

The Mapping of Flood Prone Areas for Development of Settlement

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ABSTRACT

This study aims to map flood-prone areas for settlement development. The analysis unit is a district that belongs to the area that is flood prone. The determination of the sample is based on the level of flood vulnerability using stratified sampling technique. The results showed that the researched areas are mostly prone to flood. A secure location for settlement should utilize the land in accordance with the criteria which is safe and appropriate with the layout. Low-prone areas and are not prone can be used for the allocation of space development of settlement areas in order to be safe from flood.

Key words: mapping, prone, flood, and settlement development

INTRODUCTION

Flood, globally, has occurred in the past and repeatedly (Nijland, 2005). Flood is predicted to be more frequent in the future due to rising of sea levels, climate change, and land subsidence (UN-Habitat 2009). The impact of flood is getting serious from time to time (Munich R, 2005). The impacts of flood can be viewed from two perspectives: those are human safety and property damage (Purwandari et al, 2011) and the examples of flood impacts are the loss of life or injury, loss of property, settlement damage, trade area damage, industry, agricultural land damage, drainage and irrigation system damage, road damage, bridge, and airport, telecommunications system damage, etc. (Kodoatie and Syarief, 2006; Septriyadi et al, 2013; Widiarto et al, 2014). Consequently, the agriculture in the flood area holds ecological, economic and important social (Deka et al, 2010).

The developing countries compared to developed countries if affected by natural disasters such as floods will undergo

the impact more (Hochrainer 2006 quoted Kahn, 2005). Indonesia as one of developing country is facing one of the complex problems now because of the impacts that threaten the existence of the city and its inhabitants toward flood (Rosyidie, 2013). Flood is natural disaster whose effects can be avoided when the human do not destroy the nature (Choirul, 2009). The people's ability to cope with the flood impact are related to the capacity and endurance of the community itself (Marschiavelli 2008; Damayanti et al, 2011). It means that their participation also has significant effect on controlling the flood impact (Wesli et al, 2013).

Flood occurs at every beginning of rainy season and becomes a routine problem faced by the people who live in the river flow area (Santoso, 2013) as the case that happened in Barabai sub-district, Hulu Sungai Tengah. Barabai has a narrow area with a large enough population and becomes the area with the highest population density in Hulu Sungai Tengah (Kumalawati, 2015) (see Table 1). The factor that affect Barabai becomes the area with the highest population density in Hulu Sungai Tengah is such city as the central of government that is related to easy accessibility, complete facilities and infrastructure to attract people to settle there (Kumalawati et al, 2015).

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Table 1. Population Density in Barabai,Hulu Sungai Tengah Regency

Subdistrict	Width (km ²)	Population Density (Person/Km ²)			
		2011	2012	2013	2014
Haruyan	148.63	138.00	138.54	142.01	142.73
Bt. Benawa	99.00	185.00	186.56	191.24	192.77
Hantakan	191.98	61.00	61.03	62.57	62.88
Batang Alai Selatan	189.80	115.00	115.96	118.87	119.07
Batang Alai Timur	247.94	28.00	28.36	29.07	30.25
Barabai	40.72	105.00	2155.96	2210.30	2274.85
Lab. Amasselatan	86.54	303.00	305.15	312.87	314.85
Lab. Amas Utara	161.81	169.00	169.83	174.12	175.87
Pandawan	144.24	213.00	214.55	219.97	217.17
Bau	70.00	247.00	248.44	254.67	257.33
Limpasu	77.49	127.00	127.44	130.70	135.02
Total	1458.15	169.00	169.83	174.11	176.05

Source: BPS Hulu Sungai Tengah 2011-2014 and Calculation Results, 2015

Flood that occurred in Barabai subdistricts of Hulu Sungai Tengah Regency could distract the economic activity (Kumalawati, 2015; BPS, 2014). Flood occurs in areas with high population density periodically without a good drainage system will create a big problem and consequently cause a risk to the population (Sakijege, 2013). Furthermore, it becomes a threat to the existence of settlements and will affect all activities and humans' life that inhabit these settlements (Kumalawati et al, 2015). The development of exist settlements becomes obstructed and human interaction with the surrounding environment becomes disrupted. In this phase, the information about catastrophe events and the risks are very important (Syukril et al, 2011).

