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To cite this article: Ahmad Arselan Rambe and Iqbal Putut Ash Shidiq 2019 IOP Conf. Ser.: Earth Environ. Sci. 338 012037

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A Study of Anticipating the Flood Hazard in Agricultural Areas in Ular Watershed by Using Geospatial Approach

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ABSTRACT. Indonesia is a country which is extremely vulnerable to the natural disasters, one of which is Indonesia is a country vulnerable to various natural disasters such as flood. Flood in a coastal area can cause plant damages and increase of plant diseases. Flood is potential to disrupt the food security because the production of crops decreases due to the damages to agricultural and fishery areas. Therefore, it is necessary to make some efforts to develop the anticipationability to face flood in order to reduce the flood impacts. This research is a descriptive quantitative encompassing the analysis of potentials of flood hazard in the agricultural areas and the implementation of forms of anticipation in the agricultural areas which are vulnerable to flood hazard. The mapping of distribution areas that are vulnerable to flood hazard in Ular watershed by utilizing the technology of Geographic Information System through the overlay method for rainfall, geomorphologic, land use, and flood mappings. According to the research results, The area with high flood vulnerability class is 1,105.56 ha The anticipation efforts which the farmers have carried out are: (1) building some dams and embankments along the borderline of the Ular River, (2) selecting the types of plants and patterns of planting, and (3) preparing some budget to anticipate the damage due to flood. The effort that has been done to anticipate the flood, is pay Agricultural Insurance preimium of Rp. 50.000, - per hectare, where with the sum insured price of Rp.6.000.000, - per hectare, then the cost of compensation to be prepared by the government is Rp. 6,630.000.000,00 per planting season.

1. Introduction

Flood hazard is defined as a situation where the flow or extreme water level occurred on rivers, lakes, reservoirs and other water bodies. The water floods the land area outside the water bodies. Flood hazard can also occur when the sea level rises extremely or above the coastal plain caused by tides and high waves. Flood hazard is one of the natural phenomena which causes people to lose their lives and property and even affect the social and economic conditions of society [1].

Flood hazard in the coastal areas is a natural phenomenon that will always happen constantly, because coastal area is a lowland area which is always inundated either by tides or rain. Meanwhile, coastal areas also experience changes in land use that is it becomes rapidly a densely populated residential areas, agricultural areas, industrial centers, and even the central government. Therefore, efforts are needed to reduce the risks which may be caused.
Vulnerability and risk assessment of an area against floods as part of disaster mitigation needs to be done to recognize the physical and social characteristics [2].

According to data from the flood events of the Agriculture Department of North Sumatra Province (2011) [3], the wide of the farm area located on the Ular Watershed (DAS) affected by the flood is 506 hectares. The location of flood events that are in Kecamatan Pantai Labu and Kecamatan Beringin (Deli Serdang) covering an area of 490 hectares, and Kecamatan Pantai Cermin (Serdang Bedagai) covering an area of 16 hectares. Flood events happened in January and November 2007 in Kecamatan Pantai Labu, in August 2010 in Kecamatan Beringin, and in July and August 2010 at Kecamatan Pantai Cermin.

The continuous flood hazard is the result (resulting) from the damage system in this case is a watershed (DAS). Experience has shown, in anticipation of flood hazard and inundation by the government, as long as these are not enough without the support of the public role. Instead, people are not able to overcome the problem of flooding and inundation. Required intact and transparent planning by involving community leaders, NGOs, universities, and research institutions in order to obtain a comprehensive input (Kementan, 2011)

2. Materials and Methods
The data used in this study include base maps, Thematic Map and climatology data (rainfall) acquired from the government institutions who have the data, as the following:

1. Administrative Map Regency / City from Bapeda Regency / City.
2. Digital Topographic Map of Sumatra, including the Ular watershed obtained from BIG.
3. Boundaries of ULAR watershed Map obtained from BPDAS Wampu Sei Ular.
4. Image Digital Elevation Model (DEM) / SRTM (Shuttle Radar Topographic Mission) obtained from http://www.srtm.cgiar.org.
5. Geological map obtained from Distamben SUMUT.
6. Map of Land Forms obtained from Distamben SUMUT.
7. Land Cover Map and Paddy field Map processed from the Landsat 8 in 2013 obtained from BAPPEDA SUMUT.
8. Climatological data (Rainfall) obtained from BMKG - Sampali Climatology Station.
9. Genesis Flood Map obtained from the the Department of Agriculture of North Sumatra Province.

Flood vulnerability Map is determined based on the analysis of spatial data including historical data of ponding, land covering, the average of annual rainfall, and geomorphology especially slope and contour (elevation point). Overlay from the five data which have been specified level of vulnerability assessment are then classified into 4 classes of flood vulnerability, that is the high, medium, low, and safe vulnerability. Data regarding the anticipation are obtained from the field observations and interviews with the locals in the research area. The technique used is purposive random sampling where the criteria on the sample is the Chairman of Farmers Group from the agricultural land area affected by the flood.

