SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACT OF CLIMATE CHANGE ON FISHERIES IN TRIVANDRUM DISTRICT

MSW DISASTER MANAGEMENT

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ABSTRACT

Climate change poses a significant threat to coastal fishing communities, whose livelihoods remain heavily dependent on marine resources sensitive to environmental variability. This study examines the socioeconomic and environmental impacts of climate change on fisheries in Trivandrum district, Kerala, with a focus on the perceptions, livelihood conditions, and adaptive capacity of active fishers. Adopting a quantitative research approach with a cross-sectional design, the study was conducted among fishers in selected coastal communities of Trivandrum district. A sample of 70 respondents was selected using stratified random sampling to ensure representation across different fishing occupations and localities. Primary data were collected through the survey method using a structured questionnaire covering demographic and socioeconomic profiles, occupational dependence on fisheries, perceptions of climate change (changes in rainfall, temperature, and sea-level rise), livelihood indicators (income, employment, catch variability, asset ownership), and household coping capacity. The questionnaire was refined following a pilot study conducted among a small subset of respondents.

The study is expected to reveal the extent to which fishers perceive and experience climate-related changes, the consequent effects on fishing income and livelihood security, and the coping strategies adopted by fishing households. Findings from this study aim to contribute to a better understanding of climate vulnerability in coastal fishing communities and to inform policy interventions aimed at strengthening the resilience and adaptive capacity of fisheries-dependent populations in Trivandrum district.

Keywords: Climate Change, Coastal Fisheries, Livelihood, Trivandrum district, Perception

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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Climate change has emerged as one of the most pressing global challenges of the twenty-first century, affecting ecosystems, economies, and human societies across the world. It refers to long-term alterations in temperature, precipitation, sea level, and weather patterns resulting primarily from increased greenhouse gas emissions caused by human activities such as fossil fuel combustion, deforestation, industrialization, and unsustainable land-use practices. Scientific evidence indicates that the Earth's climate system has undergone unprecedented changes over the past century, with rising global temperatures, melting glaciers, ocean warming, sea-level rise, and increasing occurrences of extreme weather events including cyclones, floods, droughts, and heatwaves. These changes pose significant risks to biodiversity, food security, water resources, public health, and the livelihoods of millions of people, particularly those who depend directly on natural resources for their survival (Intergovernmental Panel on Climate Change (IPCC, 2023).

The consequences of climate change are not uniformly distributed across regions and populations. Developing countries are disproportionately affected because of their greater dependence on climate-sensitive sectors such as agriculture, fisheries, and forestry, coupled with limited financial, technological, and institutional capacity to adapt. Coastal regions are among the most vulnerable areas due to their exposure to sea-level rise, coastal erosion, saline water intrusion, storm surges, and changing oceanographic conditions. These environmental changes threaten the lives and livelihoods of coastal communities, especially small-scale fishers who rely heavily on marine resources for food, employment, and income generation. Consequently, climate change has become not only an environmental concern but also a significant social, economic, and developmental challenge that requires integrated and sustainable policy responses (FAO, 2022).

The relationship between climate change and sustainable development has gained increasing recognition in global environmental governance. Climate change affects nearly every dimension of sustainable development by influencing poverty, food security, health, education, employment, gender equality, and environmental conservation. The 2030 Agenda for Sustainable Development identifies climate action as one of its central priorities through Sustainable Development Goal (SDG) 13, while recognizing its close

interconnections with other goals, including SDG 1 (N Poverty), SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), SDG 14 (Life Below Water), and SDG 15 (Life on Land). Achieving sustainable development, therefore, depends upon strengthening climate resilience, reducing vulnerability, and promoting adaptive strategies that safeguard both ecosystems and human well-being. Climate-resilient development emphasizes balancing economic growth with environmental protection and social equity to ensure that present developmental needs are met without compromising the ability of future generations to meet their own needs (United Nations, 2015).

Among the sectors most vulnerable to climate change, fisheries occupy a unique position because they depend directly on the health and productivity of aquatic ecosystems. Marine fisheries provide food, nutrition, employment, and income to hundreds of millions of people worldwide. However, increasing sea surface temperatures, ocean acidification, declining dissolved oxygen levels, changing ocean currents, and shifts in marine biodiversity have significantly altered fish habitats, migration routes, breeding grounds, and species distribution. These environmental changes reduce fish productivity, increase uncertainty in fish catches, and create serious challenges for fishers who rely on predictable marine conditions for their livelihoods. Small-scale fishing communities are particularly vulnerable because they possess limited assets, depend heavily on daily fishing income, and often lack access to advanced technologies and financial resources needed for climate adaptation (Barange et al., 2018).

Climate change also intensifies the occurrence and severity of coastal hazards. Rising sea levels contribute to shoreline retreat and coastal erosion, while stronger cyclones and storm surges damage fishing infrastructure, harbours, boats, nets, fish landing centres, and coastal settlements. Saltwater intrusion into freshwater sources affects drinking water availability and agricultural productivity in coastal regions. In addition, increasing sea temperatures and changing ocean chemistry threaten coral reefs, mangroves, seagrass beds, and estuarine ecosystems that serve as critical breeding and nursery grounds for numerous commercially important fish species. The degradation of these ecosystems ultimately affects marine biodiversity and reduces the ecological resilience of coastal environments, thereby

undermining the long-term sustainability of fisheries (United Nations Environment Programme (IPCC, 2023).

Coastal communities experience the impacts of climate change not only through environmental degradation but also through socio-economic disruptions. Declining fish catches and unpredictable weather reduce household income, increase indebtedness, and create employment insecurity among fishing families. Extreme weather events frequently interrupt fishing activities, resulting in income losses that affect food consumption, children's education, healthcare access, and overall quality of life. Women engaged in fish processing, drying, marketing, and value addition are equally affected because fluctuations in fish landings reduce employment opportunities and household earnings. Consequently, climate change deepens existing social inequalities and increases the vulnerability of already marginalized fishing communities (Bennett et al., 2021).

The increasing frequency of climate-induced disasters has highlighted the importance of resilience and adaptation within coastal communities. Adaptation refers to adjustments in natural or human systems that reduce the adverse effects of climate change or enable communities to take advantage of emerging opportunities. Fishing communities across the world have adopted various adaptation strategies such as livelihood diversification, modification of fishing practices, adoption of improved fishing technologies, participation in early warning systems, ecosystem restoration, community-based resource management, and capacity-building initiatives. Nevertheless, the effectiveness of these measures largely depends on institutional support, policy interventions, access to financial resources, education, and community participation. Building resilience therefore requires coordinated efforts involving governments, scientific institutions, civil society organizations, and local communities to ensure the sustainability of fisheries while protecting the socio-economic well-being of coastal populations (FAO, 2022).

Understanding the multidimensional relationship between climate change and fisheries has become increasingly important in both academic research and policy formulation. While considerable attention has been given to the ecological consequences of climate change, there remains a growing need to examine its combined socio-economic and environmental

impacts at the local level, particularly in regions where fisheries constitute a major source of livelihood. Such an understanding is essential for developing evidence-based adaptation strategies, promoting sustainable fisheries management, strengthening disaster risk reduction, and improving the resilience of vulnerable coastal communities. This study is undertaken within this broader context, focusing on the socio-economic and environmental impacts of climate change on fisheries in Thiruvananthapuram District, Kerala.

The Fisheries Sector in India

India is one of the world's leading fisheries-producing countries, with the fisheries sector playing a vital role in food security, employment generation, nutritional well-being, and economic development. The country has a coastline of approximately 7,516 km and an Exclusive Economic Zone (EEZ) of over 2 million square kilometres, providing abundant marine resources that support millions of fishers and allied workers. Marine fisheries contribute significantly to the national economy by generating employment, supporting exports, and sustaining the livelihoods of coastal communities. However, the fisheries sector is increasingly vulnerable to climate change because fish production and fishing activities are closely linked to environmental conditions such as sea temperature, rainfall, ocean currents, salinity, and monsoon patterns. Changes in these climatic variables directly influence fish abundance, species distribution, breeding cycles, and fishing operations, thereby affecting both marine ecosystems and the socio-economic conditions of fishing communities (IPCC, 2023).

Over the past few decades, India has experienced a noticeable increase in average temperatures, changing rainfall patterns, rising sea levels, and an increase in the frequency and intensity of cyclones and extreme weather events. The Indian Ocean has warmed faster than many other ocean basins, leading to marine heatwaves and significant ecological changes. These climatic changes have altered the distribution and migration patterns of commercially important fish species, reduced fishing days due to rough sea conditions, and increased the operational risks faced by marine fishers. Frequent cyclones and storm surges have also damaged fishing boats, nets, harbours, and coastal infrastructure, causing

substantial economic losses for fishing households and increasing livelihood insecurity among coastal populations (IPCC, 2023).

Marine ecosystems are highly sensitive to variations in ocean temperature and chemistry. Rising sea surface temperatures influence fish metabolism, reproduction, and migration, causing several species to shift towards cooler waters or deeper marine environments. Ocean acidification, resulting from increased absorption of atmospheric carbon dioxide, affects shell-forming organisms and disrupts marine food chains. Changes in primary productivity, plankton abundance, and nutrient circulation further influence fish recruitment and survival. These ecological changes have reduced the availability of several commercially valuable species in traditional fishing grounds, forcing fishers to travel longer distances and spend more time and fuel in search of adequate catches. Consequently, the cost of fishing has increased while the economic returns have become increasingly uncertain (Barange et al., 2018).

Fisheries in Kerala

Kerala occupies a unique position in India's marine fisheries sector because of its rich marine biodiversity, productive fishing grounds, and long tradition of marine fishing. The state has a coastline of about 590 km and hundreds of coastal villages where fisheries constitute the primary source of livelihood. Marine fisheries contribute substantially to Kerala's economy through employment, domestic fish supply, and export earnings. Thousands of families depend directly or indirectly on fishing, fish processing, transportation, marketing, boat building, and allied activities. Despite its importance, the fisheries sector in Kerala has become increasingly vulnerable to climate change due to the combined effects of environmental degradation, coastal hazards, overexploitation of marine resources, and changing oceanographic conditions (Government of Kerala, 2025).

Climate change has significantly altered Kerala's coastal and marine environment. Rising sea surface temperatures, erratic monsoon rainfall, sea-level rise, coastal erosion, saline water intrusion, and increasing frequency of extreme weather events have affected both fishery resources and fishing communities. Scientific observations indicate that

fluctuations in ocean temperature and monsoon behaviour have influenced the distribution of important commercial species such as oil sardine, Indian mackerel, anchovies, and tuna. Declining catches of several species, together with seasonal variability in fish availability, have reduced the predictability of fishing activities and increased economic uncertainty for fisher households. Climate change has therefore emerged as one of the major environmental threats to the sustainability of Kerala's marine fisheries (CMFRI, 2025).

One of the most visible manifestations of climate change along the Kerala coast is coastal erosion. High-energy waves, sea-level rise, changing monsoon conditions, and extreme weather events have accelerated shoreline retreat in several districts, including Thiruvananthapuram. Coastal erosion destroys houses, roads, fish landing centres, and community infrastructure while reducing the space available for fishing-related activities. Many fishing families are repeatedly exposed to displacement, property loss, and livelihood disruption due to recurring coastal erosion and sea turbulence. The deterioration of coastal ecosystems such as beaches, estuaries, and nearshore habitats also affects fish breeding grounds and reduces marine biodiversity, further aggravating the vulnerability of fishing communities (KSDMA, 2023).

The socio-economic impacts of climate change on Kerala's fishing communities extend beyond declining fish catches. Reduced income, increasing operational costs, indebtedness, occupational uncertainty, and declining employment opportunities have affected the overall well-being of fisher households. Rising fuel prices, maintenance costs for fishing vessels, and longer fishing trips have increased production expenses while income remains uncertain because of fluctuating fish landings. Women engaged in fish vending, processing, drying, and marketing also experience reduced earnings when fish availability declines. Consequently, climate change influences household income, food security, children's education, healthcare expenditure, and the overall quality of life of coastal communities (Salim et al., 2018).

Thiruvananthapuram District, located at the southern tip of Kerala, possesses one of the state's most active marine fishing regions. Coastal villages such as Poonthura, Valiyathura, Vizhinjam, Beemapally, Shanghumugham, and Thumba depend heavily on marine

fisheries for employment and income. Traditional and mechanized fishing coexist in these villages, where fishing is not only an economic activity but also an integral part of the social and cultural identity of coastal communities. However, these villages have become increasingly vulnerable to climate-induced hazards including sea-level rise, coastal erosion, sea turbulence, cyclones, irregular monsoon patterns, and changing marine ecosystems. These environmental changes have significantly affected fishing operations, household livelihoods, and community resilience (Government of Kerala, 2023).

Among the coastal districts of Kerala, Thiruvananthapuram has witnessed severe coastal erosion and repeated sea incursions in several fishing villages. The recurring loss of houses, fishing equipment, roads, and public infrastructure has disrupted the daily lives of fishing communities. Climate-related hazards often force fishers to suspend fishing operations for extended periods, resulting in income loss and financial insecurity. During periods of rough seas and extreme weather warnings, fishing bans further reduce employment opportunities, especially for small-scale traditional fishers who depend on daily income for household survival. These recurring disruptions have increased livelihood vulnerability and highlighted the urgent need for effective adaptation and disaster risk reduction measures.

Studies conducted by the Central Marine Fisheries Research Institute have identified Poonthura in Thiruvananthapuram as one of Kerala's climate-vulnerable marine fishing hotspots. Research indicates that fishing households in the region experience multiple dimensions of vulnerability, including declining fish catches, unstable income, occupational risks, environmental degradation, and limited livelihood alternatives. Many households have expressed the need for livelihood diversification, improved access to social protection schemes, climate-resilient fishing technologies, and institutional support to strengthen their adaptive capacity. These findings demonstrate that climate change affects not only marine ecosystems but also the broader social, economic, and developmental conditions of fishing communities (Salim et al., 2018).

Fisheries Sector in Trivandrum District

Trivandrum District possesses a highly dynamic, open, and high-energy coastline characterized by sandy beaches, rocky promontories such as Vizhinjam, and

interconnected estuarine-lagoon systems including Pozhiyoor, Veli, and Kadinamkulam. The nearshore marine environment is strongly influenced by the seasonal dynamics of the West India Coastal Current (WICC**)** and the intense coastal upwelling that occurs during the southwest monsoon. This seasonal upwelling transports nutrient-rich, cold, and oxygen-deficient subsurface waters into the photic zone, stimulating phytoplankton blooms that enhance primary productivity and support productive pelagic fisheries along the southwest coast of India (Shankar et al., 2002; Vijith et al., 2016).

