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FLOOD IDENTIFICATION BY UTILIZING REMOTE SENSING AND SPATIAL ANALYSIS TECHNIQUES IN PADANG CITY

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ABSTRACT : Natural disasters floods are the most common disasters found almost everywhere, floods can cause damage and can even take lives. The city of Padang is often hit by flood disasters which result in damage and loss for those affected. This research aims to 1) To find out the results of identifying flood-prone areas by utilizing remote sensing and spatial analysis techniques in Padang City; 2) To determine the level of flood vulnerability by utilizing remote sensing and spatial analysis techniques in Padang City. This research uses an overlay method which combines several parameters. Parameters for identifying areas that have the potential for flooding in this research include slope, rainfall, land use, elevation, soil type, and river buffer. Each of these parameters is given a different scoring value and weight, then an overlay analysis is carried out and a flood hazard map will be produced as a result of the combination of parameters used. After obtaining the results from the overlay analysis of all parameters, the map of potential flood areas will be divided into 3 vulnerability classes, namely low, medium and high vulnerability classes. The results of the research are that the low vulnerability class has an area of 33854.4 ha with a percentage of 49% of the total area of Padang City, the medium vulnerability class has an area of 26337.6 with a percentage of 38.2% of the total area, and the high vulnerability class has an area of 8823.3 ha with a percentage of 12.8% of the total area.

Keywords: Flood, Scoring, Overlay, Remote Sensing, Spatial Analysis Techniques

1. INTRODUCTION

Natural disasters are a phenomenon that can occur at any time, anywhere and at any time. According to Republic of Indonesia Law Number 24 of 2007 Article 1 Paragraph 1 concerning Disaster Risk Management, states that a disaster is an event or series of events that threatens and disrupts people's lives and livelihoods caused by both natural and non-natural factors as well as human factors, resulting in the incidence of human casualties, environmental damage, property loss, and psychological impacts. According to Nurjanah et al (2013: 21), there are three factors that cause disasters, namely: 1) Natural factors (natural disasters), namely due to natural phenomena and without human intervention; 2) Non-natural factors (non-natural disasters), namely causal factors that are not caused by nature and are not the result of human actions; 3) Social or human factors (man-made disasters), namely the causes of disasters caused by human actions, for example horizontal conflict, vertical conflict and terrorism.

Natural disasters: floods are the most common disasters found in almost all places, floods can cause damage, loss and can even take lives. Flood disasters have become a problem for humans throughout the world, this disaster is caused by natural events, human activities and activities. Almost all regions in Indonesia experience significant flood disasters and one of them is the city of Padang.

The city of Padang is located on the west coast of the island of Sumatra with an area of 694.96 km2. There are 5 large rivers and 16 small rivers that pass through this city (Cipta Karya, 2014). The city of Padang in its development refers to the old city located at the mouth of the river. Batang Arau and the development of city expansion based on the central point of the old city (Mentayani, Hadinata, & Prayitno, 2013). Padang City is a city with a fairly high frequency of rain and rainfall. Almost every year, several parts of the city of Padang experience flooding when there is high intensity rain.

In September 2020 floods hit Padang City at several points. Head of the Padang City BPBD Emergency and Logistics division, Sutan Hendra, said the flood was caused by high intensity rain. Floods inundated residents' houses and disrupted transportation routes with air concentrations ranging from 50-70 cm. It was recorded that 6 sub-districts experienced flooding, namely Pauh, Bungus Teluk Kabung, Nanggalo, Kuranji, Koto Tangah, and South Padang. It is estimated that around 500 residents' houses were submerged and around 20 families were forced to evacuate. Flooding also occurred in September 2021 due to the fairly high intensity of rain from day to night. According to a report from the Padang City Disaster Management Agency (BPBD), there were 16 flood points with varying depths with the worst being in the Tabing Banda Gadang Jondul Rawang, Dadok bungul Hitam and Lubuk

Buaya sub-districts with heights ranging from 30 cm to 1 m. As a result of this flood, around 300 residents had to be evacuated.

In remote sensing there is a concept called image interpretation. According to Este and Simonett (1975), image interpretation can be defined as the act of examining aerial photos or images with the aim of identifying objects and assessing their significance. One indicator of flooding that can be recognized through interpretation techniques is landforms. The characteristic of areas that are prone to flooding is that they have higher levels of soil moisture than areas that are not prone to flooding. These indicators are through bodies of water, landform appearance, soil moisture, aquatic vegetation, and man-made measures to overcome flooding. Flood indicators, for example the alluvial plain landform in the flood target area, will have a high level of flood vulnerability. However, soil moisture levels in alluvial plains which are often subject to flooding are higher than those in areas which are not subject to flooding.

