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Flood Disaster Risk Reduction Strategies in Urban Area, Bulukumba Regency

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Abstract

Flood is a disaster that often occurs in big cities in Indonesia, caused by the high density of buildings and the unpreparedness of infrastructure to adapt. Urban Areas of Bulukumba Regency (UABR) is one of the centers of urban areas that has experienced flooding in recent years. The urban area of Bulukumba Regency is a downstream area of the Bialo Watershed whose upstream area is also in the Bantaeng Regency area. Rapid urban development has resulted in a change in land cover to become built-up land so that catchment areas are narrower in the middle and downstream zones, as well as changes in vegetation in the upstream zone which has received land conversion from forest areas to plantation areas. In addition to the potential for flooding due to river flow, the urban area of Bulukumba also has the potential for flooding due to sea tides or tidal floods. The high level of hazard flood potential has not been followed up with sustainable flood management based on disaster risk reduction in the UABR. Based on this, it is necessary to study the level of risk of flooding in the Urban Area of Bulukumba Regency and an appropriate strategy to reduce the risk of flooding in the Urban Area of Bulukumba. The aim of this research is; (1) identify the level of risk of flooding in the UABR; and (2) formulate an appropriate strategy as an effort to reduce the risk of flood disaster in the UABR. The research approach used is the mixed method, with the analytical method used for data processing in the form of risk analysis, spatial analysis namely overlay analysis using GIS software and qualitative descriptive in formulating strategies. The results of this study are a map of the level of flood disaster risk and recommendations for flood risk reduction strategies in the UABR.

1. INTRODUCTION

Based on Law No. 26 of 2007, flooding is an event or condition where an area or land is submerged due to an increased volume of water. A flood is a type of natural occurrence that happens when there is an excess of water that cannot be handled by the area's drainage system due to heavy rainfall. This issue affects the formation of puddles in the area, which could be harmful to the neighborhood (Rahmat, 2014). The relatively high rainfall in a certain time unit, which is better known as rainfall intensity, is one of the main factors causing flooding. Rainfall intensity is the amount of rainfall that occurs in a time periode where the water is concentrated (Loebis, 1992).

Flood disaster is a disaster that often occurs in big cities caused by the increase in human population and climate change. Flood risk is particularly severe in urban areas (Chen et al., 2015). The complexity of urban areas with various economic activities and as the center of population concentration also has a major contribution to climate change. The impact of climate change can increase the potential for disasters, especially hydrometeorological disasters. PVMBG (Hermon, 2012), defines hydrometeorological disasters as events or series of events of floods, landslides, ecosystem damage, land degradation, cyclones and droughts that threaten and distrub people's lives and livelihoods caused by both natural and human factors. resulting in property losses, human casualties, environmental damage, and psychological impacts. In Indonesia, hydrometeorological disasters such as floods and tidal waves are disasters with the most frequent and routine occurrences every year (DIBI BNPB, 2022).

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The Urban Area of Bulukumba Regency (UABR) is one of the centers of urban areas where floods have occurred in recent years. Based on data in the BPBD on Disaster Risk Book for Bulukumba Regency, there are 30 flood points in Bulukumba Regency and 11 points are in the UABR. The UABR is a downstream area of the Bialo watershed who's upstream is also within the Bantaeng Regency area. Rapid urban development has resulted in changes in land cover from open field into built-up land so that the catchment area becomes narrower in the middle and downstream zones, as well as changes in vegetation in the upstream zone which undergo land conversion from forest areas to plantation areas. River silting is also a factor causing flooding and levees which still have little impact on the high risk of flooding in the Watershed (DAS). In addition to the potential for flooding due to river flow, the Bulukumba Urban area also has the potential for flooding due to high tides or tidal flooding. The flood event caused losses in the form of damage to public facilities, the emergence of casualties, environmental damage, loss of property, and inundation of productive land to residential residents.

The UABR is one of the centers of urban areas where floods have occurred in recent years. The urban area of Bulukumba Regency is a downstream area of the Bialo watershed whose upstream is also within the Bantaeng Regency area. Rapid urban development has resulted in changes in land cover from open field into built-up land so that the catchment area becomes narrower in the middle and downstream zones, as well as changes in vegetation in the upstream zone which undergo land conversion from forest areas to plantation areas. River silting is also a factor causing flooding and levees which still have little impact on the high risk of flooding in the Watershed (DAS). In addition to the potential for flooding due to river flow, the Bulukumba Urban area also has the potential for flooding due to high tides or tidal flooding. The flood event caused losses in the form of damage to public facilities, the emergence of casualties, environmental damage, loss of property, and inundation of productive land to residential residents.

Based on this, it is important to study the level of flood risk and an appropriate strategy is needed to reduce the risk of flooding in the UABR. The aim of this research is; (1) identify the level of flood disaster risk in the UABR; and (2) formulate the right strategy as an effort to reduce flood risk in the UABR.

