

Riverside Settlement Landscape Strategies for Flood Risk Reduction

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Abstract

Riverside settlements are vulnerable to flooding due to building density, a reduction in open spaces and vegetation, low infiltration capacity, and limited runoff and drainage management. This study aims to formulate landscape strategies that can be applied to riverside settlements to support flood risk reduction, particularly in the urban context of Medan. The study employed a literature review using a descriptive-qualitative approach. Data were obtained by searching for scientific articles relevant to riverside settlements, flood risk, water management, green infrastructure, and nature-based solutions. The selected literature was analyzed through the stages of identification, classification, comparison, and synthesis. The results of the study indicate that landscape strategies can focus on strengthening vegetation and open spaces, increasing water infiltration and retention areas, implementing green infrastructure and nature-based solutions, integrating stormwater management with drainage systems, and increasing community involvement in environmental management. These strategies need to be implemented in an integrated manner at the household, neighborhood, and river basin levels and combined with existing flood control infrastructure. The research findings provide a conceptual foundation for the planning of riverside settlements that are more adaptive to flood risks while taking into account ecological functions, spatial needs, and the social sustainability of the community.

Keywords: *riverside settlements; flood risk; landscape strategies; stormwater management; green infrastructure.*

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Introduction

Flooding is one of the major problems in urban areas, linked to changes in land use, the expansion of built-up areas, hydrological conditions, and increased community exposure. Urban development can reduce vegetation cover and water-absorbing surfaces, thereby increasing surface runoff and pressure on drainage systems and rivers. This situation becomes even more complex when residential areas expand into areas adjacent to rivers and floodplains. In the context of flood risk management, risk is determined not only by flood hazards but also by the level of exposure and vulnerability of affected communities and the environment (Zhou et al., 2024). Studies on nature-based infrastructure also indicate that urban growth and the dominance of built infrastructure can exacerbate runoff and flooding issues, necessitating a more integrated approach to urban water management (Md. Esraz-Ul-Zannat et al., 2024).

Riverside settlements have characteristics that make these areas vulnerable to flooding, primarily due to the proximity of buildings and community activities to the river itself. The development of settlements along riverbanks can also place pressure on the function of riparian zones as buffer zones and as part of the river's ecological system. Research on the sustainability of riverside settlements in Semarang indicates that proper building placement in accordance with riparian boundaries, environmental quality, infrastructure provision, and social, economic, and legal aspects are crucial components of riverside area planning (Pamurti et al., 2023). Another study on the management of riverside settlements in Samarinda indicates that the presence of settlements in riparian zones must be regulated through zoning, greening initiatives, community participation, and enforcement of regulations to support environmental sustainability while protecting communities from flood risks (Kedhaton & Krismondo, 2023).

In addition to buffer zone functions, the physical characteristics of residential areas also influence flood vulnerability levels. Building density, the distance of buildings from rivers, drainage conditions, and the spatial structure of the area can affect the residential environment's ability to respond to stormwater runoff. A study (Harianja et al., 2026) in the city of Medan showed that densely populated residential areas with high building density, buildings located close to rivers, and suboptimal drainage systems have higher levels of flood vulnerability. These results indicate that flood vulnerability is influenced not only by hydrological factors but also by the spatial structure and morphology of residential areas. These findings are consistent with a study in the city of Medan that showed that land use, distance from rivers, topography, and other environmental factors play a role in shaping patterns of flood vulnerability (Lumban-Gaol et al., 2024).

These conditions indicate that reducing flood risk in riverside settlements cannot be achieved solely through structural approaches, such as increasing drainage capacity or constructing flood control structures. A landscape-based approach can be used to integrate hydrological, ecological, and social functions through the management of open spaces, vegetation, infiltration areas, retention basins, and riparian zones. (Md. Esraz-Ul-Zannat et al., 2024), through a literature review, demonstrate that Nature-based Solutions (NbS) can complement conventional infrastructure in urban flood risk management, although their effectiveness may vary depending on the scale and characteristics of the area. Meanwhile, (Zhou et al., 2024) emphasize that the implementation of NbS in flood management must consider the interconnections between social and ecological systems so that flood mitigation benefits can go hand in hand with environmental benefits and community well-being.

