



Flood Rate Assessment of the Woyla River Watershed, Aceh Province, Indonesia

Rifa Alayani¹, Sugianto Sugianto^{1*}, Hairul Basri¹

¹Land Resources Conservation Study Program, Graduate Program, Syiah Kuala University, Aceh;

Soil Science Department, Agriculture Faculty, Universitas Syiah Kuala, Banda Aceh, Indonesia

*Corresponding author: sugianto@unsyiah.ac.id

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Abstract - This study aims to assess Flood susceptibility and flood hazard levels and obtain the distribution of hazard levels and flood hazards in the Woyla watershed, Aceh Province. This research design generally uses a descriptive survey method and is divided into several stages, such as data collection, data processing, data presentation, and delivery of research results. Each determinant of flood-prone areas includes a land slope, altitude, soil texture, drainage, land cover, and rain fall, analyzed spatially utilizing a map. Furthermore, based on the map, the regions are described based on the values that have been divided into classes. The results showed that the level of flood vulnerability in the Woyla watershed was divided into five classes, namely; the non-vulnerable class with an area of 14.88 Ha / 0.01%, low prone with an area of 90,731.62 Ha / 35.45%, medium with an area of 57,120.35 Ha / 22.32%, high with an area of 44,918.15 Ha / 17.55%, and very high with an area of 63,151.72 Ha / 24.67%. Also obtained a map of the distribution of flood hazard areas, the Woyla watershed area is divided into five classes, namely; the very light class with an area of 179,146.15 Ha / 70.00%, mild with an area of 32,868.84 Ha / 12.84%, moderate with an area of 20,129.93 Ha / 7.87%, danger with an area of 6,007.29 Ha / 2.35%, and very dangerous with an area of 17,784.51 Ha / 6.95%. The level of flood vulnerability in the Woyla watershed is dominant in West Aceh Regency, which is in the very high and high category classes with a total area of 56,876.65 Ha and 23,527.40 Ha. Meanwhile, the level of flood hazard in the Woyla watershed is also more dominant in West Aceh Regency than falls into the most dangerous and dangerous class category with a total area of 17,784.51 Ha and 6,007.29 Ha. With the largest part in the very light class at the flood hazard level of 179,146.15 ha.

Keywords: Mapping, flood hazard, flood

Introduction

The area of watersheds (DAS) in Indonesia is very diverse, a considerable number. Watershed damage continues from year to year, as is the case with Isnugroho's (2002) statement that damage to watersheds in Indonesia is increasing every year, causing very detrimental excess. Flood is one natural disaster that frequently occurs throughout Indonesia, Odi & Harumi (2018). The flood event in West Aceh district can be life-threatening. Because one of the variables for flooding is critical watershed conditions, such as land use irregularities. (Rahman, 2017). According to Rahma *et al.* (2016), in their research entitled "stated that flooding is a pool of water that flows swiftly with a height exceeding normal levels. During a flood, the water will inundate; most of the land is usually not flooded. Every year there are always floods, landslides, drought, and other disasters. Mawardi (2010) reports that most of the watersheds in Java are damaged and critical. The indicators can be seen from the areas of vegetated land cover in the watershed that only reaches less than 20%. Then, the river flow fluctuation is very high, and the level of erosion, sedimentation, and river water pollution is high enough. It is said that flooding is a pool of water that flows swiftly with a height exceeding normal levels. During a flood, the water will inundate; most of the land is usually not flooded. Every year there are always floods, landslides, drought, and other disasters.

Look from the watershed function; it is necessary to manage land resources in the existing watershed areas in Aceh so that their utilization can be optimal and sustainable. Apart from the above functions, several problems often occur on the South West coast, such as floods, especially in the Woyla watershed, West Aceh Regency. It was not apart from the decline of the watershed function to carry out the water management naturally. Mapping of flood-prone areas could be identified quickly through a geographic information system using the overlay method of flood parameters, such as soil infiltration, rainfall, slope, and land use, Nuryanti (2018). Mapping the flood-prone areas using the Geographic Information System and ArcGis 10.5 to produce maps of flood-prone areas according to the specified parameters. (Hamdani *et al.*, 2014).

Regions can have different causes of flooding. (Muhammad *et al.*, 2019). Multi-criteria analysis can be used to see specific criteria for the causes of flooding in an area (Haryani *et al.*, 2012). This study is essential to consider the need to assess the vulnerability and danger of flooding in the Woyla watershed and address the flood disaster. So the basic data needed in this study are several thematic maps related to flood parameters. The analysis was used with GIS. Then it will provide directions to the community regarding the settlements on the banks of the Woyla River Basin, which experience flooding every year. One of the efforts to detect floods is to carry out disaster mitigation. The recommended disaster mitigation is to create a design/scenario mapping of the vulnerability and danger of flooding to identify the community settlements affected by the flood disaster. The resulting output is mapping in flood disaster mitigation in the Woyla watershed and overcoming watershed management.

Materials and Methods

This research was conducted in the Woyla watershed. Geographically, the Woyla Watershed is located at 95° 50 '00 " - 96° 40' 00" East Longitude and 4° 13 '32 " - 4° 57' 48" North Latitude. The Woyla Watershed administratively is located within seven districts in Aceh Province, namely West Aceh District, Nagan Raya District, Central Aceh District, Pidie District, Pidie Bireun District, and Aceh Jaya District. This watershed has an area of 255,936.73 hectares that consists of 9 (nine) sub-watersheds.

This research uses descriptive survey methods divided into several stages; data collection, data processing, data presentation, and delivery of research results. Spatial data and information are the primary data. The spatial data representing the world and reality are usually processed into information summarized in a spatial-based system with specific goals (Sagita, 2016). Each determinant of flood-prone areas, including land slope, altitude, soil texture, drainage, land cover, and the spatiality of rainfall, was analyzed using overlaid map analysis. Furthermore, based on the map of the regions, the values previously divided into classes are described.

Then, the maps of flood-prone determinants areas are overlaid or overlapped to obtain the intersection of each factor. The result of this intersection then calculated the hazard values based on the score and weighted value. Then, the value of flood vulnerability describes the area of every class for each sub-district in the watershed areas of the research location.