2. METHODS

Method data collection used in the study are field observation/survey, interview, and study literature. The method analysis used for interest data processing is in the form of risk analysis, spatial analysis and descriptive qualitative. Qualitative method conducted to describe the interpretation of cluster risk flood disaster in UABR as well as formulation of the right strategy as effort flood disaster risk reduction.

2.1 Analysis Risk

To understand risk in terms of vulnerability analysis in certain threat situations, you can use the PAR (Pressure and Release) model approach. The Pressure and Release model (PAR model) was introduced as a simple way of how disasters occur when the threat of a disaster impacts the affected community. The basis of this PAR model is that a disaster event is a meeting of two opposing forces (these forces produce processes that produce vulnerabilities on the one hand, and hazards on the other).

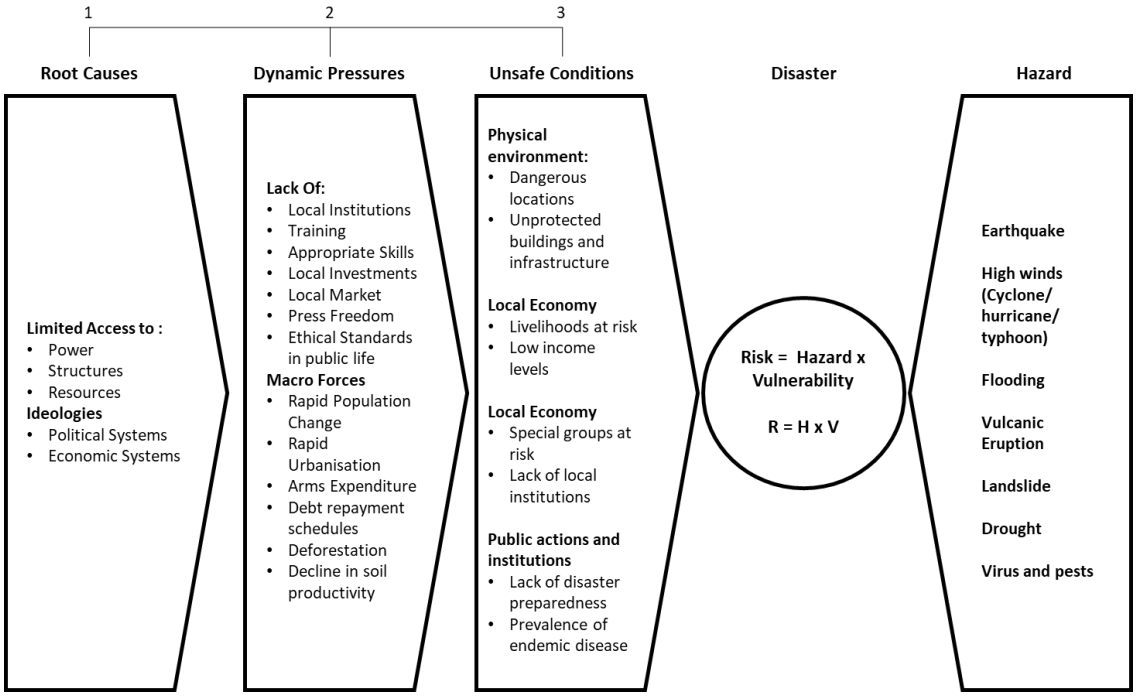


Figure 1. Pressure and Release model: the progression of vulnerability.

the concept of risk analysis is the calculation of the hazard with the affected vulnerability. Analysis risk conducted based on draft risk in change climate, then calculation risk in climate change could be conducted (Esmaiel *et al*. 2022; Gao *et al*. 2023) with formulas:

$R = H \times V$, with (II.1)
$V = f(E, S, C,)$ (II.2)
Description : R = Risk
H = Hazard
V = Vulnerability
E = Exposure
S = Sensitivity
AC = Adaptive Capacity

Table 1. Disaster Risk Matrix Flood

Risk level		Vulnerability index		
		Low	Medium	High
Hazard index	Low			
	Medium			
	High			

Source : Modification form BNPB Perka No 2 (2012); Jibhakate *et al* (2023)

2.2 Analysis Spatial

Analysis spatial is a method analysis performed with to do analysis based on available spatial data. The technique used in the analysis study is technique overlays, that is merging various thematic maps (has specific information/database). The overlay technique is used to determine the potency flood hazard in the Bialo watershed based on the area function parameters that have been set and overlay results tabulation cross Among hazard and vulnerability to determine risk.

The assessment parameters are used for knowing the existence potency of flood disaster in the form of rainfall data, slope, texture soil and land cover. Details assessment are show in Table 2 below.