3. Results and Discussion
3.1 Geomorphology
Geomorphology Classification of the research area is divided into three classes, namely (1) the slope <2% and a height of <100 m, (2) slope <2% and a height of> 100 m, and (3) the slope> 2% and a height of> 100 m , the most dominant of Geomorphology region is the region with a slope classification > 2% and a height of> 100 m, with an area of 104,988.39 hectares or 80.26 from Ular watershed area. Geomorlogy region with a slope classification <2% and a height of
<100 m an area of 25322.55 hectares or 19.36% from the area of Ular watershed. Whereas Geomorlgy region with a slope classification <2% and a height of >100 m to be the smallest area, namely, 503.87 hectares or 0.39 from Ular watershed area. Area coverage of geomorphology classification of Ular watershed can be seen in Table 1.

| Slope and height | Score | Large (Ha) | Percentage (%) |
|------------------|-------|------------|----------------|
| < 2 % dan h < 100 m | 2 | 25,322.55 | 19.36 |
| < 2% dan h > 100 m | 1 | 503.87 | 0.39 |
| > 2% dan h > 100 m | 0 | 104,988.39 | 80.26 |
| **Total** | | **130,814.81** | **100.00** |

3.2 Rainfall
Rainfall data are obtained from the average of annual rainfall data in the Ular Watershed within the period of 10 years derived from the Meteorology, Climatology and Geophysics Station Sampali Medan. The usage of the latest 10 year data is chosen with the assumption that the rainfall changes in the latest 10 years are not so significant that they could be used as a reference. The rainfall data used are the rainfall data of three rain gauge stations, that is Jaharum, Pagar Merbau and Tingga Runggu. The average of annual rainfall in Ular watershed is 2500-3500 mm/year. For more details, wide distribution and the percentage of rainfall of Ular watershed (DAS) can be seen in Table 2.

| No | Rainfall/year (mm/year) | Score | Large (Ha) | Percentage (%) |
|----|------------------------|-------|------------|----------------|
| 1  | 2.500 – 3000           | 3     | 78,793,62  | 60.23          |
| 2  | 3.000 – 3.500          | 4     | 52,021,20  | 39.77          |
| **Total** | | **130,814.82** | **100.00** |

Source: BMKG SUMUT, 2006 – 2015

3.3 Land Use
Ular watershed is divided into ten groups of land use, that is: Primary forest, secondary forest, gardens, fields, plantations, settlements, Paddy Field, Shrublands, ponds and Vacant Land. The land use of Ular watershed is dominated by gardens. Area of garden soil usage is 50568.08 hectares or 38.66% of the area of the Ular watershed. Extensive coverage of land use of Ular watershed can be seen in Table 3.
3.4 Genesis of Flood

Genesis of Flood Data obtained from the North Sumatra Natural Disaster Risk Flood and Drought Map, published by the Department of Agriculture of North Sumatra Province. Based on the data acquired, Ular Watershed are categorized into areas that often flood, covering 375,70 hectares or 0.29% of Ular watershed area. Prone to ponding is an area of 3463.64 hectares or 2.65% of Ular watershed area. While the most dominant region is the area that did not experience flood events, namely an area of 126,975.48 hectares or 97.07% of Ular watershed area. Extensive coverage and the percentage of flood incidence in Ular watershed can be seen in Table 4.

| Land Use       | Score | Large (Ha) | Percentage (%) |
|----------------|-------|------------|----------------|
| Primary forest | 1     | 54,82      | 0.04           |
| Secondary forest | 1   | 28,849,10  | 22.05          |
| Gardens        | 4     | 50,568,08  | 38.66          |
| Fields         | 3     | 19,630,17  | 15.01          |
| Plantations    | 4     | 7,281,45   | 5.57           |
| Settlements    | 5     | 11,844,18  | 9.05           |
| Paddy Field    | 4     | 2,702,65   | 2.07           |
| Shrubland      | 2     | 9,147,08   | 6.99           |
| Ponds          | 4     | 339,83     | 0.26           |
| Vacant Land    | 2     | 397,45     | 0.30           |
| **Total**      |       | **130,814,82** | 100.00     |

| Genesis of Flood | Score | Large (Ha) | Percentage (%) |
|------------------|-------|------------|----------------|
| Often flood      | 2     | 375,70     | 0.29           |
| Prone to ponding | 1     | 3,463,64   | 2.65           |
| No flooding      | 0     | 126,975,48 | 97.07          |
| **Total**        |       | **130,814,82** | 100.00     |

3.5 Agricultural areas

If the area of agricultural areas on Ular watershed is observed, it can be seen that the region of SUB DAS Ular Hilir has the most extensive agricultural areas, namely covering an area of 9050.02 hectares or 89.76% of the agricultural areas available on Ular watershed area. While the agricultural areas of SUB DA Bah Banai has the least area of agricultural areas, namely an area of 9.24 hectares, or 0.09% of the agricultural areas available on Ular watershed. SUB DAS Buaya has agricultural areas of 830.03 hectares or 8.23% of the agricultural areas available on Ular watershed. SUB DA Bah Karai has agricultural areas of 192.93 hectares or 1.91% of the agricultural areas available on Ular watershed.
3.6 Flood vulnerability Class on Agricultural areas
Overlay results produce the most dominant flood vulnerability class on agricultural areas is the moderate flood vulnerability class with the area of 7,797.16 ha (79.63%). The area with high flood vulnerability class is 1,105.56 ha (11.29%). The low flood vulnerability class covers 855.96 ha (8.74%), and the safe vulnerability class of the agricultural area covers the area of 33.30 ha (0.34%). The results are presented in Table 5 and Figure 1.

