-17***	***17-18***	***18-19***	***19-20***	***20-21***	***21-22***
Thiruvananthapuram	0.28	0.94	-	14.24	-	9.99	-	-	29.44	-
Kollam	-	-	-	-	-	-	10.00	-	-	-
Alappuzha	0.86	-	-	-	-	4.65	3.82	10.11	9.03	5.16
Ernakulam	-	4.37	9.94	5.00	5.31	9.53	7.58	3.78	6.29	-
Thrissur	3.60	6.62	10.19	23.78	-	5.73	-	1.62	13.81	-
Malappuram	-	-	-	9.47	-	14.06	-	-	-	-
Kozhikode	-	7.28	-	-	-	6.92	-	-	-	-
Kannur	6.40	4.09	4.12	14.3	5.96	9.62	-	7.08	28.65	3.28
Kasaragod	1.12	21.19	3.18	13.96	-	2.95	46.33	53.02	53.02	4.81

Source: Sulekha Portal, LSGI Department, GoK

Perhaps, what is more critical is the fact that students continue to be treated unfairly by teachers in schools. According to community members and experts in the field, the insensitive attitude of teachers towards students from a fishing background leads to large-scale dropouts even today, where even students who somehow complete twelve years of schooling lose motivation to take up higher studies. In Thiruvananthapuram district, multiple respondents said that they faced linguistic discrimination in schools from Malayali teachers. The fishing community in Thiruvananthapuram is contagious with the community in Kanyakumari district, sharing a distinct language and cultural heritage that is different from the Malayali mainstream. This cultural difference is often ignored by teachers, who behave in an insensitive manner towards students.

Photograph 9: Wall Art at Govt Fisheries LP School, Ponnani

Source: Primary Data

The economic pressure exerted by the community's general level of impoverishment also forces many students to drop out of school and go to sea for a livelihood. The lack of skill development in the school in areas other than fisheries also limits the mobility of the youngsters when they try to enter the labour market.

6.2.1.1. Policy Suggestions in the Education Front

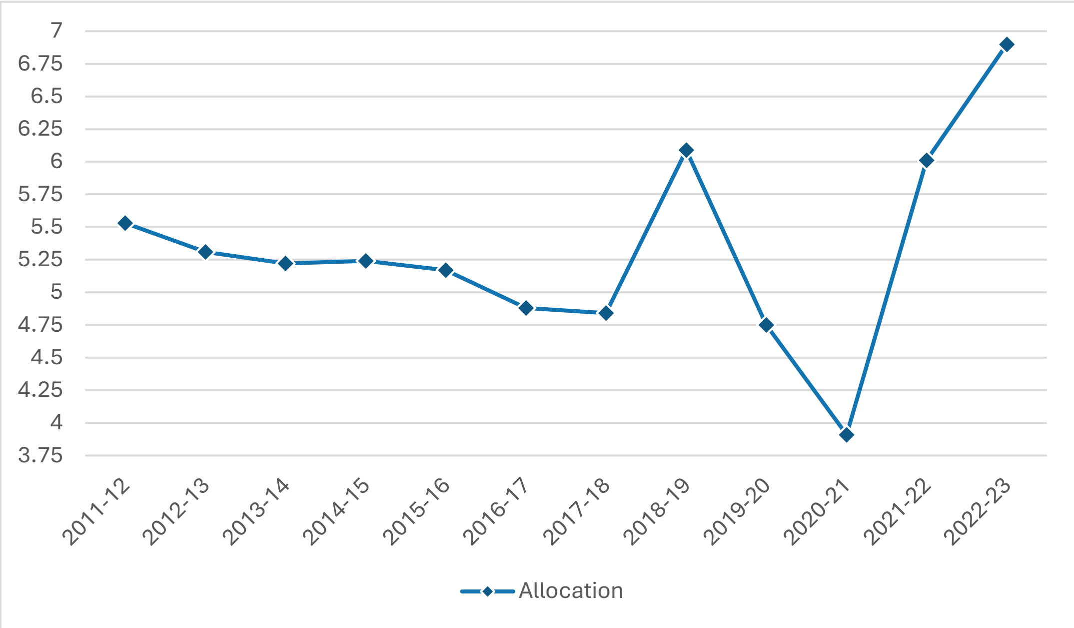
Some of the key policy suggestions to address the poor educational status of Kerala's seafolk would include:

- Implementation of a Coastal Sub Plan akin to the SCP and TSP, which has to be spent by District Panchayats (DPs) every year without much leakage. Having a dedicated Coastal Sub Plan would also lead to substantial increases in public spending on the education of coastal communities.
- Funds under the Coastal Sub Plan can be used for infrastructure development, providing mid-day meals and breakfast to students, and providing an effective community or home-based learning environment. Community-based learning environments have been successfully implemented in Adivasi hamlets of Thiruvananthapuram through the Padanamuri scheme of the DP. Such spaces can incorporate local histories of the seafolk to help the children connect with their heritage, while also providing a comfortable learning space for children who may not have a support learning environment at home. Some DPs have also undertaken schemes to provide the children of seafolk with breakfast (Subhiksha in Ernakulam, and Balakiranam in Kollam), which could become staple programmes with the help of a Coastal Sub Plan.
- Sensitization programmes for teachers should be undertaken in Government and aided schools in the coastal belt so that they can deal with the children and their issues in an empathetic manner. This would help bridge the gap between students and teachers, fostering an improved learning experience in schools for the children.
- Provide more skill-based education programmes for the children to help them explore other career opportunities. Skill training can also be given in fisheries, which could improve output from the traditional occupation of the community.

6.2.2. Livelihood Security and Diversification

As the global climate undergoes major changes, the livelihood of traditional fisherfolk is at risk. There is a general feeling among the seafolk that fishing along the Kerala coast is becoming unsustainable due to overfishing, particularly by large boats and trawlers. Fish production in Kerala, which was on a largely declining trend, had shot up just before the pandemic, before suffering a dip and recovering greatly in the last two years. Several traditional fishermen were of the opinion that large-scale mechanization in the fisheries sector was hurting the traditional artisanal fisherfolk.

Figure 99: Marine Fish Production in Kerala (Lakh Tonnes)



Source: Sulekha Portal, LSGI Department, GoK

One of the biggest impacts of climate change on the livelihoods of the seafolk is the frequent loss of workdays. Due to better weather monitoring systems and proper warnings, many seafolk do not venture out into the sea when the weather is adverse. However, due to their lack of other skills, a significant number of seafolk are left unemployed during these days. The results of the primary survey indicated the impact of extreme weather events on the work loss faced by the seafolk. Another key aspect that the seafolk pointed out was their lack of involvement in tourism projects. There was a widespread view that tourism development in the coastal regions did not consider the livelihoods of the local fishing community.

6.2.2.1. Policy Suggestions for Employment Diversification

Some steps recommended to diversify the livelihoods of Kerala's seafolk and eventually improve their standard of living are as follows:

- Provide easier access to credit for seafolk to set up their enterprises.
- Organization of the community into local collectives that undertake economic activities, with each member being an equal stakeholder and shareholder in the enterprise.
- Ensuring greater involvement of the seafolk in the tourism industry by focusing on community-based tourism initiatives. Such initiatives could include:
    - Coastal heritage tours where the community can narrate their stories to tourists
    - Community-run restaurants and curio shops in tourist spots
    - Development of shacks as a revenue source
    - Training of seafolk as divers and rescue personnel in beaches and employing them as lifeguards. This can be further expanded into organizing water sports in suitable locations.
- Implementation of circularity in the fisheries sector of Kerala. Activities could include setting up fish processing units, the waste products of which can be used for production of biofertilizers or value-added products like collagen. Technological interventions would have to be made to bring circularity into the picture, and they would have to be provided to the community at subsidized rates. The community members would also have to trained in such practices that help them diversify their incomes and ensure a better standard of living.

6.2.3. Coastal Management Practices

As Kerala becomes increasingly prone to being affected by natural disasters like cyclones and tidal floods, and eventual rise in sea level, it is imperative that policymakers revaluate existing coastal management practices and make improvements as required. Coastal management practices in Kerala today primarily includes construction of hard structures as short-term solutions, with seawalls, fishing harbours, groynes, and breakwaters being the most commonly used methods. In some locations, coastal afforestation using mangroves and *Casuarina Equisetifolia* (Windmill tree or Kattadimaram in Malayalam) being planted along eroding coasts. During the fieldwork, coastal afforestation practices were observed only in a few locations such as Chellanam, Vypeen, Mandalamkunnu, Padinjarekkara (North of Ponnani harbour), Mattool, and Valiyaparamba. Hard structures continue to be the most favoured method of coastal management.

The field survey showed that across Kerala, locations that had seawalls had almost completely eroded coastlines. Many of these were located downdrift of fishing harbours or groyne fields. This section includes a set of photographs of various parts of Kerala's coastline that have been ravaged by waves, especially in the monsoon season. These include areas ranging from the Southern border of Thiruvananthapuram to the eroded segments in Kasaragod. In most of these locations, the seawalls were constructed more than 30 years ago, and have seen little to no maintenance.

The dilapidated nature of coastal protection measures throughout Kerala are a testament to the negligence of the state's administrative machinery. In locations like Chettuva in Kadappuram Panchayat, the entire stretch of the seawall had been reduced to smooth rounded stones that do nothing to protect the coast against tidal floods and cyclones. While a tetrapod-based seawall was recently constructed in Chellanam to protect the village from tidal floods, similar endevours in other parts of

Kerala have not been undertaken with due diligence. One such case is from Ottamassery in Alappuzha, where hundreds of tetrapods were found abandoned within the compounds of nearby houses, and a single line of tetrapods was deployed along the HTL (Photograph 23). In one of the biggest acts of state negligence, erosion continues unabated in Alappad, Chavara, and Panmana panchayats of Kollam district, where indiscriminate mineral sand mining by two PSUs – IREL and KMML – have eaten away at the coast and led to the forced migration of coastal communities.

