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FLOOD VULNERABILITY CLASS STUDY FOR HYDROLOGICAL DISASTER MITIGATION INSTRUCTIONS IN KRUENG JREUE ACEH BESAR SUB-DAS

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Abstract

The increase in the intensity of land conversion in the Krueng Jreue Aceh Besar Sub-DAS from forest to non-forest or due to land use changes causes changes in the biophysical aspects of the land. Changes in the biophysical aspects of the land cause an increase in flood vulnerability. This research uses the Descriptive Method (Survey). The research results show: Variables determining the level of flood vulnerability based on the biophysical aspects of forests and land, namely: dynamic factors (rainfall, land use), and static factors (soil infiltration, slope). Flood Vulnerability Level Class (TKB), consisting of: Very Vulnerable, settlements, rice fields (42≤TKB≤50); Vulnerable, moor (34≤TKB≤41); and Medium, open land, bush, grassland, secondary forest, primary forest (26≤TKB≤33), average 32,38 (medium class). Instructions for mitigating hydrological disasters in cultivated areas (settlements, rice paddies and moors), by applying flood prevention measures and water management, the application of soil and water conservation and the regulation of planting patterns. While in non-cultivation areas (open land, bushes, grasslands, secondary forests and primary forests), by applying land rehabilitation packages and prevention against *illegal logging.*

Keywords: Land Biophysical Aspects, Flood Vulnerability Level, Hydrological Disaster Mitigation Guidelines, Cultivation Areas, Non-Cultivation Areas.

Introduction

Krueng Aceh Watershed (DAS) with an area of 176,552.45 ha is one of 153 watersheds 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 as well as the rapid conversion of land from vegetation cover to non-vegetation cover in the upstream region of the watershed caused the Krueng Aceh watershed to be included in the critical watershed category so it was designated as a priority watershed.

The priority watershed is stated in the Minister of Forestry Decision No. SK. 328/Menhut-II/2009, which designates Krueng Aceh DAS, Peusangan DAS, Jambo Aye DAS and Peureulak-Tamiang DAS as priority DAS out of 108 priority DAS in Indonesia, which is used as a directive from related agencies in efforts to determine the priority scale of forest and land rehabilitation. The land area of the very critical,

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critical, somewhat critical and potentially critical categories in the Krueng Jreue Sub -DAS increased from 2013 and 2018. 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 (47.25%) in 2018 from the total area of the Sub-DAS 23,218.06 ha (BPDASHL, 2019).

The intensity of land conversion from forest to non-forest continues to increase as time goes by, this is as a result of the pressure and dependence of the population on high land in the watershed. The increase in the intensity of land conversion, especially illegal logging and illegal mining, has a negative effect on the hydrological conditions of the Krueng Jreue Sub-DAS. This causes an increase in peak discharge, fluctuations in discharge between seasons, *runoff* coefficients , as well as an increase in flood and drought disasters (Muis, 2017). Further making this Sub DAS critical, natural disasters occur upstream, but also in the middle and downstream of the Sub DAS (Nasution, 2018).

As a result of Citra Landsat 8 land cover analysis, during the period 2014-2018, there was a change in land use patterns in the Krueng Jreue Sub-DAS. The area of forest land went from 12,598.00 ha (54.26%) to 11.748.33 ha (49.60%) or decreased by 849.67 ha (BPKH, 2019). The reduction of forest land has an impact on the flow discharge in the Krueng Jreue Sub-DAS which is decreasing, marked by water insufficiency. The results of Monday *et al* . (2012) showed, the total water availability in the Krueng Jreue Sub-DAS ranged from 0.24-3.22 $m^3 sec^{-1}$. While the total water requirement for agriculture and households amounts to 0.18-6.44 m^3 $second^{-1}$, so during the dry season the water supply in the Krueng Jreue Sub-DAS cannot meet the water requirements for agriculture and households . This water deficit condition, if continued, could result in a drought hydrological disaster during the dry season (May-September).

