Flood Risk and Vulnerability Analysis as the Basis of Disaster Mitigation Strategy in Binjai City, North Sumatra Province.

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Abstract

Flooding is one of the dominant environmental problems that occurs in urban areas, including in Binjai City, which has a fairly high level of risk due to a combination of natural factors and human activities. This research aims to analyze the existing conditions of flood events, assess the level of risk and vulnerability based on hazard*, vulnerability, and capacity*, and formulate appropriate disaster mitigation strategies. The research method used is a qualitative descriptive approach with secondary data analysis, literature studies, and document studies from related agencies. The results of the study show that the existing flood conditions in Binjai City are influenced by the relatively flat topography of the area, limited river capacity, suboptimal drainage system, and land use changes that reduce water catchment areas. The risk analysis shows that the level of flood danger is in the medium to high category, while the level of community vulnerability is relatively high due to population density, settlements in flood-prone areas, and low environmental awareness. On the other hand, the flood management capacity is still in the medium category and has not been able to optimally compensate for the level of danger and vulnerability, so that the overall level of flood risk is categorized as high. Based on these findings, the recommended mitigation strategies include a structural approach through improving drainage infrastructure and river normalization, a non-structural approach through risk-based spatial planning and strengthening of early warning systems, and a collaborative approach through increased community participation and cross-sectoral partnerships. The integration of these three approaches is expected to be able to increase regional resilience and reduce the risk of flooding in Binjai City in a sustainable manner.

Keywords: Floods, Risks, Vulnerability, Mitigation, Binjai City

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Introduction

Flood disasters are one of the most dominant environmental problems in urban areas in Indonesia, especially in areas with high population growth rates and uncontrolled land-use changes. Floods not only cause material losses, but also have a significant impact on social, economic, and public health aspects. In the context of sustainable development, understanding flood risk and vulnerability is very important as a basis for formulating effective and targeted mitigation strategies (BNPB, 2022).

Binjai City as one of the areas in North Sumatra Province has a fairly high level of vulnerability to flood disasters. This condition is influenced by several factors, including geographical conditions, relatively flat regional topography, changes in land use due to urbanization, and increasing pressure on urban drainage systems (Tarigan, 2026). In addition, the suboptimal capacity of flood control infrastructure and community behavior in environmental management also exacerbate the potential for flooding in this area (Binjai City Central Statistics Agency, 2023)

The increase in the frequency and intensity of flood events in Binjai City shows that this problem cannot be addressed through a technical approach alone, but requires a more comprehensive analysis of the level of risk and vulnerability of the area (Hartini et al., 2023). Flood risk is a combination of hazard, vulnerability (*vulnerability)*, and capacity (*Capacity*) owned by a region. Therefore, risk and vulnerability analysis is a crucial first step in developing an effective disaster mitigation strategy (Prabaswari et al., 2022)(Sugiarto, Yamin s, et al., 2024)

A number of previous studies have shown that effective flood disaster mitigation relies heavily on the ability to identify vulnerable areas and understand the factors that affect the level of vulnerability of communities. However, most research still focuses on technical aspects such as drainage and infrastructure, and has not integrated comprehensive risk and vulnerability analysis as a basis for decision-making (Fairuzzen et al., 2024) (Fairuzzen et al., 2024)

On the other hand, there is a gap between empirical conditions in the field and existing mitigation planning approaches. Although various efforts have been made by local governments, such as infrastructure development and flood control programs, the results have not been able to fully reduce the level of risk significantly (Addawiyah et al., 2025). This suggests that a more systematic and data-driven approach is needed in understanding flood risk and vulnerability (Ramadhani & Nuraini, 2024).

Based on this, this research has a novelty by comprehensively examining flood risk and vulnerability analysis as a basis for formulating disaster mitigation strategies in Binjai City. This research not only aims to produce a mapping of the risk and level of vulnerability of the region, but also provides benefits both theoretically and practically. Theoretically, this research is expected to enrich studies in the field of disaster management, especially related to risk-based and vulnerability-based approaches in mitigation planning. Practically, the results of this study are expected to be considered for local governments and related agencies in formulating more effective and targeted mitigation policies, as well as increasing public awareness in dealing with flood disaster risks (Prabaswari et al., 2022). Thus, this research is expected to be able to make a real contribution in supporting efforts to reduce disaster risk and sustainable regional development (BNPB, 2022).

Problem Identification

Based on the background that has been described, the flood problem in Binjai City is not only caused by natural factors, but is the result of complex interactions between physical, environmental, and social factors.

1. The high level of flood risk in this region shows that there is an imbalance between the potential hazard and the level of vulnerability and the capacity of the region. Relatively flat geographical conditions, coupled with changes in land use due to uncontrolled urbanization, further increase the potential for inundation and flooding in various residential areas.

2. An urban drainage system that is not optimal is one of the main factors that worsens these conditions. Drainage infrastructure that is unable to accommodate rainwater discharge optimally causes water runoff to not be drained properly, thus increasing the risk of flooding, especially in the high-intensity rainy season. This problem is exacerbated by the lack of maintenance of waterways and the behavior of people who still do not care about environmental cleanliness, such as careless waste disposal that clogs drainage flows.
3. The mitigation efforts that have been carried out by local governments have not been fully based on a comprehensive risk and vulnerability analysis. Existing policies and programs tend to be reactive and have not been thoroughly integrated with region-specific conditions. This causes the effectiveness of flood management to be limited and has not been able to significantly reduce the level of risk.
4. There is a gap between the theoretical concept of disaster mitigation and its implementation in the field. Conceptually, disaster mitigation is supposed to be based on accurate mapping of risks and vulnerabilities, but in practice such an approach has not been fully implemented. Limited data, lack of coordination between agencies, and lack of optimal use of information in planning are factors that hinder the effectiveness of mitigation.

