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Analysis Of Flood Hazard Zones Using Overlay Method With Figused-Based Scoring Based On Geographic Information Systems: Case Study In Parepare City South Sulawesi Province

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Abstract. Flooding is one of the serious problems that befell Parepare City, South Sulawesi Province. This problem has a negative impact on the surrounding community. Proper planning needs to be pursued so that losses from the disaster can be reduced. This study uses an overlay method with scoring between existing parameters, where each parameter is carried out a scoring process by giving the weight and value according to each classification which is then overlaid using ArcGIS 10.3 software. The use of this software utilizes a Geographic Information System (GIS) that can explain and present objects of flood hazard areas in digital form. The parameters which is used in this study are based on Kazakis et al. (2015), namely FIGUSED (Flow Accumulation, Rainfall Intensity, Land Use, Slope, Elevation, Distance to Drainage Network). The results obtained in the form of flood-prone maps where very vulnerable locations have an area of 10.72 Km2 or about 13.04% of the total area of the City of Parepare and the flood index value (FHI) 4.20 - 6.87 including high-hazard zones, have wide 48.04 Km2 or about 58.41% of the total area of Parepare City and the flood index value (FHI) 3.58 - 4.20 including the low hazard zone, and which has an area of 23.49 Km2 or about 28.55% of the total the area of Parepare City and the flood index value (FHI) 2.20 - 3.58 are included in the safe zone. Meanwhile, the causes of flooding in Parepare City are flow accumulation, slope, distance from the river, and landuse.

Keywords: Flood, GIS, Overlay, Parepare City, FIGUSEDThe first section in your paper

1. Introduction

Pare-pare city is located in South Sulawesi Province, is an area that has been flooded. According to Nia in Rakyatsulsel.com, October 24th 2016 edition, stated that several points in Pare-pare City were flooded. In fact, the community is estimated to suffer losses of up to millions of rupiah. The trigger for flooding is thought to be due to high rainfall plus a poor drainage system (Burhani, 2010). However, there may be other factors that cause the flooding. Based on the principles of disaster management listed in article 3 paragraph 2 of the Republic of Indonesia Law Number 24 of 2007 concerning Disaster Management which are explaining about principles of fast and proper in disaster management. Based on these principles, it is necessary to identify the distribution of the level of flood disaster risk in order to achieve the principle of disaster management based on priorities (Triwidiyanto and Navastara, 2013). The form of this effort is the making of a flood forecast map which is expected to be a priority reference for Parepare city council and Pare-pare City flood disaster mitigation. Utilization of Geographical Information Systems (GIS) is one way in the mapping process, including the creation of flood hazard maps that are the focus of this research. Flood vulnerability can be identified quickly, easily and accurately through the Geographic Information System by using overlaying methods for flood parameters. Through the Geographic Information System, it is hoped that it will facilitate the presentation of spatial information specifically related to determining the level of flood vulnerability and can analyze and obtain new information in identifying areas that are often subject to flooding (Darmawan, 2017).

2. Problem Formulation and Objectives

The formulation of the problem that can be formed, namely:
a. How is the distribution of locations prone to flooding in Parepare City?
b. What factors influence the causes of flooding in Parepare City?

Based on the formulation of the problem, the objectives of this study are as follows.
a. Knowing the distribution of flood-prone locations in Parepare City.
b. Knowing the factors that influence the causes of flooding in Parepare City.