Table 58: Environmental Softness Ladder

Solution	Methodology	Environmental Impact	Category
Steep Seawalls	Seawall/revetment to protect the land with front slope gradient >1:15	12	Hard
Low Gradient Seawalls	Seawall/revetment to protect the land with front slope gradient <1:15	11	Hard
Headland Groynes	Groynes / headlands longer than 300 m with high crest	10	Hard
Long, High-crested Groynes	Groynes longer than 100-300 m with crest above high tide	9	Hard
Short, High-crested Groynes	Groynes with crest above high tide, but less than 100 m long	8	Hard
Low-crested Groynes	Series of groynes with crests lower than high tide, and less than 100 m long	7	Hard
Nearshore Reed	A reef built close to shore or on the inter-tidal beach	6	Moderate
Offshore Islands/Breakwaters	Emerged offshore structure	5	Moderate
Offshore Reefs	Reef built offshore, normally in 3-8 m depth	4	Moderate
Nourishment	Major sand nourishment: sand source is offshore or external	3	Soft
Dune Restoration	Sand nourishment: sand source is from the beach or surf zone	2	Soft
Dune Care	Replanting, fencing, walkways on dunes	1	Soft

Source: Black et al (2019)

The Reference Manual on Climate Change Adaptation Guidelines for Coastal Protection and Management in India (Black et al, 2019) describes various coastal protection strategies in detail. The manual describes these measures along an Environmental Softness Ladder (ESL). The ESL ranks protection measures on a scale of 1-12 in terms of environmental impact, where 1 represents the softest solution with least impact and 12 the hardest with the worst consequences. The ESL is meant to be used as a process, where each solution starting from the bottom run (Environmental Impact = 1) much be fully considered and eliminated only if there are sufficient justifications, before moving higher up the ladder. The objective of the ESL is to facilitate the use of the softest possible solutions, and the ensure that hard solutions are implemented only after the softer options are fully rejected.

6.2.3.1. Seawalls and Groynes

Seawalls and groynes are often chosen for coastal protection due to their relatively lower cost of implementation. However, both strategies require constant maintenance, which increases the cost in the long-term. This is especially so in the case of seawalls since erosion continues near the base of the structure, leading to large-scale slumping and structural breakdown. Each round of maintenance on the structure would require layering large rocks or concrete alternatives like tetrapods, which would become untenable beyond a certain point of time.

Table 59: Impacts of Seawalls and Groynes

Strategy	Definition	Impacts
Seawalls	Structures constructed parallel to the shore, near the HTL to stop erosion	• Block land erosion and protect coast from flooding in the short term, but erosion continues underwater • Loss of natural beach due to greater wave turbulence at the base, burial of primary dune, and intensified longshore currents • Attacked by larger waves during high tide and cyclones • Requires more rocks/tetrapods to maintain over the years, untenable in the long run. • Create severe downdrift effect
Groynes	Structures constructed perpendicular to the coast, aimed at segmenting the sediment cell	• Designed to trap sand and facilitate local accretion but lead to erosion in downdrift zones. • Often constructed in haphazard manner with no uniformity in length and width

Source: Black et al (2019)

Groynes also cannot be implemented in a uniform manner across the coast and require careful consideration before they are constructed. The construction of a groyne field in any location requires a proper assessment of local wave and sediment transport conditions, including cross-shore and longshore sediment transport, seasonal variations, breach morphology, and several controlling factors such as waves, winds, and currents.

A groyne field can only be constructed after considering the elevation, length, spacing, and number of groynes. Case studies from Puducherry, Thiruvananthapuram, and Chennai have shown that while construction of groynes has led to formation of beach segments within the gaps between each groyne, the structures have caused significant erosion elsewhere along the coast due to a strong downdrift effect. Groyne design is an extremely complex process, and success in one location does little to guarantee the same in another location. Along with seawalls, groynes are one of the least favoured methods for coastal protection in the face of climate change.

6.2.3.2. Offshore Reefs

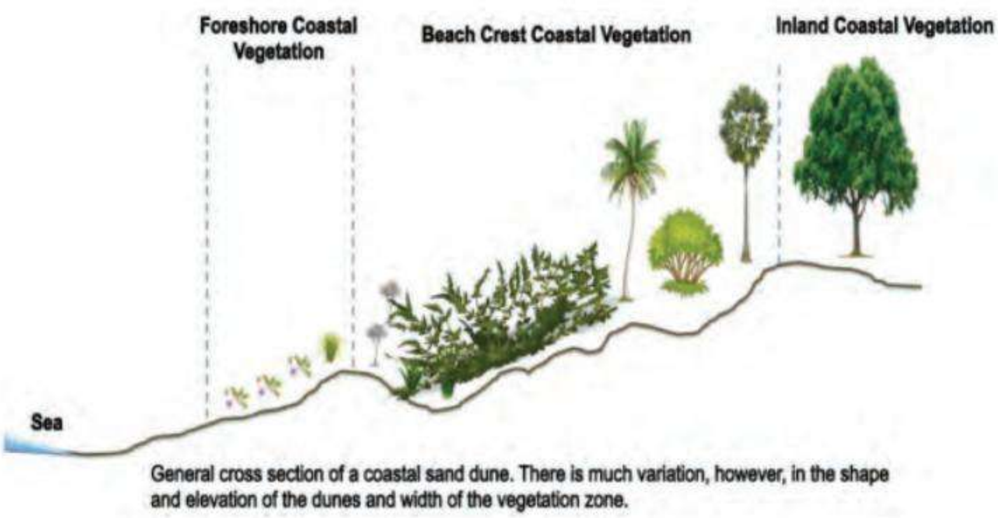
Compared to seawalls and groynes, artificial offshore reefs are a far superior choice to reduce coastal erosion and enable beach accretion. Offshore reefs are considered softer solutions since they do not meddle with the beach and facilitate a natural flow of sand along it. Black et al (2019) note that reefs have multiple benefits including beach building and shoreline protection, while not interfering with the dynamics of the beach – unlike seawalls and groynes – and having minor visual impact on the coastline. They also enable safer tourism in the beaches as the sea becomes less choppy and provides avenues for activities like surfing and snorkelling. Reefs are a widely used strategy internationally, and they also act as a breeding ground for biodiversity. They are considered one of the best strategies due to a substantial benefit to cost ratio, primarily due to the reason that they act on the waves, reducing their intensity before the reach the shore. Unlike seawalls and groynes, offshore reefs do not represent a topical treatment for a deep surgery.

The only instance of artificial offshore reefs being constructed in Kerala is in Kovalam, where 28 sand-filled geotextile tubes 1-5 to 3 metres high and 3-4 metres across were used to construct it in 2010. The activity has helped with beach building in Kovalam, although the reef needs maintenance these days to continue its viability in the region. The initial project was not undertaken by the Department of Irrigation, which has meant that maintenance activity has ground to a halt.

6.2.3.3. Soft Solutions – Dune Care

On the lowest rungs of the ESL, we have sand-based solutions that include dune maintenance and beach nourishment. These are considered the best strategies to protect coastlines in terms climate change adaptation, since beaches can use their inherently unstable nature to adjust to wave action and rising sea water levels. Four main strategies are undertaken among soft solutions – dune care, nourishment, back-passing, and bypassing.

Figure 100: Cross-section of coastal sand dune, indicating various levels of appropriate vegetation



Source: Black et al (2019)

Table 60: Examples of vegetation suitable for dune care in India

Vegetation Zone	Vegetation Type	Species
Foreshore and face of the fore dune – Exposed to waves	Sand-binding creepers	Bayhops (*Ipomoea pescaprae*) Coastal Spinifex (*Spinifex littoreus*) Shoeline Purslane (*Sesuvium portulacastrum*) Vettiver (*Chrysopogon zizanioides)* Bermuda Grass (*Cynodon dactylon*) Trailing Daisy (*Launaea sarmentosa*) Saccharum (*Saccharum sp*.) Beach Bean (*Canavalia rosea/Canavalia maritima*) Sickle Senna (*Cassia tora/Senna tora*) Coco-grass (*Cyperus rotundus*)
Fore dune crest and back dune – Exposed to winds and salt spray	Shrubs Sand-binding creepers Herbaceous plants	Aerva (*Aerva sp.*) Calotropis (*Calotropis sp.*) Crotalaria (*Crotalaria spp.)* Cissus (*Cissus sp.)* Common Wireweed (*Sida acuta*) Chinese Chaste Tree (*Vitex negundo*) Lantana (*Lantana sp.)* Glory Boer (*Clerodendrum inerme*) Bayhops (*Ipomoea pescaprae*) Opuntia (*Opuntia sp.*) Beach Cabbage (*Scaevola taccada*) Toothbrush Tree (*Salvadora persica*) Thatch Screwpine (*Pandanus tectorius*) Malabar/Indian Almond (*Terminalia catappa*) Mastwood (*Calophyllum innophyllum*) Pacific Rosewood (*Thespesia populnea*) Indian Beech (*Pongamia pinnata*) Coconut (*Cocos nucifera*)
Inner back dune – Exposed to winds, pure strand or mixed vegetation	Trees Shrubs	Palmyra (*Borassus flabellifer*) Cashew (*Anacardium oxydentrum*) Screw Palm (*Pandanus sp.)* Mastwood (*Calophyllum innophyllum*) Tamarid (*Tamarindus indica*)* Indian Coral Tree (*Erythrina indica*)* Sea Hibiscus (*Hibiscus tiliaceous*)*

**Only on the landward side of the dune*

Source: Black et al (2019)

Dune care refers to nurturing or protecting existing and artificial sand dunes on beaches by way of planting vegetation or fencing. This method has been adopted in certain parts of Kerala, such as Thalappady and Valiyaparamba in Kasaragod, Padinjarekkara in Malappuram, Mandalamkunnu in Thrissur, and Vypeen in Ernakulam. Planting vegetation does not necessarily require large trees, as is prevalent in Kerala, but can be done at a cheaper rate by the introduction of shrubs and creepers. Any plant species that can grow from a high-water line to the back of the beach through the dunes can be considered for the activity.

