ANALYSIS OF FLOOD PRONE AREAS IN NAGAN RAYA REGENCY ACEH PROVINCE

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ABSTRACT

Maps or remote sensing can be interpreted as the process of reading using various sensors where data collected remotely can be analyzed to obtain information about the object, area or phenomenon. In this study, the author develops a flood disaster mapping information system applying overlays with scoring between the parameters. The determinant factors to provide flood hazard levels includes rainfall factors in the dasarian unit, land-use factors and land-use arbitrary factors. Of all these parameters, a scoring process will be carried out by assigning weights and values according to their respective classifications, then an overlay process will be performed using ArcGIS software. The author conducted this study in Nagan Raya Regency since this area experiences flooding annually. Framing a thematic map of flood-prone areas in Nagan Raya Regency was designed using the flood hazard method. Spatial data that has been presented in the form of thematic maps as parameters are land use maps, landform maps, and dasarian rainfall maps (per 10 daily). The design of thematic maps that are prone to flooding is done by overlapping (overlay process). In contrast, the determination of the classification is done by adding scores to each parameter, with low, medium and high hazard levels. Parameter analysis shows the level of flood vulnerability in Nagan Raya Regency of each district, namely Beutong: high 0.21%, medium 13.68%, low 86.12%. Seunagan District: high 51.17%, medium 48.83%, low 0%. Seunagan Timur District: high 10.07%, medium 46.18%, low 43.75%. Kuala Subdistrict: high 29.66%, medium 68.99%, low 1.35%. Darul Makmur District: high 8.57%, medium 63.37%, low 28.06%. From the overall results of the study, it can be concluded that the danger of flooding in Nagan Raya Regency with a level of vulnerability: high 9.92%, moderate 42.65% and low 47.43%.

Keywords: *Flood, Geographic Information System, Overlay, Map.*

1.   Introduction

Earth's surface is a zone that has boundaries such as land, sea, mountains, rivers, settlements, lakes, and so on. The surface of the earth is very important to be mapped according to needs with the aim to get information in the region. The science of mapping has been known from the earliest times, although it is still simply made of animal skins, bark, and stone (Supardi, 2014). As technology develops, map processing continues to evolve as it uses computer-based software for mapping designs such as ArcView and ArcGIS. Mapping or remote sensing data by utilizing mapping is increasingly being used to map various objects both on a local and regional scale with various techniques. The use of this mapping provides valuable information

because it quickly provides information in the field (Ashourloo *et al.,* 2018). Mapping or remote sensing is a process or way of making maps by the process of shooting through the air (Huda *et al.,* 2019). So the information can be read to improve good imaging results in certain areas. The process can also be read using various sensors where data is collected from a distance far analyzed to obtain important information about the object, area or phenomenon being studied (Nugroho & Kusuma, 2018).

Efforts to reduce and to prevent flooding, for example, is by preparing information about flood-prone areas that are designed in the form of digital-based mapping. The right way to map flood-prone areas with broad coverage can be done using geographic information systems so that the time needed to get flood-prone information is relatively shorter. Flood prone mapping in Nagan Raya Regency needs to be done to improve flood disaster information management in the Nagan Raya region. Therefore, the authors conducted a study of flood hazard maps in Nagan Raya District using ArcGIS software. The results in the form of thematic maps of flood vulnerability with low, medium and high categories were obtained, which was based on the flood hazard method that equipped with an earth coordinate system from a survey obtained in Nagan Raya district. The benefits of Geographic Information System (GIS) include the ease of getting the information that has been processed and stored as an attribute of a location or object. The characteristics of the data that can be used in GIS is data that has been tied to the location and the basic data that has not been specified. The data are processed in GIS basically consists of spatial data and attribute data in the digital form so that the analysis can be used is the analysis of spatial and attribute analysis. Spatial data is data relating to spatial locations which are generally in the form of maps. While the attribute data is a data table that serves to explain the existence of various objects as spatial data (Setiadi, 2013).

Research on flood disasters has been carried out by Pradhan *et al.,* (2016) by using the Image of TerraSAR-X. First, TerraSAR-X satellite imagery was captured during a flood in Kuala Terengganu, Malaysia, to map a flooded area. The overall accuracy value of the maps classified is derived from TerraSAR-X using rule-based methods and Landsat imagery are 86.18 and 93.04, respectively. The results obtained overall accuracy for TerraSAR-X using ISODATA is very low at only 57.98. The current research combines optimization methods and techniques used as innovative flood detection applications. Research using the overlay method has also been applied by Khikmah *et al.,* (2017), where this research involves several parameters, such as soil slope, soil type, and bulk rain using GIS. Existing land use maps are produced by visual interpretation using Landsat 8 OLI satellite imagery. Field surveys used stratified random sampling to validate parameters; the accuracy of the field survey is about 68% of existing land use maps. The results based on the spatial and regional planning map of East Lombok evaluation using land-use guidelines and the existing land use suitability map are good enough, reaching 80.15% and not suitable reaching 19.85%.

Research related to natural disasters carried out by Valdika *et al.,* (2019) in Kendal Regency for mapping several natural disasters including floods, landslides and drought, the method used is using overlay method and method of valuation and weighting of Fuzzy Analytic Hierarchy Process. Accuracy results obtained include 75% threat to floods, 85% langsor and 82.5% drought. The distribution of areas affected by this disaster is for the low category with an area of 28773, 774 Ha, the medium category with an area of 69112.504 Ha, and the category of high disaster with an area of 2846,631 Ha. Subsequent research on mapping areas affected by floods was in the city of Semarang. This study uses the flood threat overlay method, flood vulnerability map, and flood capacity map based on SNI and PERKA BNBP No.2 of 2012 using the VCA matrix (Vulnerability Capacity Analysis). The threat of floods in the city of Semarang can also be done by using GIS. The results of the modelling that has been tested showing the areas with the lowest risk level area of 19535.781 ha (49.98%) of the total area of the city, the level of risk was an area of 14 358, 708 Ha (36.74%)

and high-risk level of 5,191,383 Ha (13.74%) (Ujang *et al.,* 2019). Another research was conducted by Darmawan *et al.,* (2017) to find the flood vulnerability area in Sampang Regency on Madura Island. Their study examines the parameters that become a factor for flooding include slope and land height, soil type, land use and river density. In this study, the method used was an overlay with scoring between the parameters. Each parameter scoring process is carried out with the weighting given in accordance with their respective classifications; the overlay process uses ArcGIS 10.2.1 software by utilizing a GISthat can describe the level of flood vulnerability. Almost the entire southern part of Sampang Regency is affected by flood disaster prone. From the results of this study, the vulnerability level of a very vulnerable category is 359,266 km2 (29.3%), the category is quite vulnerable 802,250 km2 (65.52%) and not prone to an area of 63,497 km^2 (5.18%).

