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Analysis of Economic Vulnerability and Resilience of Communities Affected by Floods in Central Tapanuli, North Sumatra, and Aceh

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ABSTRACT
This study examines the economic vulnerability and resilience of flood-affected communities in Central Tapanuli, North Sumatra, and Aceh through a qualitative literature review based on published articles, reports, and relevant policy documents. The study analyzes key dimensions of vulnerability, including poverty, livelihood dependence, limited financial access, housing conditions, disaster exposure, and adaptive capacity. The findings show that economic vulnerability is strongly influenced by dependence on climate-sensitive livelihoods, weak household assets, and limited access to savings, credit, insurance, and formal recovery assistance. Although affected communities demonstrate adaptive responses such as temporary relocation, livelihood diversification, housing modification, social capital utilization, and informal cooperation networks, overall community resilience remains relatively weak, particularly in social and institutional dimensions. The study highlights that flood management policies should move beyond short-term emergency relief toward integrated strategies that strengthen local economic capacity, adaptive social protection, community-based early warning systems, and sustainable livelihood diversification. These findings contribute to disaster risk reduction studies by emphasizing the need for inclusive, locally grounded, and multidimensional policy responses to reduce flood-related economic vulnerability.

Keywords: Economic Vulnerability, Community Resilience, Flood Disaster, Adaptive Capacity.

I. Introduction

Indonesia is a country with a very high level of vulnerability to various natural disasters due to its geographical position, which is located at the convergence of three major tectonic plates of the world (Priyanto et al., 2026). This geographical condition makes Indonesia highly exposed to geological hazards such as earthquakes, volcanic eruptions, and tsunamis. In addition to geological disasters, Indonesia is also vulnerable to hydrometeorological disasters, including floods, landslides, droughts, and extreme weather events. Among these disasters, flooding is one of the most frequent and destructive hazards affecting many regions in Indonesia. Flood disasters have widespread consequences, not only in terms of physical damage to settlements, infrastructure, agricultural land, and public facilities, but also in relation to social, economic,

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environmental, and psychological impacts on affected communities (Thoha et al., 2023). Therefore, the issue of flood vulnerability and community resilience has become increasingly important in the context of disaster risk reduction, regional development, and sustainable livelihood planning.

The interaction of natural factors and human activities generally causes flooding in Indonesia. Natural factors such as high rainfall intensity, river overflow, lowland topography, coastal inundation, and poor water absorption capacity contribute significantly to flood occurrence. However, the severity of flood impacts is often intensified by human-induced environmental changes, including deforestation, rapid land-use conversion, unplanned settlement expansion, weak drainage systems, and degradation of watershed areas. Deforestation has a direct impact on increasing disaster risk, particularly flooding, as forest loss reduces the land's ability to absorb rainwater and increases surface runoff (Thoha et al., 2023). As a result, communities living in river basins, coastal areas, lowlands, and other flood-prone locations become more exposed to recurring flood events. This condition shows that flood disasters cannot be understood merely as natural events, but must also be examined as the result of socio-environmental processes that increase exposure and vulnerability.

The Sumatra region, including Central Tapanuli in North Sumatra and Aceh Province, faces serious challenges related to flood disasters. These areas are characterized by diverse geographical conditions, ranging from mountainous landscapes and river basins to coastal zones and lowland settlements. Such geographical diversity makes several parts of Sumatra highly susceptible to floods and landslides, especially during periods of heavy rainfall. The risk is further aggravated by rapid land-use changes that increase community exposure and vulnerability (Budiman & Chu, 2025). In many areas, environmental degradation, conversion of forest land, and settlement development in disaster-prone zones have contributed to the rising risk of flood impacts. For instance, in Langkat Regency, North Sumatra, there are three sub-districts with high to very high flood vulnerability levels, namely Wampu Sub-district, covering 14.56% of the total area, Pematang Jaya Sub-district, covering 18.01%, and Hinai Sub-district, covering 16.05%. Similar conditions are also found in various coastal and lowland areas in Sumatra, where the increasing frequency of flood events is associated with climate change, land degradation, and limited disaster mitigation capacity.

The economic impacts of floods are particularly severe for communities whose livelihoods depend on agriculture, fisheries, small-scale trade, and informal economic activities. In Central Tapanuli, North Sumatra, and Aceh, many households rely on climate-sensitive livelihoods that are easily disrupted by disaster events. When floods occur, agricultural land may be damaged, crops may fail, livestock may be lost, fishing activities may be interrupted, and access to markets may be limited. Small traders and micro-enterprises may also suffer losses due to damaged goods, reduced customer access, disrupted transportation, and the temporary closure of business activities. These economic disruptions can reduce household income, increase expenditure, and weaken the ability of families to meet basic needs. Poor and vulnerable households are often the most affected because they have limited savings, fewer productive assets, and restricted access to credit, insurance, or formal recovery assistance.

The urgency of this research is strengthened by the floods and landslides that affected several provinces in Sumatra at the end of 2025, which caused substantial loss of life, large-scale displacement, and serious damage to public infrastructure (Marthoenis, 2025). National disaster reports recorded approximately 1,140 deaths, 163 missing persons, and nearly 400,000 displaced residents, with reconstruction needs estimated at IDR 51.82 trillion. These figures indicate that flood disasters create not only immediate emergency conditions, but also long-term development challenges. The impacts of such disasters may extend to livelihood insecurity, declining household welfare, reduced access to education and health services, psychosocial stress, and increased poverty risk. Therefore, flood disasters should not be viewed solely as physical hazards, but also as socio-economic crises that require integrated and sustainable policy responses. Agrarian communities in disaster-prone areas face vulnerability to shocks, seasonality, and long-term trends, which represent complex challenges requiring holistic analysis (Astaman et al., 2025). Shocks such as natural disasters and disease outbreaks can weaken economic resilience through infrastructure damage, loss of productive assets, and increased health-related costs. Meanwhile, seasonal pressures such as pest attacks, unstable weather patterns, and price fluctuations can increase income instability, especially among households that depend heavily on monoculture farming and have limited market access. These conditions demonstrate that community vulnerability is multid limited market access. These conditions demonstrate that community vulnerability is multidimensional. It is shaped not only by physical exposure to floods, but also by

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socio-economic factors such as poverty, education, livelihood dependence, access to information, institutional support, social networks, and adaptive capacity.