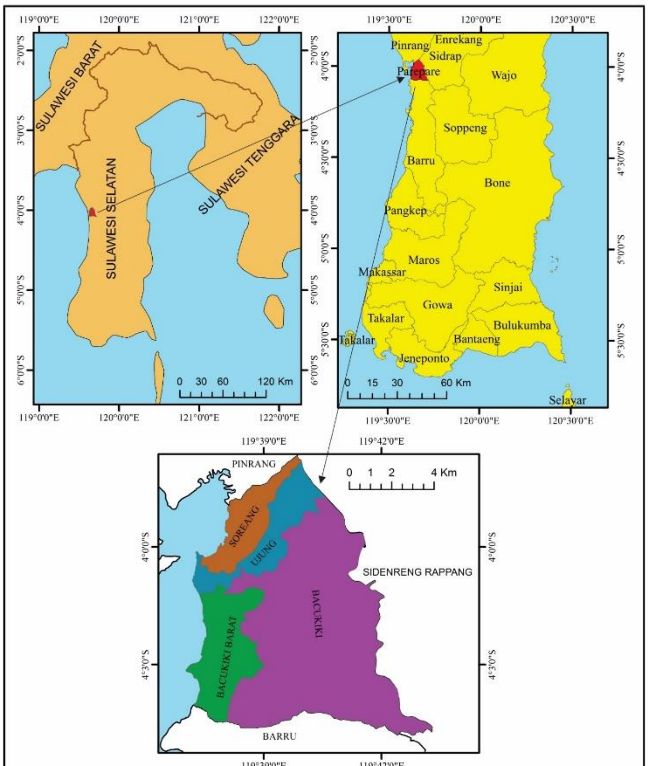

Figure 1. Designated Map of Research Location

3. Overview of Parepare City

The author have chosen Parepare City in South Sulawesi as a case study for the methodology which is developed by Kazakis, et al. (2015). The study area is located in the western part of the central part of South Sulawesi Province that covering an area of 82.27 km2. The northern boundary of the study area is Pinrang Regency, its western boundary is Teluk Parepare, the southern boundary is Barru Regency and its eastern boundary is Sidrap Regency. The permanent population is around 140,000 (BPS City of Parepare in 2016) and the main economic activities are agriculture, trade and plantations. Forests and land cover fields are the majority of this area. The morphology of the study area is generally divided into plains, hills and mountains. The average height is 81 m, the maximum height is 787 m and the minimum height is zero meters on the coastline. Various rocks and sediments form the geological background of the research area. Most of the rocks that make up the City of Parepare are volcanic and breccia tuff. In Lumpue Beach, igneous rocks are found locally. Permeability of this formation increases locally in the fault zone and fracture. Permeable sediments are located along the coast and consist of coastal sediment deposits. Limestone from the study area is included in the permeable formation due to the dissolution process. Groundwater is formed as a result of joints on rocks, karst and porous aquifers. The climate of this area is tropical and characterized by the dry season and the rainy season.

4. Factors that influence flooding

The factors or parameters which are used in the weighting of the flood prone areas of Parepare City are FIGUSED method which was initiated by Kazakis et al. (2015). These parameters will be described as follows.

4.1. Flow Accumulation

Flow accumulation is the total of water which is flowing to a lower area. The accumulation is converted into cell form as output from raster data. High values for accumulated flow indicate areas where concentrations of water flow and have consequences as flood areas. The value of flow accumulation varies from 0 - 50,250 with the highest value found in the outflow area and the lowest value is in the river with a low order.

4.2. Distance from Drainage Network

Apart from the concentrated area of surface water, river overflow is crucial at the beginning of the flood event. Often the flooding comes from the river and spreads around it. The role of the river for flooding decreases with increasing distance from the river. Class division on this criterion is based on recording in the study area. Areas less than 200 m from the river are high flood areas and the effect will decrease with increasing distance more than 2000 m.

4.3. Elevation and Slope

Water flows from high elevations to low elevations and for that, slope affects the runoff and infiltration. Flat areas at low elevation, the flood faster than areas with high elevations and steep slopes. Naturally, low slopes and elevations are placed at high weights as potentially flooded areas.

4.4. Landuse

Land use affects the level of infiltration, is related to surface water and groundwater. Forests and dense vegetation support infiltration, while urban and grassland settlements support surface runoff. However, Santoso (2012) and Abdhika (2016) provide separate classifications in land use. Settlements and buildings have the highest weight values. The vegetation is divided into rainfed rice fields, gardens, fields and rice fields. Santoso (2012) and Abdhika (2016) place forests, grasses, shrubs and fresh water as the parameters with the lowest weights.

Table 1. Classification and Rating of Landuse based on Santoso (2012) and Abdhika (2016).

Landuse Classification	Rating
Settlement	5
Rainfed rice fields and rice fields	4
Plantation	3
Field	2
Rocky land, forest, grass,	1

thicket	

4.5. Rainfall Intensity
Based on research which have conducted by Kazakis, et al (2015), the intensity of rainfall is expressed using MFI (modified Fournier index). MFI is the average monthly amount of rainfall intensity per rain station. The spatial distribution of rainfall intensity is considered based on station allocation in the study area. Based on the number of distribution stations, Kazakis et al. (2015) use spline interpolation compared to ordinary kriging or co-krigging.

4.6. Geology
Based on Kazakis, et.al (2015) research, the geological condition of an area is an important factor in the identification of flood disaster areas, because it has an impact on strengthening or weakening the strength (magnitude) of floods. Permeable rock formations support water, percolation and groundwater infiltration. In contrast, crystalline rocks which are impermeable rocks support surface flow. Karst significantly influences the formation of flash floods (Bonacci, et al., 2006). For this reason, karst and sediment lacustrin (clay, marble and silt) are given a value of 8. The low level is given to alluvial and continental deposits due to the level of infiltration they have.

Table 2. Classification of Geology based on Kazakis, et.al (2015).

Classification	Rating
Crystalline Rock	10
Lacustrine and Marble	8
Neogene Sedimentary	6
Continental Deposit	4
Alluvial	2

5. Classification Method
The classification method used is a classification method that is default to the ArcGIS application. The method uses statistics to group data so that the data set will be a group that has the same characteristics. There are five classification methods in the ArcGIS application, namely:

5.1. Natural Break
The classification method of natural break (jenks) is a method of grouping data designed to determine the best value settings in different classes. This is done by trying to minimize the average deviation of each class from the class mean, while maximizing the deviation of each class from the other groups. In other words, this method seeks to reduce variance in the class and maximize variance between classes (Jenks, 1967). Grouping data patterns, with values in the class having specified limits based on the greatest range values. The process of this method is repeated and uses different breaks in the dataset that have the smallest variance. This method is good for mapping uneven values on the histogram. But the disadvantage of this method is that the class ranges are designed for a data set, so it is difficult to compare maps for different data sets.

5.2. Quantile Interval
Quantile interval classification method is a method that divides each class so that it has approximately the same amount of data. If the data is evenly distributed and the data wants to emphasize the difference in relative position between the data, then it must use the quantile classification method. If point values are divided into five classes, points in the highest class will fall into the top five of all

points (Esri, 2014).Grouping with the same number of features, comparing data that does not require a proportional value of features with comparable values, and emphasizing the relative position between features. This method is good for emphasizing the position of a data, but various values can end up in the same class or different so that it causes a minimum of differences and overstates differences. To reduce this error requires an increase in the number of classes.

