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Assessing Disaster Risk and Enhancing Resilience in Kerala's Coastal Villages: A Case Study of Eriyad Grama Panchayat

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Abstract

Climate change is intensifying disasters worldwide. The impact of a disaster is determined by the risk associated with a hazard and the varying levels of vulnerability of the community. Hence the need for effective disaster management is underscored in today's scenario where disaster risk is being increased by climate change. The coastal communities in Kerala are exposed to disasters in various physical, social, political and economic contexts and are subjected to the losses and damage caused by coastal disasters like tsunami, cyclones, storm surges, swell waves, coastal flooding etc. To comprehensively assess their exposure levels and susceptibility to tsunami occurrences and related disasters, a systematic and multidisciplinary socioeconomic survey approach was adopted by at Eriyad Grama Panchayat in Thrissur district, Kerala, India. This survey on coastal communities highlighted the varying levels of exposure of hazards in the region. The devastating 2018 flood caused significant damage to the regions and also had an impact on the livelihoods of the people. The survey highlighted the need for strengthening community-based disaster management strategies, continuous training programs, and infrastructural improvements that are essential for further reducing disaster risks and ensuring long-term resilience in these vulnerable areas. It is very essential for the coastal people to understand how to protect themselves from these disasters and to recover from the effects. Enhancing disaster resilience through disaster risk reduction efforts is crucial for saving lives, protecting property and promoting sustainable development within the coastal community.

Keywords: Climate change, Coastal disasters, Disaster risk reduction, Community resilience

1 Introduction

The coastal zone is an essential component of the biosphere, serving as a transition zone between land and sea [1, 4]. Coastal zones are distinct due to their unique natural and socioeconomic features. These zones are prime locations for settlements, where populations engage in

activities such as trading, fishing, and tourism. These settlements range from small fishing villages to large coastal cities. The World Bank has reported in 2015 that approximately 38% of the world's population lives in coastal areas, which are defined as places within 100 km of the shore [1].

The coastal zone of Kerala stretches across an extensive 600.15 kilometres. Located at an elevation of less than 8 meters above Mean Sea Level (MSL), this region covers approximately 15% of the state's total area, spanning around 38,863 square kilometres. Stretching across nine districts - Thiruvananthapuram, Kollam, Alappuzha, Ernakulam, Thrissur, Malappuram, Kozhikode, Kannur, and Kasaragod - this 600.15-kilometer coastline encompasses 222 coastal villages [1, 5]. The region's ecosystem is further enriched by 27 estuaries and 7 lagoons, or kayals, showcasing its remarkable diversity [1, 9].

Due to the geographical positioning near the Arabian Sea, coastal areas in Kerala are prone to various natural threats. Kerala's coastline faces a multitude of threats, particularly during monsoon seasons when storm surges and flooding. The rising sea levels amplify the vulnerability of coastal communities to flooding and erosion [1]. The rising sea level has a deleterious effect on coastal fishing communities. Changes in marine fish stock distribution due to rising seawater temperatures may impact commercial fisheries [2, 5, 7]. The region is more susceptible to tsunamis also, which causes catastrophic damage. Saltwater intrusion into freshwater sources poses an additional threat that has severe impacts on agriculture and access to clean water. Furthermore, the other anthropogenic activities also trigger these risks. To safeguard the resilience and safety of coastal communities, it is essential to develop and implement effective mitigation and adaptation strategies [1].

Kerala's 370-kilometer coastline is vulnerable to coastal erosion, driven by factors such as early monsoons, high waves, and rising sea levels. Although 53% of its coast is fortified, approximately 10.3% still experiences erosion to varying degrees. Notably, erosion rates differ significantly across districts, with Thrissur facing the lowest at 1.5%, while Thiruvananthapuram is affected with 23%. This variation highlights the localized nature of coastal erosion in Kerala, underscoring the need for targeted interventions [1].

1.1 Vulnerability

The IPCC Third Assessment Report (TAR) describes vulnerability as —The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.

Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity [1].