Black et al (2019) provide a list of species that can be used for dune care in Indian beaches. Each species is suited for plantation in a specific vegetation zone within the beach, and suitability is defined by a combination of factors including elevation, soil salinity, sand texture, temperature, velocity of wind, and human interferences. Broadly speaking, creepers are ideal nearer to the shoreline, while large trees are best suited towards the back of the beach. Some locally available tree species can be planted at the back of the beach provided they face the landward side. A total of 338 plant species belonging to 69 families have been identified as ideal for dune care in the Indian context. Table 60 provides a list of some of the recommended species in India.

6.2.3.4. Soft Solutions – Beach Nourishment

Unlike dune management, beach nourishment requires artificial deposition of sand above and below the water across the entire cross-section of a beach. Restoration activities have been successfully carried out in the Unites States, for instance, and are a highly effective way to protect shorelines in a sustainable manner. Beach nourishment gives rather quick results as equilibrium conditions develop fast, and the sand deposited is not lost immediately. Although it might take some time for the beach to adjust to the new situation, the result is quite rewarding, and can provide major boosts to tourist activity while safeguarding coastal communities.

There are multiple methods to undertake beach nourishment. The first method involves surveying a contiguous non-eroding beach using detailed bathymetric surveys on the eroding and non-eroding stretches, with the difference being used to ascertain the volume of sand required to nourish the eroding segment. The second method, also known as the Dean method, after Dean (1991) who developed his model based on the equilibrium beach profile model. The Dean method defines the volume of sand required by comparing the equilibrium profile of the borrowed material to its equivalent for the native material. The third method, also known as the beach width method, is achieved by shifting the existing beach seaward by a predetermined amount.

Beach nourishment is typically done for the entire sediment cell due to alongshore spreading effect. This effect happens when a small segment of beach is filled, but the current disperses the sand throughout the sediment cell, thus making the nourishment exercise a non-starter. The sand to be used for nourishment can come from multiple sources, including dredged material from harbours and inlets, offshore sand deposits and sediment from dams. Black et al (2019) suggest using sediment from dams as a good strategy since they help reclaim the capacity of the reservoir, while simultaneously nourishing the beaches. It must also be noted that beach nourishment is not a one-off exercise and requires continued maintenance every two to ten years. The activity can be combined with dune care to efficiently maintain the beach in the long run.

6.2.3.5. Soft Solutions – Bypassing and Back-passing

The final two soft solutions for coastal protection are sand bypassing and backpassing. Bypassing refers to the process by which sand accumulated up-coast of a sediment barrier is transported downstream to an eroded coast to replenish the beach. As in the case of several stretches along Kerala's coast, the construction of groynes and large breakwaters leads to disruption of longshore sediment transportation. This leads to massive accretion updrift of the structures, and severe erosion downdrift. In sand bypassing, the sand from the accretion zone would be manually transported and deposited in the erosion zone to stabilize both stretches of the beach. No new material is added to the system, and bypassing emerges as a sustainable practice to protect coastal segments that erode due to human activity.

Backpassing involves a similar practice, except that sand is transported from a wide, stable beach downstream to a sediment-starved eroding beach located upcoast within the same sediment cell. Backpassing acts as a recycling mechanism, where excess sand that is transported from an eroding beach to a stable or accreting zone downdrift is artificially transported to its source so as to replenish the eroding coast. Similar to bypassing, backpassing is also a sustainable strategy for coastal protection.

6.2.3.6. Recommendations in the Kerala Context

Multiple reports that have come out in recent times have criticized hard structures for the massive level of coastal erosion in Kerala. These include research by the likes of Pradeep et al (2022), Thankappan et al (2018), Kankara et al (2018), Noujas and Thomas (2015), NCSCM (2013), NCCR (2020), and JPS (2023). The recommendations of the Reference Manual on Climate Change Adaptation Guidelines for Coastal Protection and Management in India also warn against increased use of hard structures for coastal protection. While some studies like Sundar et al (2023, 2024) have shown that local-level accretion happens due to the presence of groyne fields along selected locations, most available literature argues against such structures.

Despite the overwhelming evidence against hard solutions, they continue to be the favoured choice of Government departments in Kerala. Government departments that have a stake in Kerala's fisheries sector including the Department of Fisheries, Kerala State Coastal Area Development Corporation Limited, Kerala Irrigation Infrastructure Development Corporation Limited, Department of Tourism, Department of Irrigation, or the Department of Harbour Engineering, have almost never engaged in deploying measures aimed at long-term protection of the state's shoreline. Recommendations for sustainable coastal protection measures in Kerala includes construction of offshore reefs, and soft solutions, especially in areas where artificial structures have disrupted the sediment transport. The present report echoes the views of Black et al (2019) with the following steps for policy makers:

- Establishment of a State-level multidisciplinary coastal research programme, focused on developing data sets and computer models to assess appropriate strategies. Key gaps to be addressed include surf-zone dynamics on natural beaches and around artificial structures; large-scale analysis on coastal dynamics and integrated planning of projects over large zones; and assessment of inland and offshore sediment sources, and their environmental impacts prior to implementing soft solutions.
- Coordination of multiple research agencies and researchers through the establishment of a multidisciplinary research fund. The multidisciplinary teams should comprise researchers and experts from the fields of sciences including oceanography, meteorology, physics, chemistry, and biology, engineering, economics, and social sciences. A strong interdisciplinary work culture must be encouraged so that individuals across disciplines can work together to create the best solutions.
- Establishment of a coastal science and engineering department to deal with coastal projects including harbours and coastal protection measures. At present, there are multiple stakeholders in coastal management such as the Departments of Irrigation, Tourism, Harbour Engineering, and Fisheries, all of which could have conflicting interests. A single body to deal with all coastal projects would reduce the policy lag caused by the actions and disagreements of multiple departments.
- The coastal system must be studied in depth before planning a solution, and problems identified should be studied along a broad spatial domain rather than at a local scale.

- Provision for the periodic training of policymakers and officials in dealing with coastal problems to enable the implementation of climate-resilient coastal protection measures.
- Timely review and updating of coastal protection guidelines every ten years.

6.2.4. Displacement and Rehabilitation

One of the biggest fallouts of climate change in Kerala is the spectre of mass displacement among the state's coastal communities. Large swathes of Kerala's coastline are projected to be submerged due to sea level rise (SLR) in the coming decades, and there is a palpable fear among the communities that their traditional way of life would be lost forever. Perhaps more worrying than a potential displacement sometime in the future, is the pattern of displacement that is currently happening across Kerala. Households across Kerala living along eroding coastlines have been shifting away from their traditional homesteads to escape from the vagaries of nature. In many cases, the displaced households have nowhere to go, and end up moving to the houses of their relatives.

One of the major problems faced by Kerala's coastal communities is landlessness. While the Kerala Land Reforms Act (1963) and its subsequent amendments stipulate that a *Kudikidappukaran* in the state is entitled to possess 10, 5, or 3 cents of land if they live in a Gram Panchayat, Municipality, and Municipal Corporation, respectively, this stipulation is often not met in the coastal belt. The *Kudikidappukaran* in the KLR Act refers to an individuals who has "*neither a homestead nor any land exceeding in extent three cents in any city or major municipality or five cents in any other municipality or ten cents in any panchayat area or township, in possession either as owner or as tenant, on which he could erect a homestead*" (GoK, 1963).

The land reforms were a seminal moment that helped end feudalism in Kerala's rural sector, liberating the erstwhile agrarian communities from the clutches of their masters. However, coastal communities were somehow not covered under the ambit of the reforms, possibly due to the fact that coastal lands were considered common property by the communities, and the concept of private property barely existed amongst them. The lack of even a minimum entitlement has meant that the landless fisherfolk have nowhere to go other than houses of relatives, or Government-sponsored relief camps.

6.2.4.1. The Punargaeham Project

The Government of Kerala initiated the Punargaeham housing project to rehabilitate vulnerable fisherfolk living 50 meters of the HTL across the state. The project seeks to relocate the communities to safer housing structures further away from the coastline, either by providing them with apartments, or giving them a provision to construct a new house. The initial document for the project had identified 18,685 households who would need to be rehabilitated statewide, with a total of Rs. 2,450 Cr earmarked for the activities. A total of 92 apartment complexes were planned to be constructed to rehabilitate the communities. In the case of households who did not want to move into a flat, the Punargaeham project earmarks an amount of Rs. 10,00,000 for purchase of land and construction of a new house. Of this, 60 per cent is given for purchase of land up to 3 cents, inclusive of taxes and stamp duty. The remaining 40 per cent is released in three phases depending on the completion status of the house.

During the fieldwork, massive disgruntlement was observed among the fisherfolk across Kerala regarding the Punargaeham scheme. The main gripe was the fact that the scheme requires the fisherfolk to identify and purchase a new plot of land. In many parts of Kerala, land prices are at a premium, and the fisherfolk complained throughout that even if they were to move away from their traditional homesteads, finding even two or three cents of land for a figure of Rs 600,000 was a herculean task. Several households also expressed dismay that Rs 400,000 was a paltry sum to construct a decent house.