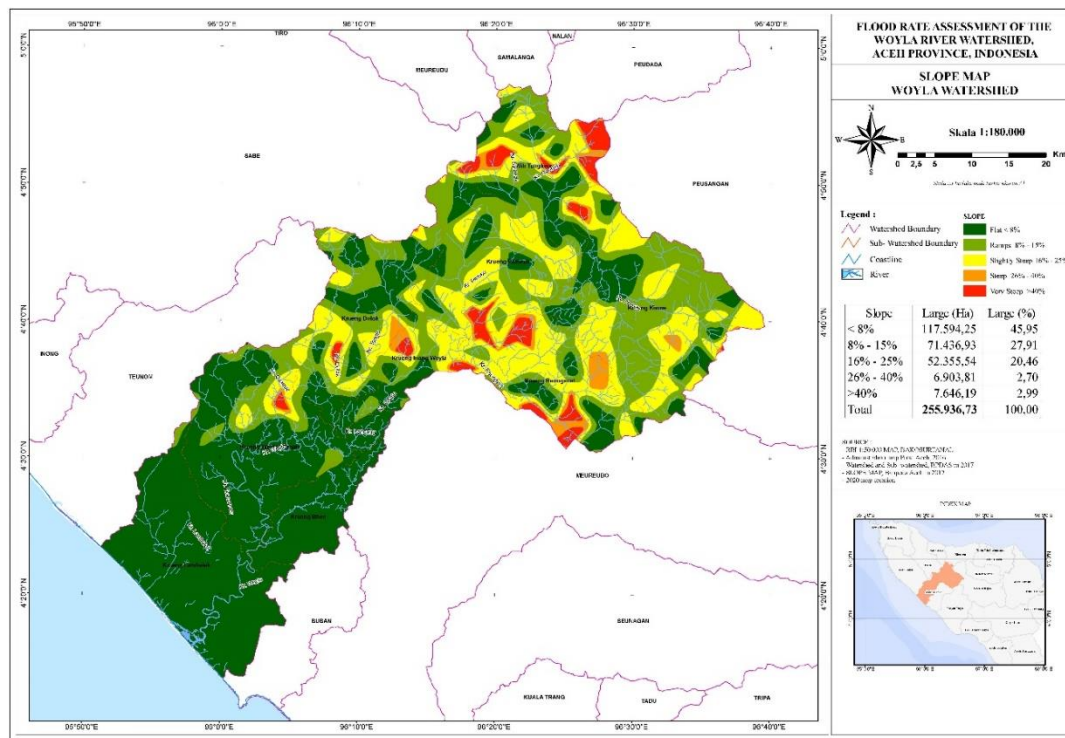


Figure 1. The slope of the Woyla watershed in Aceh Barat district and Aceh Provinces

Slope analysis

In this study, we categorized the slope of the watershed within five classes; namely very steep, steep slightly steep. Ramp, and flat (Table 1) (Paimin et al., 2009)

Table 1. Scores for the Slope classes

No.	Class	Score
1	Very Steep / Steep (> 45%)	1
2	Steep (26% - 45%)	2
3	Slightly Steep (16% - 25%)	3
4	Ramps (8% - 15%)	4
5	Flat (0% < 8%)	5

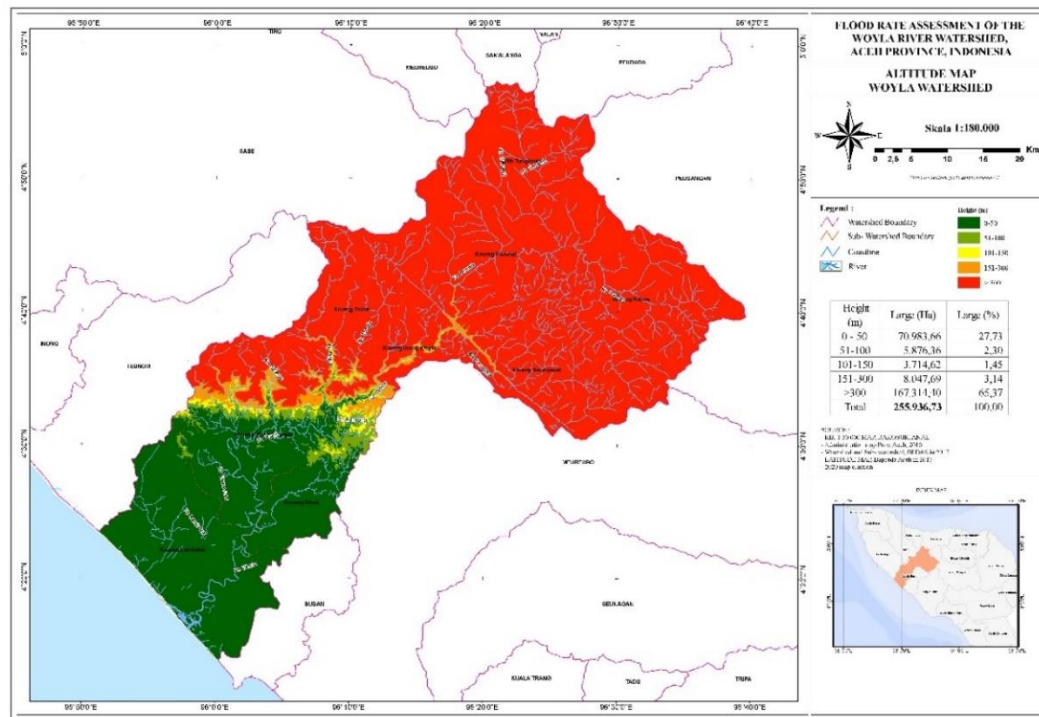


Figure 2. The altitude of Woyla watershed site in Aceh Barat District and Aceh Provinces

Altitude Analysis

They were making high-class maps using SRTM 90-meter data which is converted into contour maps. The *extension* used is Spatial Analyst - Surface Analyst - Contour. This contour functions to calculate which areas have the same high value so that the high-class classification can be carried out. After that, reclassification was done with 3D Analyst Tools - Raster Reclass - Reclassify and exported to shapefile format using Conversion Tools - From Raster - Raster to Polygon. The altitude of the area was divided into five classes (Table 2) (Damanik, 2011)

Table 2. Scores for the Altitude class

No.	Height (m)	Score
1	> 300	1
2	151 - 300	2
3	101 - 150	3
4	51 - 100	4
5	0 - 50	5

Soil Texture

Soil with fine texture has a high chance of flooding, while coarse texture has a low flooding scope. That is due to more delicate soil texture, making the surface runoff water from rain and river overflow difficult to seep into the ground, resulting in inundation. Based on this, the scoring for the land with delicate soil texture has a higher impact on the calculation. For this study, five classes of soil texture are utilized in the computation (Tabel 3) (Soepardi, 1979)

Table 3. Scores for soil texture class

No.	Texture Class	Score
1	Sand, Clay / Coarse Sand	1
2	Sandy Clay / Slightly Coarse	2
3	Clay, Clay, Dust / Medium	3
4	Clay Clay, Sandy Clay Clay / Somewhat Smooth	4
5	Clay, Sandy Clay / Smooth	5