Fisheries sector plays an important role in the economic activity of the nation, through its contribution to national income, foreign exchange, food and employment. About 12.49 lakh fisher folk operate using diverse types of craft-gear combinations with regional and seasonal variations all along the Indian coastline. It is estimated that fishery and allied activities provide livelihood security to about 30 million people. The density of population is relatively more all along the coastline as compared to the other regions like midlands and the highlands. The fisheries sector contributes significantly to India's economy, providing livelihood security to around 30 million people and supporting 1.25 million fisher folk, with high population density along the coastline. Kerala's rich marine resources and skilled fishing population make it a significant fish producer, but overfishing and climate change are threatening the sector, exacerbating marginalization and vulnerability of fishing communities [7].

Coastal zones face threats from climate change, including natural impacts like coastal erosion and sea level rise, and man-made issues like overpopulation, pollution, and habitat destruction, putting communities at risk of inundation and other severe consequences. According to projections, a 1-meter sea level rise over 20-50 years could inundate coastal villages, and global seawater temperatures are expected to rise by 0.8-2.5°C by 2050 [7].

Various communities, including low-income and marginalized groups, children, elderly, women, and rural and urban poor, face differing levels of vulnerability to climate change and other threats. Vulnerability is shaped by multiple factors that vary depending on the specific context [1].

The studies reveal that fisher households are significantly affected by climate change in the long term, particularly through loss of fishing days and erratic monsoons [2]. Fishers are aware of environmental changes but lack awareness of climate change, recognizing only immediate impacts like reduced fishing days and economic losses, rather than long-term effects [5, 6]. The awareness of fishers on climate change effects remains low, making it difficult for them to connect environmental changes to their livelihood. To address this an approach is necessary to

involve fishers in disaster preparedness. By engaging the community and primary stakeholders, fishers can be better equipped to adapt to climate change and ensure a resilient future [2].

1.2 Major Issues of Kerala Coast

Coastal zones face unique challenges like erosion, pollution, and habitat destruction, disproportionately affecting communities who face displacement and livelihood threats [9].

- India's rapid infrastructure development is driving massive sand mining, particularly in Kerala's rivers, causing devastating environmental impacts. These include river ecosystem destruction, lowered water tables, loss of biodiversity, saline water intrusion, and damage to fish breeding and migration, ultimately threatening ecosystems and wildlife [9].
- Mangroves are vital ecosystems that protect coastlines, treat wastewater, and support biodiversity. However, Kerala's mangrove forests have drastically declined due to encroachment, commercial prawn farming, sand mining, and development projects, threatening these fragile ecosystems [9].
- Kerala's coastline is highly vulnerable to erosion, affecting approximately 370 km due to factors like monsoon waves, sea level rise, and human activities such as urbanization and harbour development. The erosion is most pronounced during the monsoon season, highlighting the need for targeted conservation efforts [9].

1.3 Objectives of the study

The study aimed to provide a comprehensive understanding of the exposure, challenges, and opportunities faced by the coastal community of Eriyad Panchayat, Kerala with a focus on tsunami-related hazards and other coastal disasters. The specific goals of the study are outlined as follows:

- **To identify various disasters faced by coastal community:** This means to document the range of natural and human-induced disasters affecting the coastal population, such as tsunamis, coastal erosion, flooding, cyclones, and salinization and to assess the frequency, intensity, and impact of these disasters on livelihoods, infrastructure, and the environment.

- **To analyse the effectiveness of early warning communication system:** To evaluate the community's awareness and response to existing early warning systems for tsunamis and other disasters and also to identify gaps in communication channels, including the accessibility, timeliness, and reliability of warnings provided to the community.
- **To analyse Government schemes and funds for the coastal community:** To assess the awareness and utilization of government programs and funding initiatives aimed at improving coastal resilience and livelihoods along with identification of barriers in accessing these resources and suggesting ways to improve their effectiveness and outreach.
- **To analyse the availability of freshwater:** To assess the current state of freshwater resources in the region, including the impact of salinization and seasonal variability and also to identify challenges in accessing clean and reliable freshwater for drinking, irrigation, and other needs. Community-led solutions and policy interventions to address freshwater scarcity was also aimed to explore.
- **To understand the change in climate and associated problems:** This involves investigating how climate change is affecting the coastal community, including rising sea levels, increasing temperatures, and changing rainfall patterns and to make out the community's perception of these changes and their impacts on agriculture, fisheries, and daily life.
- **To provide educational opportunities for participating students:** Students while conducting the survey will get a practical exposure to field research and data collection methods and it will enhance their understanding on disaster risk reduction strategies, community engagement, and the socio-economic dimensions of environmental challenges. This will foster a sense of critical thinking and problem-solving skills by involving in real world applications of their academic knowledge.