To provide information regarding potential flood disasters in Padang City, mapping of areas that are potentially prone to flooding is very necessary. Mapping of areas that have a flood risk level needs to be carried out so that the government can take appropriate policies to deal with it. To obtain data or maps about areas that are potentially prone to flooding in Padang City, one method was chosen, namely Landsat 8 OLI image data processing. So that we can know the distribution of flood vulnerability levels from inundation in the form of inundation area in each flood vulnerability class in Padang City.

Based on the description presented above, research will be carried out examining the identification of potential flood areas using remote sensing and spatial analysis techniques in the city of Padang.

METHODES

1.1. Research Tools

The tools used in this research are as follows, presented in the following table:

Table 1. Research Tools

No	Tool	Utility
1	Laptop	As an analyst and data processor related to research using the ENVI and ArcGIS applications
2	Supporting hardware such as mouse and printer	Makes it easier to process data on a laptop

1.2. Research Materials

The materials used in this research are as follows, presented in the following table:

Table 2. Research Materials

No	Material	Year	Source	Utility
1	Landsat 8 OLI Image (17-07-2021; cloud cover : 9,53)	2021	USGS	To create a land use map
2	Rainfall Data	2021	CHIRPS	To create a rainfall map
3	Indonesian Administration Shapefile	2019	Indonesia Geospasial	To create administrative maps and other map purposes
4	Soil Type Shapefile	2005	Indonesia Geospasial	To create a soil type map
5	DEM (30 m)	2014	Indonesia Geospasial	To create slope maps and elevation maps
6	River Shapefile (scale 1 : 50,000)	-	Indonesia Geospasial	To create a river buffer map

1.3. Data Types and Sources
The types and sources of data required in this research are as follows:

Table 3. Research Data Sources

No	Data Type (Secondary)	Data source
1	a. Landsat 8 OLI Image	https://glovis.usgs.gov/app
	b. Rainfall Data	https://www.chc.ucsb.edu/data/chirps
	c. Indonesian Administration Shapefile	https://www.indonesia-geospasial.com/2020/04/download-shapefile-shp-batas.html
	d. Soil Type Shapefile	https://www.indonesia-geospasial.com/2020/04/download-shapefile-shp-jenis-tanah.html
	e. DEM (30 m)	https://www.indonesia-geospasial.com/2020/01/download-dem-srtm-30-meter-se-indonesia.html
	f. River Shapefile	https://www.indonesia-geospasial.com/2020/01/download-peta-rbi-per-wilayah-se.html

1.4. Data collection technique
1.4.1. Documentation
A collection of data by looking directly at related document sources. In other words, documentation is data collection through written or electronic documents. Used to support the completeness of other data. Documentation plays a role in collecting documents in the form of recording specific sources of information related to research studies. Data obtained or collected such as journals and theses/final assignments, whether written or electronic. The written data collected here was obtained from previous student research. Meanwhile, to obtain data in electronic form, it is done by downloading.
1.4.2. Literature Review
Literature review in scientific research is an important part of the overall research method steps. Cooper in Creswell stated that literature review has several objectives, namely; inform readers of the results of other research that are closely related to the research being conducted at that time, link research with existing literature, and fill in gaps in previous research. 11 Apart from that, literature review not only prevents duplication of other people's research. others, but also provide the understanding and insight needed to place the research topic we are conducting in a logical framework.

1.5. Data analysis Technique
1.5.1. Analysis of Determining Factors of Flood Vulnerability

Table 4. Scores and Weighting of Flood Vulnerability Parameters

No	Parameter Map	Classification/Class	Score	Weight (%)
1	Slope	<8 % (Flat)	9	
		8 – 15 % (Slopes)	7	
		15 – 25 % (Wavy)	5	10
		25 – 40 % (Steep)	3	
		>40 % (Very Steep)	1	
2	Rainfall	>2500 mm	9	
		2001 – 2500 mm	7	
		1501 – 2000 mm	5	25
		1000 – 1500 mm	3	
		<1000 mm	1	
3	Land Use	Open land, water bodies, ponds	9	
		Settlements, rice fields	7	
		Plantation, moor	5	25
		Mixed gardens, shrubs	3	
		Forest	1	
4	Soil Type	Vertisol, oxisol	9	
		Alfisol, ultisol, molisol	7	10
		Inceptisol	5	
		Entisol, histosol	3	