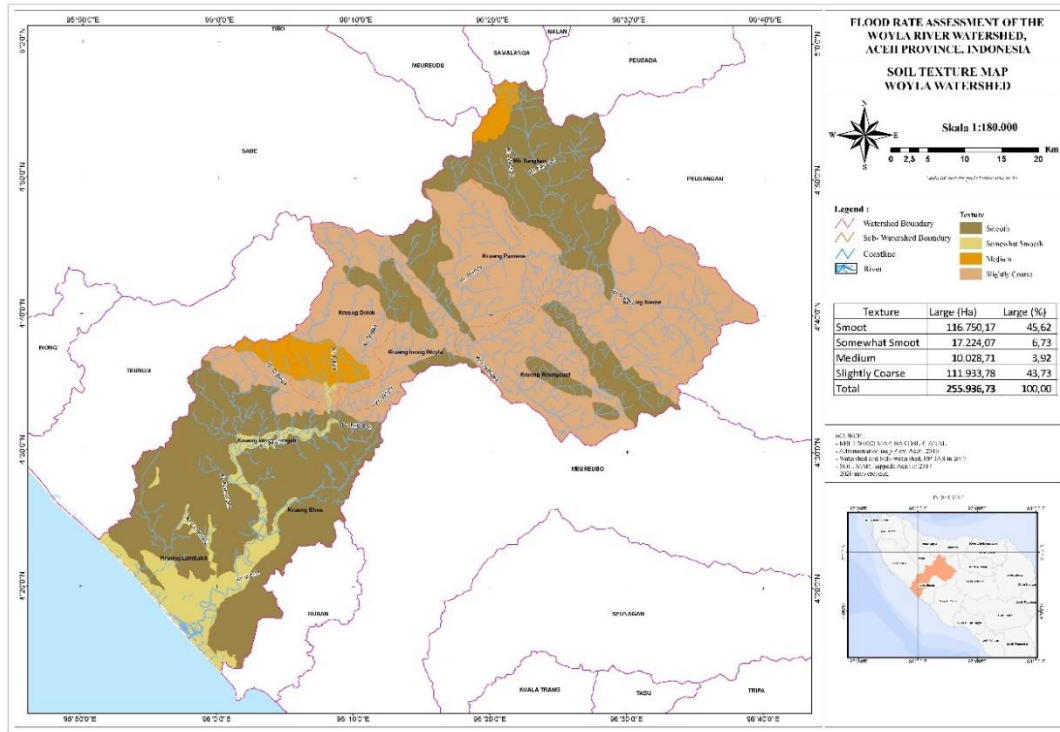


Figure 3. Soil texture in the Woyla watershed in Aceh Barat district and Aceh Provinces

Permeability

Soil with a very fine texture has a high probability of flooding, while a coarse texture has a low probability of flooding. This is because the smoother soil texture makes it difficult for surface runoff water from rain or river overflow to seep into the ground, resulting in inundation. Based on this, the scoring for areas that have a finer soil texture is higher.

After classifying the soil texture, the next step is the classification of soil drainage. Classification of soil drainage is based on soil texture. When associated with porosity and drainage, the permeability in the class:

1. Slow/Bad is the dominance of the clay fraction, causing the formation of many micropores so that the contact surface area becomes very wide. Thus the holding power of water is extreme. This condition causes water that enters the pores to be immediately trapped and difficult for air to enter. Most pore space is filled with water in this condition, so these micropores are also called capillary pores because the water loss process is slow (slow/poor drainage).

2. Fast / Good is the dominance of the sand fraction will cause a few macropores, so that the surface area touched by the material becomes very narrow so that the holding power of water is very weak. This condition causes water and air to enter and leave the soil quickly; only a tiny amount of water is stored or trapped in the soil. Most pore space is filled with air, so macropores are also called high drainage pores because the water loss process is fast (Hanafiah, 2007).

Soil drainage classification is based on soil texture. Where the bigger the soil particles, the coarser the textured and the more porous the soil. The more the soil axis, the water will be easier to circulate or drain well. Conversely, the finer or smaller the soil particles, the less porous the soil, and the water will be tough to revolve so that the drainage is poor.

Table 4. Scores for the permeability (drainage) class

No.	Permeability Class	Score
1	Very nice	1
2	Bad	5

(Source: Paimin et al., 2009)

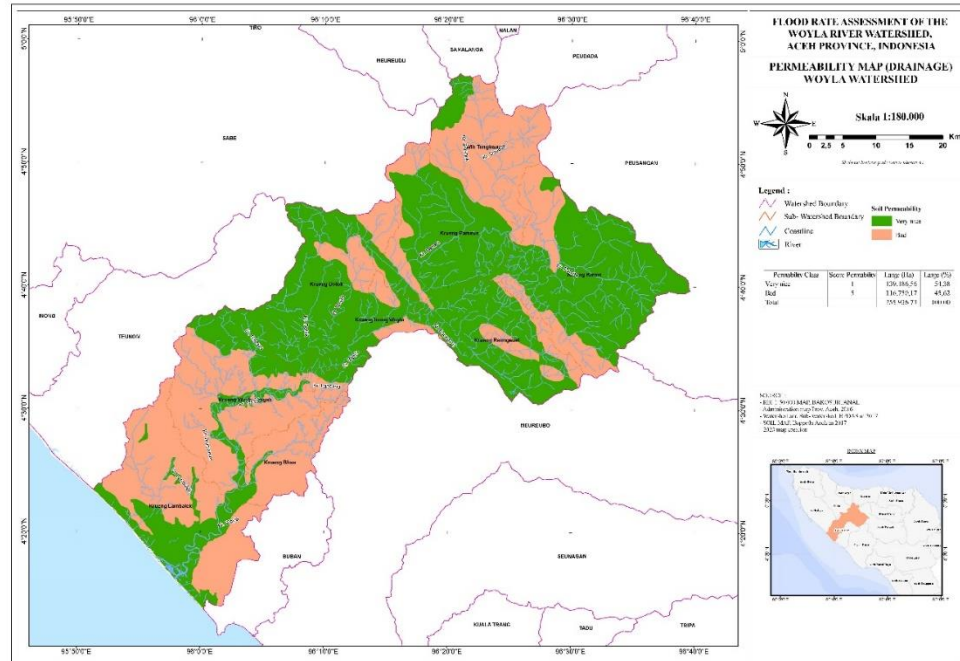


Figure 4. Soil permeability (Drainage) of the Woyla watershed in Aceh Barat district and Aceh Provinces

Land Cover analysis

The land cover will affect the flood vulnerability of an area. The land cover will play a role in the runoff water resulting from rain exceeding the infiltration rate. The region with lots of trees will find it tough to drain runoff water. This is due to the large water absorption capacity of the trees and the slow flow of runoff due to being held back by the roots and trunks of the trees, so the possibility of flooding is less than in areas that are not planted with vegetation. Table 5 shows the land cover category as one of the input data used in the map analysis to determine the flood-prone hazard analysis in the area of the study (Paimin et al., 2009)

Table 5. Scores for the Land Cover / Land Use class

No.	Land Cover Class / Land Use	Score
1	Primary Dry Land Forest, Protection Forest	1
2	Plantation	2
3	Dry Land Farming, Reeds	3
4	Scrub, Swamp Swamp	4
5	Rice fields, settlements, open land	5

Rainfall analysis

Areas that have high rainfall will have more influence on flood events. Based on this, the score for the rainfall area is getting higher; the scoring of the rainfall classes is differentiated based on the type of annual rainfall data, where the rainfall data is divisible into five categories. (In this study, researchers only need to use rainfall data obtained from the BMKG agency, namely rainfall maps. Because the process to get the flood level itself is obtained from the process carried out by mapping software, namely ArcGIS software.)

