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Flood Disaster Adaptation Model in Kampar Regency Riau Province

Nadiya Sari[1], Dedi Hermon[1*]

[1] Master of Geography Education Study Program, Universitas Negeri Padang, Indonesia.

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Corresponding Author:
Dedi Hermon
dedi.hermon@fis.unp.ac.id

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Abstract: Flood disaster risk reduction in Indonesia still focuses on structural measures with limited research examining community adaptation models. Adaptation models play an important role in planning future disaster mitigation actions. This study aims to determine the response and adaptation model in managing flood disasters by the people of Kampar Regency. Data collection was done by interviews, questionnaires on physical adaptation and social adaptation and questionnaires then FGD (Focus Group Discussion) and analyzed with AHP (Analytical Hierarchy Process). The results show that the level of flood vulnerability from the analysis of the flood vulnerability map in Kampar Regency shows that most of its areas are in the flood-prone category, Land characteristics at four sample points in Kampar Regency show significant variations. As seen in the flood vulnerability map, there are land characteristics of high hazard zones, land characteristics of medium flood hazard zones, land characteristics of low flood hazard zones and flood-free flood hazard zones, and formulating an Adaptation Model using the AHP approach through Focus Group Discussion (FGD). The results of the analysis show a pairwise priority value for land characteristics (0.03), and the level of flood vulnerability (0.03). The weight of the criteria shows land characteristics (0.105) and the level of flood vulnerability (0.258). Indicates the highest alternative is to assess the ability of the soil to absorb water. This alternative can reduce the risk of flood disaster in the study area. These findings indicate the need for special attention to flood-prone areas in Kampar Regency, Riau Province.

Keywords: Adaptation; Disaster; Flood; Risk

Introduction

Flooding is one of the natural disasters that has the potential to cause major negative impacts on social, economic and environmental life (Pawlik et al., 2025; Taryono & Iyan, 2022). In Kampar Regency, Riau Province, flooding is a threat that cannot be ignored. A flood disaster adaptation model is needed to reduce the risks and negative impacts caused by this disaster. Some of the main reasons why flood disaster adaptation models are needed include improving community preparedness, accelerating response to flood events, reducing economic losses and environmental impacts, protecting the lives and health of people living in flood-prone areas, and effectively managing water resources to prevent excessive inundation (Bellia et al., 2025; J. Wu et al., 2025).

In addition, the flood adaptation model also serves to keep critical infrastructure such as roads, bridges, buildings, and public facilities from being damaged, and helps in spatial planning and regional development to be more resilient to flood disasters (Polsomboon et al., 2025). With this adaptation model, both the government and the community can take preventive and mitigated actions to reduce the risk of flood disasters (Nhamo et al., 2025; Sciuto et al., 2025).

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Without a clear adaptation model, various losses and negative impacts can occur. These include economic disruptions such as loss of livelihoods and reduced productivity, severe infrastructure damage such as roads, bridges, houses, schools and health facilities that disrupt daily activities (Prasetyo et al., 2024; Sari et al., 2023; Selviani et al., 2024). In addition, flooding can also cause health problems, such as the spread of diseases caused by dirty water and inundation, such as skin diseases and gastrointestinal infections. Other disadvantages include very high post-flood recovery costs, which often exceed prevention and mitigation costs, as well as disruption to public services such as education, transportation and health that hamper social and economic development (Nyoman et al., 2024; Padli et al., 2024; Prasetyo et al., 2024; Selviani et al., 2023). Without a good adaptation model, communities and governments will find it difficult to mitigate and manage flood risks, which in turn can exacerbate losses and impacts (J. Wu et al., 2025).

