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The Mapping Flood Vulnerability Level at Lilirilau, Soppeng Regency

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ABSTRACT
Every year floods occur in Soppeng Regency. The biggest and the worst flood that ever happened in Soppeng Regency was in 2019, especially in Lilirilau District. There are 4,980 submerged housing units with an average height of 1 to 2 meters. To minimize the risk of damages and losses that occur every year, it is necessary to know the flood causes and to assess the level of vulnerability of the flooding area. This study aimed to assess the physical, social, economic, and environmental vulnerability. Physical vulnerability includes building density, building form, and building structure. Social vulnerability includes population density, vulnerable age population, and toddler population. Economic vulnerability includes workers in the vulnerable sector and income, while environmental vulnerability consists of rainfall intensity, topography, and land use. The research method used was descriptive qualitative while the data obtained were analyzed by using overlays based on each vulnerability variables to produce a regional vulnerability map. The results showed that the vulnerability of Lilirilau District, Soppeng Regency was classified as low and medium class, or not too risky. In addition, the factors that affect the level of vulnerability were social vulnerability in terms of the female sex ratio, economic vulnerability in terms of the agricultural sector, and environmental vulnerability in terms of the closest distance from the river. However, some areas have the high vulnerability, it is areas close to rivers with dense building conditions.

Keywords: *Flood, Vulnerability, Mapping*

1. INTRODUCTION

Vulnerability can be said as a socio-economic, physical, and environmental condition of a community or society that can cause an inability to face a dangerous threat. The bigger the disaster, the greater the loss if humans, the environment, and infrastructure are more vulnerable [1]. Considering that flood disasters can harm the population, it is necessary to study areas that are vulnerable to flooding so that countermeasures can be carried out quickly and precisely [2]. The map of the area's vulnerability to flooding is part of the early warning system of flood hazards so that the consequences of flooding can be estimated and ultimately mapped. According to Perka National Disaster Management Agency (BNPB) No. 2 of 2012, vulnerability can be grouped into four indicators, namely social, economic, physical, and environmental vulnerabilities [3].

In eastern Indonesia, especially in South Sulawesi Province, at the end of January 2019, floods were caused by heavy rains and experienced the worst flooding in the last decade. The South Sulawesi Regional Disaster Management Agency (BPBD) recorded 106 villages in 61 sub-districts spread over 13 districts/cities [4]. One of the areas in South Sulawesi that is often hit by floods every year is Soppeng Regency. The reason Soppeng Regency is an area that usually experiences flooding every year is the overflow of Lake Tempe and the overflow of the Walannae River [5]. The vulnerable area around Lake Tempe and often affected are Marioriawa District and Donri-Donri District, even though the overflow effect of the Walannae river causes flooding in the districts of Lilirilau, Ganra, and Liliriaja.

Lilirilau Subdistrict, which is passed by the Walannae River, is the most populous sub-district compared to Ganra and Liliriaja Subdistricts. This sub-

district is starting to develop in Soppeng Regency with a population that continues to increase every year. Therefore, the need for land also increases, which will impact the degradation of environmental quality, thereby accelerating the intensity of flood disasters. Almost every year, floods in Soppeng Regency occur during the rainy season. Many damages and losses were caused by floods, both physically, socially, and economically. The flood disaster is also very influential on other sectors that can hinder urban development activities. The most crucial factor is in the transportation sector, which affects the damage of the roads structure, bridge, and congestion. It disrupts economic growth [6].

The large number of vulnerable people occupying an area can cause the region's inability to face the threat of flooding. The social condition of the population is the main factor that most influences the vulnerability of the region to flood disasters. It can even pose a high risk if it is involved in a flood-prone area. Lilirilau Sub-district which is prone to flooding when viewed from the gender ratio of 89.1 [6] it can be said that this region is very vulnerable. It means that the sex ratio is below 100, which the female population (vulnerable population) is more than the male population. However, there are several other factors that can affect social vulnerability, they are population density and other vulnerable populations (old age and toddlers) [7].

