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STUDY OF FLOOD VULNERABILITY CLASS AND MAP IN THE KRUENG JREUE SUB-DAS, ACEH BESAR

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Abstract

The increasing intensity of land conversion in the Krueng Jreue Aceh Besar Sub-watershed due to changes in land use causes changes in the biophysical characteristics of the land. Changes in the biophysical characteristics of the land cause an increase in the level of flood vulnerability. This study uses a Descriptive Method (Survey). The results of the study show: The determining variables for the level of flood vulnerability based on the biophysical aspects of the land, namely: dynamic factors (rainfall, land use), and static factors (soil infiltration, slope). Flood Vulnerability Class and Map (TKB), consisting of: Very Vulnerable, settlements, rice fields (42≤TKB≤50); Vulnerable, dry fields (34≤TKB≤41); and Moderate, open land, shrubs, grasslands, secondary forests, primary forests (26≤TKB≤33), an average of 32.38 (moderate class). Primary and secondary forests in non-cultivated areas, covering 12,598.00 ha or 54.26% of the total area of the Krueng Jreue Sub-watershed (23,218.06 ha), have the lowest flood vulnerability. Flooding occurs in November-December, during periods of high rainfall, exposing residents to exposure, causing physical and economic losses, and land degradation.

Keywords: *Rainfall, Land Use, Soil Infiltration, Slope Gradient, Flood Vulnerability Class, Flood Vulnerability Map, Krueng Jreue Sub-DAS*

Abstract

The increasing intensity of land conversion in the Krueng Jreue Aceh Besar Sub-Watershed from forest to non-forest or due to changes in land use causes changes in land biophysical characteristics. Changes in land biophysical characteristics cause increased levels of flood vulnerability. This research uses descriptive method (survey). The results showed: Variables that determine the level of flood vulnerability based on biophysical aspects of the land, consisting of: dynamic factor (rainfall, land use), and static factor (soil infiltration, land slope). Flood Vulnerability Class and Map (TKB), consisting of: Very Vulnerable, settlements, rice fields (42≤TKB≤50); Vulnerable, moors (34≤TKB≤41); and Moderate, open land, shrubs, grasslands, secondary forest and primary forest (26≤TKB≤33), average 32,38 (moderate class). Primary forest and secondary forest in non-cultivated areas, an area of 12,598.00 ha or 54.26% of the total area of the Krueng Jreue Sub-Watershed (23,218.06 ha), has the lowest level of flood vulnerability. Flood disaster occurs in November-December, when the rainfall is high, which causes the population to be exposed, physical and economic losses and land damage.

***Keywords**: Rainfall, Land Use, Soil Infiltation, Land Slope, Flood Vulnerability Class, Flood Vulnerability Level Map, Krueng Jreue Sub-Watershed*

Introduction

The Krueng Aceh River Basin (DAS) with an area of 176,552.45 ha is one of 153 DAS or 3.06% of the total area of Aceh Province (5,765,798.45 ha). The Krueng Aceh Watershed is the main source of irrigation and household water needs in Aceh Besar Regency and Banda Aceh City. The high level of population growth activity in Aceh Besar Regency and Banda Aceh City and the rampant land conversion from vegetation cover to non-vegetation cover in the upstream area of the watershed cause the Krueng Aceh Watershed to be included in the critical watershed category so that it is designated as a priority watershed.

Priority watersheds are stated in the Decree of the Minister of Forestry No. SK. 328/Menhut-II/2009, which stipulates the Krueng Aceh Watershed, Peusangan Watershed, Jambo Aye Watershed and Peureulak-Tamiang Watershed as priority watersheds out of 108 priority watersheds in Indonesia, which are used as management guidelines for related agencies in efforts to determine the priority scale of land rehabilitation. The area of land categorized as very critical, critical, somewhat critical and potentially critical in the Krueng Jreue Sub -watershed increased from 2013 and 2018. The area of somewhat critical land in the Krueng Aceh Watershed increased from 21,579.90 ha (12.22%) in 2013 to 43,689.11 ha (24.75%) in 2018 from a total watershed area of 176,552.99 ha. Meanwhile, the area of somewhat critical land in the Krueng Jreue Sub-DAS increased from 3,422.61 ha (14.74%) in 2013 to 10,969.85 ha. ha (47,25%) tahun 2018 dari total luas Sub DAS 23.218,06 ha (BPDASHL, 2019).