The marine waters of Thiruvananthapuram support a diverse range of commercially important fish species that contribute significantly to Kerala's marine fisheries. Small pelagic species, particularly the Indian oil sardine (*Sardinella longiceps*) and Indian mackerel (*Rastrelliger kanagurta*), have historically dominated fish landings and constitute an important source of nutrition and livelihood for coastal communities. Offshore waters near Vizhinjam are rich in large pelagic species such as tunas, billfishes, and seer fishes, while demersal resources include threadfin breams, ribbonfishes, groupers, cephalopods, and commercially valuable crustaceans. However, the abundance and distribution of these resources are highly sensitive to changes in sea surface temperature, ocean circulation, upwelling intensity, and other hydrographic conditions associated with climate variability (Zacharia et al., 2021).

The district contains some of the most densely populated coastal tracts in Asia, with major fishing villages like Pozhiyoor, Vizhinjam, Poonthura, Valiyathura, Perumathura, and Anchuthengu. Unlike northern districts of Kerala where mechanization is dominant, Trivandrum retains a predominantly artisanal and motorized fleet structure.

Environmental Challenges of Climate Change on Marine Ecosystems

The Arabian Sea has emerged as one of the fastest-warming tropical ocean regions in the world. Over the past several decades, satellite observations and in-situ oceanographic measurements have shown that sea surface temperatures (SSTs) in the Arabian Sea have increased at a rate exceeding the average warming observed across many tropical oceans. This persistent warming has altered the thermal structure of the upper ocean by strengthening water-column stratification. As surface waters become warmer, the density

difference between the mixed layer and deeper waters increases, suppressing vertical mixing and reducing the efficiency of seasonal coastal upwelling, which is essential for sustaining marine productivity along the southwest coast of India (IPCC, 2023)

Along the Thiruvananthapuram coast, increasing thermal stratification has modified the timing, spatial extent, and intensity of seasonal upwelling. Variations in upwelling influence the transport of nutrient-rich waters into the euphotic zone, thereby affecting phytoplankton productivity and the availability of food for pelagic fish species. Rising sea surface temperatures also force temperature-sensitive (stenothermal) marine organisms to migrate toward deeper or cooler waters, resulting in shifts in species distribution, altered fishing grounds, and changes in traditional fishing practices. These environmental changes have increased uncertainty in fish availability and affected the livelihoods of coastal fishing communities (Roxy et al., 2016; Zacharia et al).

Economic Challenges on the Fisheries Sector

The economic impact of climate change on fisheries in Thiruvananthapuram District is reflected in the increasing destruction of fishing assets and coastal infrastructure. The growing frequency and intensity of extreme weather events, including Cyclone Ockhi, Cyclone Tauktae, and high-energy swell wave events locally known as Kallakkadal**,** have significantly increased the vulnerability of coastal fishing communities. These events frequently damage traditional fishing crafts, outboard motors, fishing nets, and other essential equipment, resulting in substantial economic losses for fishing households. Since many fishers invest in boats and fishing gear through formal or informal credit, repeated climate-related damages increase financial burdens, reduce household income, and undermine livelihood security. Consequently, the loss of productive assets not only affects fishing operations but also limits the adaptive capacity of coastal communities facing increasing climate-related risks (KSDMA, 2019)

Social Challenges and Vulnerabilities facing Fisher-folk

The impacts of climate change are experienced differently by women and men within fishing communities. In Kerala, women play a vital role in post-harvest fisheries by

engaging in fish vending, processing, drying, transportation, and retail marketing. Declining fish landings and increasing variability in fish availability have reduced employment opportunities and household income for women engaged in these activities. In many cases, women are compelled to travel longer distances to major fish landing centres such as Neendakara or Kochi to procure fish, thereby increasing transportation costs, reducing profit margins, and extending working hours. These challenges, combined with rising temperatures and prolonged outdoor work, increase physical fatigue and occupational health risks, highlighting the gender-specific dimensions of climate change within the fisheries sector (Salim et al, 2018)

Livelihood insecurity has become an institutionalized challenge along the Trivandrum coast. The increasing number of rough-sea days, during which formal safety warnings prohibit fishers from entering the sea, has restricted the number of annual fishing days. With fewer productive days at sea, household incomes have grown volatile and unpredictable. Climate change has intensified livelihood insecurity among fishing communities along the Thiruvananthapuram coast. Increasing occurrences of rough sea conditions, high waves, cyclones, and adverse weather warnings have reduced the number of safe fishing days available each year. Consequently, fishers experience irregular fishing operations, fluctuating fish catches, unstable household incomes, and greater economic uncertainty. Frequent interruptions to fishing activities have also increased dependence on alternative livelihood strategies and government assistance during periods when fishing is not possible **(**Salim et al., 2018)

The impacts of climate change are deeply gendered within Trivandrum's fishing communities. Women occupy a central role in the post-harvest sector, working primarily as fish vendors, processors, and retailers. They manage the preservation, transport, and sale of fish in local and inland markets, balancing these economic activities with household responsibilities. As climate change reduces nearshore fish availability and increases catch volatility, women vendors face severe operational challenges.

Climate Change Impacts on Fisheries in Trivandrum District

Empirical catch data from the Vizhinjam and Anchuthengu landing centers highlight significant fluctuations in traditional target fisheries. The Indian oil sardine, historically the most reliable and affordable source of protein for the local population, has experienced notable declines punctuated by brief, erratic recoveries. Ocean warming and altered upwelling dynamics have disrupted the planktonic food supply, shifting sardine schools away from traditional nearshore fishing zones. However, the accelerated pace of climate change is outpacing the predictive capacity of traditional knowledge. Ocean warming, altered current patterns, and unpredictable storm formations frequently contradict historical indicators, rendering traditional rules unreliable. Despite these challenges, communities are actively innovating. Fishers are forming localized communication networks via mobile applications to share real-time weather and catch data across villages. They are also modifying their gear configurations and collaborating with scientific bodies to deploy artificial reefs along the sea floor to foster localized marine habitats. (Hamza et al., 2021; George et al., 2019).

1.2 STATEMENT OF THE PROBLEM

Climate change has emerged as one of the most significant global environmental challenges, with coastal regions experiencing some of its most severe consequences. Rising sea levels, increasing sea surface temperatures, coastal erosion, unpredictable rainfall, and the growing frequency of cyclones and storm surges have significantly affected marine ecosystems and fisheries (Biju Kumar et al., 2017). These environmental changes have disrupted fish breeding grounds, altered fish migration patterns, and reduced the availability of marine resources, thereby threatening the sustainability of the fisheries sector. Since fisheries contribute substantially to food security, employment, and the local economy, climate-induced changes have become a major concern for coastal communities that depend on marine resources for their survival.

The coastal communities of Thiruvananthapuram district, Kerala, are particularly vulnerable to the impacts of climate change because of their geographical location and

heavy dependence on fishing as their primary livelihood. Declining fish catches, damage to fishing boats, nets, landing centres, and housing caused by extreme weather events have increased economic hardships among fisher households. Rising operational costs, loss of income, indebtedness, and limited livelihood alternatives have further intensified livelihood insecurity. In addition to economic losses, these communities also face social challenges such as food insecurity, occupational uncertainty, health risks, and disruptions to education and community well-being, making them one of the most climate-sensitive populations in the region.

Although fishing communities continue to experience the adverse effects of climate change, there is limited empirical evidence regarding their level of awareness, perceptions, and adaptive responses to these changing environmental conditions. Understanding how fishers perceive climate-related risks, the adaptation strategies they currently adopt, and the challenges they encounter in implementing climate-resilient practices is essential for developing effective interventions. Therefore, this study seeks to assess climate change awareness among fisheries-dependent households in Thiruvananthapuram district and examine the socio-economic and environmental factors influencing their adaptive capacity. The findings are expected to contribute to policy formulation, disaster risk reduction initiatives, and the promotion of sustainable and climate-resilient livelihoods for coastal fishing communities.

1.3 BACKGROUND OF THE STUDY

Thiruvananthapuram, the capital district of Kerala, is situated along the southern coast of the Arabian Sea and possesses a coastline of approximately 78 kilometres. The district is characterised by a diverse coastal landscape comprising sandy beaches, estuaries, rocky shores, wetlands, and fishing villages that support rich marine biodiversity and fisheries resources. Coastal communities in areas such as Poonthura, Valiyathura, Thumba, Vizhinjam, and Marianad have traditionally depended on marine fisheries as their primary source of livelihood. Fishing, fish processing, marketing, and other allied activities contribute significantly to the local economy and provide employment for thousands of households. The district's coastal ecosystem plays an important role in ensuring food

security, sustaining livelihoods, and supporting the cultural and social identity of fishing communities (Department of Fisheries, Government of Kerala, 2023).

In recent decades, Thiruvananthapuram has become increasingly vulnerable to the impacts of climate change and coastal hazards. Rising sea levels, coastal erosion, irregular monsoon patterns, high-energy waves, storm surges, and extreme weather events have intensified environmental degradation along the coastline. Several coastal stretches, particularly Valiyathura, Poonthura, and Shanghumugham, have experienced severe shoreline erosion, destroying houses, roads, fishing infrastructure, and public facilities. The increasing frequency of rough sea conditions has also affected fishing operations by reducing the number of safe fishing days and increasing the risks faced by fishers at sea. These environmental changes have created significant challenges for the sustainability of fisheries and the socio-economic stability of coastal households (KSDMA, 2022).

The fisheries sector in Thiruvananthapuram remains highly sensitive to climate variability because a large proportion of coastal households depend directly on marine resources for their income and daily subsistence. Changes in sea surface temperature, shifting fish migration patterns, declining fish availability, and increasing operational costs have reduced the profitability of fishing activities. (FAO, 2022).

1.4 SIGNIFICANCE OF THE STUDY

Climate change has emerged as one of the greatest threats to coastal ecosystems and fisheries, profoundly affecting marine biodiversity, fish productivity, and the livelihoods of millions who depend on fisheries for survival; rising sea temperatures, sea-level rise, coastal erosion, ocean acidification, and the increasing frequency and intensity of extreme weather events have substantially altered marine ecosystems and diminished fish resources, thereby intensifying the vulnerability of fisheries-dependent communities, particularly in developing countries where livelihoods are closely linked to natural resources (IPCC, 2023). Consequently, this study contributes to the growing body of knowledge by examining the multifaceted effects of climate change on fisheries-dependent households in Thiruvananthapuram district and by highlighting the environmental and socio-economic

challenges these households experience. The study is significant because it provides a comprehensive understanding of the socio-economic consequences of climatic perturbations on fishing communities: climate-driven changes in marine ecosystems have produced declining fish catches, increased operational costs, damage to fishing infrastructure, and fluctuating household incomes, which in turn precipitate livelihood insecurity, indebtedness, food insecurity, and reduced quality of life among fisher households (Allison et al., 2009). By systematically analysing these challenges, the research generates empirical evidence to inform policymakers, researchers, and development practitioners in the design of targeted interventions that enhance livelihood security and social well-being for vulnerable coastal populations. Another key contribution of the study is its focus on community awareness, adaptive capacity, and the coping strategies adopted by fisheries-dependent households; understanding how fishing communities perceive climate change, respond to environmental risks, and implement adaptation measures is essential for strengthening resilience, as it enables the identification of existing adaptation practices, barriers to climate-resilient livelihoods, and opportunities for synthesising indigenous knowledge with scientific approaches. Such evidence can underpin the development of effective climate adaptation programmes, disaster risk reduction strategies, and community-based resource management initiatives that promote sustainable fisheries and reduce climate vulnerability (IPCC, 2023; Adger, 2006).

1.5 CHAPTERIZATION

Chapter 1: Introduction

The first chapter presents an overview of the research topic and provides the background of climate change and its impacts on the fisheries sector. It explains the research problem, the significance of the study, research objectives, scope of the study, and key concepts related to climate change and fisheries in Thiruvananthapuram district.

Chapter 2: Review of Literature

This chapter discusses previous studies and research related to climate change, fisheries, livelihood vulnerability, environmental changes, and adaptation strategies among fishing communities. It reviews relevant theories and empirical studies to identify the research gap and establish the theoretical foundation for the present study.

Chapter 3: Research Methodology

This chapter describes the research design, study area, target population, sampling technique, sample size, sources of data, data collection tools, and methods of data analysis used in the study. It also explains the ethical considerations and limitations of the research.

Chapter 4: Data Analysis and Interpretation

This chapter presents and analyzes the data collected from the respondents using appropriate statistical techniques. It examines the socio-economic and environmental impacts of climate change on fishing communities, including livelihood security, income, occupational challenges, environmental changes, adaptation practices, and climate change awareness. The findings are presented using tables, charts, and detailed interpretations.

Chapter 5: Findings, Conclusion, and Suggestions

This chapter summarizes the major findings of the study and presents conclusions based on the research objectives. It also provides practical suggestions and recommendations for improving climate resilience, strengthening livelihood security, promoting sustainable fisheries, and supporting policy interventions to enhance the adaptive capacity of fishing communities in Thiruvananthapuram District

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

Climate change has emerged as one of the most significant environmental challenges confronting marine ecosystems and fisheries. Brander (2010) explains that climate change affects fisheries through both direct and indirect pathways, including changes in temperature, salinity, oxygen levels, pH, winds, and vertical mixing, all of which influence fish physiology, growth, reproduction, survival, distribution, and recruitment. These impacts are not isolated from other pressures; rather, they interact with overfishing, habitat loss, pollution, and biological interactions, making fish populations more vulnerable when ecosystem resilience is already weakened (Brander, 2010). The literature, therefore, treats climate change not simply as a background environmental trend, but as a stressor that can reshape marine productivity and alter fisheries outcomes at local, regional, and global scales.

In the Indian context, several studies have documented the growing impacts of climate change on marine fisheries and coastal communities. Salim et al. (2014) found that coastal fisher households in Kerala experience varying degrees of vulnerability due to changing climatic conditions, with factors such as income, education, access to institutional support, and livelihood diversification influencing their resilience. Shyam et al. (2014) further observed that climate-induced risks affect not only fish catches but also housing, health, and social well-being, making vulnerability a multidimensional issue. Likewise, Biju Kumar et al. (2017) emphasized that climate change has altered marine ecosystems along the Indian coast, affecting fish availability and the sustainability of coastal livelihoods.