Table 2. Parameter Determination Level of Flood Hazard

No	Parameter	Score Score	Information	Weight
1	Rainfall Intensity	1	Very low (<127 mm/ mo)	3
		2	Low (127-182 mm/ month)	
		3	Medium (183-291 mm/ month)	
		4	Height (292-346 mm/ month)	
		5	Very high (>346 mm/ month)	
2	Land Cover	1	Vegetation	3
		2	Water Body	
		3	Open space	
		4	Rice fields / Grass	
		5	Settlement	
3	Soil Texture	1	Sand	2
		2	Sand argillaceous	
		3	Clay	
4	Slope	1	Convex (>3%)	2
		2	Flat (0-3%)	
		3	Concave (<0%)	

Source : Haryani, 2017; Aziza *et al.* 2021; Li *et al.* 2023; Jibhakate *et al* (2023)

2.3 Analysis Descriptive Qualitative

Analysis descriptive qualitative is an analysis performed to describe the condition or the situation that happened in the field, where data and information couldn't be analyzed quantitatively, so needs explanation through discussion. Qualitative descriptive in this study is used from the synthesis process of various literature studies and condition of field studies on flood risk. The result of the synthesis than become the basis for preparation of appropriate strategies for reducing flood risk in UABR.

2.4 Variable Study

Variables used in flood disaster risk in urban areas of Bulukumba Regency are as follows:

Table 3. Variable study and details technique

No	Aspect	Variable	Sub Variable	Analysis Method
1	Flood Hazard Index	Determination Parameters index flood hazard	- Rainfall Intensity - Land Cover - Texture soil - Slope	*Overlays* analysis
2	Flood Vulnerability Index	Exposure	- Density population (ratio) - Density building (Ratio)	- Analysis Quantity - Analysis Scoring and Weighting
		Sensitivity	- Poverty rate (Ratio) - Community Development Index (Index)	- Analysis Quantity - Scoring and Weighting Analysis
		Adaptive capacity	- Income per capita (Rupiah) - Green Open Space Area (Percentage)	- Analysis Quantitative - Scoring and Weighting Analysis
3	Flood Risk Index	Hazard Analysis Vulnerability Analysis	- Hazard Index - Vulnerability Index	- Cross Tabulation and *Overlay Analysis*

No	Aspect	Variable	Sub Variable	Analysis Method
4	Disaster Risk Reduction Strategy	Disaster Risk Analysis (Disaster Risk Index)	- Prevention and Mitigation - Preparedness - Emergency response	- Qualitative Descriptive Analysis

Source: Analysis Results, 2022

3. RESULTS AND DISCUSSION

Ujung Bulu District is one of the districts in Bulukumba Regency which is the capital of Bulukumba Regency with an area of 14.44 km^2 which is administrative consists of 9 sub-districts. By astronomical Ujung Bulu district is located between 5° 31'S5° 35'S and 120° 10'E-120° 15'E. Administrative boundaries in Ujung Bulu District are as follows.

a. North : Gantarang District
b. South : Flores Sea
c. East : Ujung Loe District
d. West : Gantarang District