Besides social conditions, there are economic, physical, and environmental conditions that need to be considered when looking at an area prone to flooding [8]. There are two environmental factors that have the potential to affect the level of vulnerability of the Lilirilau District, namely the topographical height, which most of the area is at an altitude of <20 masl ([9) and the flow of the Walannae River which passes through several villages in the sub-district as have described before about the causes of frequent flooding in this area. Lilirilau District is a rural area where the majority of the population work as farmers and work in other vulnerable sectors so that the threat of flooding in this area can adversely affect the level of welfare or the economy of the community.

The high vulnerability factor in areas that are prone to flood threats which trigger the high risk or losses caused by floods, it is necessary to have disaster mitigation or efforts to minimize the possibility of flood disaster risks that can occur. To analyse flood risk, there are several variables that are needed, namely threats/hazards and vulnerability factors [10].

Based on the problem mentioned above, the writers formulated two research questions, they are: 1) what is the level of vulnerability of the Lilirilau District, Soppeng Regency to flood disasters? and 2) what causes the level of vulnerability of the Lilirilau District to flood disasters?

2. METHOD

This study applied descriptive quantitative research. It analyzed the level of regional vulnerability to flooding disasters which produces a map of regional vulnerability flood disasters in Lilirilau District, Soppeng Regency. This research found out the information and actual conditions that presented the data in the form of numbers. In addition, the information about areas flood-prone is crucial. Thus, a map of flood-prone was used to obtain more information in Lilirilau District, Soppeng Regency.

This research used quantitative data. There are two instruments used in this study, namely primary and secondary data. The primary data included the distribution of residential locations, the results of observations of flood-prone points, while secondary data (data obtained from various sources of scientific literature, scientific books, documentation materials, and agencies related to the problems in this research). The secondary data in this study is taken from the Central Bureau of Statistics of Soppeng Regency, the Geospatial Information Agency, and various articles from national and international journals.

The data analysis method for flood vulnerability used a weighted tiered quantitative analysis by grading and weighting each physical parameter. The process of analysing the data is divided into two, namely: attribute analysis and spatial analysis. Attributing is the process of assigning attributes or information to a coverage. This assigning attribute is easier to be done in ArcGIS, because the procedure is less complicated. The attribute analysis process is divided into two parts, namely classification, scoring, and weighting.

a. Classification and Scoring

   The classification refers to the class division of each digital map. Scoring is intended as a score for each class. The scoring is based on the effect of the class on the magnitude of the risk of flooding.

b. Weighting

   The weighting refers to giving weight to each thematic map (parameter). The determination of the weights for each thematic map is based on the consideration of how much the flood vulnerability is affected by each parameter that will be used.

Table 1. Vulnerability Variable Weights and Scores

Variable		Score	Weight	Criteria	Total Weight
Social Vulnerability	Population density	1	40%	0 - 63 jiwa/ha	40%
		2		64 – 106 jiwa/ha	
		3		107 – 149 jiwa/ha	
	Older population and toddlers	1	35%	<20%	
		2		20% - 40%	
		3		>40%	
	Female population	1	25%	92,38 – 98,88 (sex ratio)	
		2		98,89 – 105,39 (sex ratio)	
		3		105,4 – 111,9 (sex ratio)	
Economic vulnerability	Percentage of poverty rate	1	60%	11,54% - 23,00%	25%
		2		23,01% - 34,47%	
		3		34,48% - 45,94%	
	Percentage of families working in vulnerable sectors	1	40%	< 3 %	
		2		3-5 %	
		3		>5 %	
Physical Vulnerability	Building density	1	100%	< 18 building/ha	25%
		2		18-34 building /ha	
		3		> 34 building /ha	
Environmental Vulnerabilities	Topographical elevation	1	20%	>300 mdpl	10%
		2		20 – 300 mdpl	
		3		<20 mdpl	
	Rainfall intensity	1	30%	<1000 mm/th	
		2		1000-2500 mm/th	
		3		>2500 mm/th	
	Land use	1	20%	Wasteland > 50%	
		2		Agriculture & Office > 50%	
		3		Settlement & Industry > 50%	
	Distance from river	1	30%	>1000 meter	
		2		500 – 1000 meter	
		3		<500 meter	