From several studies that have been conducted by past researchers, the authors are interested in researching on how to produce a flood prone mapping. The aim is to classify the area of the impact of the flood disaster by dividing the three groups of hazard areas, namely flood areas with low, medium and high classification. Subsequently, each hazardous area is assigned a different colour to separate the level of vulnerability in this flood disaster. The problems of this research are how to make a thematic map of flood disaster prone, to determine the level of vulnerability, to measure the area affected by flood and to identify local government policy to prevent the occurrence of disaster in Nagan Raya. To provide a scientific answer to the problem of this study, the authors collected and analyzed the data to create a flood hazard map in Nagan Raya District, so that with this flood hazard map it would be easier and able to take flood prevention measures by the community and local government.

The purpose of making thematic maps of flood prone areas is to provide information on an area by classifying different levels of vulnerability from other regions in the Regency. Thus, mapping is beneficial in providing information in the form of thematic maps. Research by the author is related to flood-prone areas in Nagan Raya Regency because almost every year, this area always experiences floods. This study uses the flood hazard method based on weighting several parameters so that it will produce a thematic map prone to flooding using ArcGIS software for data processing. At present software with various types continues to experience development in search of compatibility to the current issue as well as ArcGIS software. This software continues to be developed by overviewing the aspects of the benefits of using the software so that the upgraded software provides more benefits than the previous one (Ya'u *et al.,* 2018). So in an account of the final results of data processing using ArcGIS software, decisions can be formulated based on parameters to produce logical decisions (Amsar *et al.,* 2017).

2. Literature Review

This research uses mapping based on Geographic Information System (GIS). This tool can be applied to manage (input, management, process, and output) spatial data or data that is graphically referenced (Setiadi, 2013). Remote sensing or mapping technology, especially such as Synthetic Aperture Radar (SAR), plays an important role in the rapid monitoring of flood disaster information and other geographical information. At the moment, considerable SARs deploying high resolution satellites have been set and becoming an important tool for flood monitoring, because this system can immediately observe the approximately large area regardless of the day, night, or the weather conditions (Ohki *et al.,* 2019). One feature of GIS is the ability to visualize information stored by representing objects in simple shapes using a raster or vector data model. Vector data is further divided into points, lines and polygons (Guzman *et al.,* 2019). In the map, there are attribute or tabular data, in the form of text or numbers according to the characteristics for example road, river, and irrigation. To get earth coordinate data, the Global Positioning System (GPS) is used. The use of GPS (see Figure 1)

in a GIS serves as a reference for making maps, such as measuring borders, taking coordinates, making the trajectory of an area (Khikmah *et al.,* 2017).
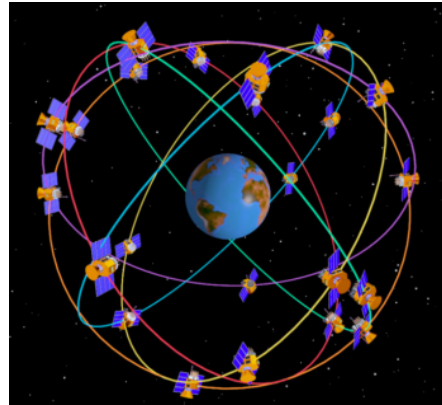

Figure 1. GPS Satelite on the orbit (Peterson & Storz, 2017)

The application of Geographic Information System-based disaster prone mapping is very helpful for disaster subscriptions, which is similar to the use of google maps which are widely used in various purposes to obtain information about the location of latitude and longitude from a point on the surface of the earth (Setiawan & Sediyono, 2018). For example, the implementation of mapping about flood disasters that are troubling communities affected by flooding. As it is known that flooding is an incident when the flow of water that enters a place from rainfall, overflow or run-up of sea tides is greater than the water credit that comes out of that place. The duration of actions taken due to flooding will cause a lot of damage to the area affected by flooding Amirioun *et al.,* (2018). According to Akhtar *et al.,* (2019), flood events are natural disasters which are the main concern to be resolved because they occur anytime with unpredicted rainfall and other natural factors that cause miserable flooding. This flood disaster also caused high human casualties and huge economic losses. For this reason, it is necessary to establish a correct, complete, reliable and unambiguous flood detection system for assisting flood hazard detection systems that provide accurate data and preparedness of emergency and rescue services in case of floods at any time. See Figure 2, an example of flood images in one of the villages in Nagan Raya.

Figure 2. Flood on Lamie Village in Nagan Raya

Large or small river flow capacity is determined by the wet cross-sectional area of the cross section of the river. Due to sedimentation, plants such as weeds that grow in river bodies, rubbish and others, in general, the capacity of the water that flows in the area decreases over time. Meanwhile, surface water debit that enters the river from time to time gets bigger. The increase in the amount of surface runoff is also caused by an increase in the

impermeable layer, high rainfall, and a decrease in the amount of cross-section of rainwater on the ground (Suharyanto, 2014). In addition, the presence of weed plants such as water hyacinth is also one of the causes of silting of rivers or waterways, which ultimately triggers flooding. Weed plants are not only a cause of flooding due to obstruction of water flow, but weeds are also one of the real threats to the production and harvest of rice plants. Because of the growth of weeds, rice growth is hampered and eventually a decline in the production of rice farmers (Jamil *et al.,* 2018). Flooding is also a worrisome threat, and this threat tends to increase due to the economic losses as well as casualties. The mapping of flood impacted area is very important to see the level of damage caused by flooding and other information that becomes a reference for region administrator (Landuyt *et al.,* 2019).

The purpose of mapping the area affected by floods is basically to provide information specifically to help the authorities to focus on areas affected by floods while continuing to monitor standing water and find solutions to flood inundation. The important role of mapping a flood disaster area is to identify flood-prone areas and examine more deeply the main causes of flooding and hope that flood disasters can be reduced with solutions needed in the area (Nogueira *et al.,* 2018). According to Li *et al.,* (2019) in his study mentioned that the damage caused by flooding is usually far more severe in densely populated areas such as urban areas compared to floods that occur in rural areas. Mapping flood areas that are made using GIS can be an effective means to obtain flood distribution information with accurate time so that flood mitigation efforts are more controlled to reduce disaster risk.

From the field survey it was found that in addition to the other causative factors, the Watershed (DAS) in this Regency also became the fundamental cause of flooding, especially the area adjacent to the watershed as shown in Table 1.