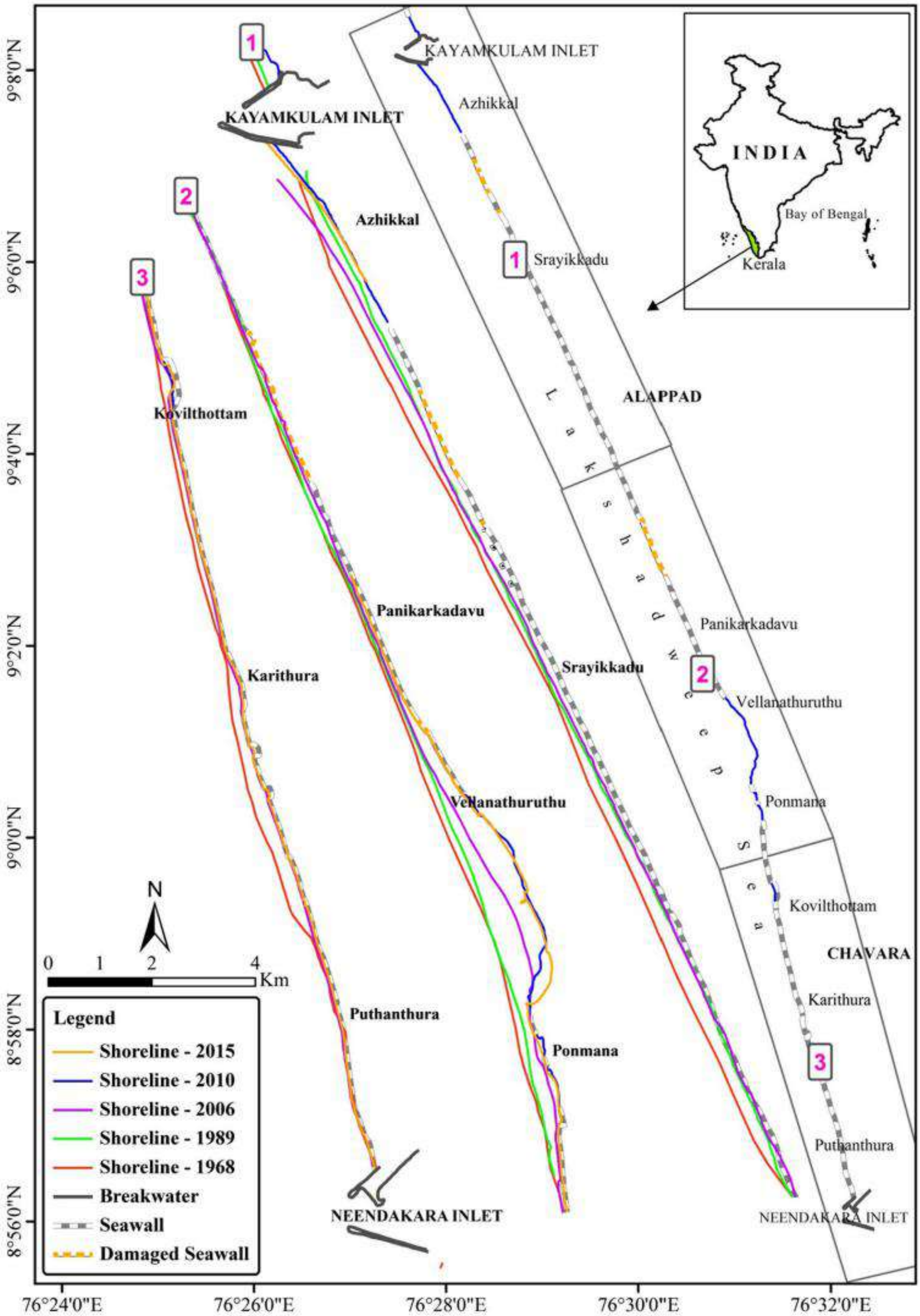
The poor experience of households who had shifted to Government-provided flats was also a major turn-off for prospective tenants. A major problem faced by fisherfolk who shifted to flats was finding a place to store their nets, vessels, and other fishing equipment, which were normally stored within the family's homestead. Flats, due to their inherently small footprint, do not allow for the safe storage of the vital fishing equipment. Even more frustrating for the community was the thought that their connection to sea would be severed by moving into a flat. Of course, in locations where there were no other options, the communities have moved into these apartments, but the experiences have been very mixed.

In many parts of Kerala, the community members were willing to relocate to locations further inland if they were given a better rehabilitation package, including land and funding to just construct the house. Several households expressed a view that they were unwilling to shift because they would inevitably be locked into a debt trap constructing a new house. The bureaucratic processes associated with the scheme were also quite confusing for several fisherfolk, who wanted a more streamlined and flexible approach to rehabilitation. The uniform compensation of Rs 10,00,000 was deemed inadequate, especially in urban areas.

6.2.4.2. The Alappad Context

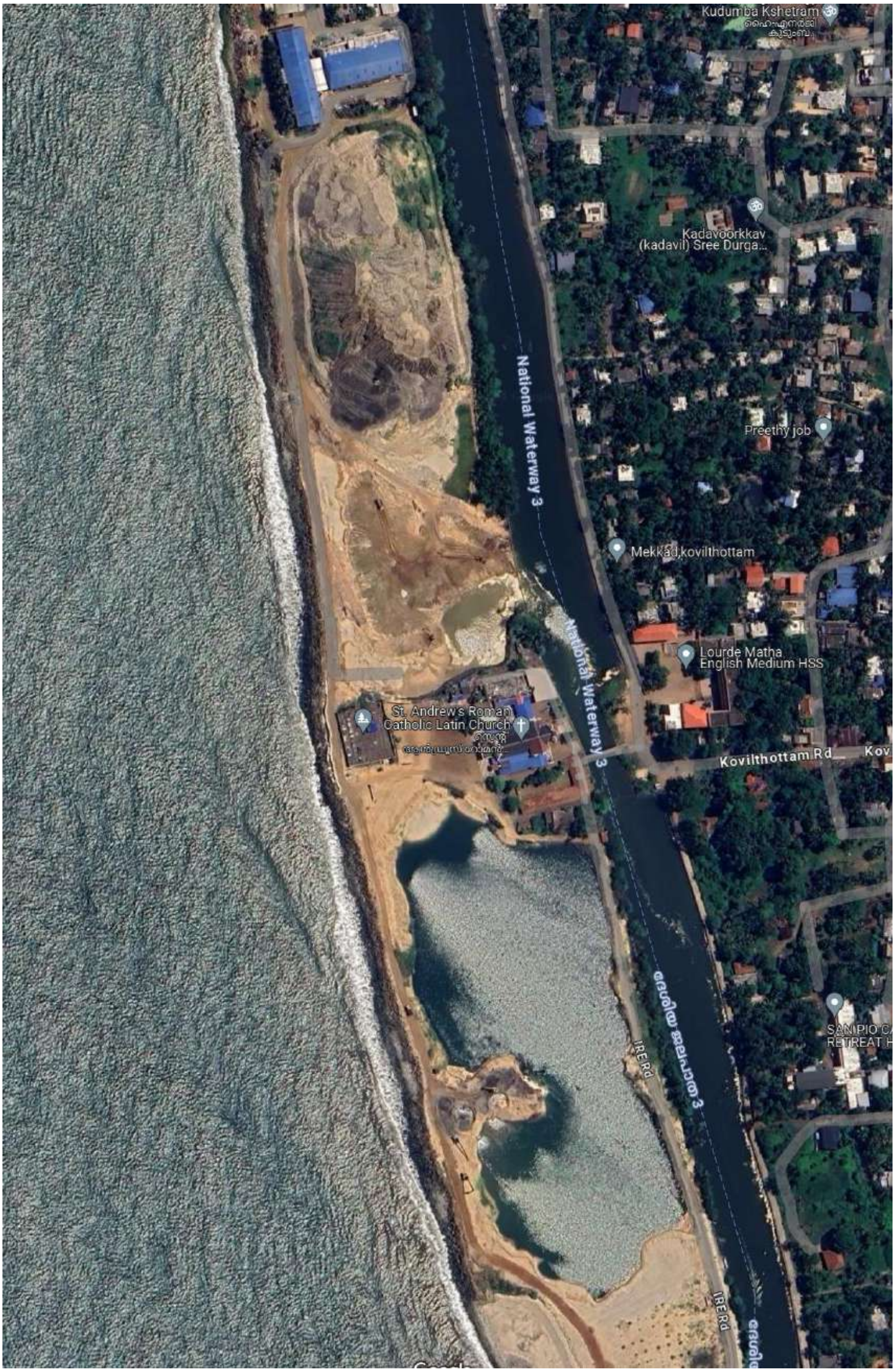
One unique case that must be examined in the context of displacement and rehabilitation is the situation along the stretch from Neendakara in Kollam to Purakad in Alappuzha, which are rich in mineral sand. Two PSUs – the Indian Rare Earths Limited and Kerala Metals and Minerals Limited, have been mining the mineral sand in three panchayats of Kollam for over thirty years, and the indiscriminate mining has led to large-scale loss of land to the sea and forced displacement of the local fishing communities.

