GUIDELINES FOR SPACE UTILIZATION BASED ON FLOOD DISASTER MITIGATION IN RESIDENTIAL AREAS IN SOUTH BALIKPAPAN DISTRICT, BALIKPAPAN CITY

Srirahadita Pamungkas, Noermaya Suvana*, Ariyaningsih, Dhyah Puspita Dewi, Mohtana Kharisma Kadri

Program Studi Perencanaan Wilayah dan Kota, Institut Teknologi Kalimantan, Indonesia

Abstract

South Balikpapan District is prone to flooding due to its location near the Ampal River basin, high land use density, and intense rainfall. This study aims to develop guidelines for flood mitigation-based spatial utilization in residential areas of South Balikpapan. Overlay analysis was used to determine flood vulnerability levels, and triangulation analysis to formulate spatial utilization guidelines. The results show that residential areas in South Balikpapan have high and moderate flood vulnerability. About 55% of the area, including Damai Bahagia, Damai Baru, Sepinggan, Gunung Bahagia, and Sungai Nangka (332.16 ha), are highly vulnerable, while 45% in Sepinggan Raya and Sepinggan Baru (157.33 ha) are moderately vulnerable. The proposed spatial utilization focuses on mitigation: prevention through relocation and infrastructure strengthening, handling via improved drainage and evacuation systems, and recovery through adaptive spatial planning. Integrating spatial utilization and flood mitigation is crucial for creating safe and sustainable residential areas.

Keywords: *Flood Disaster, Disaster Vulnerability, Disaster Mitigation, Spatial Utilization, Settlement*

Introduction

The high level of spatial utilization in densely populated urban areas often raises problems in meeting land needs, given that the limited available land is not proportional to the increasing demand from human activities. This situation has the potential to reduce environmental quality and increase the possibility of natural disasters (Azzam, 2021). Rapid urban development without adequate management systems can cause natural disasters such as flooding in various locations, which poses a challenge in providing adequate urban facilities and infrastructure (Iswandi U et al., 2017). Based on Law No. 24 of 2007, a disaster is defined as an event or series of events that has the potential to threaten and disrupt the survival and livelihoods of the community. These disasters can be triggered by natural, non-natural, or human factors, which ultimately cause significant impacts such as loss of life, environmental damage, economic losses, and psychological distress (Taryana et al., 2022). In overcoming the problem of flooding, careful spatial planning is needed, including guidelines for spatial utilization and comprehensive technical management to support the process of controlling and handling disasters (Rahmadhani, 2023), (Warno et al., 2024). Floods are a type of natural disaster that can be mitigated through a spatial planning approach, particularly through the formulation of appropriate spatial utilization guidelines as part of a flood disaster mitigation

*)Corresponding Author:
E-mail: 08211057@student.itk.ac.id

Received: 19 October 2025
Revised: 13 November 2025
Accepted: 5 January 2026
DOI: 10.23969/jcbeem.v10i1.34603

strategy (Irwan, 2018). In areas that are prone to flooding, spatial utilization guidelines should focus on mitigation strategies to reduce the impact of disasters. The formulation of these guidelines is based on an analysis of the vulnerability level of the area, which includes physical, social, economic, and environmental aspects. In addition, several other factors related to the basic physical characteristics or geomorphology of the area also influence the potential for flooding, such as rainfall intensity, land slope, area elevation, proximity to rivers, soil type, and land use patterns. According to the 2012–2032 Balikpapan City Spatial Plan (RTRW), flood-prone areas in South Balikpapan District are not limited to one sub-district but are spread across several areas. The sub-districts that are often affected by flooding include Damai Baru, Damai Bahagia, Sungai Nangka, Sepinggan, and Gunung Bahagia. When flooding occurs, the water level generally reaches a height of between 10 and 30 centimeters. The flooding is mostly triggered by overflowing rivers that pass through the area and is a major problem in South Balikpapan District (Balikpapan City Regional Disaster Management Agency, 2023). The local government has made various efforts to address this issue, such as building flood control infrastructure through the Ampal Watershed Management project. However, this infrastructure has not yet yielded optimal results and is still affected by flooding, indicating the need for a more comprehensive and targeted solution to overcome the flooding problem in this area. According to the 2022–2026 Balikpapan City Disaster Risk Assessment (KRB), flooding in this area is closely related to spatial planning and suboptimal environmental conditions. Some of the main factors that trigger flooding include inadequate drainage systems, low implementation of disaster mitigation strategies, limited water catchment areas, and the existence of settlements built along river channels. In addition, high rainfall and overflowing rivers also cause flooding in residential areas. Flooding in this region is generally caused by surface water runoff volumes that exceed the capacity of drainage channels and rivers, especially in South Balikpapan District (Balikpapan City Regional Disaster Management Agency, 2023). Previous research conducted by (Azila, 2022) related to this study discussed spatial utilization guidelines for flood mitigation through flood vulnerability analysis, land use patterns, and mitigation strategies. The results show that the area has high vulnerability due to population density and changes in land use that are not in accordance with spatial planning, thereby increasing the risk of flooding. However, the geomorphological aspects that influence flood vulnerability have not been analyzed comprehensively, even though an understanding of geomorphological characteristics is very important for developing appropriate and effective mitigation strategies. Therefore, this study aims to contribute to overcoming flooding issues that impact communities by providing alternative solutions in the form of appropriate spatial utilization guidelines for flood disaster mitigation, through analysis of flood-prone and vulnerable areas, particularly in residential areas in South Balikpapan District.