Problem Formulation

Based on the background of the problem that has been described, the formulation of the problem can be formulated as follows:

1. What are the existing conditions of flood events in Binjai City, including regional characteristics, drainage systems, and the main factors causing floods?
2. What is the level of risk and vulnerability to flooding in Binjai City based on the aspects of *hazard*, *vulnerability*, and capacity?
3. What is the right flood disaster mitigation strategy based on the results of risk and vulnerability analysis in Binjai City?

Research Objectives

Based on the formulation of the problem that has been described, the objectives of this research are as follows:

1. To analyze the existing conditions of flood events in Binjai City, including regional characteristics, drainage systems, and the main factors causing floods.
2. To analyze the level of risk and vulnerability of flooding in Binjai City based on the aspects of *hazard*, vulnerability, and capacity.
3. To formulate the right flood disaster mitigation strategy based on the results of risk and vulnerability analysis in Binjai City.

Literature Review

Flood Disaster Mitigation

Disaster mitigation is a series of efforts made to reduce the risk and impact of disasters, both through physical development and increasing community awareness and capacity (Haeril et al., 2021). According to the National Disaster Management Agency, disaster mitigation is a step taken before a disaster occurs to minimize casualties, environmental damage, and economic losses.

In the context of floods, mitigation includes various actions such as spatial management, the development of flood control infrastructure, and improving community preparedness (Fairuzzen et al., 2024). Mitigation is an important part of the disaster management cycle that is preventive and sustainable.

Flood Mitigation

Flood mitigation is a special effort aimed at reducing the risk of flooding and its impact. According to the United Nations Office for Disaster Risk Reduction, flood mitigation includes both structural and non-structural measures.

Structural mitigation includes infrastructure development such as embankments, drainage, reservoirs, and river normalization (UNDRR, 2022). Meanwhile, non-structural mitigation includes spatial planning policies, early warning systems, community education, and institutional capacity strengthening (Syahputra & Sugiarto, 2024).

Factors Causing Flooding

Floods are generally caused by a combination of natural factors and human activities (Valdewa et al., 2022), including:

1. High rainfall
2. Inadequate drainage system
3. Land conversion and urbanization
4. River siltation
5. Community behavior in waste management

These factors are interrelated and increase the risk of flooding, especially in urban areas such as Binjai City.

Purpose and Benefits of Flood Mitigation

According to the World Health Organization (WHO, 2022), disaster mitigation aims to:

1. Reduce the risk of casualties and economic losses
2. Protecting infrastructure and the environment
3. Improving community preparedness
4. Supporting sustainable development

The benefits of flood mitigation are not only in the aspect of safety, but also in increasing regional resilience and socio-economic stability of the community.

Local Government Policies in Flood Management

Public policy is a decision or action taken by the government to solve public problems. According to (Ramli et al., 2025) Public policy is what the government chooses to do or not do.

In the context of flood mitigation, local government policies include regulations, programs, and strategies designed to reduce flood risk in their areas (Ramadhani & Nuraini, 2024).

Regional Policies in Flood Mitigation

According to (Haeril et al., 2021) Local government policies in flood mitigation typically include:

1. Disaster risk-based spatial planning
2. Urban drainage management
3. River normalization
4. Community education and socialization programs
5. Development of early warning systems

According to (Ministry of Public Works and Housing, 2021) Flood control policies must be integrated between spatial planning, infrastructure, and environmental management.

The Role of Local Government

Local governments have a strategic role in flood mitigation, including:

1. As a regulator (policymaker)
2. As a facilitator (provider of facilities and infrastructure)
3. As an inter-agency coordinator
4. As an implementer of mitigation programs

The success of mitigation is highly dependent on the capacity of local governments to manage available policies and resources.

Policy Implementation Theory

Policy implementation is the process of implementing public policies that have been set to achieve certain goals (Maharaksa et al., 2025). According to (Laary et al., 2022) The success of policy implementation is influenced by four main variables, namely communication, resources, disposition, and bureaucratic structure (Muazro & Nuraini, 2020).

In addition, policy implementation is influenced by the content of policy and the context of implementation (*context of implementation*) (Merahabia & Tebay, 2022).

Implementation of Flood Mitigation Policy

In the context of flood mitigation in Binjai City, policy implementation not only involves the government, but also the community and the private sector (Putri Nadya Agustin Reyhan et al., 2025a). The success of the implementation is influenced by:

1. Coordination between agencies
2. Availability of resources
3. Community participation
4. Regulatory support
5. Environmental and social conditions

A collaborative approach is important in ensuring the effectiveness of flood mitigation strategies.

Flood Mitigation Strategy

Flood mitigation strategies are planned steps taken to systematically reduce flood risk (Rasdiana et al., 2021). These strategies include:

Structural Strategy

1. Drainage construction and repair
2. River normalization
3. Construction of embankments and reservoirs
4. Watershed control

Non-Structural Strategy

1. Risk-based spatial planning
2. Community education and socialization
3. Early warning system
4. Institutional strengthening

A combination of these two strategies is necessary to create effective and sustainable mitigation.

