MAPPING FLOOD HAZARD LEVELS IN PADDY FIELDS IN THE LABAKKANG RIVER BASIN OF PANGKEP DISTRICT, SOUTH SULAWESI

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DEPARTMENT OF AGRICULTURAL TECHNOLOGY

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ABSTRACT

MUHAMMAD RISYWAR RASYID (G041 18 1322). Mapping of Flood Hazard Levelsin Rice Fields in The Labakkang Watershed Pangkep Regency, South Sulawesi: SITTI NUR FARIDAH and MAHMUD ACHMAD

The background is South Sulawesi are the 4th largest province as a national food producer. Where agriculture in Pangkep Regency is the second largest sector contributing to regional income. As for flood events in 2021, there were 1,236 incidents recorded in Indonesia. The agricultural land that is very prone to flooding is land that is close to the watershed. **The purpose** of this study was to produce a map of flood hazard vulnerability in paddy fields in the Labakkang Watershed, Pangkep Regency. **This research method** uses a scoring and weighting system with the AHP method in the parameters of rainfall, river buffer, soil type, land elevation and slope. Furthermore, the entire map is overlayed using the ArcGIS application. **The results** obtained from this study are rice fields that have a high risk of flooding are rice fields that are 0-300 m from the river mouth with an overall percentage of 7%

Keywords :AHP, ArcGIS, Flooding

BIOGHRAPHY

Muhammad Risywar Rasyid, born in Balocci on August 2 2000, is the fourth of five children , a couple of Mr. H Abd Rasyid and Mrs. Hj Fatmaiah. The levels of formal education passed are:

1. First at the Pertiwi Balocci Kindergarten level from 2005 to 2006.
2. Continued primary school at SDN 5 Padang Tangalau from 2006 to 2012.
3. Continuing junior high school education at SMPN 2 Balocci from 2012 to 2015.
4. Continuing high school education at SMAN 13 Pangkep in 2015 until 2018.
5. Continuing education at Hasanuddin University Makassar in 2018 as one of the students in the Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture.

During his education in the world of lectures, the author was active in campus organizations, namely in the Hasanuddin University Agricultural Technology Student Association (HIMATEPA UH) as the Management of the Strategic Studies Department for the 2020/2021 period. In addition, the author is also active as a practicum assistant under the auspices of the Agriculture Study Club (TSC) in 2020-2022.

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1. INTRODUCTION

1.1 Background

Land in Indonesia is generally divided into two types, namely dry land and wet land. wetland agriculture in this case rice fields are usually used for monoculture cultivation, namely one type of plant, namely rice. besides that, it is also planted with an intercropping system, not only planted with rice but also planted with secondary crops and vegetables. Meanwhile, dry land farming is usually used for long-term crops or plantations.

As the center of the economy in eastern Indonesia, South Sulawesi is the largest food-producing province in eastern Indonesia. This makes South Sulawesi nicknamed as the national food barn in eastern Indonesia. This can be seen from the raw rice field area owned by South Sulawesi which is 654,818 ha. making South Sulawesi ranked 4th nationally. The food producing areas in South Sulawesi are: Maros, Pangkep, Takalar, Bantaeng, Pinrang, Bulukumba, Luwu, Sidrap, Soppeng, Bone and Wajo (BPS Sulawesi selatan, 2021).

Pangkep is one of the districts that provides a good contribution in the agricultural sector. as for the rice field area of Pangkep Regency, namely 16,682 ha. as for based on statistical data published by BPS Pangkep 2017 shows that most of Pangkep's regional income is obtained from the agricultural sector. The agricultural sector is ranked second after the industrial sector.

The significant potential of agriculture in a region undoubtedly has positive impacts on that area. However, one of the things that need to be vigilant about is natural disasters, which are sometimes difficult to predict. One of these natural disasters is flooding. According to the National Disaster Management Agency (BNPB), in the year 2021, a total of 2.931 disasters were recorded across Indonesia, with 1.236 of them being flood-related disasters. Flooding has a significant impact on the agricultural sector. Floods can lead to crop failure, which undoubtedly affects food reserve stability.

The agricultural land that is very vulnerable to flooding is land that is close to the watershed. The watershed in Pangkep Regency is the Labakkang watershed where there is a Tabo-Tabo dam located in the downstream part of the river. This dam is used by the community to irrigate their rice fields.

Seeing the magnitude of the flood threat to agricultural production, mapping the level of flood hazard in rice fields is needed in order to obtain data and information that can describe the level of flood hazard which can later become a reference for the preparation of flood management recommendations. Among the various methods in making maps, Geographic Information System (GIS) is more often used. this method was chosen because it can cover a wider area and a short time. Based on the description above, this research was conducted to find out how much the flood hazard is on rice fields in the Labakkang Watershed in Pangkep Regency, South Sulawesi province and produce a map of flood hazards on the land of Pangkep Regency.

1.2 Purpose and Benefits

The purpose of this research is to produce a map of flood hazard vulnerability in paddy fields in the Labakkang watershed of Pangkep Regency.

The benefits of this research is to provide information about the distribution of flood hazards in the Labakkang watershed and as reference material in research and policy-making by related agencies.

1.3 Problem Limitations

The limitations set in this study are:

1. The research was conducted only by analyzing various maps that are supporting factors for flooding.
2. The affected paddy fields will not be calculated per plot but the expansion of each level of flood impact.
3. The analyzed area specifically rice fields in the Labakkang watershed of Pangkep Regency.

2 LITERATUR REVIEW

2.1 Flood

Natural disaster events in Indonesia occur very frequently. The natural disasters that often occur in Indonesia include floods, landslides, and earthquakes. Among the three events, floods are the natural disasters with the most occurrences every year. Flood itself is the event of an increase in the volume of water in an area as a result of which the area becomes inundated (Barus et al., 2017).

Flood is defined as an event of inundation of an area around the river that occurs due to the overflow of river water due to the inability of the river to accommodate water discharge. This flood usually occurs because of the high intensity of rain that falls on an area, causing the watershed to not be able to accommodate all the water (Kusumo and Nursari, 2016). Flooding in Indonesia is generally a combination of natural and non-natural factors. The main factor that causes flooding is high rain intensity and long duration. Other factors that contribute to the occurrence of flood events are land use that is prone to water infiltration, the location of the area close to the river, as well as the level of slope of the area (Asih and Eliyani, 2022).

If grouped, it will be known that flooding is influenced by three main factors, namely meteorological factors, physical characteristics of the watershed and humans. The meteorological factors that cause flooding are intensity, rain frequency and rain duration. As for the watershed, the area of the watershed, the slope, the height and the soil water content are the determinants. Humans play a role in the occurrence of flooding in terms of land use such as uncontrolled land clearing (Kadri, 2016).

Losses caused by floods can be prevented and reduced by means of flood control. There are several flood controls including: management of water resources, spatial management, management of disaster threats and management of coastal areas (Nurdiawan and Harumi 2018).

There are two ways to control floods, namely structurally (reforestation, construction of flow control infrastructure, canalization and others) and non-structural controls including spatial planning, increasing public awareness, mapping flood-prone areas (Nurdiawan and Harumi 2018).

According to Nurdiawan and Harumi (2018), there are three things that influence the occurrence of floods, namely:

1. Meteorological factors, namely the frequency of distribution and the length of rain lasts).
2. Watershed characteristics (watershed area, land slope, elevation and soil moisture content).
3. Human factors that are very influential in terms of the diversion of conservation land use into residential areas, which causes the loss of water absorption areas. This causes the occurrence of surface flow.

2.2 Flood Parameters

Flood vulnerability maps can be created by overlaying rainfall maps, soil type maps, land elevation maps, slope maps, river buffer maps and land cover maps. as for the value of vulnerability, it is obtained by finding the overall value of the sum of the scores from all maps (Sitorus et al., 2021).

2.2.1 Land Slope

The difference in height between the two points is defined as the slope. This slope is considered when making a flood hazard map. This is because the slope can increase the chance of flooding. The units of this slope are % or degrees. The greater the slope value, the greater the amount of soil splashed down by the impact of rainwater. Areas that have a large slope will have a small possibility of flooding because water will move faster to lower areas compared to relatively sloping areas, therefore sloping areas have a high level of vulnerability because water will accumulate in these areas. (Nuryanti et al., 2018).

2.2.2 Land Elevation

Land elevation is defined as a measure of land height measured from sea level. The elevation factor is also a concern in making flood vulnerability maps. Higher areas tend to be safer from flooding than lower areas. This happens because in the lower part there is an accumulation of water so that water will gather more in the lower area, besides that the basin in the lower area increases the flood occurrence factor (Darmawan et al., 2017).

2.2.3 Rainfall

Rain is a hydrological component that has a very important role. Rain is interpreted as a phenomenon of the fall of water from the sky to the earth due to the inability of clouds to maintain their mass. As for rain in large areas, it is only local. The point is that the rain measured at the measurement post cannot represent rain for a wide area coverage. It can only represent rain in the area around the rain post. To represent a large area of rain can be seen from the extent to which the rain heading can represent the characteristics of rain for a large area. The intensity of rainfall is defined as the amount of rainfall in a unit of time. The units commonly used are mm/hour. The nature of rain that influences surface runoff is the amount, intensity and duration of rain events. The main factor causing surface runoff is the intensity of rain. If the total intensity of the rain is large, the runoff that occurs will also be large (Nuryanti et al., 2018).

Precipitation is one of the most important hydrological factors. Rain is the event of the fall of liquid (water) from the sky to the surface of the earth. This rain event is one of the inputs as well as a controlling factor that is easy to observe in the hydrological cycle in (watershed) (Nuryanti et al., 2018).

2.2.4 Soil Type

Soil type is an important factor in determining flood vulnerability. This is because the finer the soil texture, the greater the chance of flooding and vice versa, the coarser the soil texture, the smaller the chance of flooding. This is because the finer the soil texture, the more difficult it is for water to seep into the soil (Putra, 2017).

This soil type is closely related to soil infiltration. Soil infiltration is the entry of water into the soil due to gravity and capillary forces. Soil type also determines how fast the infiltration process occurs. Each type of soil has a different texture. Soil texture is also a physical property of soil that is difficult to change by humans and is fixed (Pratomo, 2008).

2.2.5 River Buffer

A river buffer is defined as an area that has a certain distance and area described around the river. The creation of this river buffer is based on the understanding and knowledge of the relationship between flood events and rivers. The closer an area is to the river, it is assumed that the chance of flooding from river overflows will also be greater (Ariyora et al., 2015).

2.2.6 Land Use

Land use is a map that describes the distribution of fiber land fields utilized by humans. Land use such as for settlements, protected forests, irrigated rice fields, industrial land and so on. Land that is not planted with vegetation will have a greater possibility of flooding than areas planted with vegetation. This is due to the large amount of infiltrated water and the longer time it takes for runoff to reach the river (Putra,2017).

2.3 GIS (Geographic Information System)

Geographic Information Systems or known as GIS began to develop in the early 1980s. Along with the development of computer equipment, software and hardware, the development of GIS was felt in the 1990s. In language, GIS is defined as: "a component consisting of hardware, software, geographic data and human resources that work together effectively to capture, store, repair, update, manage, manipulate, integrate, analyze and display data in a geographic-based information". GIS capabilities include connecting, combining and analyzing multiple data in one point on the earth's surface. The use of GIS can be used in finding: location, conditions, trends, patterns and modeling. Some of these advantages distinguish GIS from other information systems (Nurdiawan and Harumi 2018).

The use of GIS has expanded to various fields and activities. GIS has become a tool that helps researchers in making decisions used in solving problems, making choices through various methods of spatial analysis using computer devices. The use of GIS can facilitate complex data processing, such as the need for tools and results in manipulating data in the workspace including overlay, buffering, Figure planning and database manipulation.

The database in question is all the data stored in a Geographic Information System that organizes computers to process, display and store, so that all data and attributes can be imported into digital data. As a spatial data processing tool, GIS plays an important role in managing the environment and mapping natural resources and so on (Nuryanti et al., 2018).

The basis of GIS is a collection of resources that are related to each other. GIS data types are divided into two types, namely spatial and non-spatial data. Spatial data is defined as data related to data on the surface and in the earth. Spatial data can be identified and measured by astronomical line quantities, namely latitude and longitude. This spatial data is divided into three forms, namely: points, lines and polygons (areas), which are depicted in sheets (Layers). Non-spatial data are all complementary data in spatial data. This non-spatial data can be in the form of statistical data, numerical data, descriptive either in the form of tabular diagrams or contextual (Nuryanti et al., 2018).

2.4 Scoring

Scoring is a stage in flood hazard mapping where each class in one parameter will be given a value depending on how far the class influences the flood event. A high score indicates that the class has a large influence on flood events. The vulnerability value of an area to flooding is obtained by adding up all the scores of the parameters that affect the occurrence of flooding (Sitorus et al., 2021).

