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FORM OF FLOOD DISASTER HAZARD MITIGATION IN LEPO-LEPO VILLAGE, BARUGA DISTRICT, KENDARI CITY

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ABSTRACT

Flood frequency in Kendari City has sharply increased, emphasizing need for community-based mitigation strategies. However, studies examining the contributions of structural and non-structural flood mitigation at community level remain limited, particularly in flood-prone areas such as Lepo-Lepo. This study identifies and analyzes the contributions of structural and non-structural flood mitigation efforts in Lepo-Lepo Village, Baruga District, Kendari City. Research from June to July 2021 employed observation, interviews, literature studies, and document analysis, with data analyzed descriptive and qualitatively. Lepo-Lepo Village experienced five floods between 2013 and 2021. The 2013 and 2017 floods were the most severe, with water levels reaching 3–4 meters. In 2018, floods reached 2 meters and lasted several days; in 2019, 1–2 meters for five days; and in 2021, 1 meter for two days. These floods were triggered by high-intensity rainfall and overflow of the Wanggu River, resulting in casualties, infrastructure damage, and economic losses. To reduce flood risk, integrated structural and non-structural measures were implemented, including embankments, drainage improvements, retention ponds, mosque siren warnings, weather monitoring, evacuation training, and Disaster Preparedness Groups (KSB). These measures improved flood control, strengthened early warning systems, and enhanced community preparedness and through community participation and institutional coordination.
***Keywords**: flood disaster; Lepo-lepo Village; non-structural mitigation; structural mitigation.*

A. INTRODUCTION

Climate change has increased the frequency of hydrometeorological disasters, including floods, landslides, storms, and droughts, worldwide (IPCC, 2023; WMO, 2023). In Indonesia, the La Niña phenomenon contributes to prolonged heavy rainfall, increasing flood susceptibility in many regions (BMKG, 2021; Hidayat et al., 2023). Flood disasters are influenced not only by natural factors such as rainfall intensity and topography but also by human activities, including rapid urbanization, land-use change, poor spatial planning, and environmental degradation (Giofandi et al., 2026; Hoang and Liou, 2024).

Recent disaster risk reduction frameworks emphasize the importance of integrating structural and non-structural mitigation approaches to reduce flood impacts effectively (UNDRR, 2022). Structural mitigation includes physical measures such as drainage improvement, embankment construction, and river normalization, while non-structural mitigation involves disaster education, spatial planning, early warning systems, and

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community participation (Wahid, 2023; Zaenuri et al., 2025). Community-based mitigation has become increasingly important because local communities possess adaptive capacities developed through repeated experiences with disasters (Dieu et al., 2024).

Kendari City, Southeast Sulawesi Province, is one of the regions in Indonesia that frequently experiences flooding. Major floods resulting from the overflow of the Wanggu River occurred in 2013 and 2017. The 2013 flood caused one fatality and displaced 2,679 residents (DIBI BNPB, 2018). Meanwhile, the 2017 flood, which occurred from May 12 to 14, inundated nine sub-districts, resulting in one death, two injuries, and affecting 9,958 residents. It also damaged 3,016 houses, submerged 55.5 hectares of farmland, and caused estimated economic losses of IDR 42.7 billion (BPBD Kendari, 2017; Kasim et al., 2020). Recent evidence further indicates that flooding remains a major concern in Kendari City. Sakawuna (2025) recorded 127 flood events during the 1999–2024 period across several sub-districts, including Baruga, Kambu, Poasia, Kadia, Puuwatu, and Mandonga. The study also reported a major flood in 2024 that inundated 3,304 houses, indicating that flooding remains a significant and recurring hazard in the city.

