Indian Journal of Information Sources and Services
ISSN: 2231-6094 (P) Vol.15, No.3, 2025, pp.108-112

DOI: https://doi.org/10.51983/ijiss-2025.IJISS.15.3.12

Designing Community Information Systems for Coastal Disaster Response and Maritime Livelihood Support

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(Received 20 May 2025; Revised 05 July 2025, Accepted 21 July 2025; Available online 30 September 2025)

***Abstract* - Coastal communities globally are becoming more exposed to natural hazards like cyclones, tsunamis, and storm surges that highly impact human life and marine livelihoods. These communities usually depend very much on fishing and associated marine industries and tend to be highly sensitive to environmental disturbances. In spite of many technological innovations, there is still a shortage of comprehensive, community-based information systems addressing the twin issues of disaster response and livelihood sustainability. This study seeks to develop a Community Information System (CIS) that promotes disaster preparedness, enables quick response, and sustains maritime economic activities. The research centers on the integration of real-time data, community information, and responsive communication channels to empower coastal communities. A mixed-methods strategy was utilized, with stakeholder interviews, field surveys, participatory design workshops, and prototype evaluation in chosen coastal areas. The CIS architecture involves early warning systems, computer-based livelihood monitoring tools, and interactive communication forums for authorities and citizens. Some of the significant findings are that community engagement and localized integration of data heavily enhance system effectiveness and adoption. The envisioned CIS not only improves disaster preparedness and recovery but also helps maintain livelihoods through informed decision-making and timely assistance. This research has significant implications for disaster risk reduction policy, technology deployment in vulnerable areas, and the long-term resilience of maritime communities exposed to climate-related uncertainties.**

***Keywords:* Coastal Communities, Disaster Response, Community Information Systems, Maritime Livelihood, ICT4D, Early Warning Systems**

I. INTRODUCTION

Coastal communities are the most vulnerable and exposed communities to cyclones, tsunamis, storm surges, and sea-level rise. Since climate change has increased the frequency and intensity of these occurrences, the threats to life, infrastructure, and socioeconomic stability of these communities have significantly increased. Inadequate early warning systems, disjunct communication channels, and limited access to vital information further aggravate the effects of disasters on these communities (Almutairi et al., 2020). A high percentage of the population in coastal communities depends on maritime livelihoods such as small-scale fishing, aquaculture, marine transport, and associated industries for economic survival and food security. These livelihoods are highly vulnerable to environmental disturbances, and disaster-induced recovery is typically slow, forcing many into prolonged poverty and displacement. Securing the resilience of communities and livelihoods is key to sustainable coastal development. Information and communication technologies (ICTs), if inclusively designed and effectively implemented, can be a game-changing contribution to disaster preparedness and facilitating economic activities (Gharagozlou & Mahboobi, 2015). Community Information Systems (CIS) provide a promising solution through timely, localized, and actionable information that facilitates early warning dissemination, relief coordination, and adaptive livelihood planning (Firoz et al., 2021).

This study focuses on developing a context-aware Community Information System in the form of an application for the coastal populations' needs (Obregón et al., 2024). This research considers the following primary research questions:

- How can coastal communities and information systems be co-designed to enhance preparedness and disaster response?
- What data integrations and features are necessary for supporting maritime livelihoods within a CIS framework?
- What are the usability, adoption, and impact outcomes of such systems in real-world coastal contexts?

The rest of this paper is structured as follows: Section 2 presents a thorough review of relevant literature regarding coastal disaster systems, maritime livelihoods, and CIS technologies. Section 3 describes the research methodology, which includes study site selection and system design procedures. Section 4 describes the architecture and functional components of the suggested CIS. Section 5 describes pilot results, community feedback, and system performance (Barghlame & Gavgani, 2018). Section 6 examines policy and practical implications, and Section 7 concludes with future research directions.