Figure 101: Long-term shoreline change in the Neendakara-Azhikkal sector



Source: Prasad et al (2016)

Figure 102: Satellite view of IREL mining site at Kovilthottam, Chavara



Source: Google Earth

During the fieldwork, the team faced severe resistance from the officials working for IREL and KMML when trying to document the status of the shoreline and the coastal protection measures. The team was threatened with legal action by the officials of the two PSUs and was literally chased out of the mining zone by the officials at Vellanathuruthu. A photograph of the aftereffects of sand mining on the beach at Kovilthottam was captured by sneaking past the prying eyes of the IREL officials. The coastal protection measures in the stretch from Chavara to Alappad were grossly inadequate, with heavily slumped and eroded seawalls doing nothing to prevent waves from washing away the sediment. Large-scale sand mining in Chavara, close to the IREL's office, has created a huge body of water on the beach, reminiscent of granite quarries. The location also had a huge mound of mineral sand next to it.

Photograph 10: Aftereffects of mineral sand mining at Kovilthottam Beach, Chavara Panchayat

Source: Primary Data

Research has shown that the mining activities of IREL and KMML are directly responsible for the erosion in Chavara, Panmana, and Alappad panchayats of Kollam (Parvathy et al 2023, Noujas and Thomas, 2015, Prasad et al 2016, Selvan et al 2018, Satish and Geetha, 2021, Prasad et al 2020). During the field visits, coastal communities in Neendakara, Arattupuzha, Thrikunnapuzha, and Purakad panchayats revealed that both PSUs had approached them with compensation packages to evict the region and allow mineral sand mining. Popular resistance, however, was observed to be quite strong in these panchayats, having witnessed the situation in Chavara, Panmana, and Alappad. Hundreds of families have been uprooted entirely from these panchayats, moving to other areas of the district and often losing their connections with the larger fishing community. With Alappad panchayat shrinking from an area of around 89 km^2 in the late 1980s to hardly 9 km^2 today, it is quite likely that more fishing households will be forcibly displaced from their ancestral lands.

6.2.4.3. Policy Suggestions for Rehabilitation

Kerala's coastal communities have no faith left in the Government and its machinery, and the feeling was quite evident during the fieldwork, where they absolutely refused to cooperate with the team if there was even a hint of a connection between the researchers and the State Government. Building back trust with the community is the first and foremost step to be taken by the Government if it has to make any progress in the rehabilitation of coastal communities who have either been displaced or are at risk of displacement. Some of the suggested policy measures in this context include:

- Bringing Kerala's coastal communities under the ambit of the KLR Act and provide each household with sufficient land at distances which are not immediately threatened by coastal erosion. The land can be redistributed from poṛambōke land owned by the Department of Fisheries or other Government agencies/stakeholders or can be acquired by the state from other private parties.

It is critical that the land isn't located too far from the sea that it would disrupt the traditional fishing activities.

- A total overhaul and restructuring of the Punargaeham scheme, where land is provided to the households free of cost by the state, and funding is provided to construct only a house. The current package, where a uniform amount of Rs 10,00,000 is given to all households irrespective of their geographic location, does little to assuage public dissent, and is dubious given the wide variations in land prices between different parts of the State.
- It is unrealistic to assume that a household living in Fort Kochi, Gotheeswaram, or Poonthura, for instance, will be able to purchase 2-3 cents of land near their ancestral homesteads for a meagre sum of Rs. 600,000. Even in rural areas, land prices are quite high, and this sum was termed as grossly inadequate by more respondents in the field. There were even individuals who felt that the Government was mocking the community, and some who felt that the Punargaeham scheme is only a half-hearted exercise by the State, with no genuine interest in rehabilitating the fisherfolk in a just and equitable manner. These factors led to the massive distrust with the State machinery and disgruntlement with Government schemes, which has been captured by the present study.
- The bureaucratic process associated with Punargaeham can be considered for greater streamlining to ensure that families are able to construct the houses much quicker without being caught in red tape.
- Introduction of a variable compensation amount, with a floor of possibly Rs. 10,00,000 and a ceiling to be fixed based on the prevailing cost of house construction in Kerala. It is rather unrealistic to expect that house construction costs would remain constant in the future, and therefore the compensation amount would have to be revised upwards from time to time.
- Stricter enforcement or the CZR guidelines to prevent large-scale constructions and redevelopment of coastal infrastructure in sensitive areas. These activities

could include even projects like the coastal highway, whose alignment in many districts passes through heavily eroding coasts with no protection measures in place.

- Putting an immediate stop to the mineral sand mining along Kollam and Alappuzha districts to ensure that whatever remains of the coastline remains in the present condition.
- One of the most striking examples of this can be seen in Vallikkunnu in Malappuram district, where the Tipu Sultan road, an arterial road running from Kodungallur to Kozhikode, has been washed away by tidal floods and cyclones. Houses in the area have also been severely damaged and local communities have been displaced. Despite the visible trail of destruction in the region, the PWD has not changed the alignment of the coastal highway, with the alignment markers prominently visible on the eroding beach.

6.3. Final Words

Coastal communities across Kerala are one of the worst social groups affected by climate change today, and they run the risk of being fully displaced in the future due to sea level rise and natural disasters. It observed during the study that Government initiatives to improve the lives and livelihoods of the fisherfolk have often failed to meet expectations, and a deep sense of injustice prevails amongst the communities. There is deep distrust between the communities and the State Government, and addressing this issue is fundamental to solving every other issue faced by them.

A multi-pronged, comprehensive strategy is required to ensure that Kerala's coastal communities are brought within the fold of the state's mainstream, and their concerns addressed in today's scenario, which promises to worsen as climate change wreaks havoc on natural systems. There needs to be a concerted effort to improve the educational levels and skill levels of the community to help them diversify their livelihoods and survive in these uncertain times. In cases where the community is displaced from their traditional homesteads, adequate compensation packages have to be provided by the State so that the people cooperate with the efforts.

Equally important are the steps to be taken by the Irrigation Department and other stakeholders in ensuring coastal protection to shift from hard to soft solutions across the state to safeguard the remaining coastline. A clear absence of long-term strategies has hurt Kerala’s coastline significantly, with almost 67% of the coast not having natural beaches due to the presence of seawalls. Human activities that exacerbate the effects of natural disasters need to be curbed an strict regulations enforced so that the state’s fisherfolk are safeguarded from the vagaries of nature.

One of the biggest problems reported by the community members across Kerala was a feeling that the political leadership of the state, cutting across party lines, was apathetic towards their cause. The political leadership of the state’s parties also need to take an active role in rebuilding the trust that was lost, so that amicable solutions can be found to address the problems at hand.

Form 10

Parts C and D

Accomplishments of the Project and Financial Position

Part C: Achievements of the Project

I. List of Research Publications:

Sl. No.	Authors	Title of Paper	Name of the Journal	DOI No.	Year	IF of the Journal

No articles in peer-reviewed journals have been published so far, although three papers are being worked on at the moment.

II. Seminar/Conferences attended:

Throughout the tenure of the fellowship at the Department of Atmospheric Sciences, Cochin University of Science and Technology, the fellow presented papers at three conferences, certificates of which are given in Appendix – V.

- **Hazard Risk and Vulnerability to Climate Change among Coastal Communities on the Southwestern Indian Coast: The Case of the State of Kerala**, (with Nivedya V S and Arya C M) at the **International Conference on Climate Risk, Vulnerability and Resilience Building** organised by UNESCO at the UNESCO Headquarters in Paris from 19th – 21st April 2023.

- **Determinants of Female Labour Force Participation among Potter Communities in Kerala**, (with Sudev P Sukumaran, Gayatri Munappy and S Harikumar) at the **63rd Labour Economics Conference** organised by the Indian Society of Labour Economics at Rajiv Gandhi University, Itanagar from 1st – 3rd March 2023.

- **Assessing the Vulnerability of Traditional Fisherfolk to Climate Change in Six Coastal Villages of Central Kerala**, (with Nivedya V S and Arya C M) at the **3rd International Conclave on Globalizing Indian Thought** organised by Indian Institute of Management, Kozhikode from 1st – 3rd December 2022.

III. Books/Chapter published:

- **Aravindh Panikkaveettil, Nivedya V S and Arya C M (2024).** 'Hazard Risk and Vulnerability to Climate Change among Coastal Communities on the Southwestern Indian Coast: The Case of the State of Kerala'. Accepted by UNESCO for publication in a forthcoming edited volume.

IV. Manpower Trained as part of the Project:

Training was given to students of Department of Applied Economics, CUSAT, Christ College, Irinjalakuda, and other field investigators in data collection using Kobo Toolbox.

V. Innovations/Technology Developed, if any:

No new innovations or technologies were developed as part of the project.

VI. Patents Filed, if any:

No patents were filed as part of the project.

VII. Awards received as part of the Project:

No awards were received as part of the project.

VIII. Social Relevance and Tangible Output of the Project:

The project has significant social relevance since it is the first of its kind to assess the vulnerability of coastal communities in the context of climate change. In the projected scenario where natural disasters are likely to increase rapidly, it is pivotal that the vulnerabilities and adaptive capacities of fisherfolk in the face of hazards be analysed. The tangible output from the project is a set of policy guidelines to (i) improve the condition of Kerala's coastal communities; (ii) review the existing coastal protection measures in the state; and (iii) make policy suggestions to improve existing coastal protection measures.

IX. Commercialisation Efforts and Details of the Project Output:

No commercialisation angle is applicable to the current project.

X. Summary of the Work Done Highlighting the Outcome:

The current project has sought to quantify the livelihood vulnerability of Kerala's coastal communities towards climate change by adopting the three-axis vulnerability framework prescribed in the IPCC AR4. The three axes are exposure, sensitivity, and adaptive capacity, each with several subcomponents. The project required an extensive fieldwork throughout Kerala, covering 1271 households across 52 fishing villages located all across the nine coastal districts of the state. The fieldwork was undertaken between January and October 2023, covering the districts from Thrissur to Thiruvananthapuram in the first leg, and from Malappuram to Kasaragod in the second leg.