The physical condition of Kampar Regency, which has many water areas and areas prone to natural disasters, makes it highly vulnerable to flooding. When there is high rainfall for a long time, river water can overflow and cause flooding (Polsomboon et al., 2025). This often happens, as many villages in Kampar Regency are located along watersheds (Ilham et al., 2024; Selviani, Welis, 2024). Settlements located close to the river increase the risk of flooding (Nhamo et al., 2025; Sciuto et al., 2025). Based on observations, it is known that settlements in Kampar Regency are located in the lowlands and very close to the river, increasing the likelihood of flooding. One of the areas that is often hit by floods is the village that is located the lowest among other villages in Kampar Regency (Taryono & Iyan, 2022).

Community adaptation strategies refer to the steps or efforts taken by individuals, groups or communities to adjust to changes in their environment, whether social, economic or physical changes (Khatooni et al., 2025). In the context of environmental changes such as climate change, community adaptation strategies aim to reduce negative impacts, increase resilience to threats, and take advantage of opportunities that may arise due to these changes (Tian et al., 2025). These strategies involve various approaches, ranging from changes in physical infrastructure, natural resource management, to adjustments in social and economic patterns (Davlasheridze & Fan, 2025).

Physical adaptation in the context of flood disasters can be explained through the concepts of ecosystem resilience and the physical ability of humans to adapt to environmental changes caused by disasters (Ilham et al., 2024; Sari et al., 2023). Research shows that one of the most effective forms, of physical adaptation is the strengthening of infrastructure, such as the construction of embankments, improvement of drainage systems, and flood-resistant building designs. In addition, communities with strong social networks recover faster after disasters (Nhamo et al., 2025). Research also shows that communities that support each other and share resources have higher levels of social resilience (Sciuto et al., 2025).

This theory of adaptation, developed by several researchers, provides an in-depth look at how physical and social adaptations are applied in the face of flood disasters (Garschagen et al., 2021; Haque et al., 2024; Zhou et al., 2021). The importance of green infrastructure as a sustainable solution to reduce flood risk (Garschagen et al., 2021), while highlight the role of social capital in enhancing social resilience and accelerating recovery (Zhou et al., 2021). Meanwhile, theory shows how individuals and communities manage flood risk with adaptation strategies involving preventive action, evacuation and stress management (Haque et al., 2024). All three emphasize the importance of an integrated approach that includes physical and social changes to reduce their vulnerability to flooding.

The theory developed by Aksa et al. (2022) on community adaptation strategies is also relevant in this context. In his research, Aksa emphasized the importance of understanding community responses to environmental and social changes through systematic measurement instruments. Coastal communities deal with floods and tidal disasters by adapting traditional buildings, such as houses on stilts, to reduce the impact of flooding (Davlasheridze & Fan, 2025; Khatooni et al., 2025; Tian et al., 2025). The transformation of these buildings drives the importance of this study to examine the impact of tidal floods on the physical, social and economic environment and analyze the community's adaptation efforts to flood disasters and the role of the government (Hussain et al., 2024; Jiang et al., 2025; Kalita et al., 2025).

An effective flood adaptation model requires an in-depth approach, involving the government, communities and various stakeholders. In Kampar District, despite government efforts such as infrastructure improvements and the development of drainage systems, major challenges remain. One of the main challenges is how to raise community awareness of the importance of flood preparation and involve them in the adaptation process.

The impact of flooding not only damages infrastructure, but also threatens the social and economic life of the local community. Therefore, it is important to develop and implement an effective flood disaster adaptation model. This adaptation model aims to reduce disaster losses and increase community resilience to flood threats. Various approaches, such as improving early warning systems, building flood-resistant infrastructure, and empowering communities in disaster risk management, need to be developed holistically. Given the importance of flooding disasters in the context of increasingly intense climate change, the development of a specific adaptation model for Kampar Regency is very relevant. This study aims to review and design a flood disaster adaptation model that can be applied in Kampar Regency in an effort to improve community preparedness and reduce the negative impacts of flooding disasters.