In riverine areas, landscape-based strategies can also be directed toward restoring and strengthening the functions of floodplains and riparian zones. (Christopher et al., 2024), through an analysis of 29 case studies on floodplain management, demonstrated that nature-based strategies can include the restoration of floodplains, riparian forests, wetlands, and green infrastructure. The research also emphasizes the importance of considering social, technical, and institutional aspects, as well as the needs of various stakeholders, in the implementation of flood management strategies. Thus, landscape strategies for riverside settlements should be

viewed as an approach that integrates the management of water, space, vegetation, and settlements—not merely as the addition of green space.

In the context of the city of Medan, the issue of flooding is worth examining because urban development and changes in land use are linked to increased vulnerability to flooding. A study (Lumban-Gaol et al., 2024) shows that the city of Medan is among the areas with a high level of flood vulnerability based on a combination of factors including topography, land use, soil conditions, sea-level rise, and land subsidence. A study (Juliana et al., 2025) analyzed the spatial distribution of flood vulnerability in the city of Medan based on several physical and spatial parameters, namely land use, slope gradient, soil type, geological conditions, distance from rivers, and rainfall. The results of this study indicate that areas with high to very high vulnerability are predominantly found in low-lying topographic zones located near rivers and drainage channels. These findings suggest that flood vulnerability in the city of Medan is closely linked to the area's physical characteristics and patterns of urban land use.

Based on these conditions, the study “Landscape Strategies for Riverbank Settlements to Reduce Flood Risk in the City of Medan” was conducted through a literature review to identify and synthesize various landscape approaches that can be applied to riverbank settlement areas. This study did not use a specific river or residential area as a case study site but instead utilized the findings of previous research as a basis for understanding the relationship between settlement characteristics, riparian zone functions, landscape conditions, and flood risk. The results of the study were then used to formulate landscape strategies that include the management of riparian zones and vegetation, the expansion of open spaces and infiltration areas, the management of stormwater runoff, the provision of retention spaces, and the planning of residential areas that are more adaptive to flood risks.

The research question for this study is: What strategies for riverbank settlement landscapes can be implemented to reduce flood risk in the city of Medan, based on the results of a literature review? This study aims to identify, examine, and formulate strategies for riverbank settlement landscapes that can support flood risk reduction in the city of Medan, based on the results of a literature review.

Literature Review

2.1. Floods and Flood Risk in Urban Areas

Floods are one of the hydrometeorological disasters that can impact the environment, infrastructure, economic activities, and people's lives. Flood risk is influenced not only by the magnitude of the hydrological threat but is also related to a region's level of exposure and vulnerability. In an urban context, residential development and changes in land use can increase impervious surfaces, thereby reducing the land's ability to absorb and retain water. These changes can ultimately increase surface runoff and heighten the potential for flooding (Djoharam et al., 2022).

Flood risk management, therefore, cannot be focused solely on controlling water flow through technical approaches; it must also take into account the relationship between physical environmental conditions, land use, and human activities. (Djoharam et al., 2022) through a systematic review of the literature on flood management, demonstrate that changes in land cover and land use, hydrological conditions, climatological factors, and mitigation strategies are interrelated aspects of flood management. This approach highlights the importance of a holistic approach to flood management that integrates hydrological, environmental, spatial planning, and disaster mitigation aspects.

2.2. Riverbank Settlements as Part of the Urban Landscape

Riverside settlements are part of the urban landscape that have a direct relationship with the river system and the surrounding environment. The presence of settlements in areas adjacent to the river channel means that these areas are strongly linked to the dynamics of water flow, vegetation conditions, drainage, and land-use characteristics. Therefore, the management of

riverside settlements is not only related to building planning but must also take into account the ecological functions of the space as part of the river system and the urban area.

Changes in land cover that reduce vegetation and increase the use of built-up land can alter the hydrological characteristics of an area. The results of a study (Ridwan & Sarjito, 2024) indicate that land-cover changes toward more intensive land use can increase surface runoff and reduce water retention capacity. These findings suggest that the management of residential areas should focus on efforts to maintain water infiltration and retention functions through land-cover regulation and the provision of open spaces with ecological functions.

From a landscape perspective, riverbank areas can be viewed as spaces that serve both ecological and social functions. This approach treats rivers, vegetation, open spaces, drainage systems, and settlements as interconnected elements. Consequently, flood risk reduction strategies can be directed not only toward the construction of flood control infrastructure but also toward the creation of landscape structures capable of enhancing the area's capacity to receive, store, infiltrate, and discharge water in a more natural manner.