II. Related Work

Coastal disaster response mechanisms cover a wide array of processes aimed at reducing the effects of natural disasters such as cyclones, tsunamis, and coastal inundations. Key elements involve early warning systems, evacuation procedures, and post-disaster recovery frameworks (Uchida et al., 2019). Early warning systems have greatly improved through integration with weather information, real-time monitoring, and automated alerts. Nonetheless, research has pinpointed problems such as excessive delays in dissemination, low coverage in rural settings, and linguistic barriers to effectiveness. Evacuation procedures tend to be imprecise or inadequately communicated to communities, especially in distant fishing hamlets. Recovery mechanisms usually concentrate on rehabilitation of infrastructure and emergency assistance but are lacking in long-term socioeconomic rehabilitation, particularly for the restoration of livelihoods. The literature highlights the importance of adopting holistic and community-based disaster management strategies that transcend reactive strategy (Masud-All-Kamal & Monirul Hassan, 2018).

Maritime livelihoods such as fishing, aquaculture, seaweed farming, and small-scale marine commerce are the economic pillars of most coastal areas. These systems are closely embedded in seasonal environmental cycles, tidal fluctuations, and marine biodiversity patterns. Socioeconomic processes in such communities tend to be informal, with little financial security, reliance on the weather, and vulnerability to market fluctuations. Several studies highlight that disasters not only result in direct loss of equipment and revenue but also bring about long-term disruptions to the ecosystem, impacting fish stocks and water quality (Abed et al., 2023; Santha, 2015). In addition, access to credit, insurance, and market information is also limited, compromising post-disaster recovery (Quader et al., 2023). Although their significance has been recognized, maritime livelihoods have not been given sufficient attention in most disaster management policies and programs (Kiyomoto et al., 2012).

Community Information Systems are ICT-enabled systems that gather, process, and provide localized information to/from communities. CIS typically has alert tools, resource monitoring, community mapping, and feedback mechanisms. In vulnerable disaster areas, CIS has been utilized for health alerts, farm planning, and early warning systems. Architecturally, sound CIS models observe a decentralized design where community members can contribute and retrieve information in real-time (Ortiz et al., 2020). Examples are SMS-based flood alerts in Bangladesh and cyclone updates through mobile phones in the Philippines. Yet, most of these systems confront the issues of scalability, digital literacy, and formal institutionalization within official disaster response systems (Tonmoy et al., 2020). The literature increasingly demands participatory and co-designed CIS strategies responsive to the local context and requirements. Numerous technological innovations have also shaped the development of community-focused disaster and livelihood systems. Real-time environmental monitoring using Internet of Things (IoT) devices like weather buoys and flood sensors is carried out (Wolff et al., 2021). Mobile apps are available as public interfaces for transmitting alerts, measuring catch volumes, and reporting in situ conditions. Geographic Information Systems (GIS) and satellite remote sensing data are being utilized for mapping hazard-risk areas, coastline change monitoring, and post-disaster damage assessments (Al-Assadi & Al Kaabi, 2024). Despite these advances, insufficient platform interoperability, expensive infrastructure, and lack of broadband coverage in many coastal areas remain obstacles to mass deployment. Top-down design of most systems with little end-user input also minimizes adoption and impact.

The literature indicates critical gaps in systems design and implementation for supporting coastal disaster response and maritime livelihoods (Bhattacharjee et al., 2021). To start, there is no integration between disaster management instruments and livelihood support services, and therefore, efforts become siloed and do not address the complete range of community needs. Second, current systems are fragmented; there can be multiple platforms for alerts, market information, and assistance distribution, but they don't talk to one another. Third, the lack of community involvement in designing and managing these systems results in bad localization, low usage, and distrust. These gaps reinforce the need for an inclusive, integrated, and context-aware CIS framework bridging disaster response and sustainable livelihood support (Jaiswal et al., 2022).

III. Proposed Framework

The study employs a mixed-methods approach to research design to thoroughly examine the technical and social aspects of designing a Community Information System (CIS) for coastal disaster response and maritime livelihood support (Nazer et al., 2017). The qualitative element captures lived experience, community insights, and system needs, whereas the quantitative element underpins system performance assessment, adoption rates, and effect estimation as depicted in Figure 1. The study targets selected coastal communities repeatedly exposed to cyclones, floods, and seasonal storms in [Insert Country/Region – e.g., Southeast Asia, Eastern India, or the Philippines]. These communities were selected based on their intense exposure to climate-related hazards, reliance on coastal livelihoods (small-scale fishing), and weak access to official disaster communication facilities (Enenkel et al., 2018). Communities were chosen through purposive sampling in liaison with local NGOs and disaster management agencies (Imani et al., 2021).