Therefore, it is important to design an adaptation model that suits local characteristics and needs. Local wisdom-based approaches, active community participation, and comprehensive policies will be key in improving Kampar Regency's resilience to floods. This article aims to explore the challenges and opportunities in flood disaster adaptation in Kampar District, and propose more applicable and relevant solutions that can be implemented in a more integrated and sustainable manner.

Method

This research uses a quantitative approach that is systematic, structured, and planned, with the aim of analyzing the response and adaptation of the Kampar Regency community to flood disasters. This type of quantitative research focuses on the collection and analysis of countable data, in accordance with the definition put forward by Ernawati (2024). Data were collected through two main techniques, namely questionnaires and field observations, which were conducted on communities living in flood-prone areas in Kampar Regency. Field observations showed that Kampar District has the highest flood risk index among other areas in Kampar District (Figure 1).

The data collection process used Expert Choice application and Analytical Hierarchy Process (AHP) method to conduct weighting and scoring analysis. In this research, AHP is used as a tool to identify the most effective flood disaster mitigation priorities. The spatial data obtained was then processed and represented in the form of maps through the ArcGIS 10.8 application. The map shows the results of scoring and weighting calculations based on the AHP method.

Data analysis used the AHP method, which is to assign weights to spatial information attribute data in a geographic information system (GIS). This process involved assessment through interviews with various stakeholders, including local government and local communities, to identify the mitigation factors considered most important. Once the weighting was completed, a pairwise comparison analysis was conducted to evaluate the relationship between factors and ensure consistency in prioritization. This step is important to ensure that the resulting mitigation priorities are consistent and rational.

Figure 1. Land system map of Kampar Regency

After the AHP analysis was completed, the results were used to formulate a policy model for flood disaster adaptation in Kampar Regency. The model includes recommendations on resource allocation, infrastructure planning, community training, and other strategic measures that can help reduce the risk of flooding and improve community preparedness in the face of such disasters.

By using the AHP method, this research produces a data-based and participatory disaster adaptation policy model that can be implemented for disaster mitigation in a more systematic and structured manner in the Kampar Regency area. The following is an overview of the process.

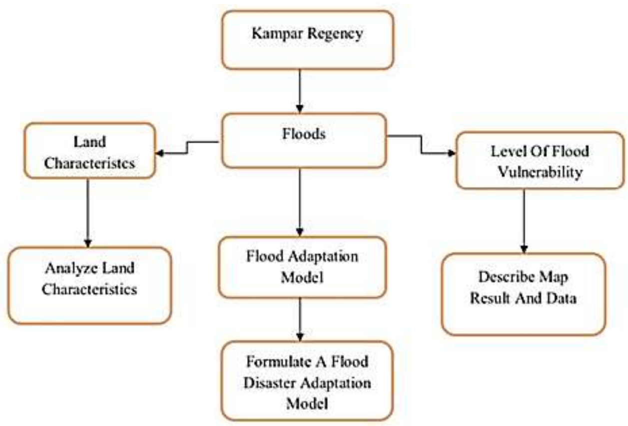

Figure 2. Research method applied in this study

Result and Discussion

Flood Risk Level Zones in Kampar Regency

Based on the analysis of the flood vulnerability map in Kampar Regency, Riau Province, it illustrates the level of flood vulnerability in various areas based on geography and environmental factors. Areas with a high level of vulnerability are generally located in low-lying areas and near rivers, such as along the Kampar River, where flooding often occurs especially during the rainy season. Meanwhile, areas of moderate vulnerability experience sporadic flooding, usually during extreme rainfall, and are often affected by inadequate drainage systems. Based on the results of the research and field tests that researchers have conducted, for clarity, it can be seen in the flood vulnerability map shown below.