2.3. Landscape and Green Infrastructure Approaches to Flood Risk Reduction

A landscape-based approach to flood management emphasizes the utilization of a space's ecological functions as part of a mitigation strategy. One relevant concept is green infrastructure—a network of spaces and vegetation elements that can provide ecological functions while supporting urban needs. Green open spaces, vegetation, infiltration areas, and other landscape elements can play a role in reducing surface runoff and increasing infiltration capacity. (Mahdiyah et al., 2022) explain that green open spaces function as water infiltration and storage areas, so their presence is linked to an area's ability to control water runoff.

This concept has evolved through the nature-based solutions (NbS) approach, which involves utilizing or restoring natural processes to address environmental issues while providing ecological and social benefits. In the context of flood risk reduction, NbS can be implemented through increased vegetation, the development of green open spaces, the restoration of riparian functions, stormwater management, and various forms of green infrastructure. A literature review (Angghita et al., 2026) indicates that nature-based solutions are emerging as a key approach in flood management and enhancing urban climate resilience.

Nature-based approaches also offer an alternative to flood management that relies solely on conventional infrastructure. The integration of green elements and physical infrastructure enables a more integrated approach to water management, ranging from reducing runoff at its source to regulating water flow at the regional scale. This aligns with the findings (Rama & Pamungkas, 2025), which indicate that spatial management strategies for flood reduction can combine vegetation, open spaces, water storage facilities, green infrastructure, and drainage systems.

2.4. Strategies for Riverbank Settlement Landscapes to Reduce Flood Risk

Based on these various studies, strategies for riverbank settlement landscapes aimed at reducing flood risk can focus on strengthening the ecological functions of these areas without neglecting social needs and settlement space. These strategies include, among others, increasing vegetation cover, providing green open spaces, enhancing infiltration areas, managing stormwater runoff, improving drainage quality, and regulating land use in a way that takes river characteristics into account. This approach positions the landscape as part of a risk-reduction system, rather than merely as an aesthetic element of the area.

Thus, the landscape planning of riverside settlements must be carried out in an integrated manner, taking into account the relationships between settlement areas, rivers, vegetation, open spaces, drainage, and water management. This approach must also consider social aspects, including community involvement in the use and maintenance of the settlement environment. Studies on flood management indicate that flood risk reduction efforts must account for the interrelationships among environmental conditions, land use, spatial planning, infrastructure, and social aspects. Nature-based solutions can also serve as an alternative approach to support

water management and enhance a region's resilience to flood risks (Angghita et al., 2026; Djoharam et al., 2022)

Based on this review, a landscape strategy for riverside settlements can be understood as an approach that integrates the ecological, hydrological, and social functions of space into a single management framework. This framework serves as the basis for identifying types of strategies that can be applied to riverside settlements, particularly those focused on increasing infiltration, reducing runoff, providing retention areas, strengthening vegetation, managing riparian zones, and improving the environmental quality of settlements.

Research Methodology

This study employs a literature review using a descriptive-qualitative approach. This method was used to identify, compare, and synthesize the findings of previous studies related to landscape strategies for flood risk reduction in riverside residential areas. The study was not conducted through field observations at a specific location but was aimed at formulating conceptual landscape strategies that could serve as a basis for the planning of riverside settlements, particularly in the context of the city of Medan.

Data collection was conducted by searching journal articles and scientific publications using keywords related to riverbank settlements, urban flood risk, flood mitigation, riparian landscapes, green infrastructure, blue-green infrastructure, nature-based solutions, and flood-resilient settlements. Priority was given to publications from the past five years to ensure the studies were aligned with recent developments in landscape-based flood management approaches. The selected articles are publications that discuss the relationship between settlement characteristics, land use, river conditions, runoff management, and the application of green infrastructure, blue infrastructure, or nature-based solutions in flood risk reduction.

Literature screening was conducted based on the relevance of the article's title, abstract, and content to the research focus. Literature not directly related to urban flood risk, riverside settlements, water management, or landscape strategies was excluded from the analysis. Relevant articles were then used as data sources to identify problems, types of landscape interventions, and the role of each strategy in reducing flood risk.

