



Multi-layered vulnerabilities of riverine island communities: Insights from Kerala, India

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Abstract

Small islands, due to their distinctive geography and environmental isolation, face heightened vulnerabilities to natural hazards, a situation exacerbated by climate change through rising sea levels, cyclones, biodiversity loss, and coastal erosion. This study investigates the multi-dimensional vulnerabilities of small riverine islands—locally known as *Thuruths*—in the Meenathucherry region of Kollam district, Kerala, India. The research specifically aims to: (1) assess physical vulnerabilities related to housing, infrastructure, and environmental systems; (2) explore economic and livelihood challenges; and (3) analyze sociocultural disruptions arising from the islands unique ecological context. A cross-sectional survey design was employed, using a structured questionnaire, administered to adult residents in July 2024. Findings reveal physical vulnerabilities related to built environment, eroding embankments, flood-resilient infrastructure, and waste management, all exacerbated by frequent and environmental degradation. Economically, heavy reliance on fishing, limited livelihood diversification, and restricted access to financial services amplify risks. Socioculturally, erosion of traditional practices, inadequate institutional support, substance abuse, and pressures from unregulated tourism, further compound vulnerabilities. The study highlights an urgent need for targeted policy interventions focusing on climate-resilient infrastructure, livelihood diversification, and cultural preservation to strengthen the resilience of these vulnerable riverine island communities.

Keywords: Riverine islands, Multiple vulnerability, Climate change, Resilience planning, Livelihood diversification, Community survey

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1 Background

Islands are landmasses that are surrounded by water and have a few unique features like isolation from the mainland, specific biodiversity, a wide variety of shapes and sizes in landmass, diversity of origin, and high oceanic climate influence and are in the front line in multiple vulnerabilities, including climatic change (Barker, 2017; Tershy et al., 2015; Baldacchino, 2007). The distinctive geography of islands increase their vulnerability to compounding disasters like sea-level rise, coastal erosion, resource scarcity, cyclones, volcanic eruptions, and biodiversity loss, and is exacerbated by climate change. It is necessary to research how infrastructure limitations and external shocks worsen the social and economic vulnerabilities of small islands, as demonstrated by the SAMOA Pathway's examination of Small Island Developing States (SIDS) (UN, 2024). The physical, social, economic, and environmental dimensions of island vulner-

abilities are additionally emphasized in the SIDS report, especially for those with limited landmass and resources.

International literature has examined and detailed the multifaceted vulnerabilities of small islands worldwide. With 39 member states and 18 associate members of the UN regional commissions, SIDS provide a leading global forum for the most marginalized and disadvantaged people on tiny islands, which confront a distinct set of difficulties (UN, 2024). Providing proper sanitation on small islands presents a number of difficulties and this issue is exacerbated by a lack of space in conventional sewage systems, a shortage of freshwater supplies, and susceptibility to natural disasters (Hadwen et al., 2015). The multiple vulnerabilities of Oceanic and Riverine islands are different. Oceanic islands are highly vulnerable to sea level rise, coastal erosion, and extreme weather events, while riverine islands face frequent flooding, riverbank erosion, and socio-economic challenges. But both are experiencing heightened risks from climate

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change, but the nature and drivers of their vulnerabilities differ significantly (Hossain et al., 2024 and Duvat et al., 2017).

Island housing is seriously threatened by rising sea levels and an increase in the frequency of extreme weather events. For instance, according to UNESCAP (2020), 57% of the structures in the capital cities of Samoa, Tonga, and Vanuatu are thought to be situated in regions vulnerable to natural disasters. Some of the highest rates of obesity and diabetes in the world are found in the Pacific Islands. For example, it is estimated that 52% of adults in Tonga have diabetes (Hawley and McGarvey, 2015). Another crucial issue in small islands is digital connectivity. Even while digital technologies have the potential to address some of the issues that island communities face, many of them lack the infrastructure required for dependable internet access (ITU, 2020).

Small islanders suffer numerous social vulnerabilities in addition to physical ones, including geographic isolation, healthcare access, social and cultural decline, and access to high-quality education (Albert et al., 2016). Economic vulnerabilities of island communities include certain financial risks and difficulties associated with relying solely on one source of income, having few options for employment, and lack of diversification of sources of income (Thomas, 2002). Small islands are also particularly vulnerable to environmental threats. The effects of climate change, particularly sea level rise, together with the problems of coastal erosion and land loss, are among the most urgent environmental threats facing island people. Potential environmental vulnerabilities for tiny islands include waste management, ocean acidification, coral reef degradation, biodiversity loss, and freshwater scarcity and quality (Acciarri et al., 2021; Lavers et al., 2019; Gheuens et al., 2019 and Hughes et al., 2018).