5.3. Equal Interval
Grouping data into subrange of the same size, emphasizing the relative number of attribute values against other values, and having familiar ranges such as percent or temperature. This method is easier to interpret and present non-technical information but if the values are gathered on a histogram, it may have many features in one class.

5.4. Geometric Interval
Distribution of class ranges based on intervals which have geometric sequences based on multipliers and their opposite, minimizing the number of squares of elements per class, suitable for continuous data, and producing interesting and complete visual results. This method minimizes the number of squares of elements per class and each class range has an amount equal to the value of each class and changes between intervals are quite consistent. This method is a combination of natural breaks, quantile, and equal interval methods.Interval geometry classifications are better than quantiles for visualizing predictive surfaces, which often do not have normal data distribution. Geometric intervals work best when data is spread over a large area and is not well distributed. In population data, for example, it is possible to show better data display and distribution in a more natural way. Differences can be seen between denser areas with medium and low areas, so that more distribution in the selected area. This classification shows more variation in data because class breaks occur in constant geometric enhancements (can double 2,4,8 ... or triple 1,1,9 ...) (Esri. 2014).

5.5. Deviation Standard Interval
The standard deviation of a random variable, statistical population, data set, or probability distribution is the square root of its variation. In algebra it is simpler, although in practice it is less strong, than the average absolute deviation. Unlike variance, standard deviation is expressed in units equal to data (Gauss, 1816; Walker, 1931).

In addition to expressing population variability, standard deviation is generally used to measure confidence in statistical conclusions. For example, the margin of error in voting data is determined by calculating the expected standard deviation in the results if the same poll is carried out many times. This derivation of the standard deviation is often called the standard error of an estimate or standard error of mean when referring to the mean. This is calculated as the standard deviation of all means to be calculated from that population if an infinite number of samples is taken and the average for each sample is calculated. Each class is defined by the distance from the average value and the standard deviation of all features.

The standard deviation classification method finds the average value of the observation then places the class breakdown above and below the average at either 0.25, 0.5, or 1 standard deviation intervals until all data values are in the class. This classification method shows how much the value of feature attributes varies from the mean. This method uses divergent color schemes to illustrate these values which are useful for emphasizing which observations are above the mean and which observations are below the mean (Esri, 2014). This method is suitable for data that has a normal distribution but if there is a value that is very high or low this can affect the mean (Mitchell, 1999).

6. Parameters Assessment
Flow accumulation has been considered as the most important parameter in various studies that discuss flood factors. The distance factor from the river and the height of the area are considered to have parallel levels as the second parameter because flood areas are often at low altitudes and close to

the river. Land use and rainfall intensity are considered as the third parameter, although according to Liu, et al. (2003) and Kourgialas, et al. (2011) this parameter is prioritized. However, Kazakis et al. (2015) prove that small basins consisting of urban settlements, land cover are very influential in flood events compared to extensive forest or agricultural areas. The intensity of rain and altitude has an indirect relationship so that the distribution is slightly determined by height. Slope slope is also considered, even though the parameter value is lower than the area height. The geology and permeability of rocks are critical factors for surface runoff and flood events, especially for small basins with rare vegetation. However, this situation is inversely proportional to the study area so that geological factors have the lowest parameter values in this analysis (Kazakis et al., 2015).

Table 3. Flood Parameters Assessment based on Kazakis, et.al (2015).

Parameters	Scoring
Flow Accumulation	0.6122
Distance of River Network	0.2944
Elevation	0.2944
Landuse	0.0971
Rainfall Intensity	0.0697
Slope	0.0168
Geology	0.0053

7. GIS Overlay Method

7.1. Weighting and Scoring

Weighting is giving weight to the digital map of each parameter that influences flooding, based on consideration of the effect of each parameter on flooding. Weighting is intended as giving weight to each thematic map (parameter). Determining the weight for each thematic map is based on consideration, how much the possibility of flooding is affected by each geographical parameter that will be used in GIS analysis (Suhardiman, 2012).

Scoring is giving scores to each class in each parameter. Scoring is based on the influence of the class on events. The greater the effect on events, the higher the score (Anas Sudijono, 2007). To get a total score / value, it is necessary to give a value and weight so that the balance between the two can produce a total value which is usually called a score. Giving values for each parameter is the same, namely 1-5, while weighting depends on the influence of each parameter which has the greatest factor in the level of flood vulnerability (Matondang, J.P., 2013).

7.2. Overlay

Overlay is an important procedure in GIS (Geographic Information System) analysis. Overlay is the ability to place one map graphics on another map graphic and display the results on a computer screen or on a plot. In short, overlays overlap a digital map on another digital map along with its attributes and produce a combined map of the two that have attribute information from both maps. Overlay is a process of integrating data from different layer layers. In simple terms, overlays are referred to as visual operations that require more than one layer to be combined physically (Guntara, I., 2013).

8. Research Method

The data collection method used in this study are two methods, namely:

- Observation is a fundamental way of finding out about something that is around us. The activity carried out in this study is to collect the flood inundation points of the City of Parepare in 2016 - 2017.