Research Methodology

This research method uses two data collection methods, namely primary data collection and secondary data collection. Primary data collection was carried out through field observation to determine the physical conditions in the research area, which is prone to flooding, by conducting a direct field survey and taking photographs documenting the existing conditions of the research location in South Balikpapan District. and through interviews with several relevant stakeholders, such as the Balikpapan City Regional Disaster Management Agency (BPBD), the Balikpapan City Land and Spatial Planning Agency (DPPR), the

Balikpapan Selatan Subdistrict Office, and community leaders affected by flooding. This primary data contributes to this study by examining the validity of the facts on the ground regarding the number of times floods have occurred in the area and the solutions that have and have not been implemented to mitigate flooding in residential areas. The secondary data collection methods used in this study were literature surveys and institutional surveys.

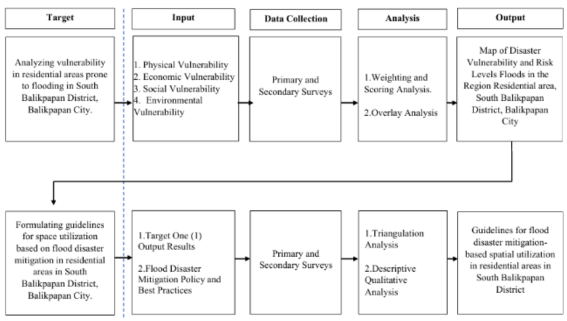

Figure 1. Research Process

Research Location

The research location was in South Balikpapan District, Balikpapan City. Geographically, South Balikpapan District is located at coordinates between 1.24'-1.26' South Latitude and between 116.86'-116.90' East Longitude. The administrative boundaries of the research location is as follows: to the north, it borders Balikpapan Tengah District; to the east, it borders the Makassar Strait; to the south, it borders East Balikpapan District, and to the west it borders North Balikpapan District.

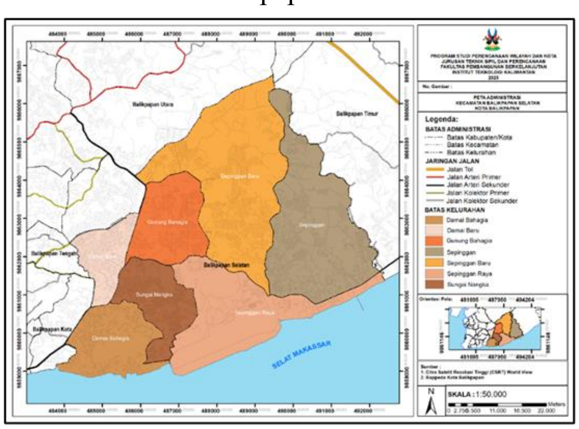

Figure 2. Map of the Research Location in South Balikpapan District

Tools and Materials

This study uses two analysis methods, namely overlay analysis and qualitative descriptive analysis. Overlay analysis is applied to assess the level of vulnerability to flooding in South Balikpapan District. The results of this analysis then form the basis for formulating flood disaster mitigation recommendations that focus on spatial utilization, in accordance with the level of flood vulnerability that has been identified in the area.

1. Analyzing the Level of Flood Vulnerability in South Balikpapan District

In this study, the analysis of flood disaster vulnerability in residential areas was conducted using the overlay method. The analysis stages included calculating the vulnerability level, which was divided into four main parameters, namely social, physical, economic, and environmental vulnerability. Each parameter was given a different weight based on its influence on the flood vulnerability level. Next, grouping or classification of classes was carried out for each type of vulnerability. Details of the parameters and weights of each aspect of social, physical, economic, and environmental vulnerability are presented as follows.

a. Social Vulnerability

In the aspect of social vulnerability, there are several parameters used to calculate the level of social vulnerability, including population density, sex ratio, age group ratio, and disability ratio. Each parameter is analyzed using a weighting method based on findings from previous journal research. The details of the parameters and their respective weights in the aspect of social vulnerability are presented as follows.