Frame of Mind

The framework of thinking in this study is built based on a logical flow that relates between empirical conditions, theoretical concepts, and the formulation of disaster mitigation strategies. The research began with the identification of the existing conditions of flood events in Binjai City which were influenced by natural factors and human activities, such as rainfall, land use changes, and limited drainage systems. These conditions are then analyzed using a disaster risk approach that includes three main components, namely *hazard*, vulnerability, and capacity to determine the level of risk and vulnerability of the region comprehensively.

The results of this analysis are the basis for understanding the pattern and level of flood threat that occurs. Furthermore, the findings are integrated with the concept of disaster mitigation, both through structural and non-structural approaches, and consider the role of local government policies and community participation. Thus, this research framework leads to the formulation of an effective, directed, and sustainable flood disaster mitigation strategy, which

is not only able to reduce flood risk, but also improve regional resilience and the quality of life of the community in Binjai City. The following is a picture of the thinking framework of this research:

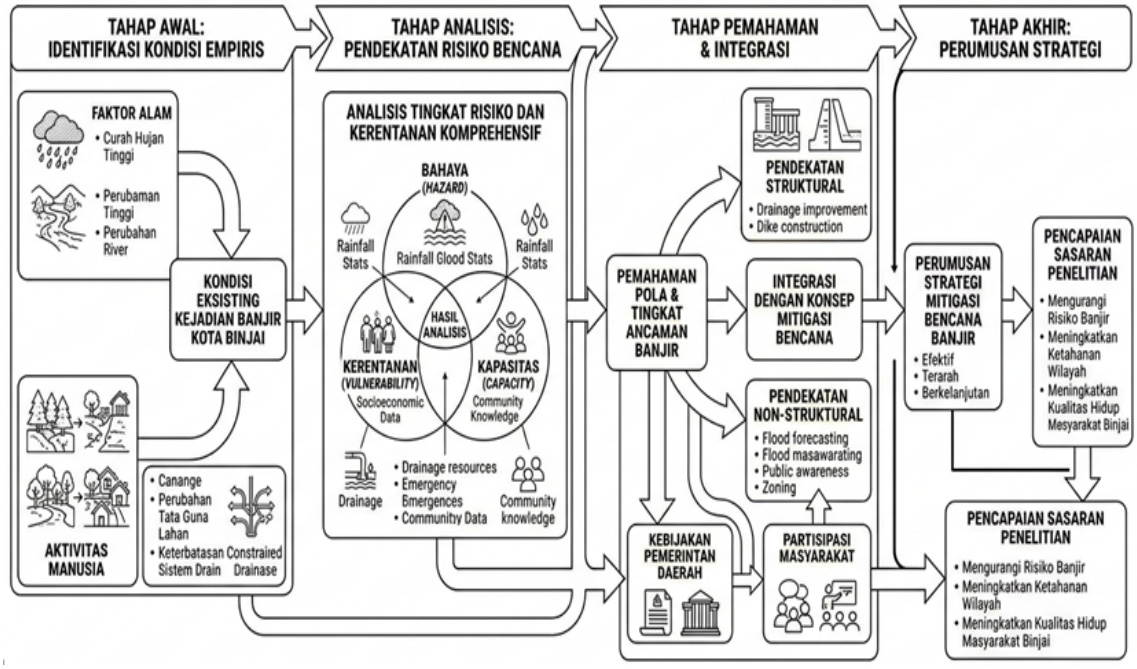

Figure 1. Frame of Mind

Research Methodology

Types of Research

This study uses a qualitative descriptive approach. This approach was chosen to systematically and in-depth describe the existing conditions of flood events in Binjai City and analyze the level of flood risk and vulnerability as a basis for formulating the right disaster mitigation strategy.

The qualitative descriptive approach allows researchers to comprehensively understand the flood phenomenon through the analysis of real conditions in the field, both from the physical aspects of the area, drainage system, and community behavior. In addition, this approach is also used to examine the relationship between hazard and vulnerability (*Vulnerability*), and capacity (*Capacity*) in shaping the level of flood risk. Thus, this research is expected to be able to produce an in-depth analysis and recommendations for mitigation strategies that are contextual and applicative (Sugiarto, Kamakaula, et al., 2024).

Research Procedure

This research procedure is carried out through several systematic stages so that the results of the research can be obtained optimally and in accordance with the goals that have been set (Sugiarto, Kamakaula, et al., 2024).

The first stage is the preparation stage, which includes a literature review to strengthen theoretical foundations related to flood risk and vulnerability, the preparation of research proposals, and the determination of research locations and informants.

The second stage is data collection, which is carried out through field observation to identify the condition of flood-prone areas, in-depth interviews with key informants, and secondary data collection such as flood event data, regional maps, and policy documents.

The third stage is data analysis, which is processing data that has been obtained through the process of data reduction, data presentation, and conclusion drawn. At this stage, an analysis of existing conditions, risk and vulnerability levels, and the formulation of flood disaster mitigation strategies are carried out.

The last stage is the preparation of a research report, which is to systematically compile research results that include results, discussions, conclusions, and recommendations for effective and sustainable mitigation strategies for Binjai City.

Research Location

This research was carried out in Binjai City, North Sumatra Province, with a focus on areas that have a high level of vulnerability to flood disasters.