In this context, resilience becomes an important concept for understanding how communities prepare for, respond to, and recover from flood disasters. Economic resilience refers to the ability of individuals, households, and communities to absorb disaster shocks, adapt to changing conditions, and restore their livelihoods after experiencing losses. Community resilience may be influenced by livelihood diversification, household savings, access to early warning systems, social capital, government assistance, disaster preparedness, and local adaptation strategies. Some communities may adapt by changing planting schedules, diversifying income sources, strengthening mutual assistance networks, improving household preparedness, or participating in disaster risk reduction programs. However, the effectiveness of these strategies depends on the availability of resources, institutional support, and the capacity of local communities to manage disaster risks. Based on this background, this study focuses on the analysis of economic vulnerability and resilience of flood-affected communities in Central Tapanuli, North Sumatra, and Aceh. This research aims to analyze the level of socio-economic vulnerability of communities affected by floods, evaluate the determining factors of community resilience, identify adaptation strategies implemented by local communities, and formulate policy recommendations to enhance adaptive capacity and reduce vulnerability to flood disasters. The study is expected to contribute to academic discussions on disaster vulnerability and resilience, while also providing practical insights for policymakers, local governments, and disaster management institutions. By understanding the economic impacts of floods and the resilience capacity of affected communities, this research may support the development of more inclusive, adaptive, and sustainable disaster risk reduction strategies in flood-prone regions of Indonesia.

II. Literature Review and Hypothesis Development

2.1. Conceptual Framework of Vulnerability and Resilience

Vulnerability is a multidimensional concept that refers to the extent to which individuals, households, or communities are exposed and sensitive to hazards, as well as their capacity to cope with and recover from disaster impacts. In the context of flood disasters, vulnerability is commonly assessed through four main dimensions: social, economic, physical, and environmental dimensions (Yanto et al., 2025). These dimensions are interrelated and collectively determine the level of risk experienced by communities in flood-prone areas. Social vulnerability may be reflected in demographic characteristics such as age, disability, education level, and household dependency ratio. Economic vulnerability is often associated with poverty, income instability, limited access to productive assets, and dependence on climate-sensitive livelihoods. Physical vulnerability refers to the condition of housing, infrastructure, settlement patterns, and access to basic facilities, while environmental vulnerability is related to land degradation, deforestation, watershed conditions, and exposure to hydrometeorological hazards.

Research conducted in Tulang Bawang Regency shows that the most vulnerable populations are individuals in vulnerable age groups, poor communities, and persons with disabilities, while the highest level of economic vulnerability is closely linked to poverty experienced in Rawa Jitu District (Yanto et al., 2025). This finding indicates that vulnerability is not distributed equally across society. Households with fewer resources and limited access to institutional support tend to experience greater losses and face more difficulties in recovering from flood impacts. In this sense, vulnerability is not only a matter of physical exposure to flooding, but also a reflection of broader social and economic inequalities that shape people's ability to prepare for, respond to, and recover from disasters.

Household vulnerability to flooding is influenced by several factors, including income level, housing type, settlement pattern, home ownership, and access to alternative sources of income, all of which affect preparedness decisions and the adoption of risk reduction measures (Atie & Sibiri, 2024). Flood-risk households often face food insecurity, livelihood loss, and displacement, with limited or no opportunities to improve their welfare due to deepening hunger and poverty. This condition demonstrates that flood

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vulnerability can generate a cumulative burden for affected households. When a disaster destroys productive assets, reduces income, and disrupts access to food and basic services, vulnerable households may become trapped in a cycle of poverty and insecurity.

Community resilience, on the other hand, refers to the capacity of communities to absorb shocks, adapt to changing conditions, and recover from disaster impacts while maintaining their social and economic functions. In the context of flood disasters, community resilience is strongly determined by the ability of local people to adapt to recurring flood events (Ernawati et al., 2025). Studies in Kemaman, Terengganu, Malaysia, and Padang City, West Sumatra, Indonesia, reveal that communities continue to live in flood-prone areas despite repeated disaster exposure. These communities show relatively high resilience because they are able to respond quickly, take initiatives, and develop adaptive practices in dealing with floods. Interestingly, the relationship between resilience and education level was found to be insignificant, suggesting that community resilience is shaped not only by formal education but also by local knowledge, social experience, collective action, and practical adaptation strategies.

The factors influencing community resilience include social factors, economic conditions, physical aspects of housing, and policy-related factors, all of which have positive and significant effects (Andie et al., 2025). Resilience in flood-prone communities is not determined by a single factor, but by the interaction of multiple dimensions. Communities may choose to remain in flood-prone areas because they have strong social capital, established economic adaptation strategies, housing modifications suited to environmental conditions, and support from government policies. This shows that resilience must be understood as a dynamic process that involves the interaction between households, communities, institutions, and the physical environment.