Table 1. Social Vulnerability Parameters and Weights (Sapoetra, 2024)

Parameter	Weight (%)	Low Class	Medium Class	High Class	Score Basis
Population Density	40	< 500 people/km²	500–1000 people/km²	> 1000 people/km²	Class / Maximum Value
Age Group Ratio	30	< 20	20–40	> 40	
Gender Ratio	15	< 20	20–40	> 40	
Disability Ratio	15	< 20	20	> 40	

After that, the vulnerability index for each social vulnerability variablewas obtained, then calculations were made based on previous research journals using the following equation. (1)

Social Vulnerability = (0.4 × Population Density Score) + (0.3 × Gender Score) + (0.15 × Age Group Score) + (0.15 × Disabled Population Score) (1)

b. Physical Vulnerability

In terms of physical vulnerability, the parameter used to calculate the level of physical vulnerability is the density of buildings in the study area. Through an analysis of building density, it can be seen that the more densely populated an area is, the higher its vulnerability to flooding. This condition occurs because there is less land available to serve as water catchment areas. The parameters and weights in the physical vulnerability aspect refer to the results of previous studies and are presented as follows.

Table 2. Physical Vulnerability Parameters and Weights (Sapoetra, 2024)

Parameter	Weight (%)	Class			Score
		Low	Medium	High	
Building Density	100	<18 Units/Ha	18-34 Units/Ha	>34 Units/Ha	Class/Maximum Value Class

After determining the weight and index of the physical vulnerability parameter in the form of building density, the physical vulnerability index can be calculated using the formula (2).

Physical Vulnerability = (1.0 × Building Density Score) (2)

c. Economic Vulnerability

In terms of economic vulnerability, the parameter used is productive land. The analysis of this productive land parameter aims to determine the potential economic losses that may be incurred, with reference to the economic value of the analysis data. The calculation of economic vulnerability based on productive land is carried out using the overlay analysis and scoring methods on land use maps, which are classified based on the type of productive land. The parameters and weightings for economic vulnerability are compiled based on references from previous studies as described below.

Table 3. Economic Vulnerability Parameters and Weights (Sapoetra, 2024)

Parameter	Weight (%)	Class			Score
		Low	Medium	High	
Productive Land	100	<100 million	100-300 million	>300 million	Class/Maximum Class Score

After determining the weights and indices of the economic vulnerability parameters in the form of productive land, the economic vulnerability index can be calculated using the formula (3).

Economic Vulnerability = (1.0 × Productive Land Score) (3)

d. Environmental Vulnerability

In terms of environmental vulnerability, several parameters are used, namely Shrubs, Fields, Settlements, Rice Fields, and Water Bodies. The assessment of environmental vulnerability is carried out using a weighting method through an environmental vulnerability index, in which each parameter has a different value. These values are obtained from the average of the weighting results based on land cover data. The assessment of the parameters and the weight of each environmental vulnerability parameter refer to a previous research journal as in Table 4.

Table 4. Environmental Vulnerability Parameters and Weights (Rahmadhanty et al., 2022)

Parameter	Weigh t (%)	Class			Score
		Low	Medium	High	
Thicket	10	<20 ha	20-50 ha	>50 ha	Class/Maximum Value Class
Dryland	20	<10 ha	10-30 ha	>75 ha	
Settlements	20	<10 ha	10-30 ha	>30 ha	
Rice fields	20	<10 ha	10-30 ha	>30 ha	
Water bodies	30%	<10 ha	10-30 ha	>20 ha	

Environmental vulnerability parameters are adjusted according to conditions in each hazard class. After obtaining the scores for each parameter, environmental vulnerability can be calculated using the equation (4).

Environmental Vulnerability = (0.1 × Scrubland) + (0.2 × Dry Fields) + (0.2 × Settlements) + (0.2 × Rice Fields) + (0.3 × Water Bodies) (4)

After determining and calculating the weighting values of several flood disaster vulnerability indices, the next step to determine the flood disaster vulnerability index and the total weighting value of the flood disaster vulnerability level obtained from the combined results of social vulnerability, physical vulnerability, economic vulnerability, and environmental vulnerability parameters can be calculated using the equation (5).

Flood Disaster Vulnerability Index
(IKS × 0.4) + (IKF × 0.25) + (IKE × 0.25) + (IKL × 0.10) (5)

With the following explanation:
IKS = Social Vulnerability Index
IKF = Physical Vulnerability Index
IKE = Economic Vulnerability Index
IKL = Environmental Vulnerability Index

2. Formulating guidelines for flood disaster mitigation-based spatial utilization in residential areas in South Balikpapan District