2 Methodology

A systematic and multidisciplinary survey using a random sampling method that integrates both qualitative and quantitative methods were used to comprehensively assess the vulnerability and susceptibility to coastal hazards in the study area. Structured and semi-structured questionnaires covering areas such as the community's past experiences with coastal disasters, awareness about disaster risk and



existing early warning systems, preparedness measures at household levels etc. were incorporated. Initially the survey focused on the most exposed areas followed by covering the whole panchayat. The questions were open-ended so as to gather qualitative insights on specific community experiences. The survey was community-based and focused to gather first-hand information from the local population regarding their vulnerabilities, experiences, and resilience strategies. The data was collected from individual households in the study area by considering them as a representative sample to ensure diversity in terms of age, gender and occupation. The survey responses were cross-verified for ensuring quality and integrity of data. The data was analysed for getting meaningful insights that highlight vulnerability and strength within the community.

2.1 Introduction to study area and its vulnerability

Our study area was the Eriyad Grama Panchayat, situated in the Thrissur district of Kerala. This Gram Panchayat comprises 23 wards each with unique characteristics and varying levels of vulnerability. The coastal wards such as ward (1,17,18,20,22,23) are generally more susceptible to sea-related calamities like tsunami and cyclone due to their proximity to the coast. The remaining are the wards located at offshore areas and are categorized as least exposed wards. Major disasters faced by the Eriyad coastal community are flood (2018), Cyclone Ockhi (2017) and tsunami (2004). Some areas also experience saltwater intrusion and sea surges. The devastating 2018 flood has also caused significant damage to the regions and also had a significant impact on the livelihoods of the people.

2.2 Questionnaire analysis

During the survey, separate sets of questionnaires were prepared for both the high susceptible and least susceptible wards.

2.2.1 Major topics addressed by the questionnaire for high susceptible wards

- Community's awareness about coastal disasters
- The effectiveness of existing early warning system
- Statistics regarding loss and destruction due to disasters
- Specific challenges faced while evacuation from coast
- Effectiveness of awareness classes conducted about coastal disasters

- Knowledge about precautions and instructions during disaster
- Organisation of mock drills regarding evacuation procedures
- The number of people those who experienced a coastal evacuation
- Impact of climate change on daily life as perceived by the people

2.2.2 Major topics addressed by the questionnaire for least susceptible wards

- Effectiveness of trainings conducted as part of disaster response
- Effectiveness of early warning systems in the region
- Statistics regarding special health care needs of the community
- Statistics regarding loss and destruction due to disasters
- Effectiveness of organized mock drills on evacuation
- Special challenges encountered during evacuation
- Major impacts of climate change as perceived by the community
- Major impacts of climate change on daily life of people

