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Analysis of Settlement Patterns and Flood Resilience in the Bingai River Border Area, Binjai City

Usman[1], Ruri Prihatini Lubis[2], Abdiyanto[3]
Universitas Pembangunan Panca Budi, Medan, North Sumatra [1,2,3]
Corresponding email: usmaniskandar0120@gmail.com[1] ,
Author email: *ruriprihatinilubis@dosen.pancabudi.ac.id*[2], abdiyanto@dosen.pancabudi.ac.id[3]

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ABSTRACT

Riverbanks constitute an essential component of urban spatial systems, functioning as ecological buffers as well as spaces for community activities. In rapidly developing urban areas, riverbanks are often subjected to intense land-use pressure, which may lead to environmental degradation and increased hydrological vulnerability. This study aims to formulate strategies for the arrangement and restoration of the Bingai River riverbank based on existing conditions and the watershed (DAS) management policy framework. The research employs a descriptive approach combining qualitative and quantitative methods, complemented by SWOT analysis as a strategic synthesis tool. Data were collected through field observations, documentation, questionnaires administered to communities living along the riverbank, and a review of secondary data and relevant policy documents. The results indicate that the existing conditions of the Bingai River riverbank are not yet fully aligned with watershed management and spatial planning policies, as reflected by settlement pressure, limited riparian vegetation, and suboptimal environmental infrastructure. The SWOT analysis generates strategic directions emphasizing the strengthening of riverbank ecological buffer functions, gradual control of riverbank land use, and the integration of riverbank arrangement with existing watershed management policies and programs. This study is expected to provide an initial reference for the contextual and applicable management of urban riverbanks.

Introduction

Urban rivers have a strategic role in the spatial structure and sustainability of the urban environment. In addition to functioning as a natural flow system, rivers also act as ecological spaces that support environmental balance as well as social spaces that interact directly with community activities. However, in many developing cities in Indonesia, the existence of rivers and riverbanks is facing increasing pressure due to population growth,

expansion of built-up areas, and limited availability of urban land. These pressures encourage the use of riverbanks as residential spaces and other supporting activities, which ultimately degrades the ecological function of rivers and increases the vulnerability of urban environments (Alexander et al. 1977; Suripin, 2021; Kodoatie, 2020).

The Bingai River in Binjai City is one of the urban rivers that faces this dynamic. This river is in the Wampu–Sei Ular Watershed system which is designated as a priority river area in water resource management and environmental degradation control. In the policy framework, the riverbank area is directed as a buffer space that functions to maintain the stability of the river ecosystem, control surface runoff, and minimize the risk of flooding and environmental damage. The directive is reflected in various regional planning documents at the provincial and city levels that affirm the importance of protecting river border areas as part of integrated watershed management (Binjai City Government, 2012; North Sumatra Provincial Government, 2019). However, the implementation of riverbank protection policies in urban areas often faces limitations. Binjai City as a city with a relatively high population density experience significant space utilization pressure. Population growth and urban activity encourage the use of marginal spaces, including the banks of the Bingai River, as residential areas and small-scale economic activities. Population data shows that the increase in population density in Binjai City in the last decade has implications for increasingly limited open space and increased pressure on urban protected areas (BPS Binjai City, 2023). This condition gives rise to a discrepancy between the direction of spatial planning and the existing conditions in the field, especially in the riverbank area.

From the perspective of regional and urban planning, riverbanks have a strategic position because they function as ecological buffer spaces as well as social interaction spaces for urban communities. Studies have shown that the pressure on space utilization in riverbank areas tends to increase as cities grow, especially in developing areas without consistent spatial control. This situation demands an arrangement approach that is not only oriented to physical aspects, but also considers policy, social, and environmental dimensions in an integrated manner (Nuraini, 2017; Lubis, 2018). The problem of riverbanks in urban areas is also closely related to the dynamics of settlements and environmental quality. The imbalance between the need for residential space and the carrying capacity of the environment has the potential to reduce the function of riverbanks and increase environmental risks, such as inundation and a decrease in the quality of people's living spaces (Milanie, 2019; Sugiarto, 2020). Therefore, the arrangement of riverbanks needs to be understood as an integral part of sustainable urban space management efforts. On the other hand, spatial planning and regional development policies play an important role in directing the use of riverbank areas. The challenges of implementing policies at the local level often create a gap between normative direction and existing conditions in the field, so adaptive and contextual structuring strategies are needed (Abdiyanto, 2017). This approach based on real conditions and policy frameworks is important as the basis for the formulation of strategies for structuring and restoring the banks of the Bingai River.

