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Research Article

Socio-Ecological Adaptation Strategies of the Rowoterate Community, Malang, in Responding to Persistent Flooding

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ABSTRACT

This research aims to find out how the people of Rowoterate Hamlet, Sitiarjo Village, Malang Regency, adapt to frequent flooding. This area is prone to flooding because it is in the lowlands, at the confluence of two large rivers, and influenced by sea tides. The research was conducted using descriptive qualitative methods through observation, interviews, and documentation. The results showed that the community made social adaptations such as creating an early warning system, a joint evacuation site, and houses on stilts. Economically, they make a special place called “plenggrongan” to store valuables during floods. This strategy was born from experience, local wisdom, and the desire to continue to survive in the midst of disasters. The results of this study are expected to contribute to the development of theory and practice of socio-ecological adaptation in disaster-prone areas and become a reference for community-based flood risk management.

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1. Introduction

Global climate change has emerged as a critical issue affecting multiple dimensions of human life, including the increasing intensity and frequency of hydrometeorological hazards. Flooding is among the most tangible impacts experienced by many communities. Flood events are often difficult to predict because they can occur suddenly and with irregular periodicity. In Indonesia, flooding is commonly associated with several key determinants, including slope gradient and terrain elevation, soil type and land use, river network density, and high rainfall intensity, all of which contribute to a locality’s susceptibility to flood hazards (Darmawan et al., 2017).

Malang Regency, one of the largest regencies in East Java, is not exempt from flood-related problems. Rowoterate Hamlet, the study area in this research, is among the localities in Malang Regency that experiences persistent (semi-permanent) flooding. The hamlet is considered highly vulnerable due to its elevation being nearly at sea level and representing one of the lowest topographic positions relative to mean sea level in the surrounding area. In addition, the hamlet is located near the confluence of the Penguluran River and the Mbambangan River. Its proximity to the river mouth further exposes Rowoterate to tidal influences, meaning that seawater intrusion during high tides can exacerbate river levels. The accumulation of upstream river discharge combined with tidal surges increases the likelihood of river overtopping, generating flash floods; consequently, Rowoterate is identified as one of the areas facing the greatest flood risk (Amaliya & Dewi, 2019).

These conditions have substantial implications for the socio-ecological life of the local community. Socio-ecological adaptation refers to the capacity of individuals, groups, or communities to adjust to environmental changes through social, economic, technological, and physical responses to persist and develop sustainably (Minarti et al., 2024). In 1998, the Stockholm Environment Institute (SEI), a group of environmental advocates, formulated a conceptual framework for implementing sustainable development. To strengthen this perspective, SEI articulated the notion of a socio-ecological system, emphasizing the interdependence among three core elements of human life: society, the economy,

and the environment. Society depends on the environment as a basis for livelihoods; the economy organizes and drives social activities; and the environment provides resources that sustain economic processes. In turn, the ways these resources are managed feed back into environmental conditions, indicating that the three components interact dynamically in the pursuit of sustainable development (Suhada, 2015).

Socio-ecological adaptation strategies are therefore essential for the long-term viability of residents in Rowoterate Hamlet, Sitiarjo Village, Malang Regency, because the persistent flooding they face produces serious and enduring impacts on social life, livelihoods, and public health. An approach that integrates social dimensions (community life and institutions) with ecological dimensions (natural and hydrological conditions) provides a more comprehensive understanding of how people interact with their environment and how they can endure continuous environmental stress. Through this lens, Rowoterate residents can be understood not only as adjusting their everyday lives to recurrent flooding, but also as developing strategies to remain resilient—and potentially to improve their well-being—despite sustained and severe environmental challenges.

2. Methods

2.1 Type of Research

This study employs a qualitative method with a descriptive approach. Data were collected through a literature review and in-depth interviews with key informants, namely community leaders and long-term residents who have lived in the area for an extended period. This approach was selected to enable a detailed, context-sensitive understanding of local socio-ecological conditions and community adaptation practices.

2.2 Time and Study Site

Fieldwork was conducted on 3 May 2025, from 09:00 to 12:00. The research took place in Rowoterate Hamlet, Sitiarjo Village, Sumbermanjing Wetan Subdistrict, Malang Regency, East Java, Indonesia.