Based on the background above, the people who live in flood areas have high level of insecurity and vulnerability. One effort that can be done to reduce the insecurity and the vulnerability of the population against flood in the future is by conducting the research entitled "Mapping Flood Prone Areas for Development of Settlements". The purpose of the research is to map the flood prone areas and evaluation of settlement development.

METHODS

Generally this study can be divided into three stages; the preparatory stage, the field survey stage and the process and analysis stage (Kumalawati et al, 2012; Kumalawati et al, 2013). The field research was conducted in Barabai subdistricts of Hulu Sungai Tengah regency, South Kalimantan. The determination of the sample was based on the level of flood vulnerability using stratified sampling technique. The main data were collected using a questionnaire and interview. The questionnaires were distributed based on households in each level of vulnerability. The secondary data was collected to obtain information related to flood and physical conditions in the study area. Secondary data was taken from previous research report (Bappeda, PU, and Kesbangpollinmas), statistics (BPS), and previous researches.

The stages of data process and analysis include the analysis of primary and secondary data. The data collected were processed and analyzed using statistical tools, *Arc View* and *Arc GIS*. *Arc View* and *Arc GIS* proved to be an effective and efficient tool to produce maps (Ward PJ et al, 2011; Marfai 2011; Kumalawati, 2015). Data analyses are:

Analysis of the Flood Vulnerability Level Mapping

The factors that influence the mapping of vulnerability level of one area to the hazards that threaten include geographic situation, hazard elements pattern and distribution, hazard element sensitivity, special geomorphology place or location (Bacharudin and Wirakusumah, 1998). The data used to build the mapping of flood vulnerability is based on four factors that influence vulnerability those are Flood Hazard Level Map, House Map and Slope Map. The classifications of disaster-prone areas are obtained from the accumulated weight classification (Kumalawati, 2014; Kumalawati et al, 2015). The decreasing in accumulated weight is done based on weight criteria matrix. The Vulnerability level mapping results indicate that there are four areas of high, medium, and low vulnerability and also invulnerable.

Evaluation of Settlement Development

The evaluation of Settlement Development is done by adjusting the RTRW (Region Spatial Planning) by adding knowledge aspect

about disasters in existing spatial plan. The flood prone mapping is done for the region that has been built and are planned to be built in the future. The region that has been built to be hazard maps should be made to identify the areas of the building structure, and infrastructure need to be strengthened in order to withstand disasters. The area that is planned for the construction of the new settlement area should include the hazard factors and flood.

RESULTS AND DISCUSSION

Flood Vulnerability Map Flood Hazard Level Map

The identification of flood hazard zone is required hazard areamapping with the approach of physical condition characteristics (Adi, 2013). The hazard level map represents the pattern and distribution of hazard elements (Bacharudin and Wirakusumah, 1998). The determination of hazard areas is done by overlaying a map of river buffer, the frequency of flood, the flood elevation, and land use map. Land Use Classification use the basic of Meijerink, 1970. The overlay result is known the most extensive high hazard area (45.42%) of the entire study area (Table 2).

Tabel 2. Hazard Level of Barabai Subdistrict, Hulu Sungai Tengah Regency

No.	Hazard Level	Width (Km ²)	%
1	High	18.49	45.42
2	Medium	7.70	18.91
3	Low	6.72	16.49
4	Not hazardous	7.81	19.18
	Total	40.72	100.00

Source: Primary Data, Analysis and Processing Flood Hazard Level Map, 2015

The area which is not flood hazard of low hazard flood can be used for evacuation or for referrals to settlement for residents who live in areas of high flood hazard and medium flood hazard (Kumalawati et al, 2012; Kumalawati et al, 2013; Kumalawati, 2015). Furthermore, it is needed to do the idea of socialization and to improve the society's capacity so that they are able to manage the risks, such as able to cope with disasters,

reduce the impact and ready to avoid the risks (Susanto, 2010). Spengler (2001) states that the risk management should be applied and developed and is one of the preventive step in aquatic activities. Precaution is taken to minimize the possibility of a more severe risk such as death, especially in hazard area and flood prone.

Map of Building Blocks (Home)

Building block map (house) represents the geographic situation of hazard element (Bacharudin and Wirakusumah, 1998). Settlement is one of the human's basic needs (Hakim, 2009; Kumalawati, 2015). The healthy and livable settlement is the right of every human being, but the thing is not fulfilled after the flood. Many houses were damaged because of the flood, damaged sanitation, hard access of clean water causing the bad and health of a settlement (Kodoatie and Syarief, 2006; Rosyidie, 2013; BNPB, 2013; Numandei, 2014). The previous place of residence which is considered safe from disaster brings the unexpected impacts such as in Barabai subdistrict.