The intensity of land conversion from forest to non-forest continues to increase over time, this is a result of high population pressure and dependence on land in the watershed. The increasing intensity of land conversion, especially illegal logging and illegal mining, has a negative impact on the hydrological conditions of the Krueng Jreue Sub-watershed. This causes an increase in peak discharge, fluctuations in discharge between seasons, *runoff* coefficients , as well as increased erosion, sedimentation, flooding, and drought (Muis, 2017). Furthermore, this sub-watershed is critical, with natural disasters occurring in the upstream, but also in the middle and downstream areas of the sub-watershed (Nasution, 2018).

The results of the study of land cover using Landsat 8 imagery , during the period 2014–2018, showed changes in land use patterns in the Krueng Jreue Sub-watershed. The area of forest land decreased from 12,598.00 ha (54.26%) to 11,748.33 ha (49.60%) or decreased by 849.67 ha (BPKH, 2019). The reduction in forest land has an impact on the flow discharge in the Krueng Jreue Sub-watershed which is decreasing, marked by water insufficiency. The results of research by Isnin *et al* . (2012) show that the total water supply in the Krueng Jreue Sub-watershed ranges from 0.24–3.22 $m^3 s^{-1}$. While the total water demand for agriculture and households is 0.18–6.44 $m^3 s^{-1}$, so that in the dry season the water supply in the Krueng Jreue Sub-watershed cannot meet the water needs for agriculture and households. If this water deficit condition continues, it could result in a hydrological disaster of drought in the

JURNAL PENELITIAN PROGRESSIF
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dry season (May-September).

Integrated and sustainable watershed management can be achieved by identifying the interrelationships between the biophysical characteristics of the land, hydrology, and the interconnectedness of upstream and downstream areas that influence the watershed ecosystem units (Susetyaningsih, 2012). One approach to improving management, land use systems, and land carrying capacity in a watershed is through flood management. Flood management is inseparable from water resource management. Delays in flood response are generally caused by a lack of information on the biophysical characteristics of the land in a watershed. To mitigate flood disasters , mapping of watersheds that are vulnerable and at risk of flooding is necessary (Nurjanti *et al* ., 2018).

The study and management system of the Krueng Jreue Sub-watershed is a form of regional development that places the Sub-watershed as a management unit, with the upstream and downstream areas having a biophysical land relationship through the hydrological cycle. One important factor that must be realized in every Sub-watershed management system is maintaining the function of the Krueng Jreue Sub-watershed as a good water system regulator. Therefore, the hydrological function of the Sub -watershed must be maintained sustainably, characterized by the availability of water resources including good quantity, quality and distribution throughout the year throughout the Sub-watershed.

Based on the above background, it is important to conduct research on flood vulnerability class and level maps based on land biophysical aspects and climatological aspects to improve and maintain land and water quality sustainably and reduce negative impacts and the risk of damage caused in the Krueng Jreue Sub-DAS. Specifically, the objectives to be achieved in this research are: (1) To determine flood vulnerability class levels based on land biophysical conditions, and (2) To describe flood vulnerability level maps based on Land Map Units (SPL).

Materials and Methods

The research was conducted in the Krueng Aceh River Basin (DAS), Krueng Jreue Sub-DAS. Administratively, this area is part of Aceh Besar Regency. The research location is at coordinates 05 ° 12'36"–05 ° 26'09" North Latitude and 95 ° 20'28" – 95 ° 30'28" East Longitude, with an area of 23,218.06 ha (2,321.81 sq mi). km ^{2}). The research was conducted in October 2018–February 2019. The Administrative Map of the Krueng Jreue Sub-DAS is shown in Figure 1.