The use of the scoring method is used to see the priority scale of each parameter class in determining the area analysis. Scoring method is a method used to evaluate land capability according to its intended use. Basically, this method is a method used to analyze the extent to which each class affects land capability so that later it can be used in determining the land capability class based on the calculation of the rank of each parameter (Raharjo, 2021).

In making a flood hazard map, it is necessary to determine in classifying each parameter used. The classification in question is the distribution of classes in each parameter or thematic map. Scoring is a process where each class contained in each parameter will be given a value. The class classification in each parameter and the scoring for each class will be subjective, meaning that there is freedom in giving scores and groupings. This is done to free users to adjust to the benefits of these variables and the needs of the analysis to be carried out. In giving this score based on logical nature, the class with the highest adverse impact will be given a high score and conversely the class with the smallest adverse effect will also receive a low score. meaning that quantitatively the value of the value is a relative number or score (Raharjo, 2021).

2.5 Weighting

In mapping vulnerable areas, it is very important to do a weighting process. Weighting is done by giving a value to each parameter used. This weighting is done to see or give clusters to the analyzed parameters. Later, when the weighting has been done, it will be seen how much influence the parameter has in contributing. The greater the weight of the parameter, it means that the parameter also contributes greatly to the event being analyzed (Primayuda, 2006).

2.6 Analytical Hierarchy Process (AHP)

The AHP method is a method of solving complex problems by reducing them into a hierarchy or level. This hierarchy begins at the top level, namely goals or goals, then the factor level, criteria level, sub-criteria level, and so on to the last level (Sudarmadi, 2017). AHP is a multicriteria statistical approach that helps a framework of thinking where in the process, logic factors, experience factors, knowledge, emotions, and feelings are needed. AHP is indispensable in situations that require consideration in complex conditions. The condition in question is when there is limited data and statistics which are only information from experts, AHP is able to provide an assessment of the qualitative data into quantitative data by giving values arranged in an analytical hierarchy (Setiawan *et al.,* 2016).

2.7 Matrix Pairwise Comparison

Basically, the use of AHP is to use a pairwise comparison matrix to get definite and measurable values between criteria and alternatives. One criterion and other criteria will be compared compared to see the level of importance of criteria towards achieving existing goals. In AHP, human perception is the main tool in formulating a functional hierarchy. The hierarchy can solve complex or less systematic problems into sub-problems, then organized into a hierarchical form. (Hamdani et al., 2014).

Table 1. Pairwise Comparison Scale

Importance Level	Definition	Explanation
1	Equally Important	The effect is the same between the two criteria
3	A little more important	a condition in which the importance of the criterion is obvious compared to other criteria but this is not the case convincing.
5	More important	conditions where it is clear, evident in several incidents that these criteria are more important than other criteria.
7	Very important	conditions where it is clear, evident in several events shows that these criteria are far more important than other criteria.
9	Absolutely more important	conditions where it appears clear, real and conclusively proven in several events shows that these criteria are very important.
2,4,6,8	Middle value	Given as the median value between two criteria where there is an element of doubt.

(Source: Hamdani et al, 2014).

The assessment used in the rocess is a comparison between criteria which is independent so that it is very prone to the occurrence of inconsistencies in statements.

Saaty (1990) in Hamdani, Permana and Susetyaningsih, (2014) has formulated that the consistency index of the "n" order matrix can be calculated using the formula:

$$CI = \frac{\lambda max - n}{n - 1} \quad (1)$$

Description:

CI is the consistency index

λ maks is the largest eigenvalue of the “n” order matrix

The largest eigenvalue is obtained by adding the results of multiplying the eigenvectors by the number of columns. consistency ratio (CR), is used as a measure of the uncertainty limit of the statement. The consistency ratio (CR) is the quotient between the consistency index (CI) and the random generator value (RI). The random generator value will be adjusted to the order of the n matrix. The consistency ratio is calculated by the formula:

$$CR = \frac{CI}{RI} \quad (2)$$

Description:

Inconsistency is acceptable when the CR value is smaller than 10%.

Table 2. Random Index of Consistency (RI)

CI	RI	CI	RI
1	0,0	8	1,41
2	0,0	9	1,45
3	0,58	10	1,49
4	0,90	11	1,51
5	1,12	12	1,48
6	1,24	13	1,56
7	1,32	14	1,57
		15	1,59

(Source : Hamdani et al., 2014).

3 RESEARCH METHODS

3.1 Time and Place of Research

The study began in May to August 2022. Data collection was carried out at agencies related to the Labakkang River Basin.

3.2 Tools and Materials

The tools needed in this study are cameras, writing equipment and laptops in which there is an *ArcGIS* 10.4 application. and a *Superdecisions* application. Meanwhile, the materials needed in this study are annual rainfall data (2017-2021), land slope maps, altitude class maps, soil type maps, river maps, watershed maps throughout Indonesia , RBI Indonesia maps and rice field maps of Pangkep Regency.

3.3 Data Collection

Mapping flood risk in rice fields requires several data tosupport the analysis of flood-prone areas, including:

1. DEM Map
2. Digital maps of RBI, particularly maps of administrative boundaries
3. River Map
4. Soil type map
5. Labakkang Watershed Map
6. Map of rice fields
7. Rainfall data for the last 5 years (2017- 2021).

3.4 Research Procedure

The method used in this study is a quantitative method by looking at the influence of each flood parameter to determine the level of flood vulnerability. The stages passed during this study are:

3.4.1 Database building

At this stage, all base maps are made which will later be analyzed as parameters for causing flooding. The map to be made is as follows:

1. Making a map of the Labakkang watershed.
2. Making a rainfall map of the Labakkang watershed area.
3. Making a map of the slope of the Labakkang watershed area.
4. Making a map of the land height of the Labakkang watershed area.
5. Making a map of the soil type of the Labakkang watershed area.
6. Making a river *buffer* map of the Labakkang watershed area.

3.4.2 Attribute analysis

3.4.2.1 Scoring

The scoring looked at how influential the class was on flooding.

Table 3. Score for Each Parameter

No	Parameter Map	Classification or Class	Score
1	Slope slope	0-8%(flat)	9
		8-15%(ramps)	7
		15-25%(a bit steep)	5
		25-40%(steep)	3
		>40%(very steep)	1
2	Rainfall	>2500 mm	9
		2001-2500 mm	7
		1501-2000 mm	5
		1000-1500 mm	3
		<1000 mm	1
3	Soil Type	Regosol, lithosol	9
		Humus, pedsol	7
		Alluvial, andosol, mediteran	5
		Podzolik, andosol	3
		Regosol, lithosol, organosols	1
4	Elevation	0-20 masl	9
		21-50 masl	7
		51-100 masl	5
		101-300 masl	3
		>300 masl	1
5	River Buffer	0-100 m	9
		100-200 m	7
		200-300 m	5
		300-500 m	3
		>500 m	1

(Source : Kusumo and Nursari 2016)

3.4.2.2 Weighting

Weighting is done by means of *Analysis Hierarchy Process* (AHP) using *software superdecisions*

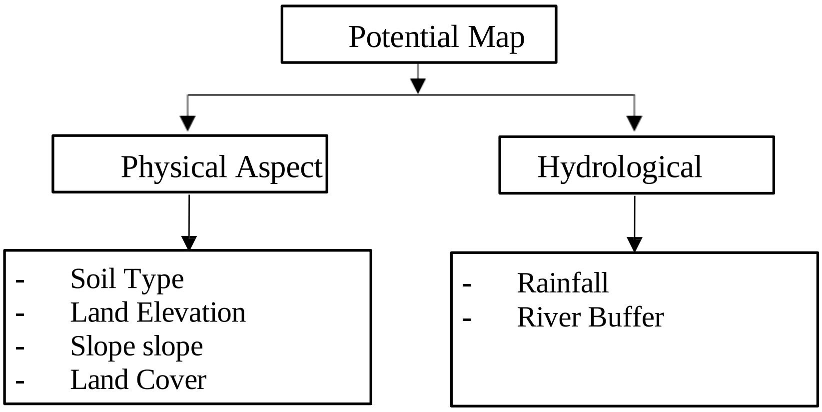


Figure 1. Heirarki Structure Flood Potential Map

3.4.3 Vulnerability value analysis

Great flood vulnerability in an area. Determined by the equation:

$$X=\sum_{i=1}^{n} Bi \text{ x } si \quad (3)$$

Information:

X = Flood vulnerability value

Bi = Weights for the i-th parameter

The = Score for parameter class

According to (Aziza et al., 2021) the determination of the interval for each vulnerability class to be used. can be searched by the equation:

$$i = R/n \quad (4)$$

Information:

I = Interval width

R = Minimum and maximum score difference

N = Number of vulnerability classes

3.4.4 Overlay

This stage is the stage where all maps are arranged overlapping each other to produce a new map, namely the flood vulnerability map.

3.4.5 Validation

This stage is the stage where checks are carried out at several points on the map that has been produced, is it appropriate or not?

According to (Ujung A. T et al, 2019) the map is declared valid when 80% of the map matches the sample point in the field.

$$A = \frac{S}{n} \quad (5)$$

Information:

A = Accuracy (%)

S = Corresponding point

n = numbe of sample points cheked

3.5 Flow Chart

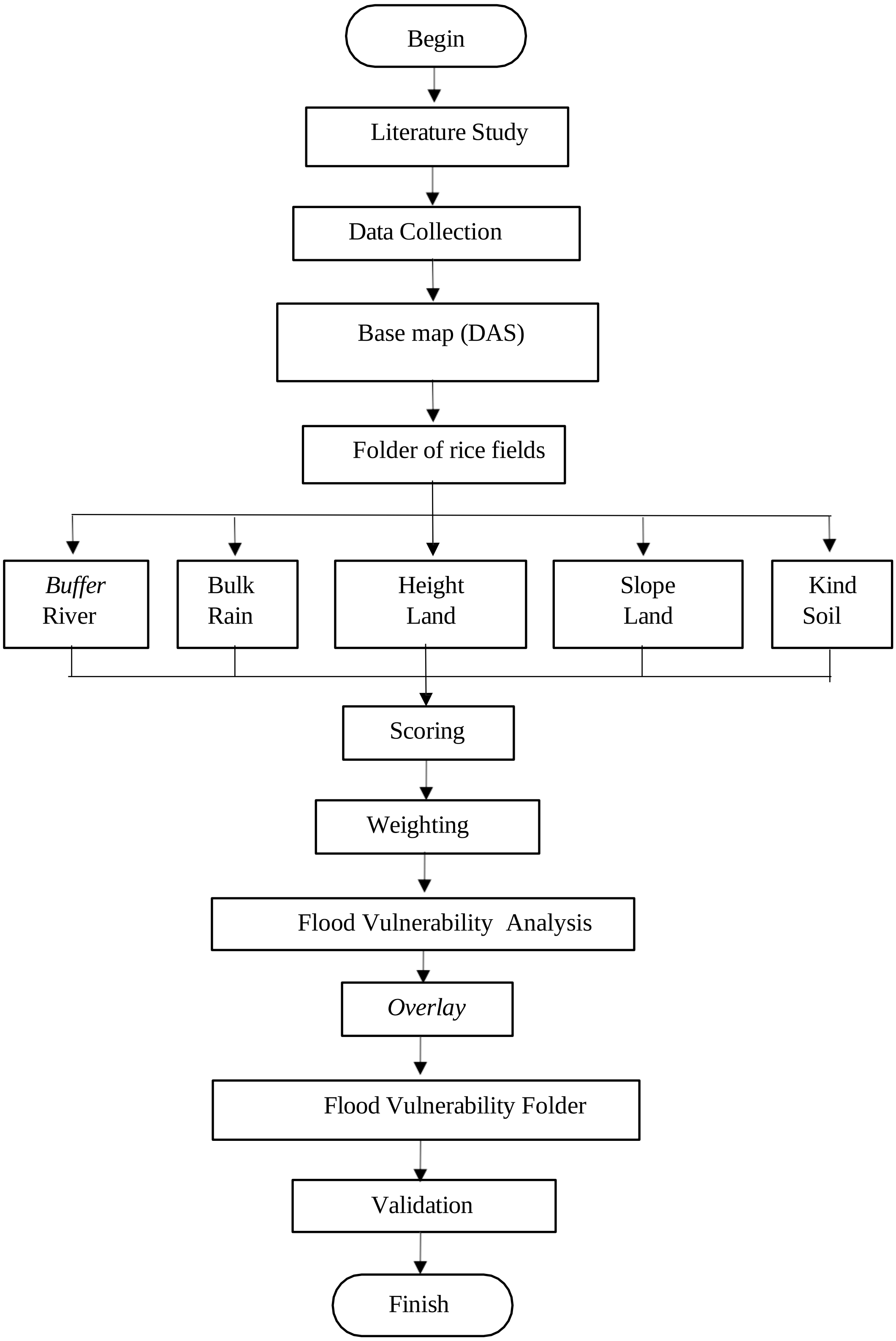


Figure 2. Research Flow Chart

4 RESULTS AND DISCUSSION

4.1 General Description of the Research Area

Astronomicaly, the Labakkang watershed is located between 119°27'30"E to 119°39'40"E and -4°48'30"S to -4°39'50"S. The catchment area of the Labakkang watershed is 15,621.75 hectares. The Labakkang watershed is under the jurisdiction of the Jeneberang Walanae River Basin Authority. The Labakkang watershed is a watershed that crosses two districts in Pangkep Regency, namely Labakkang and Segeri districts. According to Figure 3, it can be seen that the river flow pattern in the Labakkang watershed is a dendritic flow pattern or resembles a tree branch. The dendritic system flow pattern is a flow pattern that has many streams that then merge into the main tributary. This is in accordance with (Yanmadi and Supriyono 2016) the dendritic river flow pattern has the characteristics of a river flow that branches then merges into the main river and then flows directly into the sea. The following map of the watershed can be seen in Figure 3.