Physically and environmentally, the banks of the Bingai River in the urban segment show a variety of contrasting conditions. Some segments still have buffer vegetation that serves to protect the riverbanks, while other segments have been occupied by residential buildings, farms, and other activities that reduce the ecological capacity of the banks. These variations reflect differences in anthropogenic pressure levels and the ability of riverbanks

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to perform their protective functions. Degradation of riverbanks has the potential to increase surface runoff, sedimentation, and deterioration in water quality, which ultimately impacts the sustainability of urban areas as a whole (Lubis, 2024b; Azadgar et al., 2024).

Various studies on urban rivers generally focus on technical, hydrological, or flood vulnerability mapping approaches based on spatial analysis. This approach is important in understanding the physical aspects of rivers, but it has not fully answered the problem of arranging riverbanks as a transitional space that brings together ecological, social, and policy interests. Studies that specifically link the existing conditions of riverbanks with watershed management policy frameworks to formulate contextual structuring and restoration strategies, especially at the microscale of urban areas, are still relatively limited.

Based on these conditions, this study is directed to examine the banks of the Bingai River as an integral part of urban space that requires an arrangement and restoration approach based on an understanding of real conditions in the field. This study does not aim to examine the cause-and-effect relationship or influence between variables, but rather to diagnose the existing conditions on the banks of the Bingai River and assess its suitability with watershed management policies and spatial planning. Through a descriptive approach combined with strategic analysis, this research is expected to be able to formulate an adaptive, applicative, and adaptive planning and restoration strategy for the banks of the Bingai River.

Method

This study uses a descriptive approach with a combination of qualitative and quantitative methods combined with SWOT analysis. This approach is used to obtain a comprehensive picture of the existing condition of the banks of the Bingai River and its relationship with watershed management policies and spatial planning, as the basis for the formulation of strategies for the arrangement and restoration of the riverbanks.

The research location is in the area on the banks of the Bingai River which is administratively included in the Binjai City area and is part of the Wampu-Sei Ular watershed. This area was chosen because it has a strategic role in the regional hydrological system, as well as facing high pressure on space utilization due to the development of urban settlements and community activities along the riverbank. The focus of the study is directed at the riverbank segment which shows variations in physical conditions, space utilization, and environmental pressure levels, identify the physical condition of the riverbank, the pattern of the use of the riverbank, the existence of buildings, local drainage conditions, the vegetation of the banks, and community activities that have the potential to cause pressure on the environmental function of the riverbank. Visual documentation is used to reinforce the description of the existing condition and support the analysis process. The questionnaire is used as a supporting instrument to complement the results of field observation and secondary data analysis. The distribution of questionnaires was carried out to 35 respondents who were selected purposively, namely the community and parties who interact directly with the area on the banks of the Bingai River. The determination of the number and character of respondents was adjusted to the descriptive research objectives, so the questionnaire was used to obtain a perception and confirmation picture of the existing conditions of the riverbanks, not to make statistical generalizations. The questionnaire instrument was prepared in the form of closed questions that referred to aspects of the

physical condition of the slope, space utilization, and environmental problems identified in the field. Before being used in the analysis, the questionnaire instrument was tested for validity and reliability as part of data quality control. The validity test is carried out to ensure that each question item is able to represent the aspect studied, while the reliability test is used to assess the consistency of the respondents' answers. These tests are intended to guarantee the feasibility of the instrument and are not used as a basis for inferential analysis or hypothesis testing. Secondary data was obtained from various official and relevant sources, including Regional Medium-Term Development Plan (RPJMD) documents, documents and maps of the management of the Wampu–Sei Ular watershed, river basin maps, regional administrative maps, as well as Regional Spatial Plan (RTRW) documents and regulations related to the determination of river boundaries. The secondary data is used to understand the physical characteristics of the area, watershed structure, and the direction of policies for spatial planning and management of riverbank areas.

Data analysis is carried out gradually and systematically in accordance with the conceptual framework of the research. The first stage is a descriptive analysis of the existing conditions of the banks of the Bingai River (X1) which includes the physical condition of the banks, the use of the banks space, and the pressure of settlement and environmental activities. This analysis was carried out by integrating the results of field observations, visual documentation, questionnaire results, and relevant secondary data. The second stage is the analysis of watershed management and spatial planning (X2) policies which includes watershed management policies, river boundary provisions, as well as RTRW directions and environmental regulations. Policy analysis is conducted to assess appropriateness and identify gaps between the existing conditions of the riverbanks and the applicable policy directives. The results of the analysis of the existing conditions of the riverbank (X1) and the policy framework for watershed management and spatial planning (X2) were then synthesized using SWOT analysis. SWOT analysis is used to integrate the internal conditions of the riverbank area with external opportunities and challenges sourced from policies, urban dynamics, and environmental characteristics. This synthesis is the basis for the formulation of strategies for structuring and restoring the banks of the Bingai River (Y) that are contextual, applicative, and relevant to regional conditions.