Awareness of climate change has become a defining factor in shaping the adaptive capacity of coastal communities whose lives are intertwined with fragile marine ecosystems. Studies from Kerala reveal that traditional fisherfolk are increasingly aware of the shifting sea, as rising temperatures, altered water currents, frequent cyclones, and coastal erosion disrupt both their fishing patterns and livelihood security. The study also shows that nearly all respondents identified climate-driven natural hazards as the most significant reason behind occupational shifts, indicating strong community-level recognition of environmental change and its socioeconomic consequences. Such insights underline that enhancing

climate change awareness is not merely informative but essential for strengthening local resilience, promoting informed adaptation, and guiding coastal communities toward sustainable, climate-resilient futures. (Anju et al., 2023).

Anthropogenic global warming has significantly influenced physical and biological processes globally and regionally, presenting major challenges and opportunities for societies and economies. Fisheries are a critical resource, providing over 2.6 billion people with at least 20% of their average annual per capita protein intake. As the planet warms, climate changes are expected to have profound consequences for fish populations, species, and ecosystems. (Allison et al., 2009). Variations in monsoon-driven ocean currents affect the distribution of nutrients and fish stocks, making fisheries in the Arabian Sea highly sensitive to climatic and oceanographic changes (Shankar et al., 2002).

Climate change has significantly influenced plankton ecosystems by altering their abundance, distribution, and seasonal timing, thereby affecting the structure and functioning of marine food webs. These changes have important implications for fisheries, as shifts in plankton communities can reduce food availability for commercially important fish species and ultimately influence marine productivity (Richardson & Schoeman, 2004). Coastal upwelling is a major oceanographic process along the southwest coast of India, particularly during the southwest monsoon season. Upwelling transports cold, nutrient-rich waters from deeper layers to the ocean surface, enhancing phytoplankton production and supporting high levels of marine productivity. This process plays a crucial role in sustaining commercially important fish species, including sardines and mackerel. However, changes in climatic conditions and ocean circulation patterns may alter the intensity and timing of upwelling, thereby affecting fish distribution, abundance, and fisheries productivity (Rao, 2015).

Research from Kerala's marine hotspots further deepens our understanding of how climate change reshapes coastal livelihood systems. It highlights that climate impacts in southwest India are already unfolding in highly visible ways, particularly in fishing villages like Poonthura and Elamkunnapuzha, where shoreline shifts, extreme weather events, and

declining fish availability intensify livelihood insecurity. Their study reveals that vulnerability is shaped by the interaction of exposure, sensitivity, and adaptive capacity, with most households falling into high or very high vulnerability categories due to their strong dependence on fisheries, limited livelihood alternatives, and low awareness of climate risks. The authors argue that although Kerala boasts high human-development indicators overall, fisher communities remain socio-economically marginalised, lacking the institutional support and flexibility needed to cope with climate variability. (Salim, Bhat, & Thomas, 2014)

2.2 REVIEWS

Climate change has emerged as one of the most significant challenges affecting marine fisheries worldwide, influencing fish distribution, productivity, ecosystem stability, and the livelihoods of millions of fishing communities. Rising sea surface temperatures, ocean acidification, changing monsoon patterns, and the increasing frequency of extreme weather events have altered marine ecosystems, causing shifts in fish stocks and reducing the reliability of traditional fishing practices. These environmental changes not only threaten biodiversity but also create economic uncertainty and food insecurity among fishing-dependent populations (Brander, 2010; Perry et al., 2005; IPCC, 2023).

Climate change represents a significant global challenge that disproportionately affects vulnerable and marginalized populations (Agrawal et al., 2024). Historically, cumulative emissions from industrialized nations since the mid-19th century have driven the current rise in global temperatures, necessitating international commitments like the Paris Agreement to limit warming to 1.5°C. India has responded by pledging to reach net-zero emissions by 2070, a task that requires balancing the "trilemma" of energy security, economic development, and environmental sustainability. While the state has taken decisive steps such as reducing hydrocarbon subsidies by 59% since 2014, global geopolitical instability and volatile energy prices continue to complicate the transition to renewable energy (Agrawal et al., 2024) Recent assessments indicate that changing oceanographic conditions, including fluctuations in sea surface temperature and weather-

related disturbances, continue to influence marine fish landings and species distribution along the Indian coast. These changes have important implications for fisheries management, resource sustainability, and the livelihoods of coastal fishing communities (CMFRI, 2024).

The escalating impacts of climate change on the southwest coast of India have introduced severe operational and economic volatility for artisanal fishing sectors. Empirical assessment indicates that erratic weather disruptions, shifting monsoons, and thermal anomalies have triggered an acute reduction in annual fishing days, plunging vulnerable artisanal families into deeper cycles of seasonal unemployment and income depletion (Sudhakaran, 2025).

The compounding vulnerabilities of coastal fishing communities along the southwest coast of India highlight a direct link between micro-level socio-economic stress and macro-scale oceanographic disruptions. Environmental shifts in the southeastern Arabian Sea, marked by climbing sea surface temperatures and altered monsoonal upwelling patterns, have induced major fluctuations and distribution shifts in crucial pelagic fish stocks, particularly the Indian oil sardine (Sajna et al., 2019). These ecological alterations do not merely disrupt marine biodiversity; they trigger severe asset losses, critical livelihood damage, and unexpected occupational shifts among traditional fishers who lack diversified safety nets (Alex et al., 2023). Consequently, local community resilience is heavily strained by structural infrastructure gaps and uneven social support systems, turning what begins as an environmental crisis into a profound socio-economic threat to the survival of coastal household. Variations in climatic conditions influence fish survival and recruitment, leading to fluctuations in fish stocks and affecting fisheries productivity (Stige et al., 2006).

The Thiruvananthapuram region in Kerala, India, faces significant challenges due to climate change, including sea-level rise, coastal flooding, erosion, and altered precipitation patterns. These impacts are exacerbated by high population density, low coastal elevation, and high erosion rates, making coastal communities highly vulnerable to climate-related hazards. Coastal erosion has led to the loss of approximately 650 hectares of land between 2004 and 2020, with wards like Valiyathura, Harbour, and Vizhinjam being the most

affected. The study by Ramamurthy et al. (2025) highlights that approximately 650 acres of land have been eroded from the mainland in the past two decades, directly impacting coastal communities and their livelihoods Additionally, 13 out of 15 coastal wards in the region are highly susceptible to multi-hazard risks, including storm surges, floods, and erosion. Integrated climate-adaptive strategies, such as living breakwaters, geotubes, and flood protection measures, are essential to enhance the resilience of these communities and safeguard their livelihoods and infrastructure (Ramamurthy et al., 2025).

A major theme in the literature is that climate change affects marine ecosystems through changes in primary and secondary production. Brander (2010) notes that alterations in ocean temperature and nutrient supply can modify phytoplankton dynamics, which then cascade through food webs to affect fish stocks. Studies cited in the review show that climate-driven shifts in plankton abundance and timing can produce trophic mismatches, where fish larvae emerge at times when food is less available, reducing survival and recruitment (Edwards & Richardson, 2004). Similarly, warming and altered ocean circulation can shift fish distributions poleward or into deeper waters, changing the spatial pattern of catches and creating new pressures on fishing communities (Perry et al., 2005). This evidence suggests that climate change influences not only the amount of fish available, but also where and when fish can be harvested.

Another important strand of research focuses on the relationship between climate variability and fish stock dynamics. Brander (2010) highlights that decadal oscillations such as the North Atlantic Oscillation and Pacific Decadal Oscillation can strongly affect recruitment, abundance, and productivity of commercially important species. In the North Atlantic, climate-linked changes in cod recruitment and growth have been documented across multiple stocks, showing that environmental variability can amplify or worsen the effects of fishing pressure (Brander, 2005). The literature also shows that regime shifts can produce abrupt changes in ecosystem state, making fisheries management more difficult because stock responses are rarely linear or predictable (Beaugrand, 2004; King, 2005). These findings emphasize the need for long-term monitoring and adaptive management strategies that can respond to both gradual climate trends and sudden environmental shifts.

Thiruvananthapuram is a critical hub for Kerala's fisheries, housing the state's highest number of fishing villages and landing centers. However, the region faces severe climate change indicators, including rising sea surface temperatures, sea-level rise, ocean acidification, and extreme weather events such as cyclones and storms. These environmental shifts significantly threaten the sustainable livelihoods of the coastal communities that rely almost exclusively on marine resources for income. Local communities have observed these alterations and recognize their direct implications on fishery resources and community well-being. The impact of climate change manifests in tangible disruptions such as fewer fishing days, reduced fish catch, and decreased profitability for local fishers (Anjitha & Bhattacharjee, 2026). Extreme weather events, such as Cyclone Ockhi, have resulted in the tragic loss of lives and the destruction of thousands of fishing boats, which are essential assets for coastal livelihoods. In specific areas like Anchutheng village, the community is particularly vulnerable to tidal surges and sea erosion, which often force residents to relocate after losing their homes to natural disasters. Furthermore, climate-related changes in wave patterns frequently lead to the physical destruction of gear and infrastructure

The socio-economic dimension of climate change is also well established in the fisheries literature. Brander (2010) points out that fish stock fluctuations have historically had serious economic consequences for fishing communities, particularly where livelihoods depend heavily on a small number of species or a single fishing area. Climate-induced changes in stock abundance, fishing days, and catch composition can reduce household income, increase livelihood insecurity, and intensify competition for marine resources. Vulnerability is especially high in coastal communities with limited alternative employment, weak adaptive capacity, and dependence on small-scale fishing systems (Brander, 2010). In this sense, climate change is not only an ecological issue but also a social and developmental one, with implications for food security, employment, migration, and equity.

The livelihoods of fishing communities are closely linked to their social and economic conditions, making them particularly vulnerable to the impacts of climate change. At the global level, Adger (2006), through a conceptual analysis of climate vulnerability,

explained that social factors such as education, income, institutional support, and adaptive capacity determine how communities respond to environmental change. Similarly, Allison et al. (2009), in a cross-national study covering fisheries-dependent economies across Asia, Africa, and Latin America, found that countries with limited economic resources and high dependence on fisheries are more vulnerable to climate-induced livelihood risks. In Kerala, Salim et al. (2014) examined coastal fisher households across the state's fishing villages and reported that education, livelihood diversification, access to credit, and institutional support significantly influence household resilience to climate change. Likewise, Shyam et al. (2014), studying traditional fishing communities along the Kerala coast, observed that climate variability affects not only fishing income but also housing conditions, health, social well-being, and overall community resilience. Expanding beyond climate impacts alone, Bennett et al. (2021), drawing evidence from small-scale fishing communities across Asia, Africa, Oceania, and Latin America during the COVID-19 pandemic, demonstrated how environmental and socio-economic shocks together expose existing inequalities within coastal communities. More recent evidence from Thiruvananthapuram district, Kerala, further highlights these challenges. Anjitha and Bhattacharjee (2026), in their study of coastal fishing communities in Thiruvananthapuram, identified inadequate climate-resilient infrastructure, weak social support systems, and unequal access to public services as major barriers to adaptation.

Similarly, Ramamurthy et al. (2025), focusing on coastal communities in the Thiruvananthapuram region, found that although local fishers have developed coping strategies, resilience remains constrained by socio-economic inequalities, limited institutional assistance, and inadequate infrastructure. Collectively, these studies demonstrate that climate change reshapes the social fabric of fishing communities by increasing livelihood insecurity, disrupting traditional occupations, weakening social networks, intensifying migration, and reducing access to education, healthcare, and social protection. They also indicate that improving resilience requires integrated interventions that strengthen social welfare, education, institutional support, community participation, and livelihood diversification alongside environmental adaptation.

Studies on marine ecosystems suggest that climate-driven regime shifts can fundamentally alter the structure and functioning of marine food webs, affecting fish recruitment, productivity, and long-term stock sustainability. These ecosystem changes often occur abruptly and reduce the predictability of fisheries, highlighting the importance of adaptive ecosystem-based fisheries management and long-term environmental monitoring to enhance resilience under changing climatic conditions (King, 2005).

Climate change is fundamentally altering the productivity and sustainability of fisheries in Kerala, driven by extreme temperatures, shifting precipitation patterns, and rising sea levels. These environmental changes directly result in a loss of productivity in fisheries and aquaculture, posing a significant threat to the state's coastal economy. Beyond physical climate shifts, the process of ocean acidification, where the ocean's pH drops as it absorbs carbon dioxide, is causing harmful consequences for marine life and disrupting the interconnected food chains that sustain commercial fish stocks. Consequently, the commercial fishing industry is identified as one of the sectors most susceptible to the environmental repercussions of climate change, which include habitat degradation and animal extinction.

The vulnerability of fishing communities in Kerala is exacerbated by their high geographic exposure and heavy reliance on marine resources for survival. In the Thiruvananthapuram region, for example, nearly 23% of the coastline is vulnerable to erosion, which has already led to the loss of approximately 650 hectares of land. This loss of territory, combined with more frequent storm surges and flooding, directly threatens the livelihoods and infrastructure of coastal fishing villages. Furthermore, socioeconomic factors such as limited resources and a lack of access to essential services like healthcare and education increase the difficulty for these communities to successfully adjust to climate-induced disruptions.

To address these challenges, the sources emphasize the need for integrated climate-adaptive livelihood strategies and nature-based solutions. Interventions such as the implementation of "living breakwaters" and the restoration of mangrove forests are suggested to bolster fishery resources while simultaneously mitigating the risks of coastal flooding. Additionally, researchers highlight the importance of exploring alternative

livelihood options for vulnerable fishing villages to enhance their adaptive capacity. However, the sources caution that efforts to build assets for resource exploitation must be managed carefully to avoid undermining the long-term sustainability of coastal ecosystems, which could inadvertently increase community vulnerability. (Ramamurthy, etal, 2025)

Recent studies indicate that the consequences of climate change extend beyond declining fish catches to include occupational transitions and asset losses. Alex et al. (2023) found that many fishermen in central Kerala have been compelled to seek alternative occupations because of declining fishing opportunities and increasing environmental uncertainty. Similarly, Panikkaveettil et al. (2024) reported that recurring extreme weather events have caused substantial damage to fishing boats, nets, engines, and coastal infrastructure, resulting in prolonged livelihood disruptions and financial stress. Aswathy et al. (2023) also highlighted the economic consequences of declining Indian oil sardine landings, emphasizing their effects on household income and food security.

Adaptation and resilience have become central themes in climate change research as fishing communities increasingly face environmental uncertainty and livelihood disruptions. Globally, Barange et al. (2018) emphasized that sustainable adaptation in fisheries requires a combination of ecosystem-based management, diversified livelihoods, improved governance, and community participation to reduce long-term climate risks. Similarly, the Intergovernmental Panel on Climate Change (IPCC, 2023) highlighted that adaptive capacity is strongly influenced by socio-economic conditions, institutional effectiveness, and access to financial and technological resources rather than environmental factors alone. In India, Salim (2014) identified several climate change hotspots along the coastline and argued that strengthening resilience requires location-specific adaptation strategies, including early warning systems, insurance mechanisms, and capacity-building programmes for fishing communities.