The selection of the location was based on the consideration that Binjai City is one of the areas that often experience floods due to relatively flat geographical conditions, changes in land use, and a drainage system that is not optimal. In addition, the increasing frequency of flooding events shows that this region needs a more in-depth study of risk and vulnerability analysis as the basis for mitigation strategies.

Subjects and Objects of Research

The subjects in this study are all parties related to the handling and mitigation of flood disasters in Binjai City, which include local governments, technical agencies, and the community.

The object of the research was determined using the purposive sampling technique, which is the deliberate selection of informants based on certain criteria relevant to the purpose of the research (Arikunto, 2013).

The informants in this study include:

1. Local government officials (BPBD, PUPR Office, and related agencies)
2. Implementer or manager of flood management program
3. People affected by floods (±30 people)
4. Private parties or organizations involved in disaster mitigation

The selection of this informant aims to obtain comprehensive data related to flood conditions, risk and vulnerability levels, as well as mitigation strategies that have been and can be implemented.

Data Collection Techniques

The data collection technique in this study is carried out through several methods referring to the theory (Creswell & Cresswell, 2021), namely:

1. **Observation**
   is carried out by directly observing the condition of flood-prone areas, drainage systems, and the implementation of flood mitigation programs in the field.
2. **In-depth**
   interviews are conducted with key informants, such as government officials, policy implementers, and the public, to obtain information on policy implementation, obstacles faced, and the effectiveness of flood mitigation strategies.
3. **Documentation**
   is carried out by collecting data in the form of official documents, regional regulations, activity reports, flood incident data, and other documents related to flood mitigation policies.

Data Analysis Techniques

The data analysis in this study uses qualitative descriptive analysis techniques (Braun, V. & Clarke, V, 2021). The data obtained was analyzed through several stages, namely:

1. **Data Reduction**
   The process of sorting and simplifying data is relevant to the focus of research, especially related to the implementation of flood mitigation policies.
2. **Data Presentation**

The data that has been reduced is then presented in the form of a descriptive narrative to provide a systematic picture of the conditions of implementation of flood mitigation policies.

3. **Conclusion**
   The final stage is in the form of drawing conclusions based on the results of data analysis, which is used to formulate effective and sustainable flood mitigation strategies.

Data Validity

To ensure the validity of the data, this study uses a data triangulation technique, which is comparing data obtained from various sources and methods such as observation, interviews, and documentation (Flick, 2021).

In addition, a member check is also carried out, which is reconfirming the results of the interview to the informant to ensure the suitability of the data with the actual conditions in the field. Thus, the results of the research are expected to have a high level of validity and credibility.

Results

1. Existing Conditions of Flood Events in Binjai City

Based on the results of secondary data analysis, literature studies, and document studies from related agencies, it shows that Binjai City is one of the areas in North Sumatra Province with a fairly high rate of flood incidence and tends to increase in recent years, especially in the rainy season period with high rainfall intensity (Putri Nadya Agustin Reyhan et al., 2025b).

Geographically, Binjai City has a relatively flat topography with an average height ranging from 20 –30 meters above sea level. This condition causes a low ability of water flow by gravity, thereby increasing the potential for inundation, especially in densely populated areas (Binjai City Central Statistics Agency, 2023).

From a hydrological aspect, Binjai City is passed by several main rivers, such as the Bingai River and the Mencirim River, which function as a natural drainage system. However, the results of the analysis show that the capacity of the river has decreased due to sedimentation and narrowing of the river body, so that it is not able to accommodate water discharge when there is high intensity rain. This condition causes an overflow that inundates the surrounding residential areas (National Disaster Management Agency, 2023).

Problems are also found in urban drainage systems that are not optimal. Some key findings include:

1. Dimensions of drainage channels that do not correspond to water runoff discharge
2. Sedimentation and blockage due to domestic waste
3. Lack of regular maintenance and normalization of the channel
4. Lack of integration of primary, secondary, and tertiary drainage systems

In addition, changes in land use due to rapid urbanization have significantly reduced the area of water catchment areas. Many open lands and green areas have been converted into residential and commercial areas without being balanced with runoff management systems such as infiltration wells or retention ponds (Hasibuan et al., 2025).

Spatially, the areas most often affected by floods include North Binjai, East Binjai, and South Binjai Districts, with inundation heights ranging from 30 cm to more than 100 cm. In some extreme events, inundation can last for 1–3 days, which has an impact on people's social and economic activities (Binjai City Regional Disaster Management Agency, 2025).

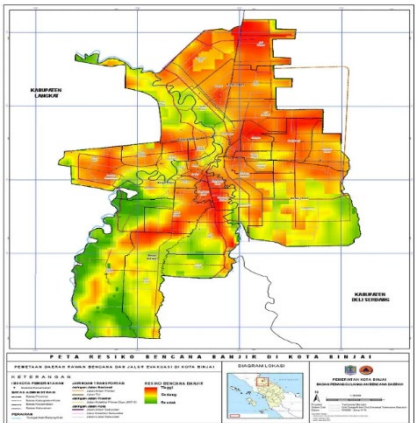

Figure 2. Distribution Map of Flood-prone Areas of Binjai City

Figure 3. Drainage Conditions and Flood Inundation in Binjai City

2. Flood Risk and Vulnerability Analysis

Hazard Analysis

The results of the analysis show that the level of flood danger in Binjai City is moderate to high, which is influenced by the high intensity of rainfall and limited river capacity. Erratic rainfall patterns due to climate change also increase the frequency of flooding events (Binjai City Regional Disaster Management Agency, 2025).