- Library Studies is a technique in collecting data used to collect data by means of study studies of books, notes, literature, and reports relating to the problem solved.

The literature study conducted during the research was in the form of map making using ArcGIS by implementing the overlapping method as a determinant of the flood prone areas of the City of Parepare.The data which are collected comes from the website and various scientific reports and writings. Rainfall data is obtained from the Office of the Central Water Resources of South Sulawesi Province in 2010 - 2017. Geological data comes from the mapping report and geological research of Parepare City. Land use data comes from the Geospatial Information Agency's Peta Tanah Air website. Data on accumulation of flow, river, slope and altitude are extracted from the USGS SRTM 30 meters resolution. The use of stacking overlap methods is obtained from various theses, theses and journals that discuss the problem.

Data processing uses overlapping method with weighting and scoring between existing parameters, namely slope, elevation, geology, rainfall, land use, flow accumulation and distance from the river. Of all these parameters will be scored by giving weights and values according to their respective classifications which are then overlapped using ArcGIS 10.3 software.

Data that has been processed using the specified application will be analyzed further. Data processing results will be classified using the natural break classification method with 3 classes and 5 classes. This classification method was chosen because according to Crisana (2014) the type of algorithm that is good for the process of classification of spatial data and attribute data is natural break. Regarding the number of classes used, this is based on research by Arifin and Kasim, (2012) and Mudin, et al. (2015) who divided flood-prone classes into three classes and Kazakis, et al. (2015) and Hamdani, et al. (2014) who divided flood-prone classes into five classes.

After that, the validation of flood hazard maps produced on the Parepare City flood history data is carried out in 2016 - 2017. Areas that have the most matched flood history points are considered as flood hazard maps that are close to conditions in the field.

Table 4. Research Data Sources

No.	Jenis Data	Sumber Data
1.	Slope	SRTM USGS 30 m Resolution
2.	Elevation	
3.	Flow Accumulation	
4.	Landuse	Geospatial Information Agency 2017
5.	Distance from River Network	
6.	Geology	Geological Mapping reported by Fitrawati Marhum (2010) dan Fauzi Arifin (1985) and Kaharuddin, dkk (2014) research
7.	Rainfall Intensity	Rainfall Data of Central of Water Resources Service South Sulawesi Province 2010 – 2017