There is a significant gap with regard to how economic activities, such as tourism, fishing, interact with and influence small island communities because traditional studies frequently place a higher priority on ecological or environmental concerns. The importance of focusing on small islands has been emphasised by very recent studies such as Lessy et al. (2025) and Pathirana (2025), which argue that there is still a shortage of island-scale data on climate impacts, ecosystem services, and socioeconomic vulnerabilities. Additionally, there has been a lack of assessment of community-based adaptation strategies, particularly with regard to their scalability and long-term resilience, which clearly calls for more research.

The present study focuses on the ‘Thuruths’ of Meenathucherry, a group of small islands located at the confluence of Ashtamudi Lake and the Kallada river in Kollam district, Kerala, South India (Fig.1). ‘Thuruth’ in Malayalam language means small island. Common social, cultural, economic, and environmental traits specific to their island environments are shared by these communities. Because of their remote location and unique environmental circumstances, the Thuruth inhabitants are vulnerable in a number of ways (Sajilkumar, 2016; Sajilkumar et al., 2020). Since most studies concentrate on oceanic islands and SIDS, the particular environmental, economic, social, and infras-

tructure challenges faced by smaller islands like these are ignored. This study has identified a significant research gap in literature regarding the specific vulnerabilities of small river islands.

2 Research objectives

To enhance the inquiry and search process, the following objectives were formulated and explored. The general objective of the study is to identify multiple vulnerabilities of small island communities, specifically the case of selected riverine islands (Thuruths) of Meenathucherry. Three specific objectives are: (1) To assess the present physical vulnerabilities through indicators related to housing, waste, water, vector issues, and environmental degradation, (2) to explore the economic and livelihood challenges of the respondents and (3) to analyse the socio-cultural challenges faced by the community due to their unique ecosystem. A pilot study was conducted in the Thuruths of Meenathucherry between July 6–14, 2024, during which the research team visited the area to identify routes, select samples, determine locations, build initial rapport, and pretest the research tool with the community.

3 Methods

This study primarily employs a quantitative research approach with a survey design, using a structured questionnaire as the data collection tool, and the unit of study comprises adult residents (18 years and above) from the study area. The questionnaire included a mix of closed-ended questions for quantitative data and few open-ended questions for qualitative insights. The researcher administered the questionnaire and collected the data directly from the respondents. The study gathered data through random sampling, focusing on adults because they tend to have firsthand experiences, responsibilities, and decision-making roles related to the vulnerabilities being examined. Data were collected with proper informed consent and adherence to ethical research principles. The quantitative data from the questionnaire is processed and analyzed mainly by using Microsoft Excel.

4 Results and discussion

The questionnaire survey was conducted in July 2024, with a total of 71 respondents. The research and discussion section provides a detailed analysis of the three aspects of vulnerabilities examined in the questionnaire: physical, economic and livelihood, and sociocultural. The frequency percentages for all these questions were calculated, and the results are presented in descriptive text. At the end of each section, a discussion is provided.

4.1 Demographics

The respondents were selected from four neighboring riverine islands: Arulappam Thuruth, St. Thomas Island, Fathima Island, and Panchayath Thuruth. Out of 71 respondents, 39 (55.6%) are male, and 32 (44.4%) are female. The majority belong to the 41–55 age group (40.8%).