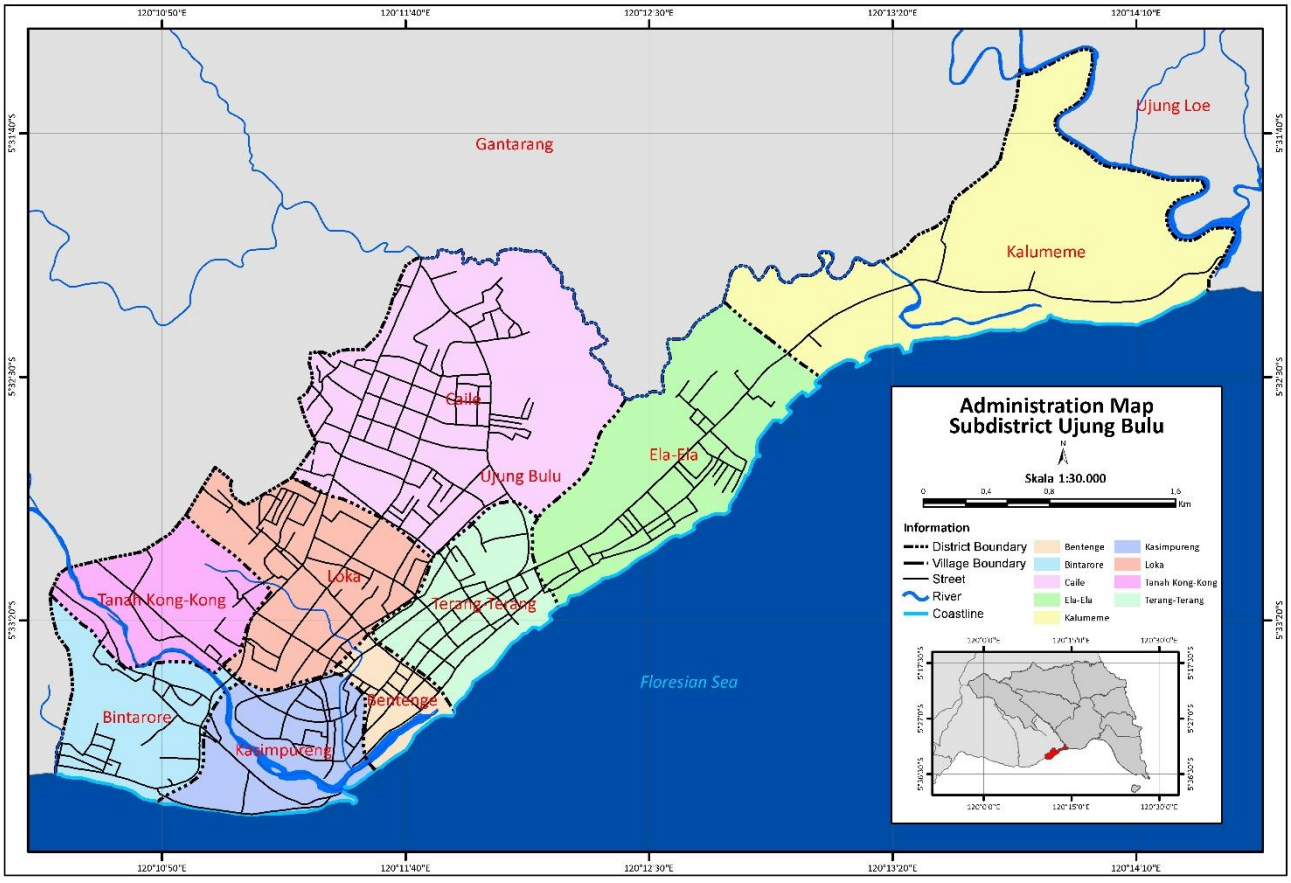


Figure 2. Administration Map

Source: Spatial Plan Bulukumba Regency 2012-2032

Based on the spatial plan of Bulukumba Regency From 2012-2032, Ujung Bulu District entered into the strategic area of the economy which includes area tourism, area trade and area strategic coast with the development of urban with waterfront city concept so that many developments around beach done. Besides that, according to the spatial plan of Bulukumba Regency, the Watershed has the potential to raise flood hazard in UABR. the downstream area of the Bialo watershed with a length of 191.26 km and the Kirasa watershed with a length of 26.50 km is a UABR district that often experiences flooding. (RBI Scale 1:25,000 in 2012 and Interpretation of Spot Imagery 6 in 2016, Bulukumba Regency).

Local Disaster Management Organisation (BPBD) Bulukumba put forward there are 30 points of disaster flood. Based on the survey data amount point disaster flood the most occurred in Ujung Bulu District (UABR) i.e there are 9 dots of incident flood. Besides potency flood consequences Genre River, an urban area of Bulukumba Regency also has potency flood due to tides or tidal floods. The reality indicates that UABR is an area that has the threat of flood disaster.

3.1 Hazard

Hazard is something condition or action or possible potential that raises loss of people, property or environment. Hazard is a source or a hazardous situation and potency for accident or disease in humans, damage to equipment and damage environment. Hazard is all of something including a situation or potential action for raises accident or human injury, damage or other disturbance (Ramli, 2010:57). Potency or threat alone could be grouped into 2, i.e potency main hazard and potency collateral hazard.

The level of hazard is based on the possibility happening disaster and the resulting impact of consequence disaster (BNPB No. 2 of 2012). Hazard follow to flood disaster flood rated very high in urban areas. For example, UABR (Ujung Bulu District) which is the centre of activity society, will impact more disaster-critical an area around. As for parameters used to determine flood hazard in the UABR with method overlays with GIS where combine intensity rain, land cover, texture land, and slope.

