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Architectural Adaptation Strategy for Flood-prone Settlements in the Riverbank Area of Medan City in Hydromythological Disaster Mitigation

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ABSTRACT

Medan Maimun District, as the cultural and historical center of Medan City, faces serious challenges related to flooding due to the density of organizations along the banks of the Deli River. This study aims to examine the characteristics of vulnerable organizations and the adaptation strategies implemented by the community in facing the threat of hydrometeorological disasters. Based on observations and information, it was found that many buildings were constructed without adequate planning, resulting in high infrastructure vulnerability. The community has implemented architectural adaptation techniques such as raising floors, building stilt houses, and selecting waterproof materials. Flood mitigation efforts at the neighborhood scale, such as improving drainage systems and providing evacuation routes, are also needed to increase the area's resilience. The results of the study indicate that implementing architectural maintenance is an effective strategy to reduce flood risk. However, the government is expected to be more active in monitoring land use and raising public awareness through education related to disaster mitigation. Furthermore, further research is expected to explore more adaptive organizational designs to disasters, which incorporate aspects of poverty, social characteristics, and the physical conditions of the area.

Keywords: Architectural adaptation techniques, Flood, Infrastructure, Medan Maimun

ABSTRAK

Kecamatan Medan Maimun, sebagai pusat budaya dan sejarah Kota Medan menghadapi tantangan serius terkait kejadian banjir akibat tingginya kepadatan permukiman di sepanjang bantaran Sungai Deli. Penelitian ini bertujuan untuk mengkaji karakteristik permukiman yang rentan terhadap banjir serta strategi adaptasi yang diterapkan oleh masyarakat dalam menghadapi ancaman bencana hidrometeorologi. Penelitian dilakukan melalui observasi lapangan dan pengumpulan informasi mengenai kondisi fisik permukiman, karakteristik bangunan, serta bentuk adaptasi yang dilakukan oleh masyarakat. Hasil penelitian menunjukkan bahwa banyak bangunan dibangun tanpa perencanaan yang memadai sehingga memiliki tingkat kerentanan infrastruktur yang tinggi terhadap banjir. Sebagai bentuk adaptasi, masyarakat menerapkan berbagai strategi arsitektural, seperti meninggikan elevasi lantai bangunan, membangun rumah panggung, serta menggunakan material bangunan yang tahan terhadap air. Selain itu, upaya mitigasi banjir pada skala lingkungan, seperti peningkatan kapasitas sistem drainase dan penyediaan jalur evakuasi, diperlukan untuk meningkatkan ketahanan kawasan terhadap bencana. Penelitian ini menyimpulkan bahwa penerapan strategi adaptasi arsitektural merupakan salah satu upaya yang efektif untuk mengurangi risiko banjir di kawasan permukiman. Namun demikian, pemerintah diharapkan lebih aktif dalam mengawasi pemanfaatan lahan di kawasan bantaran sungai serta meningkatkan kesadaran masyarakat melalui edukasi mengenai mitigasi bencana. Penelitian selanjutnya disarankan untuk mengembangkan model desain permukiman yang lebih adaptif terhadap banjir dengan



mempertimbangkan aspek kerentanan sosial, kondisi ekonomi masyarakat, serta karakteristik fisik kawasan.

Kata kunci: adaptasi arsitektural, banjir, infrastruktur, Kecamatan Medan Maimun, permukiman rentan.

Introduction

Medan Maimun District is one of the sub-districts in Medan City that has an important role as a central area for urban, historical, and cultural activities. This area is known as the location of various historical building relics of the Deli Sultanate, such as the Maimun Palace and the Al-Mashun Grand Mosque, which are the cultural identity of the city of Medan. In addition to functioning as a residential and trade area, Medan Maimun also has strategic value in the development of historical tourism and urban public spaces. The existence of the Deli River, which crosses part of the sub-district, also affects the pattern of land use and the development of the surrounding area (Fernando et al., 2024). The Medan Maimun District area includes riverside settlements. According to (Chumairah et al., 2024), riverbank settlements are residential areas located along the banks of rivers and inhabited by the community to meet residential needs and socio-economic activities. This area usually develops due to the increasing need for residential land, especially in urban areas, so that the area around the river becomes an alternative residential location. These conditions often cause various environmental problems and vulnerability to flood disasters if not accompanied by good management and arrangement. is developed because of its proximity to water sources, economic access, and urban development. However, unplanned settlement development causes building density to increase and environmental quality to decrease, increasing the risk of flooding.