JURNAL PENELITIAN PROGRESSIF
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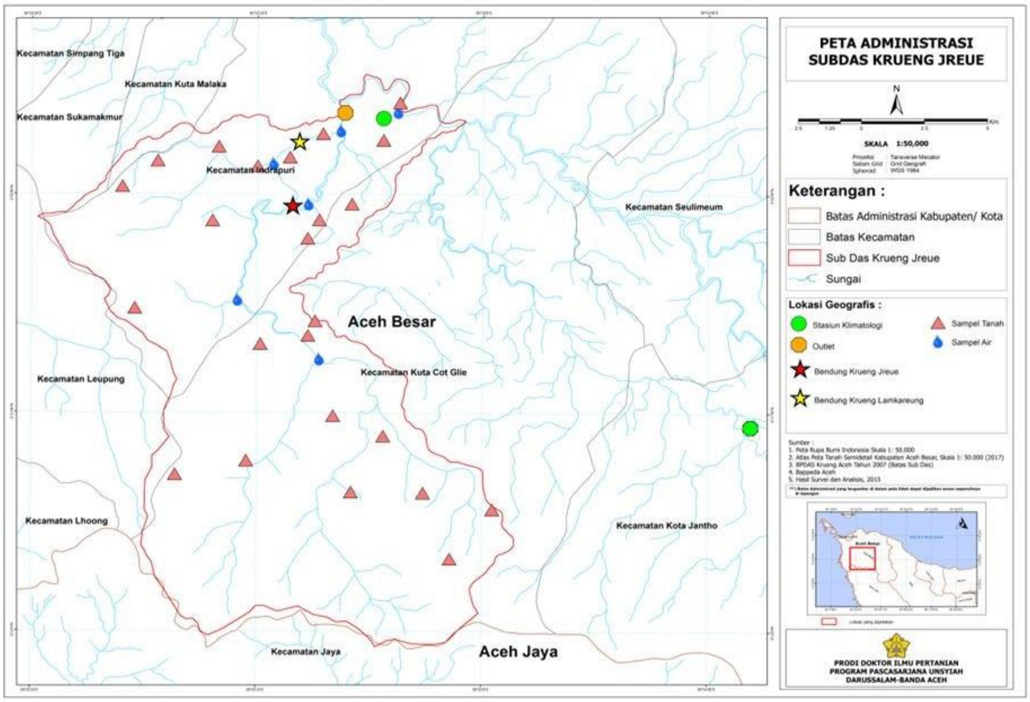

Figure 1. Administrative map of the Krueng Jreue sub- watershed

Materials used : administrative map , rainfall map scale 1 : 50,000. Rainfall data for 2008-2017, monthly flow discharge data, irrigation area and population of Indrapuri sub-district, Aceh Besar Regency. The research was conducted using the Descriptive Method (Survey) **.** The stages of the Flood Vulnerability Level (TKB) class and map study include: (1) Identification of flood vulnerability level parameters; (2) Transformation of qualitative data into quantitative data with weighting and grading of each flood vulnerability level parameter; and (3) Flood vulnerability level based on the scoring method to obtain a flood vulnerability level class based on the condition of the biophysical characteristics of the land and the flood vulnerability level map in each land map unit (SPL).

To determine the level of flood vulnerability, quantitative analysis is used, namely the results of calculations of flood vulnerability variables , including: rainfall , land use, soil infiltration and slope gradient (Sigit *et al* ., 2011). Spatial data of flood vulnerability variables are qualitative, so they need to be transformed into quantitative form with weighting and rating. The weighting is given to rainfall 1, land use 2, soil infiltration 3, and slope gradient 4.
listed in Tables 1, 2, 3, and 4.

Table 1. Rainfall Classification

No.	Rainfall (mm year - ^{1})	Description	Weight	dignity	Score
1	> 3.000	Tinggi		5	5

VOL 3 NO 2 | AGUSTUS 2024 | DOI: https://doi.org/ 10.61992/jpp.v3i2.109 | E-ISSN: 2963-4369

2	2.500 – 3.000	Quite Tall		4	4
3	2.000 – 2.500 (Currently)	Secondary	1	3	3
4	1.500 – 2.000 Low	Quite a bit		2	2
5	< 1.500	Low		1	1

Source: Center for Soil & Agroclimate Research (1995); and Sigit *et al* . (2011)

Table 2. Land Use Classification

No.	Land Use	Weight	dignity	Score
1	Open Land , River, Reservoir, Swamp, Grassland		5	10
2	Residential, Mixed Gardens		4	8
3	Agriculture, Rice Fields, Dry Fields	2	3	6
4	Gardening , Shrubs		2	4
5	Primary Forest , Secondary Forest		1	2

Source: Meijerink (1970); and Sigit *et al* . (2011)