Table 1. Three Watershed Areas (DAS) in Nagan Raya Regency (Ibrahim, 2016)

No	DAS Name	Region	Width DAS	Status
1	Meurebo	Upstream in Nagan Raya and Downstream Area Coverage in West Aceh	192.724 Ha	Damaged watershed: 56,201 Ha (29.16%) Non-forested area: 65,353 Ha (33.9%)
2	Seunagan	upstream and downstream are in Nagan Raya Regency	99.734 Ha	Damaged and Non-Forested: 40,890 Ha (41%)
3	Tripa	upstream in Gayo Lues and downstream Regions in Gayo Lues and Nagan Raya	315.889 Ha	Damaged: 117,517 Ha (37.2%)

High levels of rainfall caused an area to affect flood vulnerability when supported by waterlogging factors. According to Danianti *et al.,* (2015), a vulnerability in an area can also be interpreted as a state of society that leads to or causes an inability to deal with the dangers that come from various directions. The elements that cause vulnerability can be grouped into three factors, including the factor of exposure which shows data on topography and slope such as coastlines, cliffs, and basins. The sensitivity level factor is the community's access to clean water, the rate of waste production and waste management, and the third is the adaptive capacity factor, namely the ability of regional systems such as the strength of community institutions in dealing with impacts arising from climate change. According to Akhtar *et al.,* (2019) maps in general function to clarify the role of space and human travel. Maps are made to provide topographic observations of the shape and character of the earth's surface, where topographic maps are also becoming increasingly useful clues to exploring, understanding and analyzing the environment. Topographic maps store and provide topographic information

from large to small scale and provide a spatial reference framework for other data about the Earth and its resources. In addition, topographic maps provide information for various regional information needs such as infrastructure planning and management, resources, exploitation, demographic analysis, recreational activities, and military planning, areas affected by natural disasters and other information. Topographic maps are high complexity maps with various features related to one another.

Therefore, the use of geospatial data to measure the value of exposure level indicators is very important. Level of Sensitivity (Sensitivity) is the condition of the internal environment of a system that shows the level of vulnerability to interference Danianti *et al.,* (2015). As an illustration, what happens at this sensitivity level is data to identify the level of sensitivity, which is people's access to clean water that is difficult to obtain, as well as the rate of waste production and management capabilities that have not been maximized and adaptive capacity. Adaptive Capacity is the potential or ability of a system, region or community to adapt to the effects or impacts arising from climate change (Kumalasari, 2014).

3.   Material and methods

The method used in this research, for data processing using the overlay method with scoring between parameters be the determining factor for generating vulnerability factors such as rainfall flooding in units dasarian, factors land use maps and landform maps factors. Of all these parameters, a scoring process will be carried out by assigning levels and values according to their respective classifications then an overlay process will be performed using ArcGIS software. The research carried out is located in Nagan Raya Regency, Aceh Provision. The population of the population in Nagan Raya Regency in 2017 amounted to 161.329 inhabitants with an area of $3.544,90$ Km^2 (Raya, 2017). To get the classification of flood hazard levels, the method used is Flood Hazard Mapping. The reason for using the flood hazard mapping method is because it strongly supports the parameters used in this study by adjusting existing conditions in the study area, namely Nagan Raya Regency. The parameters used are landform factor using the landform unit approach, land use and rainfall in millimeters. These three parameters are combined into one new theme, from the result of overlays (overlapping layers) as illustrated by the overlays in Figure 3 below.

Figure 3. Overlay Process

The overlay process in this study begins by using the three layers namely land use maps, landform factor maps and *dasarian* rainfall maps (Darmawan, 2008). The overlapping data processing or so-called Overlay is done first on the parameter that has the lowest weight value, then with higher weighted parameters and so on so that the suitability of low weighted parameters can be selected by the suitability of high weight, so that the final result is more determined by the suitability of the high weighted parameters. To get the data of the three layers that will be used, it is necessary to carry out a survey to the field or take both from

government agencies and from the public directly by making a questionnaire in the form of several questions about the flood disaster that struck the Nagan Raya Regency so that from sources obtained in the field will be analyzed by the method used. The map design of the three layers are shown in Figure 4.
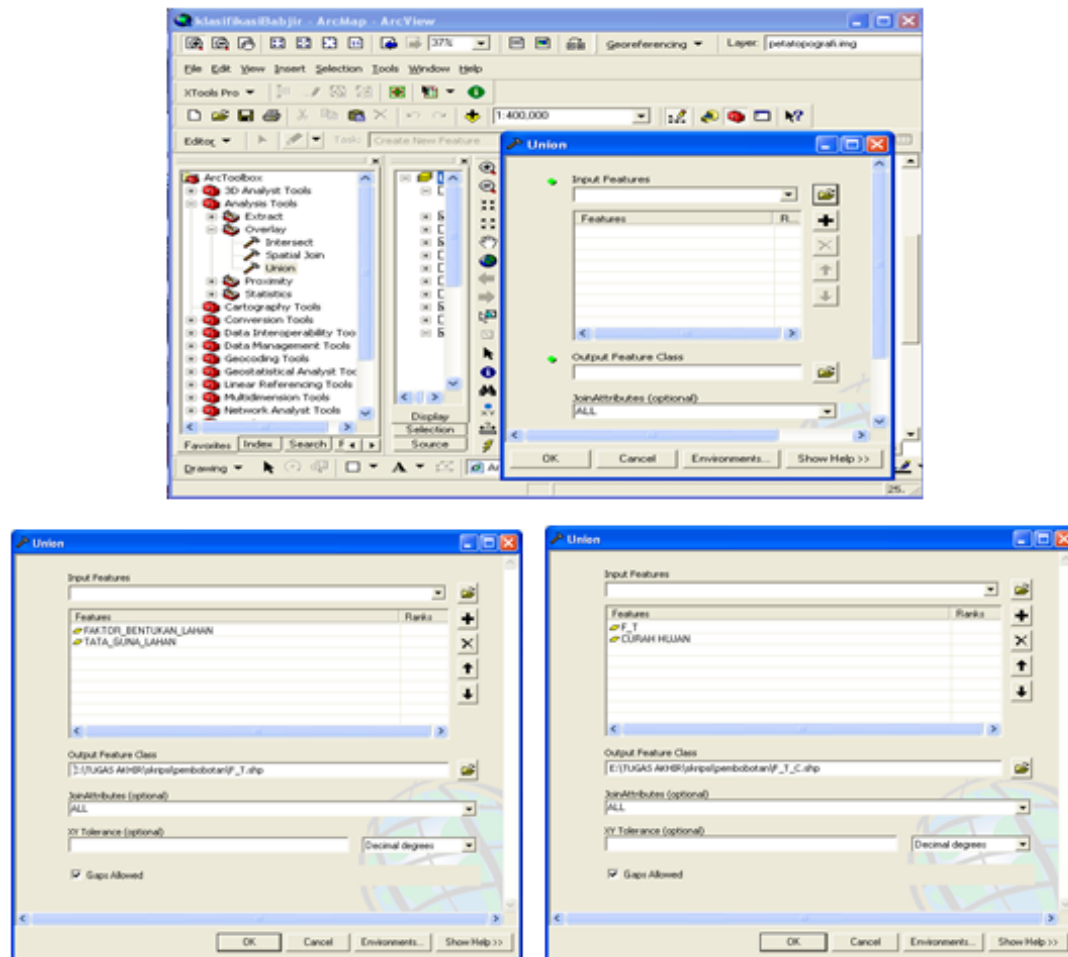

Figure 4. The union dialogue box in the overlay process

After these three parameters are combined into one new theme. The sum of the scores is done, resulting in three classes of flood hazard, as shown in Table 2 bellow.