Research Conceptual Framework

The conceptual framework of this study was prepared to understand the problem of the banks of the Bingai River as part of urban space that experience pressure on space utilization and degradation of environmental functions. In this framework, the arrangement and restoration of riverbanks does not only depart from normative policy provisions, but is also based on an understanding of existing conditions in the field and the applicable watershed management policy framework.

The existing condition of the banks of the Bingai River is positioned as the main study aspect (X1), which includes the physical condition of the banks, the use of bank space, and the pressure of settlement and environmental activities. This aspect is analyzed descriptively based on the results of field observations, inventory of slope conditions, and relevant secondary data. In addition, the policy aspects of watershed management and spatial planning (X2) were analyzed to understand the direction of river boundaries, watershed management policies, and spatial planning regulations that regulate the use of

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riverbank areas. The analysis of X2 aims to assess the suitability of the policy with the existing conditions on the banks of the Bingai River.

The results of the X1 and X2 analyses were then synthesized through SWOT analysis as the basis for the formulation of strategies for the arrangement and restoration of the banks of the Bingai River (Y). In this framework, X1 and X2 are not positioned as independent variables that are tested for influence, but rather as aspects of study that are analyzed descriptively and synthesized to produce contextual and applicable structuring strategies. The conceptual framework of this research is described as follows:

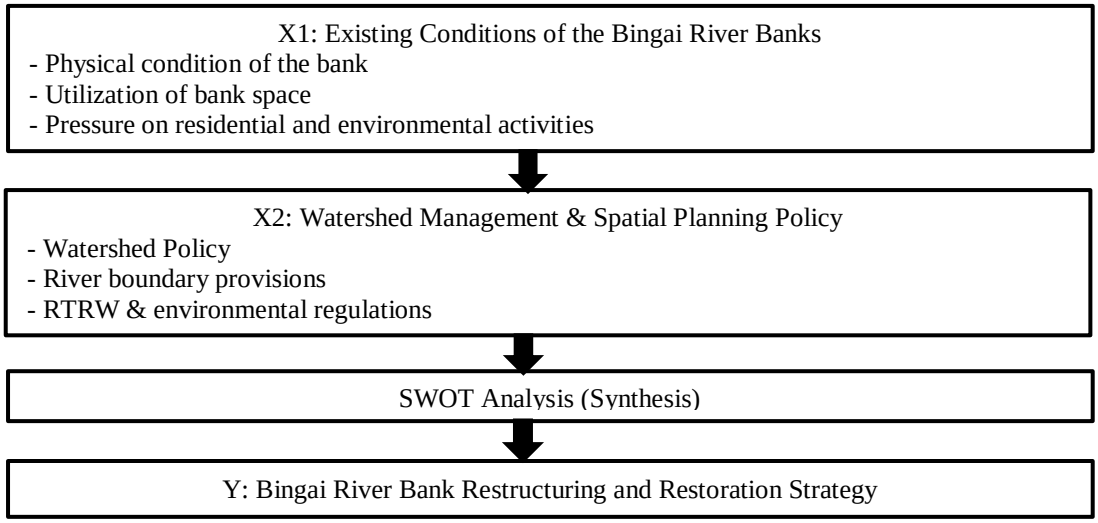

Figure 1. Research Conceptual Framework
Source: Author, 2025

Results and Discussion

Overview of the Region and Characteristics of the Bingai River Watershed

Binjai City is one of the cities in North Sumatra Province that has developed as a buffer urban area for the city of Medan. Administratively, Binjai City is directly adjacent to Langkat Regency in the west and north and Deli Serdang Regency in the east and south. This position places Binjai City in the dynamics of the development of metropolitan areas which is characterized by increasing pressure on space utilization, especially in strategic areas such as riverbanks. An overview of the location of the research area and the position of the Bingai River in the administrative area of Binjai City is presented on the following map:

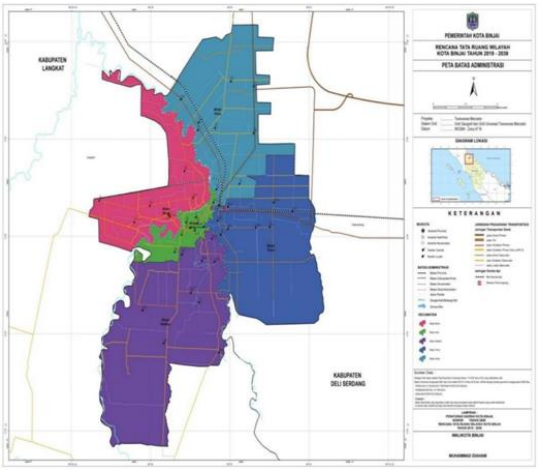

Figure 2. Map of the Administrative Area of Binjai City and the Position of the Bingai River

Source: RPJPD of Binjai City for 2025–2045, processed by the author.