Table 3. Soil Infiltration Classification

No.	Tektur Tanah [a]	Laju Infiltrasi[b]	Weight	dignity	Score
1	Look	Very slow		5	15
	Sandy Clay	Slow			
	Clay Dust Clay			4	12
2	Loam				
	Sandy Clay Loam	Currently			
			3	3	9
3	Dusty Clay Loam				
	Clay				
	Dusty Clay	Fast			
4	Sandy Loam			2	6
5	Sand	Very fast			
	Clayey Sand			1	3

Source: (a) Rahayu *et al.* (2009); (b) Budiyanto *et al.* (2014); and Sigit *et al* . (2011)

Table 4. Slope Gradient Classification

No.	Slope Gradient Class (%)	Description	Weight	dignity	Score
1	0- < 8	Datar		5	20
2	8- <15	Landai		4	16
3	15- <25	I'll take care	4	3	12
4	25- <40	of you.		2	8

JURNAL PENELITIAN PROGRESSIF
"Lembaga Naskah Aceh" VOL 3 NO 2 | AGUSTUS 2024 | DOI: https://doi.org/ 10.61992/jpp.v3i2.109 | E-ISSN: 2963-4369

5	≥40	Very Steep	1	4

Source: Director General of Reforestation & Land Rehabilitation (1998); and Sigit *et al* . (2011)

Evaluation of the flood vulnerability level criteria (TKB) is to determine the flood vulnerability level class based on the scoring method (Sigit *et al* ., 2015), consisting of five classes, namely: (1) Very Vulnerable, (2), Vulnerable, (3) Quite Vulnerable (Medium), (4) Somewhat Vulnerable, and (5) Not Vulnerable. The flood vulnerability level class based on the flood vulnerability level criteria (total score) is shown in Table 5.

Table 5. Flood Vulnerability Classes Based on Flood Vulnerability Level Criteria

No.	Flood Vulnerability Level Criteria (Total Shoes)	Kelas Tingkat Kerentan's Banjir
1	42 ≤ TKB ≤ 50	Very
2	34 ≤ TKB ≤ 41	Vulnerable
3	26 ≤ TKB ≤ 33	Vulnerable
4	18 ≤ TKB ≤ 25	Moderately Vulnerable
5	10 ≤ TKB ≤ 17	(Moderate) Somewhat
		Vulnerable
		Not Vulnerable

Source: Modification of Sigit *et al.* (2011)

Results and Discussion

Kelas Tingkat Kerentan's Banjir

Risk assessment and flood vulnerability class in the Krueng Jreue Sub-DAS is the most important part used as a basis for directing hydrological disaster mitigation efforts which is seen from: (1) Potential population exposure, (2) Potential losses (physical and economic), and (3) Potential environmental or land damage (BNPB, 2012). Flood Vulnerability Class (TKB) based on land map units consists of three classes, namely: (1) Quite vulnerable/moderate (total score = 26 ≤TKB≤ 33), (2) Vulnerable (total score = 34≤TKB≤ 41), and (3) Very vulnerable (total score = 42≤TKB≤ 50). The flood vulnerability level value (total score) ranges from 27.00-43.00, the higher or the value closer to the total score = 50, indicates the greater vulnerability/higher level of flood vulnerability. The flood vulnerability class in cultivated and non-cultivated areas in the Krueng Jreue Sub-DAS in 2008-2017 is shown in Table 6.

JURNAL PENELITIAN PROGRESSIF
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Table 6. Flood Vulnerability Classes in Cultivated and Non -Cultivated Areas of the Krueng Jreue Sub-DAS 2008-2017

SPL	Usage Land	Flood Vulnerability Level (Total Shoes) [a]	
		Criteria	Class
I			
10	Settlement	42,00	Very Vulnerable
11	Ricefield	43,00	Very Vulnerable
12	moor	40,00	Prone to
13	moor	33,00	Quite Vulnerable
II	Non- Cultivation Area		
1	Open Land	36,00	Prone to
2	Open Land	29,00	Quite Vulnerable
3	Shrubs	38,00	Prone to
4	Shrubs	28,00	Quite Vulnerable
5	Shrubs	33,00	Quite Vulnerable
6	Shrubs	29,00	Quite Vulnerable
7	Shrubs	22,00	Quite Vulnerable
8	Grassland	31,00	Quite Vulnerable
9	Grassland	29,00	Quite Vulnerable
19	Grassland	41,00	Prone to
20	Grassland	36,00	Prone to
21	Grassland	25,00	Prone to
14	Hutan Second	33,00	Quite Vulnerable
15	Hutan Second	29,00	Quite Vulnerable
16	Hutan Second	28,00	Quite Vulnerable
17	Hutan Second	18,00	Quite Vulnerable
18	Hutan Primer	28,00	Quite Vulnerable
	Total	271,40	
	Rerata	33,93	