2.2. Methods for Measuring Vulnerability

One of the commonly used methods to measure the socio-economic vulnerability of communities to flood impacts is the Livelihood Vulnerability Index, or LVI (Putri et al., 2024). The LVI approach is useful because it allows researchers to assess vulnerability by examining various components of livelihood systems, including socio-demographic characteristics, livelihood strategies, social networks, health, food security, access to water, natural disasters, and climate variability. A study in Bandar Lampung City used the LVI to measure the social and economic vulnerability of coastal communities to tidal flood impacts. The results showed an overall LVI score of 0.25, indicating that the livelihood vulnerability of the community to climate-related flooding was categorized as vulnerable (Putri et al., 2024).

The most vulnerable component identified in the study was natural disasters and climate variability, as coastal areas are more exposed to climate-related changes and are among the most severely affected when disasters occur. Other vulnerable components included socio-demographic conditions, livelihood strategies, social networks, and health. These findings suggest that vulnerability assessment should not focus only on economic loss, but also on the broader livelihood system that determines people's ability to withstand and recover from disasters. Based on this analysis, policy formulation is needed to support sustainable economic development for coastal communities and to reduce their exposure to climate-induced flood risks.

Another important method for measuring flood vulnerability is spatial Multi-Criteria Decision Analysis, or MCDA. This approach integrates four main aspects of vulnerability, namely social, physical, economic, and environmental aspects, to produce a comprehensive assessment (Yanto et al., 2025). In Tulang Bawang Regency, the use of spatial MCDA revealed that projected material losses due to flooding reached IDR 23,125.11 million for physical damage and IDR 50,356.32 million for economic losses, while potential environmental damage was estimated to affect 35,508.18 hectares (Yanto et al., 2025). These results demonstrate the importance of combining spatial data, socio-economic indicators, and environmental variables in assessing flood vulnerability. Such an approach can help policymakers identify priority areas for disaster risk reduction, infrastructure improvement, land-use planning, and community-based mitigation programs.

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2.3. Economic Impacts of Flood Disasters

Flood disasters have significant economic consequences for households, particularly those living in rural and agrarian areas. Natural disasters have been found to reduce per capita consumption among rural households by 2.29% (Muhammad & Qibthiyyah, 2025). Although this decline does not always immediately push households into poverty, it reflects underlying economic pressure that may develop into long-term poverty if not properly addressed. The findings also indicate that savings play a crucial role in mitigating the negative impacts of disasters on household consumption. This highlights the importance of access to basic financial instruments, including savings, credit, insurance, and emergency assistance, in strengthening household resilience. Flooding also creates livelihood vulnerability among farming households that depend on agricultural land as their primary source of income (Yamin & Putri, 2024). When floods damage agricultural land, destroy crops, delay planting seasons, or reduce harvest yields, farmers experience direct income losses. The income structure of farmers shows that non-agricultural activities provide the second-largest contribution after farming, while off-farm activities contribute the smallest share. Based on land carrying capacity and agrarian density, rice farming remains sustainable despite the challenges posed by flood disasters (Yamin & Putri, 2024). This suggests that agricultural communities may continue to depend on farming even when exposed to recurrent flood risks, but their resilience depends heavily on income diversification, land management, and access to support systems.

The relationship between poverty and disaster is also an important aspect in understanding the economic impacts of floods. Poor communities are disproportionately affected by natural hazards and disasters (Hallegatte et al., 2020). This condition is explained by three main mechanisms: exposure, vulnerability, and socio-economic resilience. Poor people are often more likely to live in hazard-prone areas, although this is not always the case. When affected by disasters, they tend to lose a larger proportion of their wealth, and they generally have lower capacity to cope with and recover from disaster impacts. As a result, there is a measurable and significant vicious cycle between poverty and increasing disaster losses (Hallegatte et al., 2020). Globally, approximately 1.81 billion people, or 23% of the world's population, are directly exposed to 1-in-100-year flood risk (Rentschler et al., 2022). Of this number, 1.24 billion people are located in South and East Asia. In addition, around 170 million people exposed to flood risk live in extreme poverty, defined as living on less than USD 1.90 per day, with 44% of them located in Sub-Saharan Africa (Rentschler et al., 2022). These figures show that flood risk is not only an environmental or infrastructural issue, but also a major development challenge. Regions with high flood exposure and high poverty levels require priority attention in mitigation planning, social protection, and climate adaptation policy.

2.4. Community Adaptation Strategies

Community-based adaptation, or CBA, is an important approach in strengthening resilience to flood and climate-related disasters. The implementation of CBA in Indonesia has shown a positive resilience score of 35% (Tota et al., 2024). Infrastructure resilience and cohesion in community disaster preparedness were measured using a standardized resilience index. Over a five-year period, climate-related economic losses decreased by 40%, accompanied by improvements in disaster management, aquaculture, food security, and water resilience. The Climate Village Program, or Kampung Iklim, in Indonesia provides an effective example of CBA through collaborative governance, public awareness, and sustainable practices (Tota et al., 2024).

Community adaptation strategies in flood-prone areas include elevating house foundations, building attics inside houses, constructing floating raft houses, and strengthening cooperation in maintaining river and drainage cleanliness (Ernawati et al., 2025). These strategies show that local communities often develop practical and context-specific responses based on their experience with recurring floods. In addition, community participation in flood mitigation programs contributes to the development of social resilience through activities such as mangrove planting, drainage cleaning, and community-based training programs

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(Sulaeman & Sawar, 2025). Such forms of participation are important because they not only reduce physical exposure to flooding, but also strengthen collective awareness, cooperation, and preparedness.