Integrated and sustainable watershed management can be done by identifying the connection between the problems of biophysical characteristics of the land, hydrology and the connection between the upstream and downstream regions that are interconnected and affect the watershed ecosystem unit. One of the approaches to improve the management and carrying capacity of land in a watershed through flood management efforts . Flooding is a high-risk disaster threat in Indonesia, especially to property and infrastructure and is a serious threat to the community's economy. Flood disasters have an impact on damage to infrastructure, agriculture and plantations (Raimi *et al* ., 2017) **.** For flood disaster mitigation , it is necessary to know the level of vulnerability and risk to floods as well as flood disaster mitigation instructions both based on the biophysical aspects of the land, both technically and non-technically in a watershed (Putri *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 connection to the land through the hydrological cycle . One of the important factors that must be established in every Sub DAS management system is to maintain the function of the Krueng Jreue Sub DAS as a good water system regulator. Therefore, the hydrological function of the Sub-DAS must be sustainably maintained which is characterized by the availability of water resources that cover good quantity, quality and distribution throughout the year

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throughout the Sub -DAS.

Based on the above background, it is important to study the level of flood vulnerability based on the biophysical aspect of the land as well as the climatological aspect to improve and maintain the quality of soil and water on a sustainable basis and reduce the negative impact and risk of damage caused by it in the Krueng Jreue Sub-DAS. The objectives to be achieved in this research are: (1) Determine the flood vulnerability level class based on the Land Map Unit (SPL), and (2) Establish hydrological disaster mitigation instructions for agricultural and non-agricultural areas based on the flood vulnerability level in the Krueng Jreue Aceh Besar Sub-DAS.

Materials and Methods

The research was carried out in the Krueng Aceh Watershed District, Krueng Jreue Sub-Watershed. Administratively, this region is included in the region of Aceh Besar Regency. The research location is at coordinates 05 º 12'36" - 05 º 26'09" LU and 95 º 20'28" - 95 º 30'28" BT, with an area of 23,218.06 ha (2,321,81 km ^{2}). The research was carried out between October 2019 and February 2020. Krueng Jreue Sub-DAS Administrative Map, shown in Figure 1.