Lepo-Lepo Village in Baruga District is among the areas most severely affected by flooding within the Wanggu Watershed. Baruga District covers approximately 1,377 ha and has the highest flood susceptibility in the watershed (Kasim, 2020). Flooding in Lepo-Lepo Village is primarily caused by the overflow of the Wanggu River during periods of intense rainfall. The impacts are further exacerbated by dense residential settlements located along the riverbanks, which increase community exposure and vulnerability to flood hazards. Despite experiencing floods almost every year, many residents continue to reside in the area due to economic, social, and cultural considerations. Previous studies suggest that residents in flood-prone areas often choose to remain in their communities despite recurrent flood events because of their attachment to place, social networks, and livelihood dependence. Consequently, they tend to develop local adaptation and coping strategies rather than relocate to safer areas (Lie et al., 2023). Repeated exposure to flood events has encouraged communities to accumulate local knowledge and practical experience in dealing with flood impacts, thereby strengthening their adaptive capacity and resilience to future floods (Puspitasari & Herdiansyah, 2021).

The capacity of local communities to adapt to recurring floods has become an important aspect of disaster risk reduction. However, previous studies in Kendari City have primarily focused on hydrological analysis, watershed characteristics, flood hazard mapping, and

environmental impacts (Kasim et al., 2020; Nurliah et al., 2024). Although these studies provide valuable information on flood causes and risks, limited attention has been given to community-based mitigation practices at the settlement level, particularly in highly vulnerable areas such as Lepo-Lepo Village. Furthermore, existing studies have largely emphasized structural mitigation measures, while non-structural dimensions, including community preparedness, local knowledge, adaptation strategies, and adaptive capacity, remain insufficiently explored.

Addressing this gap, the present study focuses on both structural and non-structural flood mitigation measures implemented by local communities in Lepo-Lepo Village. By examining how communities combine physical mitigation efforts with locally developed adaptation strategies, this study contributes to a better understanding of community resilience, participatory disaster risk reduction, and sustainable flood management in urban watershed areas. Therefore, this study aims to identify and analyze form of mitigation of structural and non-structural flood disaster hazards in Lepo-Lepo Village, Baruga District, Kendari City.

B. MATERIALS AND METHODS

This research was conducted in Lepo-Lepo Village, Baruga District, Kendari City, Southeast Sulawesi Province, from June to July 2021. This study employed a qualitative descriptive approach. The data used in this research consisted of primary and secondary data. Primary data were obtained through field observations and interviews on flood conditions in Lepo-Lepo Village, while secondary data included rainfall, population, and climate data, as well as records of flood events from relevant institutions. These data were used to support the descriptive analysis of flood conditions and mitigation efforts in the study area. The data sources used in this study consisted of primary and secondary data.

Table 1. Types and Sources of Research Data

No	Data Type	Data	Data Source
1	Primary Data	Respondent identities, community perceptions, and information related to flood hazard mitigation efforts.	Field observations and interviews with household heads using questionnaires
2	Secondary Data	Rainfall data, population data, climate information, flood event records, maps, and supporting documents related to flood conditions and mitigation.	Village Office, BPBD, BPS, BMKG, BPDAS-HL, Regional Office of Public Works and Public Housing (PUPR), BWS Sulawesi IV, previous studies, and related documentation

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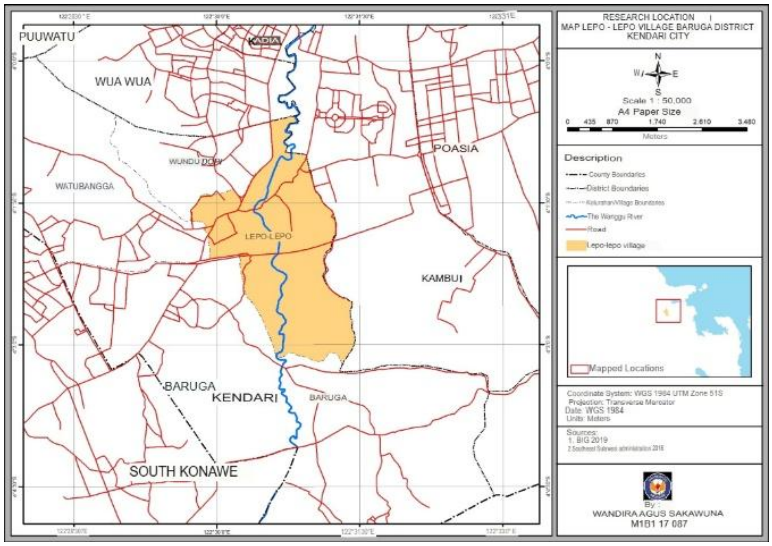