No	Parameter Map	Classification/Class	Score	Weight (%)
		Spodosol, andisol	1	
5	Elevation	0 – 20 masl	9	
		21 – 50 masl	7	
		51 – 100 masl	5	20
		101 – 300 masl	3	
		>300 masl	1	
6	River Buffer	0 – 25 m	9	
		25 – 50 m	7	
		50 – 75 m	5	20
		75 – 100 m	3	
		>100 m	1	

Source : (Kusumo & Nursari, 2016)

1.5.2. Scoring

After each parameter has been given a score or value and weight according to the reference table, the next step is to overlay the entire parameter map and continue by calculating the vulnerability index using the following arithmetic formula:

$$FV = (10\ x\ S) + (25\ x\ LU) + (15\ x\ R) + (10\ x\ ST) + (20\ x\ E) + (20\ x\ RB)$$

Information :
FV : Flood Vulnerability
S : Slope
LU : Land Use
R : Rainfall
ST : Soil Type
E : Elevation
RB : River Buffer

The formula above is based on AHP analysis using the Pairwise Comparison method to determine the level of importance or priority scale of each parameter. The parameter with the highest weight is the parameter with the most influencing factors on the occurrence of flooding. Then the determination of areas with potential for flooding is carried out by analyzing the results of the overall calculation of parameters to be classified. According to Saputra, (2013) in determining the interval for flood vulnerability levels in classification the following formula is used:

$$I = \frac{R}{K}$$

Information :
I : Interval width
R : Range or difference between the highest data value minus the lowest data
K : Number of class intervals

2. RESULTS AND DISCUSSION

The results of this research consist of 7 class or classification maps, including slope map, rainfall map, land use map, soil type map, elevation/height map, and river buffer map, as well as an overlay map of the six previous parameter maps. , namely a map of flood-prone areas.

2.1. Slope Class Map

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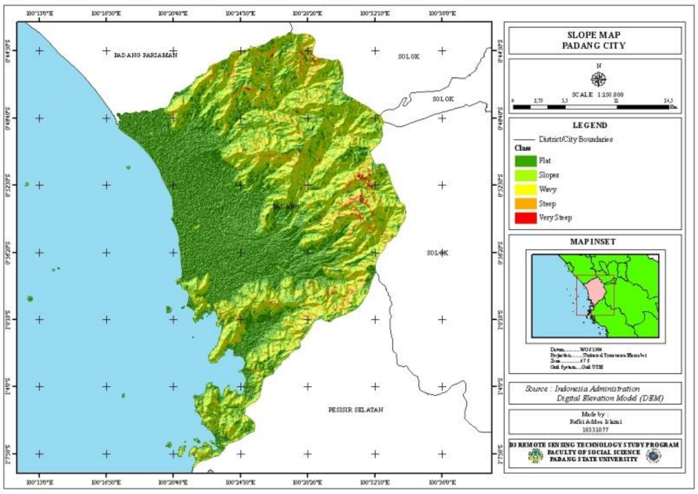

Figure 1. Slope Map of Padang City

The map above shows that Padang City has 5 slope classes. The class that has the largest area and percentage is flat (<8%) with an area of 41,667.5 ha with a percentage of 60.4%, of which this flat class has the greatest potential for flooding. Meanwhile, the slope class with the smallest area is very steep with an area of 72.4 ha with a percentage of 0.1%.

2.2. Rainfall Class Map

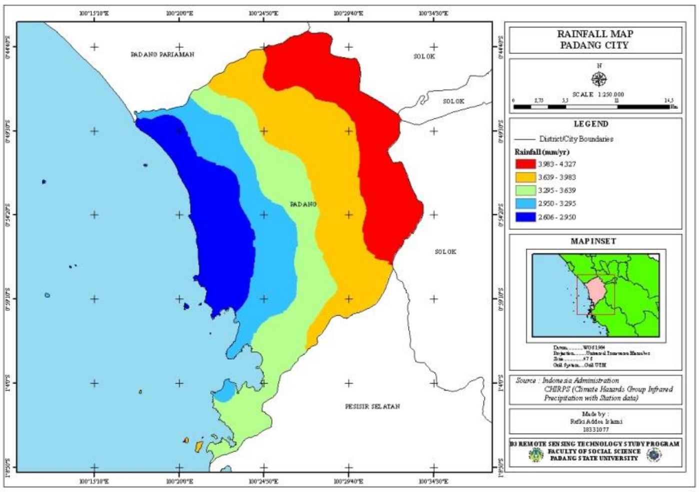

Figure 2. Rainfall Map of Padang City

Padang City has a high average rainfall in 2021, namely between 2,606 mm/year to 4,327 mm/year. Judging from the annual rainfall, Padang City only has one rainfall class, namely >2500 mm.