Source: (a) Modification of Sigit *et al.* (2011), and Data Analysis Results (2020)

Table 6, the average total score of flood vulnerability level in Krueng Jreue Sub- watershed is 33.93 (moderately vulnerable class), with distribution from moderately vulnerable, vulnerable and very vulnerable classes. The highest total score of flood vulnerability level is in SPL 11 (rice fields); SPL 10 (settlements) and SPL 12 and 13 (dry fields), with very vulnerable and vulnerable classes (total score of 43.00 and total score of 42.00) and a total score of 36.50. While the lowest is in SPL 18 (primary forest), total score = 28.00, and SPL 17 (secondary forest), total score = 27.00, with a moderately vulnerable class (moderate).

Primary and secondary forests covering an area of 12,598.00 ha or 54.26% of the total area of the Krueng Jreue Sub-DAS (23,218.06 ha), have a relatively higher capacity element when compared to several other land use patterns, so that the level of flood vulnerability in the forest is lower. Naryanto (2011), if the capacity of an area is high, then the level of flood vulnerability

JURNAL PENELITIAN PROGRESSIF
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regional disasters become lower, and conversely, if the capacity of the region is low, then the level of disaster vulnerability in that region becomes high.

The better the management of land use patterns and the increasing area of forest cover, the lower the level of vulnerability or the less vulnerable it is to flooding . The capacity to absorb groundwater in forest land is wider and wider because the soil has a good structure and high porosity, which affects the soil's capacity to absorb water (Ishak, 2011). The decreasing area of forest cover due to forest conversion generally increases the average volume of *runoff* (Suryatmojo *et al* ., 2013), ultimately causing flooding in the rainy season and drought in the dry season, because the land has been degraded (critical) and exposed.

Primary forests and secondary forests as non-cultivated areas play a role in maintaining water supplies, providing soil protection in a watershed, and minimizing the impact of floods and droughts, but their role is limited. The capacity of forests in the protection function and direct flow control is limited, which depends on forest management, rainfall characteristics and biophysical characteristics of the land (Nagel, 2011), such as land use, soil infiltration and slope gradient. As the lungs of the world, forests can reduce global warming, are highly adaptive to climate change, reduce the risk of flooding during the rainy season and drought during the dry season, where flood disasters with a return period of once every five years in the Krueng Aceh watershed can cause physical damage, and annual droughts can cause non-physical damage (Praja, 2017).

Flood disasters (*floods disaster*) as a natural disaster event in Aceh Province ranks first among other disaster events such as: drought, extreme waves and abrasion, earthquakes, tsunamis, forest and land fires, epidemics and disease outbreaks, volcanic eruptions, extreme weather, and landslides (BPBA, 2015). The flood vulnerability class can be determined based on variables that influence the occurrence of flood disasters, such as land biophysical conditions (land use, soil infiltration, and slope gradient), and climatological conditions (rainfall) (Sigit *et al* ., 2011). The flood vulnerability class is analyzed based on land biophysical conditions and climatological conditions, not analyzed based on fluctuations in water levels (river flow discharge) in the Krueng Jreue Sub-DAS. Rainfall, as one of the main climate elements that greatly influences the vulnerability of flood disasters (Wismarini & Sukur, 2015). In conditions of above normal rainfall, land use and physical conditions in the form of a slope of 0-<8%, there is a threat of flood disasters. Flood disasters are caused by large amounts of rainfall and the influence of rivers in the watershed within it (Asdak *et al* ., 2018).

The risk of flood disasters in the form of *direct run-off* in conditions of above - normal rainfall in the projection period >89.00 mm month $^{-1}$, which hits a slope of 0-<8% facing various levels of flood vulnerability (ICCSR, 2010), or >140.00 mm month $^{-1}$ (Estiningtyas *et al* ., 2009). This rainfall is still below the average rainfall that occurs in the Krueng Jreue Sub-watershed of 152.55 mm month $^{-1}$. Meanwhile, areas that are significantly at risk or prone to flooding are low-lying areas, especially in the downstream of the Sub- watershed and rice fields, with a flat slope (0-

VOL 3 NO 2 | AGUSTUS 2024 | DOI: https://doi.org/ 10.61992/jpp.v3i2.109 | E-ISSN: 2963-4369

<8%). Meanwhile, areas that have the potential to cause flooding are the upstream areas of the Sub-DAS, because they have hilly, steep , and very steep slopes (Utama & Naumar, 2015).