Table 2. Flood prone classification

No	Range	Information
1	1 - 4	Low
2	5 - 8	Medium
3	9 - 13	High

The level of flood vulnerability, as shown in Table 2 above illustrates the condition in the field of flood disaster vulnerability. If the scores obtained in the range of 1 to 4, this region is an area that is still a low flood hazard level. Scores of 5 to 8 indicate the level of moderate flood hazard and the last category at scores of 9 to 13. This shows the area is a high level of flood vulnerability. Furthermore, the land shape is also a determining factor in this study because the area taken as a research area has different landforms. This is certainly a natural factor that can not be avoided. Landform factors, as in Table 3, can be grouped into 4 (four) sections, each part having different characteristics and shapes. These differences in landform are formed naturally; for example, the level of the slope of the land and the type of soil has different sizes from one another. This is also one of the factors in the occurrence of floods in the Nagan Raya Regency.

Table 3. Landform factor

No	Landform Types	Characteristics	Score
1	Denudational, structural, karst, or volcanic	The topography of the mountain plains denudation process, structural, soil has no aquatic properties.	0
2	Alluvial plain (fluvial / marin, volcanic)	Flat topography, flat slope (0-8%), *Aquents* soil type, drainage is somewhat obstructed, rarely inundated	1
3	Flood Plain A	Flat topography, sloping flat slope (0-2%), soil type *Aquents*, *Aquepts*, blocked drainage is very inhibited, and meandering drainage patterns are often flooded with seasonal water	2
4	Flood Plain B	Flat topography, sloping flat slope (0-2%), soil type *Aquents*, blocked drainage is very inhibited, and meandering drainage patterns are often flooded	3

Landform classification
1. Denudasional is a form of land that results from gradation and agradation denudation processes.
2. Structural is a form of land resulting from endogenous processes due to tectonics / uplift.
3. Kars is a form of land that results from the dissolution process of limestone
4. Volcanics are landforms resulting from volcanic processes due to volcanic eruptions.
5. Fluvial is the result of fluvial / sedimentation process results of river water transport.
6. Marin is a form of land that results from marines in coastal areas.

Furthermore, land cover is also a parameter determining the level of vulnerability in this study; land use will greatly affect the level of flood vulnerability in an area. Land use will have a major effect on the high runoff water from high rainfall intensity. Usually land with vegetation, rainwater will be infiltrated much, and more time will be taken by the overflow to get to the river; consequently, the possibility of flooding is less than the area without vegetation. For more details on land cover, see Table 4.

Table 4. Land cover factor

No	Land cover type	Score
1	Forest	1
2	Bushes	2
3	Field/ Garden	3
4	Rice field/pond	4
5	Settlements	5

Rainfall is water that falls in a region of the earth at a certain time. Rainfall which is a parameter of vulnerability level used in this study is not rainfall at a certain point or commonly called regional rainfall, but the rainfall data used in this study is the average rainfall in all regions in Nagan Raya Regency Province Aceh. So, the higher the intensity of rainfall, the possibility of flooding also increases, conversely the lower the rainfall that occurs, the lower the impact of flooding. Table 5 below shows the rainfall data in dasarian units used as one of the parameters in this study.

Table 5. The Dasarian Rainfall Factor

No	Dasarian factor	Score
1	< 50 mm/dasarian	1
2	50 – 100 mm/dasarian	2
3	100 – 200 mm/dasarian	3
4	200 – 300 mm/dasarian	4
5	> 300 mm/dasarian	5

Information: Rainfall of 1 (one) millimetre, meaning that in an area of one square meter in a flat place that holds water as high as one millimetre or one litre of water is stored. While dasarian means a span of 10 (ten) days.

4. Result

Rainfall data is obtained from the Nagan Raya Regency Government in the form of an annual rainfall map that has been converted into a dasarian rainfall map, and this data change discusses the flood-prone method in this study to use rainfall data on a basis (per day / dasarian) basis. To get the value of rainfall in the form of dasarian, what needs to be done is to take annual rainfall data, then change it in the form of monthly rainfall data and then convert it again into the form of dasarian rainfall. So Table 6 shows the results of changes in annual rainfall to dasarian rainfall, the calculation can be done by calculating the annual rainfall in 12 months and the dasarian category then it is divided again into 3 parts (per day). The grouping of each range of rainfall is divided into five parts, in the first part, which is 2800 - 3100 mm / year, the calculation is that the rainfall is 2800 mm / year divided by 12 months obtained 233.33 mm / month then divided by 3 (per day / day dasarian) then the value of 77.77 mm / dasarian is obtained and then fulfilled to 78 mm / dasarian, then rainfall of 3100 mm / year divided by 12 months is obtained 258.33 mm / month starting divided by 3 (per day / dasarian) then the value of 86 is obtained, 11 mm / dasarian was subsequently fulfilled to 86 mm / dasarian. For the category of the first part, dasarian rainfall is obtained in

the range 78-86 mm / dasarian. The assessment carried out in the first section is the same as the other sections so as to produce a rainfall value in the form of a dasarian obtained in Table 6.

Table 6. Rainfall Data

No	Annual Rainfall	Dasarian Rainfall
1	2800 – 3100 mm/year	78 – 86 mm/dasarian
2	3100 – 3400 mm/ year	86 – 94 mm/dasarian
3	3400 – 3700 mm/ year	94 – 103 mm/dasarian
4	3700 – 4000 mm/ year	103 – 111 mm/dasarian
5	> 4000 mm/ year	111 mm/dasarian

Millimeter (mm) of rainfall is the height of rainwater collected in a flat, non-evaporating, non-absorbing, and non-flowing place. Rainfall in Nagan Raya District which has five Districts has some rainfall data as shown in Table 7 below, where the highest rainfall is sequentially based on the range of rainfall intensity at an intensity above 111 millimetres per year with an area of an area of 62,871.22 Ha. Each of them is in Kuala District with an area of 24,053.90 Ha or 38.26%, East Seunagan District with an area of 16,388.82 or 26.07%, Darul Makmur District with an area of 13,827.62 Ha or 21.99 %, Seunagan District with an area of 6,834.49 Ha or 10.87% and Beutong District with an area of 1,766.39 Ha or 2.881%. Rainfall at an intensity of 103-111 millimetres per year with an area of 201,425.89 Ha. Each of them is in Beutong District with an area of 80,177.44 Ha or 39.80%, Darul Makmur District with an area of 77,572.88 or 38.51%, Kuala District with an area of 30,876.44 Ha or 15.33%.