The formulation of flood disaster mitigation-based spatial utilization guidelines in residential areas in this study is based on the results of flood disaster vulnerability analysis, which is classified into high, medium, and low categories. In addition, these guidelines are also compiled based on the results of flood disaster mitigation identification. This study uses a qualitative descriptive approach by applying triangulation analysis techniques conducted through comparisons between various data and theories relevant to previously established disaster mitigation policies based on flood disaster mitigation efforts carried out continuously through three main stages of the mitigation cycle, namely prevention before flooding occurs (prevention), response/intervention during floods, and recovery after floods (Urbanus et al., 2021). The types of triangulation techniques used in this study are source triangulation, method triangulation, and theory triangulation (Moleong, 2017). The data for this analysis utilizes these references as a reference in designing development plans to minimize the impact of flooding in an area. These policies originate from relevant institutions that focus on flood disaster management, such as Law – Law of the Republic of Indonesia Number 24 of 2007 concerning Disaster Management, Regulation of the National Disaster Management Agency Number 7 of 2022, Ministerial Regulation Number 16 of 2013 concerning Guidelines for Emergency Management of Flood Disasters Caused by Water Damage, Balikpapan City Regulation Number 12 of 2012 concerning the 2012-2032 Balikpapan City Spatial Plan, Balikpapan City Regulation Number 2 of 2018 concerning Regional Disaster Management.

Result and Discussion

Analysis of Flood Disaster Vulnerability Levels in South Balikpapan District

The analysis of flood disaster vulnerability levels was obtained from the calculation of flood vulnerability parameter scores, namely social, physical, environmental, and economic vulnerability. Then, after determining the vulnerability class based on the calculation of the final score interval for each parameter, a map was produced based on the flood vulnerability level for each parameter in South Balikpapan District.

a. Social Vulnerability

The social vulnerability aspect includes several parameters, namely population density and the existence of vulnerable groups consisting of gender ratio, age ratio, and disability ratio. Based on data from each social vulnerability parameter in South Balikpapan District, a social vulnerability index value was obtained. Next, the total social vulnerability value will be calculated based on this data. The process of calculating the level of social vulnerability is carried out using the following formula.

Table 5. Total Social Vulnerability Value in South Balikpapan District

Village	Parameter	Class	Weight	Score	Vulnerability
Damai Baru	Population Density	High	40%	1.0	
	Sex Ratio	High	30%	1.0	
	Age Group Ratio	Medium	15%	0.6	
	Disabled Population Ratio	Low	15%	0.3	
Damai Bahagia	Population Density	High	40%	1.0	
	Sex Ratio	High	30%	1.0	
	Age Group Ratio	Medium	15%	0.6	
	Disabled Population Ratio	Low	15%	0.3	
Sepinggan Baru	Population Density	High	40%	1.0	
	Sex Ratio	High	30%	1.0	
	Age Group Ratio	Medium	15%	0.6	
	Disabled Population Ratio	Low	15%	0.3	
Nangka River	Population Density	High	40%	1.0	
	Sex Ratio	High	30%	1.0	
	Age Group Ratio	Medium	15%	0.6	**0,83**
	Disabled Population Ratio	Low	15%	0.3	
Sepinggan Raya	Population Density	High	40%	1.0	
	Sex Ratio	High	30%	1.0	
	Age Group Ratio	Medium	15%	0.6	
	Disabled Population Ratio	Low	15%	0.3	
Gunung Bahagia	Population Density	High	40%	1.0	
	Sex Ratio	High	30%	1.0	
	Age Group Ratio	Medium	15%	0.6	
	Disabled Population Ratio	Low	15%	0.3	
Sepinggan	Population Density	High	40%	1.0	
	Sex Ratio	High	30%	1.0	
	Age Group Ratio	Medium	15%	0.6	
	Disabled Population Ratio	Low	15%	0.3	
South Balikpapan District	Population Density	High	40%	1.0	
	Sex Ratio	High	30%	1.0	
	Age Group Ratio	Medium	15%	0.6	
	Disabled Population Ratio	Low	15%	0.3	

Based on the data in the table above regarding social vulnerability in South Balikpapan District, the total social vulnerability score is 0.83, classified as high level. From this calculation, which is close to 1.0, it can be concluded that South Balikpapan District is increasingly vulnerable to flooding, as determined by the total score for the social vulnerability parameter using the following calculation formula.

The total social vulnerability value is calculated by calculating the social vulnerability value of one subdistrict and each urban village in the study area. The following is the calculation of the total social vulnerability value in South Balikpapan Subdistrict.

Social Vulnerability = $(0.4 \times 1.0) + (0.3 \times 1.0) + (0.15 \times 0.6) + (0.15 \times 0.3) = 0.4 + 0.3 + 0.09 + 0.04 =$ **0.83**

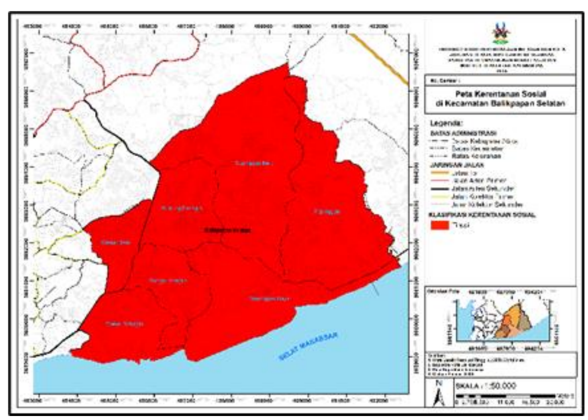

Figure 3. Social Vulnerability Map in South Balikpapan District

b. Physical Vulnerability

Physical vulnerability aspects include parameters such as building density, both residential and public facilities such as public service buildings. A high number of buildings in an area has the potential to increase vulnerability to flooding because it can cause damage and loss in the event of a disaster. Based on data from each physical vulnerability parameter in South Balikpapan District, the following physical vulnerability index values were obtained. Next, the total physical vulnerability value will be calculated based on building density data in the area. This physical vulnerability calculation is performed using the following formula.