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2.3. Land Use Classification Map

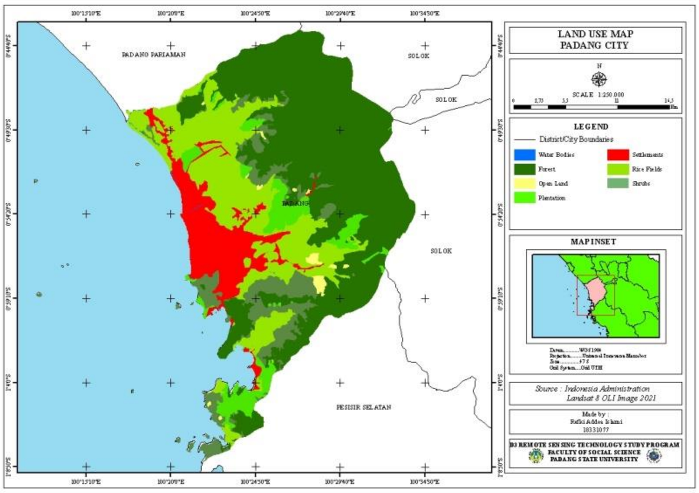

Figure 3. Land Use Map of Padang City

From the map above it is shown that Padang City has 7 land use classifications, including water bodies, settlements, bushes, forests, open land, rice fields and plantations. Forests are the largest land use, namely 33,154.3 ha with a percentage of 48.6%, which is almost half the area of Padang City. Meanwhile, the smallest land use is water bodies, namely 257.9 ha with a percentage of 0.4%.

2.4. Soil Type Classification Map

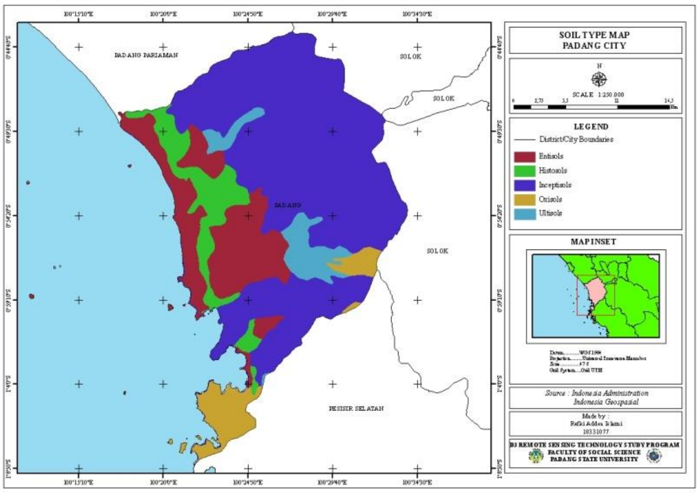

Figure 4. Soil Type Map of Padang City

The city of Padang itself has 5 classifications of soil types, namely oxisol, ultisol, inceptisol, entisol and histosol. The inceptisol soil type is the dominant soil type and the area of this soil type is more than half of the area of Padang City with an area of 41,616.5 ha and a percentage of 60.9% of the total area of Padang City. Meanwhile, the type of soil that has the smallest area is the ultisol type of soil with an area of 3,479 ha with a percentage of 5.2% of the total area of Padang City. Classification is based on order classification.