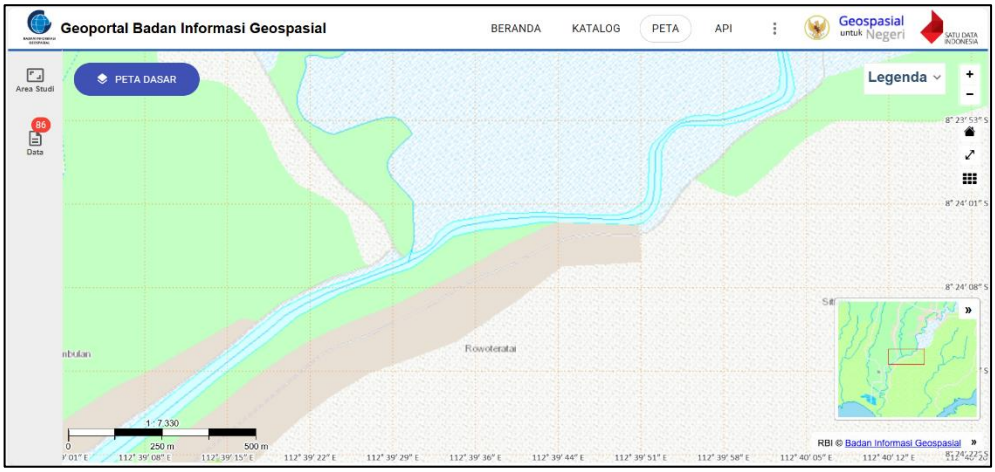

Figure 1. Map of the Study Area (Geospatial Information Agency, 2025)

Sitiarjo Village is situated along the Penguluran River. The presence of the Penguluran River is one of the principal factors that makes Sitiarjo prone to flooding, particularly flash floods. The upstream section of the river is characterized by steep slopes and high gradients; consequently, when rainfall occurs in the hilltop areas, runoff is rapidly conveyed downslope toward the downstream reaches.

2.3 Types and Sources of Data

This study utilizes both primary and secondary data. Primary data were obtained through observation, documentation, and in-depth interviews with three key informants: Mr. Wiwit (42 years old, private-sector employee), Mrs. Dwi Rahayu (36 years old, trader), and Mr. Ponidi (53 years old, farmer). Primary data collection also involved direct field observations of environmental conditions, community activities, and the forms of adaptation employed in response to flooding. Secondary data

were derived from scholarly journal articles addressing flooding and community adaptation, as well as relevant theoretical frameworks, including adaptation theory and early warning theory.

2.4 Data Collection Techniques

Data collection was conducted in an integrated manner through three principal methods: in-depth interviews, participant observation, and documentation. Interview guidelines were developed in both structured and semi-structured formats to elicit detailed information from community leaders and long-term residents of Rowoterate Hamlet. Through these interviews, the study gathered accounts of flood history, evolving social adaptation strategies, early warning systems in use, the meanings and motivations underlying adaptation, and the challenges and opportunities faced by the community in mitigation efforts. Participant observation was employed to directly examine the physical environmental context, including housing modifications, structural changes to buildings, and the socio-economic activities of residents in everyday life. This observation was supported by a pre-designed observation checklist intended to systematically record key physical and social aspects in the field. Documentation—consisting of photographs and written field notes—was used to substantiate and triangulate findings from the interviews.

2.5 Data Analysis Techniques

Data analysis followed the Miles and Huberman interactive model, which comprises three main stages: data reduction, data display, and conclusion drawing/verification. During data reduction, the researcher selected, simplified, and focused the raw data, retaining only information relevant to the study's objectives. This process was supported by thematic coding to identify and cluster the data into major themes aligned with the research focus, thereby facilitating the identification of patterns and relationships across the dataset. Subsequently, the reduced data were presented in the form of descriptive narrative to support systematic interpretation of emerging patterns. The final stage involved drawing conclusions, in which the researcher formulated the principal findings based on the recurring patterns identified throughout the analytic process.