Focusing on Kerala, Panikkaveettil et al. (2024) reported that repeated climate-induced disasters have resulted in extensive losses of fishing assets and coastal infrastructure, making financial assistance, infrastructure development, and community-based disaster preparedness essential for sustainable recovery. Alex et al. (2023), studying fishing

communities in central Kerala, found that many fishers have gradually shifted to alternative occupations due to declining fishing opportunities, illustrating how adaptation often occurs through livelihood diversification rather than improvements within the fisheries sector itself. At the district level, Ramamurthy et al. (2025) observed that coastal communities in Thiruvananthapuram have adopted coping measures such as modifying fishing schedules, seeking supplementary sources of income, and strengthening community cooperation; however, these strategies remain constrained by limited institutional support and persistent socio-economic inequalities. Likewise, Anjitha and Bhattacharjee (2026) concluded that improving climate resilience in Thiruvananthapuram's fishing communities requires investments in climate-resilient infrastructure, enhanced social protection, and stronger community support networks. Collectively, these studies suggest that while fishing communities have demonstrated considerable adaptive capacity, long-term resilience depends on integrated policies that combine livelihood security, social welfare, institutional support, disaster risk reduction, and climate-responsive coastal governance

Overall, the literature indicates that climate change is reshaping fisheries through interconnected ecological and socio-economic pathways. The strongest evidence shows impacts on fish physiology, ecosystem productivity, species distribution, recruitment success, and fishing-community livelihoods (Edwards & Richardson, 2004). However, the literature also makes clear that local responses differ depending on geography, species composition, fishing intensity, and institutional capacity. This means that district-level studies are necessary to understand how global climate processes translate into place-specific impacts, especially in highly dependent coastal regions such as Kerala.

2.3 RESEARCH GAP ANALYSIS

The existing literature provides substantial evidence that climate change has significantly affected marine fisheries, coastal ecosystems, and the livelihoods of fishing communities across the globe and in India. Previous studies have extensively documented the impacts

of rising sea surface temperatures, changing monsoon patterns, ocean acidification, coastal erosion, declining fish stocks, and extreme weather events on fisheries productivity and the socioeconomic well-being of fishing households (IPCC, 2023; Allison et al., 2009). Several studies conducted in Kerala have also highlighted the vulnerability of fisher households, livelihood insecurity, occupational shifts, infrastructure losses, and adaptation strategies adopted by coastal communities in response to climate change (Panikkaveettil et al., 2024).

Although these studies provide valuable insights into the environmental and socioeconomic consequences of climate change, several research gaps remain. First, most studies have primarily focused on the physical impacts of climate change, livelihood vulnerability, and adaptation practices, while comparatively little attention has been given to fishers' awareness and perception of climate change and how this awareness influences their adaptive behaviour and resilience. Second, many investigations have been conducted at the state, national, or regional level, with relatively few empirical studies concentrating specifically on the coastal fishing communities of Thiruvananthapuram District, despite the district experiencing severe climate-related hazards such as coastal erosion, sea-level rise, sea turbulence, and extreme weather events.

Furthermore, existing research has largely relied on qualitative assessments, vulnerability indices, or environmental analyses, whereas quantitative evidence examining the relationship between climate change awareness and socioeconomic characteristics, livelihood conditions, and adaptive capacity among fishers remains limited. There is also insufficient understanding of how demographic factors such as age, education, fishing experience, income, and occupational dependence influence climate change awareness and adaptation among fishing households.

Therefore, this study seeks to address these gaps by adopting a quantitative cross-sectional research design to assess the level of climate change awareness among fishers in selected coastal communities of Thiruvananthapuram District. The study further examines the association between climate change awareness, socioeconomic characteristics, livelihood conditions, and adaptive capacity, thereby providing empirical evidence to support the

development of context-specific policies and community-based climate adaptation strategies for Kerala's coastal fishing communities.

CHAPTER 3 METHODOLOGY

3.1 INTRODUCTION

Research methodology refers to the systematic framework and procedures used to collect, analyze, and interpret data to answer research questions and achieve the objectives of a study. It provides a logical and scientific approach for conducting research by outlining the research design, study area, sampling techniques, sources of data, methods of data collection, research instruments, and techniques of data analysis. A well-defined methodology enhances the reliability, validity, and credibility of the research findings by ensuring that the study is conducted in a structured, transparent, and objective manner (Creswell & Creswell, 2018). The selection of an appropriate methodology depends on the nature of the research problem, the objectives of the study, and the type of information required to address the research questions (Kothari, 2004).

In the present study, the research methodology provides the framework for examining the Socio-Economic and Environmental impact of climate change among fisheries-dependent households in Thiruvananthapuram district. It explains the procedures adopted for selecting respondents, collecting primary data through a structured questionnaire, and analyzing the data using appropriate statistical techniques. The methodology has been designed to ensure that the findings accurately reflect the perceptions, awareness, and experiences of fisheries-dependent households regarding the socio-economic and environmental impacts of climate change. The following sections describe the research design, study area, sampling design, sources of data, data collection methods, research instruments, and techniques used for data analysis.

3.2 TITLE OF THE STUDY

Socioeconomic and Environmental Impacts of Climate Change on Fisheries in Trivandrum District

3.3 RESEARCH OBJECTIVES

The study mainly focuses on understanding and analyzing the socio-economic and environmental impacts of climate change on the fisheries sector in Thiruvananthapuram

District, Kerala. It aims to examine how climate change has affected the livelihoods, income, employment opportunities, and overall well-being of fishing communities

General Research Objective:

To study Socio-Economic and Environmental Impact of Climate Change on Fisheries in Trivandrum District

Specific Objectives:

- To identify the key economic impacts of climate change on the fisheries sector.
- To assess the social dimensions and implications of climate change on fishing communities and fisheries-dependent livelihoods.
- To analyze the environmental impacts of climate change on fisheries resources and coastal ecosystems.

3.4 DEFINITION OF CONCEPTS

Climate Change

Conceptual Definition

Climate change refers to long-term shifts in temperatures and weather patterns, primarily due to human activities such as burning fossil fuels, leading to global warming and associated impacts (IPCC, 2021).

Operational definition

In this study, it is measured by the perception of fishers regarding changes in rainfall, temperature, and sea-level rise in Trivandrum district.

Coastal Population

Conceptual Definition

Coastal population refers to people living in areas adjacent to the coast whose social, economic, and cultural activities are closely linked to marine and coastal resources. These populations often depend on fisheries and related activities for their livelihoods and are particularly vulnerable to environmental and climatic changes (Salim, Bhat & Thomas, 2014).

Operational Definition

In this study, the coastal population refers to fishers, fish vendors, fish-processing workers, and households residing in the selected coastal fishing communities of Trivandrum district, measured through demographic characteristics, occupational dependence on fisheries, and exposure to climate-related environmental and socioeconomic impacts.

Livelihood

Conceptual Definition

A livelihood comprises the capabilities, assets (both material and social), and activities required for a means of living, and is sustainable when it can cope with and recover from stresses and shocks (Chambers & Conway, 1992).

Operational Definition

This study examines the impacts of climate change on fisheries and coastal ecosystems in Thiruvananthapuram district, assessing indicators such as fishing income, employment opportunities, fish catch variability, livelihood security, asset ownership, and household capacity to cope with climate-related risks.

3.5 PILOT STUDY

A pilot study is a small-scale preliminary investigation conducted before the main research to evaluate the feasibility and effectiveness of the research design and data collection instruments. It serves as a trial run that enables the researcher to identify potential methodological issues, assess the clarity and relevance of the questionnaire, estimate the time required for data collection, and ensure that the questions are understandable to the target respondents. A pilot study also helps improve the validity and reliability of the research instrument by identifying ambiguous, repetitive, or culturally inappropriate questions before the commencement of the main study. Conducting a pilot study is an essential step in social science research, as it enhances the quality and credibility of the research findings by minimizing errors during the actual data collection process (Creswell & Creswell, 2018; Kothari, 2004)

In the present study titled "Socioeconomic and Environmental Impacts of Climate Change on Fisheries in Trivandrum District," a pilot study was conducted before the main survey to assess the suitability of the structured questionnaire among members of the fishing community. The pilot study was carried out with a small group of respondents who possessed characteristics similar to those of the target population but were excluded from the final sample. It helped determine whether the questions effectively captured information related to the socioeconomic and environmental impacts of climate change, livelihood challenges, fishing practices, adaptation measures, and respondents' perceptions of climate-related changes. Feedback obtained during the pilot study facilitated the refinement of the questionnaire by improving the wording, sequence, and clarity of the questions, thereby ensuring that the final instrument was appropriate, reliable, and easy for respondents to understand during the main survey.

3.6 RESEARCH DESIGN

Research design is the overall plan or blueprint that guides the process of conducting a research study. It provides a systematic framework for collecting, measuring, and

analyzing data to answer the research questions and achieve the objectives of the study. A well-developed research design ensures that the study is carried out in a logical, organized, and scientifically rigorous manner, thereby enhancing the validity and reliability of the findings. It specifies the methods to be used for data collection, sampling, measurement, and analysis while minimizing bias and maximizing the accuracy of the results (Creswell, 2018).

A quantitative approach was adopted for this study since it allows the systematic collection and statistical analysis of numerical data, enabling the researcher to measure the perceptions, experiences, and socioeconomic conditions of fishers in relation to climate change in an objective and generalizable manner. This approach is suited to testing relationships between variables such as climate-related environmental changes and livelihood outcomes.

A cross-sectional design was employed, wherein data were collected from the sample population at a single point in time. This design is appropriate for capturing a snapshot of the current socioeconomic and environmental conditions of fishing communities, and for identifying associations between climate change indicators and livelihood/occupational variables without following respondents over an extended period.

3.7 DESCRIPTION OF RESEARCH SITE AND PARTICIPANTS

The present study was conducted in the coastal region of Thiruvananthapuram district, Kerala, which is one of the state's major marine fishing regions (Fig. 3. 7. 1). The district extends along the Arabian Sea and comprises several fishing villages that are highly dependent on marine fisheries for their livelihood. Coastal areas such as Poonthura, Valiyathura, Thumba, and Marianad are frequently exposed to climate-related hazards, including coastal erosion, sea-level rise, high waves, storm surges, and changing weather patterns. These environmental changes have significantly affected fishing activities, marine resources, and the socio-economic conditions of fishing households. Due to its high exposure to climate variability and dependence on fisheries, Thiruvananthapuram district

presents an ideal setting for examining climate change awareness and its socio-economic and environmental implications among fisheries-dependent communities.

The population for this study comprises active fishing practitioners (fishers) residing in the selected coastal fishing communities of Trivandrum district. These include individuals directly engaged in fishing-related occupations whose livelihoods are closely tied to marine and coastal resources, and who are therefore directly exposed to the socioeconomic and environmental consequences of climate change.

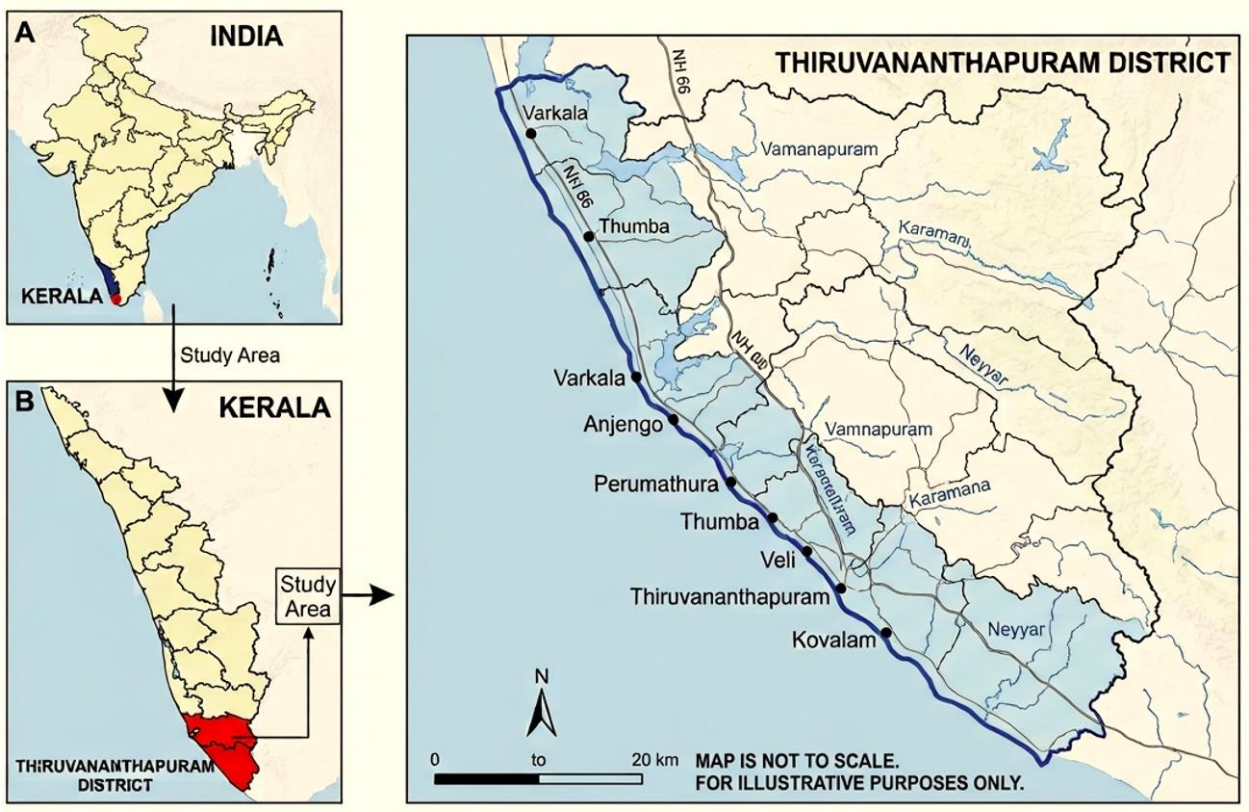

Fig. 3. 7. 1. Study area location map

3.8 SAMPLING STRATEGY

Sampling is the process of selecting a representative subset of individuals from a larger population to obtain information that can be used to make inferences about the entire population (Kothari C. R,2004). It is a fundamental aspect of research methodology

because studying every member of the target population is often impractical due to constraints of time, cost, and accessibility. An appropriate sampling strategy enables the researcher to collect reliable and representative data while minimizing bias and ensuring that the research findings accurately reflect the characteristics of the study population. The selection of a sampling technique depends on the nature of the research, the objectives of the study, and the characteristics of the target population.