The study highlights the poverty and material deprivation faced by Kerala's fishing communities, as well as their poor levels of educational attainment and occupational mobility. The study also finds varying levels of income inequality across the nine districts, with Malappuram having the highest income inequality and Kasaragod the lowest. In terms of the vulnerability analysis, the study calculated two indices – the Livelihood Vulnerability Index and Climate Change Vulnerability Index. Both the analyses showed that Thiruvananthapuram had the most vulnerable fishing population in Kerala, followed by Malappuram and Thrissur.

The primary outcome of the study was to generate a set of policies that reviewed the status of Kerala's coastal communities, and the existing coastal management practices in the state. The project has undertaken a thorough analysis of the livelihood status of the coastal communities, including the impact of climate change on work loss and the determinants of labour force shift from fisheries to other sectors in Kerala. In terms of coastal management practices, the research team travelled across the 593 km of Kerala's coastline, documenting the status of seawalls or other protection measures in each location, and identifying the most vulnerable stretches of the state's coastline. Regression analysis was undertaken based on the fisherfolk's perception of coastal erosion to understand the role of anthropogenic activities in exacerbating the effects of climate change on the coastal areas.

The study puts forth a detailed set of policy guidelines along four themes principal theses – education attainment, livelihood diversification, coastal management practices, and displacement and rehabilitation. The policy suggestions have been drawn up after discussions with stakeholders including community members, NGOs, and external experts.

XI. Scope for Future Work:

The present study only examines a fraction of the problems faced by Kerala's fishing communities. There is significant scope for future research in the domain, focusing on the following areas:

- No proper studies have been undertaken in Kerala to examine the intergenerational occupational mobility among the coastal communities. The present study gives a rough picture of the current situation, but a full-fledged study focusing exclusively on the intergenerational educational and occupational mobility of the communities can be undertaken.
- The current study does not go into significant detail about the situation of every household that has been relocated under the Punargaeham scheme and focused on the experiences of individuals based on a few case studies, and interactions with other community members who were dissuaded by the current situation. A new short-term study can be done to examine in detail the situation of households who have chosen to move to Government-sponsored flats or similar mechanisms.

- Natural disasters and displacement can have a significant impact on the physical and psychological health of the community members affected. An in-depth study can be undertaken to assess the health status of fisherfolk affected by natural disasters, with special emphasis on the problems faced by women, children, and the elderly.
- Women's health can take the priority in another study, with particular focus laid on maternal and reproductive health.
- Studies emphasizing the mental health of the community members, especially those directly affected by natural disasters, can be undertaken to frame policies that can be implemented on the ground by volunteers, NGOs, and social workers to ensure that the community is able to cope with the disaster. The fellow was able to leverage his experience as part of the current project to work with the District Administration in Thiruvananthapuram to formulate a Standard Operating Procedure (SOP) to deal with disaster-induced trauma among coastal communities in the district. Such SOPs can be formulated for the other eight coastal districts as well, especially if they are backed up be actual field data.
- In-depth studies have to be undertaken to assess the coastal protection measures, with a multidisciplinary team spearheading the efforts. A comprehensive review of the state's existing coastal protection measures has to be undertaken as the need of the hour, and appropriate steps taken to safeguard the coastline. The suggestions given in the current report can be used a starting point for this proposed research.

The current report has the potential to act as a springboard for serious research into the problems faced by Kerala's coastal communities going into a heavily uncertain future. It is imperative that policies are formulated to help the communities navigate the troubled waters up ahead, and dedicated research can form the bedrock for effective policymaking.

Part D: Financial Position

No amount was utilized of the allocated contingency amount by the fellow during the tenure of the fellowship at the Department of Atmospheric Sciences, CUSAT. All expenses were borne by the fellow out of the fellowship amount. An amount equivalent to Rs. 50,000/- pertaining to the first year of contingency has been transferred back to the Kerala State Higher Education Council by the Cochin University of Science and Technology.

Total Amount Received	Rs. 0
Expenditure Details	
Books and allied items	Rs. 0
Typing	Rs. 0
Printing	Rs. 0
Stationery	Rs. 0
Postage	Rs. 0
Analysis	Rs. 0
Attending conference/workshop	Rs. 0
Chemical and other consumables	Rs. 0
Travel/field work	Rs. 0
Total expenditure	Rs. 0
Audited statement of expenditure submitted (Y/N)	Yes

Name and Signature with Date

a. ____________________________

(Mentor)

b. ____________________________

(Co-investigator, if any)

c. ____________________________

(Head of the Institution)

Institution Seal

This page is intentionally left blank

Bibliography

Bibliography

A. Satish and G. P, "Assessment of Shoreline Change Detection in Alappad region Kerala using Geospatial Technology," *2021 Fourth International Conference on Electrical, Computer and Communication Technologies (ICECCT)*, Erode, India, 2021, pp. 1-7, doi: 10.1109/ICECCT52121.2021.9616727.

Abraham, A., & Kundapura, S. (2022). Evaluating the long-term trends of the climatic variables over three humid tropical basins in Kerala, India. *Arabian Journal of Geosciences*, *15*(9), 811.

Adger WN, Brooks N, Bentham G, Agnew M, Eriksen S (2004) New indicators of vulnerability and adaptive capacity. Technical Report, 7. Norwich, UK, Tyndall Centre for Climate Change Research.

Adger, W. N. (1999). Social vulnerability to climate change and extremes in coastal Vietnam. *World development*, *27*(2), 249-269.

Adger, W. N., T. P. Hughes, C. Folke, S. Carpenter, and J. Rockström (2005), Social-ecological resilience to coastal disasters, Science, 309: 1036–9

Adger, W. N., Eakin, H., & Winkels, A. (2009). Nested and teleconnected vulnerabilities to environmental change. *Frontiers in Ecology and the Environment*, *7*(3), 150-157.

Adu, D. T., Kuwornu, J. K., Anim-Somuah, H., & Sasaki, N. (2018). Application of livelihood vulnerability index in assessing smallholder maize farming households' vulnerability to climate change in Brong-Ahafo region of Ghana. *Kasetsart journal of social sciences*, *39*(1), 22-32.

Ahsan, M. N., & Warner, J. (2014). The socioeconomic vulnerability index: A pragmatic approach for assessing climate change led risks–A case study in the south-western coastal Bangladesh. *International Journal of Disaster Risk Reduction*, *8*, 32-49.

Alam, E. and E. Collins, 2010, Cyclone disaster vulnerability and response experiences in coastal Bangladesh, Disasters 34(4): 931–54.

Allison, E., Andrew, N. L., & Oliver, J. (2007). Enhancing the resilience of inland fisheries and aquaculture systems to climate change.

Ancy, V. P., & Raju, K. V. (2014). Structural Changes in the Fisheries Sector of Kerala: An Overview. IOSR Journal of Economics and Finance (IOSR_JEF), 5(6), 14-18.

Asfaw, A., Bantider, A., Simane, B., & Hassen, A. (2021). Smallholder farmers' livelihood vulnerability to climate change-induced hazards: agroecology-based comparative analysis in Northcentral Ethiopia (Woleka Sub-basin). *Heliyon*, *7*(4).

Baba, M., Kurian, N. P., Hameed, T. S., Thomas, K. V., & Harish, C. M. (1987). Temporal and spatial variations in wave climate off Kerala, southwest coast of India.

Baba M. and Thomas, K.V. (1987). Performance of a seawall with frontal beach, Proc.`Coastal Sediments 87', American Society of Civil Engineers, New Orleans, pp 1051-1061.

Bahadur, A. V., Ibrahim, M., & Tanner, T. (2013). Characterising resilience: unpacking the concept for tackling climate change and development. Climate and Development, 5(1), 55-65.

Balica, S. F., Douben, N., & Wright, N. G. (2009). Flood vulnerability indices at varying spatial scales. *Water science and Technology*, *60*(10), 2571-2580.

Balica, S., & Wright, N. G. (2009). A network of knowledge on applying an indicator-based methodology for minimizing flood vulnerability. *Hydrological Processes: An International Journal*, *23*(20), 2983-2986.

Balica, S., & Wright, N. G. (2010). Reducing the complexity of the flood vulnerability index. *Environmental hazards*, *9*(4), 321-339.

Black, K. P., Baba, M., Mathew, J., Chandra, S., Singh, S. S., Shankar, R., ... & Greer, R. (2019). Reference Manual on Climate Change Adaptation Guidelines for Coastal Protection and Management in India. *New Delhi, India: Prepared by FCG ANZDEC (New Zealand) for the Global Environment Facility and Asian Development Bank, Volumes I*.

Bonetti J, Klein AHF, Muler M, De Luca CB, Silva GV, Toldo Jr EE, Gonzalez M (2013) Spatial and numerical methodologies on coastal erosion and flooding risk assessment. In: *Coastal Hazards. Chapter 16. Coastal Research Library Series.* (ed Finkl C) pp 423-442. Dordrecht, Springer.

Briguglio L (2003) The Vulnerability index and small island developing states. A Review of Conceptual and Methodological Issues. In: *Paper Prepared for the AIMS Regional Preparatory Meeting on the BPoA+10 Review.* Praia, Cape Verde.

Briguglio L (2004) *Economic Vulnerability and Resilience: Concepts and Measurements*. UNU - WIDER Working Paper 55/2008.

Brooks N (2003) *Vulnerability, risk and adaptation: A conceptual framework*. Working Paper 38. Tyndall Centre for Climate Change Research.

Can, N. D., Tu, V. H., & Hoanh, C. T. (2013). Application of livelihood vulnerability index to assess risks from flood vulnerability and climate variability-A case study in the Mekong Delta of Vietnam. *Journal of Environmental Science and Engineering. A*, *2*(8A), 476.