Vulnerability Analysis

The level of community vulnerability to floods in Binjai City is relatively high (Binjai City Regional Disaster Management Agency, 2025), with the following indicators:

1. High population density in flood-prone areas
2. Thriving settlements on the banks of rivers
3. Building quality that is not resistant to inundation
4. Low public awareness in environmental management

In addition, socio-economic vulnerability can be seen from the limited ability of the community to adapt, such as raising houses or access to disaster information (De Silva & Kawasaki, 2018).

Capacity Analysis

The flood management capacity in Binjai City is generally in the medium category, which is shown by the existence of formal institutions such as BPBD, the availability of various flood management policies and programs, and the existence of basic flood control infrastructure that has been built by the local government. However, this capacity is not fully optimal in significantly reducing flood risk (Binjai City Regional Disaster Management Agency, 2025).

This is due to several main obstacles, including limited regional budgets that limit the development of infrastructure and mitigation programs, inter-agency coordination that has not been implemented effectively and integrated, an early warning system that has not yet been fully developed, and a low level of community participation in supporting mitigation efforts (Tarigan, 2025). This condition shows that although institutional and policy foundations are in place, further strengthening is needed in the aspects of funding, governance, technology, and community empowerment so that the capacity of flood management in Binjai City can increase sustainably (Binjai City Government, 2025).

Flood Risk Level

Based on the integration of *hazard, vulnerability, and capacity*, the flood risk level in Binjai City is categorized as high risk. High vulnerability that is not offset by adequate capacity

is a major factor that increases disaster risk. The following is a diagram of the flood risk analysis of Binjai City and the Matrix of the flood risk level of Binjai City.

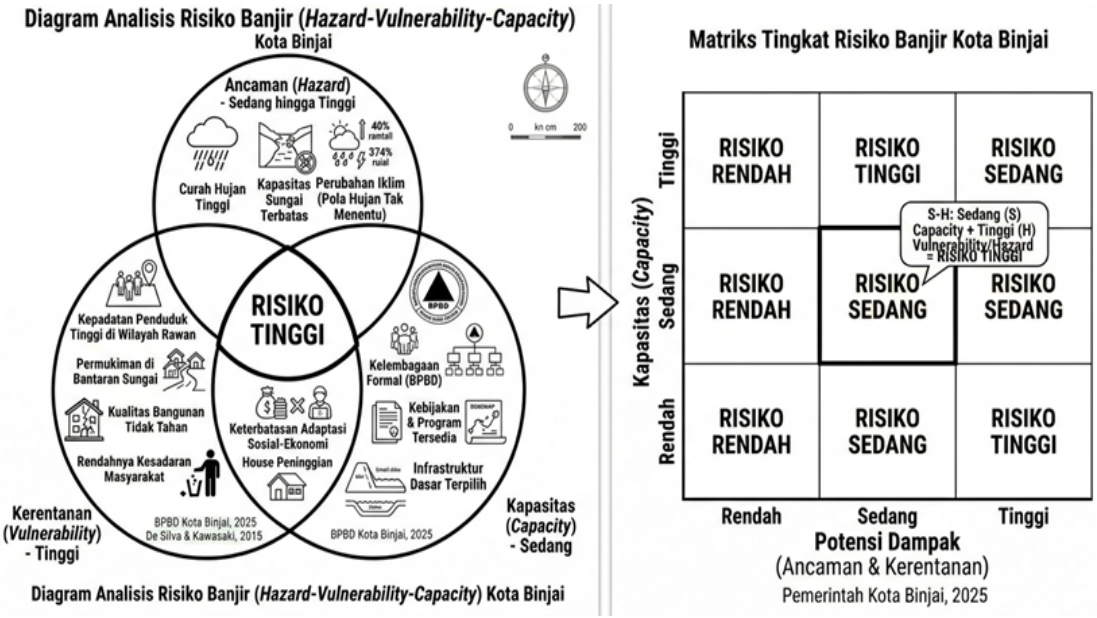

Figure 4. Binjai City Flood Risk Analysis and Risk Level Diagram

3. Flood Disaster Mitigation Strategy in Binjai City

Based on a synthesis between high risk levels and empirical findings in the field, this study formulates three pillars of a comprehensive mitigation strategy. This strategy is designed to reduce the vulnerability index while increasing the regional capacity index in a sustainable manner.

Structural Strategy (Physical Mitigation)

The structural strategy is focused on technical engineering to manage high post-precipitation water discharge and improve the hydrological characteristics of the region.

1. Rehabilitation and Drainage Capacity Improvement. Redesigning urban drainage systems by considering projected flood discharge for a return period of 25-50 years to anticipate climate change.
2. River Normalization and Restoration. Periodic dredging of sediment on the main rivers in Binjai City to restore the natural capacity of the river cross-section.
3. Retention Infrastructure Development. Procurement of *retention ponds* and communal infiltration wells as run-off control instruments before entering the main water body.
4. Integrated Watershed Management. Watershed Management from upstream to downstream to mitigate water delivery through vegetative and civil technical conservation.

Non-Structural Strategies (Adaptive Mitigation)

Non-structural mitigation aims to reduce vulnerability through policy frameworks, space management, and system preparedness.