Figure 2, shows the administrative area of Binjai City and the main river network that passes through it, including the Bingai River as the object of research study. The map shows that the Bingai River runs through several sub-districts in Binjai City and interacts directly with residential areas and urban infrastructure networks. The position of the Bingai River in the middle of the built area shows that the riverbank is closely related to the pattern of urban space utilization and the socio-economic activities of the surrounding community.

Based on population data, Binjai City is an area with a relatively high population density compared to the surrounding districts. In 2020, the population of Binjai City was recorded at around 295 thousand people, with a population density of more than 4,000 people per square kilometer. This figure shows a tendency to increase in the following years along with the growth of urban residential areas. This high population density has implications for the increasing need for built space and the reduced availability of open space, so that riverbank areas tend to experience increasingly intensive space utilization pressure.

In a broader hydrological context, the Bingai River does not stand alone as a local system, but is part of the Management Area Unit (SWP) of the Wampu–Sei Ular Watershed. The position of the Bingai River in the regional watershed system is shown on the following map:

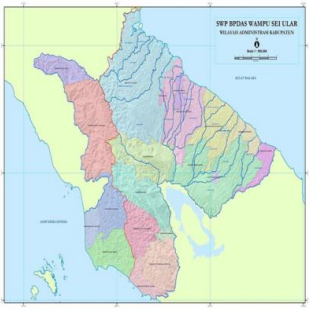

Figure 3. Map of the Wampu–Sei Ular Watershed Management Unit (SWP

) Source: Wampu–Sei Ular Watershed Management Center (BPDAS), accessed through the PPID of the Ministry of Home Affairs, processed by the author.

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Figure 3, shows that the Wampu–Sei Ular watershed covers a large area and crosses several districts/cities in North Sumatra Province, with diverse regional characteristics ranging from upstream to downstream areas. The Bingai River is one part of the system and serves as a link for water flow from the upstream area to the downstream area which has developed as an urban area. With this position, the condition of the Bingai River, especially in the urban segment, is influenced not only by local activities in Binjai City, but also by the dynamics of management and environmental conditions in the watershed area as a whole.

Watershed management and regional planning documents show that urban areas downstream, including Binjai City, have a higher level of vulnerability to hydrological problems, such as inundation and seasonal flooding. Factors such as changes in land cover, increased surface runoff, and limited environmental drainage capacity contribute to these conditions. In this context, the banks of the Bingai River have a strategic role as an ecological buffer space that should be able to reduce hydrological risks while maintaining the quality of the urban environment.

However, the pressure on space utilization due to population growth and urban activities causes the function of the riverbank to not be fully optimal. This condition shows that there is a gap between the ideal function of the riverbank as directed in the watershed management and spatial planning policy and the reality of space utilization in the field. Therefore, understanding the general description of the area and the characteristics of the Bingai River watershed is an important foundation in analyzing the existing conditions of the riverbank in more detail.

Based on this description, it is known that the Bingai River has a strategic and vulnerable position in the spatial structure of Binjai City and the Wampu-Sei Ular watershed system. This river functions as an ecological and hydrological element of the city, as well as a space that is in direct contact with the dynamics of urban development.

Overview of the Existing Conditions of the Bingai River Bank

The existing condition of the banks of the Bingai River reflects the dynamics of the use of urban space that develops along with population growth and socio-economic activities in Binjai City. The riverbank not only functions as an ecological buffer space, but also becomes a space that directly intersects with settlements, environmental infrastructure, and daily community activities. To provide an initial overview of these conditions, a map of the existing condition of the banks of the Bingai River is presented in the following image:

Figure 4. Map of the Existing Conditions of the Bingai River Banks
Source: Public Works and Spatial Planning Office of North Sumatra Province, processed by the author.

Figure 4 shows that the use of the banks of the Bingai River in the urban segment is dominated by built-up areas, especially settlements that develop to close to the river body. In some locations, the distance of the building to the river bank is relatively narrow and does not fully follow the provisions of the river boundary as directed in the spatial planning policy. This condition has implications for the reduced function of the banks as hydrological and ecological buffer spaces.