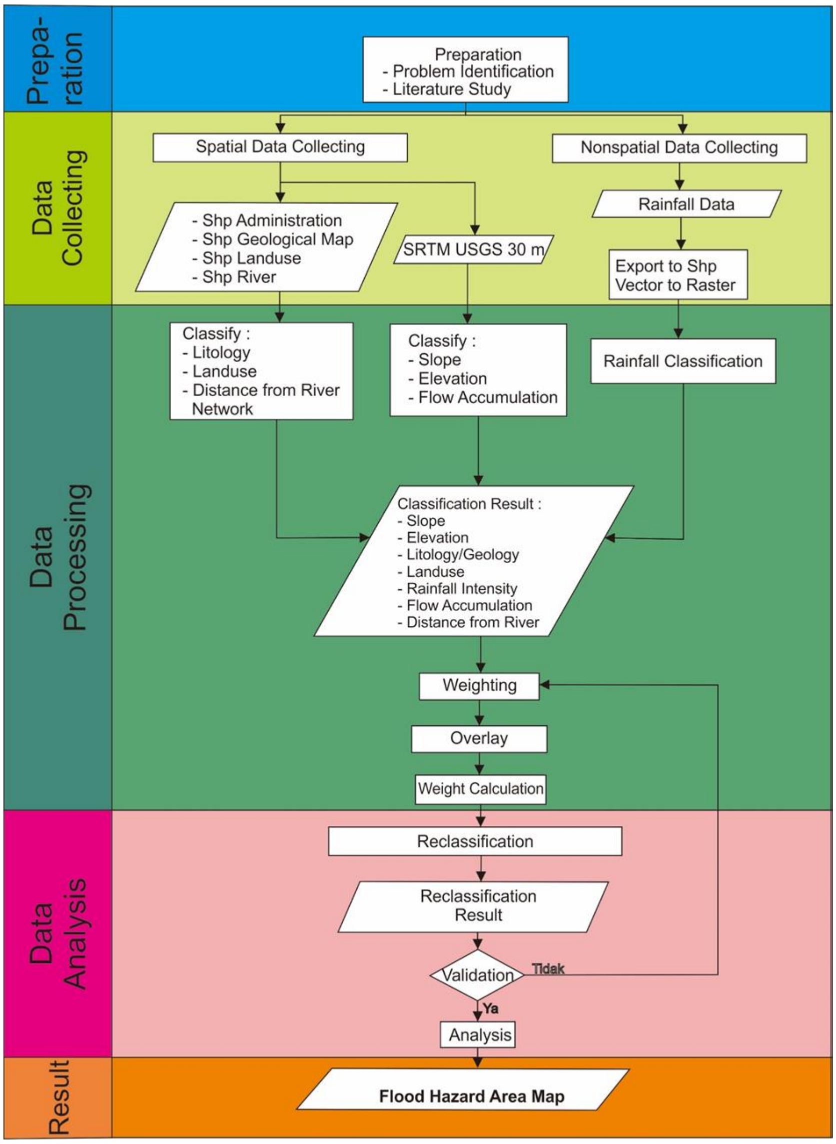

Figure 2. Designated Map of Research Location

9. Analysis of Factors Causing Floods

9.1. Flow Accumulation

This parameter considers the zone of accumulation of water flow entering a basin. The data is obtained through the processing of DEM data so that the flow accumulation zone can be generated. Determining the classification of zones for each parameter into 5 classes is because the division of 5 classes is a common thing in research like this (Kazakis, et al., 2015; Hamdani, et al., 2014; Lestari, 2008; Pratomo, 2008). This division is also considered by the author as the ideal division because if divided into three classes it is too rigid and if the distribution is more than five classes, the division of classes is too much. Flow accumulation parameters have a range of values 0 - 72,829. The higher the accumulated flow value, the higher the water accumulated in the area. Based on the results of spatial analysis of the parameters of accumulated flow, the river order also influences the accumulated value of flow. The higher the order value of the river, the higher the accumulated value of the flow. In addition, the pattern of river flow in the study area that shows the pattern of dendritic flow is also a factor that determines the spread of flow accumulation values in the study area (the closer to the downstream of the river, the greater the accumulation of flow values).

9.2. Slope

The slope in this study uses units of degrees (°). The data source for this parameter is the DEM data 30 m resolution. Slope parameters have a range of values from 0^0 - $33{,}02^0$. Steep slopes can be found in the south of Parepare City. The majority of Parepare has a slope range of 0^0-$16{,}5^0$ which has the greatest value. Areas that have a gentle slope have greater flood potential than areas that have steep slopes. This parameter classification method uses natural break (Jenks).

9.3. Elevation

The elevation parameters are obtained through DEM data are 30 m resolution. The range of values in the altitude parameter is -2 - 787 m. The more northeastern direction of Parepare, the greater the value of the elevation. Generally, Parepare has altitudes ranging from 0 - 81 m, although through DEM data there are identified areas that have a height of -2 m. In general, areas that have low altitude have the potential to become flood inundation areas due to water flowing from areas that have high altitude to areas that have low altitude. This parameter classification method uses natural break (Jenks).

9.4. Distance from River Network

The data source of this parameter is the website map of the Indonesian homeland (peta tanah air Indonesia) scale 1: 25,000. The data obtained has the format of river shapefile (vector) data. Based on these data zoning distance from the river will be generated based on the euclidean distance method. The range of values in the distance parameters of the river are 0 - 2,000 m. Most of the flood disasters inundated areas close to the river. The closer it is to an area with a river, the more potential it becomes a flood-prone area. This parameter classification method uses natural break (Jenks).

9.5. Landuse

Land use describes the area of land use in the research location. The data source for this parameter is a website map of the Indonesian homeland of 1: 25,000 scale. The effect of land use on flood events is seen from the ability of water infiltration. Land use that has a high degree of similarity has characteristics, namely low infiltration ability that supports flooding. The presence of dense vegetation increases the ability of land to infiltrate surface water. This causes areas that have dense vegetation, such as forests, can reduce the risk of flooding.

9.6. Rainfall Intensity

The source of rainfall data comes from Central of Water Resources Service South Sulawesi Province in 010 - 2017. The data was taken from 22 stations and rainfall posts spread in South Sulawesi Province. Each rainfall data from each station is summed and divided by the number of months for 12 months to produce average monthly rainfall. The rainfall interpolation method used is the spline method (Kazakis et al., 2015; Purnomo et al., 2013). The range of values on rainfall parameters is <45 - 361 mm / month. This value is the value of the distribution of rainfall classes throughout South Sulawesi. However, after the data extraction process was only carried out for Parepare, there were only two rainfall zones in the City of Parepare, namely zones 145 - 213 mm / month and 213 - 361 mm / month. This shows that rainfall in the city of Parepare is relatively high. The higher rainfall, the greater potential for floods in an area.

9.7. Geology

Based on regional stratigraphy (Sukamto, 1982), the study area is included in the Parepare Volcanic Formation (Tppv) and Coastal Alluvium Deposition. The Parepare Volcanic Formation consists of tuff, breccia, conglomerate and lava lithology while coastal deposits consist of sand and clay. The age of the Parepare Volcanic Formation is Pliocene.The source of geological data for the City of Parepare comes from the geological mapping carried out by Fauzi Arifin (1985) and Fitrawati Marhum (2010) and Research Kaharuddin, et al. (2014) who conducted a lithofacial analysis of parepare volcanic rocks. Based on the research, there are 5 rock units found in Parepare, namely:

- Alluvial
- Volcanic Breccia Unit
- Limestone Unit
- Trackite Intrusion Unit
- Tuff Unit

The geological conditions of a region also influence the strength of a flood. Unconsolidated rocks and sediments (alluvial) that permeable support water, percolation and groundwater infiltration. In contrast, crystalline rocks which are impermeable rocks support surface flow. The more permeable lithology or materials that make up an area, the potential to become a flood-prone area will be smaller.