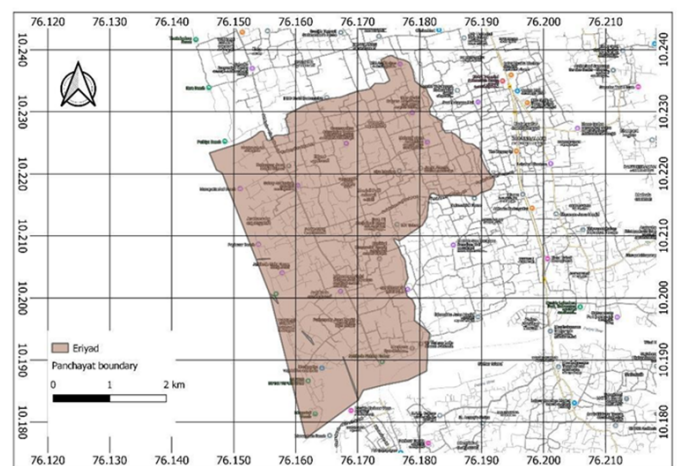


Fig. 1: The geospatial map of Eriyad Gramapanchayat in Thrissur

3 Results and Discussion

3.1 Key responses from high susceptible wards

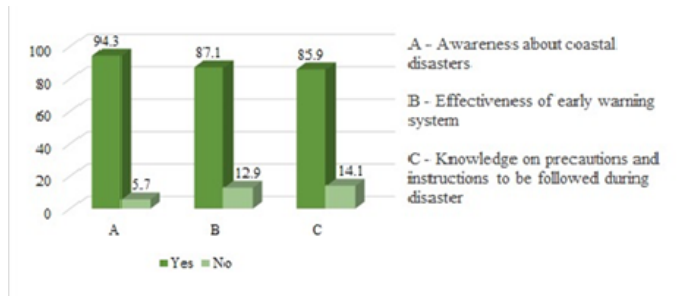


Fig. 2: Bar chart of some key survey responses

94.3 % of the community is aware of the different types of natural disasters like tsunami, flood, cyclone, hurricane etc. that are likely to occur in coastal areas while 5.7 % were not. The given data shows 87.1% of the coastal community receives warnings or information about the potential natural disasters in their area and 12.9% of the people were not aware of these information. Majority of the people, 85.9% have knowledge about the precautions and instructions that should be taken during disasters. While 14.1 % of the community lacks knowledge on these precautions and instructions [Fig. 2].

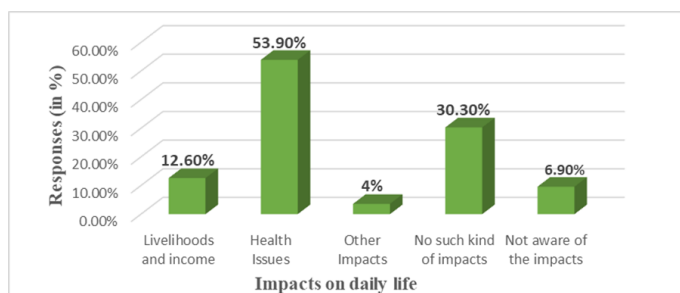


Fig. 3: Chart showing impact of climate change on daily life

43.3% of surveyed population indicated that climate change has caused changes in their living conditions, such as temperature rise, impacting their daily lives. 53.3% identified health problems as a major effect of climate change in their lives. This is the most significant concern among the participants. Only 2% noted issues related to reduced availability of essential resources such as food and water. 20.4% stated that they have not experienced any

noticeable effects of climate change on their daily lives. 6.9% expressed uncertainty or had no opinion about the impacts of climate change [Fig. 3].

3.2 Key responses from least susceptible wards

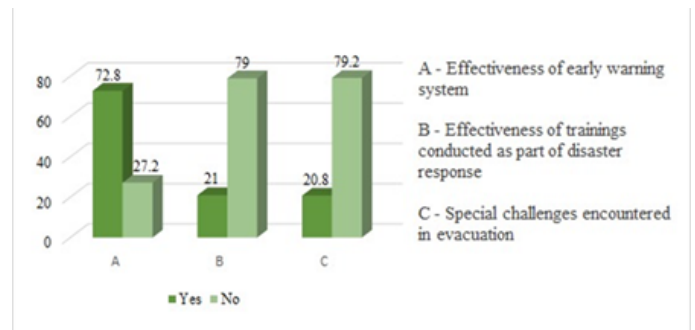


Fig. 4: Chart showing key responses from least susceptible wards

72.8% of people in the Eriyad gram panchayat are getting warnings regarding the shore land related natural disasters and 27.2% people are not yet getting these warnings properly. 79% have not received any training or coaching regarding tsunamis, cyclones, and similar events and hence this indicates a clear communication gap in information dissemination. Regarding the percentage of people who experienced difficulties when leaving the coastal area during an emergency, 20.8% of the respondents had to evacuate, and the majority were within a short distance from the coast. The evacuation process has left the majority of individuals safe [Fig. 4].