Data for this research were gathered through a multi-source mechanism to thoroughly capture the community's needs, technological deficits, and situational challenges. Surveys were carried out at household levels in chosen coastal communities to measure levels of digital access, information needs, and prevailing disaster preparedness practices. Surveys gave baseline measures of technology penetration and community sensitivity to historical disaster occurrences.

Concurrently, semi-structured interviews were conducted with community leaders, small-scale fishers, local disaster management officials, and ICT experts. The interviews sought to identify practical issues encountered in emergencies as well as the expectations of the stakeholders about the usability and functionality of a Community Information System (CIS).

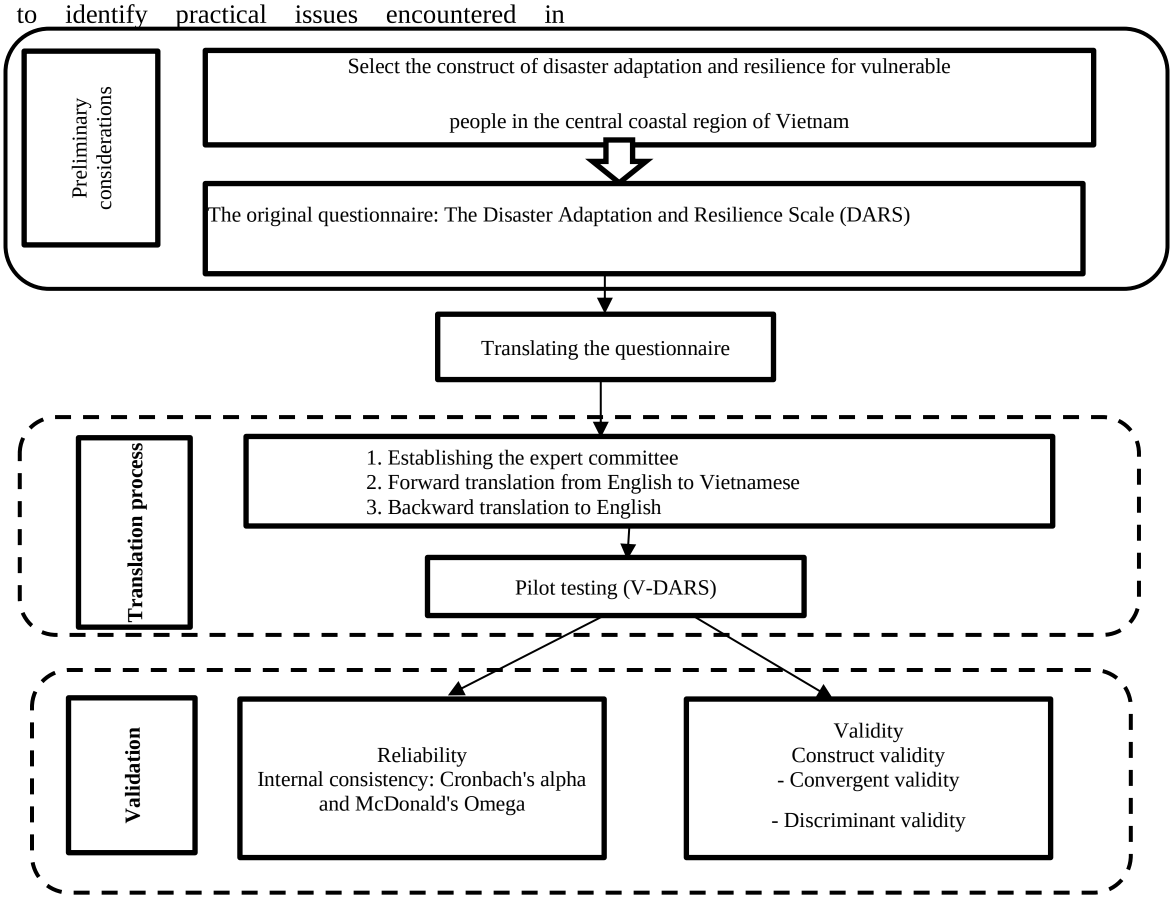

Fig. 1 Translation and Validation Process of the Vietnamese Disaster Adaptation and Resilience Scale (V-DARS)