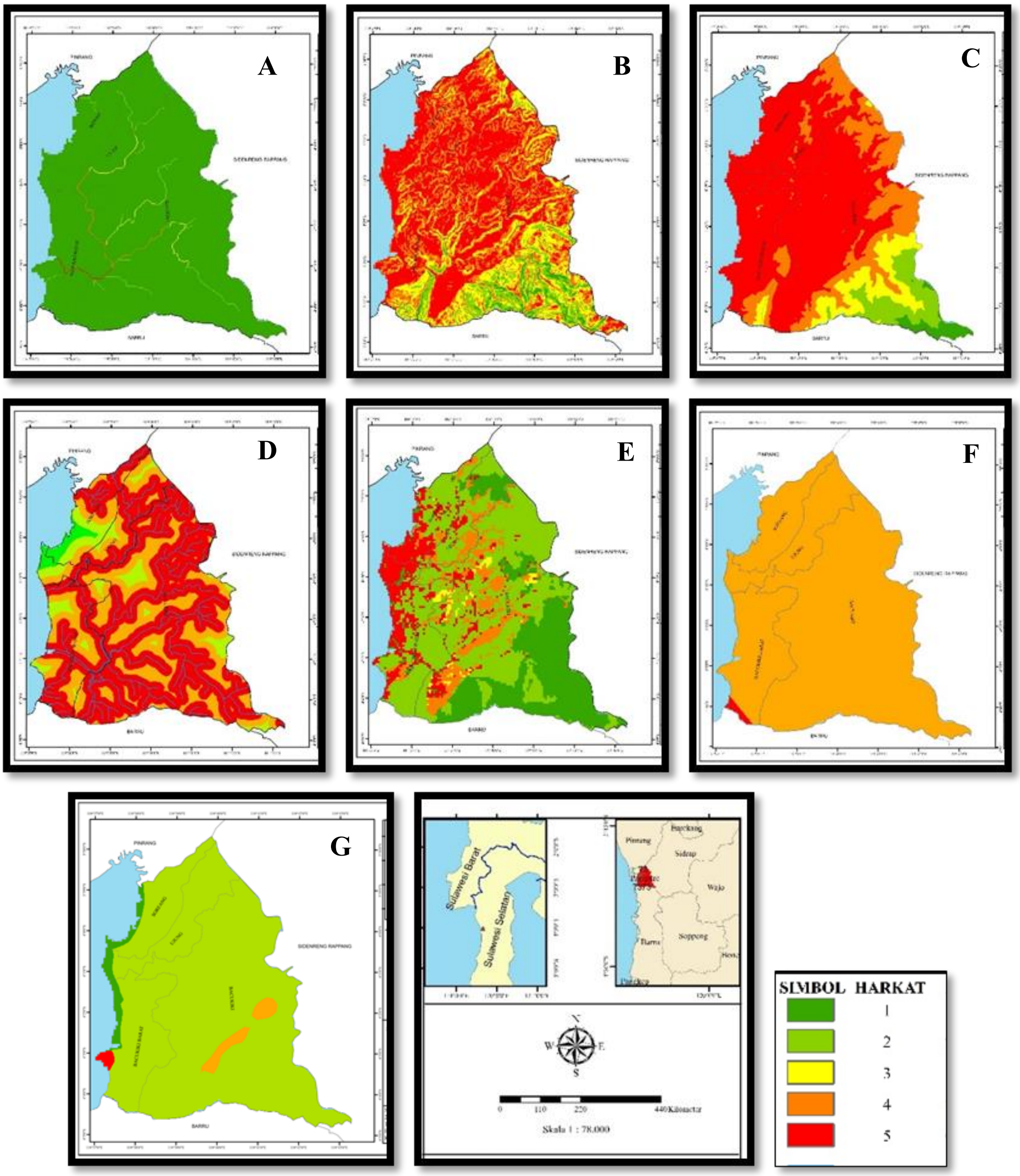

Figure 3. Parameter maps that have been reclassified. A. Flow accumulation, B. Slope, C. Elevation, D. Distance from river network, E. Landuse, F. Rainfall and G. Geology

10. Zoning Validation Flood Index Value

After standardization of all raster data, the next step is to create a flood index value zone. After that, the author reclassified the flood index value produced. This is done to divide this value into levels of flood-prone zones. The classification method used is the natural break classification method with the division of 3 classes and 5 classes.

The validation method used is based on the Kazakis method, et al. (2015) in determining flood-prone zones. The method places a very flood-prone zone as a zone that has the most flood events and a very safe flood zone as a zone that does not have or has a little history of flood events.

Table 5. The percentage of flood events against flood-prone zoning maps of various classification methods with three classes

Zona	III	II	I	Total
Flood Index Value	4,20 – 6,87	3,58 – 4,20	2,20 – 3,58	-
Events	14	8	2	24
Percentage (%)	58,33	33,33	8,33	100,00

Table 6. The percentage of flood events against flood-prone zoning maps of various classification methods with five classes

Zona	V	IV	III	II	I	Total
Flood Index Value	4,84 – 6,87	3,99 – 4,84	3,63 – 3,99	3,19 – 3,63	2,20 – 3,18	-
Events	5	16	1	2	0	24
Percentage (%)	20,83	66,67	4,17	8,33	0,00	100,00