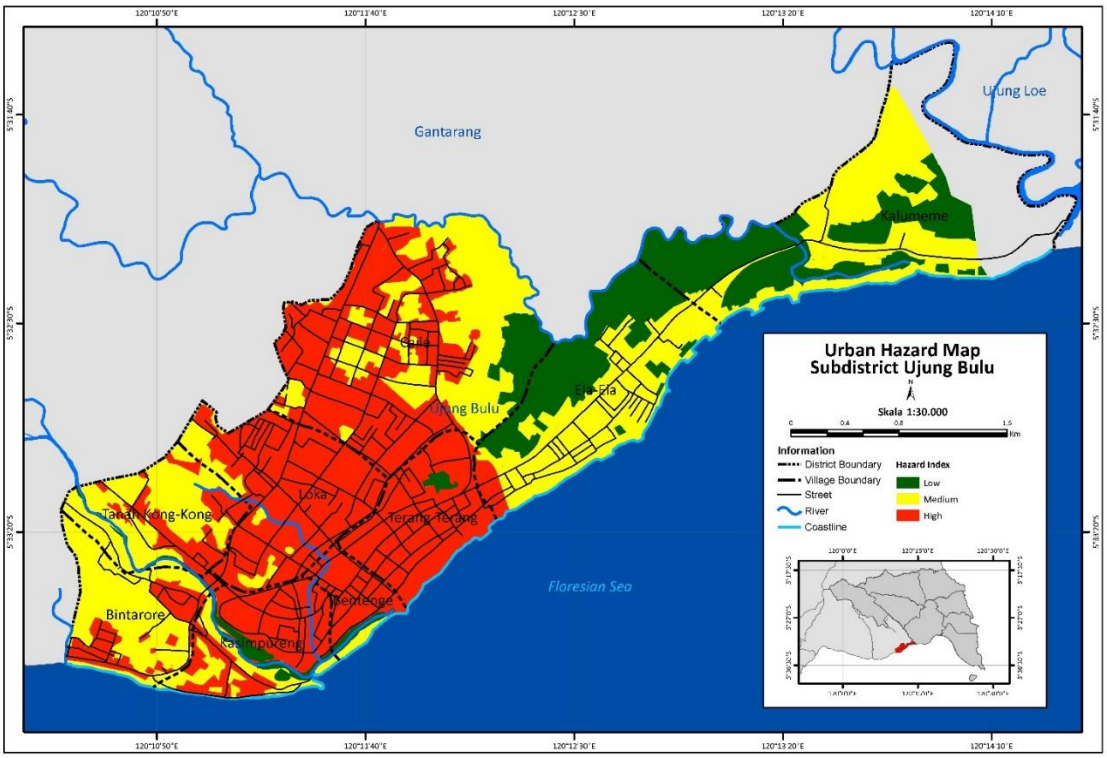


Figure 3. Flood Hazard Map
Source: Analysis Results, 2022

Analysis results overlay hazard flooding in UABR, showing that the level of hazard in the UABR consists of three hazard zones that are high, medium, and low.

3.2 Vulnerability

According to Minister of Environment and Forestry Law Number P.7/Menlhk/Setjen/Kum.1/2/2018, vulnerability is a trend system for impact negative includes sensitivity to impact negative and lacking the adaptive capacity for resolve negative impact. vulnerability of climate change could be studied from three components vulnerability that is exposure, sensitivity, and adaptive capacity. Analysis of vulnerability to potency hydrometeorology hazard (flood) as a consequence of impact climate change, so indicator vulnerability needs consider potency disaster affected. Indicators of vulnerability to disasters due to climate

change are dynamic. vulnerability of flood determined by the parameters of exposure, sensitivity, and adaptive capacity. Indicator vulnerability of this research is served in Table 4.

Table 4. Indicator vulnerability

No	Vulnerability	Indicator
1	Exposure	Density Population
2		Density Building
3	Sensitivity	Human Development Index
4		Poverty level
5	Adaptive capacity	Income per capita
6		Green Open Space Area

Source: Analysis Results, 2022

3.2.1 Exposure

Exposure is a trend for climate change in the future and potential hazard related based on the climate change model, and in some cases, based on records of the meteorological pattern. Exposure was analyzed with method scoring. Assessment parameters in exposure in UABR in the form of density population and density building. Development sector economics in urban areas of Bulukumba Regency is dominated by sector trade, triggering urbanization from village to city. The reality makes lthe evel of density of residents in UABR considered susceptible to flood disaster. Besides that, residents naturally need lodging and buildings like trading area buildings, offices, and other facilities. The existence of more building density is considered susceptible to hydrometeorology hazard (flood) in an area. Data and rate exposure in UABR are served in Table 5.

Table 5. Index exposure

Indicator	Data	Score	Index
Population Density (people /km)	3,397	3	high
Building Density (Ratio)	44.92 %	2	medium
Index exposure		2,5	high

Source: Analysis Results, 2022

The results of the analysis obtained show that the level of exposure in UABR is a population density have 3,397 people/km2 with a score of 3 categories high and building density has a ratio of 44.92% with a score of 2 categories medium.

3.2.2 Sensitivity

Sensitivity is how much a system will be affected or responsive to climate stimuli but can be changed through socio-economic changes. Sensitivity is the extent to which various social systems and economic sectors are impacted by the relevant climate risk. Parameters that determine the level of community sensitivity include the poverty level and the community development index. The higher the sensitivity level of the community, the higher the level of flood vulnerability will be. Disaster events, including hydrometeorological disasters, can reduce the value of the human development index and increase poverty which will have an impact on the city's economic sector. The sensitivity index is obtained by multiplying the weight and score of each indicator. Data and sensitivity level of UABR are presented in Table 6.