In addition, a flood is an event in which water overflows and causes an area to be flooded because the capacity of rivers, drainage channels, or other water bodies is not able to accommodate the existing volume of water. This condition is generally triggered by high rainfall, reduced infiltration areas, changes in land use, and drainage systems that do not function optimally. Floods can have various impacts, such as damage to infrastructure, disruption of community activities, economic losses, and deterioration of environmental quality (Rosyidie, 2013). People who live on the banks of the Deli River, especially in Medan Maimun District, show the ability to adapt to repeated flood conditions. This form of adaptation can be seen in physical adjustments to buildings, such as raising the floor of the house, using materials that are more resistant to waterlogging, and building stilt houses or stilted houses in several locations that are prone to flooding. The community also made behavioral adjustments by preparing essential items on higher ground, increasing vigilance during the rainy season, and building social networks between residents to help the evacuation process when floods occurred (Rahmadi et al., 2023).

Therefore, this study aims to examine the characteristics of riverbank settlements with varying levels of flood vulnerability in Medan Maimun District, as well as analyze various forms of vulnerability found in buildings and residential environments to the impact of



flooding. In addition, this study also aims to identify various architectural adaptation efforts that have been carried out by the community in response to the risk of hydrometeorological disasters. The results of the study Are then used as a basis for formulating appropriate architectural adaptation strategies to increase the resilience of riverbank settlements to the threat of flooding and support sustainable disaster mitigation efforts in the Medan Maimun District area.

Research Methods

This study applies a qualitative descriptive method with a case study approach to obtain an in-depth understanding of the condition of riverbank settlements that are vulnerable to flooding in Medan Maimun District. The selection of this method is based on the objectives of the research, which focus on identifying settlement characteristics, analyzing the vulnerability of buildings and the environment to flood disasters, as well as studying the forms of architectural adaptation carried out by local communities. The case study approach was used to explore the phenomenon that occurred contextually through direct observation in the field and documentation of the physical conditions of the flood-affected areas. In addition, this research is supported by a literature review sourced from scientific journals, books, and previous research relevant to settlement architecture adaptation and hydrometeorological disaster mitigation, as a basis for the analysis and preparation of research recommendations. The research method describes the stages of research implementation carried out to achieve the research objectives.

The data used in this study consisted of primary data and secondary data. Primary data was obtained through field observation, visual documentation, and semi-structured activities with people living in the Deli River bank area. According to (Moleong, 2017), the data collection was carried out to identify the physical condition of the settlement, including the characteristics of the building, the height of the floor of the house to the flood water level, the type of building materials used, the condition of the drainage system, environmental accessibility, and various forms of architectural adaptation applied by the community in dealing with flood risk. Meanwhile, secondary data was obtained through the study of various literature sources, such as scientific journals, books, disaster documents, government regulations, and other supporting data relevant to the topic of riverbank settlements, architectural adaptation, and flood disaster mitigation efforts, so as to support the analysis process and strengthen the research results. This section describes the data analysis methods used to uncover research findings.

This research was carried out in Medan Maimun District, Medan City, which is one of the areas crossed by the Deli River and has dense settlements that develop along the riverbanks. The focus of the research is directed at four villages, namely Aur Village, Hamdan Village, Sei Mati Village, and Jati Village, which are known to have a relatively high level of flood vulnerability. The selection of the location was based on the characteristics of the area which showed high building density, limited environmental access, the condition of the drainage system that has not functioned optimally, and the frequency of flood events



that are quite frequent due to the overflow of the Deli River. These characteristics make this area relevant for assessing the vulnerability of settlements and various forms of adaptation carried out by the community in dealing with the risk of hydrometeorological disasters.

Discussion

Overview Of Research Locations

Medan Maimun District is one of the sub-districts in Medan City that is passed by the Deli River. This area has settlements with a fairly high level of density, especially in areas located on the banks of rivers (Suprayitno, 2018). The research is focused on four villages, namely Aur Village, Hamdan Village, Sei Mati Village, and Jati Village. The research area has the characteristics of settlements that develop following the flow of the river with a building distance that is relatively close to the riverbank. In addition, the limited environmental drainage conditions and high building density cause this area to have a fairly high level of flood vulnerability.