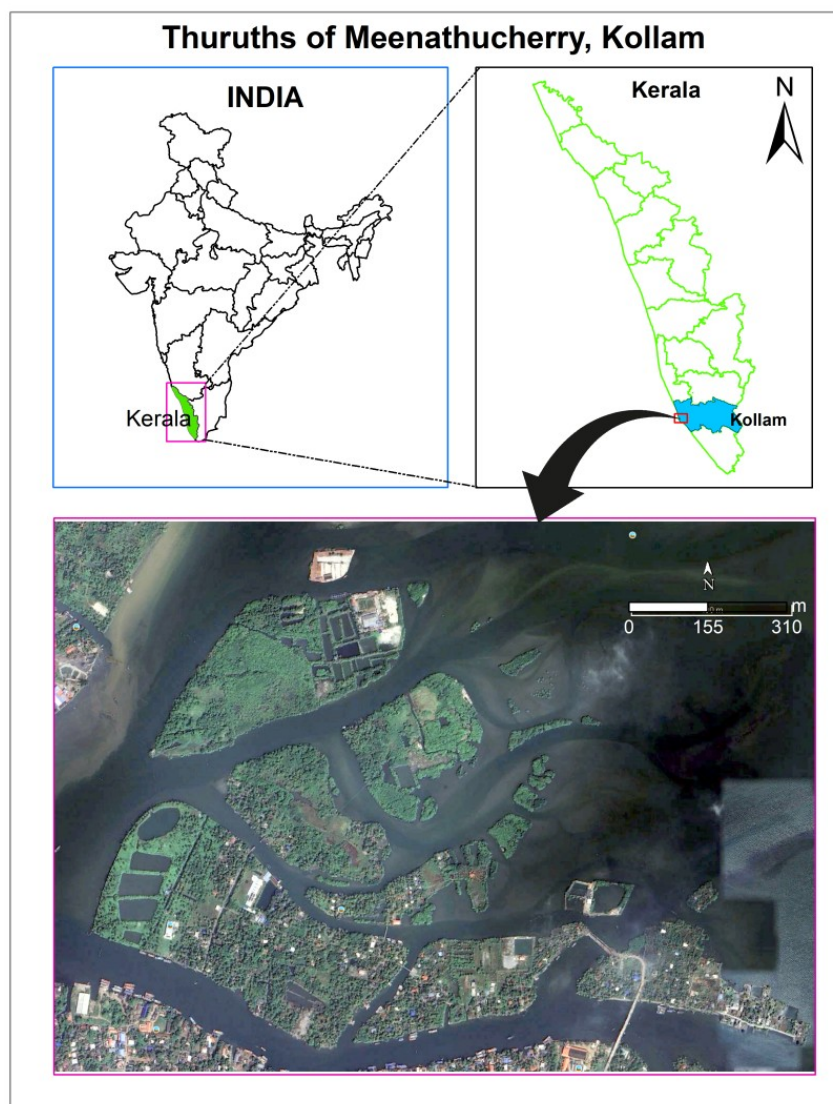


Fig. 1. Location map of the study area: Riverine islands (*Thuruths*) in Meenathucherry, Kerala, India.

Additionally, 83.3% of the respondents are married, and 37.1% have received primary education.

4.2 Physical hazards

The questions asked to the respondents regarding physical hazard aspects include flood affecting house, house damage, reason for damage, waste management, waste handling, sewage, source of water, perspectives on water pollution, rodent and mosquito problem, soil erosion, increase in hazard occurrences, biodiversity loss and natural resource exploitation.

The majority of respondents (43%) reported that their homes are affected by flooding and when faced with flooding 52.9% of respondents seek refuge in relief camps. The survey revealed that a significant number of houses on the island have sustained damage, with various types of issues reported. Cracked walls were the most common problem, affecting 25.7% of the respondents homes, followed by leakage of the roof (20%), weak foundation and a combination of issues (21.4%). A significant 98.6% of respondents indicated the absence of a waste management plant on the

islands, highlighting a critical environmental concern. 70% reported handing over their waste to the Haritha Karma Sena, a local initiative responsible for collecting and processing waste. All the respondents confirmed that there is no sewerage in the islands and that rodent and mosquito problems were rampant on the islands. More than half of the respondents (54.3%) reported experiencing soil erosion or flooding recently, highlighting the frequency and severity of these environmental hazards in the area. The survey revealed a critical issue in flood resilience, as all respondents confirmed that there were no flood-resistant houses in islands. Most respondents (71.0%) believe that disasters are becoming more frequent in their area, while a small number (4.3%) disagree. The loss of biodiversity is another concern in physical vulnerability, with 53% of respondents indicating that biodiversity is indeed getting lost and another 57.1% believing that natural resources are being exploited unsustainably.

Global research also supports the findings of this study, highlighting the physical vulnerabilities of small riverine islands. Flooding poses a significant threat to island

communities. This highlights the vulnerability of island infrastructure and housing to flood events, emphasizing the need for resilience building measures (Coulthard, 2012). The lack of waste management facilities can lead to severe consequences, including environmental contamination, health hazards, and economic challenges (Hadwen et al., 2015). The lack of a functional sewage system poses a significant challenge, as wastewater cannot be disposed of effectively (WHO, 2021). Rodents and mosquitoes are known vectors of diseases and can cause significant distress in island communities (Steiger et al., 2016). Island ecosystems are particularly vulnerable to biodiversity loss due to their unique geography and ecological characteristics and research has shown that island species are more prone to extinction due to factors such as habitat fragmentation, invasive species, and climate change (Walker and Bellingham, 2011). Research has shown that island soils are particularly vulnerable to erosion due to factors such as steep slopes, high rainfall, and limited soil depth (Nanda et al., 2021). Thus an urgent need exists for integrated resilience-building strategies to address the interconnected challenges of flooding, waste management, rodent control, biodiversity loss, and soil erosion in small riverine islands.