Table 6. Index Sensitivity

Indicator	Data	Score	Index
Poverty Rate (Ratio)	7.43%	1	Low
Community Development Index (Index)	69.26	2	Medium
Index Sensitivity		1.5	Low

Source: Analysis Results, 2022

The results of the analysis show that the sensitivity value in the UABR is the poverty rate of 7.43% with a score of 1 being in the low category and the community development index being 69.26% with a score of 2 being in the medium category.

3.2.3 Capacity Adaptive (*Adaptive Capacity*)

Adaptive capacity is the potential or ability of a system to adapt to climate change, including climate variability and extreme climates, so that potential damage can be reduced/prevented. In order to reduce the possible effects of climate change hazards, individuals, families, communities, businesses, or institutions must act individually or collectively. Parameters that determine the level of adaptive capacity include per capita income and the percentage of green open space. Per capita income is the average income of people in the UABR. The higher the level of per capita income, the higher the community's ability to adapt to the economic sector when a hydrometeorological disaster (flood) occurs. The data and level of adaptive capacity of the UABR are presented in Table 7.

Table 7. Index Adaptive Capacity

Indicator	Data	Score	Index
Income Per Capita (Rupiah)	33.80 million	2	medium
Green Open Space Area (percentage)	10.56	3	high
Index Adaptive Capacity		2,5	high

Source: Analysis Results, 2022

The results of the analysis show that the adaptive capacity in the UABR is 33.80 million incomes per capita with a score of 2 in the medium category and the presentation of green open space area of 10.65 % with a score of 2 in the medium category.

The results of the analysis of the parameters of exposure, sensitivity, and adaptive capacity. From the index value of each aspect, the vulnerability index is determined using a matrix. The impact index is carried out by connecting the exposure and sensitivity aspects described as presented in Table 8 below.

Table 8. Matrix Index Impact

Index Impact		Exposure		
		Low	Medium	High
Sensitivity	Low			V
	Medium			
	High			

Source: Analysis Results, 2022

The impact index in Table 8 is high. Furthermore, the results of the impact index matrix are then connected with the adaptive capacity aspect to determine the vulnerability index. The higher the adaptive capacity it has, the lower the vulnerability index will be. The vulnerability index is presented in the following table 9.

Table 9. Matrix Index Vulnerability

Index Impact		Exposure		
		Low	Medium	High
Capacity Adaptive	Low			
	Medium			
	High		V	

Source: Analysis Results, 2022

Based on Table 9, the vulnerability index in the UABR to hydrometeorological disasters is on high level.