Figure 1. Kecamatan Medan Maimun

Alfarisi & Rujiman, 2023

Characteristics of Riverbank Settlements

According to Afdholy et al. (2025), Riverbank settlements can be interpreted as residential areas that are formed and developed due to the existence of rivers as the main



element of the surrounding environment. The life of the community and the layout of buildings in this area generally have a close relationship with the river, so the orientation of the settlement tends to face or follow the existence of the river. The pattern of settlements along the riverbanks generally develops longitudinally following the direction of the river flow. However, according to Nasution (2020), in some locations, there is also a pattern of settlements that are grouped or scattered, depending on the physical condition of the area and the dynamics of regional development. The characteristics of riverbank settlements are generally characterized by a high level of population density. This condition is influenced by the increasing rate of urbanization and limited land availability, especially in urban centers and areas that function as centers of government and economic activities (Pamurti et al., 2023).

In the Medan Maimun District area, namely Aur Village, Hamdan Village, Sei Mati Village, and Jati Village, there is a fairly high density. According to the population growth rate of Medan Maimun District in December 2024, there were as many as 52,591 people. The number of female population is larger than the number of male population, shown by the sex ratio of 97.36, which means that out of about 1,000 female population, the male population is 974 people (Disdukcapil Medan Maimun, 2025). The Medan Deli area is an area with a high level of flood vulnerability and also includes areas close to the city center and the Deli River bank area; the area upstream of the Deli River is only 3,655 hectares, or only 7.59 percent of the 48,162 hectares of the Deli watershed area. In fact, the Deli River has an area of 48,162 hectares, a length of 71.9 km, and a width of 5.58 km (Khairuni, 2018).



Figure 2. River Flow Mapping

Personal Documentation, 2026

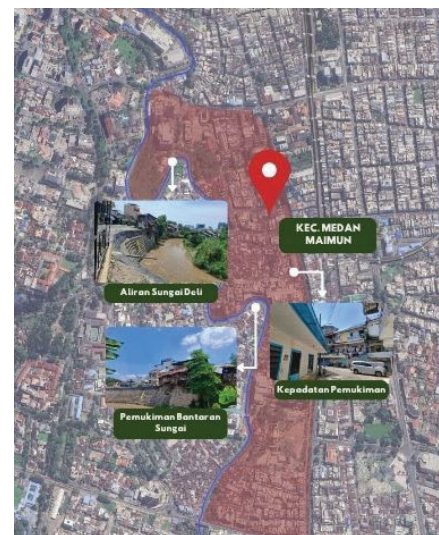


Figure 3. Research Location

Personal Documentation, 2026



Table 1. Settlement Characteristics

Image	Conditions
	• Permanent buildings Semi-permanent buildings Permanent buildings are made of strong and durable materials, such as concrete, brick, and brick. Meanwhile, semi-permanent buildings use a combination of permanent and non-permanent materials, such as wood, board, and zinc.

Personal Documentation, 2026

Based on the results of field observations, settlements on the banks of the Deli River, Medan Maimun District, show a linear settlement pattern that develops along the direction of the river flow. And according to (Putro & Nurhamsyah, 2015), the arrangement of buildings that extend along the river corridor indicates that the existence of the river is the main factor that affects the orientation and development of settlements can be called linear settlement arrangements. Along with the increase in population density and the development of urban areas, in some parts there is also a pattern of grouping with relatively close distances between buildings. Therefore, the characteristics of settlements on the banks of the Deli River in Medan Maimun District can be categorized as a linear pattern that develops into dense residential areas. Some buildings have a very close distance to the river so they are vulnerable to inundation when the water discharge increases.

Vulnerability of Settlements to Flooding

Vulnerability of settlements occurs as a result of the physical impact of the environment and population. Covering construction and building elements, composition, road infrastructure, public facilities vulnerability was analyzed Each structural type that experienced the same level of damage from vulnerability was poverty, uneven development, population growth, urbanization, disproportionate land ownership, low education, marginal land, improper selection of settlement locations, poor housing, malnutrition deforestation,



high unemployment and illiteracy. As a result of this vulnerability, many settlements are placed in flood-prone areas (Muslim et al., 2017).

Riverbank settlements in Medan Maimun District have several forms of vulnerability to flooding, such as low building elevations, proximity to rivers, and limited evacuation routes (Batubara & Rambe, 2024). In addition, the high density of the building makes it difficult for water to flow when inundation occurs. Another vulnerability can be seen in the condition of building utilities and house materials that are easily damaged by waterlogging. Some people also still have limited safe spaces to store goods when floods occur.