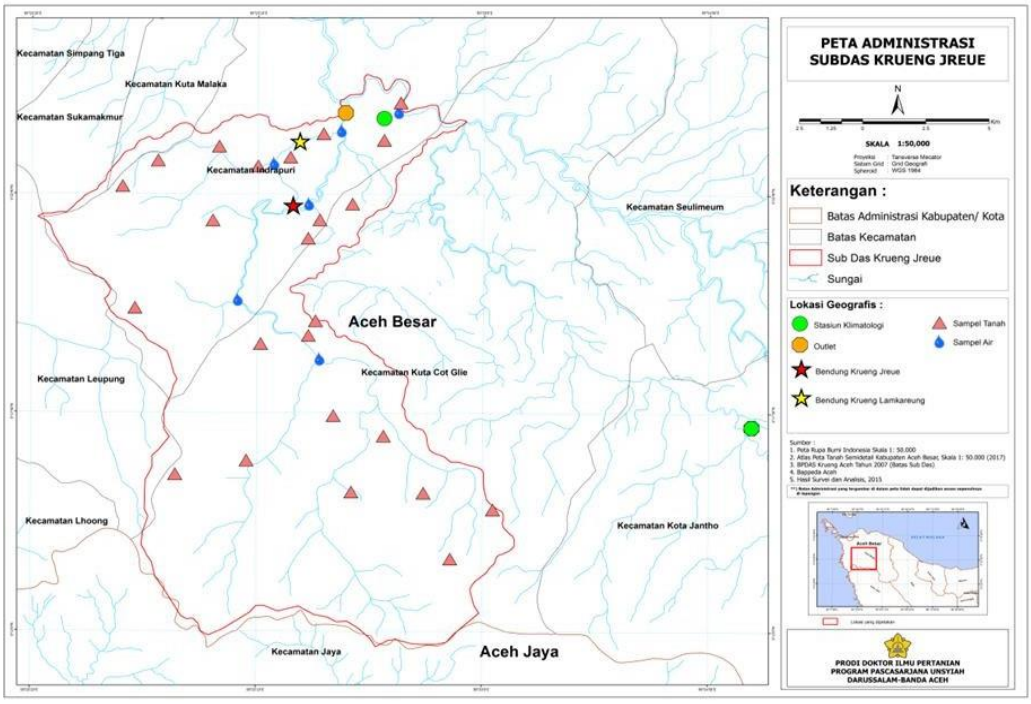

Figure 1. Administrative Map of Krueng Jreue Sub- Watershed

Materials used : administrative map , rainfall map scale 1 : 50,000. Rainfall data from 2008-2017, land use map, soil infiltration map and slope slope map. The research was conducted using the Descriptive Method (Survey) **.** The analysis stages of the Flood Vulnerability Level (TKB), include: (1) Identification of flood vulnerability level parameters; (2) Transformation of qualitative data into quantitative data with weighting and emphasis on each parameter of flood vulnerability level; and (3) The level of flood vulnerability based on the scoring method to obtain classes and hydrological disaster mitigation instructions based on the biophysical

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characteristic conditions of the land map unit (SPL).

Quantitative analysis is used to determine the level of flood vulnerability, which is the result of the calculation of flood vulnerability variables , including: rainfall , land use, soil infiltration and slope (Sigit *et al* ., 2011). The spatial data of flood vulnerability variables is qualitative, so it needs to be transformed into a quantitative form with weighting and enhancement. Weighting of rainfall 1, land use 2, soil infiltration 3, and slope slope 4,
shown in Tables 1, 2, 3, and 4.

Table 1. Classification of Rainfall

No.	Rainfall (mm year - 1)	Description	Weight	Dignity	Score
1	> 3,000	High		5	5
2	2,500 – 3,000	Quite High		4	4
3	2,000 – 2,500	Secondary (Meaning)	1	3	3
4	1,500 – 2,000	Quite a bit Low		2	2
5	< 1,500	Low		1	1

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

Table 2. Land Use Classification

No.	Land Use	Weight	Dignity	Score
1	Open Lands , Rivers, Reservoirs, Swamps, Grassland		5	10
2	Settlement, Mixed Garden		4	8
3	Agriculture, Rice Fields, Peatlands	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. Classification of Soil Infiltration

No.	Soil Texture [a]	Infiltration Rate [b]	Weight	Dignity	Score
1	Clay	Very Slow		5	15
2	Sandy Clay Silty Clay Clayey Clay	Slow		4	12
3	Sandy Clay Dusty Clay Clay	Medium	3	3	9
4	Dusty Clay Sandy Clay	Fast		2	6
5	Sand Clayey Sand	Very Fast		1	3

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

Table 4. Slope Slope Classification

No.	Slope Slope Class (%)	Description	Weight	Dignity	Score
1	0- < 8	Flat Slightly		5	20
2	8- <15	Steep Steep		4	16
3	15- <25	Very Steep	4	3	12
4	25- <40			2	8
5	≥40			1	4

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

The evaluation of 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) Sufficiently Vulnerable (Moderate), (4) Somewhat Vulnerable, and (5) Not Vulnerable. Flood vulnerability level classes based on flood vulnerability level criteria (total score), listed in Table 5.

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

No.	Flood Vulnerability Level Criteria (Total Score)	Flood Vulnerability Level Class
1	42 ≤ TKB ≤ 50	Very Vulnerable
2	34 ≤ TKB ≤ 41	Vulnerable
3	26 ≤ TKB ≤ 33	Quite Vulnerable
4	18 ≤ TKB ≤ 25	
5	10 ≤ TKB ≤ 17	(Meaning)
		Quite Vulnerable
		Not Vulnerable

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

Results and Discussion

Hydrological Disaster Vulnerability Level Class

The risk assessment and disaster vulnerability class in the Krueng Jreue Sub-DAS is used as a basis for directing hydrological disaster (flood) mitigation efforts, seen from: (1) Potential exposed population, (2) Potential loss (physical and economic), and (3) Potential damage to the environment or land (BNPB, 2012). The Flood Disaster Vulnerability Level Class (TKB) based on the land map unit consists of three classes, namely: (1) Sufficiently 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 disaster vulnerability level value (total score) ranges

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between 27,00-43,00, The higher or the value approaching the total score = 50, indicates the more vulnerable/higher to the flood disaster vulnerability level. The flood disaster vulnerability class in cultivated and non-cultivated areas in Krueng Jreue Sub-DAS from 2008-2017, shown in Table 6.