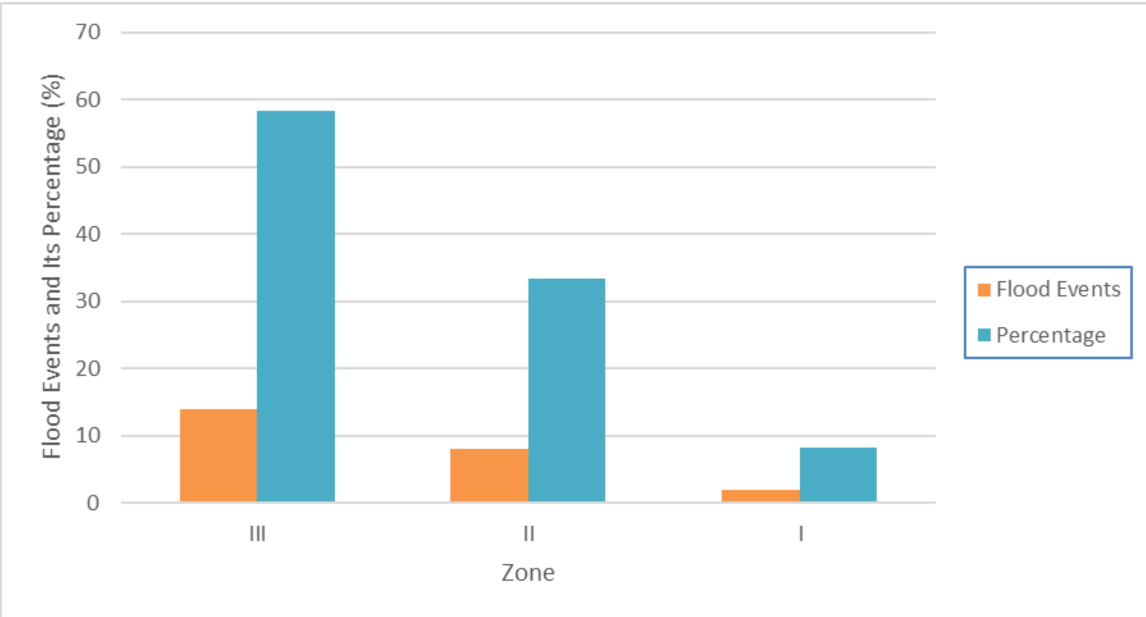

Figure 4. The graph of the number of flood events and the percentage of flood events against flood-prone zoning maps of various natural break classification methods with three classes

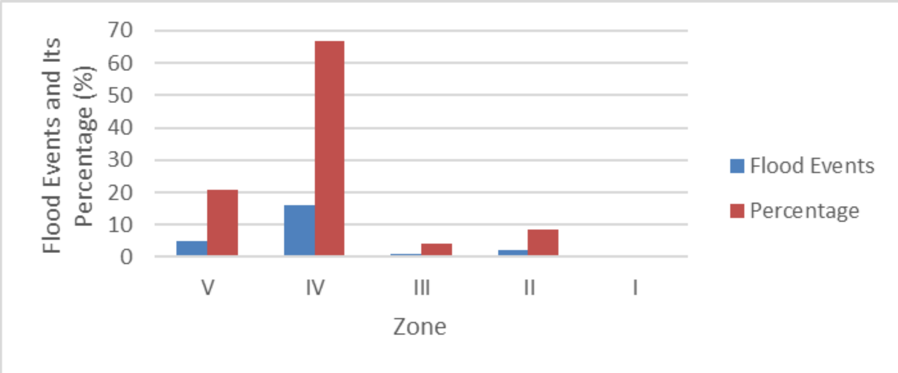

Figure 5. The graph of the number of flood events and the percentage of flood events against flood-prone zoning maps of various natural break classification methods with three classes

Based on the graph, the number of classes that meet the requirements of Kazakis et al. (2015) is a natural break classification method with three classes. This was proven by the fact that in the class division, Zone III had the highest number of flood events and Zone I had the least number of flood events. Therefore, the distribution of the flood hazard zones of Parepare City uses the natural break classification method with three classes, namely Zone III as the High Hazard Zone, Zone II as the Low Hazard Zone and Zone I as the Safe Zone.

Table 7. Class Distribution of Parameters and Weight of Each Parameter

Parameters	**Classification**	**Rating**	**Weight**
Flow Accumulation	0 – 1.570	1	0.6122
	1.570 – 6.370	2	
	6.370 – 15.861	3	
	15.861 – 36.548	4	
	36.548 – 72.829	5	
Slope (º)	0 – 6,5	5	0.2944
	6,5 – 13,5	4	
	13,5 – 22,3	3	
	22,3 – 33,02	2	
	> 33,02	1	
Elevation (m)	-2 – 81	5	0.2944
	81 – 190	4	
	190 – 353	3	
	353 – 550	2	
	550 – 787	1	
Distance from River Network (m)	0 – 250	5	0.0971
	250 – 570	4	
	570 – 975	3	
	975 – 1.465	2	
	1.465 – 2.000	1	
Landuse	Ponds,	5	0.0697

Parameters	Classification	Rating	Weight
	Settlements, Rivers and Buildings		
	Rainfed rice fields and rice fields	4	
	Plantation	3	
	Sand Hill	2	
	Unirrigated agricultural field, Forest and Bush	1	
Rainfall Intensity	213 - 361	5	0.0168
	145 - 213	4	
	113 - 145	3	
	45 - 113	2	
	< 45	1	
Geology	Trackite	5	0.0053
	Limestone	4	
	Tuff and Volcanic Breccia	2	
	Alluvial	1	