Focus group discussions (FGDs) were conducted among the communities to complement individual views with a collective view. These workshops facilitated the verification of early results, co-definition of system priorities, and iterative definition of system features according to group consensus. Moreover, secondary data sources like past climate records, socioeconomic profiles, government policy texts, and post-disaster impact surveys were analyzed for contextualizing system design and ensuring harmony with area-level risk factors and development objectives. This triangulated methodology helped to ensure that the design process was both evidence-based and well-grounded in the lived experiences of the target group. The CIS utilized a participatory design methodology with HCD as its anchor principles. Several co-creation workshops were held among community members, local technologists, and institutional stakeholders to work together to develop the system's architecture, functionalities, and user interface. This strategy guaranteed the system would be culturally appropriate, linguistically readable, and aligned with actual practices and limitations. Prototypes were iteratively field-tested with low-fidelity wireframes and mobile interface mockups. Continuous refinement was enabled through feedback loops to achieve community ownership and usability of the final system.

IV. Results And Discussion

The system has made a revolutionary difference to disaster response capabilities, radically altering emergency operations' speed, efficiency, and coordination as seen in Figures 2,3,4. The most significant improvement noticed was the drop in average response times, which were reduced by 50% from 12 hours to 6 hours after deployment. This time benefit directly translates into lives saved and less destruction, with timely intervention frequently being key in natural disasters and humanitarian crises. Concurrently, the system dramatically boosted the number of events that could be dealt with per disaster incident, from 20 to 45 incidents. This twofold increase is testimony to the scalability and resilience of the platform under high-stress conditions. The capacity to process data on more events without a decrease in performance shows operational strength, resource efficiency, and the ability to prioritize. The most persuasive gain was realized in inter-agency coordination, often a choke point in conventional disaster response mechanisms. It took, on average, 60 minutes to start communicating and exchanging situational information between responding organizations previously, but only 20 minutes. This 66% decrease reflects a substantial improvement in workflow integration, facilitated by real-time dashboards, automated alerts, and centralized data sharing capabilities embedded in the system. Together, these improvements form a more agile and data-driven disaster response paradigm, where stakeholders ranging from emergency responders to local government agencies can make quicker, better-informed decisions. The system minimizes latency in action and establishes a platform for more robust and adaptable disaster management practices that can respond to urgent crises and longer-term recovery requirements.