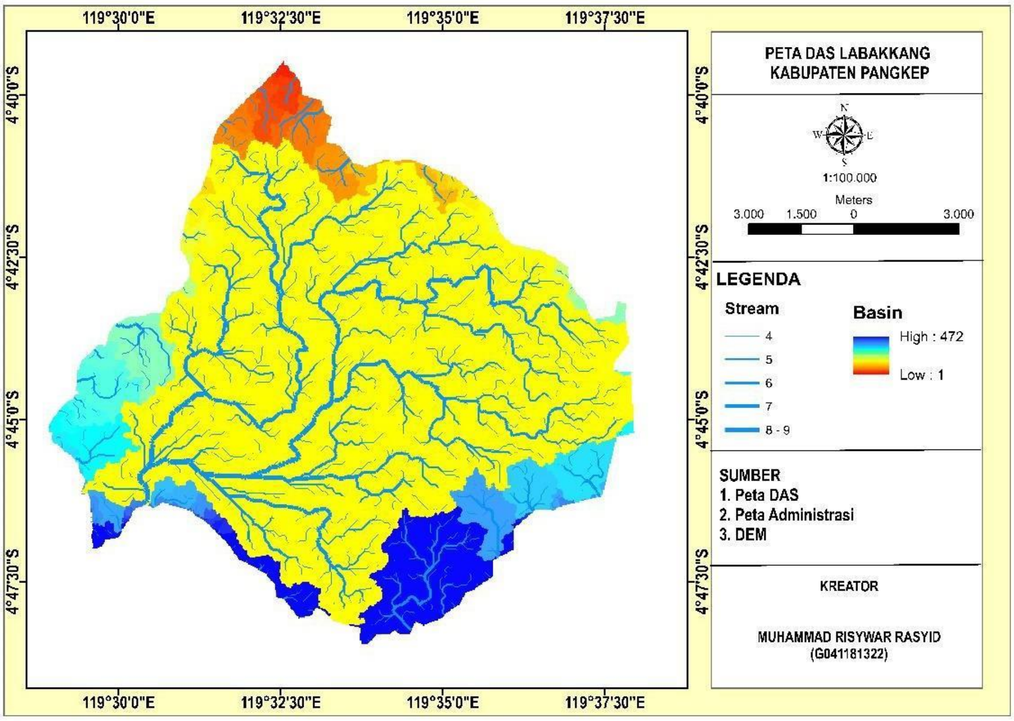


Figure 3. Map of the Labakkang River Basin

4.2 Slope

A slope map is a map that can describe the slope of an area. The distribution of slopes in the study area can be seen in Figure 4, where the slopes of the study area are divided into five classes: 0-8% (flat), 8-15% (gentle), 15-25% (slightly steep), 25-40% (steep), and >40% (very steep). From the map shown in Figure 4, it is known that the study area is a flat area with a slope of 0-8%. The percentage of flat areas is 4,053.42 ha, or 92.88% of the total study area. With this slope, the study area is highly prone to flooding, where flooding will occur when rainfall is high. This is in line with the statement of (Nuryanti, 2018), which states that the greater the flatness of an area, the greater the potential for flooding or flooding, while the steeper an area, the less likely it is to flood because surface runoff will flow faster so that the rainwater that falls will be directly drained and will not flood the area. The map of the distribution of slope in the study area can be seen in Figure 4, and the data on the area and percentage of slope classes can be seen in Table 4.

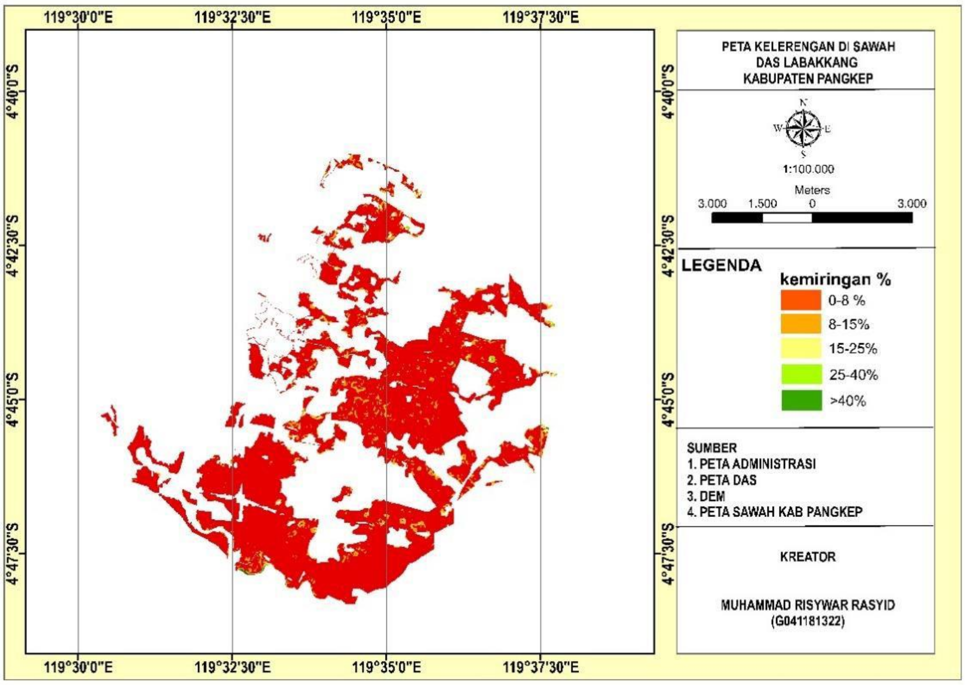


Figure 4. Rice Terrace Slope Map of the Labakkang Watershed

Table 4. Area and Percentage of Rice Terrace Slopes in the Labakkang Watershed

No.	Explanation (5)	Large (Ha)	Percentage(%)
1	0-8	4.053,42	92,88
2	8-15	274,692	6,29
3	15-25	26,6377	0,61
4	25-40	5,82182	0,13
5	>40	3,43617	0,08
	SUM	4364,01	100

Source : DEM Map

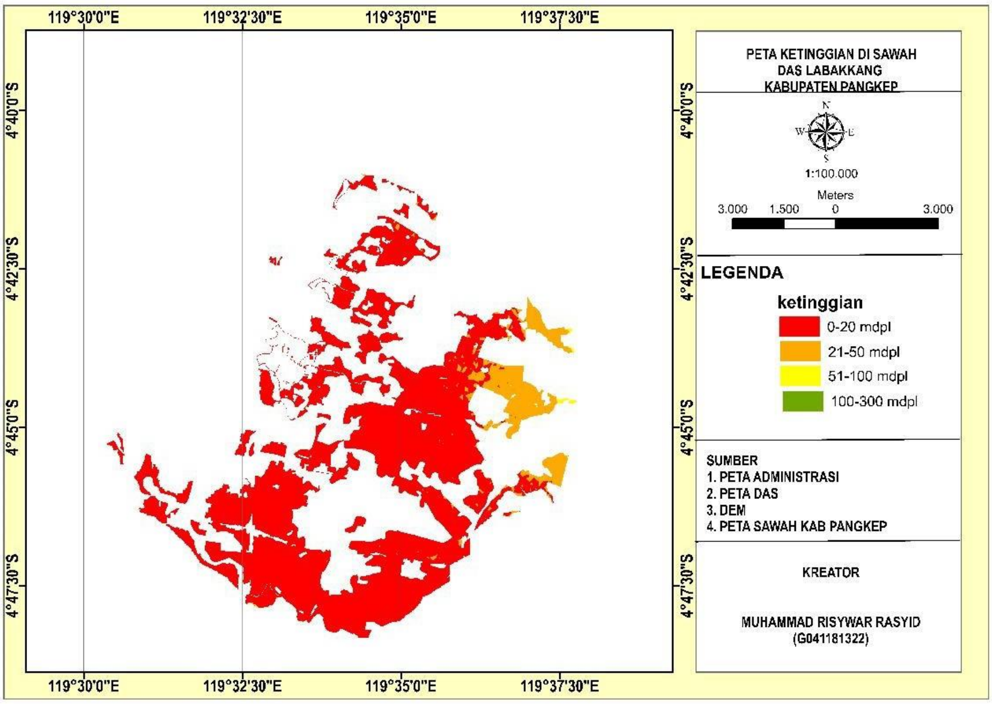
4.3 Land Elevation

The research area is divided into 5 land elevation classifications: 0-20 meters above sea level (masl), 21-50 masl, 51-100 masl, 101-300 masl, and >300 masl. The research area is dominated by low-lying areas, ranging from 0-20 masl. The percentage of low-lying areas (0-20 masl) is 90% of the total research area. This low elevation makes the research area very prone to flooding. This is because low-lying areas are more likely to receive runoff during heavy rains, as water flows from high-lying areas to low-lying areas. This is similar to the statement of Azizah (2021), who states that high-lying areas have a lower risk of flooding because during heavy rains, low-lying areas will receive runoff from high-lying areas. For a more complete picture, see Figure 5 and the table of percentage areas of each rice field elevation class in Table 5.

Table 5. Area of Each Parameter of Rice Field Elevation in the Labakkang River Basin

No	Height (mdpl)	Large(Ha)	Percentage(%)
1	0-20	3.957,048	90,614
2	21-50	401,240	9,188
3	51-100	8,570	0,196
4	100-300	0,050	0,001
5	>300	0	0
	SUM	4366,91	100

Source : DEM Map



Gambar 5. Peta Ketinggian Sawah pada DAS Labakkang

4.4 Soil Type

The soil type score is based on the texture of each soil type. Soils with very fine textures have a high risk of flooding, while coarse textures have a low risk of flooding. This is because the finer the texture of the soil, the more difficult it is for surface runoff from rain or river flooding to seep into the soil, resulting in flooding. Based on this, the highest score is given to soil types with very fine textures such as grumosol, latosol, and alluvial, while the lowest score is given to soils with coarse textures such as regosol, litosol, and organosol. The analysis of the map shows that the soil types in the study area are divided into three soil types: alluvial, lateritic, and regosol. The study area is dominated by lateritic soils, which cause the Labakkang watershed to have a high risk of flooding due to the lateritic soil characteristic of having clay textures that are less sensitive to infiltration. This is in line with the statement of Darmawan et al. (2017), who state that lateritic soils are soil types that have fine textures that are less sensitive to infiltration. The soil type map of the study area can be seen in Figure 6. The percentage of soil types can be seen in Table 6.