Social capital plays a central role in strengthening community resilience. Social capital is considered the dominant asset owned by local communities, reaching 94% (Pangesti & Hizbaron, 2026). This asset includes factors related to social participation, leadership, trust, mutual assistance, and community organization. Bonding social capital is the main form of social capital, involving cooperation among residents in community services, local groups, and social events. The F-test results reveal that vulnerability contributes 45% to resilience, while the T-test results identify four variables that influence resilience development: number of house floors, income, number of vulnerable groups in the household, and education level (Pangesti & Hizbaron, 2026). These findings demonstrate that resilience is strongly connected to both material and social resources. Communities with strong social ties may be better able to mobilize support, share information, organize collective action, and recover more effectively after flood events.

2.5. Policy Framework for Disaster Risk Reduction

Adaptive Social Protection, or ASP, is an important policy approach for improving the welfare of at-risk communities. ASP builds an interface between Disaster Risk Management, Climate Change Adaptation, and Social Protection (Sett et al., 2022). The design of meaningful ASP measures must be informed by specific information about risks, risk drivers, and impacts on at-risk communities. Multidimensional risk assessment is therefore essential for the successful implementation of ASP. This approach is relevant in flood-prone communities because disaster impacts are not limited to physical damage, but also include income loss, food insecurity, displacement, health risks, and long-term welfare decline.

Existing social protection systems generally perform well in lifting people out of poverty under normal conditions, but they are often insufficient in helping communities prepare for and cope with shocks (Gasior et al., 2023). This is particularly true for large households, households with more than two children, individuals in their 20s and 80s, and persons with disabilities. Hypothetical reforms tested in previous studies show that improved social protection design can reduce the impact of shocks and better target those who require greater support (Gasior et al., 2023). Therefore, disaster-responsive social protection should be designed to anticipate shocks before they occur, provide timely assistance during emergencies, and support long-term recovery after disasters. Integrated watershed management is also an important component of disaster risk reduction. Integrated Watershed Management, or IWM, has been identified as one of the key programs for reducing greenhouse gas emissions and adapting to climate change (Basuki et al., 2022). The implementation of the Micro Watershed Model, supported by local culture, indigenous wisdom, and traditional community knowledge, can be used to strengthen existing watershed management practices. Strengthening synergy among institutions responsible for climate change mitigation and adaptation is essential to improve the effectiveness of disaster risk reduction programs (Basuki et al., 2022). In the context of flood-prone areas such as Central Tapanuli, North Sumatra, and Aceh, integrated watershed management, adaptive social protection, community-based adaptation, and social capital strengthening should be developed as complementary strategies to reduce vulnerability and enhance community resilience.

III. Research Method

This study employs a qualitative library research method using a literature review approach to analyze the economic vulnerability and resilience of flood-affected communities in Central Tapanuli, North Sumatra, and Aceh. The data used in this study are secondary data obtained from published scientific articles, journals, research reports, books, and official documents relevant to flood disasters, socio-economic vulnerability, community resilience, livelihood vulnerability, disaster risk reduction, and adaptation strategies. The selected literature is analyzed by identifying key concepts, theoretical frameworks, research findings, and policy recommendations related to the economic impacts of flooding on affected communities. The analysis is conducted descriptively and thematically by grouping the findings into several main themes, including socio-

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economic vulnerability, household livelihood disruption, community resilience, adaptation strategies, social capital, and disaster risk reduction policies. Through this method, the study aims to synthesize existing scholarly findings and provide a comprehensive understanding of how flood disasters affect community economic conditions and how resilience can be strengthened in disaster-prone regions.

IV. Results and Discussion

4.1. Economic Vulnerability Profile of Flood-Affected Communities

The findings indicate that economic and physical vulnerability are among the most dominant dimensions experienced by communities affected by floods. Index-based assessments in flood-prone areas show that economic and physical dimensions tend to have higher vulnerability levels compared to social and environmental dimensions. A study in Pekalongan City, for instance, found that the highest level of vulnerability was identified in the economic and physical dimensions, while environmental and social vulnerability were categorized as moderate (Ilyas et al., 2025). This finding suggests that flood disasters directly affect the material and livelihood foundations of communities, particularly through damage to housing, infrastructure, productive assets, and income-generating activities. In the context of Central Tapanuli, North Sumatra, and Aceh, this pattern is relevant because many communities depend on agriculture, fisheries, small-scale trade, and informal economic activities that are highly sensitive to flood disruption. Similar findings are observed in Losari District, Brebes Regency, where more than half of the community was categorized as having high social vulnerability, high economic vulnerability, and high physical vulnerability, while environmental vulnerability was classified as low (Sadanna et al., 2024). Overall, more than half of the population in Losari District was classified as highly vulnerable, with a low level of flood resilience. This indicates that economic vulnerability is closely related to other dimensions of vulnerability. Households with poor housing conditions, limited access to infrastructure, and unstable sources of income tend to experience greater difficulty in coping with and recovering from flood disasters. Therefore, economic vulnerability should not be understood separately from physical and social conditions, but rather as part of a broader vulnerability system.