Table 6. Total Physical Vulnerability Values in South Balikpapan District

Village	Building Density (Units/Ha)	Weight (%)	Building Density Class	Score
Damai Baru	13.85	100	High	1
Damai Bahagia	12.07	100	High	1
Sepinggan Baru	9.97	100	Low	0.333
Sungai Nangka	15.59	100	High	1
Sepinggan Raya	6.18	100	Low	0.333
Gunung Bahagia	15.55	100	High	1
Sepinggan	12.83	100	High	1
Balikpapan Selatan District	**11.35**	**100**	**High**	**1**

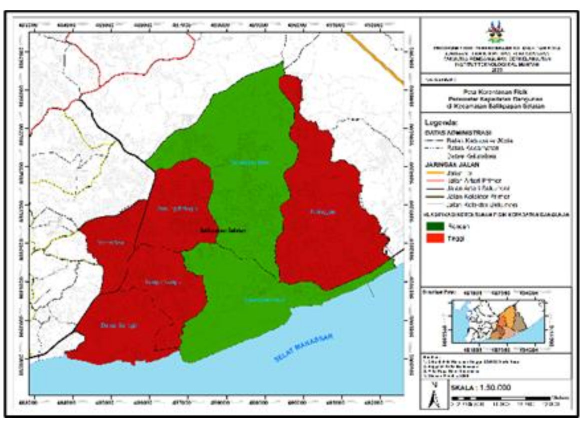

Figure 4. Physical Vulnerability Map in South Balikpapan Subdistrict

Based on the results of the physical vulnerability calculation for the building density parameter, a value of 1 was obtained. If the calculation result is close to 1, it can be said that the area in the Balikpapan Selatan Subdistrict is increasingly vulnerable to flooding. Next, the total value for the physical vulnerability parameter will be calculated. The total physical vulnerability value is calculated by determining the physical vulnerability value for one subdistrict and each village in the study area. The following is the calculation of the total physical vulnerability value in the South Balikpapan District.

Physical Vulnerability = (1.0 × Building Density Score) = (1.0 × 1) = **1**

c. Environmental Vulnerability

The environmental vulnerability aspects in South Balikpapan Subdistrict consist of several elements, including shrubs, moorland, residential areas, rice fields, and water bodies. Each of these elements is classified into classes and indices based on references from previous research journals, with the aim of calculating the area of land that has suffered environmental damage and comparing it with the level of vulnerability to flooding. This classification of environmental vulnerability is compiled using parameters in the form of weights, classes, and scores determined based on the level of environmental damage in South Balikpapan District, as explained below.

Table 7. Total Environmental Vulnerability Values in South Balikpapan District

Village	Parameter	Weight	Score	Vulnerability Value	Class
Damai Baru	Scrub	10%	0.666	0.47	Low
	Field	20%	0.333		
	Settlements	20%	1.000		
	Rice fields	20%	0.333		
	Water bodies	30%	0.333		
Damai Bahagia	Scrub	10%	0.666	0.47	Low
	Field	20%	0.333		
	Settlements	20%	1.000		
	Rice fields	20%	0.333		
	Water bodies	30%	0.333		
Sepinggan Baru	Scrub	10%	1.000	0.63	Moderate
	Field	20%	0.333		
	Settlements	20%	1.000		
	Rice fields	20%	0.333		
	Water bodies	30%	0.666		
Nangka River	Scrub	10%	0.666	0.47	Low
	Field	20%	0.333		
	Settlements	20%	1.000		
	Rice fields	20%	0.333		
	Water bodies	30%	0.333		
Sepinggan Raya	Scrub	10%	1.000	0.51	Moderate
	Field	20%	0.333		
	Settlements	20%	1.000		
	Rice fields	20%	0.333		
	Water bodies	30%	0.333		
Gunung Bahagia	Scrub	10%	0.666	0.47	Low
	Field	20%	0.333		
	Settlements	20%	1.000		
	Rice fields	20%	0.333		
	Water bodies	30%	0.333		

Village	Parameter	Weight	Score	Vulnerability Value	Class
Sepinggan	Scrub	10%	1.000	0.51	Moderate
	Field	20%	0.333		
	Settlements	20%	1.000		
	Rice fields	20%	0.333		
	Water bodies	30%	0.333		
South Balikpapan District	Scrub	**10%**	**1.000**	**0.72**	**Moderate**
	Field	**20%**	**0.333**		
	Settlements	**20%**	**1.000**		
	Rice fields	**20%**	**0.333**		
	Water bodies	**30%**	**1.000**		

Based on the results of the environmental vulnerability calculation for the parameters of shrubland, dry fields, settlements, rice fields, and water bodies, a value of 0.72 was obtained, which indicates that the level of environmental vulnerability to flooding in South Balikpapan District is moderate and that the area is not completely vulnerable to flooding. After obtaining the environmental vulnerability data from several parameters consisting of shrubs, fields, settlements, rice fields, and water bodies, the total environmental vulnerability value will be calculated using the following formula.