Table 2. Vulnerability of Settlements

Image	Conditions
	• Houses with more than 1 storey Houses with more than 1 floor allow the use of space vertically where the needs of residents' space are still met without having to expand the building to an area that increasingly consumes pastureland. And the lower floor can be used for supporting activities and on the upper floor can be used as a safe space during flooding.
	• House Elevation The floor height of houses in flood-prone areas, which only ranges from 30-70 cm, is still classified as vulnerable to inundation. The recommended building elevation is at least 1 meter above ground level to reduce the risk of flood impacts. If the height of the building is below this standard, then the possibility of flood water entering and inundating the house will be greater when there is an overflow of water.
	• Residential drainage The drainage flow in Medan Maimun District is mostly covered by the floor and courtyard of the residents, where the absorption area in the area is not good due to the lack of infiltration area for drainage.

Personal Documentation, 2026



Forms of Residential Architecture Adaptation

Based on (Ticoalu et al., 2024), adaptation is one of the three basic dimensions of resilience which can be described as the ability or capacity of a system that can change its characteristics and behavior, so as to be able to adjust to existing conditions or anticipate external factors. There are 3 types/forms of adaptation, namely: (1) Morphological adaptation, (2) Physiological adaptation and (3) Behavioral adaptation.

According to (Faradiba et al., 2020) There are several criteria that can be referred to as adaptation in the context of flood disaster risk, namely:

1. Residential buildings by building houses with 2nd floors, raising the floor of the house/foundation, making water barriers, using waterproof paint, and so on. The form of physical adaptation of the building is divided into 2, namely dry-floodproofing and wet-floodproofing.
2. Lingkungan sekitar, dengan perbaikan bibir sungai yang terkena langsung oleh banjir akibat hujan, memperbaiki tanggul sungai yang ambrol, membuat sumur resapan, biopori, perbaikan saluran air, membuat tanggul dari karung pasir, membuat bronjong, dan sebagainya.

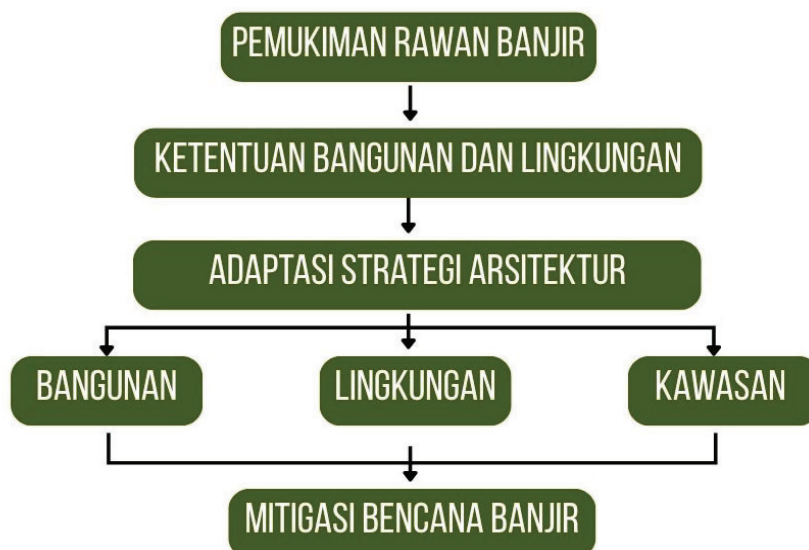


Figure 4. Building Adaptation Process

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Architectural Adaptation Strategies in Disaster Mitigation

Elevation of Floor Elevation in Buildings

Raising the elevation in the area can be one of the effective strategies to reduce the impact of flooding and and new adaptations to flood-prone areas because it has benefits in



the form of protection from flooding because buildings become higher than the flood water level that may occur, the second is to reduce the risk of damage because with a higher elevation the possibility of water entering becomes smaller (Alfarizi et al., 2024).