The determinants of economic vulnerability are influenced by both structural and individual factors. High vulnerability is often associated with low elevation, proximity to riverbanks, poor housing quality, and limited access to early warning systems (Abdulazi et al., 2026). In Kebbi State, Nigeria, 72% of respondents reported high vulnerability to annual flooding, 65% experienced significant agricultural losses, and 58% reported declining household income after major flood events (Abdulazi et al., 2026). These findings demonstrate that households located in physically exposed areas and dependent on natural-resource-based livelihoods are more likely to suffer severe economic losses. In addition, poverty, low education levels, single-parent household status, limited resources, narrow livelihood strategies, and inadequate social connections further worsen vulnerability (Dinh et al., 2023). These factors reduce household capacity to prepare for disasters, diversify income, access assistance, and recover after flood events. A comparison of vulnerability levels across several flood-prone areas also shows that communities with high exposure and limited adaptive capacity tend to be classified as vulnerable or highly vulnerable. Coastal communities in Bandar Lampung recorded an LVI score of 0.25 and were categorized as vulnerable, while communities in Sunamganj, Bangladesh, recorded LVI values ranging from 0.555 to 0.610, indicating very high vulnerability. In Langsa, Aceh, vulnerability was generally categorized as moderate to high, while Losari, Brebes, showed high levels of social, economic, and physical vulnerability. These findings suggest that flood vulnerability is shaped by the interaction between exposure, livelihood dependence, poverty, infrastructure quality, and community preparedness. In the case of Aceh and North Sumatra, the presence of coastal settlements, riverine communities, and agrarian households increases the urgency of strengthening economic resilience and disaster risk reduction strategies.

4.2. Economic Impacts of Flood Disasters

The economic impacts of flooding are multidimensional and include both direct and indirect losses. Direct losses occur when floods damage houses, agricultural land, livestock, fishing equipment, business assets, roads, bridges, and public facilities. Indirect losses occur when floods disrupt employment, reduce household income, interrupt market access, increase transportation costs, and weaken local economic activities. In Kebbi State, flooding caused significant agricultural losses for 65% of the population and reduced

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household income for 58% of respondents (Abdulazi et al., 2026). This evidence shows that the economic burden of flooding is particularly severe for households whose livelihoods depend on agriculture and other climate-sensitive sectors. The impact of flooding on household welfare is also closely linked to structural poverty, weak infrastructure, and limited governance capacity. Flood vulnerability is not only driven by biophysical changes, but also by the politics of climate resilience, especially in relation to contested resource allocation and coordination failures in local governance (Mustikaningsih & Ananda, 2026). In many affected areas, traders and small business owners attempt to optimize social capital and informal solidarity networks as autonomous adaptation strategies. However, these efforts are often constrained by unequal power relations and the lack of integrated policy support. This suggests that community resilience cannot rely solely on individual or informal coping mechanisms; it must also be supported by inclusive and coordinated government intervention.

Flood disasters also have differentiated impacts on vulnerable groups. Older people, children, and households consisting of both older persons and children tend to experience the most severe impacts of urban flooding (Susilawati et al., 2025). Social, economic, and environmental factors can further intensify the vulnerability of these groups. Therefore, flood resilience policies should be personalized and contextualized according to the characteristics of vulnerable populations in each location. In addition, female-headed households, households with low educational attainment, large households, households located in high-risk areas, and households with damaged dwellings are consistently more likely to experience multidimensional poverty after disasters (Umaroh et al., 2026). Government assistance has been associated with a reduction in the Multidimensional Poverty Index, often within a short time lag, which highlights the importance of timely and well-targeted policy intervention. These findings are highly relevant to flood-affected communities in Central Tapanuli, North Sumatra, and Aceh. In these areas, many households depend on agriculture, fisheries, and informal trade. When floods occur, the disruption of productive activities may reduce income, increase household expenditure, and weaken food security. For poor households, the loss of assets and income may lead to debt, reduced consumption, school disruption, and delayed recovery. Therefore, the economic impact of flooding should be analyzed not only in terms of immediate monetary losses, but also in relation to long-term welfare decline, livelihood insecurity, and the risk of falling into persistent poverty.

4.3. Community Resilience Level

The level of community resilience to flood disasters is uneven across different dimensions. A multidimensional sustainability index showed an overall score of 49.06, which categorized the observed area as “less sustainable” in terms of flood resilience (Syamsaputri & Hermon, 2025). The dimension-specific scores were 50.29 for the economic dimension, 46.08 for the social dimension, 50.10 for the health dimension, and 49.76 for the education dimension. These results indicate that economic and health dimensions were slightly stronger compared to social and educational dimensions, although the overall level of resilience remained relatively weak. This finding suggests that resilience-building requires a multidimensional approach, not only through economic recovery programs but also through strengthening education, health services, social networks, and institutional capacity. Community participation is a critical factor in improving flood resilience. The Analytical Hierarchy Process framework has been used to identify priorities in disaster preparedness efforts, showing that economic recovery was the most important priority at 46.1%, followed by infrastructure at 29.7% and physical aspects at 24.2% (Zainal et al., 2025). This result emphasizes the importance of integrating local knowledge and encouraging collaborative strategies in disaster management. Economic recovery becomes a major priority because floods directly disrupt household income, employment, agricultural production, trade, and access to markets. Infrastructure improvement is also essential because damaged roads, bridges, drainage systems, and public facilities can slow down emergency response and recovery processes.

Community resilience is not determined by a single factor, but by the interaction of social, economic, physical, and policy dimensions (Andie et al., 2025). Communities tend to remain in flood-prone areas because they possess strong social capital, established economic adaptation strategies, housing modifications suited to environmental conditions, and support from government policies. This finding suggests that resilience is both a social and institutional process. Strong social capital enables communities to share information, provide mutual assistance, mobilize collective action, and recover more quickly. At the same time, government support is needed to improve housing quality, strengthen local economies, expand access to early warning systems, and provide disaster-responsive social protection. For Central Tapanuli, North Sumatra, and Aceh, strengthening community resilience requires an integrated strategy that addresses both household-level and community-level capacities. Household resilience can be improved through livelihood

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diversification, savings, microinsurance, disaster preparedness, and access to financial services. Community-level resilience can be strengthened through local organizations, early warning systems, community-based disaster training, and participatory infrastructure maintenance. Without such integrated efforts, communities may continue to experience repeated economic losses and slow recovery after flood events.