Figure 1. Study area

The population of this study consisted of 200 households affected by the 2017 flood in Lepo-Lepo Village, Baruga Subdistrict (BPBD Kendari City, 2017). Respondents were selected using purposive sampling, which is a sampling technique used to select participants based on specific characteristics and their relevance to the objectives of the study (Etikan et al., 2016). The criteria for selecting respondents were: (1) households directly affected by the 2017 flood; (2) residents aged 30–65 years; (3) individuals who had lived in the area for at least ten years; and (4) households located within 0–500 meters of the Wanggu River. A total of 67 household heads were considered adequate to provide relevant information and support the descriptive analysis of flood conditions and mitigation efforts in the study area. The research procedure includes:

1. Literature study – collecting, reviewing, and organizing relevant references and research materials.
2. Preliminary observation – conducting direct field visits in Lepo-Lepo Subdistrict, Baruga District, to understand the study area.
3. Formulating research problems and objectives which are the line of research question.
4. Preparation stage – obtaining research permits and preparing questionnaires.
5. Field data collection – conducting surveys, interviews, and documentation to obtain primary data.
6. Data tabulation and analysis – processing field data through reduction and presentation carried out simultaneously with data collection:

Table 2. Stages of data analysis

No	Analysis Stage	Description
1	Data Reduction	Selecting, classifying, and simplifying data obtained from observations, interviews, and documentation related to flood conditions and mitigation efforts in the study area.
2	Data Presentation	Organizing the reduced data into descriptive narratives, tables, and supporting documentation to facilitate interpretation and understanding of the findings.
3.	Conclusion Drawing	Interpreting the findings to identify flood impacts, community responses, and mitigation efforts implemented in Lepo-Lepo Village.

Data were analyzed using a qualitative descriptive approach through data reduction, data display, and conclusion drawing. Data were collected using interview guides, observation, and documentation to describe structural and non-structural flood mitigation in the study area. Data validity was ensured through source, technique, and time triangulation. Source triangulation involved comparison among community members, the Head of the Disaster Preparedness Group (KSB), Lepo-Lepo Village officials, and relevant institutions. Technique triangulation was conducted by cross-checking interview, observation, and documentation data. Time triangulation was performed by examining data across different periods to ensure consistency.

C. RESULTS AND DISCUSSION

Flood events in Lepo-Lepo Village, Baruga District, Kendari City, have occurred repeatedly over the past decade, indicating that the area remains highly vulnerable to hydrometeorological disasters. Major floods were recorded in 2013, 2017, 2018, 2019, and 2021, with the most severe events occurring in 2013 and 2017 when water levels reached approximately 3–4 meters. Flood events in 2018, 2019, and 2021 were relatively less severe, with inundation heights ranging from 1–2 meters and shorter flood durations. These recurring flood events indicate that flood hazards in Lepo-Lepo Village are recurrent rather than incidental (Ilham et al., 2024).

Although flood intensity decreased after 2018, inundation continued to occur during periods of high rainfall. This condition indicates that flood mitigation efforts implemented in Lepo-Lepo Village have reduced flood impacts but have not completely eliminated flood hazards. Increasing flood frequency and recurring inundation demonstrate the need to strengthen community preparedness and disaster awareness through education and technological innovation to improve flood mitigation capacity (Lestari et al., 2024).

The recurring nature of flooding also influenced community preparedness and adaptive behavior. Residents who frequently experienced flooding demonstrated greater awareness of rainfall conditions, river water levels, and evacuation procedures. Previous

flood experiences encouraged communities to adopt adaptive behaviors, such as cleaning drainage channels, monitoring weather conditions, and preparing evacuation equipment during the rainy season. This finding supports Kurata et al. (2023), who stated that disaster experience strongly influences preparedness behavior and community resilience. However, the present study further demonstrates that repeated flood experiences form practical local knowledge that becomes part of everyday community adaptation and local resilience.