Based on the results of field observations, the physical condition of the banks of the Bingai River shows a variety of characteristics. In some segments, the riverbank has undergone modifications in the form of paving or simple retaining structures, while in other segments it is still in the form of earthen cliffs with limited vegetation. The lack of bank vegetation in some locations makes the banks relatively vulnerable to erosion, especially when river discharge increases. This condition is reinforced by the field documentation presented in Figure 5.

(a) (b)

(c) (d)

Figure 5. Existing Conditions of the Bingai River Bank

(a) The physical condition of the riverbank; (b) Settlements on the banks of rivers; (c) Environmental drainage conditions; (d) Indication of inundation susceptibility.

Source: Author's documentation, 2025.

In addition to the physical condition of the banks, the pattern of space utilization along the Bingai River also shows a fairly high pressure. The riverbank is used as a residential area with medium to high density, accompanied by the existence of small-scale

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economic activities and environmental road access that is very close to the river body. This utilization pattern shows that the riverbank has functioned as a space for community activities, although normatively the area has limitations in the use of space.

The condition of environmental infrastructure in the Bingai River bank area varies between segments. Environmental drainage in several residential areas is still in the form of open channels with limited capacity and not optimal maintenance levels. In the rainy season, this condition contributes to the occurrence of inundation in the environment around the banks. Neighborhood road access is generally available, but in some locations the width of the road is relatively narrow and directly adjacent to the riverbank, increasing vulnerability to safety risks and infrastructure damage.

Regional planning and watershed management documents show that the urban areas of Binjai City, especially areas around the Bingai River channel, have a level of vulnerability to seasonal inundation and flooding. This vulnerability is influenced by a combination of factors, including rainfall intensity, changes in land cover in the upstream watershed area, and limited capacity of drainage systems in residential areas. The dominance of built-up areas on the banks of the Bingai River strengthens the potential for inundation when river discharge increases.

To complement the results of field observations, this study also involves collecting public perception data through a questionnaire with a total of 35 respondents who live around the banks of the Bingai River. The results of the questionnaire are presented descriptively to describe the community's assessment of the condition of the riverbanks, as summarized in Table 1.

Table 1. Summary of Respondents' Perception of the Condition of the Bingai River Bank

Aspects Assessed	Dominant Categories	Percentage (%)
Physical condition of the banks	Less good	54,3
Environmental drainage conditions	Inadequate	60,0
Risk of inundation/flooding	Frequent	57,1
Comfort of the shoreline environment	Less comfortable	51,4

Source: Results of the research questionnaire, 2025.

The results of the questionnaire showed that most of the respondents assessed that the condition of the banks of the Bingai River was still not good, especially related to the limited vegetation of the banks and the proximity of the buildings to the river body. The perception of environmental drainage conditions is also dominated by inadequate assessments, which are in line with the findings of field observations related to limited capacity and maintenance of drainage channels. In addition, more than half of the respondents stated that inundation or flooding still often occurs in the area around the banks, especially in the rainy season.

Based on the results of mapping, field observations, visual documentation, and public perception, it is known that the existing conditions of the banks of the Bingai River show that there is a fairly high pressure on space utilization. The riverbank has functioned as a space for community activities, but it has not been fully able to carry out its ecological and hydrological functions optimally.

Suitability of the Condition of the Bingai River Bank with Watershed Policy and Spatial Planning

The analysis of the suitability of the Bingai River bank conditions in this study refers to several main policy frameworks that govern river management, watersheds, and regional spatial planning. The policy framework includes: (1) watershed management policies in the Wampu–Sei Ular Watershed SWP area prepared by the Watershed Management Center (BPDAS); (2) regional development planning and spatial planning documents, namely the Regional Spatial Plan (RTRW) and the Regional Long-Term Development Plan (RPJPD) of Binjai City for 2025–2045; and (3) general provisions regarding river boundaries that are part of the policy of water resources management and protection of protected areas.

In principle, these policies place rivers and their boundaries as part of the regional protection system that functions to maintain hydrological balance, control flood risk, and limit the use of built-up space in the coastal area. In the context of the management of the Wampu–Sei Ular watershed, the river is positioned as a system unit from upstream to downstream, so that the condition of the banks of the Bingai River in the urban segment of Binjai City cannot be separated from the dynamics of watershed management as a whole.

In line with the watershed management policy, the Binjai City RTRW and RPJPD documents also direct the river area as a structural element of the city that has ecological and hydrological functions. The spatial planning directive emphasizes the importance of controlling the use of space around the river as well as the protection of border areas as part of the open space system and flood disaster control.

In the management policy of the Wampu–Sei Ular watershed, rivers are positioned as a single system from upstream to downstream, so that conditions in the urban segment cannot be separated from the dynamics of watershed management as a whole. The policy directive emphasizes the importance of protecting the banks as a buffer space to reduce surface runoff, minimize flood risk, and maintain the stability of river banks. In line with that, the Binjai City spatial planning document also directs that the use of space around the river be carried out in a limited and controlled manner, taking into account the function of environmental protection and safety.