Data analysis was conducted in four stages: identification, classification, comparison, and synthesis. The identification stage involved compiling a list of factors contributing to flood risk in riverside residential areas. Next, the information obtained was classified based on landscape issues and the types of interventions proposed, such as riparian zone management, riparian vegetation, increased infiltration, retention and detention areas, runoff management, and adaptive settlement planning. The comparison stage involved examining the similarities, differences, functions, and potential applications of each strategy. The results of the comparison were then synthesized to formulate groups of complementary landscape strategies at the household, neighborhood, and river basin scales.

The results of this synthesis are then linked to the characteristics of riverside settlements in the city of Medan, primarily based on the findings of previous research on the Deli River and urban flooding issues. The strategies formulated are not intended as technical designs for specific locations, but rather as conceptual guidelines that integrate ecological, hydrological, and spatial aspects. Using this approach, the study produced a landscape strategy that combines green, blue, and gray infrastructure elements to support flood risk reduction in riverside settlements in the city of Medan.

Results

3.1. Characteristics of Riverbank Settlements and Flood Risks

Based on the results of a literature review, riverside settlements exhibit characteristics closely linked to the presence of the river channel, land-use patterns, drainage conditions, building density, vegetation, and the availability of open space. The proximity of settlements to rivers creates a direct relationship between settlement conditions and water flow dynamics. Changes in land cover from vegetation or open land to built-up areas can increase impervious surfaces, thereby reducing the soil's ability to absorb water and increasing surface runoff. A systematic review (Ridwan & Sarjito, 2024) shows that changes in land cover toward built-up areas and a reduction in vegetation can increase surface runoff and reduce water retention capacity, which ultimately contributes to an increased risk of flooding.

These conditions indicate that the risk of flooding in riverside settlements is determined not only by the river's capacity to accommodate water flow but also by the surrounding landscape. Building density, a reduction in open spaces, low infiltration rates, and inadequate drainage systems can increase the amount of runoff flowing into drainage channels and rivers. Therefore, riverside settlements must be understood as part of an urban hydrological system characterized by reciprocal relationships among land use, water, vegetation, and community activities.

From this perspective, the risk of flooding in riverside settlements can be reduced through land-use planning that preserves the ecological functions of the area. Land management should not only be directed toward meeting residential space needs but also toward preserving areas that serve as sites for infiltration, retention, and runoff control. This demonstrates that flood risk reduction strategies must focus on integrated area management, ranging from the scale of individual residential sites to the relationship between the area and the river and drainage systems.

The planning of riverside settlements is a key component of efforts to reduce flood risk, as settlement patterns can influence a region's vulnerability to river flooding. Uncontrolled population growth and land use can increase pressure on natural resources and the environment, including driving the use of riverside areas for residential purposes (Sugiarto et al., 2024). This is consistent with the findings of (Kardipo & Sugiarto, 2025), who demonstrated that settlement development in watershed areas that does not consider disaster mitigation aspects can increase flood risk. Therefore, landscape strategies for riverside settlements must include controlling building development, protecting riparian zones, and providing landscape elements that can serve as buffer zones between settlements and the river channel.

Stormwater management in residential areas is a key aspect of efforts to reduce the risk of urban flooding. Dense residential conditions and limited drainage capacity can prevent rainwater from being properly managed, thereby increasing the potential for ponding and flooding. (Tarigan & Supiyandi, 2025) indicate that flooding issues in the urban areas of Medan are linked to rainfall intensity, residential density, and the limited capacity of the drainage system. These conditions underscore the importance of integrated stormwater management to enhance the area's ability to control runoff. In residential areas along riverbanks, stormwater management should focus on retaining, absorbing, and controlling runoff before it reaches the river channel.

3.2. Landscape Strategies for Reducing Flood Risk

The results of the literature review indicate that landscape strategies for reducing flood risk can be grouped into several main approaches: increasing infiltration, providing retention areas, enhancing vegetation, managing surface runoff, and increasing drainage capacity. These strategies work by slowing water flow, increasing the soil's ability to absorb water, and reducing the volume of runoff that flows directly into drainage channels or rivers.

One strategy that can be implemented is increasing open spaces and vegetation. Open spaces with vegetation cover can function as part of a water infiltration and retention system. Efforts to maintain or increase vegetation can also help reduce surface runoff caused by an

increase in built-up land. Findings (Ridwan & Sarjito, 2024) reinforce the importance of maintaining vegetation cover and implementing ecosystem-based land management as part of flood mitigation efforts.