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3. Results and discussion

3.1 Results

3.1.1 Flood History and Causes in Rowoterate Hamlet

The findings indicate that flooding in Rowoterate Hamlet is not a new phenomenon; rather, it has long been embedded in the everyday life of the local community. As stated by Mr. Wiwit (42 years old), "Rowoterate Hamlet has indeed been known as a flood-prone area for a long time. Since I was born, floods have occurred here frequently." The primary causes of flooding are identified as a combination of geographic conditions and environmental change, including the confluence of three waterways (the Penguluran River, the Mbambangan River, and the Bangbang Stream), upstream deforestation, and the hamlet's location on low-lying terrain with an elevation nearly at sea level.

The study also documents changes in flood intensity over time. Mrs. Dwi Rahayu explained that "Flooding in Rowoterate does not occur every year, but a major flood happened in 2013 that claimed two lives." Flood occurrence is not driven solely by local rainfall; it is also influenced by runoff originating from the upstream areas of Sumbermanjing Wetan and by tidal dynamics that exacerbate inundation in downstream sections.

3.1.2 Social Networks and Community Cooperation

The research reveals a strong social networking system within the Rowoterate community as a form of social adaptation to flooding. Technology-mediated communication—particularly through WhatsApp groups—functions as a primary channel for disseminating information among residents. As Mr. Wiwit noted, "Residents share updates through a WhatsApp group when there is potential flooding."

Patterns of community cooperation exhibit a distinct characteristic: collective action is more intensive after floodwaters recede than during the flood event itself. Mrs. Dwi Rahayu reported, "When floods occur, residents do not directly help one another; each person focuses on saving themselves and their belongings. However, after the flood subsides, residents then help each other clean several public spaces."

Figure 2. Shelter Space (Evacuation Facility)

Formal structures such as *MTB* (*Masyarakat Tanggap Bencana*) and the active involvement of the *PKK* in organizing communal cooking for flood victims indicate the presence of local institutions that strengthen community resilience. The early warning mechanism is further supported by an Early Warning System (EWS), with alerts disseminated to residents through handheld radios (HT) and mobile phones to ensure timely communication across the community.

3.1.2 Architectural Modification of Houses as a Physical Adaptation

Physical adaptation through housing modifications constitutes a principal strategy employed by Rowoterate residents to cope with recurrent flood risks. One particularly salient local innovation is the construction of *plenggrongan*, an elevated platform built above typical floodwater levels to protect valuable household items. As Mr. Wiwit explained, “Every house in Rowoterate is equipped with a *plenggrongan*—boards installed higher than the floodwater level to secure valuable belongings.”

Figure 3. Stilt House

In addition to *plenggrongan*, residents also implement structural adaptations by constructing stilt houses and elevating house floors. As Mrs. Dwi Rahayu noted, “I built a stilt house so that it is higher, so the water that enters is not too deep.” Such modifications function not only to protect property, but also to provide temporary shelter for household members during flood events.

Figure 3. Stilt House

This strategy illustrates the community's capacity to develop locally appropriate technological adaptations that respond to geographic conditions and economic constraints. In effect, each dwelling has become a self-sufficient evacuation unit, thereby reducing dependence on external evacuation shelters.

3.1.2 Meaning and Motivations for Disaster Adaptation

The study reveals psychological and cultural dimensions underlying Rowoterate residents' adaptive responses to flooding. Floods are not primarily perceived as hazards that must be avoided; instead, they are understood as an integral component of everyday life. Mr. Wiwit stated, "We interpret floods as part of life in Rowoterate, and we remain here because we feel comfortable and it is easy to make a living in Rowoterate."

Motivations for remaining in Rowoterate despite recurrent flood threats are shaped by several key factors, including emotional attachment to one's place of origin, economic accessibility—particularly through agriculture, and a sense of comfort derived from long-established social relations. Mrs. Dwi Rahayu affirmed, "For me, floods have become part of my life in Rowoterate. I was born and raised here, so I am already accustomed to flooding." The community's rejection of a government relocation program in 2013 further demonstrates the strength of residents' socio-ecological attachment to their territory. Moreover, solidarity forged through shared experiences of disaster functions as social capital that reinforces collective resilience.