Based on the results of the study of existing conditions, the banks of the Bingai River in the urban segment show quite intensive use of space, especially in the form of residential areas that develop to approach the river body. This condition indicates a gap between the policy direction that places the riverbank as a protected space and the reality of space utilization in the field. In some locations, the existence of permanent buildings and environmental infrastructure located close to the riverbank has the potential to reduce the capacity of the banks in carrying out their hydrological functions.

From the aspect of physical condition, watershed management policies direct the protection of river banks and the existence of shoreline vegetation as important elements in maintaining the stability of river channels. However, the results of field observations show that the vegetation on the banks of the Bingai River in some segments is still limited, while some of the river banks have undergone partial structural modifications. This condition shows that the ecological function of the riverbank has not been fully in accordance with the protection principles mandated in the watershed management policy.

In terms of environmental infrastructure, spatial planning policies and urban environmental management emphasize the importance of drainage systems that are integrated with river networks. However, existing conditions show that environmental

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drainage in the Bingai River bank area in several locations still has limited capacity and maintenance that is not optimal. This has implications for the increased potential for inundation, especially during the rainy season, as reflected in public perception.

To clarify the results of the conformity analysis, a summary of the comparison between the policy direction and the existing conditions of the banks of the Bingai River is presented in the following table:

Table 2. Conformity of the Condition of the Bingai River Bank with the Watershed Policy Direction and Spatial Planning

Aspects Studied	Policy Directive	Existing Conditions	Compatibility Level
Function of riverbanks	Hydrological shelter and buffer	Dominated by built-up areas	Not fully compliant
Space utilization	Limited and controlled utilization	Settlements close to the river body	Not yet compliant
Shoreline vegetation	Protection and reinforcement of vegetation	Vegetation is limited to a few segments	Less suitable
Environmental drainage	Integrated with river system	Limited and uneven capacity	Less suitable
Flood risk management	Prevention through shoreline management	Seasonal inundation still occurs	Not optimal yet

Source: Author's analysis results, 2025.

Based on the table, it can be concluded that the condition of the banks of the Bingai River in general is not fully in accordance with the directions of the applicable watershed management and spatial planning policy. These inconsistencies are not only seen in the aspect of space utilization, but also in the physical aspects and environmental infrastructure that support the function of the riverbank. This condition shows that the banks of the Bingai River require more targeted structuring and restoration efforts so that its protective and hydrological functions can run optimally.

The results of this suitability analysis confirm that the problem of the banks of the Bingai River is not solely technical, but also related to how policies are implemented in the context of urban development. Therefore, the findings in this Subchapter are an important foundation in the formulation of strategies for structuring and restoring the banks of the Bingai River, which are further discussed through SWOT analysis in the next Subchapter.

SWOT Analysis and Formulation of Bingai River Banks Arrangement Strategy

The SWOT analysis in this study is used as a synthesis tool to formulate strategies for structuring and restoring the banks of the Bingai River based on existing conditions and policy frameworks that have been analyzed in the previous subchapter. The internal and external factors used in the SWOT analysis were compiled based on the results of field observations, mapping of slope conditions, public perception through questionnaires, and the study of watershed management policy documents and spatial planning. Thus, the SWOT analysis in this study is positioned as a result of data processing, not as a theoretical discussion.

Based on the results of the analysis of the existing conditions of the banks of the Bingai River, internal factors that affect the arrangement of the riverbank consist of strengths and weaknesses. The main strength of the banks of the Bingai River lies in the existence of the river as a structural element of the city which still has open space on several segments of the banks as well as the potential as a public space and ecological corridor. In addition, the position of the Bingai River in the regional watershed system provides opportunities to integrate the arrangement of banks with a broader watershed management program.

On the other hand, the weaknesses identified include the dominance of the use of built-up space in the embankment area, the limitation of buffer vegetation, the suboptimal environmental drainage conditions, and the still vulnerability to inundation and seasonal flooding. These weaknesses reflect the limited function of the riverbank in carrying out its ecological and hydrological role optimally.

External factors in the SWOT analysis include opportunities and threats stemming from the policy environment and urban dynamics. The main opportunity is shown by the existence of the Wampu-Sei Ular watershed management policy framework and the spatial planning document of Binjai City which in principle supports the protection and arrangement of river areas. In addition, increasing attention to urban environmental issues and flood control opens up opportunities to strengthen the integrated riverbank arrangement program.