District of East Seunagan with an area of 8,792.76 Ha or 4.37% and District of Seunagan with an area of 4,006.67 Ha or 1.99%. Rainfall at an intensity of 94-103 millimetres per year with an area of 57,076.29 Ha, each found in Beutong District with an area of 32,523.74 Ha or 56.98%, Darul Makmur District with an area of 24,552.55 or 43.02%. Whereas in Kuala Subdistrict, East Seunagan and Seunagan Subdistricts, there is no rainfall in the range of 94-103 millimetres per year but included in the group with rainfall intentions above 103 millimetres per year. Rainfall at an intensity of 86-94 millimetres per year with an area of 29,491.29 Ha, each located in Beutong District with an area of 24,195.29 Ha or 82.04%, Darul Makmur District with an area of 5,296.01 or 17.96%. Whereas in Kuala Subdistrict, East Seunagan and Seunagan Subdistricts there is no rainfall in the range of 86-94 millimetres per year, but it is included in the group with rainfall intentions above 103 millimetres per year. And the last rainfall at an intensity of 78-86 millimeters per year, there is only one District, namely in the District Beutong with an area that has rainfall area of 4027.19 Ha or 100%. Whereas in Darul Makmur District, Kuala District, East Seunagan and Seunagan District, there is no rainfall with this low intensity. For more details, see Table 7.

Table 7. Classification of Rainfall With An Area In Hectares (Ha)

District	Width (Ha)				
	> 111 mm	103-111 mm	94-103 mm	86-94 mm	78-86 mm
Beutong	1766.39	80177.14	32523.74	24195.28	4027.19
Darul Makmur	13827.62	77572.88	24552.55	5296.01	
Kuala	24053.90	30876.44	-	-	-
Seunagan	6834.49	4006.67	-	-	-
Seunagan Timur	16388.82	8792.76	-	-	-
Total	62871.23	201425.88	57076.28	29491.30	4027.19

Besides the high intensity of rainfall, flooding is also vulnerable due to land-form factors. Landforms are *geomorphological* forms of the earth that are formed as a result of geomorphic processes (geomorphic is the process of morphological formation of the earth), both from endogenous energy (in the face of the earth such as rock or plate movements) or exogenous (external factors such as erosion and other environmental effects). Landform can be used as an indicator of flood area vulnerability. Examples of landforms are alluvial plains, flood plains, *denudational* hills and mountains. By understanding the characteristics of landforms and topography, landforms can be classified into several classes as in Table 8. In theory, landforms are created by visual interpretation of aerial photographs, radar images, or high-resolution satellite imagery (such as quick birds). The area distributed in the classification of land types per district is shown in Table 8. Land use based on 2004 - 2018 data sourced from the Nagan Regency spatial map, area and land use map can be seen in Table 9.

Table 8. Classification And Area Of Landform

Districts	Width (Ha)			
	Alluvial Plain (fluvial / marin, volcanic)	Flood Plain A	Flood Plain B	Denudational, Structural, karst, or volcanic
Beutong	253.52	0.82	1089.22	141346.17
Darul Makmur	37066.83	27062.18	9312.45	47929.25
Kuala	5006.34	13075.33	16341.17	21097.99
Seunagan	794.93	1395.67	5598.89	3154.11
Seunagan Timur	718.20	528.97	2420.04	21514.37
Total Area	**43839.82**	**42062.97**	**34761.77**	**235041.89**

Table 9. Land Use Classification By Area

Districts	Width (Ha)				
	Forest	Settlements	Plantation	Ricefield	Bush
Beutong	121158.77	1042.99	15248.54	1674.26	3565.16
Darul Makmur	33010.06	1371.72	83490.85	761.71	2614.73
Kuala	747.46	3807.10	47519.05	457.65	2399.09
Seunagan	-	1034.73	7924.80	1881.63	-
Seunagan Timur	11016.85	769.01	9451.76	162.22	3781.74
Total area	**165933.14**	**8025.55**	**163635.00**	**4937.47**	**12360.71**

4.1   Flood Prone Point

To obtain information on flood vulnerability in the Nagan Raya Regency area, a field survey was conducted involving 30 villages as a sample of flood hazard points, the results of the field survey are presented in Table 10.

Table 10. Flood Hazard Points

No	Y	X	Villages	Water Level (cm)	Frequency /Annual
1	4.09485	96.208741	Suak Puntong	20 – 70	2 times
2	4.06186	96.239578	Langkak	121 – 170	3 times
3	4.03725	96.263416	Kuala Trang	20 – 70	1 time
4	3.99937	96.293563	Cot Rambong	71 – 120	2 times
5	3.89208	96.364924	Kuala Teripa	171 - 220	6 times
6	3.91633	96.422778	Lueng Keubeu Jagat	121 – 170	1 time
7	3.98765	96.481429	Lamie	171 - 220	3 times
8	3.99657	96.489574	Pasar Lamie	221 - 270	2 times
9	3.97623	96.645671	Krueng Seumanyam	-	-
10	3.97026	96.651939	Panton Bayu	-	-
11	4.0206	96.561963	Alue Wakie	20 - 70	1 time
12	4.04697	96.461682	Lamie Ateuh	-	-
13	4.09569	96.401078	Tadu Raya	-	-
14	3.83291	96.584146	Seumanyam	171 - 220	3 times
15	3.81624	96.604714	Kuala Seumanyam	121 - 170	12 times
16	3.91397	96.595876	Alue Bateng Brok	-	-
17	3.88288	96.504895	Alue Kruet	71 – 120	2 times
18	4.25795	96.416227	Ulee Jalan	-	-
19	4.2585	96.334022	Lhok Pange	371 - 420	2 times
20	4.26796	96.338805	Balang Teungku	121 - 170	3 times
21	4.28947	96.352258	Kila	-	-
22	4.27869	96.369743	Pulo Teungoh	171 - 220	2 times
23	4.23526	96.349738	Suak Peureubong	20 – 70	3 times
24	4.23025	96.306779	Jeuram	20 – 70	2 times
25	4.23423	96.304787	Pante Ceureumen	171 - 220	2 times
26	4.11818	96.292486	Simpang Peut	71 – 120	1 time
27	4.21247	96.314059	Meureubo	121 – 170	2 times
28	4.11786	96.34247	Babah Dua	-	-
29	4.06522	96.300795	Lawa Batu	20 – 70	2 times
30	3.93797	96.427582	Neubok Yee PP	121 – 170	2 times

Naturally, watersheds are also a factor in the danger of floods that hit settlements. Proximity to settlements with watersheds will be at high risk for objects that live in the vicinity. The results of interviews with several residents in Nagan Raya Regency as shown in Table 10 above indicate that high rainfall which resulted in the Nagan Raya Regency area of most of these Sub-districts often experiencing seasonal flood disasters at least once a year. Prevention of flood-prone gets serious attention from the regional government of Nagan Raya. But the terrain is difficult to pass and areas that are vulnerable to standing water, so it takes time to handle when a flood disaster occurs. As a result, residents around the area affected by flooding can only make rudimentary drainage. The flooding that occurred in Nagan Raya Regency was very perturbing because most of the areas affected by the flood were residential areas in the local area, especially settlements in areas close to watersheds.