1. Risk-Based Spatial Planning: Strict control of space utilization, especially in riverbank areas, through flood zoning instruments in the Regional Spatial Plan (RTRW).
2. Strengthening Policy Regulations: Law enforcement against land use violations and IMB (Building Permit) standardization which requires the application of biopore holes/infiltration.
3. Early Warning System (EWS): Implementation of water level sensor technology that is integrated in *real-time* with people's mobile devices to speed up evacuation response times.

4. Strengthening Institutional Capacity: Improving cross-sector coordination between BPBD, the PUPR Office, and DLH to ensure the synchronization of disaster management programs.

Collaborative Strategy (Participatory Mitigation)

This strategy prioritizes social aspects and partnerships in creating inclusive *urban resilience*.

1. Increased active community participation. The transformation of the role of the community from the affected object to the subject of mitigation through a culture of mutual cooperation in cleaning environmental channels.
2. Triple Helix Partnership (Government–Private–Community). Encouraging private sector involvement through *Corporate Social Responsibility* (CSR) programs in the procurement of evacuation facilities or the construction of disaster response parks.
3. *Community-Based Disaster Risk Management* (CBDRM). The establishment of the "Disaster Resilient Village" group to conduct routine education and emergency response simulations independently at the village level.

The integration of the three strategies above is expected to change the paradigm of flood management in Binjai City, which was originally responsive (emergency) to preventive (mitigative). Structural strategies serve as short-term technical solutions, while non-structural and collaborative strategies are key to long-term sustainability of mitigation to create cities resilient to hydrometeorological threats. The following is a picture of the Integrated Flood Mitigation Strategy Scheme

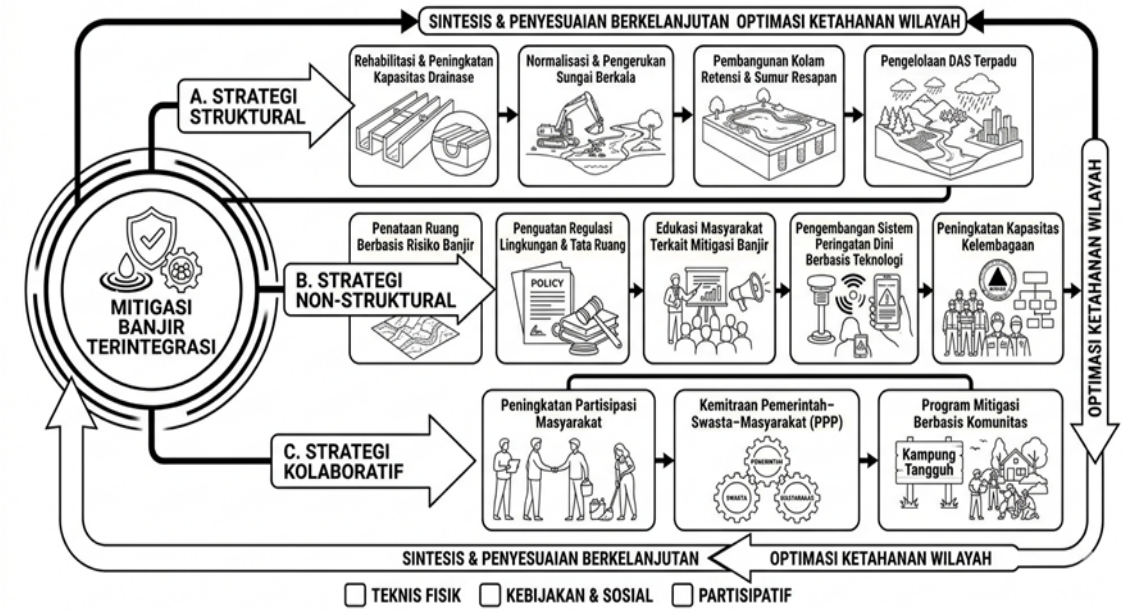

Figure 5. Integrated Flood Mitigation Strategy Scheme

From the results of the explanation above, the results of the study show that flooding in Binjai City is a complex and multidimensional problem, which is influenced by the interaction between physical, environmental, and social factors. The high level of flood risk is caused by the dominance of vulnerability factors that are not balanced by adequate capacity in disaster management.

Therefore, effective mitigation strategies must be carried out in an integrated and sustainable manner, combining structural, non-structural, and collaborative approaches. This approach is expected to increase regional resilience and significantly reduce the risk of flooding in the future.

Conclusion

Based on the results of the research that has been carried out, it can be concluded that:

1. The existing conditions of flood events in Binjai City show a high level of vulnerability due to a combination of physical and anthropogenic factors. Geographically, the relatively flat topography of the area and hydrological conditions influenced by the existence of rivers with limited capacity are the main triggers for inundation. These problems are exacerbated by urban drainage systems that are not optimal, changes in land use that reduce water catchment areas, and community behavior that does not fully support sustainable environmental management. As a result, flood events tend to occur repeatedly with varying intensities in several densely populated areas.
2. The results of risk and vulnerability analysis show that the level of flood risk in Binjai City is in the high category. This is due to the high level of hazard due to high rainfall and limited river capacity, as well as the high vulnerability of people living in flood-prone areas. Meanwhile, flood management capacity is still at a moderate level and has not been able to optimally compensate for the existing level of danger and vulnerability. Budget limitations, weak coordination between agencies, lack of optimal early warning systems, and low community participation are the main factors that hinder the capacity building.
3. Flood disaster mitigation strategies in Binjai City need to be designed comprehensively and integrated through three main approaches, namely structural, non-structural, and collaborative strategies. The structural strategy is focused on improving the quality of flood control infrastructure, the non-structural strategy emphasizes on strengthening policies, spatial planning, and early warning systems, while the collaborative strategy focuses on increasing community participation and cross-sectoral partnerships. The integration of these three strategies is expected to be able to significantly reduce the level of flood risk and increase the resilience of the Binjai City area in dealing with flood disasters in a sustainable manner.