The threats faced include the pressure of urban settlement growth, the increasing need for built-up space, and the potential for land cover changes in the upstream watershed area that can affect the hydrological condition of the Bingai River. This threat has the potential to worsen the condition of the riverbank if it is not balanced with efforts to organize and control adequate space utilization.

A summary of the internal and external factors used in the SWOT analysis is presented in the following table:

Table 3. Identification of SWOT Factors on the banks of the Bingai River

Internal Factors	**Description**
Strengths (S)	The existence of the Bingai River as a structural element of the city; the potential for open space of the impact; linkage to regional watershed systems
Weaknesses (W)	The use of built space on the banks; vegetation limitations; environmental drainage is not optimal; Vulnerability to Inundation
External Factors	**Description**
Opportunities (O)	Policy support for watershed management and spatial planning; Urban Environment Program Integration Opportunities
Threats (T)	Pressure on settlement growth; increased space requirements; The Effect of Changes in Upstream Watershed Conditions

Source: Author's analysis results, 2025.

Based on these factors, a SWOT matrix was then prepared to formulate an alternative strategy for structuring and restoring the banks of the Bingai River. The SWOT matrix is presented in the following table:

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Table 4. SWOT Matrix and Alternative Strategies for Structuring the Bingai River Bank

Strategy	Strategy Formulation
SO (Strength–Opportunity)	Optimizing the potential of riverbanks as open spaces and ecological corridors by utilizing watershed management and spatial planning policy support
WO (Weakness–Opportunity)	Improving the physical quality of the banks through strengthening vegetation, improving environmental drainage, and structuring the banks settlements based on policy directions
ST (Strength–Threat)	Strengthening the function of riverbanks as a buffer space to reduce the impact of settlement growth pressure and hydrological risks
WT (Weakness–Threat)	Control of the use of bank space and mitigation of inundation risk through the gradual arrangement and restoration of critical areas of the banks

Source: Author's analysis results, 2025.

The results of the SWOT analysis show that the strategy for structuring the banks of the Bingai River needs to be directed to an integrative approach between existing conditions and the applicable policy framework. The SO and WO strategies show the importance of utilizing policy support as an opportunity to improve the physical condition and function of riverbanks, while the ST and WT strategies emphasize the need to control space use and mitigate environmental risks due to the pressures of urban development.

Thus, the SWOT analysis in this study produces a strategic framework for structuring and restoring the banks of the Bingai River that is contextual and applicative, and based on field conditions and watershed management policies. The results of this analysis are the basis for the formulation of conclusions and research recommendations presented in the next chapter.

Discussion

The results of the study show that the existing condition of the banks of the Bingai River reflects the general dynamics of urban rivers that experience pressure on space utilization due to the growth of built-up areas. The dominance of settlements around the banks, limited vegetation buffer space, and environmental infrastructure problems indicate a reduction in the ecological function of the riverbanks. This pattern is in line with the view that places urban space as an arena of interaction between physical, social, and governance aspects, where changes in the use of coastal space have a direct impact on environmental quality and hydrological risks (Cervero 2013; Ewing & Handy 2009; Lubis, 2016; Lubis, 2018).

The findings are also consistent with studies of urban riverbanks in Indonesia that show that the development of riverside settlements often exceeds the capacity of spatial control and environmental infrastructure. This condition strengthens the argument that the degradation of riverbanks is not only a physical problem, but also related to the weak integration between spatial planning policies and the spatial needs of the community (Abdiyanto, 2015; Abdiyanto, 2017). In the context of the Bingai River, this pressure is

reflected in the fact that settlements are still being found that are developing close to the river body and the limitations of the environmental drainage system.

In terms of policy, the results of the suitability analysis show that there is a gap between the normative direction of watershed management and spatial planning with the existing conditions in the field. This phenomenon is in line with studies that state that spatial planning policies at the document level often face challenges at the implementation stage, especially in fast-growing urban areas (Abdiyanto, 2018; Abdiyanto, 2020). Thus, the inconsistency found on the banks of the Bingai River can be understood as a problem of policy implementation, not just a lack of regulatory norms.

When compared to the international literature, the condition of the banks of the Bingai River is in accordance with the concept *of urban stream syndrome*, which explains the degradation of river functions in urban areas due to increased watertight surfaces, drainage connectivity, and pressure of human activities (Walsh et al., 2005; Bernhardt & Palmer, 2011). Within this framework, the increasing potential for inundation and the deterioration of the quality of the shoreline environment are common symptoms in urban rivers in various parts of the world.