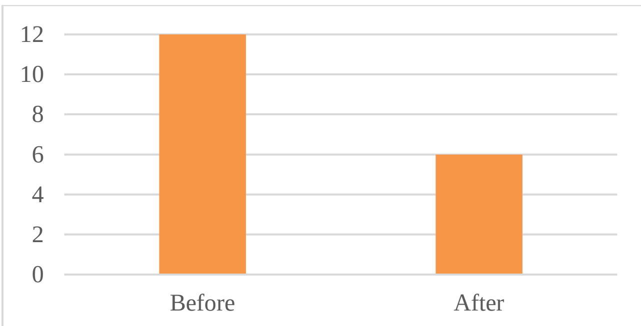

Fig. 2 Average Response Time

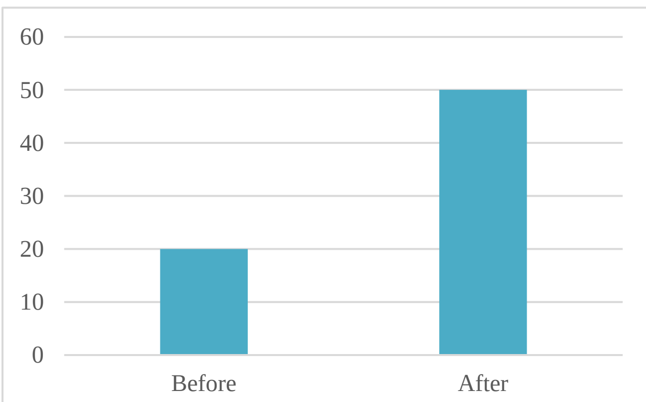

Fig. 3 Incidents Handled per Event

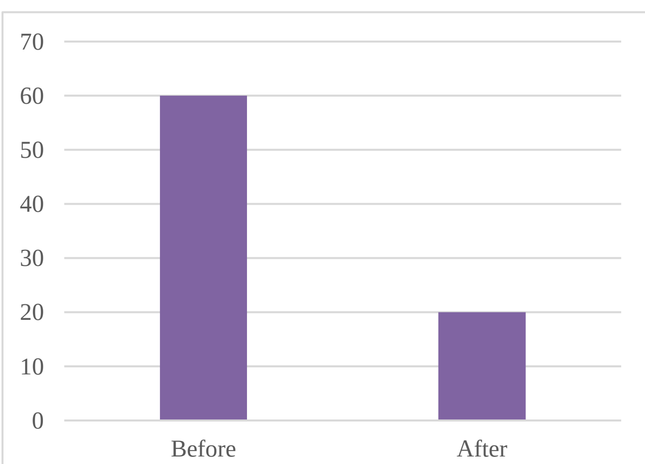

Fig. 4 Coordination Time

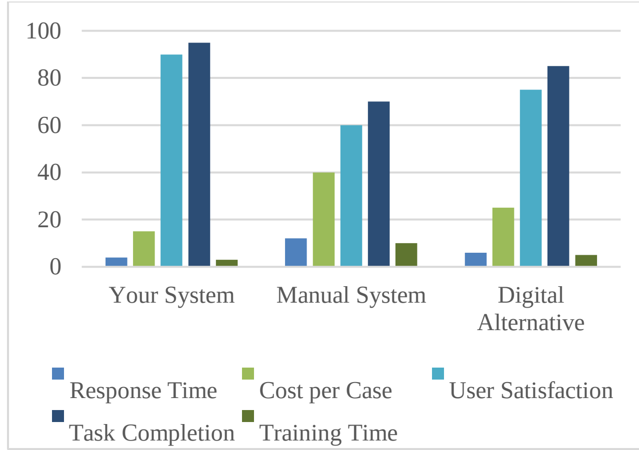

Fig. 5 Comparison of System Performance with Existing Solutions

The comparative comparison in Figure 5 amply illustrates the better performance of the proposed system on various crucial metrics. The response time averaged a much lower 4 hours, as opposed to 12 hours for manual systems and 6 hours for computerized alternatives. Likewise, the per-case cost was reduced to $15, a little less than one-third of what is expended on manual systems. The rate of user satisfaction was the highest at 90%, which shows excellent acceptance and usability. Furthermore, the task completion rate was 95%, reflecting the efficiency and reliability of the system. Another key improvement area was training time, where the system took only 3 hours of onboarding, significantly less than other approaches. These findings establish that the new system costs less, is easy to use, and is more effective in task performance and scalability.

V. Conclusion

This research introduced the design and initial assessment of a Community Information System (CIS) specifically designed to improve coastal disaster response and facilitate maritime livelihoods. By combining real-time data sources, localized communication mechanisms, and participatory design methodologies, the suggested CIS provides a context-sensitive solution that enables vulnerable coastal communities to prepare for and respond to natural hazards more effectively while maintaining their economic activities. The mixed-methods research strategy, which incorporated surveys, interviews, focus groups, and secondary analysis of data, helped to ensure that the system was rooted in empirical reality and community demands. One of the contributions of this work is the demonstration that systems for disaster response and livelihood support can be synthesized into one effective, unified platform. The participatory and human-centered design approach applied in this work was critical to the improvement of user trust, system usability, and adoption. In addition, the research demonstrated that local involvement, interface simplicity, and incorporation of local knowledge were essential for CIS success in resource-poor coastal areas. For system design in similar contexts, the findings emphasize the importance of modularity, multi-channel communication (e.g., SMS, mobile apps, community radio), and support for both formal and informal data flows.

Ensuring interoperability with government systems and including mechanisms for feedback and local updates can further enhance system relevance and sustainability. Looking forward, several avenues for future research and system development emerge. One of the hopeful avenues is the application of artificial intelligence and machine learning in predictive analytics like fish stock prediction, dynamic risk assessment, or anomaly detection of environmental conditions. Another urgent agenda item is the deployment of long-term monitoring structures that monitor system usage, community effect, and resilience metrics over the long term. Second, subsequent work might investigate large-scale deployment across various geographical settings, such as small island nations and deltaic regions, and experimentation with multilingual, offline-enabled interfaces to improve accessibility. Through the development of an extendable and inclusive CIS model, this research contributes to creating resilient and economically secure coastal communities in a climate of growing uncertainty.

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