The next strategy is the implementation of green infrastructure and nature-based solutions (NbS). Green infrastructure can take the form of bioswales, infiltration gardens, green roofs, rain gardens, retention ponds, and rainwater harvesting systems. A study (Rama & Pamungkas, 2025) indicates that a combination of converting land into vegetated areas and water retention basins, implementing green infrastructure in residential areas, and improving drainage capacity can be part of a flood risk reduction strategy.

This approach is consistent with a study (Angghita et al., 2026) showing that nature-based solutions can be used to reduce the risk of hydrometeorological disasters while supporting urban climate resilience. However, the implementation of NbS is not only related to physical infrastructure or ecological technologies but also requires performance evaluation, community engagement, and cross-sectoral collaboration to ensure sustainable implementation.

Therefore, landscape strategies should not be viewed as a substitute for all technical infrastructure, but rather as a complement to and reinforcement of flood control systems. The combination of green and technical elements enables water management from the source of runoff all the way to drainage channels and rivers.

3.3. Synthesis of Landscape Strategies

Based on the results of the literature review, landscape strategies for reducing flood risk can be categorized into three main groups: ecological strategies, spatial-infrastructure strategies, and social-management strategies.

Ecological strategies are aimed at enhancing the natural functions of the landscape through the addition of vegetation, the protection of open spaces, the expansion of infiltration areas, and the strengthening of the ecological functions of riverbanks. These strategies serve to increase water infiltration and retention while reducing surface runoff. Land-cover management that preserves vegetation is crucial because a shift toward built-up land use can increase runoff and reduce water retention capacity (Ridwan & Sarjito, 2024).

Spatial and infrastructure strategies are aimed at regulating the relationships between buildings, open spaces, drainage, and water management systems. These strategies may include the provision of retention ponds, infiltration gardens, bioswales, rainwater harvesting systems, green roofs, and improvements to drainage capacity and functionality. The results of a study (Rama & Pamungkas, 2025) indicate that a combination of green infrastructure, water retention areas, and improvements to drainage systems can form part of a more integrated flood management strategy.

Meanwhile, social and management strategies emphasize community involvement, facility maintenance, coordination among stakeholders, and sustainable land use. (Angghita et al., 2026) indicate that community participation and multisectoral collaboration are key aspects of implementing nature-based solutions.

Based on this synthesis, a landscape strategy can be defined as an approach that integrates ecological functions, spatial planning, water management infrastructure, and community engagement. These four aspects are not isolated from one another but rather complement each other in creating residential areas that are more resilient to flood risks.

3.4. Landscape Strategies for Riverbank Settlements in the City of Medan

Based on the results of the literature review, relevant landscape strategies for riverside settlements in the city of Medan can focus on strengthening the ecological functions of the river and the settlement environment through the expansion of open spaces, vegetation, infiltration areas, runoff management, and the integration of drainage systems. Since this study did not involve field observations, these strategies are presented as conceptual recommendations based on the literature review, rather than as the results of direct testing in riverside settlements in the city of Medan.

At the residential neighborhood level, strategies can be implemented by increasing the proportion of water-absorbent surfaces, providing gardens or open spaces for water infiltration, and incorporating green infrastructure elements into buildings and public spaces. The implementation of rainwater harvesting, bioswales, infiltration gardens, and vegetation elements can help retain rainwater before it becomes runoff that enters the drainage system. This approach aligns with the findings of a study on the application of green infrastructure and land-use management to reduce runoff and enhance the infiltration capacity of the area (Rama & Pamungkas, 2025).

In areas adjacent to rivers, strategies can focus on enhancing vegetation and open spaces that function as part of the river's ecological system. These spaces should not be viewed merely as leftover areas, but as part of the landscape infrastructure that can help manage water, improve environmental quality, and provide space for community activities. This principle aligns with the nature-based solutions approach, which leverages ecosystem functions to reduce hydrometeorological risks while delivering environmental and social benefits (Angghita et al., 2026).

In addition, the landscape strategy in the city of Medan needs to be integrated with existing drainage systems and flood control infrastructure. A landscape-based approach does not eliminate the need for technical infrastructure, but rather reduces the burden on these systems through water management at the source. In this way, stormwater can be retained, absorbed, or stored before being channeled into drainage networks and rivers.