4.4. Community Adaptation Strategies

Flood-affected communities develop various adaptation strategies to reduce disaster impacts and maintain their livelihoods. These strategies can be classified into structural and non-structural adaptation. Structural adaptation includes elevating house foundations, building attics inside houses, constructing floating raft houses, improving drainage systems, and strengthening physical protection around settlements. Non-structural adaptation includes strengthening cooperation in maintaining river and drainage cleanliness, developing alternative livelihoods, temporary relocation, using local flood forecasting practices, and participating in disaster preparedness activities (Ernawati et al., 2025). These strategies show that communities are not passive victims of disaster, but active agents who continuously adjust their practices based on repeated flood experience. Despite high exposure to flood hazards, communities often demonstrate adaptive responses. In Kebbi State, for example, adaptation practices included temporary relocation by 61% of respondents, livelihood diversification by 47%, and indigenous flood forecasting practices by 39% (Abdulazi et al., 2026). These findings show that adaptation is shaped by both material resources and local knowledge. Temporary relocation helps households avoid immediate danger, while livelihood diversification reduces dependence on a single income source. Indigenous forecasting practices also contribute to early preparedness by allowing communities to anticipate flood events based on environmental signs and traditional knowledge.

Local knowledge and traditional wisdom play an important role in community adaptation. In Nagari Aie Angek, communities are highly vulnerable to flash floods, locally known as *galodo*, which threaten public safety, infrastructure, and socio-economic activities (Fauzan et al., 2025). Community service programs that integrate sensor-based Early Warning Systems with local knowledge have been shown to increase community awareness and preparedness in using early warning systems. This indicates that modern technology becomes more effective when it is combined with local experience and community participation. Disaster risk reduction programs should therefore not replace local knowledge, but integrate it into formal preparedness and response systems. Sustainable agricultural practices also contribute to flood adaptation and livelihood resilience. Practices such as intercropping, conservation tillage, and integrated pest management can improve soil health and reduce flood-related damage (Satriyono et al., 2025). These approaches are particularly important for agrarian communities whose livelihoods depend on land productivity. In flood-prone areas of Central Tapanuli, North Sumatra, and Aceh, sustainable farming practices can help reduce crop losses, maintain food security, and improve household income stability. Community-based approaches that utilize local knowledge to support early warning systems and post-disaster recovery are therefore essential in building long-term resilience.

4.5. Policy Implications

The findings of this study highlight the need to strengthen adaptive social protection as part of flood disaster risk reduction. Simple financial instruments such as savings, community-based microinsurance, and local risk-sharing mechanisms should be promoted to increase household resilience (Muhammad & Qibthiyyah, 2025). Financial inclusion is important because households with access to savings, credit, and insurance are better able to absorb disaster shocks and avoid long-term poverty traps. In contrast, households without financial buffers may be forced to sell productive assets, borrow at high interest rates, reduce consumption, or withdraw children from school after a disaster. Policy interventions should also combine income support with targeted investments in education continuity, primary health care, and basic services, particularly in vulnerable areas (Umaroh et al., 2026). Non-monetary poverty may persist even when monetary indicators begin to improve, which means that income-based monitoring may underestimate continuing welfare losses. For this reason, post-disaster recovery programs should not focus only on financial compensation or infrastructure rehabilitation. They should also address education, health, housing, food security, psychosocial well-being, and livelihood restoration.

Collaborative governance is another important requirement for strengthening flood resilience. Sustainable resilience is often hindered by a formalistic and reactive disaster management paradigm (Mustikaningsih & Ananda, 2026). To overcome this limitation, a transition toward collaborative governance

is necessary. This approach emphasizes the alignment between state-led infrastructure development and community-based early warning systems. Collaborative governance requires coordination among local governments, disaster management agencies, community organizations, academic institutions, private actors, and vulnerable groups. Such coordination is needed to ensure that disaster risk reduction programs are inclusive, context-specific, and responsive to local needs. In the context of Central Tapanuli, North Sumatra, and Aceh, policy responses should prioritize the reduction of economic vulnerability and the strengthening of community resilience. This can be achieved through integrated watershed management, improvement of drainage and settlement infrastructure, livelihood diversification programs, community-based early warning systems, social protection for vulnerable households, and stronger institutional coordination. Since flood disasters are closely linked to poverty, land-use change, environmental degradation, and weak adaptive capacity, disaster risk reduction should be integrated into broader regional development planning. By doing so, flood-prone communities can be supported not only to recover from disasters, but also to build more secure, adaptive, and sustainable livelihoods.

V. Conclusion

This study shows that the economic vulnerability of flood-affected communities in Central Tapanuli, North Sumatra, and Aceh is mainly influenced by poverty, dependence on a single source of livelihood, limited access to financial instruments, and weak household capacity to cope with disaster shocks. The level of community resilience remains relatively unsustainable, particularly in the social and institutional dimensions. Nevertheless, communities have demonstrated various forms of adaptation, such as temporary relocation, livelihood diversification, housing structure modification, the use of social capital, and the strengthening of informal networks to face recurring flood threats. These findings indicate that flood management policies should not focus solely on emergency assistance, but should also be directed toward strengthening the economic and social capacity of communities in a sustainable manner. The government and relevant stakeholders need to promote local economic diversification, expand access to microcredit, strengthen small enterprises, provide alternative skills training, and develop adaptive social protection systems that are responsive to disasters. In addition, community-based early warning systems should be strengthened through a combination of modern technology and local knowledge so that communities can respond to flood risks more quickly, accurately, and independently. This study has limitations because it only uses published articles and does not involve direct field data collection; therefore, the analysis depends on the availability and quality of the literature used. In addition, the scope of the study, which focuses on Central Tapanuli, North Sumatra, and Aceh, means that the findings should be applied cautiously to other regions with different social, economic, and environmental characteristics. Future research is recommended to use field data, a longitudinal approach, and a deeper analysis of gender roles, long-term impacts on household welfare, and the effectiveness of various flood mitigation strategies.