Suggestions

Based on the results of the research that has been obtained, some suggestions that can be submitted as an effort to increase the effectiveness of flood disaster mitigation in Binjai City are as follows:

1. For Local Governments
   Local governments are expected to increase their flood management capacity through strengthening risk- and vulnerability-based planning. This can be done by improving and expanding drainage infrastructure, normalizing rivers regularly, and building flood control facilities such as retention ponds and infiltration wells. In addition, it is necessary to increase adequate budget allocation and strengthen coordination between related agencies so that mitigation programs can run effectively and integrated.
2. For Related Agencies (BPBD, PUPR Office, DLH)
   Related agencies need to increase synergy and collaboration in the implementation of flood mitigation programs, especially in terms of drainage management, spatial control, and the development of technology-based early warning systems. In addition, it is necessary to periodically monitor and evaluate the programs that have been carried out to ensure their effectiveness and sustainability.
3. For the Community
   The community is expected to increase awareness and active participation in flood mitigation efforts, such as maintaining environmental cleanliness, not throwing garbage into waterways, and participating in mutual cooperation activities for drainage cleaning. In addition, the community also needs to improve disaster preparedness through understanding disaster information and participation in educational programs and emergency response simulations.
4. For the Private Sector

The private sector is expected to play an active role through corporate social responsibility (CSR) programs in supporting flood mitigation efforts, such as the construction of supporting facilities, the provision of evacuation facilities, and support for education and community empowerment programs.

5. For the Next Researcher
   Further research is recommended to develop more in-depth studies using quantitative or spatial approaches, such as GIS-based risk mapping, hydrological analysis, and flood modeling. This is important to produce more accurate data and support more appropriate policy-making in future flood disaster mitigation.

References

[1] Addawiyah, Lolita Febrian, & Nurul Fadillah. (2025). Efektivitas Implementasi Kebijakan Publik dalam Mewujudkan Pelayanan Publik yang Responsif: Tinjauan Teoritis dan Empiris. *Jurnal Riset Rumpun Ilmu Sosial, Politik dan Humaniora*, *4*(1), 27–35. https://doi.org/10.55606/jurrish.v4i1.4438

[2] Arikunto. (2013). *Prosedur Penelitian: Suatu Pendekatan Praktik (Edisi Revisi)*. Rineka Cipta.

[3] Badan Nasional Penanggulangan Bencana. (2023). *Indeks Risiko Bencana Indonesia Tahun 2022*. Pusat Data, Informasi dan Komunikasi Kebencanaan (Pusdatinkom) BNPB.

[4] Badan Penanggulangan Bencana Daerah Kota Binjai. (2025). *Data kejadian banjir dan dampaknya di Kota Binjai Tahun 2025*. BPDB Kota Binjai.

[5] Badan Pusat Statistik Kota Binjai. (2023). *Kota Binjai dalam angka 2023*. BPS Kota Binjai.

[6] BNPB. (2022). *Indeks risiko bencana Indonesia*. BNPB.

[7] Braun, V., & Clarke, V. (2021). *Using thematic analysis in psychology. Qualitative Research in Psychology*. *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

[8] Creswell, J. W., & cresswell, J. D. (2021). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (5th ed.)*. SAGE Publications, Inc.

[9] De Silva, M. M. G. T., & Kawasaki, A. (2018). Socioeconomic Vulnerability to Disaster Risk: A Case Study of Flood and Drought Impact in a Rural Sri Lankan Community. *Ecological Economics*, *152*, 131–140. https://doi.org/10.1016/j.ecolecon.2018.05.010

[10] Fairuzzen, M. R., Merpaung, V. H., Putra, A. A., Malik, A. A., & Mahipal. (2024). *Peran Tata Ruang dalam Mitigasi Resiko Pembangunan dan Pencegahan Bencana Alam*. *2*(3).

[11] Flick, U. (2021). *An introduction to qualitative research (7th ed.)*. SAGE Publications, Inc.

[12] Haeril, H., Mas'ud, M., Iradat, T., & Hendra, H. (2021). Penerapan Kebijakan Mitigasi Bencana (Fisik dan Nonfisik) dalam Mengurangi Risiko Bencana di Kabupaten Bima. *Journal of Governance and Local Politics (JGLP)*, *3*(1), 23–47. https://doi.org/10.47650/jglp.v3i1.179

[13] Hartini, M. I., Nuraini, C., Milanie, F., Abdiyanto, A., & Sugiarto, A. (2023). Characteristics and Management of Drainage Infrastructure in Medan Sunggal District, Medan City. *International Journal Papier Advance and Scientific Review*, *4*(4), 62–90. https://doi.org/10.47667/ijpasr.v4i4.259

[14] Hasibuan, A. P. M., Milanie, F., & Tarigan, R. R. A. (2025). Road Infrastructure Arrangement In The Fisherman Village Residential Environment Across Belawan. *Bulletin of Engineering Science, Technology and Industry*. https://doi.org/10.59733/besti.v3i3.131

[15] Kementrian PUPR. (2021). *Pedoman Pengelolaan Lumpur Tinja Terjadwal (LLTT)*. Kementrian PUPR.