Stratified Random Sampling

Stratified random sampling is a probability sampling technique in which the population is first divided into distinct, homogeneous subgroups (strata) based on shared characteristics, and respondents are then randomly selected from each stratum in proportion to its size within the population. This technique ensures adequate representation of all relevant subgroups and reduces sampling error compared to simple random sampling. (Creswell & Creswell, 2018).

The present study employed stratified random sampling, which is a probability sampling technique in which the population is first divided into distinct and homogeneous subgroups, known as strata, based on common characteristics. Respondents are then selected randomly from each stratum, either proportionately or disproportionately, depending on the objectives of the study. Stratified random sampling ensures that all important subgroups within the population are adequately represented, thereby improving the precision of the sample and reducing sampling error. This technique is particularly useful when the population is heterogeneous but contains identifiable subgroups that differ in characteristics relevant to the research.

In the present study titled "Socioeconomic and Environmental Impacts of Climate Change on Fisheries in Trivandrum District," stratified random sampling was considered the most appropriate sampling strategy because the fishing population comprises different categories of respondents with varying socioeconomic characteristics and experiences of climate change. The study area was divided into different strata based on the selected coastal fishing villages, and respondents were randomly selected from each stratum to

ensure adequate representation of the study population. This approach enabled the researcher to capture variations in the socioeconomic and environmental impacts of climate change across different fishing communities while minimizing selection bias. By ensuring that respondents from each stratum had an equal opportunity to participate, stratified random sampling enhanced the representativeness, reliability, and validity of the data.

Sample Size:A total of 70 respondents were selected for the study, drawn proportionately across the identified strata.

3.9 CRITERIA FOR SELECTION OF PARTICIPANTS

Inclusion Criteria

Participants were selected based on the following criteria:

- Permanent residents of the selected coastal communities in Thiruvananthapuram district.
- Members of households that are directly or indirectly dependent on marine fisheries for their livelihood, including fishers, fish vendors, fish processors, and other fisheries-related workers.
- Individuals who had been residing in the study area for at least one year, ensuring adequate experience of local climatic and environmental conditions.
- Participants who were willing to provide voluntary informed consent to participate in the study.

Exclusion Criteria

The following individuals were excluded from the study:

- Temporary residents or migrant workers who had not lived in the study area long enough to experience local climate-related changes.
- Individuals whose households were not dependent on fisheries as a primary or significant source of livelihood.

- Persons who were unwilling or unable to provide informed consent or complete the questionnaire.
- Respondents who submitted incomplete questionnaires or withdrew from the study before its completion.

3.10 DATA COLLECTION

Sources of Data

Sources of data refer to the origins from which information is collected for research or analysis. In this study, both primary and secondary data sources were utilized.

Primary Data

Primary data were collected directly from 70 fisheries-dependent household members residing in the selected coastal communities of Thiruvananthapuram district. A structured questionnaire was used to obtain firsthand information on the respondents' socio-economic characteristics, climate change awareness, perceived environmental changes, and adaptation practices. The primary data formed the basis for achieving the objectives of the study and provided reliable information specific to the research problem.

Secondary Data

Secondary data were collected from various published and unpublished sources to provide theoretical and contextual support for the study. These sources included books, peer-reviewed journals, government reports, publications of the Department of Fisheries, Kerala State Disaster Management Authority (KSDMA), the Intergovernmental Panel on Climate Change (IPCC), the Food and Agriculture Organization (FAO), Census reports, research articles, dissertations and other incredible online sources.

3.11 METHOD OF DATA COLLECTION

Survey Method

The survey method is a quantitative data collection technique that involves gathering information directly from respondents using a standardized set of questions. It enables researchers to systematically collect self-reported data on respondents' socio-economic characteristics, attitudes, perceptions, experiences, and behaviours related to the research problem. According to Creswell and Creswell (2018), the survey method is widely used in social science research because it facilitates the collection of reliable and comparable data from a defined population.

In the present study, the survey method was employed to collect primary data directly from 70 fisheries-dependent household members in the selected coastal communities of Thiruvananthapuram district. A structured questionnaire was administered through face-to-face interviews in the local language to ensure that respondents clearly understood each question and were able to provide accurate and meaningful responses. This method enabled the researcher to obtain comprehensive information on the respondents' socio-economic characteristics, climate change awareness, perceived environmental changes, and adaptation practices.

3.12 TOOLS FOR DATA COLLECTION

The main tool used to collect information in this study was a questionnaire**.** A structured questionnaire is a standardized research instrument consisting of a predetermined set of questions arranged in a logical sequence to obtain uniform information from all respondents. It enables the researcher to collect reliable, systematic, and comparable data, making it particularly suitable for quantitative research (Creswell & Creswell, 2018).

The questionnaire comprised both closed-ended questions and statements measured using five-point and three-point Likert scales. The five-point Likert scale was used to measure the respondents' level of awareness and agreement regarding climate change and its impacts, with response categories ranging from Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). The three-point Likert scale was employed to

assess respondents' knowledge, perceptions, livelihood impacts, adaptation practices, and access to support systems using response categories such as Yes–Sometimes–No, High–Moderate–Low, or Agree–Undecided–Disagree, depending on the nature of the variable being measured.

The structured questionnaire consisted of the following major sections:

Demographic and Socioeconomic Profile: This section collected basic information about the respondents, including age, gender, marital status, educational qualification, family size, occupation, fishing experience, monthly household income, and type of fishing practiced.

Climate Change Awareness: This section assessed the respondents' awareness and understanding of climate change, including knowledge of changing weather patterns, rising temperatures, sea-level rise, coastal erosion, extreme weather events, and their perceived causes and consequences. These items were measured using a five-point Likert scale**.**

Socioeconomic Impacts of Climate Change: This section examined the effects of climate change on fishing livelihoods, including changes in fish catch, income, employment opportunities, occupational risks, fishing expenditure, household livelihood security, and overall economic well-being. Responses were measured using a three-point Likert scale

Climate Change Knowledge, System and Perception: This section evaluated the respondents' knowledge of climate change, perceptions regarding its impact on fisheries and coastal ecosystems, and their views on the future sustainability of fishing livelihoods. Statements in this section were measured using both three-point and five-point Likert scales, depending on the nature of the variables.

Before the final administration, the questionnaire was pre-tested through a pilot study to assess its clarity, relevance, and suitability among a small group of respondents from the study area. Based on the feedback received during the pilot study, necessary modifications were made to improve the wording, sequence, and comprehensibility of the questions. The finalized questionnaire was subsequently administered to **7**0 respondents selected for the

study to collect primary data on the socioeconomic and environmental impacts of climate change on fisheries in Thiruvananthapuram District.

3.13 DATA ANALYSIS

Quantitative data collected through the structured questionnaire were analyzed using SPSS (Statistical Package for the Social Sciences) and Microsoft Excel. Descriptive statistics (frequencies, percentages, means, standard deviations) were used to summarize the socioeconomic profile and perceptions of respondents, while statistical techniques (such as cross-tabulations or correlation analysis, as applicable) were used to examine relationships between climate change indicators and livelihood outcomes. Data were also presented using tables, charts, and graphs generated in Excel for clarity of interpretation.

3.14 ETHICAL CONSIDERATIONS

Ethical considerations are fundamental to ensuring the integrity, credibility, and protection of participants in research. Researchers are responsible for conducting studies honestly, maintaining confidentiality, obtaining informed consent, minimizing potential harm, and respecting the rights and dignity of participants throughout the research process. Adhering to ethical principles enhances the quality and trustworthiness of research findings while promoting responsible scientific practice (Resnik, 2020).

Ethical principles were observed throughout the study to protect the rights and well-being of the participants. Before data collection, informed consent was obtained from all respondents after clearly explaining the purpose, objectives, and procedures of the study in a language they could easily understand. Participation was entirely voluntary, and respondents were informed that they had the right to decline or withdraw from the study at any stage without any consequences. Confidentiality and anonymity were ensured by not recording any personally identifiable information, and the data collected were used solely for academic and research purposes. Privacy was maintained during the data collection

process, and all responses were handled with honesty and integrity. The researcher adhered to ethical standards of respect, beneficence, and justice throughout the research process.

3.15 ASSUMPTIONS, LIMITATIONS & SCOPE

Assumptions

- The respondents provided honest, accurate, and unbiased responses to the questionnaire.
- The selected sample of 70 fisheries-dependent household members adequately represents the study population.
- Respondents possess sufficient knowledge and experience to express their perceptions regarding climate change and its impacts.
- The structured questionnaire was appropriate for measuring climate change awareness and related socio-economic and environmental aspects.
- The data collected during the study accurately reflect the prevailing conditions in the selected coastal communities.

Limitations

- The study was confined to selected coastal communities in Thiruvananthapuram district; therefore, the findings cannot be generalized to all fishing communities in Kerala or India.
- The sample size was limited to 70 respondents due to time and resource constraints.
- The study relied on self-reported responses, which may be influenced by respondents' perceptions, recall bias, or personal opinions.
- The research focused only on fisheries-dependent households and did not include the perspectives of government officials, policymakers, or other stakeholders.
- Seasonal variations and changing climatic conditions during the study period may have influenced respondents' perceptions and experiences.

Scope

The study focuses on assessing socio-economic and environmental impact of climate change on fisheries-dependent households in selected coastal communities of Thiruvananthapuram district, Kerala. It examines respondents' socio-economic characteristics, awareness of climate change, perceived environmental changes, and the impacts of climate change on fisheries and livelihoods.

The study also explores the adaptation practices adopted by fishing households and identifies the socio-economic and environmental factors influencing climate change awareness. The findings are expected to provide useful information for researchers, policymakers, and development agencies in designing climate adaptation strategies, strengthening disaster risk reduction initiatives, and promoting sustainable fisheries management in coastal communities.

CHAPTER 4 - DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

This chapter presents the analysis and interpretation of the data collected for the study titled "Socio-Economic and Environmental Impact of Climate Change on Fisheries in Thiruvananthapuram District." The primary objective of the analysis is to examine the socio-economic and environmental impacts of climate change on fisheries and to understand how these changes have affected the livelihoods of fisheries-dependent households in the study area. The analysis also explores respondents' perceptions of climate-related changes and the challenges they face in adapting to these impacts.

The primary data were collected from 70 fisheries-dependent household members using a structured questionnaire. The collected data were coded, entered, and analyzed using the Statistical Package for the Social Sciences (SPSS)**.** Descriptive statistical techniques, including frequencies, percentages, means, and standard deviations, were used to summarize and present the characteristics of the respondents and their responses. Inferential statistical techniques, such as the cross-tabulation correlation analysis, were employed to examine the relationships between selected variables. The findings are presented in the form of tables with appropriate interpretation to facilitate a clear understanding of the socio-economic and environmental impacts of climate change on fisheries in Thiruvananthapuram district.

4.2 DEMOGRAPHIC DETAILS OF THE RESPONDENTS

The demographic profile of the respondents provides essential background information that helps in understanding the socio-economic characteristics of the fisheries-dependent households included in the study. Variables such as the fishing village, years of experience, fishing category, ownership status, monthly income, education level, marital status, family size, number of earning members, primary source of income, type of housing, organizational membership, distance from the shoreline, and type of fuel used for fishing operations were examined. An analysis of these characteristics provides a comprehensive understanding of the respondents' socio-economic conditions and serves as a foundation

for interpreting the socio-economic and environmental impacts of climate change on fisheries in Thiruvananthapuram district.

Demographic details		**Frequency**	**Percentage**
Name of the fishing village	Maryanadu	4	5.7
	Pallithura	10	14.3
	Perumathura	3	4.3
	Poonthura	10	14.3
	Pozhiyoor	7	10.0
	Puthenthope	13	18.6
	St Andrews	7	11.4
	Thumba	1	14.3
	Valiyathura	10	5.7
	Vettuthura	1	1.4
Years of experience	Less than 10 years	7	10.0
	11- 20 years	18	25.7
	21 – 30 years	19	27.1
	More than 30 years	26	37.1
Fishing category	Traditional (vallom)	4	5.7
	Motorized	62	88.6
	mechanized	4	5.7
Ownership status	Boat owner	28	40.0
	Laborer	20	28.6
	Crew	22	31.4

Monthly income	10,000	40	57.1
	10,000 – 20,000	27	38.6
	More than 20,000	3	4.3
Education level	Primary	49	70.0
	Secondary	20	28.6
	Illiterate	1	1.4
Marital status	Single	5	7.1
	Married	63	90.0
	Widowed	1	1.4
	Divorced	1	1.4
Family Size	1-3 members	38	54.3
	4-6 members	31	44.3
	More than 6 members	1	1.4
Number of earning members	Only me	37	52.9
	Two members	30	42.9
	Three or more	3	4.3
Primary source of income	Fishing	59	84.3
	Allied activities	11	15.7

Type of housing	Kutcha	1	1.4
	Semi pucca	9	12.9
	Pucca (concrete)	60	85.7
Membership in organization	SHG	5	7.1
	Trade union	8	11.4
	Cooperative society	24	34.3
	none	33	47.1
Distance from shoreline	50 metres	29	41.4
	50 – 200 metres	38	54.3
	More than 200 meters	3	4.3
Type of fuel used	Keroscene	2	2.9
	Petrol	54	77.1
	diesel	6	8.6
	N/A	8	11.4

Table. 4 .2.1 Demographic details of Respondents

The demographic profile of the respondents shows that the largest proportion of fishermen belonged to Puthenthope (18.6%), followed by Pallithura (14.3%) and Poonthura (14.3%).

Respondents from St. Andrews (11.4%) and Pozhiyoor (10.0%) also constituted a notable share, while only a small percentage came from Valiyathura (5.7%) and Thumba (1.4%). This indicates that the study covered respondents from several major fishing villages of Thiruvananthapuram, with greater representation from Puthenthope.

Regarding fishing experience, 37.1% of the respondents had more than 30 years of experience, while 27.1% had 21–30 years and 25.7% had 11–20 years of experience. Only 10.0% had less than 10 years of experience. This suggests that the majority of respondents were highly experienced fishermen with extensive knowledge of fishing practices and environmental changes.

In terms of fishing category, a vast majority (88.6%) were engaged in motorized fishing, whereas only 5.7% each belonged to the traditional and mechanized categories. This reflects the widespread adoption of motorized fishing methods among the fishing communities.

The ownership status of respondents reveals that 40.0% were boat owners, while 31.4% were crew members and 28.6% were laborers. This indicates a relatively balanced distribution of occupational roles within the fisheries sector.