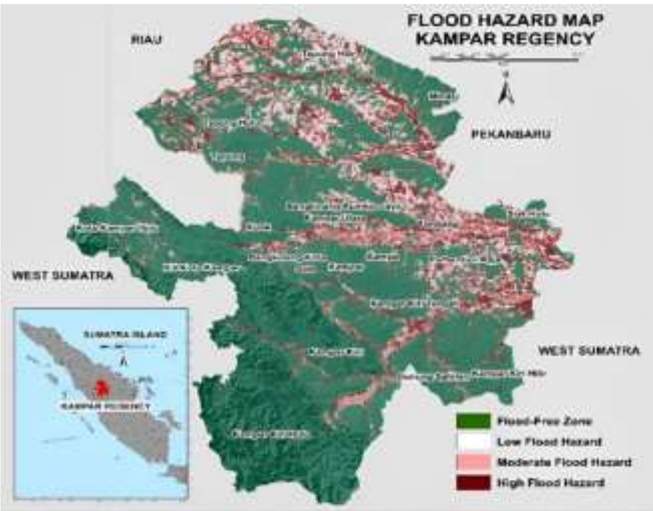

Figure 3. Flood vulnerability map of Kampar Regency

Areas with low vulnerability rarely experience flooding, usually due to higher land elevations and good water management infrastructure. This map is very important for spatial planning and disaster mitigation, helping the government and communities to prepare for potential flooding in the future. Most of this sub-district is in the lowlands, with a flat topography, making it vulnerable to inundation during the rainy season. Passing rivers, such as the Kampar River, have the potential to cause flooding, especially in areas close to the river. In Kecamatan Perhentian Raja, the area is generally low-lying and has a relatively flat topography, making it prone to inundation during high rainfall. Streams, including the Kampar River, contribute to flood risk, especially in adjacent areas. Whereas in Kecamatan XII Koto Kampar this area is rather low because this area has a relatively higher topography than the surrounding areas, thus reducing the potential for inundation during heavy rainfall and Kecamatan Kampar Kiri Hulu is a very low vulnerability zone, this area has a higher topography and soil contours that support good drainage, thus reducing the risk of inundation during high rainfall.

High Hazard Zone Land Characteristics

Based on the results of research and field tests that researchers have conducted, four flood zone points were determined on the land characteristics in Kampar Regency, Riau Province, which can be seen in the table below: Land characteristics based on the results of the analysis of flood vulnerability maps in Kampar Regency have land characteristics that are affected by flood risk, as shown in the flood vulnerability map. Most of these sub-districts are in the lowlands, with a topography that tends to be flat, making them vulnerable to inundation during the rainy season. Passing rivers, such as the Kampar River, have the potential to cause flooding, especially in areas close to the river. The soil type in the region, which is often alluvial, supports agriculture but also increases vulnerability to inundation. Numerous areas of poor drainage add to the risk of flooding, causing negative impacts on agriculture and settlements. Based on effective land management and drainage systems are essential to reduce the impact of flood vulnerability. The results of the high hazard zone land characteristics are explained in the table below:

Table 1. Land Characteristics of High Flood Hazard Zones

Criteria	Data	Description
Landform	Fluvial (F)	Bad
Natural levees/dams with flood potential	Left and right river embankments slope >8% with high flood potential	Good
River flow pattern	Annular, Multi basinal	Bad
Rainfall (mm/year)	>25000	Bad
Land slope left and right of river %	<2 (inhibited)	Bad
Damming by river branching and tides	Main River	Bad
Meandering P= Pj of river according to turn/straight distance	>2.0	Bad
Average slope of watershed (%)	>8	Bad
Land Use	Settlement/city	Somewhat Bad

Sample Point 1 Poor Land Characteristics

Figure 4. Land characteristics of high flood hazard zones in Kampar Regency

Land Characteristics of Moderate Flood Hazard Zones

Based on the analysis of the flood vulnerability map of the moderate flood hazard zone, several land characteristics were revealed that affect the vulnerability of this area. Areas with flat topography and low elevation become critical points, facilitating the accumulation of water during high rainfall. The soil type in this area, which mostly consists of clay, has a low absorption capacity, exacerbating waterlogging. In addition, diverse land uses, such as agriculture and settlements, are often not accompanied by effective drainage systems, increasing the risk of flooding.