In this study, to make Flood Vulnerability Map, the arithmetic method used from the flood vulnerability parameters is a multiplication method between the score and the weight of each flood vulnerability parameter. Moreover, the interval value of the flood vulnerability class can distinguish between one flood vulnerability class and another. The formula used to create an interval class is:

$$\text{Ki} = \frac{Xt - Xr}{k}$$ *Source: Kingma in Wismarini, 2015*

Explanation:

Ki : Interval Class

Xt : Highest Data

Xr : Lowest Data

k : Total Class used

Vulnerability = (0.4 x social vulnerability score) + (0.25 x economic vulnerability score) + (0.25 x physical vulnerability score) + (0.1 x environmental vulnerability score).

Table 2. The Flood Vulnerability Map will be divided into three levels, namely Low, Medium, and High.

Vulnerability	Score
Low	1 – 1,7
Medium	1,8 – 2,3
High	2,4 - 3

3. RESULT AND DISCUSSION

The results of the data analysis showed that the level of vulnerability in Lilirilau District to flood disasters are found in two classes, namely class 1 (low) and class 2 (medium). It means that if the Lilirilau District is faced with a flood disaster, the area is not too risky or low risk. The low-class villages include Masing, Parenring, Abbanuangnge, Tetewatu, Baringeng, Palangiseng, and Paroto village. There is also a low class in a small area of Kebo and Macanre Village. Moreover, class 2 (medium) includes all areas of Pajalesang, Cabenge, and Ujung Village. Not only those villages but also most areas of Kebo and Macanre Village, and a small area of Palangiseng Village including grade 2 (medium).

Based on the results of the analysis of all regional vulnerability variables, namely social, economic, physical, and environmental vulnerability, it can be seen on the vulnerability map of the Lilirilau District below that there are two classes of vulnerability, namely low and medium. Lilirilau District area can be said as not too risky if there is a threat of flood disaster.

Areas that are classified as a low class are caused by factors of physical vulnerability and environmental vulnerability that are not vulnerable or low class. The variables that greatly affect physical vulnerability are building density, while the environmental vulnerability is the distance from the river and the topography of the area that is not vulnerable to flooding. The further the area is from the river, the less vulnerable it is to flooding. Likewise with topography, the higher an area is, the less vulnerable it is to flood disasters. Meanwhile, areas that are classified as medium class are caused by social, economic, and environmental vulnerability factors in the medium class. The most influential variable in this medium class is the distance of the area from the river. This medium vulnerability class area is around the Walannae River flow.

Table 3. Level of Vulnerability Analysis of the Lilirilau District

Social, Physical, Economic, and Environmental Vulnerability	The Value of Vulnerability Score x Weight	District Area Vulnerability to flood disaster
Low/Low/Medium/Low	1.25	Low
Medium/Low/Medium/Low	1.65	Low
Medium/Low/Medium/Medium	1.75	Medium
Medium/Low/Medium/High	1.85	Medium