Table 6. Scores for Rainfall Class

No.	Rainfall Class	Score
1	<1500mm (Very Dry)	1
2	1501 mm - 2000 mm (Dry)	2
3	2001 mm - 2500 mm (Wet)	3
4	2501 mm - 3000 mm (Wet)	4
5	> 3000 mm (Very Wet)	5

(Source: BMKG, 2013)

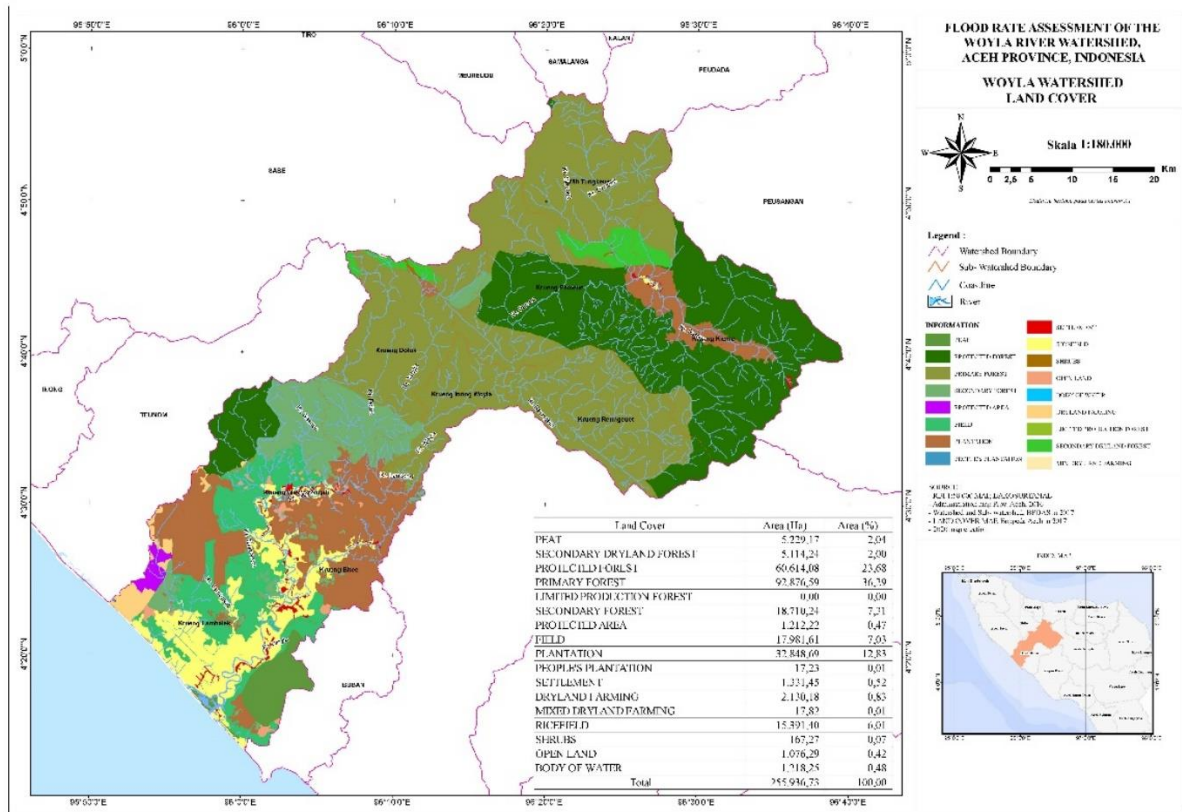


Figure 5. Woyla Watershed Land Cover in Aceh Barat district and Aceh Provinces

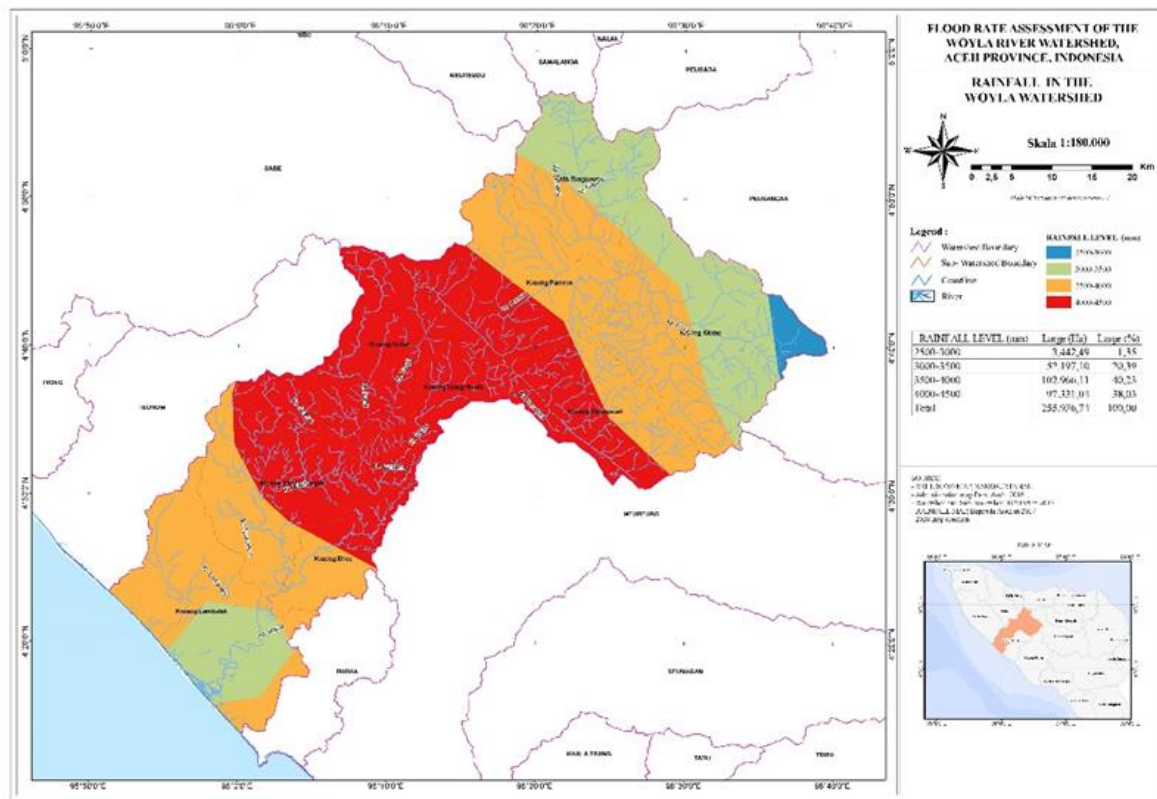


Figure 6. Rainfall in the Woyla Watershed in Aceh Barat district and Aceh Provinces

Weights of Flood Causes Parameters

Furthermore, the weighting is the weighting of the digital map for each parameter that affects the flood. The greater the influence of the parameters on the occurrence of flooding, the higher the weight is given a high value on the land slope and rainfall parameters because high rainfall with a sloping/flat slope can cause flooding.