Environmental Vulnerability = (0.1 × Scrubland) + (0.2 × Cropland) + (0.2 × Settlements) + (0.2 × Rice Fields) + (0.3 × Water Bodies) = (0.1 × 1.0) + (0.2 × 0.3) + (0.2 × 1.0) + (0.2 × 0.3) + (0.3 × 1.0) = 0.1 + 0.06 + 0.2 + 0.06 + 0.3 = **0.72**

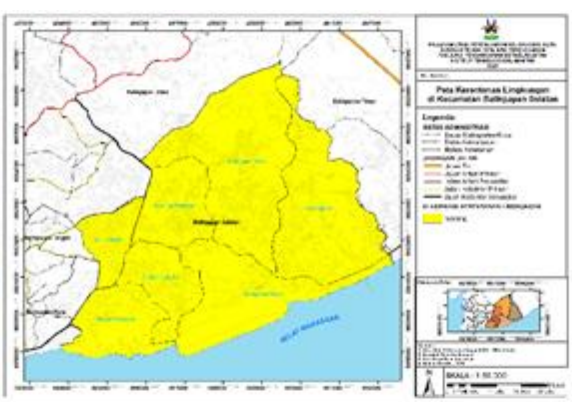

Figure 5. Environmental Vulnerability Map in South Balikpapan District

d. Economic Vulnerability

Economic vulnerability to productive land in South Balikpapan District covers various types of land use, such as trade and services, industry, plantations, and tourism. This analysis produced data on the total land value, the affected area, and the estimated economic loss. The data was obtained through an overlay process between the productive land map and the flood disaster vulnerability map, as well as using economic vulnerability class scores or indices in the study area. The following presents the calculation of the total economic vulnerability value of productive land, which includes the overall vulnerability value at the subdistrict level and each urban village in South Balikpapan Subdistrict.

Table 8. Total Economic Vulnerability Value in South Balikpapan Subdistrict

Village	Parameter	Class	Weight	Score	Vulnerability Score
Damai Baru	Productive Land	High	100	1	1
Damai Bahagia	Productive Land	High	100	1	1
Sepinggan Baru	Productive Land	High	100	1	1
Sungai Nangka	Productive Land	High	100	1	1
Sepinggan Raya	Productive Land	High	100	1	1
Gunung Bahagia	Productive Land	High	100	1	1
Sepinggan	Productive Land	High	100	1	1
Balikpapan Selatan District	**Productive Land**	**High**	**100**	**1**	**1**

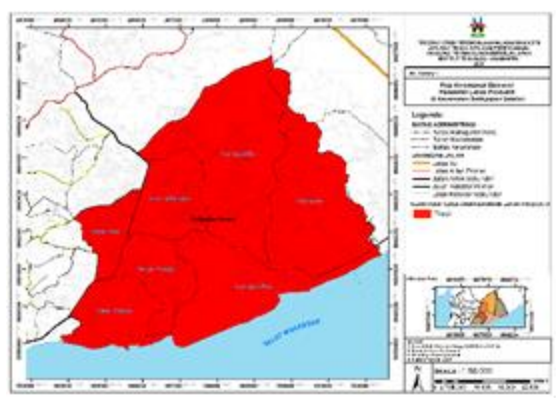

Figure 6. Economic Vulnerability Map in South Balikpapan Subdistrict

Based on the economic vulnerability calculations for productive land, the result is 1. If the calculation result is close to 1, it can be said that the area in South Balikpapan District is increasingly vulnerable to flooding. The following is the calculation of the total economic vulnerability value of productive land by calculating the economic vulnerability value of one district and each sub-district in the research area in South Balikpapan District.

Economic Vulnerability = (1.0 × Productive Land Score) = (1.0 × 1) = **1**

Based on the results of the analysis of the calculation of a number of vulnerability parameters to flood disasters in Balikpapan Selatan Subdistrict, the flood vulnerability values for each village have been obtained. Furthermore, a comprehensive calculation of flood vulnerability was carried out, which is a combination of four main aspects, namely economic, social, physical, and environmental vulnerability, using a specific calculation formula as the basis for the analysis.