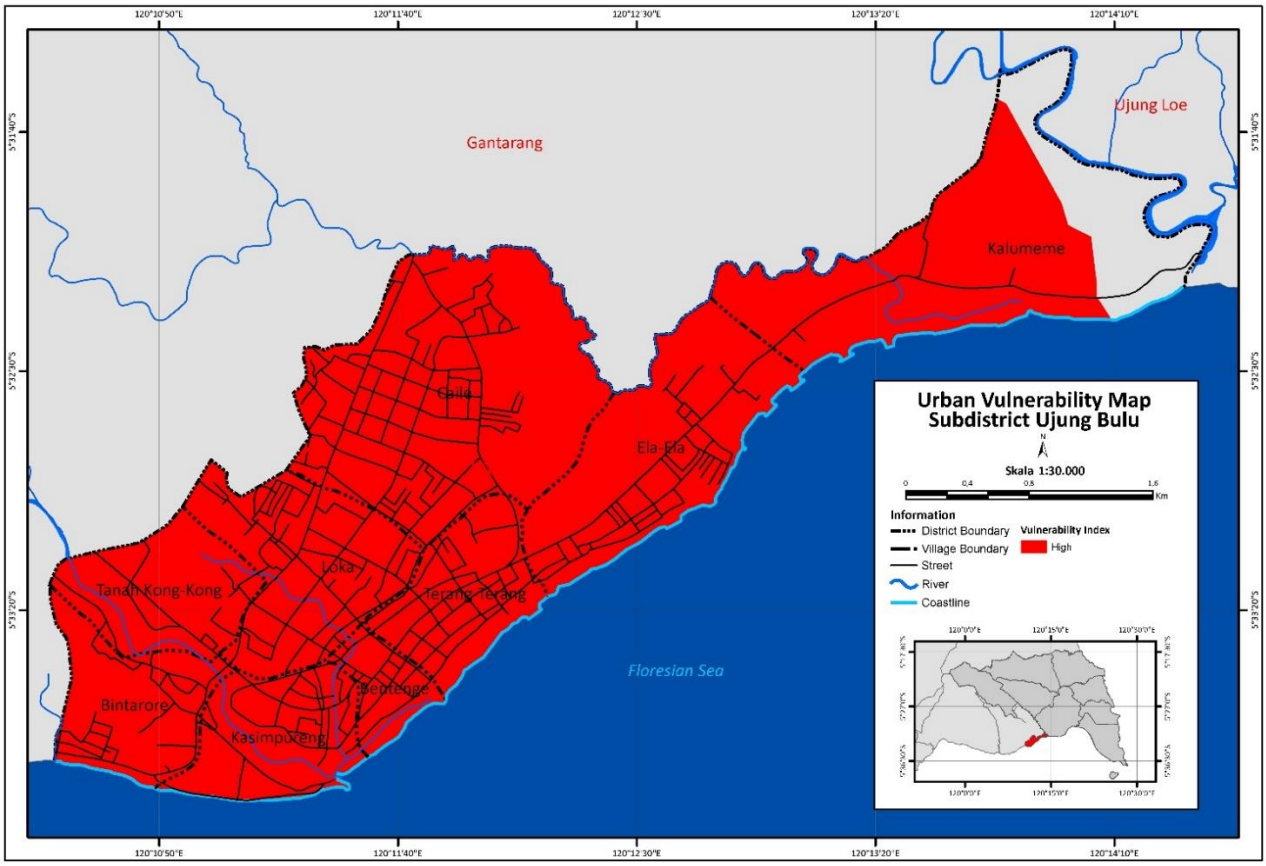


Figure 4. Vulnerability Map Flood
Source: Analysis Results, 2022

3.3 Risk

Regulation of the Head of the National Disaster Management Agency No. 2 of 2012 concerning General Guidelines for Disaster Risk Assessment explains that the level of disaster risk is determined by combining the level of hazard and the level of vulnerability. The assessment of the level of flood risk in the UABR is based on the results of the cross-tabulation between the level of hazard and the level of vulnerability. The results of the analysis of the flood risk level in the UABR are presented in Figure 10 below.