Table 7. Weights of flood cause parameters

No.	Flood Causes Parameters	Weight
1	Slope of Land	0.20
2	Altitude Class	0.15
3	Soil Texture	0.15
4	Permeability (drainage)	0.15
5	Land Use	0.15
6	Rainfall	0.20

(Source: Paimin et al., 2009)

Flood hazard level

This analysis is conduct to determine the vulnerability of an area to flooding. The value of an area's susceptibility to flooding is obtainable by combining the scores and weights from data on the land slope, altitude, soil texture, permeability/drainage, land use, and rainfall. The determination of the interval value of each flood hazard class aims to distinguish between non-prone, low, medium, high, very high hazard classes.

Table 8. Flood hazard level

No.	Flood Hazard Level	Total value
1	Not Prone	1.0 - 1.8
2	Low Prone	1.81 - 2.6
3	Intermediate	2.61 - 3,4
4	High	3,41 - 4,2
5	Very high	4.21 - 5.0

(Source: Mutia and Firdaus, 2011)

After obtaining a flood hazard map, arrange a flood hazard map by overlaying a flood-prone zone map with a map of human settlements and land use. Land use is a form of human interference with a collection of natural resources and not for a specific purpose. The availability of land use forms in flood target areas needs to be known to determine the flood hazard level. Each shape of land use has different potential flood hazards at the same flood hazard level. For example, settlements with a higher flood hazard potential than moor are by permanent human presence in residential areas.

Flood hazard analysis is brought by overlapping the flood hazard level map with the land use map where land use classes for settlements are included. The assumption used in specifying the flood hazard level is the possibility of the presence of residents in each type of land use, such as in solution resulting in a high flood hazard level at a certain flood vulnerability level.

Table 9. Two-dimensional table between land use classes and levels flood hazard

No.	Land Use	Flood Hazard Level				
		SB	B	S	R	SR
1	Settlement	5	4	3	2	1
2	Mixed garden	5	4	3	2	1
3	Bush	5	4	3	3	3
4	Moor	5	4	3	3	3
5	Irrigation Paddy	5	4	3	2	2
6	Rainfed rice fields	5	4	3	2	2
7	Forest	3	3	2	1	1
8	Open field	5	4	3	2	1
9	Swamp	4	4	3	3	2
10	Mangroves	5	4	4	3	3
11	Pond	5	4	4	3	3

Source: (Abdi Tunggal, 2002)

Flood Hazard level: SB=very dangerous, B=danger, S=moderate, S=moderate/less dangerous, R=low, SR=very low

Flood hazard class 5 = Very dangerous, 4= Danger, 3 = Less dangerous, 2 = Potential for flooding, 1 = There is no danger

To make the analysis easier two-dimensional table is filled to state the relationship between the level of flood hazard and land use classes in the study area. Each land-use class is filled with a score based on the population table present in each type of land use.

Results

The Woyla river basin is geographically located at 95°50'00" - 96°40'00" East Longitude (BT) and 4°13'32"- 4° 57' 48" North Latitude (LU) and has administrative boundaries of 7 (seven) regencies within Aceh province, namely West Aceh Regency, Nagan Raya Regency, Central Aceh Regency, Pidie Regency, Pidie Jaya Regency,

Bireun Regency, and Aceh Jaya Regency and have 9 (nine) sub-watersheds. Which consists of the Wih Tungkeum sub-watershed having a longitude limit of $96^{\circ}18'18''$ - $96^{\circ}28'17''$ and latitude $4^{\circ}57'18''$ - $4^{\circ}44'45''$, the Krueng Kieme sub-watershed has a longitude boundary. $96^{\circ}23'20''$ - $96^{\circ}39'36''$ and latitude $4^{\circ}50'03''$ - $4^{\circ}32'34''$, the Krueng Pameue sub-watershed has a longitude limit of $96^{\circ}13'51''$ - $96^{\circ}26'14''$ and latitude $4^{\circ}51'42''$ - $4^{\circ}38'41''$, the Krueng Reungeuet sub-watershed has a longitude limit of $96^{\circ}17'20''$ - $96^{\circ}30'59''$ and latitude $4^{\circ}40'45''$ - $4^{\circ}30'24''$, Krueng Inong Woyla sub-watershed has a longitude limit of $96^{\circ}08'17''$ - $96^{\circ}18'16''$ and latitude $4^{\circ}41'14''$ - $4^{\circ}31'23''$, the Krueng Dolok sub-watershed has a longitude limit of $96^{\circ}04'44''$ - $96^{\circ}16'14''$ and latitude $4^{\circ}47'09''$ - $4^{\circ}32'11''$, the Krueng Woyla Tengah sub-watershed has longitude limit $95^{\circ}57'11''$ - $96^{\circ}12'4''$ and latitude $4^{\circ}38'22''$ - $4^{\circ}23'00''$, Krueng Bhee sub-watershed has a longitude limit of $96^{\circ}01'59''$ - $96^{\circ}12'05''$ and latitude $4^{\circ}31'28''$ - $4^{\circ}21'36''$, and the Krueng Lambalek sub-watershed has a longitude limit of $95^{\circ}51'15''$ - $96^{\circ}05'29''$ and latitude $4^{\circ}32'32''$ - $4^{\circ}13'41''$.