Table 6. Area of Each Type of Paddy Field in the Labakkang Watershed

No.	Soil Type	Large(Ha)	Percentage (%)
1	Aluvial	1.391,188	32,112
2	Lateritik	2.932,473	67,688
3	Regosol	8,619	0,001
Total		4332,280	100

Source : Forestry Office

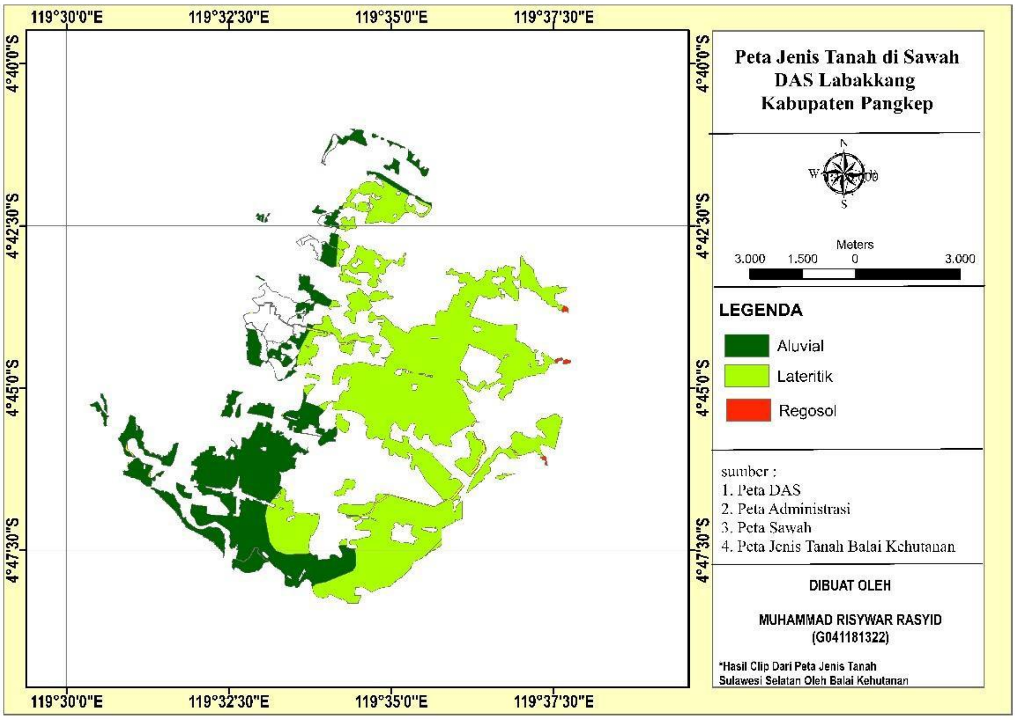


Figure 6. Map of Paddy Soil Types in the Labakkang Watershed

4.5 River Buffer

A river buffer is one of the maps used to create a flood zoning map. A river buffer map is a map that shows the distance between a point and the riverbank. As explained by Ariyora et al. (2015), a river buffer is defined as an area with a certain distance and area that is depicted around a river. The creation of a river buffer is based on an understanding and knowledge of the relationship between flood events and rivers. The closer an area is to a river, the greater the chance of flooding from river overflow. According to Kusumo and Nursari (2016), river buffer parameters are divided into 5 groups: (0-100 m) very dangerous, (100-200 m) dangerous, (200-300 m) quite dangerous, (300-500 m) safe, (>500) very safe. The river buffer map in the study area can be seen in Figure 7. Where the percentage of areas that are classified as very dangerous is 7%, while the largest percentage is the area that is classified as very safe (>500m) at 64%. The percentage of river buffer classes can be seen in Table 7.

No.	Distance from the river (m)	Large(Ha)	Percentage(%)
1	0-100	322,0664	7
2	100-200	365,85033	8
3	200-300	349,11745	8
4	300-500	620,57978	14
5	>500	2.910,3097	64
	SUM	4.567,9237	100

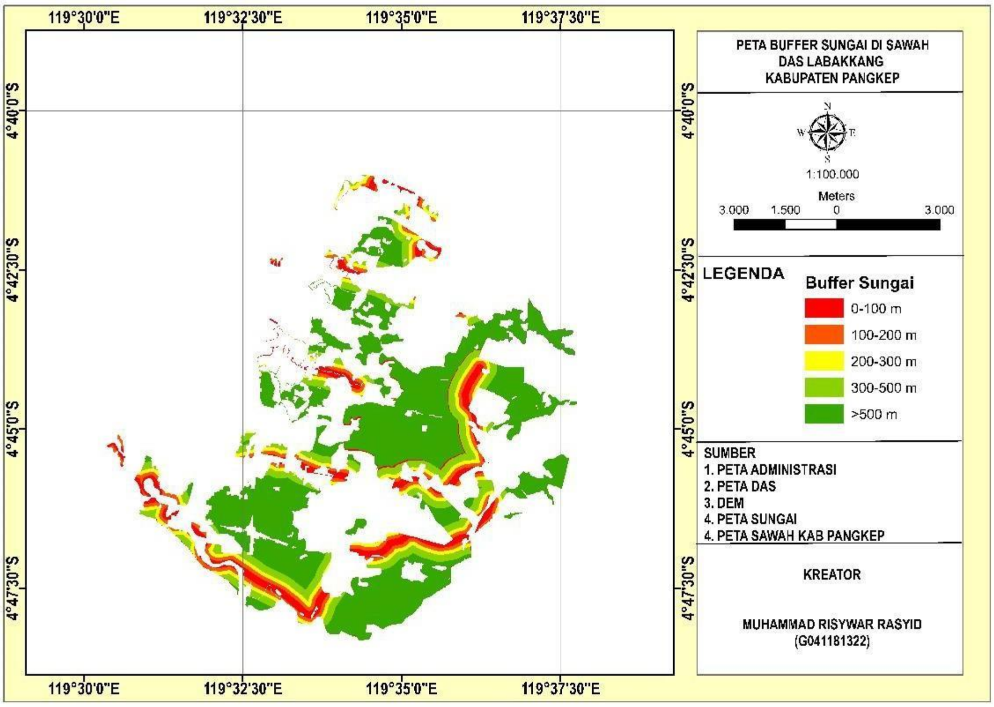


Figure 7. Buffer map of Sawah River on the Labakkang Table Watershed

4.6 Rainfall

Rainfall is one of the hydrological factors that plays a major role in flooding. Rainfall is measured by each rain gauge station that is scattered in several points in each region. This measurement is carried out to calculate daily, monthly, and annual rainfall for each region. In carrying out flood vulnerability analysis, a rainfall distribution map is needed to show the rainfall that occurs in an area. The production of a rainfall map is done by processing rainfall data obtained from the Meteorology, Climatology and Geophysics Agency (BMKG) in the form of monthly rainfall data for the past 5 years (2017-2021) from three rain gauge stations, namely the Labakkang, Bungoro, and Ma'rang stations.

Rainfall mapping was carried out using ArcGIS 10.4 software. The method used was the Thiessen polygon method. This method is a method of determining rainfall with the aim of seeing the rainfall of the area by taking into account the coverage area of each measurement station. This is in accordance with the statement of Nuryanti et al., (2018) that the Thiessen polygon is a method of determining rainfall by looking at how far the rain gauge can represent the characteristics of rain for a wide area.

The results obtained from the data processing at the Pangkep station showed that the rainfall in Pangkep Regency, especially in the research area, is a region with high rainfall, where the rainfall in the Pangkep Regency area is >2500 mm/year. This is in accordance with the statement of Kusumo and Nursari (2017) who classified rainfall above 2500 mm/year as very high rainfall. Where the rainfall at the Bungoro station recorded 3234.2 mm/year, at the Labakkang station recorded 3234.2 mm/year and the rainfall at the ma’rang station is 3742.2 mm/year. The results of the rainfall map in the research area can be seen in Figure 8. The coverage area of each rain gauge station in the research area can be seen in Table 8.

Table 8. Coverage of Rice Rainfall Stations in the Labakkang Watershed

No.	Station	Rainfall (mm/tahun)	Large (Ha)	Percentage(%)
1	Bungoro	3234,2	980,71	21,67
2	Labakkang	3382,2	2.895,47	66,27
3	Ma'rang	3742,2	487,82	12,06
	SUM		15.610,99	100

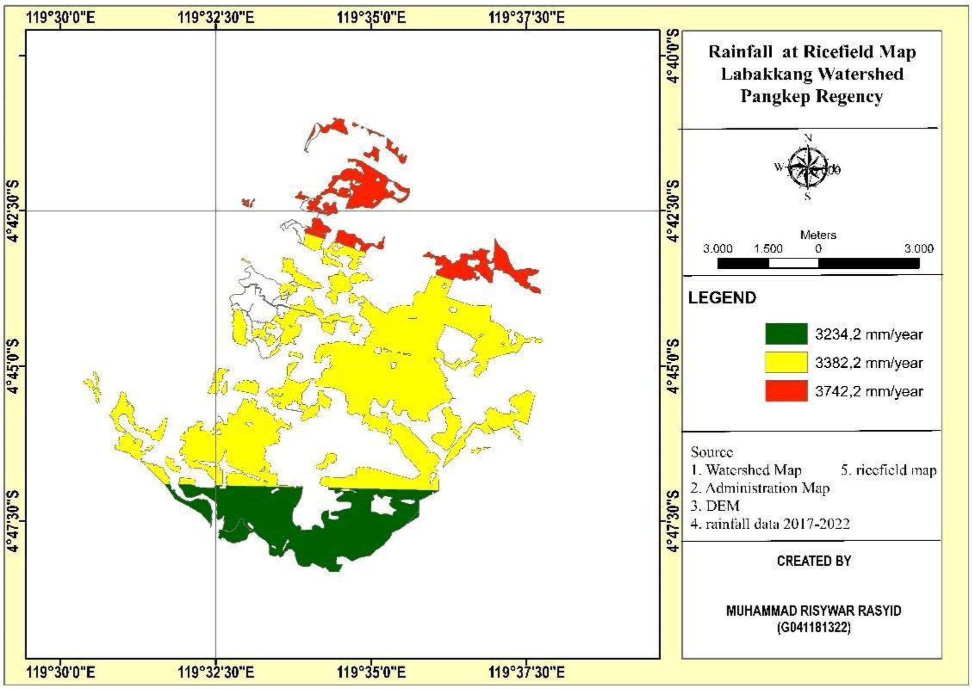


Figure 8. Map of Rice Rainfall in the Labakkang River Basin

4.7 Weight

One of the steps in the study of flood-prone areas is the process of assigning weights to the parameters used in flood zoning. This is done to see the influence of each factor analyzed. With this assessment, it can be determined which factors have the highest to lowest priority in supporting flooding.

In this study, the method used is the analytical hierarchy process (AHP) method, which requires an expert with experience in the field of watershed management. The initial stage involved giving a set of questions to respondents who had been determined in advance. The questions involved pairwise comparisons between one factor and another, with weighting using the Matrix Pairwise Comparison method. The results were then tested using the SuperDecision software to check for inconsistency in the respondents' assessments. The AHP method requires that the inconsistency not exceed 10% or 0.1. This means that the assessment can be used or considered valid when the test results meet the inconsistency requirement. The results of the statement test by the respondents showed that the river buffer is the parameter with the greatest influence on flooding, with a value of 0.443. This means that 43.3% of flooding in the study area is influenced by the river buffer, 26.6% by rainfall, 8% by soil type, 5.1% by slope, and 15.1% by land elevation. The results of the assessment test from the three respondents can be seen in Table 9.

Table 9. Weight of AHP test result

Finalists/criteria	Weight					Inconsistency
	CH	**BS**	**JT**	**S**	**E**	
Expert 1	0,280	0,438	0,076	0,045	0,158	0,087
Expert 2	0,259	0,443	0,084	0,046	0,166	0,079
Expert 3	0,260	0,448	0,080	0,051	0,151	0,071
Average	0,266	0,443	0,080	0,047	0,158	0,079

Explanation: rainfall, river buffer (RB), soil type (ST), slope (S), elevation (E).

4.8 Flood Risk Map

In this study, several parameters were first created to be used in analyzing the potential for flooding in rice fields in the Labakkang Watershed. Then, each parameter map that has been created will be stacked with the overlay command in ArcGIS to obtain a new map. By looking at the score and weight of each parameter, the vulnerability to flooding in rice fields in the Labakkang Watershed is divided into 3 levels. These are low, medium and high. The overlay map can be seen in Figure 10.