References

Abdulazi, B. G., Ogah, A. T., & Alkali, M. (2026). Assessing community-level flood vulnerability, socio-economic impacts, and adaptation strategies in ngaski, yauri, shanga, and bagudo LGAs of kebbi state, nigeria. *Journal of Innovative Social Science and Humanities Research*. https://doi.org/10.70382/hujisshr.v11i6.046

Akbar, S., Syahreza, S., & Oktari, R. S. (2024). Enhancing regional resilience: Assessing tidal flood vulnerability and adaptation strategies in a coastal community. *IOP Conference Series: Earth and Environment*. https://doi.org/10.1088/1755-1315/1356/1/012050

Andie, Sutrisno, H., Permana, I., Sudyana, I. N., & Susi, T. (2025). Analysis of community resilience factors in one area against flood disasters. *Jurnal Sosial Dan Sains*. https://doi.org/10.59188/jurnalsosains.v5i6.32340

Astaman, P., Hikmah, A., Dassir, M., Siregar, A. R., Qinayah, M., Aisyah, M., & S., H. (2025). When risks collide: Compound vulnerability to natural disasters, market fluctuations, and pandemics – insight from enrekang, indonesia. *Tarjih Agribusiness Development Journal*. https://doi.org/10.47030/tadj.v5i01.981

Atie, F. E., & Sibiri, E. A. (2024). Flood warnings and preparedness uptake of flood-risk households in bayelsa state, nigeria. *International Journal of Research and Innovation in Social Science*. https://doi.org/10.47772/ijriss.2024.8110173

Basuki, T. M., Nugroho, H. Y. S. H., Indrajaya, Y., Pramono, I. B., Nugroho, N. P., Supangat, A. B., Indrawati, D. R., Savitri, E., Wahyuningrum, N., Purwanto, P., Cahyono, S. A., Putra, P. B., Adi, R. N., Nugroho, A., Auliyani, D., Wuryanta, A., Riyanto, H. D., Harjadi, B., Yudilastyantoro, C., … Simarmata, D. P. (2022). Improvement of integrated watershed management in indonesia for mitigation and adaptation to climate change: A review. *Sustainability*. https://doi.org/https://doi.org/10.3390/su14169997

Budiman, D., & Chu, C. (2025). Flood crisis, ecological degradation, and hospital resilience in sumatra. *Sociality: Journal of Public Health Service*. https://doi.org/10.24252/sociality.v5i1.63464

Dinh, N. C., Tan, N. Q., Tinh, B., Ha, V., Kien, N. D., Hung, P. X., Linh, N. H. K., & Phuong, H. (2023). Decoding the livelihood vulnerability of flood-prone communities in vietnam: Implications for disaster risk reduction and sustainable rural development. *Journal of Agriculture and Environment for International Development*. https://doi.org/10.36253/jaeid-14811

Ernawati, E., Yulfa, A., Rahmi, L., & Ibrahim, M. H. (2025). Resilient communities: Adapting to flood disasters in kemaman, terengganu, malaysia and padang city, indonesia. *Aplinkos Tyrimai, Inzinerija Ir Vadyba / Environmental Research, Engineering and Management*. https://doi.org/10.5755/j01.erem.81.3.39073

Fauzan, F., Zaini, Z., Basyar, B., P., R. E., Aprisal, A., Lubis, F., L., R. A., A., R. F., Syahmina, L., S., R. A. R., M., F. A., K., M. R., & Uais, U. (2025). Implementation of a sensor-based flash flood early warning system and river normalization design in aie angek village, tanah datar regency, west sumatra. *Dinamisia : Jurnal Pengabdian Kepada Masyarakat*. https://doi.org/10.31849/dinamisia.v9i6.31119

Gasior, K., Wright, G., Barnes, H., & Noble, M. (2023). Adaptive social protection in indonesia: Stress-testing the effect of a natural disaster on poverty and vulnerability. *Social Policy &Amp; Administration*. https://doi.org/10.1111/spol.12983

Hallegatte, S., Vogt-Schilb, A., Rozenberg, J., Bangalore, M., & Beaudet, C. (2020). From poverty to disaster and back: A review of the literature. *Economics of Disasters and Climate Change*. https://doi.org/https://doi.org/10.1007/s41885-020-00060-5

Ilyas, T. A. R., Kurniawan, I., Utami, A. R., Ardiansyah, M. F., & Jalaluddin, M. (2025). Flood tidal inundation vulnerability level in pekalongan city, central java, indonesia. *Jurnal Penelitian Geografi*. https://doi.org/10.23960/jpg.v13.i2.33592

Khan, E., Kamal, A., Kabir, M., Hassan, S., Hayat, T., & Fahim, A. K. F. (2025). An empirical study to develop a relationship between vulnerability and disaster damage and loss for sylhet flood 2022. *Discover Applied Sciences*. https://doi.org/10.1007/s42452-024-06411-1

Marthoenis, M. (2025). Public health, community resilience, and psychosocial recovery after the 2025 sumatra floods and landslides. *Asian Journal of Public Health and Nursing*. https://doi.org/10.62377/crkcn684