Several studies emphasize the importance of mapping flood risk zones based on land characteristics to minimize flood damage (Davlasheridze & Fan, 2025; Nhamo et al., 2025; Polsomboon et al., 2025). In contrast, areas with dense soil structures and good drainage tend to have flood-free zones, which can retain or drain water more effectively (Di Noia et al., 2025; Lv et al., 2025). Therefore, understanding these land characteristics is essential for designing flood risk management policies, such as spatial zoning, which is effective in reducing the impact of flooding on society and the environment.

The existing river network is also potentially hampered by sedimentation and sub-optimal management, slowing down the flow of water. The lack of vegetation in some areas reduces the soil's ability to absorb water, and with high rainfall patterns and increased flood frequency, it is identified as a highly vulnerable area to flood disasters. Appropriate measures are needed for risk mitigation and community protection. The results of the medium hazard zone land characteristics are explained in the table 1.

Table 2. Land Characteristics of Moderate Flood Hazard Zones

Criteria	Data	Description
Landform	Fluvial (F)	Bad
Natural levees/dams natural with flood potential	Left and right river embankments >8% slope with high flood potential	Good
River flow pattern	Annular, Multi basinal	Bad
Rainfall (mm/year)	>25000	Bad
Land slope left and right of river %	<2 (inhibited)	Bad
Damming by river branching and tides	Main River	Bad
Meandering P= Pj of river according to turn/straight distance	>2.0	Bad
Average slope of watershed (%)	>8	Bad
Land Use	Settlement/city	Somewhat Bad

Sample Point 2: Medium Land Characteristics

Figure 5. Land characteristics of medium flood hazard zones in Kampar District

Land Characteristics of Low Flood Hazard Zone

Based on the results of the analysis of flood vulnerability maps in the low flood hazard zone, the land characteristics show a number of factors that influence flood vulnerability. The area is dominated by flat topography with some areas of low elevation, making it more susceptible to inundation when rainfall increases. The soil type, clay, has low absorbency, which exacerbates the accumulation of water on the surface. In addition, diverse land uses, including residential and agricultural land, are often not equipped with adequate drainage systems, resulting in less effective water conveyance. Existing river networks are also potentially blocked due to sedimentation, which slows down the flow of water (Di Noia et al., 2025; Wang et al., 2025). Lack of vegetation in some areas reduces the soil's ability to absorb water, increasing the risk of flooding. With high rainfall patterns and increased flood frequency. The results of the low flood hazard zone land characteristics are explained in the table 3.

Table 3. Land Characteristics of Low Flood Hazard Zones

Criteria	Data	Description
Landform	Fluvial (F)	Bad
Natural levees/dams with flood potential	Left and right river embankments slope >8% with high flood potential	Good
River flow pattern	Annular, Multi basinal	Bad
Rainfall (mm/year)	>25000	Bad
Land slope left and right of river %	<2 (inhibited)	Bad
Damming by river branching and tides	Main River	Bad
Meandering P= Pj of river according to turn/straight distance	>2. 0	Bad
Average slope of watershed (%)	>8	Bad
Land Use	Settlements/cities	Somewhat Bad

Sample Point 3 Good Land Characteristics

Figure 6. Land characteristics of low flood hazard zones in Kampar District

Land Characteristics Flood Hazard Zone Flood Free

Based on the flood vulnerability map analysis, the flood-free flood hazard zone reveals several land characteristics that affect the vulnerability of this area. The flood vulnerability map analysis shows that the flood-free hazard zone is located in areas that have higher elevations and are far from the main river flow. Areas such as plateaus and hills, as well as areas with good drainage systems, are considered safe from flood risk (Darnkachatarn & Kajitani, 2025; Kays et al., 2025).