The reduction of forest land to non-forest in 2014-2018 amounted to 849.67 ha or 3.66% in the Krueng Jreue Sub-DAS (BPKH, 2019), the vegetated land cover is getting worse, soil surface compaction can occur so that it reduces the infiltration rate and increases *run-off* . Changes in land use patterns in the watershed have an impact on reducing infiltration capacity, resulting in extreme flow discharges such as floods and droughts in downstream areas (Permatasari *et al* ., 2017).

Changes in land use from forest to non-forest can reduce land function, causing changes in land biophysical characteristics, land degradation and decreased soil quality (Sutrisna *et al* ., 2010), with increasing *bulk density* , decreasing soil porosity, and water holding capacity (Surya *et al* ., 2017), which has an impact on increasing the area of very critical and critical land by 133.04 ha (0.57%), and somewhat critical by 7,547.24 ha (32.51%) from 2013 to 2018 in the Krueng Jreue Sub-DAS (BPDASHL, 2019).

Changes in the characteristics of a watershed can affect the size of *runoff* and the occurrence of flood disasters (Rahayu *et al* ., 2017), and the criticality of a watershed can trigger the level of flood vulnerability (Rosyidie, 2013). This water surplus condition has a structural impact due to flood disasters, especially during the rainy season from October to April. Land damage due to flood disasters occurred over an area of 45.00 ha (BPBA, 2015), with an average inundation height of 50 cm, especially in rice fields and residential areas in the northern part of the Krueng Jreue Sub-watershed, which is flat (BWSS-I, 2016).

The lower the soil quality index and the increasing pollution index in the Krueng Jreue Sub-watershed, the higher the flood vulnerability class. The soil quality index and pollution index are additional components of vulnerability to flood disaster hazards (ICCSR, 2010). Soil with a high clay texture content and low infiltration rate affects changes in the height of inundation and the duration of inundation from flood disasters (Qomari *et al* ., 2017). Furthermore, human activities such as *illegal logging* and forest conversion to non-forest have increased TSS and TDS downstream. These activities cause increased soil erosion along the river flow, which has an impact on suspended solids and dissolved solids, thus decreasing the river's capacity, triggering flood disasters (Firdaus *et al* ., 2015). Changes in land biophysical characteristics such as soil quality and water quality can cause an increased level of flood vulnerability in the Krueng Jreue Sub-watershed.

Flood Vulnerability Zoning Map

The flood vulnerability zoning map in the Krueng Jreu Sub-DAS was obtained through physical and environmental analysis that influences flood disasters, such as rainfall variables (CH), land use , soil infiltration and slope.

VOL 3 NO 2 | AGUSTUS 2024 | DOI: https://doi.org/ 10.61992/jpp.v3i2.109 | E-ISSN: 2963-4369

Slope. Rainfall is the most influential variable affecting flood risk, followed by land use, soil infiltration, and slope gradient. Flood risk in the Krueng Jreue Sub-watershed ranges from very vulnerable, vulnerable, moderately vulnerable, and somewhat vulnerable.

Recorded in the northern and southern regions of the Krueng Jreue Sub-watershed, the highest rainfall was 270.50 mm in month $^{-1}$ and 249.20 mm in month $^{-1}$, respectively . The peak rainfall occurred in November-April although there was a decrease in rainfall intensity in February, with a wet climate type (B). *Runoff* can only be regulated by increasing the soil's water holding capacity , achieved through increasing infiltration capacity, which is the maximum rate of water entering the soil (Smith *et al* ., 2012). The amount of rainfall after deducting infiltration is known as excess rainfall above the ground surface, which will become *runoff* which causes flooding. The division of the area of the Krueng Jreue Sub-watershed Land Map Unit (SPL) based on the class and criteria for flood vulnerability levels in 2008-2017 is shown in Table 7.