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2.5. Elevation Class Map

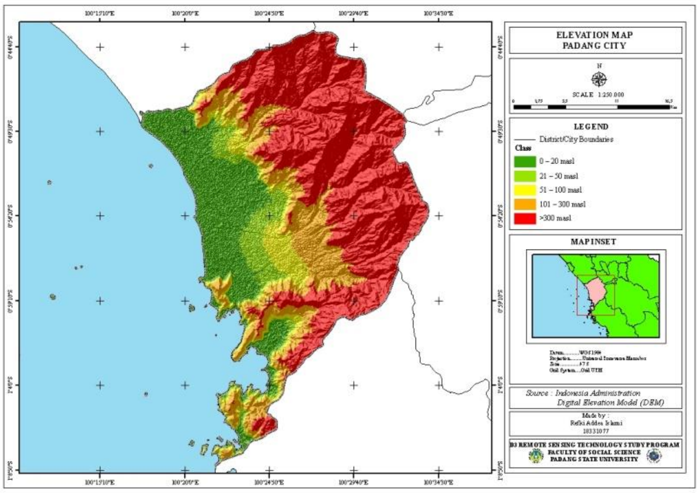

Figure 5. Elevation Map of Padang City

The map above shows that in Padang City there are 5 elevation classes, 0 – 20 meters above sea level, 21 – 50 meters above sea level, 51 – 100 meters above sea level, 101 – 300 meters above sea level, and >300 meters above sea level. The land height class >300 meters above sea level is the largest class in Padang City with an area of 35,178.8 ha and a percentage of 51%.

2.6. River Buffer Class Map

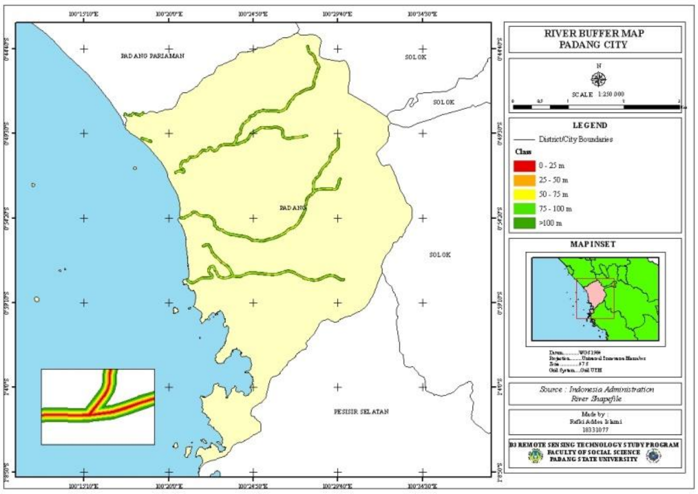

Figure 6. River Buffer Map of Padang City

The Padang City buffer map has 5 classes and each class has a different area. The five classes in question are distances 0 – 25 m, 25 – 50 m, 50 – 75 m, 75 – 100 m, and >100 m.

2.7. Overlay and Weighting

In determining the level of areas that have the potential for flooding, an overlay or overlapping of various variables determining potential flood areas is carried out using the scoring method, namely giving weights and scores to each parameter used. From the results of the overlap, the area with the largest total score is the area with the potential for flooding, while the area with the smallest score is the one with the lowest potential for flooding. Determination of scores and weights has been previously explained in the scoring table.

The potential flood map is the result of overlaying rainfall maps, slope maps, elevation maps, soil type maps, land use maps and river buffers. This aims to determine areas that have the potential for flooding in Padang City. Determining the level of areas that have the potential for flooding is based on the cumulative score obtained from all parameters. The results of the cumulative score are then classified into 3 flood vulnerability classes.

The class range from the table is obtained from the total weight calculation with the score for each parameter that causes flood hazards. By using the formula:

$$I = \frac{R}{K}$$

$$I = \frac{880 - 15}{3} = 288{,}3$$

Information :
I : Interval width
R : Range or difference between the highest data value minus the lowest data
K : Number of class intervals