4.3 Economic and livelihood challenges

The parameters examined in economic and livelihood challenges include current job, ration card details, house and land ownership, climatic change, hindrance in doing other jobs, alternative livelihood, dependency on natural resources, resource sustainability, access to credit and financial services, government initiatives for financial assistance, accessibility to bank and loan/credit accessibility.

The *Thuruth* population has diverse livelihoods. The majority, 35.7%, are involved in fishing, followed by students 12.9%, small scale industries (4.3%), another 4.3% in tourism sector, 18.6% fall under the "others" category, which includes homemakers and individuals who do not have a fixed occupation. 21.4%, are unemployed. Residents face significant challenges in pursuing alternative livelihoods, with the majority 57.1% citing dependency on fishing as the primary obstacle. Several do not have the expertise other than in fishing. Other notable challenges include connectivity issues (22.9%), which hinder access to markets, services, and opportunities, and financial constraints (15.7%), which limit the ability to invest in new ventures. Additionally, the unavailability of land (4.3%) poses a barrier to exploring alternative livelihoods such as agriculture or entrepreneurship. The majority (70%) of households hold PHH (Pink) ration cards, indicating a significant proportion of the population is eligible for subsidized benefits, additionally, 18.6% of households hold AAY (Yellow) ration cards, which are issued to the poorest of the poor. Majority of 91.4% of the respondents reported owning their homes and 91.4%, reported owning their land. 80% reported feeling the effects of climate change, indicating a strong perception of its impact on their daily lives and environment.

Being overwhelmingly dependent on natural resources poses significant economic and livelihood challenges for the islanders. A staggering 97.1% of its livelihood is derived

from fishing, while agriculture plays a relatively minor role, contributing a mere 2.9% to the island's economy. The respondents (71.4%) express doubts about the long-term viability of available natural resources. Furthermore, a notable proportion (28.6%) admitted to having no idea about the sustainability of these resources. 91.4% of respondents expressed difficulty in accessing natural resources, while only 1.4% reported easy accessibility. The government initiatives promoting sustainable financial development are crucial in the overall development of these island communities but a significant majority (78.6%) of respondents mentioned that there are no such initiatives. There is a question regarding the accessibility to banking institutions and all the respondents reported a considerable difficulty in this regard. This suggests that the island community faces substantial barriers in securing financial support for their needs, which can hinder economic development and exacerbate poverty.

Climate change is a pressing global issue, and island communities are particularly vulnerable to its impacts (Oakes, 2019). Researchers observed the challenges of diversifying livelihoods in island communities, where traditional activities often dominate, just as they do in the study area. Also they are highly dependent on natural resources for livelihood. The findings highlight the need for improved financial inclusion and access to credit in the island community and these difficulties in accessing financial services can exacerbate poverty and limit economic opportunities (Robert and Brenden, 2006).

4.4 Socio-cultural challenges

To understand sociocultural challenges, questions were asked about the preservation of island culture, relations among community members, community support, involvement in community programme, social support for people with disabilities, toilet facilities and usage, times when toilets were unusable, access to basic facilities, solutions for improving basic facilities, isolation and socio-cultural life, impacts of tourism and drug and alcohol consumption.

Cultural erosion and identity loss are crucial considerations in small riverine islands. A vast majority (70%) of respondents admitted to having no idea about the state of cultural preservation on the island and only a tiny minority (1.4%) of respondents believed that it is being conserved, while 28.6% expressed concern that the island's culture is not being preserved. 42.9% argued that isolation does not affect their social and cultural lives. Community engagement that fosters bonding and mutual support becomes critical human infrastructure that strengthens collective resilience. This is a particular importance in enclosed geographies (such as small islands) where connection to others increases adaptive capacity. 52.9% of respondents agreed that sufficient community support is provided and 51% responded positively when asked if they actively participate in common island activities. The survey showed alarming shortage in disability social support with just 4.3% of respondents having access to such support. By comparison, the overwhelming majority (68.6%) mentioned that there is no support available and 27.1% did not know or were uncertain about the presence of such support.