The monthly income pattern shows that 57.1% of the respondents earned up to ₹10,000 per month, while 38.6% earned between ₹10,000 and ₹20,000. Only 4.3% earned more than ₹20,000 monthly. This highlights the relatively low-income status of most fishing households.

Educationally, 70.0% of the respondents had completed primary education, while 28.6% had secondary education. Only 1.4% were illiterate. This indicates that basic educational attainment is common among the fishing community, although higher levels of education remain limited. With respect to marital status, 90.0% of the respondents were married, while only 7.1% were single. Widowed and divorced respondents each accounted for 1.4%. This suggests that the majority of respondents belonged to established family households.

The family composition data show that 54.3% of respondents lived in families with 1–3 members, while 44.3% had 4–6 members. Only 1.4% reported having more than six family members. Similarly, 52.9% reported being the sole earning member of the household, whereas 42.9% had two earning members and only 4.3% had three or more earners. This indicates a significant economic responsibility placed on individual earners. Fishing was identified as the primary source of income for 84.3% of respondents, while 15.7% depended on allied activities. This demonstrates the heavy dependence of coastal households on fishing for their livelihood.

Housing conditions reveal that 85.7% of respondents lived in pucca (concrete) houses, while 12.9% resided in semi-pucca houses and only 1.4% lived in kutcha houses. This suggests relatively improved housing conditions among most fishing families. Membership in organizations was comparatively low, with 47.1% reporting no organizational membership. Among those who were members, 34.3% belonged to cooperative societies, 11.4% to trade unions, and 7.1% to self-help groups. This indicates limited participation in community-based organizations. Regarding residential location, 54.3% lived 50–200 metres from the shoreline, while 41.4% resided within 50 metres of the shore. Only 4.3% lived more than 200 metres away. This indicates that most respondents reside in proximity to the coast, thereby exposing them to significant coastal environmental changes and climate-related risks. Finally, the type of fuel used for fishing activities shows that 77.1% relied on petrol, while 8.6% used diesel and 2.9% used kerosene. About 11.4% reported that the question was not applicable. This indicates that petrol is the predominant fuel used in fishing operations within the study area.

4.3 CROSS TABULATION OF YEARS OF EXPERIENCE AND TYPE OF PERCEPTION

Years of Experience	Type of Perception		Total
	Not having a better understanding of climate change	Better understanding of climate change	
Less than 10 years	13.0 %	0.0%	70.0%
11 – 20 years	18.5%	50.0%	28.6%
21 – 30 years	27.8%	25.0%	1.4%
More than 30 years	40.7%	25.0%	37.1%

Table. 4. 3. 1: Cross Tabulation of Years of Experience and Type of Perception

The relationship between years of fishing experience and perception of climate change reveals notable variations among the respondents. Among fishermen with less than 10 years of experience, all respondents (100%) reported not having a better understanding of climate change, indicating limited awareness among the least experienced group. In contrast, fishermen with 11–20 years of experience demonstrated comparatively higher awareness, with 44.4% reporting a better understanding of climate change, which represents the highest proportion among all experience categories.

Among respondents with 21–30 years of experience, 78.9% reported not having a better understanding of climate change, while only 21.1% indicated a better understanding. Similarly, among fishermen with more than 30 years of experience, the majority (84.6%) lacked a better understanding, whereas only 15.4% reported having a better understanding of climate change.

Overall, the findings show that 77.1% of the respondents did not have a better understanding of climate change, while only 22.9% demonstrated a better understanding. The results suggest that years of fishing experience alone do not necessarily contribute to

greater climate change awareness. Interestingly, fishermen with moderate experience (11–20 years) exhibited relatively higher awareness compared to those with very low or very high levels of experience. This indicates that access to information, education, training programmes, and exposure to climate-related discussions may play a more significant role in shaping climate change understanding than experience alone.

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Among respondents with 21–30 years of experience, 78.9% reported not having a better understanding of climate change, while only 21.1% indicated a better understanding. Similarly, among those with more than 30 years of experience, the majority (84.6%) lacked a better understanding, whereas only 15.4% reported having a better understanding of climate change.

Overall, the findings show that 77.1% of the respondents did not have a better understanding of climate change, while only 22.9% demonstrated a better understanding. The results suggest that years of experience alone do not necessarily contribute to greater climate change awareness. Interestingly, respondents with moderate experience (11–20 years) exhibited relatively higher awareness compared to those with very low or very high levels of experience. This indicates that access to information, education, training programmes, and exposure to climate-related discussions may play a more significant role in shaping climate change understanding than experience alone.

4.4 CROSS TABULATION OF EDUCATION LEVEL AND TYPE OF PERCEPTION

Education Level	Type of Perception		Total
	Not having a better understanding of climate change	Better understanding of climate change	
Primary	74.1%	56.3%	70.0%
Secondary	24.1%	43.8%	28.6%
Illiterate	1.9%	0.0%	1.4%

Table 4. 4. 1: Cross Tabulation of Education Level and Type of Perception

The relationship between education level and perception of climate change reveals some variation among respondents. Among those with primary education, the majority (81.6%, 40 out of 49) reported not having a better understanding of climate change, while only 18.4% (9 out of 49) indicated a better understanding. Respondents with secondary education showed comparatively higher awareness, with 35.0% (7 out of 20) reporting a better understanding of climate change, compared to 65.0% who did not. This represents the highest proportion of "better understanding" among all education categories. The single illiterate respondent fell entirely (100%) into the "not having better understanding" category.

Overall, the findings show that 77.1% of respondents did not have a better understanding of climate change, while only 22.9% demonstrated better understanding. The results suggest a general trend where higher levels of education are associated with somewhat greater awareness of climate change, as respondents with secondary education showed a notably higher proportion of better understanding (35.0%) compared to those with only primary education (18.4%) or no formal education. This indicates that formal education may play a role in shaping climate change awareness, though the overwhelming majority of respondents across all education levels still lacked a better understanding, suggesting

that factors beyond formal schooling, such as access to information, training, and community engagement, may also be important in improving climate change literacy.

4.5 CROSS TABULATION OF AGE GROUP AND TYPE OF PERCEPTION

Age Group	Type of Perception		Total
	Not having a better understanding of climate change	Better understanding of climate change	
Below 35 years	66.7%	33%	4.2%
35 – 44 years	48.8%	51.2%	9.9%
45 – 54 years	88.2%	11.8%	23.7%
55 – 64 years	77.4%	22.6%	43.7%
Above 65 years	53.8%	46.2%	18.3%

Table 4.5.1 Cross Tabulation of Age Group and Type of Perception

The age variable in this table is recorded at the individual-year level (ranging from 28 to 73), which makes it difficult to interpret age-by-age. However, when the responses are grouped into broader age brackets, a clearer pattern emerges regarding perception of climate change.

Among the youngest respondents (under 35 years), a relatively high proportion, 1 out of 3 (33.3%), reported having a better understanding of climate change. This awareness then drops sharply among those aged 35–44, none of whom (0 out of 7) reported a better understanding. In the 45–54 age bracket, awareness remains low, with only 2 out of 17 (11.8%) reporting a better understanding. The proportion rises again among those aged 55–64, where 7 out of 30 (23.3%) reported a better understanding, and it is highest among the oldest respondents, aged 65 and above, where 6 out of 13 (46.2%) reported a better understanding of climate change, the largest proportion of any age group.

Overall, the findings show that 77.1% of all respondents did not have a better understanding of climate change, while only 22.9% demonstrated a better understanding. Awareness dips in the middle-aged groups (35–54) and rises again among older respondents (55 and above), with those aged 65+ showing the strongest awareness overall. This suggests that age alone does not consistently predict climate change understanding; other factors, such as accumulated lived experience with environmental changes, exposure to community discussions, or targeted outreach to older residents, may explain the higher awareness observed among the oldest age group, while the dip in mid-life groups may reflect lower engagement with climate-related information during those years.

4.6 CROSS TABULATION OF CLIMATE CHANGE AWARENESS AND TYPE OF PERCEPTION

Climate change is the reason for the changes in fish availability	Type of Perception		Total
	Not having a better understanding of climate change	Better understanding of climate change	
Strongly disagree	100.0%	0.0%	1.4%
Disagree	100.0%	0.0%	1.4%
Neutral	100.0%	0.0%	10.0%
Agree	80.4%	19.6%	65.7%
Strongly agree	53.3%	46.7%	21.4%

Table: 4. 6. 1 Cross tabulation of the climate change is the reason for the changes in fish availability and Type of Perception

The figure presents the cross-tabulation between respondents' perception that climate change is the reason for changes in fish availability and their overall type of perception regarding climate change. Among the respondents who strongly disagreed, disagreed, or remained neutral, all (100.0%) belonged to the category of not having a better understanding of climate change, indicating relatively lower levels of climate change perception within these groups. Among those who agreed that climate change is

responsible for changes in fish availability, 80.4% were classified as not having a better understanding of climate change, while 19.6% had a better understanding. In contrast, among respondents who strongly agreed, 46.7% had a better understanding of climate change, compared to 53.3% who did not.

Overall, the findings indicate that respondents with a better understanding of climate change were more likely to strongly agree that climate change is influencing fish availability. The majority of the respondents (65.7%) agreed with the statement, while a further 21.4% strongly agreed, suggesting that most fishermen perceive climate change as an important factor affecting fish availability. This reflects a high level of awareness among the respondents regarding the influence of changing climatic conditions on fisheries and supports the view that environmental changes are increasingly being recognized as a major challenge to the sustainability of fishing livelihoods.

4.7 CROSS TABULATION ON SOCIO-ECONOMIC IMPACT OF CLIMATE CHANGE AND TYPE OF PERCEPTION

Loss of income due to unpredictable weather	Type of Perception		Total
	Not having a better understanding of climate change	Better understanding of climate change	
High/ Always	100.0%	0.0%	7.1%
Medium/ Sometimes	58.8%	41.2%	24.3%
Low/ Never	81.3%	18.8%	68.6%

Table 4. 7. 1 Cross tabulation of Loss of income due to unpredictable weather and type of Perception

The findings reveal that all respondents (100.0%) who reported experiencing high or constant income loss due to unpredictable weather belonged to the group not having a poorer understanding of climate change. Among those who experienced income loss

sometimes, 58.8% were classified as not having a better understanding of climate change, while 41.2% had a better understanding. Similarly, among respondents who reported low or no income loss, 81.3% were categorized as not having a better understanding of climate change and 18.8% as having a better understanding.

Overall, 68.6% of the respondents reported low or no income loss, 24.3% experienced income loss sometimes, and 7.1% experienced high or constant income loss due to unpredictable weather. The results indicate that unpredictable weather has affected the livelihoods of many fishermen, although the intensity of its impact varies. A relatively higher proportion of respondents with a better understanding of climate change was observed among those reporting medium levels of income loss, suggesting that personal experience of economic impacts may contribute to greater awareness and perception of climate change. However, across all categories, the majority of respondents were classified as not having a better understanding of climate change, indicating the continued need for climate awareness and capacity-building programmes within fishing communities

4.8 **CROSS TABULATION OF SYSTEMS AND TYPE OF PERCEPTION**

Authorities provide timely warnings before the storm	Type of Perception		Total
	Not having a better understanding of climate change	Better understanding of climate change	
Agree/ Effective	87.5%	12.5%	11.4%
Undecided	50.0%	50.0%	5.7%
Disagree/ Not effective	77.6%	22.4%	82.9%

Table 4. 8. 1 Cross Tabulation of Authorities providing timely warnings before a storm and type of Perception

Among the respondents who agreed that authorities provide timely warnings before a storm, 87.5% were classified as not having a better understanding of climate change, while 12.5% had a better understanding. Among those who were undecided, an equal proportion

(50.0%) belonged to both perception categories. Among respondents who disagreed that authorities provide timely warnings before a storm, 77.6% were categorized as not having a better understanding of climate change, whereas 22.4% had a better understanding.

Overall, the findings reveal that the majority of respondents (82.9%) disagreed that authorities provide timely warnings before a storm, while only 11.4% agreed and 5.7% remained undecided. This indicates that most fishermen perceive the existing storm warning system as inadequate or ineffective in providing timely information before hazardous weather events. Although respondents with a better understanding of climate change were present across all response categories, they constituted a relatively higher proportion among those who disagreed that timely warnings were provided. The findings suggest that improving the accessibility, timeliness, and effectiveness of early warning systems is essential for enhancing disaster preparedness and reducing the vulnerability of fishing communities to climate-related hazards.

CHAPTER 5 - FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents a comprehensive synthesis of the empirical evidence gathered during the field investigation regarding the socioeconomic and environmental impacts of climate change on the fisheries sector of Thiruvananthapuram (Trivandrum) district. Marine fisheries represent a highly dynamic socio-ecological system where human livelihoods are inextricably linked to climatic variables, marine ecosystems, and institutional structures. By analyzing primary data collected across diverse fishing villages, including Puthenthope, Pallithura, Poonthura, St. Andrews, Pozhiyoor, Vettuthura, and Thumba, this study delineates the structural vulnerabilities that define contemporary fishing communities in Southern Kerala.

5.2 FINDINGS

The analytical focus is dual-pronged: first, evaluating the demographic, occupational, and economic baselines that govern the adaptive capacity of coastal households; and second, deconstructing how these communities perceive, comprehend, and interpret the environmental shifts associated with global climate change. Through this cross-sectional exploration, the study maps the intricate dependencies between educational attainment, occupational longevity, generational shifts, and explicit climate literacy. Ultimately, the findings presented herein provide a diagnostic baseline intended to inform evidence-based policy interventions, community-driven adaptation strategies, and sustainable coastal zone management paradigms.

The spatial distribution of the sample population underscores a comprehensive geographical representation of the coastal belt of Thiruvananthapuram district. The empirical mapping indicates that the largest single proportion of respondents originated from Puthenthope (18.6%), followed by significant clusters in Pallithura (14.3%) and Poonthura (14.3%). Notable segments were also sampled from St. Andrews (11.4%) and Pozhiyoor (10.0%), while smaller traditional enclaves such as Valiyathura (5.7%) and Thumba (1.4%) completed the geographical matrix. This widespread spatial sampling

ensures that the data reflect varied localized ecological conditions, differing degrees of coastal erosion, and diverse landing site infrastructures within the district.

The demographic data reveal an aging and highly stable occupational workforce within the artisanal and artisanal-motorized fishing sectors. A profound majority of active fishermen have long-term occupational exposure: 37.1% of the respondents have spent more than 30 years in active fishing operations, 27.1% have between 21 and 30 years of experience, and 25.7% have been engaged in the sector for 11 to 20 years. Conversely, new entrants with less than 10 years of experience account for a mere 10.0% of the sample. This distribution signifies a stark lack of generational renewal, indicating that while the current workforce holds vast repositories of experiential and observational knowledge regarding marine environments, fewer young individuals are entering the sector due to increasing economic volatility.