2.8. Map of Potential Flood Areas

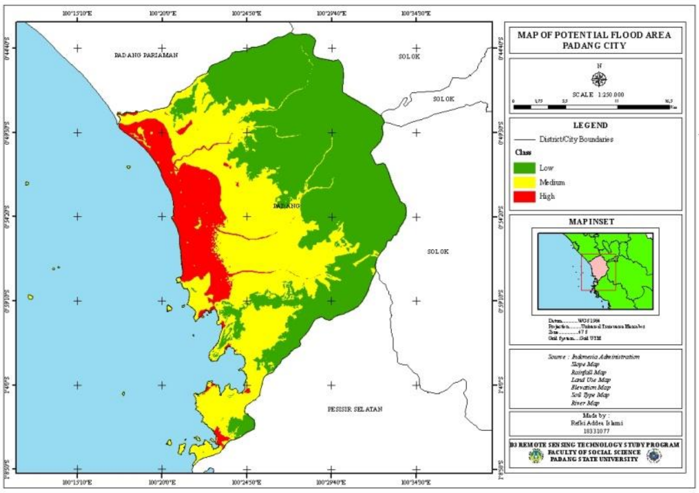

Figure 7. Map of Potential Flood Areas in Padang City

Table 5. Flood Potential Level

No	Intervals	Class	Area (ha)	Percentage (%)
1	15 – 303,3	Low	33854,4	49
2	303,3 – 591,6	Medium	26337,6	38,2
3	591,6 - 880	High	8823,3	12,8
	Total		**69015,3**	**100**

Source: Author Data Processing, 2023

Zones with high vulnerability are said to be areas that are critical for potential flooding. In general, areas that have the highest level of potential flooding are those that are close to the coast and those that are close to rivers. This is apart from the fact that the river flow in Padang City in this area is also supported by quite high rainfall. If you look at the overlay map, high flood potential zones are usually located in areas that have water bodies or land use, water bodies and the distance is close enough to the buffer area so that if it rains, it will be easier to experience excess water discharge. Another factor that causes this high flood class is the geomorphological structure, areas in high flood potential zones have lower areas compared to other areas. Meanwhile, the soil types consist of entisol and histosol, where this type of soil is quite difficult to absorb water into the soil. This area which has high flood potential has the smallest area compared to other flood potential classes, namely 8,823.3 ha with a percentage of 12.8%

Meanwhile, zones with moderate vulnerability are dominated by land use in the form of residential areas, rice fields, bushes and plantations. This is because in residential areas it is quite difficult and there are even no drainage channels. This is also supported by the fact that drainage is not good so that if it rains the water will overflow. Shrub plants/plants are also among the plants that have difficulty retaining surface water, causing the water to stagnate and when the rainy season occurs the water will overflow too. The soil types in areas with moderate flood potential are dominated by entisol, histosol and ultisol soil types. This area which has moderate flooding potential has an area of 26,337.6 ha with a percentage of 38.2%.

Lastly, low flood risk zones or which can be said to be the safest areas against the possibility of flooding are found in the western part of Padang City which has quite high slopes and elevations, namely >300 meters above sea level with areas that are undulating to very steep. This low potential flood zone area is dominated by forests, which is also the largest land use in Padang City. The soil type in the low flood potential zone is dominated by the inceptisol soil

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type, followed by oxisol. Based on the analysis results, the area of this low flood potential zone is the largest compared to other flood potential classes and is also almost half of the Padang City area, namely 33,854.4 ha with a percentage of 49%.

3. CONCLUSION

From the research results of this study it can be concluded that:

3.1. Utilization of remote sensing and spatial data analysis techniques using several parameters including rainfall, slope slope, land use, soil type, elevation, and river buffer, then all data is overlaid and classified according to flood level classes can be realized to map flood-prone areas.

3.2. From the classification results, 3 regional classes of flood potential levels were obtained in Padang City, namely low, medium and high. From each class, the low flood potential class has an area of 33,854.4 ha with a percentage of 49%, the medium flood potential class has an area of 26,337.6 ha with a percentage of 38.2%, and the high flood potential class has an area of 8,823.3 ha with a percentage of 12.8%.

3.3. The distribution of areas with high potential for flooding is in the west and slightly in the southern part of Padang City, while those with low potential for flooding are in the east and slightly in the southern part of Padang City.

3.4. Areas that are classified as having a high potential for flooding are in the lowlands with residential land use and rice fields, while areas that are classified as having a low potential for flooding or are also safe from flooding are highland areas with land use that still has a lot of vegetation, namely those that have forest land use.

4. SUGGESTIONS

Based on the research that has been carried out, the suggestions given from the results of this research are as follows:

4.1. For areas that have a high potential for flooding, it is hoped that they will always be alert and prepare themselves, especially when the rainy season arrives because at that time floods are prone to occur. Apart from being alert, people are also expected to be able to protect the environment around where they live so that flooding can be minimized in the future.

4.2. Local regional governments should routinely carry out monitoring in areas that are potential and prone to flooding to anticipate the possibility of a flood disaster.

4.3. There is a need for similar research using more accurate, actual and complete data (such as soil texture data, land direction and accumulation, land function, inundation data, etc.) so that the research results are better.

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