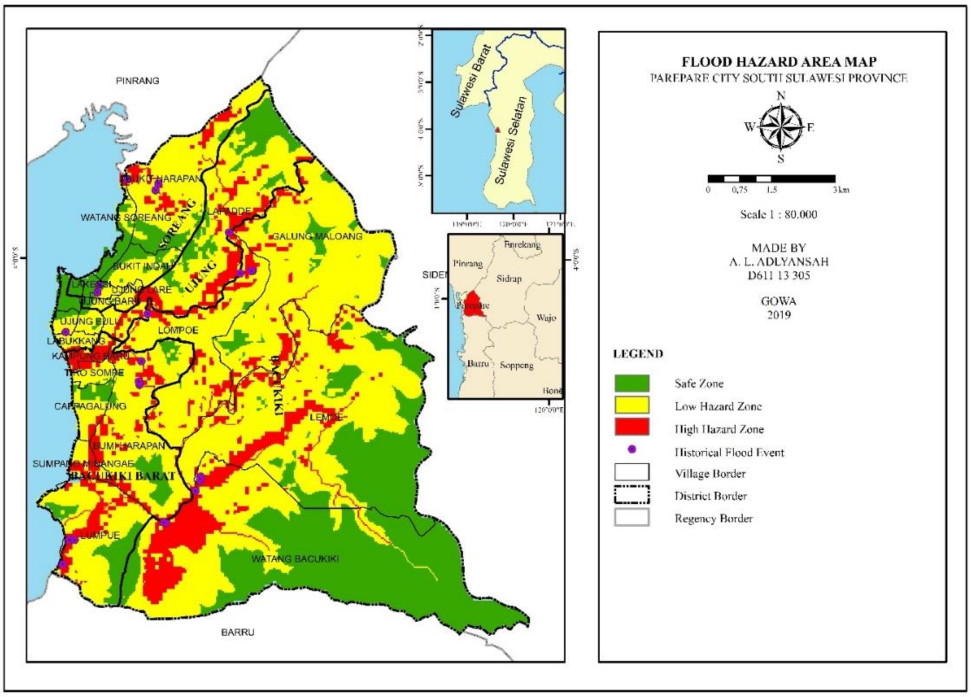

Figure 6. Parepare Flood Hazard Area Map

Table 8. Comparison Between Flood-prone Zone and Factors that is influenced it

Zone/ Parameters	Safe Zone	Low Hazard Zone	High Hazard Zone
Flow Accumulation	0 - 1570	0 – 1570	1570 - 72.829
Distance from River Network	More than 975 m	250 m – 975 m	0 – 570 m; but dominant in 0 – 250 m
Slope (°)	> 22,3	6,5 – 22,3	0 – 16,5
Elevation	0 – 787 m	< 81 m	< 81 m
Landuse	Almost are covered by forest, landfield, underbrush and unirrigated agricultural field	Forest, landfield, underbrush, settlement, fishpond, rice field and unirrigated agricultural field	Almost are covered by settlement and rice field
Geology	Tuff and volcanic breccia	Tuff, volcanic breccia, alluvial, trackite and limestone	Tuff, limestone and volcanic breccia
Rainfall Intensity	145 – 213 mm/month	145 – 361 mm/month	145 – 361 mm/month
Threatening Village	Lakessi, Watang Soreang, Bukit Indah, Ujung Baru, Ujung Bulu in Soreang District Bumi Harapan, Lumpue, Cappagalung in Bacukiki Barat District; Bumi Harapan, Lumpue, Watang Bacukiki, Lemoe, Galung Maloang, Lompoe in Bacukiki Distirct; Lapadde in Ujung District.Cappagalung in Bacukiki Barat District;	All of the village in Parepare City, except Lakessi in Soreang District.	Watang Bacukiki, Lemoe, Lompoe, Galung Maloang in Bacukiki District; Lapadde in Ujung District; Kampung Baru, Tiro Sompe, Cappa Galung, Bumi Harapan, Sumpang Ujung Baru, Bukit Harapan in Soreang Dsitrict.Minangae, Lumpue in Bacukiki Barat District;

11. Conclusion

The conclusions from this study are as follows:

- The results of the overlay method are the Parepare City flood hazard zone which is divided into three zones, namely the safe zone which has an area of 23.49 Km2 or about 28.55% of the total area of Parepare and the flood hazard index value (FHI) 2.20 - 3, 58, low hazard zone which has an area of 48.04 Km2 or around 58.41% of the total area of Parepare and the flood hazard index value (FHI) 3.58 - 4.20, and the high hazard zone which has an area of 10.72 Km2 or around 13.04% of the total area of Parepare and the flood hazard index value (FHI) of 4.20 - 6.87. Villages that are prone to flooding are Watang Bacukiki, Lemoe, Lompoe, Galung Maloang in Bacukiki District; Lapadde in Ujung Subdistrict; Kampung Baru, Tiro Sompe, Cappa Galung, Bumi Harapan, Sumpang Minangae, Lumpue in the District of West Bacukiki; Ujung Baru, Bukit Harapan in Soreang District.
- Factors that cause flooding in Parepare are flow accumulation, slope, slope, distance from the river, and land use.

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