Table 6. Flood Vulnerability Level Class in Cultivated and Non-Cultivated Areas Sub DAS Krueng Jreue Year 2008-2017

SPL	Usage Land	Flood Vulnerability Level (Total Score) [a]	
		Criteria	Class
I			
10	Settlement	42.00	Very Vulnerable
11	Rice field	43.00	Very Vulnerable
12	Moorland	40.00	Vulnerable
13	Moorland	33.00	Quite Vulnerable
II	Non- Cultivated Area		
1	Open Land	36.00	Vulnerable
2	Open Land	29.00	Quite Vulnerable
3	Check the bushes	38.00	Vulnerable
4	Check the bushes	28,00	Quite Vulnerable
5	Check the bushes	33.00	Quite Vulnerable
6	Check the bushes	29.00	Quite Vulnerable
7	Check the bushes	22,00	Quite Vulnerable
8	Grassland	31.00	Quite Vulnerable
9	Grassland	29.00	Quite Vulnerable
19	Grassland	41.00	Vulnerable
20	Grassland	36.00	Vulnerable
21	Grassland	25.00	Vulnerable
14	Secondary Forest	33.00	Quite Vulnerable
15	Secondary Forest	29.00	Quite Vulnerable
16	Secondary Forest	28,00	Quite Vulnerable
17	Secondary Forest	18,00	Quite Vulnerable
18	Primary Forest	28,00	Quite Vulnerable
	Total	271.40	
	Average	33.93	

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

Table 6, the average total score of flood disaster vulnerability in the Krueng Jreue Sub-DAS is 33.93 (quite vulnerable class), with a distribution of quite vulnerable, vulnerable and very vulnerable. The highest total score of flood disaster vulnerability is found in SPL 11 (rice fields); SPL 10 (settlement) and SPL 12 and 13 (moorland), with a very vulnerable and vulnerable class (total score 43,00 and total score 42,00) and a total score of 36,50. While the lowest is found in SPL 18 (primary forest), total score = 28.00, and SPL 17 (secondary forest), total score = 27.00, with the class quite vulnerable (moderate). Primary forests 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 relatively higher capacity elements when compared to some other land use patterns, so that the level of vulnerability to floods and droughts in the forest becomes lower. Naryanto (2011), if the capacity owned by a region is high, then

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the level of regional disaster vulnerability becomes lower, and conversely if the capacity owned by the region is low, then the level of vulnerability of the region becomes high.

The better the management of land use patterns and the increasing area of forest cover, has a relatively low level of vulnerability or is not vulnerable to flood and drought disasters. The capacity to absorb soil water in forest land is wider and wider because the soil has a good structure and a lot of porosity and affects the soil's capacity to absorb water (Ishak, 2011). The decrease in forest cover due to forest conversion generally increases the average *runoff* volume (Suryatmojo *et al* ., 2013), ultimately causing flood disasters in the rainy season and drought in the dry season, because the land has been degraded and exposed.

Primary forests and secondary forests as non-cultivated areas play a role in preserving water supply, providing soil protection in a watershed, as well as minimizing the influence of flood and drought disasters, but their role is limited. The capacity of the forest in the function of protection 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 slope. As the lungs of the world, forests can reduce global warming, are highly adaptive to climate change, reduce the risk of flood disasters during the rainy season and drought during the dry season, where the five-year flood disaster in the Krueng Aceh watershed can cause physical damage, and droughts every year can cause non-physical damage (Praja, 2017).

Hydrological Disaster Mitigation Directive

Hydrological disaster (flood) mitigation instructions on cultivated (1,548.98 ha) and non-cultivated (21,669.08 ha) areas in Krueng Jreue Sub- DAS in 2020, is a Sub-DAS whose carrying capacity will be restored (Government Regulation, 2012), and land biophysical engineering and other activities are included in integrated Sub-DAS management (Qanun, 2018).