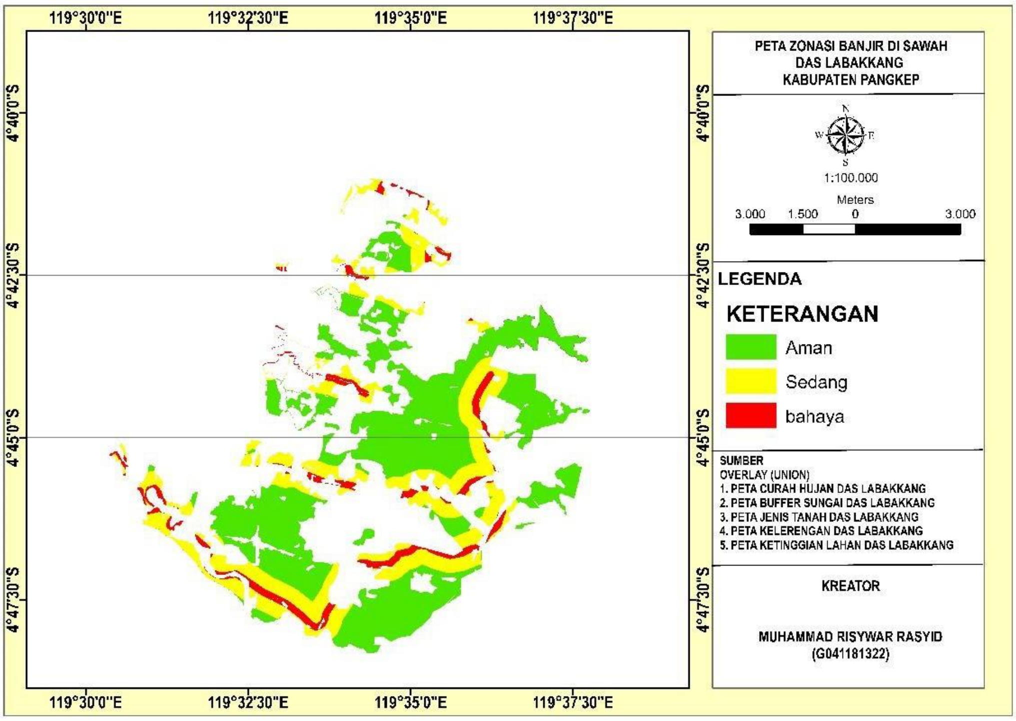


Figure 9. Flood Zonation Map in Rice Fields in the Labakkang Watershed

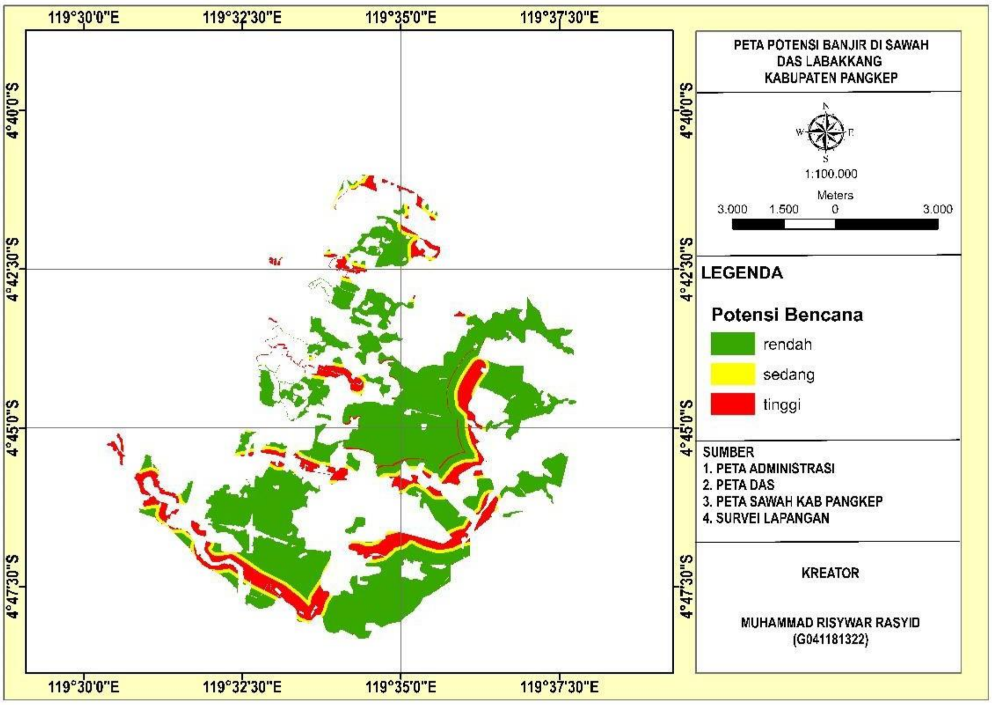


Figure 10. Map of Potential Paddy Field Floods in the Labakkang Watershed

Based on the map in Figure 10, it is clear that hazardous rice fields are scattered along the river channel. Rice fields that are 0-100 meters away are in the hazard zone, then 100-500 meters are in the moderate zone, and the rest are in the safe zone. To validate the map that has been created (Figure 9), a direct check was carried out in the research area. Validation was carried out by comparing the number of points that matched the reality in the field, which was known from 11 surveyed points, 9 of which were in accordance with field facts. This means that the accuracy rate of the map is 81%.

Based on the direct check in the field, it is known that the map of the analysis is not much different from the facts that were obtained in the field, where information was obtained that rice fields that are located at a distance of 0-200 meters from the riverbank have a high risk of flooding and usually have a flood height of >40 cm from the rice field surface with a flood frequency of 3-4 times a year with an average flood duration of 3-4 days. According to the statement of Tommi et al. (2017), rice fields that are classified as high/hazard flood risk are rice fields with a flood height of >40 cm with a flood frequency of >4 times a year and a flood duration of >3 days. The map of the field check results can be seen in Figure 11. The comparison data between the analysis map and the location check map can be seen in Table 10.

Table 10. Comparison between Analytical Map and Field Survey Map

No.	Zone	Map Analysis		Field Survey	
		Large (Ha)	Percentage (%)	Large(Ha)	Percentage(%)
1	Safe	2.902,0155	64	3.530,8895	77
2	Medium	1.319,2812	29	349,11745	8
3	Dangerous	3.17,98092	7	687,916738	15
SUM		4539,2776	100	4.567,92369	100

In addition to using on-site surveys, this study also used a map issued by the Public Works and Housing Department (PUPR) as a comparison to the research map. The map issued by the PUPR only divides two types of rice fields, namely rice fields that are affected by flooding and rice fields that are not affected by flooding. The PUPR map shows that the research area is a flood-prone area. The flooded area has an area of 3,998.277 hectares, or 92% of the total area of the research area. The PUPR map can be seen in Figure 12. The percentage of area for each class on the PUPR department map can be seen in Table 11.

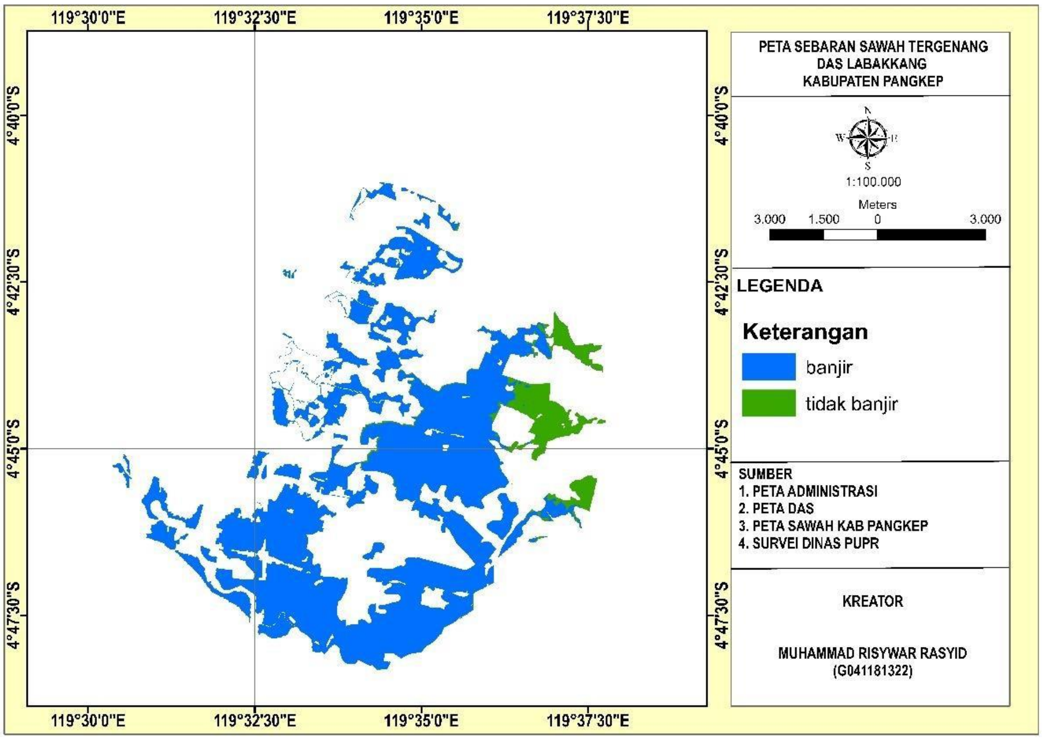


Figure 11. Map of Flooded Rice Fields in The Labakkang River Basin

Table 11. Area of Flooded Rice Fields in Rice Fields in the Labakkang Watershed

No.	Flood Event	Large (Ha)	Large (%)
1	Flood	3998.277	92
2	Not Flood	368.633	8

Source: PUPR Office

5 COVER

5.1 Conclusion

Based on the research that has been done, it can be concluded that:

1. Rice fields in the Labakkang watershed are the majority of rice fields classified as safe with a percentage of 64%, a medium zone with a percentage of 29% and a danger zone with a percentage of 7%.
2. Rice fields that have a high risk of flooding are rice fields that are 0-300 m from the riverbank.
3. River buffer is the parameter that most influences flood vulnerability in rice fields in the Labakkang watershed 3.

5.2 Advice

The suggestions that can be given by researchers are:

1. Further research is needed on the level of flood vulnerability in the Labakkang watershed by including other factors such as: infrastructure, the number of people, and the history of flooding from year to year.
2. Similar research is needed with different methods and approaches for comparison.

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APPENDICES

APPENDIX 1. DOCUMENTATION

Questionnaire Filling with Ir. Syamsul Arifin Lias, M.Si

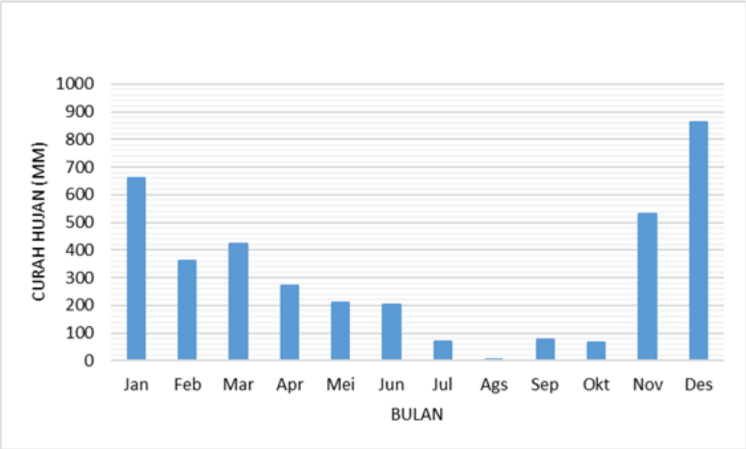
Questionnaire Filling with Andang Suryana Soma, S.Hut., MP, Ph.D.

Questionnaire Filling with Prof. Dr. Ir. Dr. Ir. Ahmad Munir, M.Eng

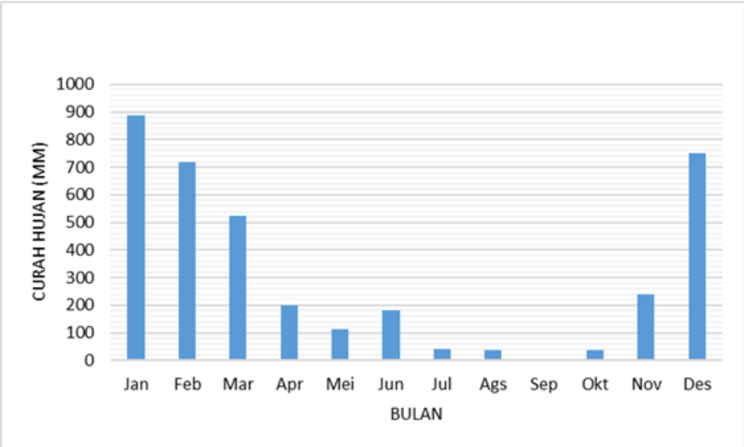
Making maps together with employees of the Public Works and Housing Office of Pangkep Regency

Research site survey photo

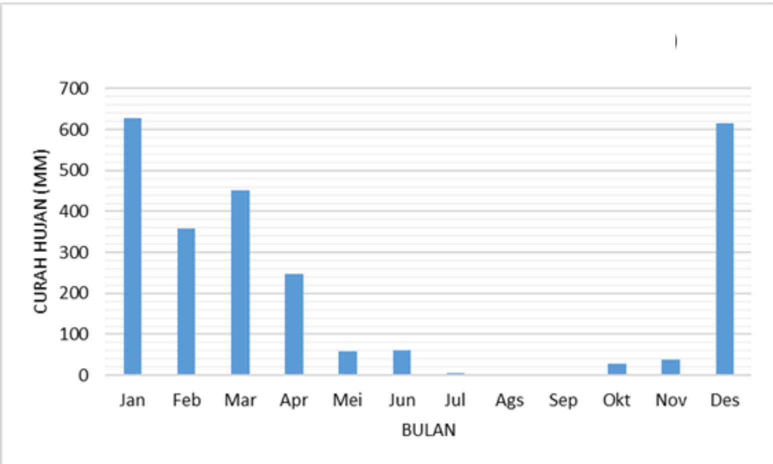
APPENDIX 2. RAINFALL DATA



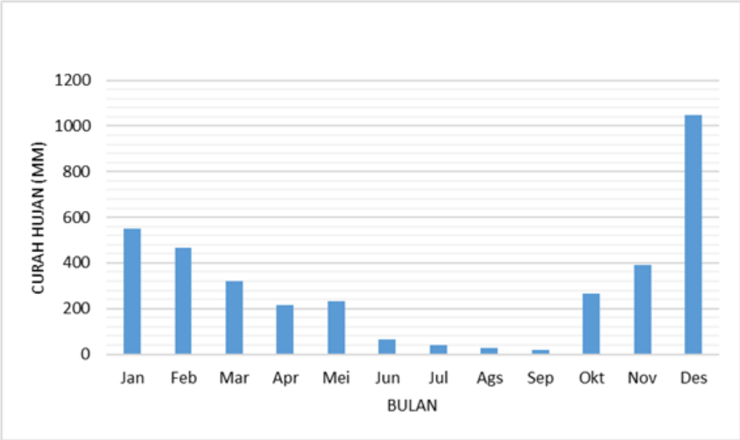
Ma'rang Monthly Rainfall 2017
(Source : BMKG).