The results of the field analysis, as shown in Table 11 and Table 12 show the level of flood hazard classification, which is divided into three levels, namely low, spring and high.

Table 11. The Results Of The Analysis Comparred To Real Condition

No	Y	X	Village	Results	Real
1	4.09485	96.208741	Suak Puntong	High	Moderate
2	4.06186	96.239578	Langkak	High	High
3	4.03725	96.263416	Kuala Trang	High	High
4	3.99937	96.293563	Cot Rambong	High	Moderate
5	3.89208	96.364924	Kuala Teripa	High	Moderate
6	3.91633	96.422778	Lueng Keubeu Jagat	High	Moderate
7	3.98765	96.481429	Lamie	Moderate	High
8	3.99657	96.489574	Pasar Lamie	High	High
9	3.97623	96.645671	Krueng Seumanyam	Low	Moderate
10	3.97026	96.651939	Panton Bayu	Low	Low
11	4.0206	96.561963	Alue Wakie	High	Moderate
12	4.04697	96.461682	Lamie Ateuh	High	Moderate
13	4.09569	96.401078	Tadu Raya	Moderate	Low
14	3.83291	96.584146	Seumanyam	High	High
15	3.81624	96.604714	Kuala Seumanyam	High	High
16	3.91397	96.595876	Alue Bateng Brok	High	Moderate
17	3.88288	96.504895	Alue Kruet	Moderate	Moderate
18	4.25795	96.416227	Ulee Jalan	Moderate	Low
19	4.2585	96.334022	Lhok Pange	High	High
20	4.26796	96.338805	Balang Teungku	Moderate	Moderate
21	4.28947	96.352258	Kila	Moderate	Low
22	4.27869	96.369743	Pulo Teungoh	High	High
23	4.23526	96.349738	Suak Peureubong	High	Moderate
24	4.23025	96.306779	Jeuram	High	Moderate
25	4.23423	96.304787	Pante Ceureumen	High	High
26	4.11818	96.292486	Simpang Peut	High	Moderate
27	4.21247	96.314059	Meureubo	High	Moderate
28	4.11786	96.34247	Babah Dua	Moderate	Low
29	4.06522	96.300795	Lawa Batu	High	High
30	3.93797	96.427582	Neubok Yee PP	Moderate	High
Low				2	5
Moderate				8	14
High				20	11
Total				**30**	**30**

From Table 11 above it can be seen a comparison between the results of the analysis using GIS and the reality found to show differences in data, this is because the Nagan Raya region has more hilly and mountainous landforms in addition to land use and rainfall factors, so that the coordinate data collection using a Global Positioning System (GPS) carried out at each village center. The difference between the results of the analysis with the methods and reality that has been happening in the field as shown in Table 12.

Table 12. Percentage Of Analysis Results With Actual Conditions

Flood-prone Criteria	Analysis Result	Actual condition	Deviation
Low	6.67%	16.67%	10 %
Moderate	26.67%	46.67%	20 %
High	66.67%	36.67%	30 %

Most of the floods that occurred in Nagan Raya Regency were due to overflowing watersheds. This flood occurred after a long process; the arrival of the flood was sudden and surprising. This flood is also seasonal and can last for days or weeks continuously. The cause is the landslide of areas that are usually able to withstand excess water, and flooding occurs along with the river system and its tributaries. In addition, flooding is also caused by floods in this area also caused by coastal flooding, where this flood which brings disaster from frequent rainwater overflows this is getting worse because of the influence of the tide as a result of the earth's gravity force and storms triggered by strong winds along the coast. Just like river floods, heavy rains that fall over a large geographical area will produce massive floods in coastal valleys that approach river mouths. In addition to the unavailability of adequate waterways in Nagan Raya District, flooding also occurs due to slope of the land, because the slope of the land is not steep, the flow of rainwater on the surface will not be as fast as on a steep slope; moreover, the surface of the land is bumpy, the surface water flow will decrease further, so that the chance of water seeping into the ground will be greater.

So this flood disaster mapping area really helps the local government to plan an area, then to design a flood hazard model, a model with a flood hazard method is carried out by involving three parameters, namely landform factor, land cover or land use and rainfall intensity factor. Of the three parameters after being combined in one layer which is also called the overlay process, the results of the value and weight obtained by the score, from these score values than the three layers are added up, so the score scores enter the class range as shown in Table 2. After overlaying then, producing a thematic map prone to flooding, thematic maps that have been obtained from the results of the parameter analysis can be seen in Figure 5.

By looking at the level of vulnerability classification divided into three classes with different colour vulnerability as in Figure 5. Then the grouped scores indicate the level of vulnerability. If a score of 1 to 4 is a location of vulnerability Low or not vulnerable is present in the mountains, a score of 5 to 8 is a rather vulnerable location or moderate vulnerability, and a score of 9 to 13 is an area with a high level of vulnerability, this is due to parameters that have valued big score. The results obtained after calculating the area will be displayed in Table 13 regarding the classification of flood-prone disasters in Nagan Raya district, Aceh Province. Classification of flood hazard levels from parameters that have been processed using ArGIS software, results obtained from flood hazard levels is: Low, Medium and High using parameters of rainfall, land use and land use in Naguap Raya District which consists of five Districts.
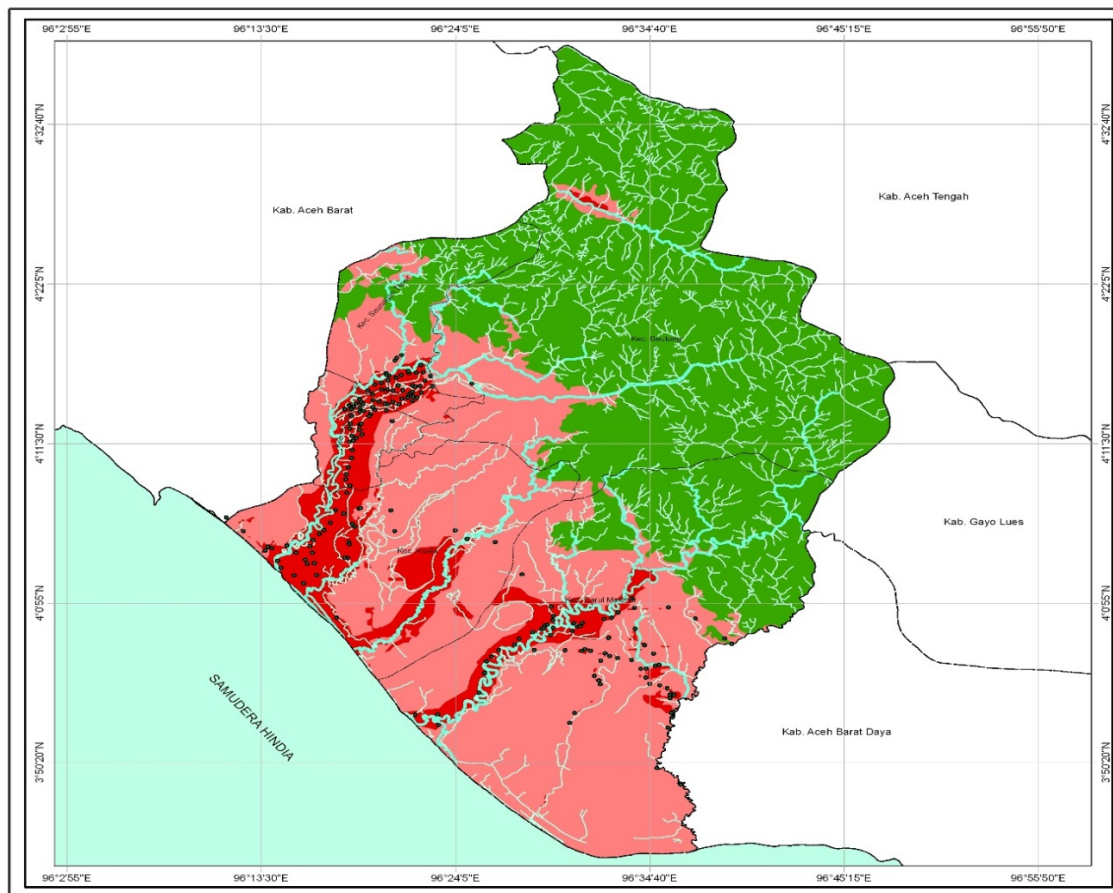
Figure 5. Classification of Flood Prone