3.1.3 Early Warning System and Disaster Preparedness

The early warning system in Rowoterate Hamlet has evolved from a traditional *kentongan* (wooden slit drum)–based alert mechanism (Mambaus et al., 2019) toward a more technologically mediated system. At present, residents utilize an Early Warning System (EWS) installed at Kedung Banteng, alongside rainfall monitoring in Sukodono Village, to detect potential flood events. Mr. Ponidi explained, "There is an EWS device at Kedung Banteng and rainfall monitoring in Sukodono Village. The information is disseminated through those communication devices."

The integration of technology with community communication networks—via WhatsApp groups, handheld radios (HT), and mobile phones—enables rapid and broad dissemination of alerts across the population. This system not only provides warnings regarding potential flooding but also facilitates emergency coordination among residents. Its effectiveness is reflected in the community's capacity to undertake preparatory actions prior to inundation, such as moving valuables to *plenggrongan* platforms and securing essential supplies to endure the flood period.

3.1.4 The Role of External Actors and Collaboration with Government

The findings indicate a constructive pattern of collaboration between the Rowoterate community and external actors, particularly the village government and relief organizations. Government support has included the provision of EWS equipment, emergency assistance in the form of food and basic necessities during flood events, and reforestation programs as part of longer-term mitigation efforts. Nevertheless, residents do not rely entirely on external assistance. As Mrs. Dwi Rahayu observed, "The government has helped by providing EWS equipment and post-disaster aid. However, for long-term solutions, residents do not expect much from the government because Rowoterate's geographical conditions place it in a low-lying area."

Figure 4. Front View of the Evacuation Shelter

The community's refusal of the relocation program indicates a clear preference for in-situ adaptation strategies rather than resettlement. Collaboration with organizations such as MTB (Masyarakat Tanggap Bencana) and the Indonesian Red Cross (PMI) reflects the presence of support networks that help strengthen local capacity in disaster response and management.

4.1.7 Socio-Economic Opportunities and Challenges

Persistent flooding in Rowoterate does not appear to generate distinct economic opportunities; instead, it tends to reinforce social solidarity through gotong royong (mutual assistance) and community cooperation. As Mr. Wiwit stated, "There are not many economic opportunities that arise from flooding; what exists is social solidarity through mutual cooperation in cleaning the environment after the flood".

Figure 5. Residents' Livelihoods

Agriculture remains the economic backbone of the community and even attracts migrants from outside the area seeking employment. Mr. Ponidi explained, "The economy in Rowoterate is dominated by agriculture and opportunities are easy to obtain; many newcomers from outside come here to earn a living".

Figure 6. Self-Managed Evacuation Facility

Key challenges include difficulties in securing heavy belongings during flood events, disruptions to daily activities, and the impact of upstream deforestation that exacerbates flood intensity. The irregular and sometimes high frequency of floods—reported by Mr. Wiwit as occurring "sometimes up to 12 times in a month"—constitutes a significant challenge that requires sustained community preparedness and high levels of vigilance.

3.2 Discussion

3.2.1 Socio-Ecological Adaptation as a Response to Recurrent Disasters

The findings of this study indicate that the Rowoterate Hamlet community has developed a complex and integrated socio-ecological adaptation system in response to persistent flooding.

Minarti et al.'s (2024) concept of socio-ecological adaptation—referring to the capacity of individuals, groups, or communities to adjust to environmental change through social, economic, technological, and physical dimensions—is clearly reflected in the range of strategies developed by Rowoterate residents.

Figure 7. Self-Managed Evacuation Facility

The adaptations observed in Rowoterate are not merely reactive responses; rather, they are proactive and anticipatory, consistent with the Adaptation Theory advanced by Burton, Kates, and White (1993), which emphasizes behavioral change and modifications to the physical environment as key responses to environmental risk. Housing modifications—particularly the construction of stilt houses and *plenggrongan*—demonstrate the community's capacity to implement locally tailored *engineering adaptations* within the constraints of local conditions and limited economic resources.

3.2.2 Community Resilience and Social Capital

The social networks and patterns of community cooperation identified in this study align with the Community Resilience Theory proposed by Norris (2008). This framework posits that community resilience is built through four core adaptive capacities: information and communication, social capital, community competence, and economic resources.