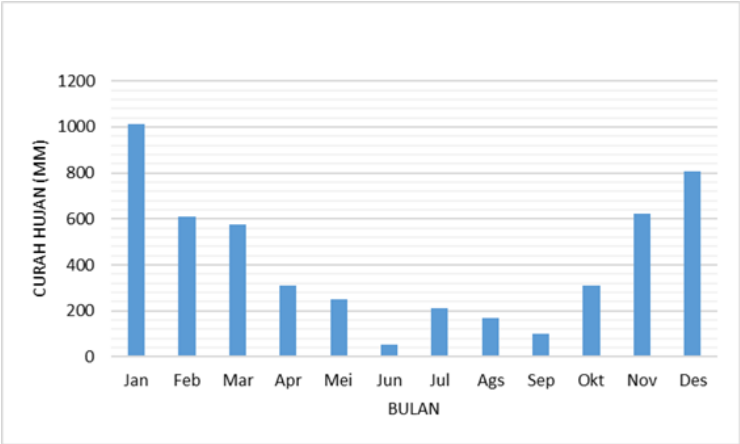
Ma'rang Monthly Rainfall 2018
(Source : BMKG).



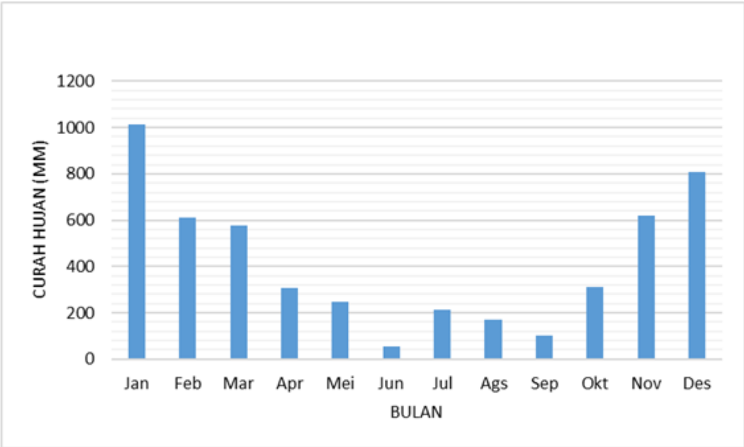
Ma'rang Monthly Rainfall 2019
(Source : BMKG).



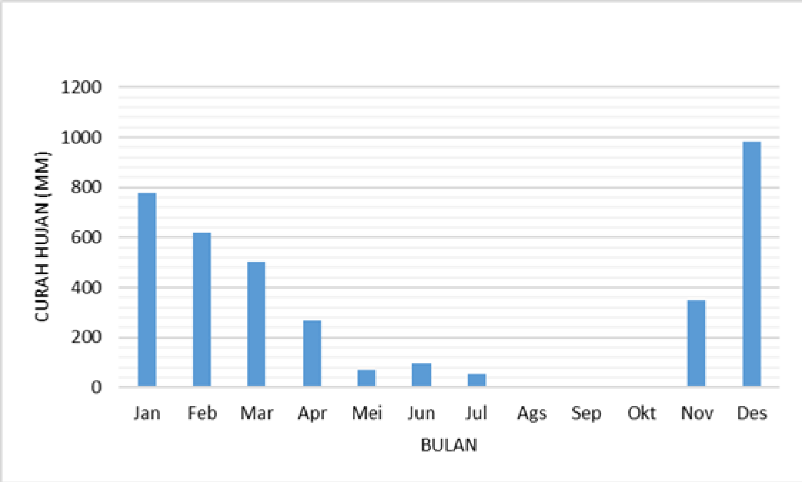
Ma'rang Monthly Rainfall 2020
(Source : BMKG).



Ma'rang Monthly Rainfall 2021
(Source : BMKG).



Bungoro Monthly Rainfall 2017
(Source : BMKG).



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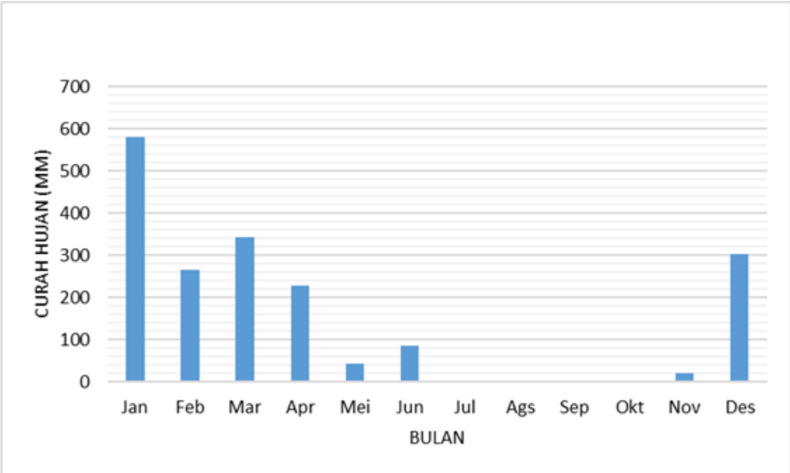
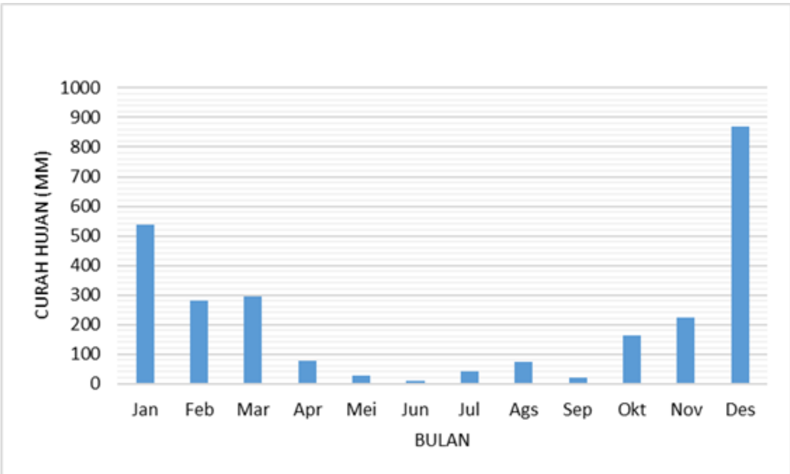
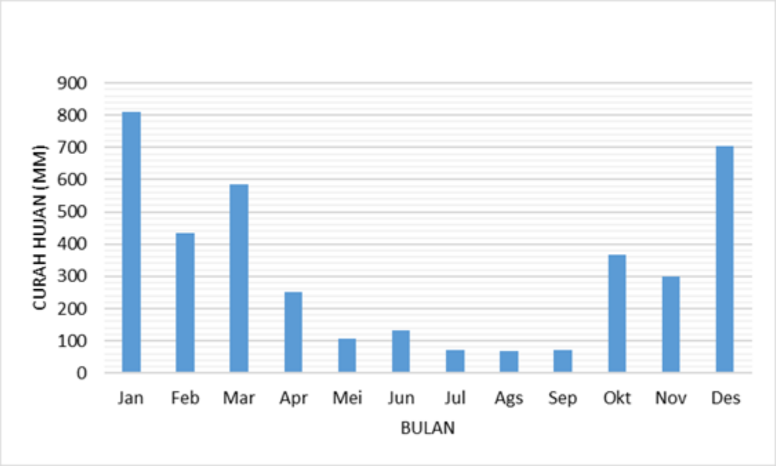
(Source : BMKG).



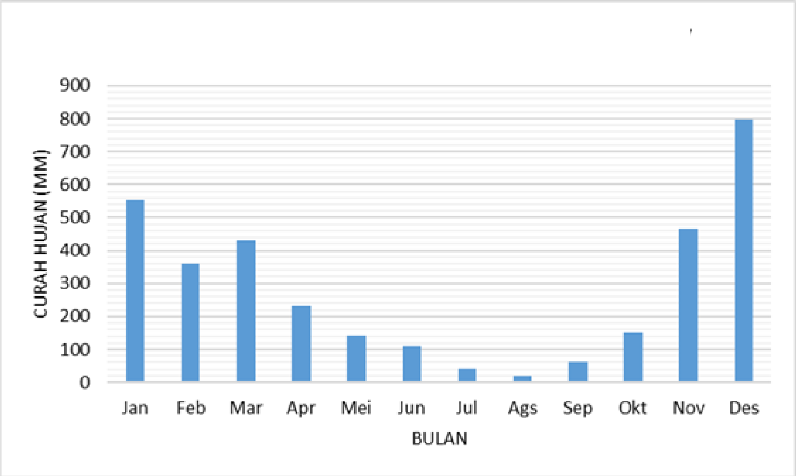
Bungoro Monthly Rainfall 2019
(Source : BMKG).



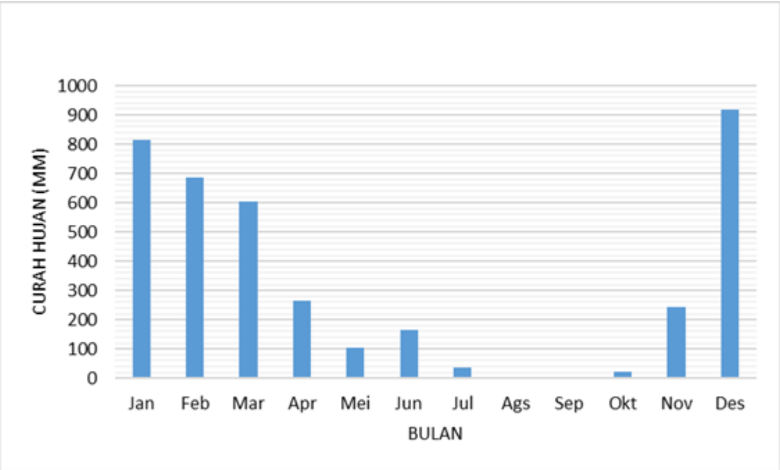
Appendix 2.9 Bungoro Monthly Rainfall 2020
(Source : BMKG).



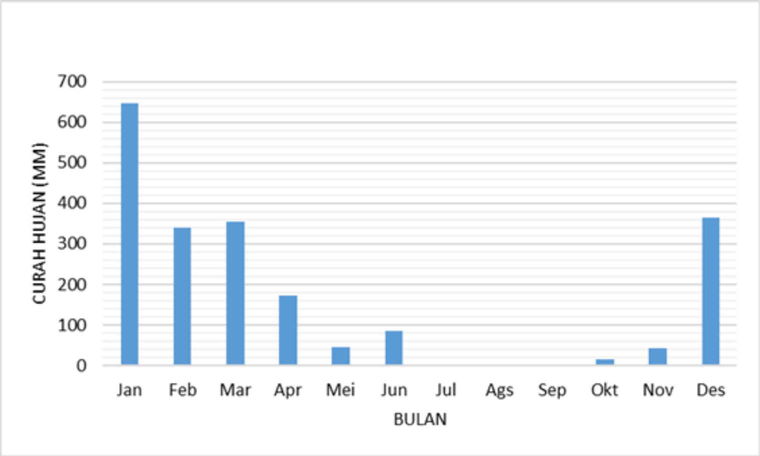
Bungoro Monthly Rainfall 2021
(Source : BMKG).