However, several other studies have shown that river restoration approaches that focus only on the physical repair of channels often do not result in sustained improvements in socio-ecological function. Research on urban river restoration emphasizes the importance of integration between physical repair, strengthening riparian function, and social acceptance of surrounding communities (Palmer et al., 2010; Booth et al., 2016). These findings are relevant to the results of the Bingai River study which shows that the problem of banks cannot be solved through a single intervention, but requires a more comprehensive structuring approach.

Reinforcement of riparian vegetation as part of the buffer function in a number of studies has shown that riparian buffer zones play an important role in reducing nutrient load and improving river bank stability, although their effectiveness is strongly influenced by local context and implementation design (Geurs & van Wee 2004; Litman 2017; Parasuraman et al. 1988; Pucher & Buehler 2012; Mayer et al., 2007; Newcomer Johnson et al., 2016). This corroborates the study's findings that the restoration of the banks of the Bingai River needs to be designed contextually and gradually, not just replicate models from other regions.

From the perspective of regional planning and governance, the results of this research are also in line with the thinking that emphasizes the importance of an integrated approach in river and watershed management. Effective river management requires integration between controlling space utilization, flood risk management, and coordination across sectors and regions (Lubis, 2020; Abdiyanto, 2021). In the context of the Bingai River, such integration is important considering the position of the river as part of the broader watershed system and at the same time as a structural element of the city.

The use of SWOT analysis in this study can be understood as a synthesis tool to connect the internal conditions of the riverbanks with external factors in the form of policies and urbanization pressures. This approach is in line with regional planning studies that utilize SWOT to formulate regional planning strategies based on existing conditions and policy opportunities, without having to quantitatively test cause-and-effect relationships (Abdiyanto, 2019; Lubis, 2022). Thus, SWOT serves as an analytical

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framework that bridges empirical results with the formulation of strategies for structuring and restoring the banks of the Bingai River.

Overall, this discussion shows that the findings of the Bingai River research do not stand alone, but are in the spectrum of problems that are also found in various national and international studies. These similarities and differences in contexts confirm that strategies for structuring and restoring the banks of the Bingai River need to be formulated adaptively, taking into account existing conditions, policy frameworks, and lessons learned from various riverbank arrangement practices in other regions.

Conclusion

This study shows that the existing condition of the banks of the Bingai River in the urban segment of Binjai City is under a fairly high pressure on space utilization. The riverbanks have interacted intensively with residential areas and community activities, so that their ecological and hydrological functions have not run optimally. Field findings show the limitations of bank vegetation, the proximity of buildings to river bodies, and environmental infrastructure conditions that have not fully supported the function of banks as buffer spaces. This condition is also reflected in the perception of the public who still feel the vulnerability of inundation and the decrease in environmental comfort in the coastal area.

The results of the suitability analysis show that the existing conditions of the banks of the Bingai River are not fully aligned with the direction of the watershed management policy and the applicable spatial planning. Normatively, policies place rivers and their tributaries as part of the protection system, but in practice there is still a gap between policy direction and implementation on the ground. This gap indicates that the problem of the banks of the Bingai River is not only technical, but also related to aspects of controlling the use of space and implementing policies at the local level.

Through SWOT analysis, this study produced a strategic framework for structuring and restoring the banks of the Bingai River which was compiled based on the synthesis of existing conditions and policy frameworks. The resulting strategy emphasizes the importance of strengthening the function of riverbanks as an ecological buffer space as well as an organized urban space, while still considering the dynamics of community activities and the limitations of policy implementation. Thus, this study emphasizes that the arrangement of the banks of the Bingai River needs to be done contextually and gradually, not through a single approach or instant solution.

Based on these conclusions, the recommendations of this study are directed at realistic and applicable steps in the urban context of Binjai City. The arrangement of the banks of the Bingai River needs to be prioritized in the critical segments that have the highest level of space utilization pressure and environmental risk, with an initial focus on strengthening the banks vegetation and gradually controlling space utilization. Efforts to restore riverbanks should be integrated with improvements in environmental infrastructure, especially residential drainage systems, so that the hydrological function of riverbanks can be improved without causing significant disruption to community activities.

In addition, the control of the use of space on the banks of the Bingai River needs to be synergized with existing spatial planning policies and watershed management programs, so that the arrangement of the banks does not run sectorally. A collaborative approach between local governments, communities around the banks, and related stakeholders is

important to ensure the sustainability of structuring results. In this context, the riverbank arrangement strategy should not only be oriented to physical aspects, but also pay attention to social acceptance and community activity patterns so that the resulting recommendations can be implemented effectively.

Overall, the recommendations resulting from this study are expected to be an initial reference in efforts to organize and restore the banks of the Bingai River based on existing conditions and watershed policy frameworks, as well as open up space for further research that can examine technical and institutional aspects in more depth.

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