![Figure 1. The Flood Vulnerability on Agriculture Area](image)

Table 5. The class vulnerability of flood on agricultural area Ular watershed

| Kecamatan    | Safe | Low     | Moderate | high     | Total (Ha) |
|--------------|------|---------|----------|----------|------------|
| BANGUN PURBA | 1.52 |         |          |          | 1,52       |
| BERINGIN     | 15.76| 627.54  | 231.26   |          | 874.56     |
| DOLOK SILAU  | 19.35| 1.14    |          |          | 20.49      |
| GALANG       | 8.47 | 195.63  | 96.80    |          | 300.90     |
| GUNUNG MERIAH| 58.76| 250.61  |          |          | 309.37     |
| KOTARIH      | 56.82| 0.65    |          |          | 57.47      |
| LUBUK PAKAM  |       | 393.52  |          |          | 393.52     |
| PAGAR MERBAU |       | 1.858.35|          |          | 1.858.35   |
| PANTAI CERMIN| 12.20| 1.876.15| 236.88   |          | 2.125.24   |
| PANTAI LABU  | 94.80| 531.88  |          |          | 626.68     |
| PEGAJAHAN    | 31.96| 104.53  |          |          | 136.48     |
| PERBAUNGAN   | 24.68| 1.934.22| 540.62   |          | 2.499.52   |
| PURBA        | 1.29 | 0.89    |          |          | 2.19       |
| RAYA         | 32.01| 158.73  |          |          | 190.74     |
| SERBA JADI   |       | 0.30    |          |          | 0.30       |
| SILINDA      | 282.14| 22.64  |          |          | 304.78     |
| STM HULU     | 89.87|        |          |          | 89.87      |
| **Total**    | 33.30| 855.96  | 7.797.16 | 1.105.56 | 9.791.98   |
3.7 Anticipation Against Flood
The farmers have realized that the areas where they reside and cultivate are vulnerable to flood. Some of the anticipation efforts which the farmers have carried out are:
1. building some dams and embankments along the borderline of the Ular River,
2. selecting the types of plants and patterns of planting, and
3. preparing some budget to anticipate the damage due to flood.

Besides, anticipations against flood which can be done in an effort to anticipate flood doing the Agricultural Insurance. Funds are collected every time the harvest by depositing it to the farmer group treasurer. Funds deposited amounting to Rp. 2,000 for each rante (one rante of 400 m² equals IDR 50,000 per hectare). Compared with the impacts, the contributions collected by farmers are not sufficient to be used as compensation costs if the farmland is puso.

The government in this case helps to seek farm protection to overcome the loss of farmers in the form of agricultural insurance. In Rice Farm Insurance, the coverage is set at Rp.6,000,000, - per hectare per planting season with the amount of premium aid from the government Rp.144,000, - / ha / MT and self-supporting farmers Rp.36,000, - / ha / Directorate of Agricultural Financing, 2016)[4]. So, if the agricultural land with high level of vulnerability in DAS Ular is flooded and puso, then the compensation cost that must be prepared by the government is Rp. 6,000,000 x 1,105.56 ha = Rp. 6,630,000,000,00 per planting season.

4. Conclusion
Agricultural areas with high flood-vulnerability include coastal regions and estuarine, flood plain area, and the river border area. Its location is at Kecamatan Beringin, Kecamatan Galang, Kecamatan Pantai Cermin, and Kecamatan Perbaungan. The most dominant flood vulnerability class on agricultural areas is the moderate flood vulnerability class with the area of 7,797.16 ha (79.63%). The area with high flood vulnerability class is 1,105.56 ha (11.29%). The low flood vulnerability class covers 855.96 ha (8.74%), and the safe vulnerability class of the agricultural area covers the area of 33.30 ha (0.34%). The farmers have realized that the areas where they reside and cultivate are vulnerable to flood. Some of the anticipation efforts which the farmers have carried out are:
1. building some dams and embankments along the borderline of the Ular River,
2. selecting the types of plants and patterns of planting, and
3. preparing some budget to anticipate the damage due to flood.

5. Suggestion
Similar research is necessary to do in another area in order to obtain a comprehensive understanding of flood-related factors and the anticipation made. There is a need for development of agricultural commodities cultivation which are resistant to puddle, so that the use of agricultural area can continue to be maximized. Anticipation which has been applied in the research area could be reviewed in greater depth in order to obtain a thorough knowledge so that it can be used by people who have similar problems in other areas.

6. References
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