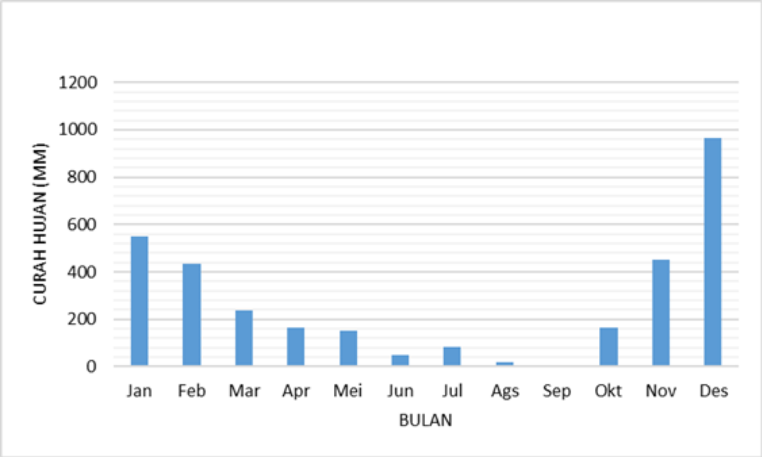
Appendix 2.11 Labakkang Monthly Rainfall 2017
(Source : BMKG).



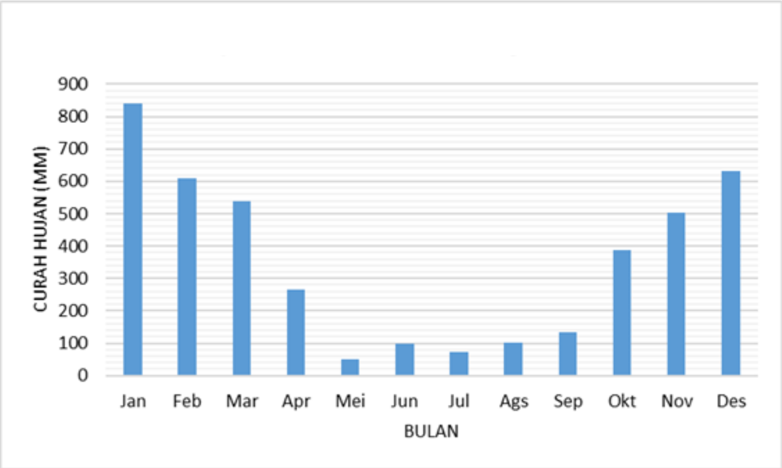
Appendix 2.12 Labakkang Monthly Rainfall 2018
(Source : BMKG).



Labakkang Monthly Rainfall 2019
(Source : BMKG).



Appendix 2.14 Labakkang Monthly Rainfall 2020
(Source : BMKG)



Labakkang Monthly Rainfall 2021

(Source : BMKG).

APPENDIX 3. QUESTIONNAIRE

RESEARCH QUESTIONNAIRE

RESPONDENT IDENTITY

Respondent Name :

Position :

Agency Origin :

Gender :

Mobile No. / E-mail :

To Dear Sir / Mother At Place

Assalamualaikum warahmatullahi wabarokatuh, introducing my name Muhammad Risywar Rasyid, an undergraduate student of the Agricultural Engineering Study Program at Hasanuddin University Makassar.

In order to complete the Final Project (Thesis) with the title "MAPPING THE DANGER LEVEL OF BANJURY IN WET LAND ON THE LABAKKANG SUNGAI FLOW DAIRY OF PANGKEP DISTRICT", in that regard, the researcher would like to thank you for your willingness to fill out this questionnaire. SOUTH SULAWESI", in connection with that, the researcher would like to thank you for your willingness to fill out this questionnaire. This questionnaire aims to assess the level of influence of the parameters used in our research on the occurrence of flooding in rice fields.

The results obtained from this questionnaire will be processed using the AHP (Analitycal Hierarchy Process) method. AHP is a method used in this research to see how much influence certain parameters have on flood events.

All activities of filling out this questionnaire will be guided by researchers in the form of guidelines that will be given to respondents when filling out the questionnaire. the information you provide in this questionnaire will be very helpful in carrying out our research. We thank you for your attention.

INSTRUCTIONS ON HOW TO FILL OUT

Respondents determine which factors are more important by comparing one factor with another.

1. Scoring each indicator on a scale of 1 less and 9 more.
2. The number shows the comparison of the level of importance between one indicator and another with the following conditions:
    - Equally important (1) is where both factors contribute equally to the same objective.
    - Relatively somewhat more important (3) is a condition where the importance of the factor is apparent compared to other factors but not so convincing.
    - More important (5) is a condition where it is obvious, evident in some events that the factor is more important than other factors.
    - Very much more important (7) is a condition where it is obvious, evident in some instances that the factor is much more important than other factors.
    - Absolutely more important (9) is a condition where it is clear, obvious and conclusively proven in some instances that the factor is very important in a high level of consensus.
    - 2, 4, 6, 8 is an intermediate value between the above two determinants

Instructions for filling out:

Give a mark (✓) on your assessment of the questions below in accordance with the instructions for filling out the questionnaire. Compare the indicators in the criteria column A with the indicators in the criteria column B.

Example of filling out a questionnaire:

Which criteria are more important between land elevation and land slope?

Example of Incorrect Filling

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation				✓						
Land Slope								✓		

Explanation:
Wrong because AHP (Analytical Hierarchy Process) is a pairwise comparison method so one of them must be selected "No".

Example of Correct Filling

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation	✓									
Land Slope								✓		

Explanation:

- The answer above shows that the land slope criterion is relatively somewhat more important with a scale value of 3, which means that the land slope is relatively somewhat more important to the land height.
- This questionnaire is a pairwise comparison, therefore one of the criteria must be selected "No".

QUIZ ON PRIORITIZING FACTORS CAUSING FLOODING

1. Which criteria are more important between land elevation and land slope?

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation										
Land Slope										

2. Which criterion is more important between land elevation and soil type?

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation										
Land Slope										

3. Which criterion is more important between land elevation and rainfall?

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation										
Land Slope										

4. Which criterion is more important between land elevation and distance from the river?

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation										
Land Slope										

5. Which criterion is more important between land slope and soil type?

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation										
Land Slope										

6. Which criterion is more important between land slope and rainfall?

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation										
Land Slope										

7. Which criterion is more important between land slope and distance from river?

Criteria	No	9	8	7	6	5	4	3	2	1
Land slope										
Distance from river										

8. Which criterion is more important between soil type and rainfall?

Criteria	No	9	8	7	6	5	4	3	2	1
Soil type										
Precipitation										

9. Which criterion is more important between soil type and distance from the river?

Criteria	No	9	8	7	6	5	4	3	2	1
Soil type										
Distance from river										

10. Which criterion is more important between rainfall and distance from the river?

Criteria	No	9	8	7	6	5	4	3	2	1
Land slope										
Distance from river										

11. Which criterion is more important between land elevation and land cover?

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation										
Land Cover										

12. Which criterion is more important between land slope and land cover?

Criteria	No	9	8	7	6	5	4	3	2	1
Land slope										
Land Cover										

13. Which criterion is more important between Soil type and land cover?

Criteria	No	9	8	7	6	5	4	3	2	1

Soil type										
Land Cover										

14. Which criterion is more important between rainfall and land cover?

Criteria	No	9	8	7	6	5	4	3	2	1
Precipitation										
Land Cover										

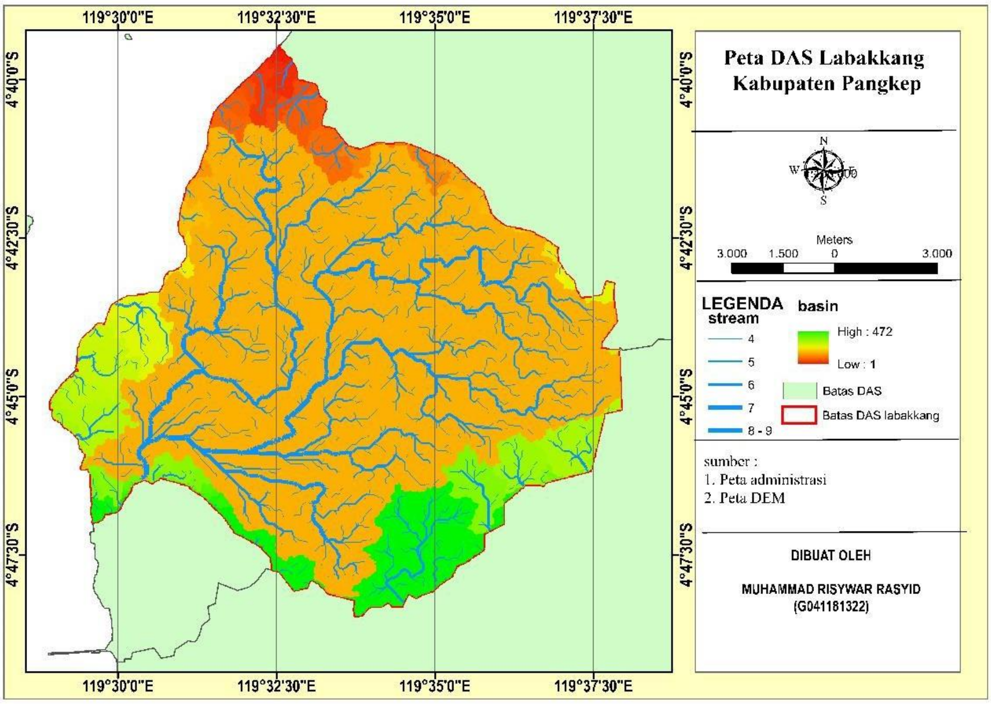
15. Which criterion is more important between distance from river and land cover?

Criteria	No	9	8	7	6	5	4	3	2	1
Land Elevation										
Land Cover										

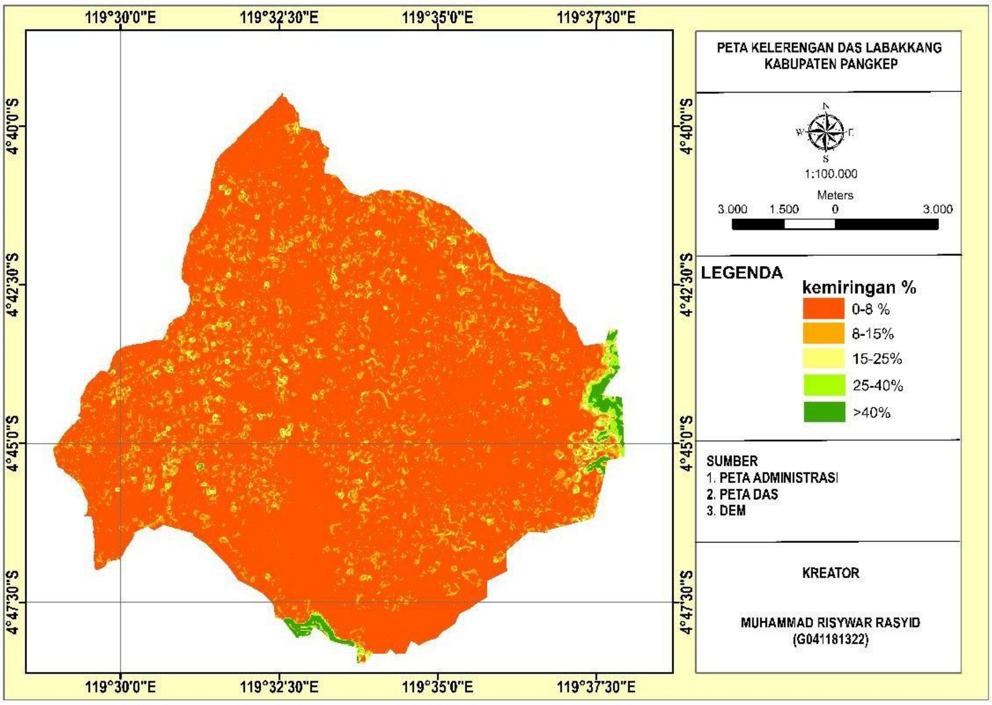
16. Which criteria are more important between physical and hydrological aspects?