Chambers, R., Conway, G., & Brighton Institute of Development Studies. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century* (Vol. 296, pp. 1-29). Brighton: Institute of development studies.

Cinner, J. E., Adger, W. N., Allison, E. H., Barnes, M. L., Brown, K., Cohen, P. J., ... & Morrison, T. H. (2018). Building adaptive capacity to climate change in tropical coastal communities. Nature Climate Change, 8(2), 117-123.

CMFRI (2016). Marine Fisheries Census 2016, India.

Cochrane, K. L., Rakotondrazafy, H., Aswani, S., Chaigneau, T., Downey-Breedt, N., Lemahieu, A., ... & Tsimanaoraty, P. M. (2019). Tools to enrich vulnerability assessment and adaptation planning for coastal communities in data-poor regions: application to a case study in Madagascar. Frontiers in Marine Science, 5, 505.

Comte, A. (2021). Recent advances in climate change vulnerability/risk assessments in the fisheries and aquaculture sector.

Cutter SL, Boruff BJ, Shirley WL (2003) Social vulnerability to environmental hazards. *Social Science Quarterly,* 84, 242-261.

Cutter, S. L., Mitchell, J. T., & Scott, M. S. (2000). Revealing the vulnerability of people and places: A case study of Georgetown County, South Carolina. *Annals of the association of American Geographers*, *90*(4), 713-737.

Davoudi, S., 2012, Resilience: A bridging concept or a dead end?, Planning Theory & Practice 13(2): 299–307.

Dekens, J., 2007 Local Knowledge for Disaster Preparedness: A Literature Review, Kathmandu: International Centre for Integrated Mountain Development.

Devika, J. (2017). Surviving in contemporary Kerala: Reflections from recent research in a fisher Village. *Development and Change*, *48*(2), 364-386.

Deshpande, M., Singh, V. K., Ganadhi, M. K., Roxy, M. K., Emmanuel, R., & Kumar, U. (2021). Changing status of tropical cyclones over the north Indian Ocean. *Climate Dynamics*, *57*, 3545-3567.

Dow, K. (1992). Exploring differences in our common future (s): the meaning of vulnerability to global environmental change. *Geoforum*, *23*(3), 417-436.

Dulal, H. B., Brodnig, G., Thakur, H. K., & Green-Onoriose, C. (2010). Do the poor have what they need to adapt to climate change? A case study of Nepal. Local Environment, 15(7), 621-635.

Duriyapong, F., & Nakhapakorn, K. (2011). Coastal vulnerability assessment: a case study of Samut Sakhon coastal zone. *Songklanakarin Journal of Science & Technology*, *33*(4).

Dwarakish, G. S., Vinay, S. A., Natesan, U., Asano, T., Kakinuma, T., Venkataramana, K., ... & Babita, M. K. (2009). Coastal vulnerability assessment of the future sea level rise in Udupi coastal zone of Karnataka state, west coast of India. *Ocean & Coastal Management*, *52*(9), 467-478.

Etwire, P. M., Al-Hassan, R. M., Kuwornu, J. K., & Osei-Owusu, Y. (2013). Application of livelihood vulnerability index in assessing vulnerability to climate change and variability in Northern Ghana. *Journal of Environment and Earth Science*, *3*(2), 157-170.

Folke, C., 2006, Resilience: The emergence of a perspective for social–ecological systems analyses, Global Environmental Change 16(3): 253–67.

Füssel HM, Klein RJT (2006) Climate change vulnerability assessments: An evolution of conceptual thinking. *Climate change,* 75, 301-324.

George, M. K., & Domi, J. (2002). *Residual illiteracy in a coastal village: Poovar Village of Thiruvananthapuram district*. KRPLLD, Centre for Development Studies.

Gornitz VM (1991) Global coastal hazards from future sea level rise. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 89, 379-398.

Greenan, B. J., Shackell, N. L., Ferguson, K., Greyson, P., Cogswell, A., Brickman, D., ... & Saba, V. S. (2019). Climate change vulnerability of American lobster fishing communities in Atlantic Canada. Frontiers in Marine Science, 6, 579.

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global environmental change*, *19*(1), 74-88.

Handmer JW, Dovers S, Downing TE (1999) Societal vulnerability to climate change and variability. *Mitigation and Adaptation Strategies for Global Change,* 4, 267-281.

Hapke, H. M., & Ayyankeril, D. (2018). Gendered livelihoods in the global fish-food economy: a comparative study of three fisherfolk communities in Kerala, India. *Maritime Studies*, *17*(2), 133-143.

Hinkel J (2011) Indicators of vulnerability and adaptive capacity: towards a clarification of the science-policy interface. *Global Environmental Change,* 21, 198-208.

Huynh, P. T., Le, N. D., Le, S. T., & Nguyen, H. X. (2021). Vulnerability of fishery-based livelihoods to climate change in coastal communities in central Vietnam. *Coastal Management*, *49*(3), 275-292.

IPCC, 2007. Fourth Assessment Report. Climate Change 2007: Synthesis Report, <http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf>

Janakeeya Padana Samithi (2023). Out Beaches, Our Sea: Heritage of Fishing Communities, Usufruct of all Citizens.

John, J. (2014). Technological Changes in Marine Fishing and Livelihood Threats of Fisher Folk. *Journal of Studies in Dynamics and Change*, *1*(1), 23-28.

Kelkar-Khambete, A. (2012). Traditional fisherfolk of Kerala—An article about their socio-economic organisation and the special relationship they share with the sea and the environment. *Retrieved May*, *7*, 2020.

Khan, N. A., Gao, Q., Abid, M., & Shah, A. A. (2021). Mapping farmers' vulnerability to climate change and its induced hazards: evidence from the rice-growing zones of Punjab, Pakistan. *Environmental Science and pollution research*, *28*, 4229-4244.

King D (2001) Uses and Limitations of socioeconomic indicators of community vulnerability to natural hazards: data and disasters in northern Australia. *Natural Hazards,* 24, 147-156.

Kleinosky LR, Yarnal B, Fisher A (2007) Vulnerability of Hampton Roads, Virginia to storm-surge flooding and sea-level rise. *Natural Hazards,* 40, 43-70.

Kurien, J. (1995). The Kerala model: Its central tendency and the outlier. *Social Scientist*, 70-90.

Lemos, M. C., 2007, Drought, Governance and Adaptive Capacity in North East Brazil: A Case Study of Ceará, UNDP Human Development Report 2007/2008 Occasional Paper, http://hdr.undp.org/sites/default/files/lemos_maria_carmen.pdf

Maher, A. (2021). Troubles of the coast: Industrialization, climate change, marginality, and collective action among fishing communities in Kerala, India. *The Yale Undergraduate Research Journal*, *2*(1), 19.

Mclaughlin S, Cooper JAG (2010) A multi-scale coastal vulnerability index: a tool for coastal managers? *Environmental Hazards,* 9, 233-248

McLaughlin, S., McKenna, J., & Cooper, J. A. G. (2002). Socio-economic data in coastal vulnerability indices: constraints and opportunities. *Journal of coastal research*, (36), 487-497.

Ministry of Environment and Forests (2011). Coastal Regulation Zone Notification 2011, Gazette of India, Extraordinary, Part-II, Section 3, Sub-section (ii), 6th January, 2011, 28p

Mohapatra, M. (2015). Cyclone hazard proneness of districts of India. Journal of Earth System Science, 124(3), 515-526.

Moss RH, Brenkert AL, Malone EL (2001) *Vulnerability to climate change: a quantitative approach prepared for the US Department of Energy*. Technical Report PNNL-SA-33642.

Murakami, H., Sugi, M., & Kitoh, A. (2013). Future changes in tropical cyclone activity in the North Indian Ocean projected by high-resolution MRI-AGCMs. Climate Dynamics, 40(7-8), 1949-1968.

Murakami, H., Vecchi, G. A., & Underwood, S. (2017). Increasing frequency of extremely severe cyclonic storms over the Arabian Sea. Nature Climate Change, 7(12), 885-889.

National Centre for Coastal Research (2022). National Shoreline Assessment System: National Assessment of Shoreline Changes along Indian Coast

Nelson, D. R., 2011, Adaptation and resilience: Responding to a changing climate, Wiley Interdisciplinary Reviews-Climate Change 2(1): 113–20.

Nelson, D. R., W. N. Adger, and K. Brown, 2007, Adaptation to environmental change: Contributions of a resilience framework, Annual Review of Environment and Resources 32: 395–420.

Nguyen, C. V., Horne, R., Fien, J., & Cheong, F. (2017). Assessment of social vulnerability to climate change at the local scale: development and application of a Social Vulnerability Index. *Climatic change*, *143*, 355-370.

Nicholls, R. J., Wong, P. P., Burkett, V., Woodroffe, C. D., & Hay, J. (2008). Climate change and coastal vulnerability assessment: scenarios for integrated assessment. Sustainability Science, 3(1), 89-102.

Nor Diana, M. I., Chamburi, S., Mohd. Raihan, T., & Nurul Ashikin, A. (2019, April). Assessing local vulnerability to climate change by using Livelihood Vulnerability Index: Case study in Pahang region, Malaysia. In *IOP Conference Series: Materials Science and Engineering* (Vol. 506, p. 012059). IOP Publishing.

Noujas, V., & Thomas, K. V. (2015). Erosion hotspots along southwest coast of India. Aquatic procedia, 4, 548-555.