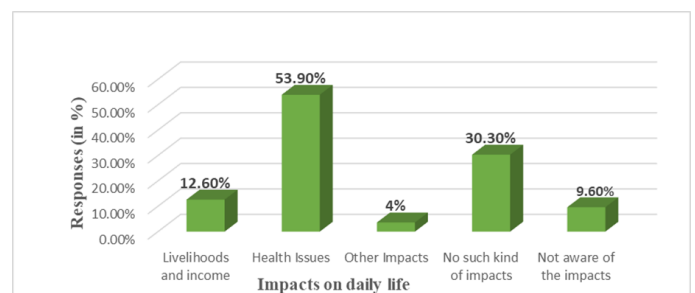


Fig. 5: Chart showing impact of climate change on daily life

53.9% voted health issues as an impact of climate change on daily life, 12.6% voted impact on the sources of livelihood, 30.3%voted no impacts, 9.6% voted lack of knowledge on the topic whereas 4% voted other factors as implications of climate change on everyday life [Fig. 5].

3.3 Other major findings from the survey



The survey responses from high susceptible wards reveals that a majority of respondents (64%) reported that a mock drill regarding evacuation has been organized in their ward. However, a significant minority (31.1%) stated that no such drill has been conducted. The survey reveals that majority of respondents near shore areas (83.9%) expressed interest in attending classes on coastal disasters, while a small minority (16.1%) showed no interest. Kallakadal or swell surge waves are coastal flash flood events that take place without any noticeable advance change in local winds or any other apparent signature in the coastal environment. By enquiring about Kallakadal among people from various wards of Eriyad Panchayat, majority of them do not know what exactly that is. Only 29.9% from least susceptible wards exactly know what that means. They are indeed those who depends on sea for their livelihood. 70.1% does not aware about this phenomenon where some of these only heard about such a phenomenon exists. The statistics on loss and destruction after natural disasters in least susceptible wards include house and land destruction/loss by 81.6%, agricultural losses by 8.6%, building destruction by 6.53% and livestock related losses by 3.26%. These statistics demonstrate the devastating impact of natural disasters on infrastructure, livelihoods, and properties, emphasizing the need for disaster risk reduction, relief, and rehabilitation efforts. A significant majority (90.4%) of respondents in nearshore regions of study area reported being aware of their nearest relief camp, reflecting the success of communication and awareness campaigns conducted by authorities or organizations. However, a smaller segment (9.6%) of respondents indicated a lack of awareness, pointing to a critical gap that could pose risks during disasters. This group likely includes individuals in remote areas, those with limited access to information, or those facing language or literacy barriers. Majority of population (85.4%) from least susceptible wards of Eriyad Panchayat knows about their nearest relief camps or assembly points when there is a need in case of emergency or disaster conditions. From these, many of them had faced a situation which triggered them to go to the relief camps. Major camps were nearest schools. Only 14.6% are not aware about these camps which includes those who do not face such a situation, those who went to relative's houses and aged people.

3.4 Benefits of the study

The study has benefitted in identifying the various levels of existing vulnerability by pinpointing the specific challenges

faced by the local population, such as income instability, unemployment, or health risks due to coastal erosion or flooding. It also helped in resource allocation by prioritising those resources needed to address critical issues like housing, education, and healthcare. The study has supported disaster management activities in the area through risk assessment for understanding the socioeconomic status of the community in order to determine their capacity to respond to natural disasters such as cyclones, flooding, or rising sea levels. As part of planning and preparedness, targeted disaster risk reduction strategies, including evacuation plans and relief measures facilitating sustainable development were developed.

The study also focused on having an environmental conservation aspect by collecting data on how socioeconomic factors influence environmental degradation (e.g., sand mining or deforestation) and proposed sustainable practices. The dependency on coastal resources for livelihoods (e.g., fishing) were understood and alternatives or supplementary income sources were explored as part of livelihood enhancement. Enabled evidence-based policies that provide data to support policies that address climate change impacts, poverty, and inequality in vulnerable coastal zones. The study findings advocate for better infrastructure like seawalls, waste management systems, or community centres needed to empower the local community.

To emphasize the need for community engagement, the local community was involved in identifying issues and solutions, fostering a sense of ownership and empowerment. The survey findings can be used to design awareness programs on health, education, and disaster resilience and can also be used to apply for government schemes, international aid, or NGO funding focused on coastal resilience and socioeconomic upliftment. As the findings highlight opportunities for sustainable tourism, fisheries, or renewable energy projects in the area, private sector investments are welcomed. As part of promoting social equity, marginalised groups or individuals disproportionately affected by vulnerabilities were identified and inclusive development initiatives were designed. The study has also contributed in empowering women and youth by understanding their specific challenges and creating programs to enhance their participation in economic and social activities.