Cultivation Area

Hydrological disaster mitigation instructions on areas with the main function to cultivate an area of 1,548,98 ha or 6,67% of the total area of the Krueng Jreue Sub-Watershed (23,218,06 ha), consisting of areas: settlements, rice fields and moors. The three regions are located outside the forest area. In an effort to mitigate hydrological disasters in cultivated areas that are vulnerable to hydrological disasters by the community and related institutions/departments/instances, it is necessary to carry out measures to prevent flood disasters and water management with the provision of facilities in the form of bore wells, water pumps, seepage wells, biopores, irrigation and drainage channels, the application of soil and water conservation systems, as well as the arrangement of planting patterns so that the function of this area can be optimized and the quality of the soil better maintained. Instructions for mitigating hydrological disasters in cultivated areas based on the biophysical aspects of the land and the level of flood disaster vulnerability in the Krueng Jreue Aceh Besar Sub- DAS in 2020, shown in Table 7.

Table 7. Instructions for Hydrological Disaster Mitigation in Cultivation Areas Based on the Biophysical Aspects of the Land and the Flood Vulnerability Level of

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the Krueng Jreue Aceh Besar Sub-Watershed in 2020

SPL	Land Use	Kemiri and Slope	Problems/Obstacles	Hydrological/Alternative Disaster Mitigation Directive Land Rehabilitation	Area (ha)
10	Human settlement	Flat – Incline (0- 8%)	This region has a good soil quality index but there is a deficit of groundwater in the dry season and it is very vulnerable to flooding	There is a need for flood prevention and water management by applying conservation agriculture systems such as: seepage wells, biopores, planting pattern arrangements, crop rotation and *cover crops*	103.88
11	Rice field	Flat–Slope (0-<8%)	This region has a moderate soil quality index but occurs groundwater deficit in	Planting pattern arrangements or selection of rice varieties are necessary drought tolerant and	520.88
			dry season as well as being very susceptible to flooding and susceptible to drought	the provision of irrigation infrastructure such as: bore wells, water pumps, as well as the application of soil and water conservation such as: crop rotation, land management	
12	Moorland	Flat-Slope (0-<8%)	This region has a moderate soil quality index but there is a deficit of groundwater in the dry season and is vulnerable to floods and droughts	Simply apply conservation farming techniques only for example with crop rotation , *cover crops, intercropping* , and recycling of materials organic	923.66

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13	Moorland	Slopes - Hilly t (8- <15%)	This region has a moderate soil quality index but is prone to erosion because it is located on sloping land and there is a deficit of groundwater in the dry season, and is not affected by floods and droughts.	Simply apply conservation agriculture techniques that is with: rorak, contour planting , rotation plants, recycling organic matter, maintaining the surface of the soil with *cover crops* and *intercropping*	0.56
	Total				1.548,98

Source: Data Analysis Results (2020)

Table 7, alternative land improvement and restoration activities (land rehabilitation) in cultivation areas , especially prioritized in settlements, rice paddies and moors that are prone to water deficits in the dry season, vulnerable to floods and droughts, both mechanically (for example making seepage wells, biopores, bore wells , managing water pumps and land management), and vegetatively (for example arranging plant patterns, selecting drought tolerant varieties, crop rotation, planting *cover crops* , *intercropping* systems and material circulation organic).

Flood prevention and water management by making seepage wells and digging biopore seepage holes, especially in residential areas. With the increase in rainfall on residential land, *runoff* causes the existing drainage channels to be insufficient so that the water overflows and stagnant floods occur. For this reason, in order to avoid this stagnant flood, it is necessary to increase the amount of rainwater that is infiltrated with seepage wells and biopore seepage holes (Ikhsan & Refiyanni, 2018).

In residential areas and moors, high strata crops such as mango and rambutan can be planted, as well as secondary strata such as bananas. Crops (peanuts, mung beans, soybeans and corn), and horticulture (scallions, red chilies, cayenne peppers, long beans, eggplant, cucumbers and watermelons). To support food security in the Krueng Jreue Sub-DAS, in addition to rice, corn and cassava can also be planted. Crop rotation in settlements and moors can increase the diversification of land cover vegetation and agricultural cultivation patterns. This system combines high strata crops (annual crops) with medium strata crops (horticulture) and low strata crops (horticulture/food) (Soewandita, 2013). Land use accompanied by vegetative conservation techniques, such as crop rotation and leguminous ground cover crops can reduce the rate of erosion in a watershed (Fitri, 2011).