Information:

| High | Moderate | Low |

For Beutong District with a flood affected area of 142,689.73 Ha, with a low category of 122,879.08 Ha or 86.12%, a medium category of 19,517.03 Ha or 13.68% and a high category with an area of 193.62 Ha affected or 0.21%. Darul Makmur sub-district with a flood-affected area of 121,373.91 Ha, with a low category of 34,061.31 Ha or 28.06%, a medium category of 76,915.96 Ha or 63.37% and a high category with an area of 10,396.65 Ha or 8.57%. Kuala Subdistrict with a flood affected area of 55,520.83 Ha, with a low category of 747.46 Ha or 1.35%, a medium category of 38,303.92 Ha or 68.99% and a high category with an area of 16,469.46 Ha or 29.66%. Seunagan Subdistrict with a flood affected area of 10,943.59 Ha, this area is a severe flood hazard compared to other Districts in this area, so the level of vulnerability occurs in the medium and high category, for the category of moderate level of a vulnerability is 5,343.35 Ha or 48, 83% and a high category with a total area of 5,600.24 Ha or 51.17%. And the last is East Seunagan District with a flood affected area of 25,181.58 Ha, with a low category of 11,016.85 Ha or 43.75%, a medium category of 11,629.30 Ha or 46.18% and a high category with an area of 2,535 affected area, 44 Ha or 10.07%. For more details can be seen in Table 13.

Table 13. Classification and area of flood-prone areas (Ha)

| Districts | Width (Ha) | | | | | | District Width (Ha) |
	Low	%	Moderate	%	High	%	
Beutong	122879.08	86.12	19517.03	13.68	293.62	0.21	142689.73
Darul Makmur	34061.31	28.06	76915.96	63.37	10396.65	8.57	121373.91
Kuala	747.46	1.35	38303.92	68.99	16469.46	29.66	55520.83
Seunagan	-	-	5343.35	48.83	5600.24	51.17	10943.59
Seunagan Timur	11016.85	43.75	11629.30	46.18	2535.44	10.07	25181.58
Total	**168704.69**	**47.43**	**151709.55**	**42.65**	**35295.40**	**9.92**	**355709.64**

4.2   Flood prone classification

Classification of flood hazard using the flood hazard method consists of three categories of vulnerability, namely Low, with an average area of flood affected 47.43%, Moderate 42.65% and High 9.92%. Low, the Low class indicates that the location is never flooded, this is due to steep slopes or mountainous areas and low rainfall, most of this area is vegetation/forest area. In the Low category, it shows that the level of vulnerability in this location is relatively small, even if there is no flood hazard experienced. Moderate, the Moderate category is influenced by the three factors that are the parameters in the method used. Sources obtained from residents said that the danger of flooding at the location was affected by obstructed drainage, as a result, the flow of water could not be continued in large numbers and the floods that hit this area were also caused near the mountains because rainwater falling in the mountains would flow in low places or the formation of water catchment areas that cause seasonal flooding occurs. High, in this region as the landform factor that has been presented in the map shows this area is a flood plain B. This area is close to the river flow. If the water collected by a river passes through a dike or riverbank, it is very dangerous because at any time water carried from upstream will be held in a place where drainage is severely blocked. Due to the low plains, high rainfall and landform factors, a portion of the area near the river flow will be inundated with rainwater and water brought from upstream areas will also be collected in this area, so that in this region the level of a vulnerability is high. As a result, the amount of water that cannot be contained by the river overflows and looks for lower areas around it. To avoid flooding, the local government needs to study and make plans for making permanent drainage. It also needs an appeal to the community to participate in preventing floods in the community starting from the steps of conceptualization, construction, operational-maintenance, participation in socialization activities such as building or cleaning environmental drainage channels, maintaining and monitoring environmental conditions.

5.   Conclusion

This research performed the classification of flood hazard levels in Nagan Raya Regency. It can be concluded that the results of flood hazard analysis show the level of vulnerability: high 35295.40 hectares (9.92%), moderate 151709.55 hectares (42.65%), and low 168704.69 hectares (47.43%). Flood hazard with a high category was found in Kuala Subdistrict with an area of 16469.46 hectares (29.66%) of the Subdistrict area. While the level of vulnerability with a low category was found in Beutong District with an area of 122879.08 hectares (86.12%) since some of these areas are mountainous. The study was limited to three parameters, namely rainfall factors, landform factors and land use factors. Therefore, it is

recommended that, further studies for this research using other methods with more supportive and complete parameters so that the results of the study being studied are more accurate.

Acknowledgements

References

Akhtar, N., Rehman, A., Hussnain, M., Rohail, S., Missen, M. S., Nasir, M., Hayder, A., Salamat, N., & Pasha, M. (2019). Hierarchical coloured petri-net based multi-Agent system for flood monitoring, prediction, and rescue (fmpr). *IEEE Access*, *7*, 180544–180557.

Amirioun, M. H., Aminifar, F., & Lesani, H. (2018). Towards Proactive Scheduling of Microgrids Against Extreme Floods. *IEEE Transactions on Smart Grid*, *9*(4), 3900–3902.

Amsar, Munadi, R., & Adriman, R. (2017). Seleksi Beasiswa Untuk Perguruan Tinggi Berdasarkan Pendekatan Keputusan Berkeadilan Dengan Fuzzy Mamdani. *Jurnal Inotera*, *2*(2), 1–8.