Table 10. Disaster Risk Index Floods in UABR

No	Risk Index	Area(Ha)
1	Medium	186.83
2	High	878.45
	Amount	1065.28

Source: Analysis Results, 2022

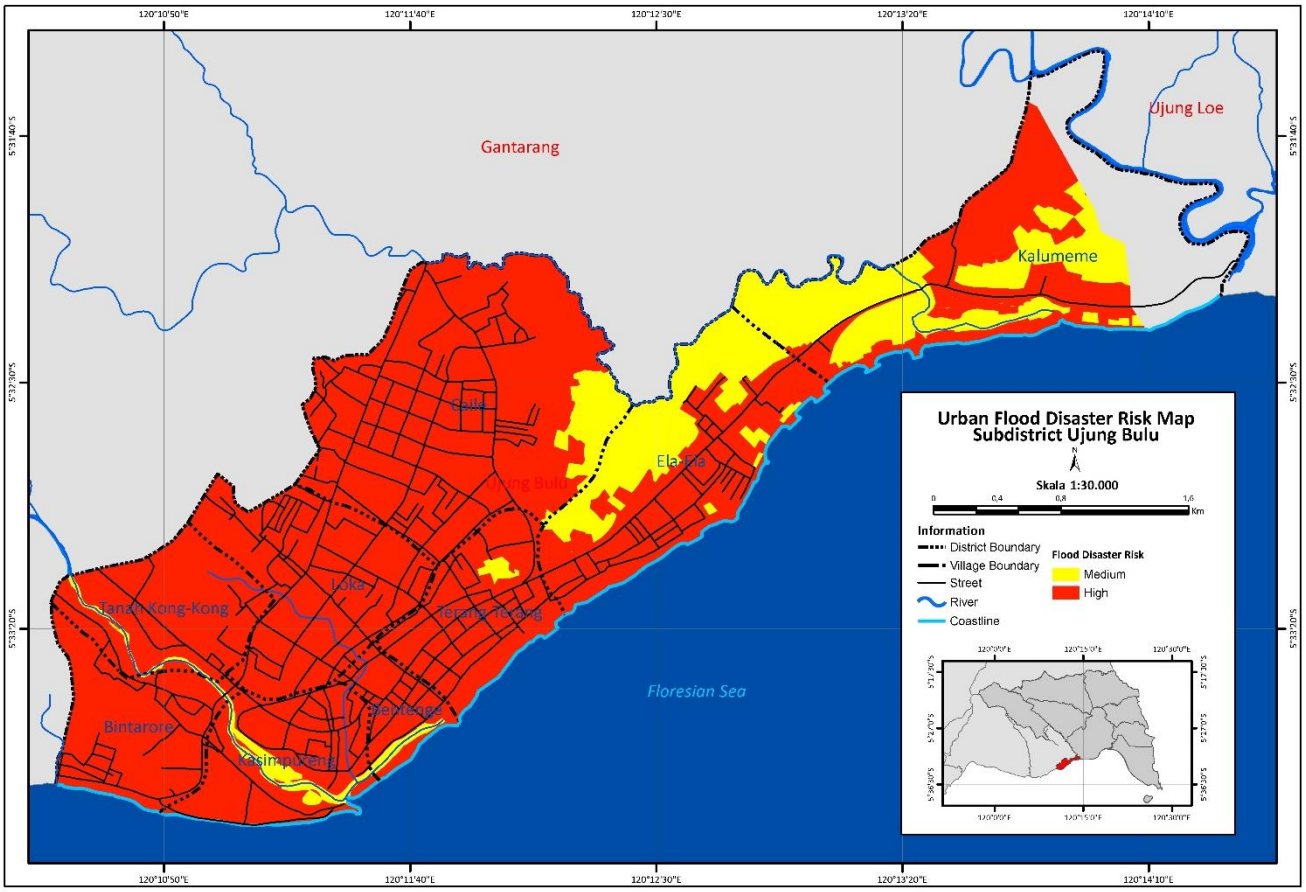


Figure 5. Flood Risk Map
Source: Analysis Results, 2022

The results of the overlay analysis and the results of the cross-tabulation between the level of hazard and the level of vulnerability to flood disaster in the UABR, indicate that the hydrometeorological risk level of the UABR consists of two zones, namely high and medium risk. This condition further emphasizes the need for disaster mitigation efforts as early as possible to minimize the impact of the risks that occur.

3.4 Strategy of Flood Disaster Risk Reduction

Flood disaster risk reduction is a series of efforts in order to reduce the risk of flood disasters with physical development efforts, awareness and increase community capacity in facing threats from flood disasters. Based on the results of a flood risk assessment in the UABR, it is dominated by a high level of risk. The results of a high level of hazard analysis require mitigation interventions and high vulnerability analysis, especially in exposure to disaster and adaptive capacity so a disaster risk reduction strategy is needed. In this study, the flood management strategy carried out by the government and the community is divided into three terms; short, mid and long-term.

3.4.1 Short Term

In the short term (1-5 years), a flood disaster reduction strategy will need to address emergency response and recovery, including an integrated end-to-end flood early warning system, which is socially and legally accepted/ supported by the triple helix, i.e., government, community and private sectors. (Rahayu, 2019). Preparation of SOPs and maps of evacuation plans in the event of a flood, and availability of flood risk information that can be accessed by the public (Rahayu, 2021).

3.4.2 Mid Term

Climate change is the main cause of flooding, so flood management is needed to anticipate future flood hazards. At this stage, both structural and non-structural mitigation strategies are needed.

a. Structural Mitigation
   - Increasing the drainage capacity is one of the countermeasures to deal with future hazards (Rahayu, 2019).
   - Protect and retrofit critical infrastructure, such as the construction of reservoirs and dams as flood control which have benefits for power generation, irrigation of agricultural land, tourism attraction and so on (Asman, 2019)

b. Non-Structural Mitigation
   - Disaster Risk Reduction is included in the RTRW or RPJMD (Asman, 2019)
   - Implementing river zonation (Rahayu, 2021)

3.4.3 Long Term

a. It is crucial to involve local populations in disaster risk reduction initiatives and to build their resilience to better prepare them for prospective disaster situations (Furqon, 2018)
b. Revitalising Informal Settlements and Their Environments (RISE) program (Wolff. E, 2021)
c. There is a SOP emergency response
d. Preparation of basic needs during the emergency response

4. CONCLUSION

The urban area of Bulukumba Regency (UABR) has high, medium, and low flood hazard potentials. This potential can cause harm to humans, property, or the environment. The level of flood vulnerability in the UABR is in the high category with exposure, sensitivity and high adaptive capacity. The results of the overlay analysis and the results of the cross-tabulation between the level of hazard and the level of vulnerability in the UABR, show that the hydrometeorological (flood) level of risk of the UABR consists of two zones, namely high and medium risk. This condition further emphasizes the need for disaster mitigation efforts as early as possible to minimize the impact of the risks that occur.

The handling strategy carried out to reduce the risk of flooding is through efforts in the pre-disaster phase (prevention and mitigation, as well as preparedness) and post-disaster (emergency response). Strategies of flood disaster risk reduction in the UABR is divided into three terms; short-term strategy are emergency response and recovery capabilities; mid-term strategy are structural and non-structural mitigation such as increasing the drainage capacity, protect and retrofit critical infrastruktur, Disaster Risk Reduction are included in the RTRW or RPJMD and river zonation; and long-term strategy is prepared communities to adapt potential disaster in the future and RISE Program.

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