1. Structural Mitigation Measures

Structural mitigation measures implemented in Lepo-Lepo Village included embankment construction, drainage development, and retention pond construction carried out by the River Basin Agency (BWS IV), the Ministry of Public Works and Public Housing (PUPR), and the Kendari City Government. The forms, effectiveness, social impacts, and community perceptions regarding structural mitigation are presented in Table 3.

Table 3. Structural Mitigation Measures

No.	Structural Mitigation Measures	Description	Effectiveness	Social Impact	Community Perception
1.	Embankment Construction	Carried out by the River Basin Agency (BWS IV) together with the Kendari City Government.	Moderately effective in reducing flood inundation during moderate rainfall, but limited during extreme rainfall events.	Reduced frequency of minor flooding in nearby settlements; however, temporary construction activities caused disruption to local mobility.	Generally perceived as beneficial, but some residents remain concerned about maintenance and overflow during heavy rain.
2.	Drainage Construction	Carried out by the ministry of Public Works and Public Housing (PUPR) together with the Kendari City Government.	Relatively effective in improving water drainage, although blockages from sediment and waste still reduce performance.	Improved environmental sanitation and reduced stagnant water, but requires continuous maintenance by community and local government.	Viewed positively by residents, especially in reducing waterlogging in residential areas, though maintenance is considered insufficient.
3.	Construction of Retention Ponds	Carried out by the River Basin Agency (BWS IV) together with the Kendari City Government.	Effective in delaying peak runoff and reducing flood pressure downstream, but capacity is sometimes insufficient during prolonged rainfall.	Helped reduce flood peak intensity in surrounding areas; also created new	Supported by most residents as a long-term solution, but some express concerns regarding land

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No.	Structural Mitigation Measures	Description	Effectiveness	Social Impact	Community Perception
				open water spaces.	use and maintenance.

Source: Data Analysis Results, 2021

The findings show that embankment construction moderately reduced flood inundation, particularly during moderate rainfall events. Residents living near riverbanks reported that the frequency of minor flooding decreased after embankments were constructed. Embankments helped control river overflow and reduced water intrusion into nearby settlements. These findings are consistent with Ahmed et al. (2021), who explained that embankments function to prevent water overflow into floodplain areas, and Sarfaraz et al. (2019), who emphasized that embankments are important for regulating river flow and protecting infrastructure from flood damage.Similarly, drainage construction improved water flow and reduced stagnant water in residential areas. Communities generally perceived drainage systems positively because they improved environmental sanitation and reduced localized inundation. These findings support Febrianita et al. (2014), who stated that drainage systems reduce excess surface water and maintain land functionality, as well as Fathi et al. (2025), who emphasized the role of drainage systems in channeling rainwater into larger water bodies. However, field observations revealed that drainage systems were frequently obstructed by sedimentation, rubbish accumulation, and vegetation growth, reducing their effectiveness during periods of heavy rainfall. This finding indicates that infrastructure maintenance remains one of the major challenges in flood mitigation implementation.

Retention ponds were identified as one of the most effective structural mitigation measures implemented in the study area. Residents explained that before the retention ponds were constructed, two consecutive days of rainfall could easily inundate settlements. However, after the retention ponds became operational in 2020, flood intensity and water accumulation decreased in several flood-prone areas. This finding indicates that retention ponds effectively delayed peak runoff and reduced downstream flood pressure, supporting previous studies by Nyame et al. (2023), who argued that retention ponds reduce flood peaks by temporarily storing runoff before releasing it into river systems. In addition, retention ponds also contribute to groundwater recharge and environmental improvement in urban areas (Su et al., 2025).

The effectiveness of retention ponds is also reflected in the reduction of Wanggu River discharge after their construction. Although rainfall intensity remained relatively high,

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river discharge data indicated improved flood control capacity in Lepo-Lepo Village. Nevertheless, flooding still occurred during prolonged rainfall events, suggesting that retention pond capacity remained insufficient during extreme weather conditions. This finding differs from studies emphasizing retention ponds as highly effective flood-control infrastructure because, in Lepo-Lepo Village, infrastructure performance remained strongly influenced by rainfall intensity, settlement expansion, and environmental conditions.