The entire data taken during the survey has been shared with the DDMA (District Disaster Management Authority)



and KSDMA (Kerala State Disaster Management Authority) for facilitating development and effectively implementing the disaster management plans tailored to the needs of society.

3.5 Recommendations given to Eriyad Gram panchayat

The recommendations of the study include the establishment of well-defined evacuation routes that are strategically planned, clearly marked and regularly maintained to ensure quick and safe evacuation in case of emergencies, the development of emergency response teams for rescuing operations of special categories (handicapped, pregnant women, senior citizen) during disasters, conducting awareness classes to children, adults and government officials on climate change and related coastal hazards, organizing mock drills and training programs for people in coastal region to make sure that they are capable for timely response during disaster phase, to adopt strategies to prevent illegal construction in environmentally sensitive coastal areas, to adopt effective waste management methods and to implement nature-based solutions (Ipomoea species, casuarina tree) to reduce the damaging effect of coastal hazards.

3.6 Recommendations given to local community

- To practice sustainable living to reduce environmental impacts that cause any disasters.
- To participate in mock drills and classes within the Gram panchayat related to disaster management without any reluctance.
- To develop a basic understanding of the proper evacuation routes.
- To build an emergency kit containing various essentials.
- To follow scientific waste management practices.
- To properly follow the guidelines and recommendations served by the officials.
- To ensure that the warnings and alerts reach each and every one.
- To contact local authorities or organizations for relief services.

3.7 General recommendations for Climate-Resilient Coastal Development

Key measures for enhancing climate resilience in coastal regions include identifying high-risk zones and providing

capacity building training in disaster-prone areas. Constructing coastal protection structures like groins and breakwaters, establishing village-level warning systems, and ensuring mandatory insurance coverage with government support are also crucial. Additionally, providing zero-interest credit access and job-oriented skills training can help promote alternative livelihoods, while sustainable fishing practices and alternative income sources can reduce vulnerability and enhance resilience [3]. Studies emphasize the importance of a bottom-up approach, engaging fishers in developing location-specific plans that prioritize their livelihoods and promote sustainable fisheries development in the face of climate change [6]. Governments should establish Weather Watch Groups, research funding, and regional adaptation networks to support fishing communities, focusing on community-centric approaches, strengthening science-policy linkages and documenting evidence that help in addressing problems more effectively [7].

Traditional fishermen face vulnerabilities due to poor living conditions, limited resource access, and income instability. A holistic approach is needed to address these challenges and promote sustainability, incorporating sustainable development goals [7].

4 Conclusion

This disaster management survey conducted to assess the coastal vulnerability and enhance disaster preparedness has highlighted the varying levels of existing challenges and strengths in the study area. The high susceptible wards due to their frequent exposures to sea related calamities, have developed significant resilience over time. But their proximity to sea and susceptibility to tidal variations make them more vulnerable to the impact of disasters. These communities have acquired considerable knowledge in disaster response and management, effectively handling sudden emergencies with coordinated efforts. Their awareness of immediate response strategies, evacuation procedures, and resource management has contributed to their capacity to mitigate disaster impacts.

In the least susceptible wards, while the majority of residents are well-informed about disasters and response measures, a small section remains unaware of the protocols. The Gram panchayat has taken proactive steps, such as organizing mock drills to enhance preparedness. However, a significant drawback has been the low



participation in these drills, limiting the reach and effectiveness of the awareness initiatives.

To strengthen disaster resilience across all wards, it is crucial for the responsible authorities to ensure broader participation in training programs and mock drills. Moving forward, strengthening community-based disaster management strategies, continuous training programs, and infrastructural improvements will be essential to further reduce disaster risks and ensure long-term resilience in these vulnerable wards. It is very essential for the coastal people to understand how to protect themselves from these disasters and to recover from the effects. Enhancing disaster resilience through disaster risk reduction efforts is crucial for saving lives, protecting property and promoting sustainable development within the coastal community.

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