Table 7. Distribution of Land Map Unit Area of the Krueng Jreue Sub -DAS Based on Class and Criteria for Flood Vulnerability Levels in 2008-2017

Class	Land Map Unit (SPL)	Level Criteria Flood Vulnerability (Total Score)	Wide	
			(ha)	(%)
Very Prone to	10, 11	43,50	624,76	2,69
Prone to	1, 3, 12, 19, 20, 21	36,00	3.866,44	16,65
Enough Prone to	2, 4, 5, 6, 8, 9, 13, 14, 15, 16, 18	30,00	12.267,48	52,84
Quite vulnerable	7, 17	20,00	6.459,38	27,82
Total		129,50	23.218,06	100,00
Rerata		32.38 (Enough) Prone to)		

Source: Modification of Sigit *et al* . (2011), and Data Analysis Results (2020)

Table 7, the average total score of the flood vulnerability level is 32.38 (moderately vulnerable/moderate class). The average total scores of 43.50; 36.00 and 30.00 increased from the average total score of 20.00, respectively 117.50%; 80.00%; and 50.00%. The flood vulnerability level of the non-vulnerable class (total score = 10 ≤ TKBB ≤ 17), does not exist in the Krueng Jreue Sub-watershed. The dominant flood vulnerability class is the moderately vulnerable class (total score = 30.00), which is 12,267.48 ha (52.84%); while the lowest area is the very vulnerable class (total score = 43.50), which is 624.76 ha (2.69%). The *overlay* results of various thematic maps, obtained a flood vulnerability zoning map of the Krueng Jreue Sub-watershed, shown in Figure 2.

VOL 3 NO 2 | AGUSTUS 2024 | DOI: https://doi.org/ 10.61992/jpp.v3i2.109 | E-ISSN: 2963-4369