In Rowoterate, the information and communication capacity is manifested through the technology-enabled early warning system (EWS) and WhatsApp-based communication networks. Social capital is reflected in post-disaster solidarity and *gotong royong* (mutual assistance), although it follows a distinctive pattern in which cooperation becomes more intensive after floodwaters recede. Community competence is evident in residents' ability to develop local innovations such as *plenggrongan* and practical strategies for safeguarding valuable belongings.

The tendency for cooperation to intensify during the recovery phase rather than during the flood itself suggests a form of community resilience that departs from conventional models. It indicates that Rowoterate residents have developed a "each household for itself" strategy during the acute crisis phase, followed by collective action during recovery. This pattern may be particularly effective in the context of recurrent and partially predictable flooding, where each household has established self-reliant adaptive mechanisms.

3.2.4 The Social Construction of Disaster and Cultural Adaptation

Findings concerning the meanings and motivations underlying community adaptation are consistent with Oliver-Smith's (1996) Social Construction of Disaster perspective. This theory argues that the meaning of disaster is not universal; instead, it is socially constructed through collective experience and the cultural context of a given community.

In Rowoterate, floods are not constructed as "disasters" in the conventional sense, but rather as a manageable "part of life" addressed through adaptation. This meaning-making process enables residents to remain—and potentially thrive—in an area that is objectively high-risk. The community's rejection of a government relocation program further illustrates a strong place-based identity tied to the homeland and livelihood practices.

Economic motivations, combined with emotional attachment to place, produce what can be conceptualized as adaptive place attachment—a form of attachment that does not deny risk, but instead fosters strategies for living with and managing that risk.

3.2.5 The Evolution of Early Warning Systems and Adaptive Technologies

The shift from traditional *kentongan* warning mechanisms to modern EWS technology highlights the community's capacity to adopt and integrate new technologies into existing social systems. This development is consistent with Basher's (2006) Early Warning System Theory, which emphasizes the integration of risk detection, warning communication, and community response.

The effectiveness of the Rowoterate early warning system lies in its ability to combine modern technologies (EWS, WhatsApp, handheld radios/HT) with local social structures. Information generated by technical devices is not absorbed directly; rather, it is mediated through social filters such as community leaders and established communication structures. This hybrid approach enables technology to operate effectively within the local socio-cultural context.

3.2.6 Limitations of Structural Solutions and the Importance of Non-Structural Adaptation

The study suggests that structural interventions—such as relocation programs—are not always appropriate for communities that have developed effective local adaptation systems. The community's refusal of relocation indicates that "command-and-control" approaches to disaster management should be balanced with "living with risk" approaches that recognize and strengthen local adaptive capacity

Figure 8. Stilt House

The non-structural adaptation strategies developed by the Rowoterate community—such as housing modifications, early warning systems, and social networks—demonstrate effectiveness in reducing vulnerability without requiring the complete elimination of hazards. This approach is consistent with contemporary disaster risk management paradigms, which emphasize vulnerability reduction rather than the total removal of threats.

3. Conclusion

This study highlights the success of the Rowoterate Hamlet community in developing a comprehensive and sustainable socio-ecological adaptation system to cope with persistent flooding. The observed socio-ecological adaptations reflect a harmonious integration of social and ecological dimensions: residents not only modify the physical environment through local innovations such as stilt houses and plenggrongan but also strengthen technology-enabled social networks while maintaining local wisdom and community norms.

The social construction of flooding as "part of life" indicates a mature understanding of socio-ecological relationships with the environment. This perspective is evidenced by the community's rejection of government relocation initiatives and its preference for in-situ adaptation strategies. The evolution of early warning practices—from traditional kentongan alerts to modern EWS technology—further illustrates the community's capacity to integrate local ecological knowledge with contemporary technological systems. In addition, the resilience pattern described as "self-reliant

during crisis, united during recovery" reflects an effective socio-ecological strategy for managing recurrent environmental disturbances.

Overall, the success of these non-structural adaptations demonstrates that a socio-ecological approach can serve as a sustainable model for disaster risk management. Such an approach not only reduces physical vulnerability, but also strengthens social capital and community adaptive capacity, thereby fostering a resilient socio-ecological system capable of responding to future environmental change.

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