The elevation of the elevation element in the lower structure as the main structure that supports the performance of the elevation of the building due to the rise and fall of the water level due to flooding so that it can prevent the building from being flooded when flooded. So that the residents of the house are not prevented from carrying out activities when the flood comes (Moh Faisal Faris et al., 2025). And the floor elevation standard according to (PUPR, 2015), the floor elevation standard in the riverbank area generally must be at least 1 meter above the highest flood surface (guard height) or flood elevation for a certain re-period. In addition to the elevation of the floor, there are strict rules regarding the river boundary line, namely the boundary of the area must not be

Drainage System

Drainage is a system for the disposal of excess water and waste water in the form of water discharge from residential and residential areas, from industrial areas and other business activities, from agricultural areas and other open land, from road bodies and other pavement, as well as the distribution of excess water in general, both rainwater and other dirty water that flows out of the area in question (Arifin, 2018).

The implementation of environmentally friendly drainage is one of the effective strategies to reduce flood risk. The criteria for drainage channels with proper infiltration facilities and water storage are the existence of infiltration wells, retention ponds, and green open spaces, so that rainwater is not entirely drained into the river, but partially absorbed into the soil. This approach can reduce peak runoff discharge, increase groundwater reserves, and reduce inundation in residential areas (Nursella & Ariyanto, 2025).

River Border Area

According to Firdaus et al. (2021), Uncoordinated land use and escape from government supervision spurred the increasingly uncontrollable conversion of land use into built-up areas, which made the riverbank area experience inappropriate land use, with the presence of buildings along the right and left banks of the river. Even though the regulations on the riverbank area specify the boundaries of land that should not be built on. As for the river border area, it is required that there are no permanent, semi-permanent, and non-permanent buildings (buildings). The adaptation strategy efforts carried out by the community and the government in the Aur Village, Hamdan Village, Sei Mati Village, and Jati Village areas are:



Table 3. Adaptation of settlements to disaster mitigation

Image	Strategy
	<i>Increase in floor elevation height.</i> The addition of a higher floor elevation, so that flood water does not easily enter the house so that damage to building structures, furniture, and occupant activities can be minimized. The elevation increase in the attached photo is 220 cm from the ground level.
	<i>Creation of drainage flows.</i> Drainage in riverbank residential areas is needed to support the water control function while increasing the resilience of the area to the overflow of the Deli River. Because in Medan Maimun District, many drainage flows are covered by the floor and residents' yards, where the absorption area in the area is not good due to the lack of infiltration areas for drainage. The well-connected drainage channels are able to smooth the flow of rainwater from residential environments to river bodies so that they can reduce the length of inundation that occurs after heavy rains
	<i>Restoration of river boundaries.</i> Restore the river boundary area according to its designation as a river protection zone that is free from buildings and activities that have the potential to disrupt water flow.

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The strategy of architectural adaptation in the riverbank area is not only carried out at the scale of buildings, but also at the scale of the residential environment. At the building scale, adaptation strategies are carried out through raising the floor of the house, using stilt houses, and securing building utilities. On an environmental scale, the strategy is carried out through improving drainage, providing evacuation routes, gathering points, and controlling development at the river border. The strategy is expected to increase community resilience to flood disasters in the Deli River bank area.



Conclusion

The results of the study show that residential areas on the banks of the Deli River, Medan Maimun District, have a fairly high level of vulnerability to flooding. This condition is influenced by the high density of buildings, drainage systems that have not functioned optimally, and the location of residences that are very close to the river flow. The characteristics of these areas increase the potential for inundation and overflow of river water, which can threaten community safety and the sustainability of residential activities. Therefore, local residents are required to develop various forms of adaptation to environmental conditions that are prone to hydrometeorological disasters. Various forms of architectural adaptation applied by the community include raising building floors, building stilt houses, providing upper floors as temporary evacuation areas, and using building materials that are more resistant to water exposure. In addition to adaptation at the building level, mitigation efforts also need to be carried out at the regional scale through improving the quality of drainage systems, providing adequate evacuation routes, and rearranging riverbank areas in a more planned manner. Thus, the application of architectural adaptation can be one of the effective strategies in reducing flood risk while increasing the resilience of riverbank settlements in Medan Maimun District to hydrometeorological disasters. The government's role is to strengthen efforts to organize riverbank areas through supervision of land use, control of settlement development, improvement of the quality of drainage systems, and the provision of safe evacuation facilities and routes for the community when floods occur. In addition, public awareness of the importance of implementing building adaptation and disaster mitigation measures needs to be increased through continuous education and socialization programs. To support the development of areas that are more resilient to disasters, further research is expected to more comprehensively examine the concept of flood-adaptive settlement design that integrates aspects of environmental sustainability, social characteristics of the community, and the physical condition of riverbank areas.

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