[16] Laary, Y., Tulusan, F. M. G., & Dengo, S. (2022). Implementasi Kebijakan Keamanan dan Ketertiban di Desa Baru Kecamatan Ibu Selatan Kabupaten Halmahera Barat. *Jurnal Administrasi Publik*.

[17] Maharaksa, M. S., Triharjono, H. D., Fadilah, F. N., Kania, S. A. Z., Firda, S. M., & Hidayat, Z. A. (2025). Implementasi Kebijakan Publik: Pengertian, Model-model dan Penerapannya Dalam Contoh studi kasus. *Jurnal Penelitian Nusantara*.

[18] Merahabia, V. M., & Tebay, V. (2022). Implementasi Kebijakan Pengembangan Kapasitas Aparatur Pemerintah Kampung Nafri Di Distrik Abepura Kota Jayapura. *JURNAL KEBIJAKAN PUBLIK*, *5*(3), 1–14. https://doi.org/10.31957/jkp.v5i1.2422

[19] Muazro, A. Z., & Nuraini, C. (2020). Analysis of the Use of Green Open Space and Its Impact on the Welfare of Residents in Batu Bara Regency. *Universitas Pembangunan Panca Budi*.

[20] Pemerintah Kota Binjai. (2025). *Peraturan Daerah Kota Binjai Nomor 2 Tahun 2025 tentang Rencana Pembangunan Jangka Menengah Daerah (RPJMD) Tahun 2025–2029. Pemerintah Kota Binjai.* Pemerintah Kota Binjai.

[21] Prabaswari, P., Alfikri, M., & Ahmad, I. (2022). Evaluasi Implementasi Kebijakan Pembentukan Tim Tanggap Insiden Siber pada Sektor Pemerintah. *Matra Pembaruan*, *6*(1), 1–14. https://doi.org/10.21787/mp.6.1.2022.1-14

[22] Putri Nadya Agustin Reyhan, Ely Lestari Br Purba, & Leni Marlina. (2025a). Analisis Kesiapan BPBD Kota Binjai dalam Penerapan Kecerdasan Buatan untuk Sistem Peringatan Dini Bencana Banjir. *Bridge : Jurnal Publikasi Sistem Informasi dan Telekomunikasi*, *3*(3), 131–141. https://doi.org/10.62951/bridge.v3i3.596

[23] Putri Nadya Agustin Reyhan, Ely Lestari Br Purba, & Leni Marlina. (2025b). Analisis Kesiapan BPBD Kota Binjai dalam Penerapan Kecerdasan Buatan untuk Sistem Peringatan Dini Bencana Banjir. *Bridge : Jurnal Publikasi Sistem Informasi dan Telekomunikasi*, *3*(3), 131–141. https://doi.org/10.62951/bridge.v3i3.596

[24] Ramadhani, Y., & Nuraini, C. (2024). The Role of Stakeholders in Managing the Public Open Space Area of Bangkatan, Binjai City. *International Journal of Mechanical, Electrical and Civil Engineering*. https://doi.org/10.61132/ijmecie.v2i1.116

[25] Ramli, M., Maryani, H., & Batubara, I. (2025). *Tanggung Jawab Hukum Pemerintah Dalam Mitigasi Dan Penanganan Bencana Banjir Di Kota Medan*. *6*.

[26] Rasdiana, R., Barkey, R. A., & Syafri, S. (2021). Mitigasi Dan Adaptasi Bencana Banjir di Kecamatan Pallangga Kabupaten Gowa: Pendekatan Kerentanan. *Urban and Regional Studies Journal*, *4*(1), 1–14. https://doi.org/10.35965/ursj.v4i1.1213

[27] Sugiarto, A., Kamakaula, Y., Susanty, L., & Periansya. (2024). *Metodologi Penelitian. Teori & Praktik*. Saba Jaya Press.

[28] Sugiarto, A., Yamin s, M., Harahap, K. A. M., & Akmal, R. (2024). *Perencanaan pembangunan wilayah*. Saba Jaya Press.

[29] Syahputra, D., & Sugiarto, A. (2024). Flood Management Solutions at Panca Budi School in Medan. *Journal of Information Technology*, *1*(3).

[30] Tarigan, R. R. A. (2025). *Analysis Of Land Cover Change And Its Impacts On Soil Quality And Water Availability*. *6*(2). https://jurnal.ceredindonesia.or.id/index.php/injects

[31] Tarigan, R. R. A. (2026). *Mapping Land Vulnerability to Degradation using a Geographic Information System (GIS)*. *16*(01).

[32] UNDRR. (2022). *Disaster Risk Reduction and Resilience Framework*. UNDR.

[33] Valdewa, S., Syahlani, C. N. S., Cinta, M., Ghifari, M. A. R., & Saefudin, A. (2022). *Analisis Penyebab dan Dampak Banjir di Perumahan Villa Pamulang, Kecamatan Bojongsari*.

[34] WHO. (2022). *Guidelines on Sanitation and Health*. WHO.

[35] Zannatun, B., & Tarigan, R. R. A. (n.d.). *Analysis of the Availability and Need for Public Facilities Based on Population Growth in the Next 20 Years in the Urban Area of Sei Rampah*.