Flood Disaster Vulnerability Index

Flood Disaster Vulnerability Index
= (IKS × 0.4) + (IKF × 0.25) + (IKE × 0.25) + (IKL × 0.10) = (0.83 × 0.4) + (1.0 × 0.25) + (1.0 × 0.25) + (0.72 × 0.10) = **0.90**

The results of the total flood disaster vulnerability calculations in South Balikpapan District are as follows.

Table 9. Total Flood Disaster Vulnerability Values in South Balikpapan District

Village	Total Vulnerability Index	Flood Vulnerability Class Level
Damai Baru	0.87	High
Peace and Happiness	0.87	High
New Sepinggan	0.72	Moderate
Sungai Nangka	0.87	High
Sepinggan Raya	0.70	Moderate
Happy Mountain	0.87	High
Sepinggan	0.88	High
South Balikpapan District	**0.90**	**High**

Based on the results of the total vulnerability score and flood disaster vulnerability level in each urban village in South Balikpapan Subdistrict, they are classified into two levels of flood disaster vulnerability, namely high vulnerability and moderate vulnerability, which are located in South Balikpapan Subdistrict. The subdistrict with a moderate vulnerability level is due to the condition of the land, which is partly located on high ground. These results emphasize the importance of integrating structural and non-structural mitigation in spatial planning policies. The implementation of these guidelines is expected to form the basis for zoning policies and disaster mitigation-based urban planning.

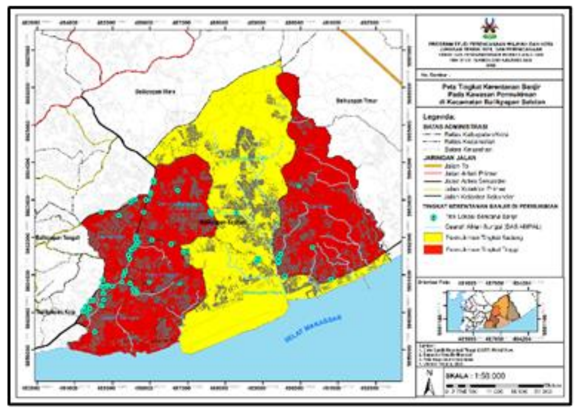

Figure 7. Flood Disaster Vulnerability Level Map in settlement South Balikpapan District

Guidelines for flood mitigation-based spatial utilization in residential areas in South Balikpapan District

Guidelines for flood mitigation-based spatial utilization in residential areas with moderate to high vulnerability levels in South Balikpapan District were developed in response to the identification of vulnerable areas, particularly the villages of Damai Bahagia, Damai Baru, Sepinggan, Gunung Bahagia, and Sungai Nangka, which require special attention due to the high risk to safety and environmental sustainability. These guidelines refer to three disaster mitigation cycles, namely prevention, management, and recovery. This strategy not only aims to reduce the impact of flooding but also to strengthen the resilience of the area to similar events in the future.

In terms of prevention, the focus is on strengthening the drainage system, normalizing rivers, and implementing green infrastructure such as infiltration parks, biopores, and green open spaces. Residential zoning also needs to be adjusted to the physical conditions of the area. The response phase focuses on community preparedness through the provision of evacuation routes, safe gathering points, training, disaster simulations, and the development of early warning systems. Meanwhile, the recovery phase includes infrastructure repair, land function restoration, and socio-economic support for affected residents, involving cross-sector coordination and community participation. Overall, these guidelines are expected to serve as a roadmap for adaptive and sustainable residential area management to enhance the resilience of the region to flooding.

Conclusions

Based on the results of the analysis, it was concluded that from the results of the overlay analysis, scoring, and weighting of social, physical, economic, and environmental aspects, residential areas in South Balikpapan are dominated by moderate to high levels of flood vulnerability. Social vulnerability has a high vulnerability value of 0.83, physical vulnerability is 1.0, economic vulnerability is 1.0, and environmental vulnerability is moderate with a score of 0.72. The sub-districts of Damai Baru, Damai Bahagia, Sungai Nangka, Gunung Bahagia, and Sepinggan are in the high vulnerability category with scores between 0.87 and 0.88, while the sub-districts of Sepinggan Baru and Sepinggan Raya are classified as moderate with scores of 0.72 and 0.70, respectively. Overall, this area has a total vulnerability index of 0.90 and is classified as highly vulnerable to flooding.

Flood mitigation based spatial utilization guidelines are implemented through a triangulation approach that considers these four aspects, divided into three stages.