Arrangement of planting patterns of rice and other crops (corn, soybeans, peanuts and mung beans) in the rice fields. The selection of the rice planting season in the paddy fields, which has been initiated by the leading sector of the Aceh Besar Department of Agriculture, should be adapted to local wisdom such as the climate regulation system (*keuneunong*), so that the irrigation water needed during the dry season can be met (Faisal *et al* ., 2018). Cultivation of drought -tolerant varieties of rice , and the application of agricultural cultivation of water-efficient crops and inputs, especially crops: corn, soybeans and mung beans in the gadu growing season.

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The rice paddy area can be planted in a pattern: Padi Gadu-Bera-Padi Rendengan-Bera or it can be done in crop rotation with legumes such as peanuts , mung beans and soybeans. Bera system (leaving land without crops for a certain period). Planting patterns that are accompanied by the fallow system become important, because fallow land is usually left uncultivated, in order to return to its fertility in the next planting period (Pardosi *et al* ., 2013).

Soil management such as no tillage and minimal tillage , especially during the dry season, aims to improve the physical properties of the soil, including increasing the content of soil organic matter, aeration pores and water pores available compared to conventional tillage and intensive tillage . The application of no tillage and minimal tillage in the Krueng Aceh watershed can reduce the risk of crop failure or heart disease due to drought compared to conventional tillage (Meylis *et al.* , 2012). The arrangement of rice and other crops during the gadu planting season is very necessary, considering the low rainfall, and the need for water for irrigation obtained from the Krueng Jreue and Krueng Lamkareung dams.

The application of rorak technology in moorland regions with undulating slopes (8-<15%), aims to minimize soil degradation. Rorak can increase the infiltrated rainwater and prevent flooding. Increasing the filling of pores and soil percolation by making rorak will significantly reduce *the runoff* that comes out of the parcel of land and contribute to the control of flood disasters in the upper Krueng Aceh watershed (Rusdi *et al* ., 2013).

Optimizing the land with the *intercropping* system on the moorland, in addition to making use of the empty land between the trees , means a lot in the more effective use of light, water and nutrients. *Intercropping* systems can increase land potential and crop production and are more productive compared to monoculture systems, especially in conditions of low to medium soil quality, as well as suppressing pest activity by increasing plant diversity (Ceunfin *et al* ., 2017).

To support the growth and production of plants, the use of organic materials and organic mulch is done, especially in the moors. The recycling of organic matter can increase potential soil fertility and increase the conservation of soil organic matter and suppress CO_2 emissions . Organic matter and organic mulches help reduce erosion, maintain soil moisture, control pH, improve drainage, reduce soil compaction, increase ion exchange capacity, and increase soil biological activity. The sponge effect of organic matter and forest litter can absorb rainwater and regulate its flow to reduce the impact of flood disasters in the downstream region and regulate the availability of water in the dry season in the Krueng Aceh watershed (Muis, 2017).

Non- Cultivated Area

Hydrological disaster mitigation instructions on non-cultivated areas that function to protect the sustainability of forests and land, consisting of regions: open land, bushes, grasslands, secondary forests and primary forests. Hydrological disaster mitigation instructions in non-cultivated areas based on the biophysical aspects of the land and the level of flood vulnerability in the Krueng Jreue Aceh Besar Sub-DAS in 2020, shown in Table 8.