Along the river in Barabai subdistrict is functioned as densely populated settlement, and categorized as a flood hazard area (see Table 3). (Kumalawati et al, 2015). The

population which is quite dense along the river in Barabai subdistrict causing new problem during flood such as the damage of settlements. The residents' settlement along the river in Barabai subdistrict can be obtained from the interpretation of high-resolution image.

Overall, the number of houses in the area which is not harmful is as much as 183 houses or 1.19% of total houses in the study area. The area which is not hazardous is far from the source of the disaster. The total of houses which is located in a high hazard level are 10 766 (70.02%). High hazard area can be wider if the flood occurs with greater strength. The map of the house at any level of flood hazards in the study area can be used to determine the mitigation effort that will be done to minimize the impact and risk of flood. Smith and Petley (2009) and Kumalawati (2015) the reduction of impact and risk can be done through the protection of pre- and post-disaster recovery.

Tabel 3. The Total of Houses at Every Flood Hazard Level in Study Area

No.	Flood Hazard Level	The Total of Houses	%
1	High	10766	70.02
2	Medium	2176	14.15
3	Low	2250	14.63
4	Not hazardous	183	1.19
	Total	15375	100

Source: Data Primer, 2015; Image Interpretation, 2015; RBI maps Indonesia, 2001; and Flood Hazard Level Map, 2015

Slope Map

The slope represents the place or special geomorphology situation (Bacharudin and Wirakusumah, 1998). The flat areas will be

more prone to flood due to the flow stream will tend to overflow towards the lower region (Kodoatie and Sugiyanto, 2002; Kusumadewi et al, 2012).

Tabel 4. Slope Map and The Number of Houses in Study Area

No.	Slope (%)	Total of Houses	%
1	< 8	7122	46.32
2	8-15	7124	46.33
3	16-25	1025	6.67
4	>25	104	0.68
	Total	15375	100

Source: Chow, 1984 with writer's modifications

Flood flow has an energy force that is strong enough, and then the flood flow can damage the houses building around. The flood flow that occurred in the study area has overflowed from the main river channels. The flow of existing flood damage and soak settlement building (houses) in its path because of most of the settlements were in the flat area (see Table 4).

Map overlaying usingSIG and SIG Result Process Map

Overlaying map is one of the facilities of SIG software to analyze the spatial (Sigit et al, 2011; Kumalawati, 2015). Overlaying process is a process of overlaying thematic maps which is analyzed based on the weight of each theme (Prasad 2009; Sigit et al, 2011). Based on the accumulated weight, then the

final results of the process will be a map that contains a mosaic map which has a weight. The weights are then combined and delineated based on a predetermined weight range. The thematic maps that have been prepared in this study then will be entered the value of its weight and overlaid one by one.

Thematic map that will be overlaid to be a map of the flood hazard level is 1) map of the flood hazard level represents patterns and distribution of the hazard element, 2) map of the house represents the geographic situation of hazard element, and 3) Slope Map, represents a place or special geomorphology situation. Once the entire process has been done, then it will be obtained the map of flood hazard level (see Table 5 and Figure 1).

Tabel 5. Map of Houses' Numbers in Every Level of Vulnerability in Study Area

No.	Flood Prone Level	The Number of Houses	%
1	High	10684	69.49
2	Medium	2584	16.81
3	Low	2000	13.01
4	Invulnerable	107	0.70
	Total	15375	100

Source: Results of Field Measurements and Processing, 2015

A quite big flood happened in Hulu Sungai Tengah. Hulu Sungai Tengah is several times affected by the flood, and it is proved that the Hulu Sungai Tengah is categorized included on flood-prone areas. The worst-affected region in Hulu Sungai Tengah is in Barabai subdistrict (Kumalawati et al, 2015; Kumalawati, 2015). All regions in the Barabai subdistrict are prone to flood whether the High Prone, Medium Prone, Low Prone and Not Prone (see Table 5 and Figure 1). The villages which are most severely affected by the flood in Barabai subdistrict are North Barabai village, South Barabai village, East Barabai village, Barabai Darat village, Pajukungan and Bukat villages.