The operational characteristics of the regional fleet demonstrate near-total dominance of intermediate technological adoption. A vast majority of 88.6% of the respondents are engaged in motorized fishing operations, utilizing traditional hulls fitted with outboard marine engines. In contrast, purely traditional, non-motorized craft (5.7%) and heavily capitalized mechanized vessels (5.7%) represent marginal outliers. This pattern highlights a clear technological lock-in: the community has shifted away from zero-emission traditional crafts to escape physical exhaustion and expand their fishing range, yet they lack the capital resources required to transition into deep-sea mechanized trawling.

The internal socioeconomic hierarchy of the Thiruvananthapuram fishing sector reveals a highly stratified occupational division of labor. Boat owners comprise 40.0% of the sample population, representing the primary capital investors within the artisanal sector. The remainder of the community consists of dependent labor forces: 31.4% operate as designated crew members (often working under profit-sharing or wage agreements), and 28.6% are classified as generic or seasonal fish laborers. This division emphasizes that nearly 60% of the active fishing community does not own assets, rendering them highly sensitive to localized catch failures and variations in owner-led compensation models.

The financial profile of the surveyed households reveals deep, structural income compression and widespread economic vulnerability as:

- Monthly Income Distribution: A staggering 57.1% of fishing households earn up to only ₹10,000 per month, while 38.6% subsist on incomes between ₹10,000 and ₹20,000. A marginal fraction (4.3%) manages to clear more than ₹20,000 monthly.
- Livelihood Dependency: This low-income threshold is exacerbated by an extreme reliance on a single sector: 84.3% of respondents depend entirely on primary fishing operations as their sole source of income, while a minor 15.7% derive sustenance from ancillary or allied activities (such as net repairing, fish vending, or minor drying operations).
- Dependency Ratios: The domestic demographic balance places intense pressure on individual earners. Households with 1–3 members constitute 54.3% of the sample, while 44.3% support larger families of 4–6 members. Critically, 52.9% of these households rely on a single earning member, leaving them highly vulnerable to economic shocks if that individual experiences injury, illness, or climate-induced loss of fishing days.

The human capital profile of the coastal community is characterized by widespread primary literacy alongside a clear ceiling on advanced educational progression. The data shows that 70.0% of respondents completed primary education, and 28.6% achieved secondary schooling. Total illiteracy remains remarkably low at 1.4%, reflecting Kerala's historically strong social development indicators. However, the total absence of tertiary, vocational, or technical education across the sample demonstrates a profound barrier to occupational mobility. This historical lack of higher education locks households into coastal extraction, preventing them from diversifying into non-fishery white-collar or technical jobs.

The physical asset mapping of the coastal zone presents an interesting contrast between housing structural quality and spatial environmental risk:

- Housing Quality: A high proportion of the respondents (85.7%) reside in pucca (permanent, concrete-built) housing structures, while 12.9% occupy semi-pucca

units, and only 1.4% live in fragile kutcha dwellings. This indicates substantial historical public housing assistance and capital investment in domestic structures.

- Spatial and Environmental Risk: Despite resilient building materials, the physical positioning of these homes exposes them to severe environmental hazards. The data proves that 95.7% of all fishing households live within immediate, hazardous proximity to the ocean: 41.4% reside within a critical 50-metre zone from the active shoreline, and 54.3% live between 50 and 200 metres from the coast. Only 4.3% reside safely beyond the 200-metre mark. Consequently, nearly the entire community is directly exposed to coastal erosion, storm surges, sea-level rise, and the cyclonic events that increasingly impact the Thiruvananthapuram coast.

A major structural weakness identified by the study is the widespread fragmentation of social and institutional capital within these communities. Nearly half of the respondents (47.1%) report absolutely no active membership in any professional, community, or civic organization**.** Among those who do maintain institutional ties, 34.3% participate in traditional primary fisheries cooperative societies (such as Matsyafed networks), 11.4% are affiliated with marine trade unions, and a minimal 7.1% engage with neighborhood Self-Help Groups (SHGs). This lack of institutional connection severely reduces the community's capacity for collective bargaining, limits their access to formal credit markets, and hinders the smooth dissemination of state-led climate adaptation aid.

The operational inputs of the artisanal fleet reveal a near-total dependence on petroleum products. The data demonstrates that 77.1% of motorized fishing crafts rely strictly on petrol to power their outboard motors, whereas 8.6% utilize diesel and 2.9% utilize subsidized kerosene. This profound reliance on petrol exposes the economic viability of everyday fishing trips to severe volatility driven by international fossil fuel price hikes and shifting domestic tax structures. This vulnerability is magnified when climate-induced disruptions force fishermen to travel further out to sea to locate shifting pelagic fish schools.

To understand the socio-environmental interface, the study cross-tabulated the respondents' subjective "Understanding of Climate Change" against key demographic indicators, including occupational experience, formal education, and age. The overarching finding is alarming: 77.1% of the total fishing population lacks a proper, functional understanding of climate change, leaving only 22.9% with a clear comprehension of the global atmospheric and marine shifts affecting their local waters. The empirical correlation between active field experience and climate change literacy highlights a non-linear relationship that challenges conventional assumptions. Among the youngest, least-experienced tier (less than 10 years), 100.0% reported no clear understanding of climate change, indicating a major lack of introductory environmental training for new entrants.

Crucially, the highest level of climate awareness was observed among fishermen with moderate experience (11–20 years), where 44.4% demonstrated a solid understanding**.** This group represents a critical demographic capable of bridging empirical field observations with modern climate information systems. Conversely, awareness drops sharply among highly experienced cohorts. Among fishermen with 21–30 years of service, 78.9% lacked a clear understanding, and this deficit peaked among veterans with over 30 years of experience, 84.6% of whom could not articulate a clear comprehension of formal climate change concepts**.** This data proves that decades of practical fishing experience do not automatically translate into a structural understanding of global climate change. While veteran fishermen are highly adept at identifying localized weather disruptions, they frequently lack the vocabulary or conceptual frameworks to link these shifts to systemic, global anthropogenic climate change.

Cross-tabulating educational levels against climate awareness demonstrates that formal schooling acts as a vital catalyst for environmental literacy. Among respondents who only received a primary school education, 81.6% lacked a clear understanding of climate change, with only 18.4% displaying basic comprehension. In contrast, respondents who completed secondary education demonstrated a significantly higher capacity for climate literacy: 35.0% of secondary-educated fishermen displayed a solid understanding of climate change dynamics, marking the highest awareness level across all educational brackets. The small illiterate segment (1.4% of the total sample) showed a complete absence of climate

awareness (100.0% lacking understanding). These findings confirm that formal secondary education equips individuals with the fundamental scientific literacy required to comprehend, interpret, and act upon complex scientific information, early warning alerts, and institutional climate literature.

When raw individual ages (ranging from 28 to 73 years) are aggregated into broader generational cohorts. Among the youngest cohort (under 35 years), climate awareness is relatively resilient at 33.3%, which is likely driven by higher secondary school completion rates and early exposure to digital media and mobile-based information networks. However, this awareness drops to 0.0% within the 35–44 age bracket and remains highly compressed at 11.8% within the 45–54 age group. Surprisingly, climate literacy rises again in the older demographics: it climbs to 23.3% among those aged 55–64 and peaks at an impressive 46.2% among the oldest cohort aged 65 and above. The middle-aged cohorts (35–54) appear caught in a structural gap, lacking both the formal education of the youth and the long-term historical perspective of the elderly, which leaves them highly vulnerable to climate misinformation.

5.3 SUGGESTIONS/ RECOMMENDATIONS

1. Strengthen Climate Change Awareness and Capacity Building

Regular climate change awareness programmes should be organized for fisheries-dependent communities through the Department of Fisheries, local self-governments, and research institutions. Awareness campaigns should be conducted in Malayalam using simple and locally relevant educational materials to improve understanding of climate change, marine ecosystem changes, sustainable fishing practices, and disaster preparedness. Community-based training programmes should particularly target fishers with limited educational backgrounds and those having lower levels of climate awareness.

2. Promote Sustainable Coastal Protection and Climate Adaptation

Government agencies should prioritize ecosystem-based coastal protection measures such as mangrove restoration, beach nourishment, and coastal vegetation instead of relying

solely on hard engineering structures. Coastal erosion-prone areas should be continuously monitored, and vulnerable households residing close to the shoreline should be provided with safe housing, adequate compensation, and climate-resilient infrastructure. Effective implementation of Coastal Regulation Zone (CRZ) guidelines is essential to minimize environmental degradation and reduce disaster risk.

3. Enhance Livelihood Diversification and Financial Security

Considering the heavy dependence of households on marine fisheries, alternative livelihood opportunities should be promoted to reduce economic vulnerability during fishing bans and extreme weather events. Programmes supporting aquaculture, seaweed farming, ornamental fish culture, fish processing, value addition, and small-scale entrepreneurship should be strengthened. Access to affordable institutional credit, insurance coverage, and livelihood assistance should also be expanded to improve the financial resilience of fishing households.

4. Strengthen Fisheries Cooperatives and Community Participation

Fisheries cooperatives should be strengthened to function as community resource centres for climate adaptation, welfare services, and disaster preparedness. Greater efforts should be made to encourage the participation of fishers who are currently not members of any cooperative or community organization. These institutions can play a significant role in disseminating weather advisories, providing access to government welfare schemes, organizing capacity-building programmes, and facilitating community-based adaptation initiatives.

5. Improve Access to Climate Information and Early Warning Systems

Timely dissemination of weather forecasts, early warning messages, and ocean information should be enhanced through mobile applications, SMS alerts, community radio, and public announcement systems in the local language. Collaboration between agencies such as the India Meteorological Department (IMD), the Indian National Centre for Ocean Information Services (INCOIS), and the Department of Fisheries should be strengthened

to ensure that fishers receive reliable and accurate information before venturing into the sea. This would improve preparedness and reduce the risks associated with extreme weather events.

6. Encourage Sustainable Fisheries Management and Future Research

Sustainable fisheries management practices should be promoted through scientific monitoring of fish stocks, responsible fishing methods, and conservation of marine ecosystems. Greater collaboration among government agencies, research institutions, and coastal communities is necessary to develop evidence-based climate adaptation policies. Future studies may include larger sample sizes, comparative analyses across different coastal districts, and longitudinal assessments to better understand the long-term socio-economic and environmental impacts of climate change on fisheries.

5.4 CONCLUSION

This dissertation reveals a critical structural paradox within the marine fisheries sector of Thiruvananthapuram district: the very population living on the absolute geographic and economic frontline of global climate change is largely locked out of the systemic knowledge frameworks required to build long-term resilience, and this exclusion compounds the severe socio-economic precarity that characterizes artisanal-motorized fishing communities in the district; with over 95% of households earning less than ₹20,000 per month and more than half surviving on less than ₹10,000, almost no surplus capital exists to absorb or recover from systemic disruptions, while high dependency ratios—where a single working member typically supports an entire family on income derived exclusively from an unstable, weather-dependent marine ecosystem—intensify vulnerability, reduce capacity for investment in adaptive measures, and heighten the risk of cascading livelihood failures during climate-driven shocks.

Environmentally, the physical risks facing these communities are immediate and acute. The fact that 95.7% of the entire sample population resides within 200 metres of the high-tide line indicates an extraordinary degree of exposure to coastal hazards. As climate change increases the frequency and intensity of severe cyclonic disruptions along India's

southwestern coast, these households face simultaneous threats to both their livelihoods at sea and their physical homes on land. The core issue highlighted by this research is the extensive 77.1% climate literacy deficit. The cross-tabulation data clearly demonstrate that decades of practical fishing experience do not automatically help individuals understand the larger scientific drivers of climate change. This lack of structural understanding limits the community's capacity to move beyond short-term reactive measures toward long-term proactive adaptation. Furthermore, the high reliance on petrol fuel ties the daily survival of these fishermen directly to volatile fossil fuel markets. When local fish populations migrate unexpectedly due to rising sea surface temperatures, fishermen are forced to spend more on fuel to search for catch, driving them deeper into debt.

In conclusion, the fishing communities of Thiruvananthapuram are entrenched in a self-reinforcing cycle of vulnerability driven by high geographic exposure to climate hazards, acute economic precarity, heavy reliance on fossil-fuelled operations, limited climate literacy, and a fragmented institutional landscape that leaves many households outside formal safety nets and dependent on informal, high-cost credit; breaking this cycle requires a shift from episodic relief to integrated, long-term structural adaptation that strengthens community organization and cooperative participation, expands access to climate and fisheries science, improves financial resilience through inclusive credit and insurance mechanisms, promotes fuel-efficient and climate-smart fishing technologies, and mainstreams locally grounded knowledge into policy and planning—measures that together can enhance adaptive capacity, secure livelihoods, and reduce the deep-rooted socio-environmental risks faced by artisanal-motorized fishers.

CHAPTER 6 – REFERENCES AND ANNEXURES

6.1 REFERENCES

1. Adger, W. N. (2006). Vulnerability. *Global Environmental Change, 16*(3), 268–281.
2. Agrawal, K., Sharma, D., & Sharma, S. (2024). Integrating energy security, economy, and environment for just energy transition policies for India. *Environmental Science & Policy, 151*, 103620.
3. Alex, A., Ancy, V. P., & Shibu, A. V. (2023). Climate change induced occupational shifts of fishermen in selected coastal areas of central Kerala. *Journal of Aquatic Biology & Fisheries, 11*, 89–97.
4. Allison, E. H., Perry, A. L., Badjeck, M. C., Adger, W. N., Brown, K., Conway, D., Halls, A. S., Pilling, G. M., Reynolds, J. D., Andrew, N. L., & Dulvy, N. K. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries, 10*(2), 173–196.
5. American Psychological Association. (2020). *Publication manual of the American Psychological Association* (7th ed.). American Psychological Association.
6. Anjitha, M. C., & Bhattacharjee, S. (2026). Understanding climate vulnerability, infrastructure gaps, and social support in coastal fishing communities: A preliminary factor study from Thiruvananthapuram, India. *Ocean & Coastal Management, 272*, 107941.
7. Aswathy, N., Narayanakumar, R., Geetha, R., Salim, S. S., Najmudeen, T. M., Safeena, P. K., & Antony, B. (2023). Economic and livelihood impacts of the decline in Indian oil sardine landings in Kerala State, India. *Indian Journal of Fisheries, 70*(2), 114–121.
8. Barange, M., Bahri, T., Beveridge, M. C. M., Cochrane, K. L., Funge-Smith, S., & Poulain, F. (Eds.). (2018). *Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options* (FAO Fisheries and Aquaculture Technical Paper No. 627). Food and Agriculture Organization of the United Nations.
9. Beaugrand, G. (2004). The North Sea regime shift: Evidence, causes, mechanisms and consequences. *Progress in Oceanography, 60*(2–4), 245–262.
10. Bennett, N. J., Finkbeiner, E. M., Ban, N. C., Belhabib, D., Jupiter, S. D., Kittinger, J. N., Mangubhai, S., Scholtens, J., Gill, D., & Christie, P. (2021). The COVID-19

pandemic, small-scale fisheries and coastal fishing communities. *Coastal Management, 49*(2), 199–224.