The area of the Woyla river basin is 255,936.73 Ha or 25,593.6 Km² consisting of 9 (nine) sub-watersheds, such as the Wih Tungkeum sub-watershed with an area of 25,018.11 ha, the Krueng Kieme sub-watershed with an area of 46,132.65 ha, Krueng Pameue with an area of 29,455.85 ha, the Krueng Reungeuet sub-watershed with an area of 24,872.51 ha, the Krueng Inong Woyla sub-watershed with an area of 10,644.44 ha, the Krueng Dolok sub-watershed with an area of 30,150.19 ha, the Krueng Woyla Tengah sub-watershed with an area of 39,344.75 ha, the Krueng Bhee sub-watershed with an area of 12,776.73 ha, and the Krueng Lambalek sub-watershed with an area of 37,831.32 ha. And it has a percentage of the total Woyla watershed, namely the Wih Tungkeum sub-watershed with an area of 9.76%, the Krueng Kieme sub-watershed with an area of 18.00%, the Krueng Pameue sub-watershed with an area of 11.50%, the Krueng Reungeuet sub-watershed with an area of 9.71%, the Krueng Inong Woyla sub-watershed with an area of 4.15%, the Krueng Dolok sub-watershed with an area of 11.77%, the Krueng Woyla Tengah sub-watershed with an area of 15.36%, the Krueng Bhee sub-watershed with an area of 4.99%, and Krueng Lambalek watershed with an area of 14.76%.

Climatic characteristics

West Aceh Regency has a relatively high rain intensity, with rainy days in the high category. From the record of rainfall throughout the year in ten years (10 years), it is known that the lowest rainfall is in July, and the highest rainfall is in October-November. In high areas, rain is also more increased where the average annual rainfall is high. The Woyla watershed area itself has a climate type A. This type is classified as the very wet type based on the Schmidt-Ferguson climate liquefaction method, which with an average monthly rainfall is classified as a wet > 100 mm / month.

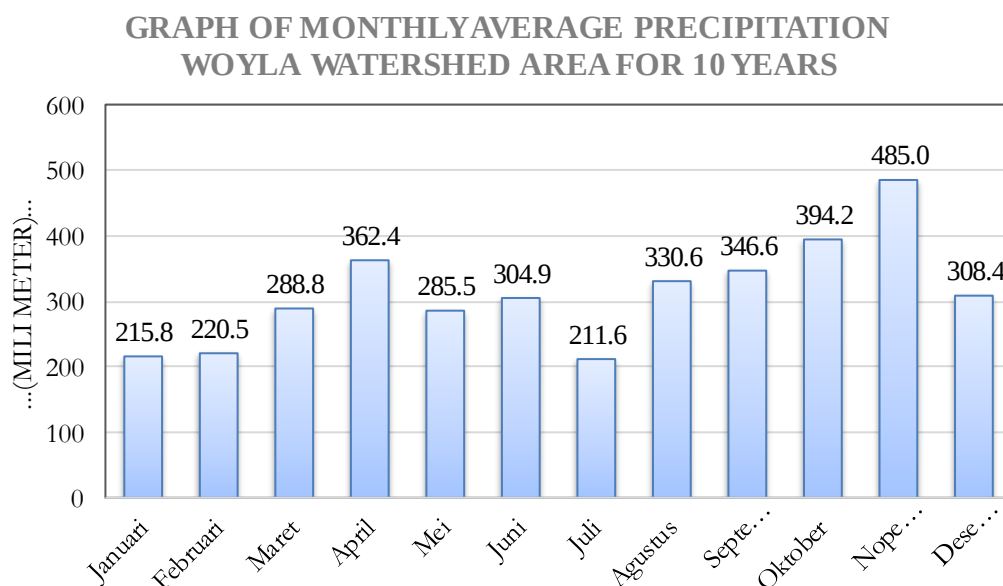


Figure 7. Average Monthly Rainfall of Woyla Watershed (BMKG Cut Nyak Dhien 2008-2017)

Discussion

After the determinants of flood-prone areas, namely, land slope, altitude, soil texture, permeability (drainage), land cover dan rainfall, are mapped. Next, intersect the maps with the Analysis Tool - Overlay - Intersect. The intersection results on the map contain a combination of attributes on the map of the determinants of flood-prone areas. Furthermore, the intersect result map attribute was added to a new field. In the new domain, the hazard value is calculated by weighting each determining factor for flood-prone areas. To figure this, the field calculator is used. After obtaining the hazard value, the value is mapped, the site of each hazard class is calculated in each sub-district in each district in the Woyla River Basin.

The hazard map intersects with the administrative map of the district with the *Analysis Tool - Overlay - Intersect tool*. Furthermore, the result of this intersect is opened by the Attribute Table and added a new field. In the new field, then the area is calculated in hectares with the Geometry Calculator. After obtaining the site, the *Table Attributes* are exported in text format and opened with Microsoft excel to combine each sub-district with the same class. The total area for each class in each district is calculated.

Table 10. Table of Flood Hazard Level in the Woyla Watershed

Flood Risk Level	Total Value	Large (Ha)	Large (%)
Not Prone	1,0 - 1,8	14,88	0,01
Low Prone	1,81 - 2,6	90.731,62	35,45
Medium	2,61 - 3,4	57.120,35	22,32
High	3,41 - 4,2	44.918,15	17,55
Very High	4,21 - 5,0	63.151,72	24,67
Total		255.936,73	100,00

Source: Results of the 2019 analysis

Table 10. Distribution table of flood hazard level in the woyla watershed.

Districts	Districts	Vulnerability Level (Ha)				
		Very high	High	Intermediate	Low Prone	Not Prone
West Aceh	Arongan Lambalek	6,340.63	4,719.44			
	Bubon	543.14				
	Pante Ceureumen		570.00	1,695.48	6,324.05	
	Samatiga	3,148.86	1,388.86			
	Sungaimas	8,088.94	12,579.00	25,356.24	30,758.62	
	Woyla	9,073.10	446.50			
	West Woyla	16,778.87	3,103.45			
	East Woyla	12,903.11	720.14			
	TOTAL	56,876.65	23,527.40	27,051.71	37,082.67	
Aceh Jaya	Pasie Raya	859.11	3,151.93	1970.20	335.66	
	Teunom	5,229.89	654.49			
	TOTAL	6,089.00	3,806.41	1970.20	335.66	
Central Aceh	Ketol			213.88	832.66	
	Rusip Between	136.26	4,638.14	6,559.96	40,843.22	14.88
	TOTAL	136.26	4,638.14	6,773.83	41,675.89	14.88
Bireun	Samalanga				222.01	
	Mamplam intersection			404.24	24.70	
	TOTAL			404.24	246.71	
Nagan Raya	Beutong Ateuh Benggalang		2,253.28	1,752.99	3,219.91	
	TOTAL		2,253.28	1,752.99	3,219.91	
Pidie	Geumpang	49.81	10,692.93	19,167.38	8,016.64	
	Mane				80.87	
	TOTAL	49.81	10,692.93	19,167.38	8,097.52	