Mashudi, E., Irawan, B., Prakoso, C. T., Widanti, N. P. T., & Akbar, P. (2025). Mapping the flood risk index of bontang city: A fundamental effort for sustainable city resilience. *E3S Web of Conferences*. https://doi.org/10.1051/e3sconf/202565706001

Muhammad, F., & Qibthiyyah, R. M. (2025). The impact of natural disasters on poverty in rural area. *Jurnal Ilmu Ekonomi Terapan*. https://doi.org/10.20473/jiet.v10i2.74908

Mustikaningsih, W., & Ananda, A. R. (2026). Climate resilience politics: Flood disaster governance and socio-economic vulnerability among urban traders in palangka raya. *Politeia: Journal of Public Administration and Political Science and International Relations*. https://doi.org/10.61978/politeia.v4i2.1366

Naithani, M. (2025). Geo-environmental risks and community-based disaster management in chamoli, tehri, pauri, and rudraprayag districts of uttarakhand. *International Journal of Management and Development Studies*. https://doi.org/10.53983/ijmds.v14n9.002

Pangesti, L. V., & Hizbaron, D. R. (2026). An overview on determinant factors of coastal community resilience at bantul, yogyakarta, indonesia. *IDRiM Journal*. https://doi.org/10.5595/001c.155291

Priyanto, Augustinah, F., Ayuningtiyas, G. A., & Marwiyah, S. (2026). Build resilience community through mapping participatory: Implementation community-based disaster risk reduction. *Formosa Journal of Business and Economic Statistics*. https://doi.org/10.55927/fjbes.v2i1.617

Putri, R., Gunarto, T., & Husaini, M. (2024). Socio-economic vulnerability through the lvi approach (livelihood vulnerability index) towards flood disasters in the coastal area of bandar lampung city. *Proceedings of the 7th International Conference of Economics, Business, and Entrepreneurship, ICEBE 2024, 4-5 September 2024, Shah Alam, Selangor, Malaysia*. https://doi.org/10.4108/eai.4-9-2024.2353960

ISSN [Online]: 2776-6381

Rentschler, J., Salhab, M., & Jafino, B. A. (2022). Flood exposure and poverty in 188 countries. *Nature Communications*. https://doi.org/https://doi.org/10.1038/s41467-022-30727-4

Sadanna, A. P., Setyowati, D. L., & Suharini, E. (2024). Community vulnerability and resilience to flood disaster in losari district, brebes regency. *IOP Conference Series: Earth and Environment*. https://doi.org/10.1088/1755-1315/1314/1/012125

Satriyono, R. D. A. P., Setiawan, E., Chasanah, Y. N., & Astuti, S. P. (2025). Enhancing disaster resilience through sustainable farming in flood-prone areas of the bengawan solo delta areas. *E3S Web of Conferences*. https://doi.org/10.1051/e3sconf/202565206002

Sett, D., Waldschmidt, F., Rojas-Ferreira, A., Sagala, S., Mojica, T. A., Koirala, P., Sanady, P., Widjala, C., Kreft, S., Souvignet, M., & Sandholz, S. (2022). *Climate and disaster risk analytics tool for adaptive social protection*. https://doi.org/10.53324/wnsg2302

Sulaeman, N., & Sawar, A. (2025). Community participation in flood mitigation programs and its effect on social resilience in semarang city. *Moccasin Journal De Public Perspective*. https://doi.org/10.37899/mjdpp.v2i3.246

Susilawati, C., Devi, B., Rachmawati, F., Soemitro, R., Teo, M., Goonetilleke, A., & Wilkinson, S. (2025). Local vulnerability factors can be used as an innovative approach for developing inclusive urban community flood resilience policies. *Journal of Flood Risk Management*. https://doi.org/10.1111/jfr3.70140

Syamsaputri, A. D., & Hermon, D. (2025). Sustainability of community social resilience in flood disaster mitigation and adaptation for global flood-prone communities: Evidence from kampar regency, riau, indonesia. *JAMBURA GEO EDUCATION JOURNAL*. https://doi.org/10.37905/jgej.v6i2.33524

Thoha, A. S., Slamet, B., Harahap, M. M., Sari, T., & Hulu, D. (2023). Spatial distribution of flood vulnerability in langkat regency, north sumatera province, indonesia. *IOP Conference Series: Earth and Environment*. https://doi.org/10.1088/1755-1315/1188/1/012009

Tota, W., Maulud, K. N. A., & Noor, N. M. (2024). Impact of community-based adaptation methods in creating resilient communities in indonesia and philippines. *E3S Web of Conferences*. https://doi.org/10.1051/e3sconf/202459905003

Umaroh, R., Amrina, D., & Ayun, I. Q. (2026). Tracking the multidimensional poverty post-disaster: Empirical evidence of the 2004 tsunami in indonesia. *Poverty &Amp; Public Policy*. https://doi.org/10.1002/pop4.70051

Yamin, M., & Putri, N. (2024). Agricultural household economic in condition flood impact of climate change in indonesia. *IOP Conference Series: Earth and Environment*. https://doi.org/10.1088/1755-1315/1364/1/012017

Yanto, N. P., Sahid, S., Aziz, F., Mustofa, A. N. ajiid, & Prizkanisa, S. (2025). MCDA spatial approach for flood disaster vulnerability assessment in tulang bawang regency. *Media Komunikasi Geografi*. https://doi.org/10.23887/mkg.v26i1.83950

Zainal, M., Widyastuti, Rahmawati, & Muis, A. Abd. (2025). Community participation on flood-prone areas in torue village using analytical hierarchy process. *Jurnal Pendidikan Geografi Undiksha*. https://doi.org/10.23887/jjpg.v13i3.91803