Table 8. Instructions for Hydrological Disaster Mitigation in Non-Cultural Areas Based on Biophysical Aspects of Land and Level of Flood Vulnerability Sub DAS Krueng Jreue Aceh Besar Year 2020

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SPL	Land Use	Kemiri and Slope	Problems/Obstacles	Disaster Mitigation Instructions Hydrological/ Land Rehabilitation Alternatives	Area (ha)
1 & 2	Open Land	Hilly - Quite Turbulent (15-<40%)	This region has a moderate soil quality index but is very prone to erosion and there is a deficit of ground water in the dry season, and is not affected by floods but is very vulnerable against drought	It is necessary to conserve the land intensively by creating terraces, plants that strengthen the cliffs and plant conservation trees and *cover crops* or return the land to forest (intensive reforestation)	20.06
37th grade	Check the bushes	Flat– Useful for	This region has soil quality index is medium but vulnerable	Need for land conservation intensively by making terraces ,	3,917.67
		(0-≥40%)	until very sensitive to erosion and there is a deficit of ground water in the dry season, and vulnerable to very vulnerable to floods and drought	cliff strengthening plants and planting conservation trees, *cover crops*, agroforestry and re-greening	
8 & 9	Grassland	Ramp-Quite Useful for (8-<40%)	This region has a low to medium soil quality index and is very prone to erosion and there is a groundwater deficit in the dry season, and is vulnerable to drought	Need to make terraced, cliff strengthening plants and planting conservation trees , *cover crops* and re -greening	2.519,13
19 until 21	Grassland	Flat-Useful for (0-≥40%)	This region has a low to moderate soil quality index and is very prone to erosion and there is a groundwater deficit in the dry season , vulnerable to floods and droughts	Need to make terraced, cliff strengthening plants and planting trees conservation, and re-greening intensively	2,614.22

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14 sd 17	Secondary Forest	Flat-Useful for (0-≥40%)	This region has a moderate soil quality index and is very prone to erosion and there is a groundwater deficit in the season drought, and susceptible to drought	Defending secondary forests into forests or enrichment with forest plants/ reforestation	11.002,94
18	Primary Forest	Useful (Steep) (≥40%)	This region has a good soil quality index, but there is a deficit of ground water in the dry season, and it is very prone to erosion if open and susceptible to drought	Defend existing forests and prevent illegal logging / deforestation	1.595,06
	Total				19.134,86

Source: Data Analysis Results (2020)

Table 8, efforts to mitigate hydrological disasters in non-cultivated areas that are vulnerable to flood and drought disasters by related institutions/departments/instances , can be done by applying land improvement and restoration alternatives (land rehabilitation) in the form of terracing, greening/reforestation, agroforestry, and prevention of *illegal logging* . Alternative land rehabilitation activities in non-cultivated areas, especially prioritized on open land, grasslands and bushes that are prone to land degradation due to erosion to be returned to forest so that it functions as a conservation area , both mechanically (for example terraced systems), and vegetatively (for example planting cliff strengthening plants , conservation trees , planting *cover crops* , agroforestry systems , greening and reforestation programs). The greening program on bushland and grassland is adapted to the potential of the area/locality, while the reforestation program on open land, secondary forest and primary forest is adapted to the activities of the Ministry of Environment and Forestry (LHK). Land rehabilitation in non-cultivated areas mechanically can be applied by making terraces, both credit terraces (3- <10%), guludan terraces (10-<15%) and bench terraces (10-<15%). Making terraces in non-cultivated areas on land whose topography is undulating to mountainous, such as on open land, bushes and grasslands , aims to reduce the length of the slope and hold water, thus reducing the speed and amount *of runoff* , and allowing the absorption of water by the soil. The Terasering system can control erosion on dry, sloping land and is one of the alternatives for mechanical rehabilitation or restoration of critical land in the watershed
(Ijuddin, 2011).

An intensive greening program with an agroforestry system on bushland, aims to reduce *runoff* , maintain and increase its fertility, by planting multi - *purpose tree species* can reduce the level of erosion danger in the Krueng Aceh watershed (Jayanti *et al* ., 2019). Multipurpose tree planting with one-season crops, such as peanuts, mung beans and soybeans, two-season crops such as bananas, among annual crops:

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mahogany, eucalyptus and pine, as well as rambutan and mango. Rambutan and mango plants are the main commodities in Aceh Besar Regency. Changing the land use pattern on the moor to agroforestry can reduce *runoff* by 0.86%. Water seepage in agroforestry or forestry systems (75%) is higher than monoculture system planting around <70% (Laturua *et al.* , 2018).