3.5. Strategic Implications for the City of Medan

The study's findings indicate that the implementation of landscape strategies in riverside settlements in the city of Medan has implications for three main aspects: the environment, space, and society. From an environmental perspective, landscape strategies can be directed toward increasing infiltration, preserving vegetation, reducing surface runoff, and strengthening the ecological functions of spaces associated with rivers. This approach is important because changes in land cover and an increase in built-up areas can reduce the area's ability to retain water and increase surface runoff (Ridwan & Sarjito, 2024).

From a spatial perspective, this strategy implies that riverside settlements should be viewed as part of a broader spatial system, rather than as standalone areas. Spatial planning must take into account the relationships between buildings, roads, open spaces, vegetation, drainage, and rivers. Open spaces, which were previously viewed merely as complementary spaces, can be developed into part of the area's ecological infrastructure through their functions of infiltration, retention, and runoff control. A spatial planning approach that integrates vegetation areas, water retention basins, green infrastructure, and drainage has also been identified as one strategy to enhance the area's capacity to cope with flooding (Rama & Pamungkas, 2025).

From a social perspective, the implementation of these strategies must take into account the communities already living in the riverbank areas. Area planning is not solely aimed at reducing the number of buildings but also at improving the quality of the residential environment, providing open spaces, and involving the community in the management and maintenance of the area. Thus, landscape strategies need to be implemented gradually and tailored to the physical conditions, land constraints, and social characteristics of the communities in each area.

Thus, the main implication of this study for the City of Medan is the need to shift the approach from flood control that is solely focused on water flow to landscape management that also emphasizes water retention, infiltration, storage, and integrated water management. This strategy can be implemented through a combination of green open spaces, vegetation, infiltration areas, green infrastructure, stormwater management, drainage improvements, and enhanced community participation. Based on the results of the literature review, this integrated approach has the potential to serve as a conceptual foundation for developing riverside settlements that are more resilient to flood risks.

3.6. Summary of Research Findings

Table 1.1. Strategy Summary Table

Aspek	Identified Issues	Landscape Strategy	Functions Related to Flood Risk
Eco-friendly	Decrease in vegetation and water absorption areas	Increased vegetation and infiltration areas	Increasing infiltration and reducing runoff
Land Use Planning	Surface dominance has been established	Open Space Proportion Settings	Improving water retention capacity
River boundary	Weak ecological function of the areas surrounding rivers	Enhancing vegetation and open spaces	Supporting ecological functions and water management
Rainwater	Rainwater immediately becomes runoff	<i>Rainwater harvesting</i> , rain garden, bioswale	Retaining and reducing runoff
Infrastructure	High drainage load	Integration of green infrastructure and drainage	Reducing the load on the drainage system
Social	The maintenance of the space is not yet optimal	Community participation	Ensuring sustainable management
Governance	Management is sector-based	Cross-sector collaboration	Strengthening the implementation of the strategy

Conclusion

Based on the results of a literature review, strategies for riverbank settlements to reduce flood risk must be implemented through an integrated approach that combines ecological functions, spatial planning, water management, infrastructure, and social aspects. Riverside settlements are strongly interconnected with river systems and the surrounding landscape conditions; thus, increased flood risk is influenced not only by river conditions but also by changes in land cover, reduced vegetation and infiltration areas, increased built-up surfaces, and suboptimal drainage management.

The synthesis results indicate that landscape strategies can be directed toward five main approaches: strengthening vegetation and open spaces; increasing water infiltration and retention areas; implementing green infrastructure and nature-based solutions; integrating

stormwater management with drainage systems; and enhancing community involvement in environmental management and maintenance. These strategies are not intended to replace technical infrastructure but to complement flood control systems by leveraging the landscape's natural functions in retaining, absorbing, storing, and regulating water flow.

In the context of the city of Medan, the findings of this study provide a conceptual basis for the idea that the planning of riverside settlements should be directed toward landscape management that is not only focused on technical flood control but also on strengthening ecological functions and the quality of residential spaces. This approach can serve as a foundation for formulating settlement planning that is more adaptive to flood risks while still taking into account community needs and environmental sustainability. Since this research is a literature review, the strategies formulated are still conceptual in nature and require further research through field studies, spatial mapping, and testing the effectiveness of the strategies to determine the form of intervention best suited to the characteristics of riverside settlements in the city of Medan.

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