Another important issue identified in this study concerns the sustainability of structural mitigation programs. Although communities generally viewed embankments, drainage systems, and retention ponds positively, several residents expressed concerns regarding maintenance continuity and the possibility of overflow during extreme rainfall. Infrastructure maintenance remained highly dependent on government intervention, while community participation in maintenance activities was still relatively limited. Without regular maintenance and infrastructure upgrading, the effectiveness of structural mitigation may decline over time, particularly under increasing climate variability and urban expansion pressures.

Overall, the findings indicate that structural mitigation in Lepo-Lepo Village successfully reduced flood intensity but was insufficient to completely eliminate flood risk. Compared with previous studies focusing mainly on engineering approaches, the present study demonstrates that physical infrastructure alone cannot fully address flood vulnerability without long-term maintenance, environmental management, and community participation.

2. Non-Structural Mitigation Measures

Non-structural mitigation measures implemented in Lepo-Lepo Village focused on strengthening community preparedness, disaster awareness, and local response capacity. These measures included flood early warning systems, flood preparedness activities, disaster education, and the establishment of Disaster Preparedness Groups (KSB). The forms, effectiveness, social impacts, and community perceptions regarding non-structural mitigation are presented in Table 4.

Table 4. Non-Structural Mitigation Measures

No.	Structural Mitigation Measures	Description	Effectiveness	Social Impact	Community Perception
1.	Early warning system for flooding	The community uses mosque sirens to promptly alert the public when flooding is imminent, enabling residents to prepare or	Relatively effective in providing early response time before floodwater rises significantly.	Strengthens collective awareness and coordination during flood events.	Generally perceived as helpful and easy to access because it uses

		evacuate in a timely manner.			familiar community facilities.
2.	Flood preparedness.	The community regularly monitors local weather updates and cleans rubbish and weeds from channel walls and bottoms to maintain drainage. The Regional Disaster Management Agency (BPBD) installs water level gauges for monitoring and designs clear evacuation routes to improve community safety during floods.	Effective in reducing blockage of drainage channels and improving preparedness, although less effective during extreme rainfall events.	Encourages active participation between government and community in disaster risk reduction.	Considered beneficial, though some residents still rely on direct observation rather than formal warnings.
3.	Disaster Knowledge.	The community conducts socialisation and training sessions on evacuation procedures and administering first aid to victims during floods. In addition, Disaster Preparedness Groups (KSB) are established to coordinate and enhance overall community readiness.	Moderately effective in improving awareness and response capacity, especially in trained groups.	Improves disaster literacy and strengthens community organization.	Viewed positively, but participation levels vary among residents.

Source: Data Analysis Results, 2021

One important non-structural measure identified in this study was the community-based flood early warning system. During periods of heavy rainfall, mosque sirens were used to warn residents about potential flooding, enabling communities to prepare and evacuate more quickly. Residents considered this system effective because it utilized familiar community facilities that were easily accessible to local people. In addition, the warning system strengthened collective awareness and social coordination during emergencies. These findings support Bajracharya et al. (2021), who emphasized that community-based early warning systems improve disaster preparedness and emergency response by providing localized and accessible warnings. Similarly, Ramsden et al. (2025) explained that locally integrated warning systems strengthen community resilience by combining official flood information with community-based monitoring practices.The findings indicate that non-structural mitigation plays an important role in strengthening community resilience because it directly influences preparedness behavior and local adaptive capacity. Communities routinely monitored weather conditions, cleaned drainage

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channels, removed rubbish and weeds, and prepared evacuation routes during the rainy season. These activities demonstrate that flood preparedness in Lepo-Lepo Village was supported not only by government intervention but also by active community participation. This finding supports Smith et al. (2017), who argued that community-based preparedness systems are essential for strengthening resilience and reducing disaster losses.