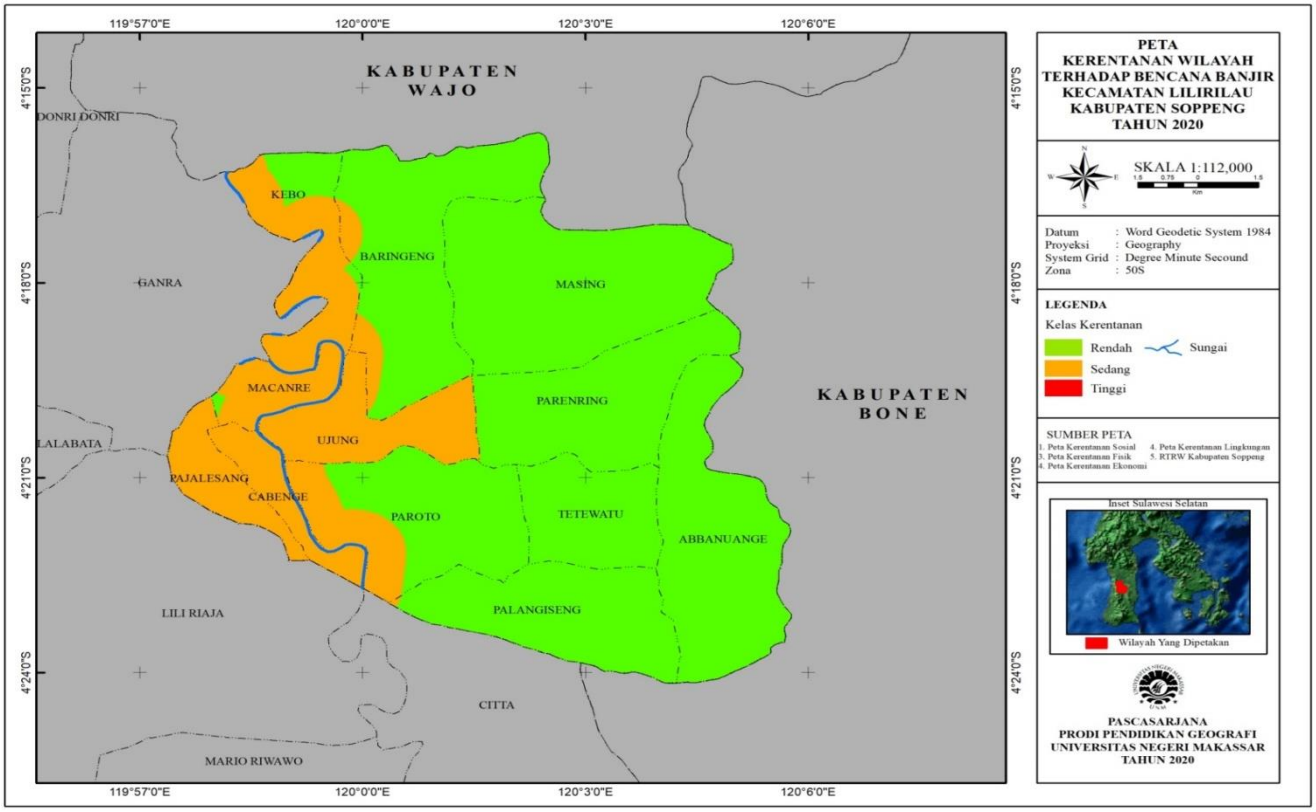

Figure 1. Map of regional vulnerability to flood disasters Kecamatan Lilirilau, Kabupaten Soppeng

4. CONCLUSION

The vulnerability of the Lilirilau District area is classified as low and medium, or not too risky if it gets a flood threat. Although Lilirilau District is one of the sub-districts in Soppeng Regency that hit by floods every year.

Several factors that influence the level of vulnerability of the Lilirilau District in flood disasters are social vulnerability in terms of the high female sex ratio, economic vulnerability in terms of the highest percentage of the population working in vulnerable sectors, and environmental vulnerability in terms of the distance from the river. In addition, topography belongs to the highly vulnerable class. However, in this study, the distance region variable from the river has a significant effect based on the results of data analysis. The area of “moderate” vulnerability is around the main river of Walannae.

Areas around the main river Walannae can have a high level of vulnerability if the physical conditions (physical vulnerability) such as the density of buildings in this area are classified as a dense or highly vulnerable class. This factor makes the area around the river not classified as a highly vulnerable class because the entire area of the Lilirilau District is a rural area that is not built densely.

AUTHORS’ CONTRIBUTIONS

1. Author 1 as the head of the research implementer is responsible for coordination and research ideas and Corresponding author
2. Author 2, 3, 4, acted as the initial problem analysis at the research site and helping data analysis and finalizing article manuscripts and acts as a data collector in the field

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