11. Biju Kumar, A., Bhagyalekshmi, V., & Riyas, A. (2017). Climate change, fisheries and coastal ecosystems in India. *International Journal of Marine Science, 7*(12), 108–126.
12. Brander, K. M. (2005). Cod recruitment is strongly affected by climate when stock biomass is low. *ICES Journal of Marine Science, 62*(3), 339–343.
13. Brander, K. M. (2010). Impacts of climate change on fisheries. *Journal of Marine Systems, 79*(3–4), 389–402.
14. Brander, K. M., Blom, G., Borges, M. F., Erzini, K., Henderson, G., MacKenzie, B. R., Mendes, H., Ribeiro, J., Santos, A. M. P., & Toresen, R. (2003). Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature? *ICES Marine Science Symposia, 219*, 261–270.
15. Brander, K. M., & Mohn, R. K. (2004). Effect of the North Atlantic Oscillation on recruitment of Atlantic cod. *ICES Journal of Marine Science, 61*(8), 1158–1164.
16. ICAR–Central Marine Fisheries Research Institute. (2024). *Annual report 2023–2024*. ICAR–Central Marine Fisheries Research Institute.
17. Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
18. Department of Fisheries. (2023). *Kerala fisheries statistics 2023*. Government of Kerala.
19. Edwards, M., & Richardson, A. J. (2004). Impact of climate change on marine pelagic phenology and trophic mismatch. *Nature, 430*(7002), 881–884.
20. Food and Agriculture Organization of the United Nations. (2022). *The state of world fisheries and aquaculture 2022: Towards blue transformation*. FAO.
21. Hamza, F., Valsala, V., Anju, M., & George, G. (2020). Climate impacts on the landings of Indian oil sardine over the south-eastern Arabian Sea. *Fish and Fisheries, 21*(3), 515–532.
22. Intergovernmental Panel on Climate Change. (2023). *Climate change 2023: Synthesis report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Core Writing Team, H. Lee, & J. Romero, Eds.). IPCC.

23. Kerala State Disaster Management Authority. (2022). *Kerala state disaster management plan*. Government of Kerala.
24. King, J. R. (2005). *Report of the Study Group on Fisheries and Ecosystem Responses to Recent Regime Shifts* (PICES Scientific Report No. 28). North Pacific Marine Science Organization.
25. Kothari, C. R. (2004). *Research methodology: Methods and techniques* (2nd ed.). New Age International Publishers.
26. Mohamed, K. S., Zacharia, P. U., Rohit, (2014). *Marine fish diversity of the Indian coast*. ICAR–Central Marine Fisheries Research Institute.
27. National Centre for Sustainable Coastal Management. (2018). *Shoreline change atlas of the Indian coast: Kerala coast*. Ministry of Environment, Forest and Climate Change.
28. Panikkaveettil, A., Satheesan, K., Sukumaran, S. P., & Madanarajan, A. C. (2024). Impact of climate change on asset loss and livelihood disruption in Kerala's traditional fisheries sector. *Marine Policy, 160*, 105982
29. Perry, A. L., Low, P. J., Ellis, J. R., & Reynolds, J. D. (2005). Climate change and distribution shifts in marine fishes. *Science, 308*(5730), 1912–1915.
30. Ramamurthy, A., Chandran, A. G., & Chundeli, F. A. (2025). Resilience of coastal communities to climate change in the Thiruvananthapuram region, Kerala, India. *Indian Journal of Geo-Marine Sciences, 54*(1), 45–58.
31. Rao, R. R.,(2015). Coastal upwelling processes along the southwest coast of India and their influence on marine productivity. *Journal of Geophysical Research: Oceans, 120*(11), 7421–7438.
32. Rehman, S., Azhoni, A., & Chabbi, P. H. (2022). Livelihood vulnerability assessment and climate change perception analysis in Arunachal Pradesh, India. *Environmental Development, 42*, 100705.
33. Resnik, D. B. (2020). *What is ethics in research & why is it important?* National Institute of Environmental Health Sciences.
34. Richardson, A. J., & Schoeman, D. S. (2004). Climate impact on plankton ecosystems in the Northeast Atlantic. *Science, 305*(5690), 1609–1612.

35. Sajna, V. H., Zacharia, P. U., Liya, V. B., Rojith, G., Somy, K., Joseph, D., & George, G. (2019). Effect of climatic variability on the fishery of Indian oil sardine along the Kerala coast. *Journal of the Marine Biological Association of India, 61*(2), 22–31.
36. Salim, S. S. (2014). Climate change hotspots, vulnerability assessments and resilience options: Lessons from India. *Indian Journal of Geo-Marine Sciences, 43*(6), 943–952.
37. Salim, S. S., Bhat, A. A., & Thomas, J. (2014). Vulnerability assessment of coastal fisher households in Kerala to climate change. *Indian Journal of Fisheries, 61*(4), 112–118.
38. Shankar, D., Vinayachandran, P. N., & Unnikrishnan, A. S. (2002). The monsoon currents in the north Indian Ocean. *Progress in Oceanography, 54*(1–4), 547–586.
39. Shyam, S., Salim, S. V., Kripa, V., Zacharia, P. U., Mohan, A., Ambrose, T. V., & Manjurani, M. (2014). Vulnerability assessment of coastal fisher households in Kerala: A climate change perspective. *Marine Fisheries Information Service: Technical and Extension Series, 220*, 3–10.
40. Stige, L. C., Ottersen, G., Brander, K., Chan, K.-S., & Stenseth, N. C. (2006). Cod and climate: Effect of the North Atlantic Oscillation on recruitment of Atlantic cod. *Marine Ecology Progress Series, 325*, 243–256.
41. United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. United Nations General Assembly.
42. Vijith, V., (2016). Seasonal upwelling along the southwest coast of India and its ecological significance. *Continental Shelf Research, 117*, 67–79.
43. Zacharia, P. U., Hussain, S. V., Joseph, D., Somasekharan, A., Rojith, G., Benny, S., & Ninan, R. G. (2021). Impact of climate change on the fishery of Indian mackerel (*Rastrelliger kanagurta*) along the Kerala coast in the southeastern Arabian Sea. *Journal of the Marine Biological Association of India, 63*(1), 112–118.
44. Chambers, R., & Conway, G. R. (1992). *Sustainable rural livelihoods: Practical concepts for the 21st century* (IDS Discussion Paper No. 296). Institute of Development Studies. Cited by: 11324
45. Sudhakaran, B. V. (2025). Climate change vulnerabilities on livelihood of fishing and allied communities of southwest coast of India: A case study of Azheekkal fishing

village, Kerala, India. *International Journal of Ecology and Environmental Sciences*, *51*(5)

6.2 ANNEXURES

Questionnaire

1. Name:
2. Age:
3. Name of the fishing village:

4. Years of Experience

a) Less than 10 years

b) 11–20 years

c) 21–30 years

d) More than 30 years

5. Fishing Category

a) Traditional (Vallom)

b) Motorized

c) Mechanized

6. Ownership Status

a) Boat Owner

b) Laborer

c) Vendors

d) Crew

7. Monthly Income (Avg)

    a) 10,000

    b) 10,000–20,000

    c) More than 20,000

8. Education Level

    a) Primary

    b) Secondary

    c) Graduate & Above

    d) Illiterate

9. Marital Status

    a) Single

    b) Married

    c) Widowed

    d) Divorced

10. Family Size

    a) 1–3 members

    b) 4–6 members

    c) More than 6 members

11. Number of Earning Members

    a) Only me

    b) Two members

    c) Three or more

12. Primary Source of Income

    a) Fishing

    b) Fishing + Allied activities

    c) Daily wages

13. Type of Housing

a) Kutcha

b) Semi-Pucca

c) Pucca (Concrete)

14. Membership in Organizations

a) SHG

b) Trade Union

c) Cooperative society

d) None

15. Distance from Shoreline

a) 50 meters

b) 50–200 meters

c) More than 200 meters

16. Type of Fuel Used

a) Kerosene

b) Petrol

c) Diesel

d) N/A

17. Noticed a rise in sea level over the last decade.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

18. The sea is becoming rougher more frequently than in the past.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

19. Changes in wind patterns are affecting my fishing trips.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

20. Climate Change is the reason for the change in fish availability.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

21. I believe changes in the climate are directly causing the disappearance of certain local fish species.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

22. I have observed an increase in sea surface temperature in recent years.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

23. The timing of the monsoon has become more unpredictable.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

24. Noticed an increase in the frequency of "Kallakkadal" (swell surges).

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

25. The color or clarity of the seawater has changed over the last decade.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

26. I notice more plastic and debris being washed ashore after storms.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

27. Coastal erosion is significantly reducing the space for parking boats.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

28. I believe human activities (like pollution) are worsening climate change.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

29. Deep-sea currents have become stronger and harder to navigate.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

30. There is a noticeable decrease in the size of the fish being caught.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

17. I have noticed a rise in sea level over the last decade.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

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18. The sea is becoming rougher more frequently than in the past.

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a) Strongly disagree

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e) Strongly agree

29. Deep-sea currents have become stronger and harder to navigate.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

30. There is a noticeable decrease in the size of the fish being caught.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

. I have started seeing "new" or unfamiliar fish species in my nets.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

32. Traditional "Chakara" (mud banks) are appearing less frequently now.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

33. I feel the summer heat has become more intense while out at sea.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

34. Frequent cyclones in the Arabian Sea are a relatively new phenomenon.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

35. The number of "no-fishing" days due to bad weather has increased.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

36. I believe the shore is moving closer to my village every year.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

37. Changes in the sea are making it harder to find traditional fishing spots.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

38. Increased rainfall intensity is causing more runoff into the coastal waters.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

39. The sea stays rough for a longer duration than it used to in the past.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

40. I have heard about "Climate Change" through the media or local meetings.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

41. I am worried that the sea will eventually submerge my house/village.

a) Strongly disagree

b) Disagree

c) Neutral

d) Agree

e) Strongly agree

42. Loss of income due to unpredictable weather.

a) Low/Never

b) Medium/Sometimes

c) High/Always

43. Reduction in the quantity of high-value fish species.

a) Low/Never

b) Medium/Sometimes

c) High/Always

44. Need for taking loans to cover fishing losses.

a) Low/Never

b) Medium/Sometimes

c) High/Always

45. Frequent need for expensive repairs to nets/boats due to unexpected storms.

a) Low/Never

b) Medium/Sometimes

c) High/Always

46. Stress or mental pressure due to fear of the sea.

a) Low/Never

b) Medium/Sometimes

c) High/Always

47. Physical health issues (heat exhaustion/injuries).

a) Low/Never

b) Medium/Sometimes

c) High/Always

48. Damage to housing or property due to coastal erosion.

a) Low/Never

b) Medium/Sometimes

c) High/Always

49. Lack of access to clean drinking water or sanitation in the coastal colony.

a) Low/Never

b) Medium/Sometimes

c) High/Always

50. Increased expenditure on fuel to find fish in deeper waters.

a) Low/Never

b) Medium/Sometimes

c) High/Always

51. Decrease in the number of fishing days per month.

a) Low/Never

b) Medium/Sometimes

c) High/Always

52. Difficulty in repaying existing bank or private loans.

a) Low/Never

b) Medium/Sometimes

c) High/Always

53. Reliance on jewelry pawning or selling assets to meet daily needs.

a) Low/Never

b) Medium/Sometimes

c) High/Always

54. High fluctuation in fish market prices affects daily profit.

a) Low/Never

b) Medium/Sometimes

c) High/Always

55. Need for additional part-time work outside of fishing to survive.

a) Low/Never

b) Medium/Sometimes

c) High/Always

56. Reduction in household spending on quality food or nutrition.

a) Low/Never

b) Medium/Sometimes

c) High/Always

57. Difficulty in paying for children's school or college fees.

a) Low/Never

b) Medium/Sometimes

c) High/Always

58. Family members migrating to other cities/states for work.

a) Low/Never

b) Medium/Sometimes

c) High/Always

59. Conflict within the community over dwindling fishing territories.

a) Low/Never

b) Medium/Sometimes

c) High/Always

60. Feeling of insecurity regarding the future of the fishing village.

a) Low/Never

b) Medium/Sometimes

c) High/Always

61. Increased cost of ice and cold storage due to rising temperatures.

a) Low/Never

b) Medium/Sometimes

c) High/Always

62. Loss of traditional drying grounds due to sea-level rise or erosion.

a) Low/Never

b) Medium/Sometimes

c) High/Always

63. Damage to community buildings (schools/hospitals) near the coast.

a) Low/Never

b) Medium/Sometimes

c) High/Always

64. Inability to afford new safety equipment (GPS, Life jackets).

a) Low/Never

b) Medium/Sometimes

c) High/Always

65. Dependence on government free rations during the off-season.

a) Low/Never

b) Medium/Sometimes

c) High/Always

66. Total loss of workdays due to harbor or landing center damage.

a) Low/Never

b) Medium/Sometimes

c) High/Always

67. Authorities provide timely alerts before a storm.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

68. The warning messages (TV/Mobile/Radio) are easy to understand.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

69. Traditional signs (clouds/birds/wind) are still reliable.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

70. Local knowledge is more useful than official weather reports.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

71. I would encourage my children to take up fishing as a career.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

72. Government support (subsidies/insurance) is sufficient.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

73. I receive weather alerts in my local language (Malayalam) early enough to secure my boat.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

74. I am willing to relocate if the government provides housing in a safer area.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

75. Community-led groups (Church/Mosque/Temple committees) are helpful during sea surges.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

76. Traditional fishing calendars and seasonal signs are no longer reliable for planning trips.

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

77. Have you noticed an increase in accidents or injuries at sea due to unpredictable weather?

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

78. How much has climate change increased the physical danger of your daily work?

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

79. Have you considered moving to a different region because fishing is no longer viable?

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective

80. How often has the lack of fish/income made it difficult to provide nutritious food for the children?

a) Disagree/Not Effective

b) Undecided

c) Agree/Effective