Ashourloo, D., Shahrabi, H. S., Azadbakht, M., Aghighi, H., Matkan, A. A., & Radiom, S. (2018). A Novel Automatic Method for Alfalfa Mapping Using Time Series of Landsat-8 OLI Data. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *11*(11), 4478–4487.

Danianti, R. P., & Sariffuddin, S. (2015). Tingkat Kerentanan Masyarakat Terhadap Bencana Banjir Di Perumnas Tlogosari, Kota Semarang. *Jurnal Pengembangan Kota*, *3*(2), 90-99.

Darmawan, K., Hani'ah, & Suprayogi, A. (2017). Analisis Tingkat Kerawanan Banjir Di Kabupaten Sampang Menggunakan Metode Overlay Dengan Scoring Berbasis Sistem Informasi Geografis. *Jurnal Geodesi Undip*, *6*(1), 31–40.

Darmawan, M. (2008). *Katalog Methodologi Penyusunan Peta Goe Hazard Dengan GIS*. BRR NAD-Nias.

Guzman, A., Arguello, A., Quiros-Tortos, J., & Valverde, G. (2019). Processing and correction of secondary system models in geographic information systems. *IEEE Transactions on Industrial Informatics*, *15*(6), 3482–3491.

Huda, F., Anuar, K., Syafri, S., & Susilawati, A. (2019). Pembuatan Peta Geospasial Melalui Pemetaan Udara Pada Kelurahan Batu Bersurat, Kecamatan Xiii Koto Kampar, Kabupaten Kampar, Provinsi Riau. *Dinamisia : Jurnal Pengabdian Kepada Masyarakat*, *3*(1), 76–83.

Ibrahim, M. (2016). *Wahana Lingkungan Hidup Indonesia (WALHI-ACEH)*. http://www.walhi.or.id/kampanye/bencana/banjirlongsor/banj_hil_ladgaska_11054.

Jamil, M. Z. A., Mutalib, S., rahman, S. A., & Aziz, Z. A. (2018). Classification of Paddy Weed Leaf using Neuro-Fuzzy Methods. *Malaysian Journal of Computing*, *3*(1), 54–66.

Khikmah, F., Andhika, M., Dewanto, H. D., Venuary, A., Arfiansyah, M. F., Fauziah, W. N., Raharja, M. A. E., & Hidayati, I. N. (2017). Evaluation of spatial and regional planning map using remote sensing and GIS in East Lombok Indonesia. *Proceeding - 2017 3rd International Conference on Science and Technology-Computer, ICST 2017*, 61–65.

Kumalasari, N. R. (2014). Kapasitas Adaptasi terhadap Kerentanan dan Bencana Perubahan Iklim di Tambak Lorok Kelurahan Tanjung Mas Semarang. *Jurnal Pembangunan Wilayah & Kota*, *10*(4), 476–487.

Landuyt, L., Van Wesemael, A., Schumann, G. J. P., Hostache, R., Verhoest, N. E. C., & Van Coillie, F. M. B. (2019). Flood Mapping Based on Synthetic Aperture Radar: An Assessment of Established Approaches. *IEEE Transactions on Geoscience and Remote Sensing*, *57*(2), 722–739.

Li, L., Chen, Y., Xu, T., Shi, K., Huang, C., Liu, R., Lu, B., & Meng, L. (2019). Enhanced Super-Resolution Mapping of Urban Floods Based on the Fusion of Support Vector Machine and General Regression Neural Network. *IEEE Geoscience and Remote Sensing Letters*, *16*(8), 1269–1273.

Nogueira, K., Fadel, S. G., Dourado, I. C., De Werneck, R. O., Munoz, J. A. V., Penatti, O. A. B., Calumby, R. T., Li, L. T., Dos Santos, J. A., & Torres, R. D. S. (2018). Exploiting ConvNet diversity for flooding identification. *IEEE Geoscience and Remote Sensing Letters*, *15*(9), 1446–1450.

Nugroho, A., & Kusuma, W. A. (2018). Sistem Informasi Geografis Pemetaan Lokasi Bird Contest Kota Malang Berbasis Android. *SISTEMASI*, *7*(3), 212–219.

Ohki, M., Tadono, T., Itoh, T., Ishii, K., Yamanokuchi, T., Watanabe, M., & Shimada, M. (2019). Flood area detection using PALSAR-2 amplitude and coherence data: The case of the 2015 heavy rainfall in Japan. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *12*(7), 2288–2298.

Peterson, D., & Storz, M. (2017). Group Orbits of GPS Satellite Configurations for Constellation Management. Journal of Mathematics and System Science, 7, 1-13.

Pradhan, B., Tehrany, M. S., & Jebur, M. N. (2016). A New Semiautomated Detection Mapping of Flood Extent from TerraSAR-X Satellite Image Using Rule-Based Classification and Taguchi Optimization Techniques. *IEEE Transactions on Geoscience and Remote Sensing*, *54*(7), 4331–4342.

Raya, N. (2017). *web Nagan raya*. Kabupaten Nagan Raya. http://bappeda.naganrayakab.go.id/index.php/site/demografi.

Setiadi, T. (2013). Perancangan Sistem Informasi Geografis Pemetaan Daerah Rawan Tanah Longsor, Mitigasi Dan Manajemen Bencana Di Kabupaten Banjarnegara. *Jurnal*

Kesehatan Masyarakat (Journal of Public Health), *7*(1), 33–42.

Setiawan, A., & Sediyono, E. (2018). A new determination of regional area by utilizing rectangular approach method and google maps. *Proceedings - 2017 2nd International Conferences on Information Technology, Information Systems and Electrical Engineering, ICITISEE 2017*, *2018–Janua*, 417–420.

Suharyanto, A. (2014). Prediksi titik banjir berdasarkan kondisi geometri sungai. *Jurnal Rekayasa Sipil*, *8*(3), 229–238.

Supardi, N. (2014). Kehadiran Peta Model " T-O " dalam Sejarah Peta Dunia. *Jurnal Museum Nasional*, *2*(1), 105–117.

Ujang, A. T., Nugraha, A. L., & Firdaus, H. S. (2019). Kajian Pemetaan Risiko Bencana Banjir Kota Semarang Dengan Menggunakan Sistem Informasi Geografis. *Jurnal Geodesi Undip*, *8*(4), 154–164.

Valdika, R. rahmad, Nugraha, A. L., & Firdaus, H. S. (2019). Analisis ancaman multi bencana di Kabupaten Kendal Berbasis Fuzzy Analytic Hierarchy Process. *Jurnal Geodesi Undip*, *8*(1), 133–140.

Ya'u, B. I., Nordin, A., & Salleh, N. (2018). Meta-Modeling Constructs for Requirements Reuse (RR): Software Requirements Patterns, Variability and Traceability. *Malaysian Journal of Computing*, *3*(2), 119–137.