Pidie Jaya Meurah Two
TOTAL

73.26
73.26

Source: Results of 2019

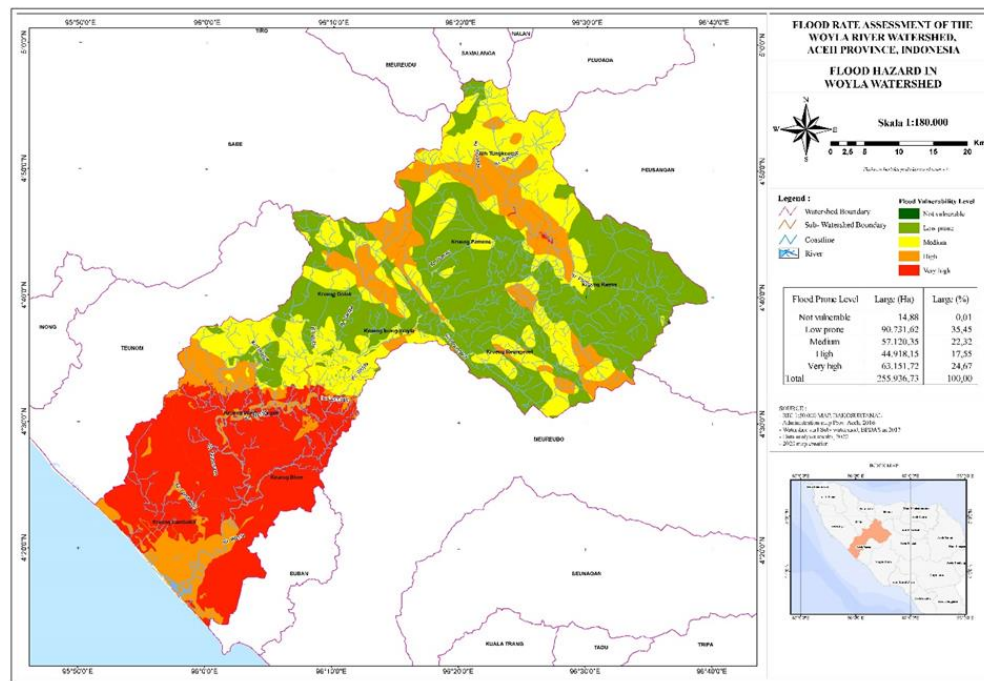


Figure 7. Flood Hazard in Woyla Watershed in Aceh Barat district and Aceh Provinces.

Flood-prone area areas that a physical and climatological perspective have the possibility of flooding several times and the potential to damage nature. So the flood hazard level is obtained from the Overlay of the tire hazard level map like as overlaid back with the land use map that has scored. The flood hazard level map results can be combined with the flood hazard level map to find locations that have become dangerous and must be evacuated or protected from the impact of floods. Especially during times of high rainfall, as shown in the annual rainfall data table graph. From various stages starting from analysis, scoring, and weighting of each of the factors causing flooding in the Woyla watershed, the level of flood vulnerability is obtained (Table 10).

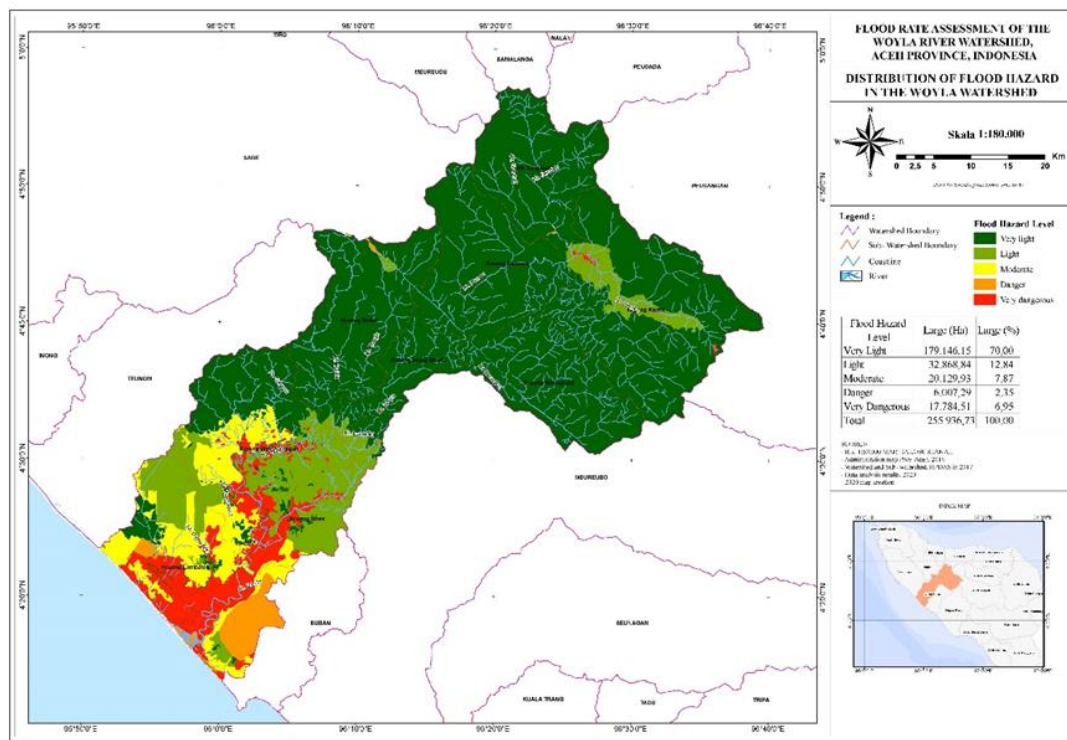


Figure 8. Distribution of Flood Hazards in the Woyla Watershed in Aceh Barat district and Aceh Provinces

Table 11. Flood hazard level in Woyla Watershed

Flood hazard level	Flood hazard class	Large (Ha)	Large (%)
Very light	1	179.146,15	70,00
Light	2	32.868,84	12,84
Moderate	3	20.129,93	7,87
Danger	4	6.007,29	2,35
Very dangerous	5	17.784,51	6,95
Total		255.936,73	100,00

Source: Results of the 2019 analysis

Table 4.10 Distribution Table of Flood Hazard Levels in the Woyla Watershed.