Several studies show that factors such as topography, land use, soil type, and groundwater depth greatly affect the level of vulnerability to flooding. For example, areas with low ground surfaces and close to river flows tend to have a higher risk of flooding compared to higher areas or more stable plains. (Darnkachatarn & Kajitani, 2025; Maharjan et al., 2025; Tian et al., 2025; H. Wu et al., 2025).

The map also considers factors such as extreme rainfall and land use patterns, so areas with good vegetation cover and adequate flood control infrastructure are categorized as flood-free zones. It is important for communities and stakeholders to understand these maps in order to develop effective mitigation policies and protect high-risk areas. The results of the flood-free hazard zone land characteristics are explained in the table 4.

Sample Point 4 Good Land Characteristics

Figure 7. Land characteristics of flood free danger zones in Kampar District

Table 4. Land Characteristics of Flood Free Hazard Zones

Criteria	Data	Description
Landform	Fluvial (F)	Bad
Natural levees/dams natural with flood potential	Left and right river embankments slope >8% with high flood potential	Good
River flow pattern	Annular, Multi basinal	Bad
Rainfall (mm/year)	>25000	Bad
Land slope left and right of river %	<2 (inhibited)	Bad
Damming by river branching and tides	Main River	Bad
Meandering P= Pj of river according to turn/straight distance	>2. 0	Bad
Average slope of watershed (%)	>8	Bad
Land Use	Settlement/city	Somewhat Bad

Prioritization of Disaster Adaptation Policy Model

The selection of adaptation model priorities is based on the amount of weight (eigenvalue) on each policy alternative accountable. Priority selection analysis is carried out if the consistency ratio value of the paired criteria CR value < 0.1 is a value whose consistency level is good and can see in Figure 8.

Based on the results of pairwise prioritization between criteria, the value of land characteristics shows (0.03) then the pairwise priority value of the level of flood vulnerability shows (0.03) and the value of pairwise priorities between criteria on formulating adaptation models shows (0.05).

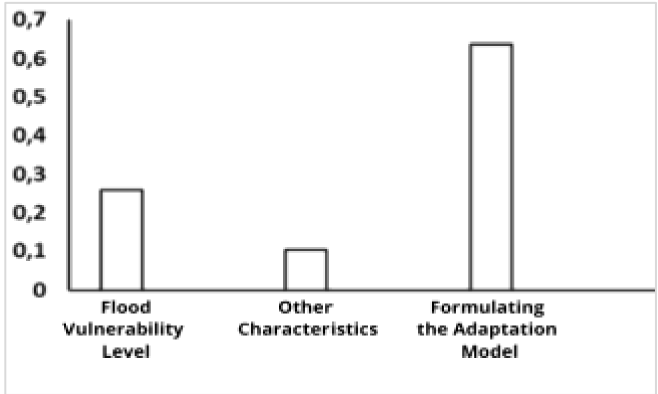

Figure 8. Pairwise prioritization between criteria

Figure 9. Results of AHP analysis of the disaster adaptation model

Conclusion

The conclusion of the research on optimizing the flood disaster adaptation model in Kampar Regency shows that most areas of Kampar Regency are prone to flooding. Factors such as flat topography, high rainfall, and poor drainage exacerbate this vulnerability. Flood vulnerability mapping shows variations in land characteristics in different zones, indicating the need for special attention to areas with poor land conditions to improve resource management and support sustainable development. The flood adaptation model that is applied can minimize the risk and impact of flood disasters by involving the community in preventive and mitigation efforts.

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Author Contributions

Nadiya Sari and Dedi Hermon contributed to the analysis of flood vulnerability maps, identification of factors causing vulnerability, AHP and FGD approaches, prioritization of land characteristics and flood vulnerability levels, and recommendations for improving preparedness, water resources management, and infrastructure improvements for flood mitigation.

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Conflicts of Interest

The authors declare no conflict of interest.

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