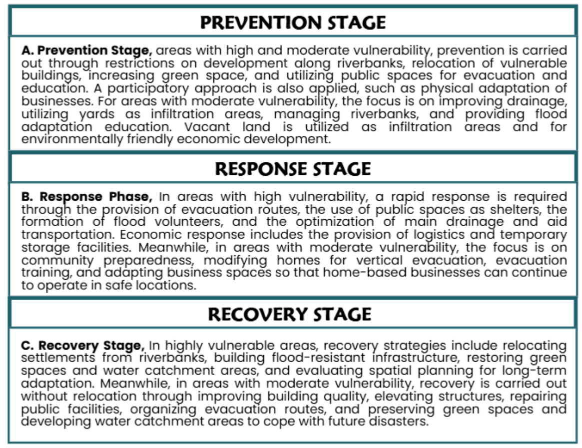

Figure 8. Stages of Guidance on Space Utilization Based on Flood Disaster Mitigation

The prevention stage focuses on restricting development along riverbanks, relocating vulnerable buildings, increasing green open spaces, education, and community participation. In areas of moderate vulnerability, efforts are directed at improving drainage and utilizing land as infiltration areas. The response stage includes providing evacuation routes, public spaces as shelters, forming volunteers, and increasing community preparedness. Meanwhile, the recovery stage is carried out through relocation, construction of flood resistant infrastructure, repair of public facilities, and preservation of green open spaces and development of infiltration areas. Therefore, this study concludes that flood disaster mitigation-based spatial management needs to be carried out in an integrated manner and based on spatial data, and can be used as a basis for the formulation of spatial planning policies and zoning regulations for flood-prone areas in the city of Balikpapan.

Acknowledgement

We would like to express our deepest gratitude to our supervising lecturer for all her contributions, guidance, and support in the process of preparing and completing this research. We also express our high appreciation to the stakeholders, namely the Balikpapan Regional Disaster Management Agency, the Balikpapan Land and Spatial Planning Agency, and the community in South Balikpapan District, who have taken the time and participated in providing information and support during the implementation of this study. The contributions of all these parties were very significant in completing the data and achieving the objectives of this study.

References

Azila M, Dr. Ir. Abdullah Aman Damai, M. Si., & Adnin Musadri Asbi. (2021). *Guidelines for Space Utilization Based on Flood Disaster Mitigation in Kelumbayan District, Tanggamus Regency.* University of Lampung.

National Disaster Management Agency. (2012). *Regulation of the Head of the National of 2012 concerning general guidelines for disaster risk assessment.* Jakarta: BNPB.

Balikpapan City Regional Disaster Management Agency. (2022). *Balikpapan City Disaster Risk Assessment Document 2022–2026.* Balikpapan: BPBD Kota Balikpapan.

Balikpapan City Central Statistics Agency. (2024). *Balikpapan City in Figures 2024.* Balikpapan: BPS Balikpapan City.

Iswandi, U., & Dewata, I. (2017). *Natural disaster-based settlement area planning and sustainable development policy guidelines in Lima Puluh Kota Regency, West Sumatra Province.* Padang: Padang State University Press.

Balikpapan City Government. (2012). *Balikpapan City Regional Regulation Number 12 of 2012 concerning the 2012 2032 Balikpapan City Spatial Plan.* Balikpapan: Balikpapan Government.

Pozoukidou, G., & Chatziyiannaki, Z. (2021). 15-minute city: Decomposing the new urban planning eutopia. *Sustainability (Switzerland), 13(9),* 1 25.https://doi.org/10.3390/su13020928

Rahmadhani, R. (2023). *Flood Prevention Strategies and Programs in Indonesia.* https://www.researchgate.net/publication/3 70934983

Rahmadhanty, N.R., Muryani, C., Tjahjono, G.A. (2022). Analisis Tingkat Kerentanan Masyarakat Terhadap Banjir Rob Di Kecamatan Tegal Barat Kota Tegal Tahun 2021. *Indonesian Journal of Environment and Disaster*, *1*(1), 73-82. https://doi.org/10.20961/ijed.v1i1.62

Sapoetra, R., Mustofa, U., Pratomo, R. A., & Hidayat, A. (2024). Arahan Mitigasi Bencana Banjir Pada Kecamatan Balikpapan Timur. *COMPACT: Spatial Development Journal*, *3*(1), 167-173. https://doi.org/10.35718/compact.v3i1.11 46

Taryana, A., El Mahmudi, M. R., & Bekti, H. (2022). Analisis kesiapsiagaan bencana banjir di Jakarta. *Jurnal Administrasi Negara, 13* (2), 302-311. https://doi.org/10.24198/jane.v13i2.37997

Law of the Republic of Indonesia Number 24 of 2007 concerning Disaster Management. (2007). *State Gazette of the Republic of Indonesia Year 2007 Number 66.* Jakarta: State Secretariat.

Urbanus, A., Rieneke, L. E. S., & Aristotulus, E. T. (2021). *Structural and non-structural flood disaster mitigation in South Bolaang Mongondow Regency. National Seminar on Geography and Disaster Mitigation.* Manado State University.

Warno, W., Syafari, M. R., Irwansyah, I., & Fitriadi, F. (2025). Flood Management Strategy In Muara Teweh City, North

Barito Regency. *International Journal Political, Law, and Social Science*, *5*(3). Retrieved from https://ijpls.org/index.php/IJPLS/article/view/152