Districts	Districts	Danger Level (Ha)				
		Very dangerous	Danger	Moderate	Light	Very Light
West Aceh	Arongan Lambalek	6,455.45	1,505.66	2,546.77	245.34	306.86
	Bubon	0.25	531.62	10.80	0.47	
	Pante Ceureumen					8,589.53
	Samatiga	593.63	2,259.91	970.13	537.37	176.67
	Sungaimas	1,024.38		3,666.80	5,146.91	66,944.72
	Woyla	3,623.93	594.97	2,511.50	2,242.55	546.64
	West Woyla	3,526.81	947.85	8,267.21	5,634.67	1,505.78
	East Woyla	2,338.71		10.00	10,503.88	770.67
TOTAL		17,563.15	5,840.01	17,983.20	24,311.20	78,840.87

Acch Jaya	Pasie Raya		186.07	445.67	5,685.16
	Teunom	1.43	1,942.84	2,335.27	1,604.84
	TOTAL	1.43	2,128.90	2,780.94	7,290.00
Central Aceh	Ketol				1,046.54
	Rusip Between	219.93		5,776.70	46,195.83
	TOTAL	219.93		5,776.70	47,242.37
Bireun	Samalanga				222.01
	Mamplam intersection				428.94
	TOTAL				650.95
Nagan Raya	Beutong Ateuh Benggalang				7,226.18
	TOTAL				7,226.18
Pidie	Geumpang	167.28	17.82		37,741.66
	Mane				80.87
	TOTAL	167.28	17.82		37,822.53
Pidie Jaya	Meurah Two				73.26
	TOTAL				73.26

Source: Results of the 2019 analysis Yes

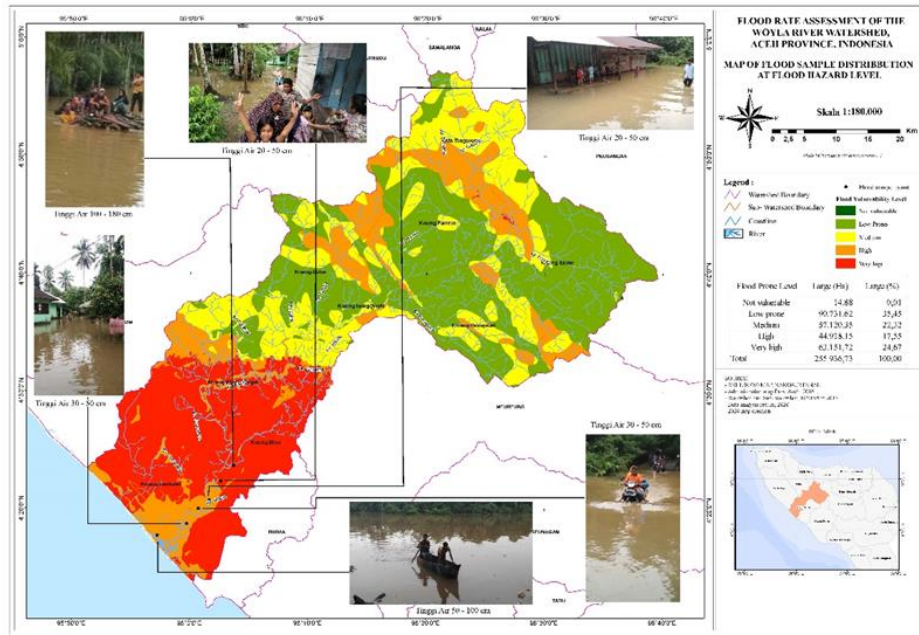


Figure 9. Map of Flood Sample Distribution at Flood Hazard Level

Based on the distribution of the flood hazard map, the Woyla watershed area is divided into five classes, that is the very light class with an area of 179,146.15 Ha / 70.00%, mild with an area of 32,868.84 Ha / 12.84%, moderate with an area of 20,129.93 Ha / 7.87%, danger with an area of 6,007.29 Ha / 2.35%, and very dangerous with an area of 17,784.51 Ha / 6.95%.

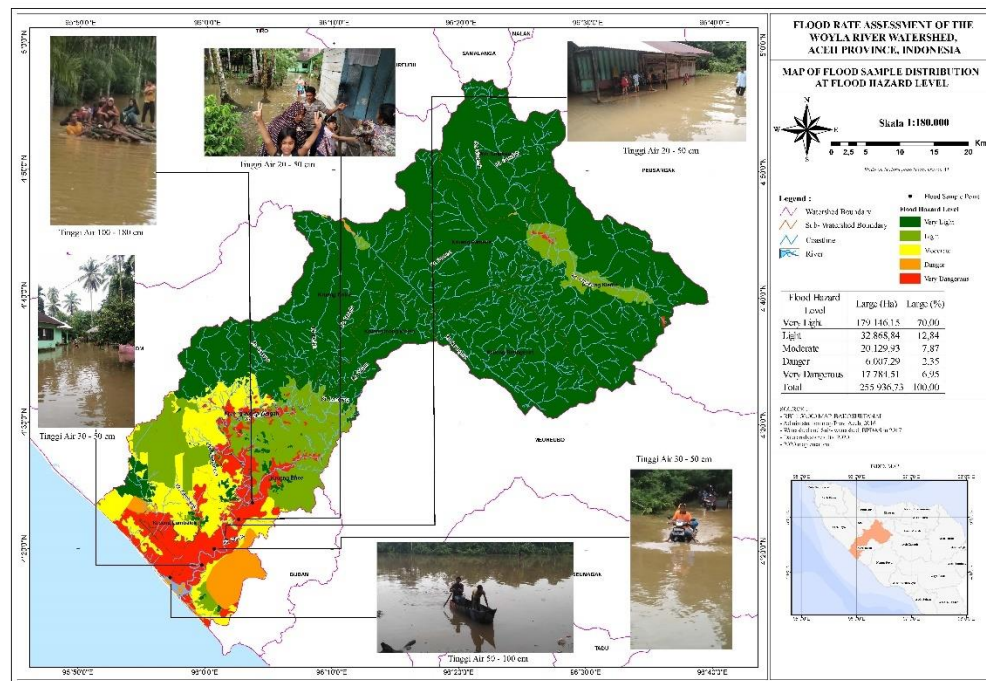


Figure 10. Map of Flood Sample Distribution at Flood Hazard Level

Conclusion

Based on the distribution of the map of the flood-prone areas above the Woyla watershed, it is divided into five classes, namely; the non-vulnerable class with an area of 14.88 Ha / 0.01%, low prone with an area of 90,731.62 Ha / 35.45%, medium with an area of 57,120.35 Ha / 22.32%, high with an area of 44,918.15 Ha / 17.55%, and very high with an area of 63,151.72 Ha / 24.67%. There is also a map of the distribution of the flood hazard area; the Woyla watershed is divided into five classes, namely; the very light class with an area of 179,146.15 Ha / 70.00%, mild with an area of 32,868.84 Ha / 12.84%, moderate with an area of 20,129.93 Ha / 7.87%, danger with an area of 6,007.29 Ha / 2.35%, and very dangerous with an area of 17,784.51 Ha / 6.95%. The level of flood vulnerability in the Woyla watershed is dominant in West Aceh Regency, which is in the very high and high category classes with a total area of 56,876.65 Ha and 23,527.40 Ha. The level of flood hazard in the Woyla watershed is also more dominant in West Aceh Regency in the very hazard and hazard class category with a total area of 17,784.51 Ha and 6,007.29 Ha. With the widest area in the very light class at the flood hazard level, with an area of 179,146.15 ha.

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