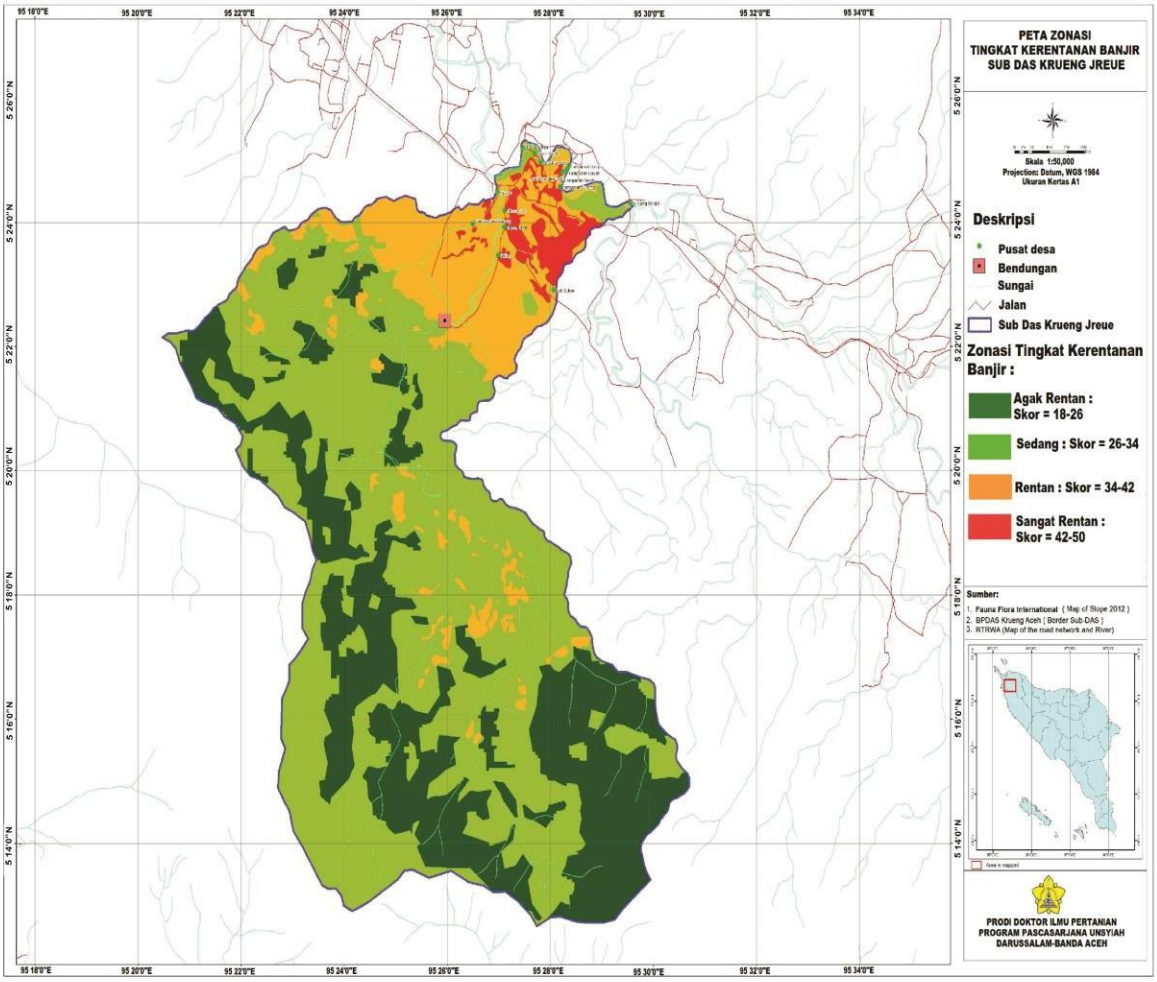

Figure 2. Flood Vulnerability Zoning Map of the Krueng Jreue Sub- DAS

Figure 2: The flood vulnerability class zones in the Krueng Jreu Sub-watershed are dominated by vulnerable, moderately vulnerable, and very vulnerable classes. Zones with a vulnerable flood vulnerability class include SPL 12 and 13 (dry fields) spread across the north of the sub-watershed. The moderately vulnerable flood vulnerability class includes SPL 3, 4, 5, 6 , and 7 (shrubs), SPL 8, 9, 19, 20 , and 21 (grasslands), and SPL 1 and 2.

(open land), SPL 14, 15, 16 and 17 (secondary forest) and SPL 18 (primary forest) are spread across the north, east and south of the Sub-DAS. Meanwhile, the very vulnerable flood vulnerability zone includes SPL 10 (settlements) covering 103.88 ha, and SPL 11 (rice fields) covering 520.88 ha, spread across the north of the Krueng Jreue Aceh Besar Sub-DAS.

According to the results of data analysis and interviews, SPL 10 (settlements) and 11 (rice fields) as utilization areas often experience flooding disasters, because they are located in the lowlands (downstream) of the Sub -DAS with a slope of 0-<8% and low drainage density. Flood disasters that have structural impacts (exposed residents, physical and economic losses, land damage) and occur every five years (in 1995, 2000, 2005, 2010, and 2015), especially in the downstream area (northern part) of the Krueng Jreue Sub-DAS in the land use patterns of rice fields and settlements.

VOL 3 NO 2 | AGUSTUS 2024 | DOI: https://doi.org/ 10.61992/jpp.v3i2.109 | E-ISSN: 2963-4369

The high intensity of rainfall causes overflow floods. This is a characteristic of flood disasters in highly vulnerable areas. Based on the river flow pattern, the Sub-DAS has a bird's-feather shape with the main river receiving flow from tributaries on the left and right sides and then flowing into the Krueng Aceh Watershed, causing a relatively long peak discharge duration (BPDAS Krueng Aceh, 2010). The area that is a highly vulnerable zone to five-year return period floods is the northern part of the Krueng Jreue Sub-DAS, namely along the downstream river flow which is dominated by rice fields (SPL 11), SPL 10 (settlements), and SPL 12 and 13 (dry fields). Flood disasters generally occur in November-December, when rainfall is high.

Conclusion

The results of the flood vulnerability class identification (TKB) consist of: Very Vulnerable covering an area of 624.76 ha (2.69%), Vulnerable covering an area of 3,866.44 ha (16.65%), Moderately Vulnerable/moderately Vulnerable covering an area of 12,267.48 ha (52.84%), and Somewhat vulnerable covering an area of 6,459.3827.82 ha (27.82%), with an average of 32.38 (moderately vulnerable class). Areas that are highly vulnerable to flood disasters are found in cultivated areas in residential areas, while those that are vulnerable are found in rice field patterns. Both of these areas consist of the Inceptisols order with flat to gentle land slopes (0-8%) or at SPL
10 (settlements) and 11 (rice fields) with an area of 624.76 ha. Flooding generally occurs in November-December, when rainfall is high, causing structural damage.

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