Multiple Vulnerabilities of Riverine Islands	Dimension	Indicators	Interventions
	Hazards or Stressors (External environmental threats)	- Flooding - Soil erosion - Climate change - Unregulated tourism	- Construction of elevated and and natural flood barriers - Revegetation/bioengineering - Integrated adaptation strategies - Promote responsible tourism policies
	Community Vulnerabilities (Conditions of susceptibility)	- Economic: Dependence on limited livelihood sources - Physical: Poor infrastructure (housing, sanitation, waste management) - Social: Limited financial access, social isolation, inadequate community support - Cultural: Loss of traditional identity, diminished social cohesion	- Create diverse employment opportunities other than fishing - Enhancement of infrastructure, including housing, sanitation, and waste management - Community-based microfinance initiatives - Ccommunity-led heritage programs
	Consequences or Outcomes (Results of vulnerabilities exposed to hazards)	- Infrastructure damage - Economic hardships - Increased substance abuse - Cultural erosion	- Introduce resilient infrastructure rebuilding strategies - Microfinance and livelihood support initiatives - Strengthening social support networks - Promoting cultural preservation through education and engagement

Fig. 2. Multiple vulnerabilities in riverine islands and possible interventions.

The survey indicated that there are mixed views on how tourists impact their lives, with 50% looking at it positively, 5.7% noting no effect and 44.3% neither agreeing nor disagreeing, or saying they lack knowledge. 91.4% of respondents stated that they have a toilet in their household, proving almost universal access to this sanitation facility. And 37.1% reported to have been able to utilize their toilets any time, a greater proportion (62.9%) reported their toilets to be non-usable mainly due to the difficulty of getting rid of water. The poll found a high level of agreement about the need to tackle community drug and alcohol use, with most (54.3%) deeming it very significant.

Tourism may help the economies of islands by creating jobs and developing infrastructure, but it can also put pressure on local resources and disrupt traditional ways of life. Strategically managing economic activity while ensuring environmental and cultural preservation is essential for sustainable development (Abeyratne, 1999; Battle and Robledo, 2000; Styliadis et al., 2007). The lack of access to bathrooms presents a socio-cultural issue for small islands which influences their public health and decreased their overall quality of life. The use of outdated methods, limited space, and poor facilities make it a lot harder to improve sanitation systems in such areas (Raimi et al., 2019). A few studies have examined patterns of alcohol and substance use among the general population specifically young people in island communities (Seru et al., 2011, Gatidou et al., 2016 and Quinn et al., 2017). These reports emphasize the need for interventions in these communities because of their distinct cultural, social, and geographical features.

5 Conclusions

The study highlights that small river islands or *Thuruths* like Meenathucherry are particularly vulnerable to a range of socio-environmental challenges. These include geographic isolation, limited resources, and the impacts of climate change, all made worse by a heavy dependence on single source of livelihood and poor infrastructure. This is evident in the widespread damage to homes and the lack of proper waste management systems. The community's risks are amplified by deteriorating housing and the absence of vital services, which heightens both environmental and health concerns. Frequent disasters and the loss of biodiversity put even more pressure on these delicate ecosystems, while threats to cultural identity add to the socio-ecological difficulties faced by island communities. An integrated visualization of the overlapping vulnerabilities and possible policy and community-level interventions are given in Fig. 2, summarizing the multi-dimensional risks facing small riverine island communities.

This research emphasizes the specific challenges faced by small riverine islands in a heavily populated, climate-vulnerable tropical country using data from recent community surveys. The islands of Meenathucherry remain particularly vulnerable to multiple dimensions, primarily because of their remote location, scarcity of resources, and reliance on a single source of income. These issues are made worse by climate change and unsustainable land use. The primary conclusions of this study call for immediate attention from policymakers, particularly with regard to the rise in natural hazards, particularly floods and improper waste

management, lack of varied livelihoods, loss of island biological diversity and erosion of cultural identity. Kerala's strong emphasis on community involvement, which was evident during the 2018 floods, underlines the need for additional training for island communities that have previously shown themselves to have the capacity to save people from flooding. To lessen the vulnerability of tiny island communities, governments can more successfully implement Kerala's institutional practices, such as the State Disaster Management Policy, the Kerala Climate Change Adaptation Mission, and the Punargeham project to effectively reduce the vulnerability of small island populations. Successful models, like the UN's SIDS initiatives demonstrate how small islands may take a holistic approach to addressing multiple risks and achieve sustainable development. In small riverine islands like Meenathucherry, future research is recommended on socio-ecological impacts of climate change, preservation of ecological health, developing climate-resilient infrastructure, community resilience practices and developing and promoting sustainable livelihoods.

Conflict of Interest

The authors declare no conflict of interest.

CRediT statement

AS: Data Collection, Analysis, Writing Original Draft.

JKJ: Conceptualization, Supervision, Writing – Review & Editing

Data availability

The questionnaire (in Malayalam) can be accessed at <http://bit.ly/4d2nf6E>

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