Criteria	No	9	8	7	6	5	4	3	2	1
Physical aspects										
Hydrological aspects										

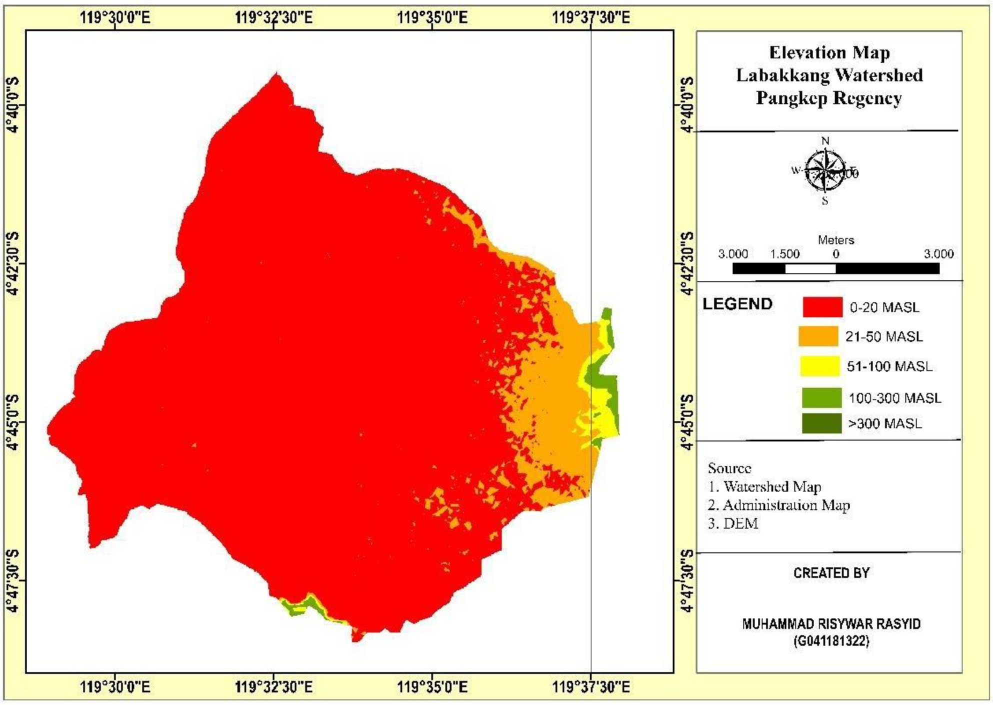
APPENDIX 4. Map of Each Parameter in the Labakkang Watershed



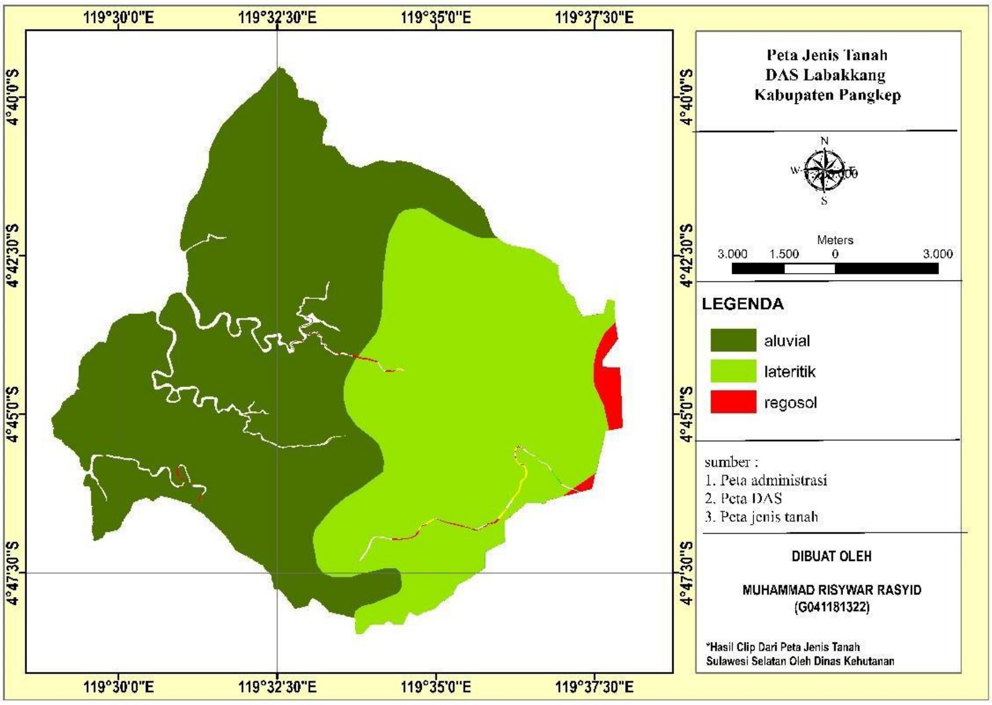
Map of Labakkang Watershed.



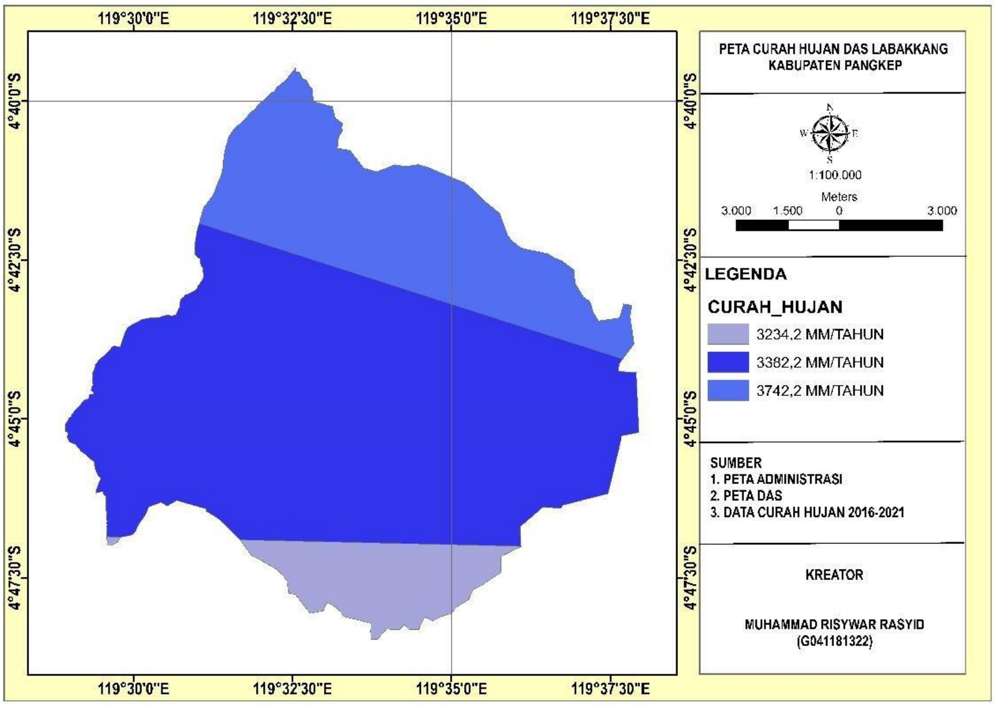
Slope Map of the Labakkang Watershed.



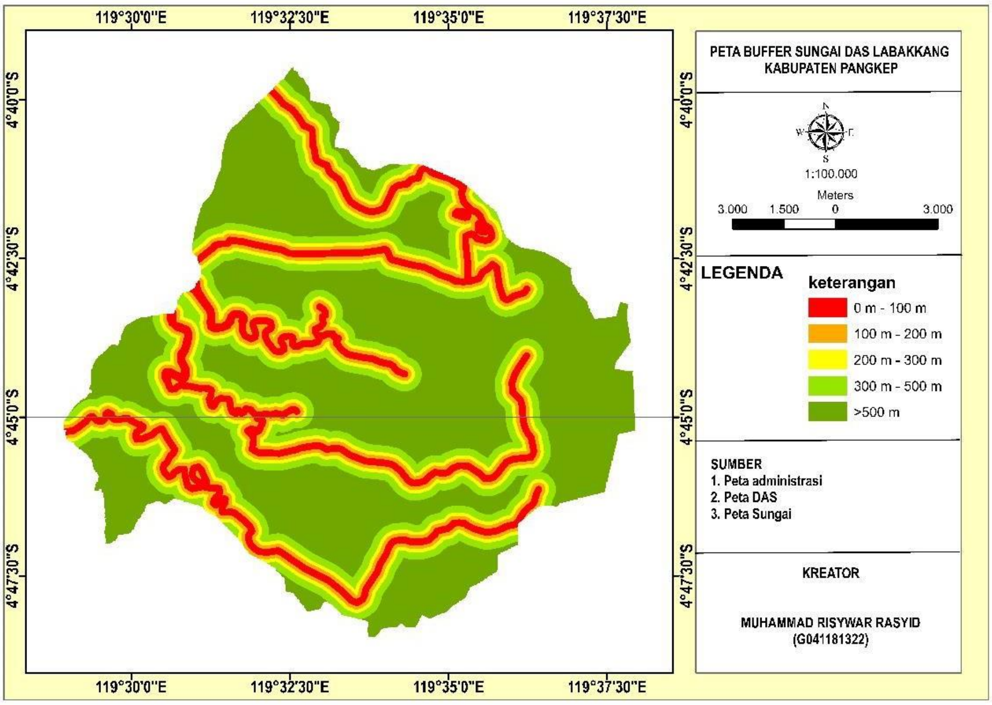
Elevation Map of the Labakkang Watershed.



Map of Soil Types in the Labakkang Watershed.

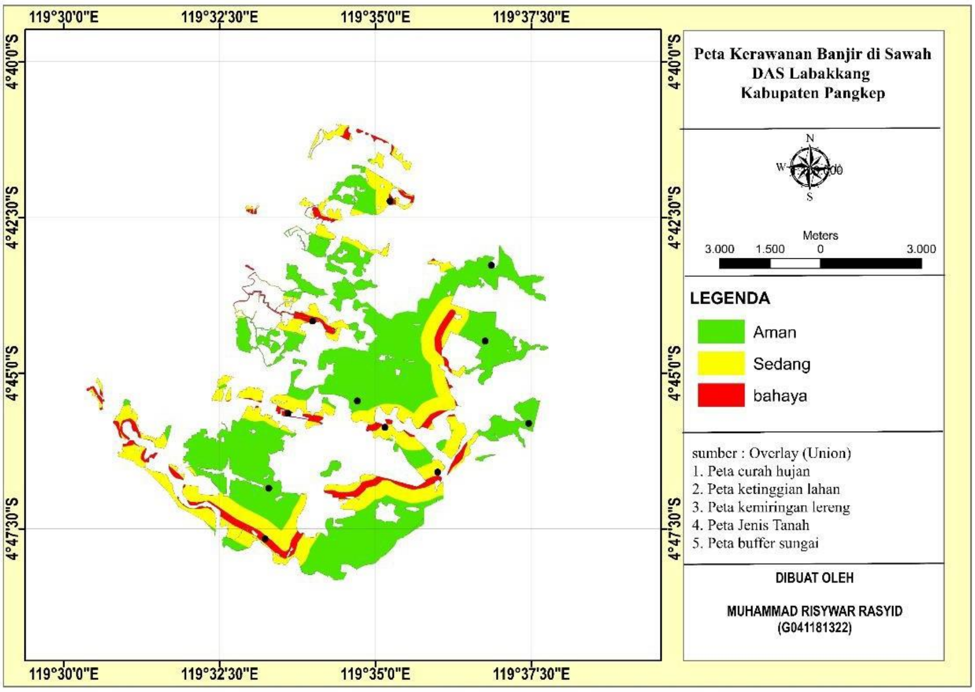


Rainfall Map of Labakkang Watershed.



Map of river buffers in the Labakkang watershed.

APPENDIX 5. Site Survey Result Data



Map of the distribution of site survey points in the Labakkang Watershed.

Point	X	Y	Survey		Maps
			Variable	Description	PUPR
1	119.565	-4.794	Inundation Height	>40 cm	
			Flood Frequency	3-4 kali	Flood
			Duration of Inundation	3-5 hari	
2	119.567	-4.789	Inundation Height	30-40 cm	
			Flood Frequency	2 kali	Flood
			Duration of Inundation	2 hari	
3	119.59	-4.787	Inundation Height	>40 cm	
			Flood Frequency	3-4 kali	Flood
			Duration of Inundation	3-5 hari	
4	119.589	-4.793	Inundation Height	30-40 cm	
			Flood Frequency	2-3 kali	Flood
			Duration of Inundation	2 hari	
5	119.622	-4.772	Inundation Height	10-20 cm	
			Flood Frequency	1 kali	No Flood
			Duration of Inundation	1 hari	
6	119.613	-4.757	Inundation Height	10-20 cm	
			Flood Frequency	1 kali	No Flood
			Duration of Inundation	1 hari	
7	119.604	-4.754	Inundation Height	>40 cm	
			Flood Frequency	3-4 kali	Flood
			Duration of Inundation	3-5 hari	
8	119.594	-4.729	Inundation Height	>40 cm	
			Flood Frequency	3-4 kali	Flood
			Duration of Inundation	3-5 hari	
9	119.578	-4.752	Inundation Height	>40 cm	
			Flood Frequency	3-4 kali	Flood
			Duration of Inundation	3-5 hari	
10	119.574	-4.771	Inundation Height	>40 cm	
			Flood Frequency	3-4 kali	Flood
			Duration of Inundation	3-5 hari	
11	119.6	-4.767	Inundation Height	20-30 cm	
			Flood Frequency	2-3 kali	Flood
			Duration of Inundation	2 hari	

APPENDIX 6. Analysis of vulnerability

Max vulnerability score: 8,626

Min vulnerability score:3,724

Interval :3

No.	Interval Class	Description
1	3,724 - 5,358	Safe
2	5,358 - 6,992	Medium
2	6,992 - 8,626	Danger