O'Brien P, Mileti D (1992) Citizen participation in emergency response following the Loma Prieta Earthquake. *International Journal of Mass Emergencies and Disasters,* 10, 71-89

O'Brien, K., R. Leichenko, U. Kellar, H. Venema, G. Aandahl, H. Thompkins, A. Javed, S. Bhadwal, S. Barg, L. Nygaard and J. West, 2004, Mapping vulnerability to multiple stressors: Climate change and globalization in India, Global Environmental Change 14: 303–13.

Oo, A. T., Van Huylenbroeck, G., & Speelman, S. (2018). Assessment of climate change vulnerability of farm households in Pyapon District, a delta region in Myanmar. *International Journal of Disaster Risk Reduction*, *28*, 10-21.

Oommen, M. A., & Shyjan, D. (2014). *Local Governments and the Inclusion of the Excluded: Towards a Strategic Methodology with Empirical Illustration* (No. id: 6338).

Paavola, J. (2008). Livelihoods, vulnerability and adaptation to climate change in Morogoro, Tanzania. Environmental Science & Policy, 11(7), 642-654.

Pandey, R., & Jha, S. (2012). Climate vulnerability index-measure of climate change vulnerability to communities: a case of rural Lower Himalaya, India. Mitigation and Adaptation Strategies for Global Change, 17(5), 487-506.

Parappurathu, S., George, G., Narayanakumar, R., Aswathy, N., Ramachandran, C., & Gopalakrishnan, A. (2017). Priorities and strategies to boost incomes of marine fisher folk in India. *Agricultural Economics Research Review*, *30*(conf), 205-216.

Parvathy, M. M., Balu, R., & Dwarakish, G. S. (2023). Time-series analysis of erosion issues on a human-intervened coast–A case study of the south-west coast of India. *Ocean & Coastal Management*, *237*, 106529.

Peduzzi P, Dao H, Herold C, Mouton F (2003) *Feasibility Study Report - on Global Risk and Vulnerability Index -Trends per Year* (GRAVITY). Phase III: Drought analysis. Geneva, United Nations Development Programme Emergency Response Division UNDP/ERD.

Peduzzi P, Dao H, Herold C, Rochette D, Sanahuja H (2001) *Feasibility Study Report - on Global Risk and Vulnerability Index -Trends per Year* (GRAVITY). Geneva, United Nations Development Programme Emergency Response Division UNDP/ERD.

Pelling, M. and C. High, 2005, Understanding adaptation: What can social capital offer assessments of adaptive capacity?, Global Environmental Change 15: pp. 308–19.

Pradeep, J., Shaji, E., Chandran, S., Ajas, H., Chandra, S. V., Dev, S. D., & Babu, D. S. (2022). Assessment of coastal variations due to climate change using remote sensing and machine learning techniques: A case study from west coast of India. *Estuarine, Coastal and Shelf Science*, *275*, 107968.

Prasad, G., Rajesh, R., & Arun, K. (2020). Land use pattern as an indicator of sustainability: a case study. In *10th Annual International Conference on Industrial Engineering and Operations Management. IEOM Society International. ISSN* (pp. 2169-8767).

Prasad, R., Nair, L. S., Kurian, N. P., & Prakash, T. N. (2020). Shoreline evolution along a placer mining beach of south-west coast of India. *Journal of Coastal Research*, *89*(SI), 150-157.

Prowse, M., & Scott, L. (2008). Assets and adaptation: an emerging debate. *IDS bulletin*, *39*(4).

Punya, P., Kripa, V., Padua, S., Mohamed, K. S., Narayanakumar, R., & Nameer, P. O. (2021). Socio-economic impact of cyclone Ockhi on fishers along the Kerala and Tamil Nadu coasts, India. Journal of the Marine Biological Association of India, 63(1), 89-96.

Rajeeve, B., & Rajasenan, D. (2015). *SHGs and Cooperatives in the Fishing Sector: An Inclusive Development Option for the Fisher folk of Kerala* (Doctoral dissertation, Cochin University of Science and Technology).

Ramachandran, B. B. (2021). *An Anthropological Study of Marine Fishermen in Kerala: Anxieties, Compromises and Survivals*. Cambridge Scholars Publishing.

Sabu, M., & Shaijumon, C. S. (2014). Socio-economic impact of information and communication technology: A case study of Kerala marine fisheries sector. *International Journal of Information Dissemination and Technology*, *4*(2), 124-129.

Santha, S. D. (2015). Adaptation to coastal hazards: the livelihood struggles of a fishing community in Kerala, India. *Disasters*, *39*(1), 69-85.

Sathiadhas, R. (2006). Socio Economic Scenario of Marine Fisheries in Kerala-Status and Scope for Improvement.

Sathiadhas, R. (2009). Inter-sectoral Disparity and Marginalization in Marine Fisheries in India. *Asian Fisheries Science*, *22*(2), 773-786.

Schröter D (2004a) And the ATEAM in consortium 2004: *Global change vulnerability - assessing the European human-environment system*. Potsdam Institute for Climate Impact Research.

Schröter D, *et al.* (2004b) *Advanced Terrestrial Ecosystem Analysis and Modelling*- ATEAM Final report (PIK).

Selvan, S. C., Kankara, R. S., Prabhu, K., & Rajan, B. (2020). Shoreline change along Kerala, south-west coast of India, using geo-spatial techniques and field measurement. Natural Hazards, 100(1), 17-38.

Shah, K. U., Dulal, H. B., Johnson, C., & Baptiste, A. (2013). Understanding livelihood vulnerability to climate change: Applying the livelihood vulnerability index in Trinidad and Tobago. *Geoforum*, *47*, 125-137.

Shyam, S. S., Antony, B., & Geetha, R. (2011). Women empowerment and fisheries sector in Kerala.

Shyam, S. S., Joseph, L., Elizabeth James, H., Shinu, A. M., Athira, N. R., & Rosey Xavier, S. (2019). Assessing the Alternative Livelihood Options for Climate Change Vulnerable Coastal Fishing Villages in Kerala, India. *International Journal of Environment and Climate Change (Previously known as British Journal of Environment & Climate Change)*, *9*(4), 204-216.

Shyam, S. S., Kripa, V., Zacharia, P. U., Shridhar, N., & Ambrose, T. V. (2014). Climate change awareness, preparedness, adaptation and mitigation strategies: fisherfolks perception in coastal Kerala. *Journal of Aquatic Biology and Fisheries*, *2*, 670-681.

Smit, B. and J. Wandel, 2006, Adaptation, adaptive capacity and vulnerability, Global Environmental Change 16(3): 282–92.

Soares MB, Gagnon AS, Doherty RM (2012) Conceptual elements of climate change vulnerability assessments: a review. *International Journal of Climate Change Strategies and Management,* 4, 6-35.

Sreekala, S. P., Baba, M., & Muralikrishna, M. (1998). Shoreline changes of Kerala coast using IRS data and aerial photographs.

Srinivasan, J., & Burrell, J. (2013, December). Revisiting the fishers of Kerala, India. In *Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers-Volume 1* (pp. 56-66).

Sullivan C (2002) Calculating a Water Poverty Index. *World Development,* 30, 1195-1210.

Sullivan CA, Meigh JR, Giacomello AM *et al.* (2003) The Water Poverty Index: development and application at the community scale. *Natural Resources Forum,* 27, 189-199.

Sundar, V., Sannasiraj, S. A., Murali, K., & Singaravelu, V. (2022). Impact of coastal structure on shorelines along the southeast and southwest coasts of india. *ISH Journal of Hydraulic Engineering*, *29*(5), 592–610.

Thankappan, N., Varangalil, N., Kachapally Varghese, T., & Njaliplackil Philipose, K. (2018). Coastal morphology and beach stability along Thiruvananthapuram, south-west coast of India. *Natural Hazards*, *90*, 1177-1199.

Thiault, L., Marshall, P., Gelcich, S., Collin, A., Chlous, F., & Claudet, J. (2018). Mapping social–ecological vulnerability to inform local decision making. Conservation biology, 32(2), 447-456.

Torresan S, Critto A, Dalla Valle M, Harvey N, Marcomini A (2008) Assessing coastal vulnerability to climate change: comparing segmentation at global and regional scales. *Sustainability Science,* 3, 45-65.

Tschakert, P., & Dietrich, K. A. (2010). Anticipatory learning for climate change adaptation and resilience. Ecology and society, 15(2).

UNFCCC (2005) *Compendium on Methods and Tools to Evaluate Impacts of, and Vulnerability and Adaptation to, Climate Change*. Bonn, United Nations Framework Convention on Climate Change: UNFCCC

Vipinkumar, V. P., Shyam, S. S., Pushkaran, K. N., Harshan, N. K., Salini, K. P., & Sunil, P. V. (2014). Role of Self Help Groups on coastal indebtedness in marine fisheries sector–a case study from Kerala, south India. *Indian Journal of Fisheries*, *61*(1), 36-41.

Vogel, C., I. Koch, and K. van Zyl, 2010, "A persistent truth"—reflections on drought risk management in Southern Africa, Weather, Climate, and Society 2(1): 9–22.

Wisner, B., P. Blaikie, T. Cannon, and I. Davis, 2004, At Risk: Natural Hazards, People's Vulnerability, and Disasters, New York: Routledge.

Yesodhara, E. P., Kokkal, K., and Harinarayan, P. (Ed.). (2007). State of Environment Report of Kerala 2007-Volume II: Natural Hazards. Thiruvananthapuram: Kerala State Council for Science, Technology and Environment, Government of Kerala.

Yohe G, Tol RSJ (2002) Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity. *Global Environmental Change,* 12, 25-40.

Zhang, Q., Zhao, X., & Tang, H. (2019). Vulnerability of communities to climate change: Application of the livelihood vulnerability index to an environmentally sensitive region of China. *Climate and Development*, *11*(6), 525-542.