The Kendari City Regional Disaster Management Agency (BPBD) also contributed significantly through evacuation simulations, first aid training, and the installation of water-level monitoring instruments. In addition, the establishment of the Disaster Preparedness Group (KSB) in 2019 strengthened community coordination and disaster response capacity. Through these programs, communities developed practical knowledge and response skills related to flood emergencies. This finding is consistent with Sorna et al. (2025), who stated that disaster preparedness training improves knowledge, attitudes, and practical response skills during emergencies. Furthermore, Pradhananga et al. (2022) emphasized that participatory disaster training and community involvement are important factors in strengthening proactive disaster behavior and local preparedness.

This study further found that repeated flood experiences significantly influenced community preparedness behavior. Residents who had previously experienced severe floods demonstrated greater awareness of flood risks and responded more quickly to disaster warnings. Previous disaster experiences shaped practical local knowledge that became part of everyday community adaptation strategies. This finding supports Kurata et al. (2023), who explained that disaster experience contributes to stronger preparedness behavior and adaptive capacity. However, the present study further demonstrates that local capacity is formed not only through disaster experience but also through continuous interaction between social learning, community participation, and institutional support.

Compared with structural mitigation, non-structural mitigation appears more sustainable because it strengthens community awareness and collective action rather than relying solely on physical infrastructure. Communities with stronger preparedness capacities were better able to adapt and recover from recurring flood events. This finding suggests that social mitigation is equally important as engineering-based mitigation in reducing disaster impacts. The present findings therefore differ from previous studies that mainly emphasized structural infrastructure as the primary flood solution because the results demonstrate that

community preparedness and local participation are critical components of long-term flood resilience.

However, several implementation challenges were also identified. Community participation remained uneven, with active involvement generally dominated by community leaders and trained groups. Some residents still relied heavily on government assistance during emergencies and depended more on direct environmental observations than formal warning systems. In addition, disaster education and preparedness programs require continuous implementation to maintain community awareness and preparedness levels. Without regular training and institutional support, preparedness levels may gradually decline over time. These findings indicate that the sustainability of non-structural mitigation depends strongly on continuous community engagement, institutional commitment, and participatory disaster governance.

Therefore, the findings indicate that sustainable flood mitigation in Lepo-Lepo Village requires integration between structural and non-structural approaches. Structural mitigation reduces physical flood exposure, while non-structural mitigation strengthens local adaptive capacity and social resilience. Effective flood management should therefore combine physical infrastructure development with continuous community empowerment, participatory disaster governance, and long-term environmental management.

The findings of this study suggest that engineering-based mitigation alone is insufficient to address flood vulnerability in highly exposed urban areas such as Lepo-Lepo Village. Although structural measures reduced flood intensity, their effectiveness remained limited during prolonged and extreme rainfall events. In contrast, non-structural mitigation strengthened community preparedness, adaptive behavior, and collective response capacity, which proved essential during recurring flood events. These findings indicate that social mitigation plays a critical role in long-term flood resilience because community capacity, local knowledge, and participatory preparedness remain functional even when physical infrastructure experiences limitations. Therefore, sustainable flood mitigation requires not only infrastructure development but also continuous community empowerment and adaptive disaster governance to respond to increasing climate-related risks.

D. CONCLUSIONS

Based on the findings, flood mitigation in Lepo-Lepo Village is implemented through a combination of structural and non-structural measures. Structural mitigation includes embankments, drainage systems, and retention ponds to reduce flood impacts and regulate water flow, while non-structural measures involve community-based preparedness such as mosque sirens as an early warning system, weather monitoring, drainage cleaning, evacuation simulations, and first-aid training. These findings indicate that flood risk reduction in Lepo-Lepo Village depends not only on physical infrastructure but also on community participation and adaptive capacity, highlighting the importance of integrated mitigation approaches in recurrent flood-prone areas.

This study contributes to the understanding of community-based flood mitigation in urban watershed areas by emphasizing the role of local knowledge, preparedness, and collective action in strengthening community resilience. The findings imply that structural measures alone are insufficient without strong community engagement. Therefore, future flood management programs should strengthen collaboration between local government, disaster management agencies, and communities to improve preparedness, maintain mitigation infrastructure, and support sustainable flood risk reduction in flood-prone settlements.

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