Increased water seepage and *run-off* management with the agroforestry system , planting types of plants with deep rooting , close rooting and binding soil aggregates and light biomass weight (Muis, 2017). The sparse density is filled with grass plants and *cover crops* in the bushes, thus reducing the danger of erosion. Optimizing plant variation and soil fertility in the utilization of agroforestry systems that involve communities around forest areas, is a form of adaptation and flood and drought mitigation efforts (Rendra *et al.* , 2016).

Some bushes, moors and grasslands are areas that are prone to flooding , due to having a topography of 0- <8%. While open land and other grasslands are areas that are potentially critical to flood vulnerability, due to having a topography of 15-<25% to ≥40%. Flood-prone areas are found in downstream areas, with flat slopes . Meanwhile, the areas that have the potential to cause flooding are the upstream areas, because they have a slope of 8->25% (Utama & Naumar, 2015). Flood incidents do not only occur in the downstream region, but lately many have occurred in the upstream region of the watershed, called flash floods (Rosyidie, 2013).

Intensive reforestation programs, for example by planting pine, eucalyptus or mahogany trees on open land and secondary forests, are reforestation and forest rehabilitation efforts. Pine trees, eucalyptus, mahogany are exotic types used for enrichment or filler trees in forest areas (Maimunah, 2015). Reforestation in forest areas can improve the hydro-orological conditions of a region, namely the planting of trees aimed at preventing floods, erosion, landslides, as well as preserving water resources (Pratomo, 2018).

Land rehabilitation with intensive greening of grasslands and bushes is an effort to restore critical land outside the forest area to restore land fungi. An intensive greening program in a watershed can reduce *runoff* , maintain and increase its fertility. Indirectly , greening plants can prevent flooding by absorbing rainwater into the soil and reducing water discharge on the surface of the soil which works to prevent floods, landslides and anticipate drought (Murdiyanto & Gutomo, 2018) .

On land with a topography of 0-≥40%, *cover crops* and conservation trees are planted, especially on open land, bushes and grasslands. Meanwhile, on land with a topography of 8-≥40%, cliff strengthening plants are planted. Generally, conservation trees in forests in a watershed are Moraceae family (banana), Lauraceae family (medang), and Dipterocarpaceae family (meranti). Conservation trees, producing quality wood predicates, play a role in soil and water conservation, such as holding water, reducing runoff and reducing *runoff* capacity , reducing the rate of erosion, and preventing sedimentation (Hidayati *et al* ., 2019).

High biomass production from planting *cover crops* on open land, bushes and grasslands is correlated to the return of nutrients to the soil in improving soil fertility, protecting the soil surface from rainwater, and reducing erosion (Saputra & Wawan, 2017). All types of core on land with a topography of 8-<25% must be accompanied by the planting of core bank strengthening plants (grasses and legumes). The diversity of vegetation in the watershed from floor covering plants is one of the indicators in determining the quality of the core bank, so it is used as one of the alternatives to prevent landslides and erosion, because the cover of vegetation affects the soil's ability to hold water (Wang *et al* ., 2013).

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Causes of secondary and primary forest damage include forest conversion to other sectors, *illegal logging* activities and concern for the sustainability of the Krueng Jreue Sub DAS ecosystem (Mechram & Jayanti, 2013). In order to maintain the existence of forests and prevent *illegal logging* , a reforestation program is needed in forests that have undergone degradation with forest tree types suitable for the local area, to rehabilitate the functions of forests that have been damaged and provide good benefits for the community, especially those around the forest area (Harryanto *et al* ., 2017).

Conclusion

Cultivation areas in residential areas, rice paddies and moors that are vulnerable to flooding by the community and related agencies, it is necessary to carry out flood prevention and water management measures with the provision of facilities in the form of bore wells, water pumps, seepage wells, biopores, irrigation and drainage channels, the application of soil and water conservation systems, as well as the arrangement of planting patterns so that the function of these areas can be optimized and improved. Non-cultivated areas, flood disaster mitigation in the Krueng Jreue Aceh Besar Sub- DAS , is done by applying land rehabilitation packages in the form of terracing, greening/reforestation, agroforestry, and prevention of *illegal logging* . Land rehabilitation activities are prioritized on open land, grasslands and bushes that are prone to degradation to be returned to forests so that they function as conservation areas.

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