Evaluation of Settlement in Flood Prone Areas

The evaluation of settlement development in flood prone areas are indispensable because a place to stay is one of the basic human needs (Hakim, 2009). Flood-prone areas need the laws of the government for the construction of settlements and it is forbid to let the settlement is rebuilt in areas that have high or medium levels of flood vulnerability; legislation is in Law No. 1 of 2011 and Law No. 24 of 1992. The orientation that is used by governments to improve the institutional role in the construction of settlements is Law No. 1 of 2011 on Housing and Settlement Region. The Law states that the settlements are part of the environment outside of the protected forest area, either in the form of an

urban area or rural area that functioned as a living environment or residential environment and the activities that support life and livelihood. Each functional developed area

requires residential areas to accommodate the population growth which continues to increase (Mononimbar, 2014).

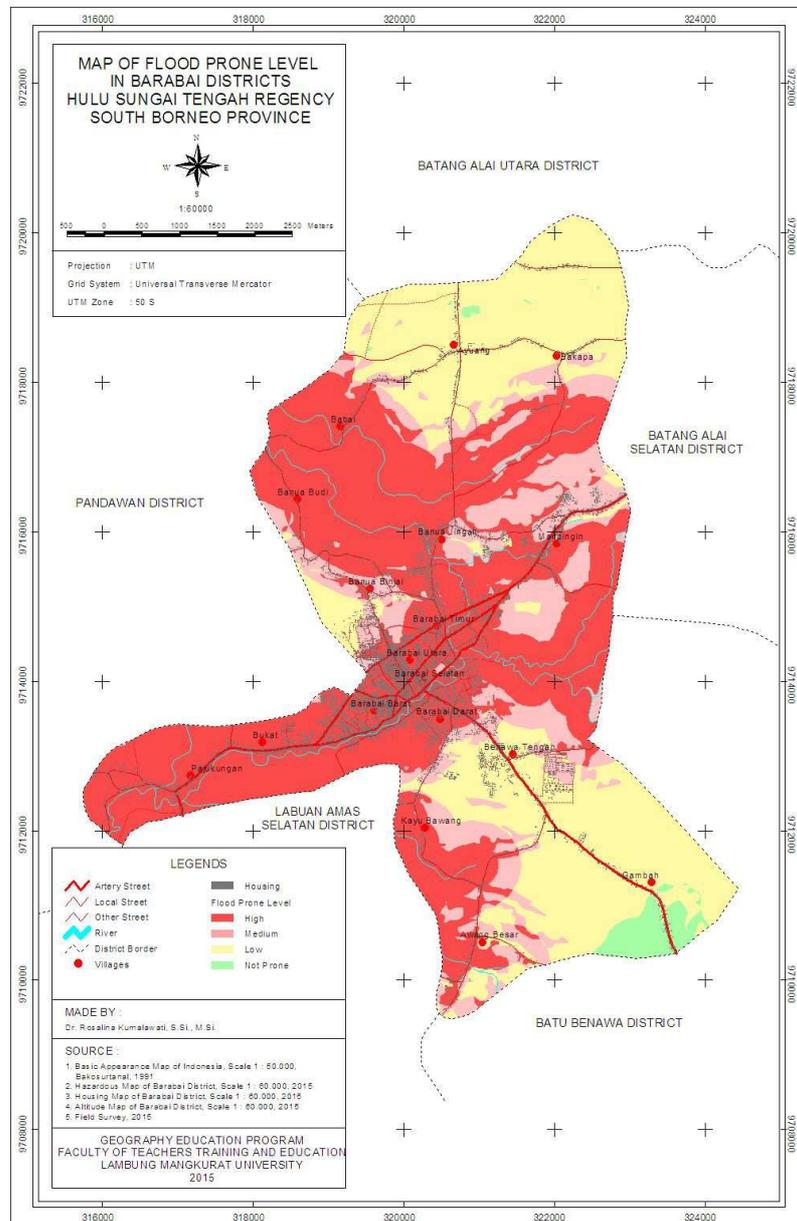


Figure 1. Map of Flood Prone Level in Study Areas

The manifestation of a mitigated and adaptive settlement requires a comprehensive policy intervention, especially in flood prone areas. The issues related to space in Indonesia has been regulated in Law No. 26 of 2007 on Spatial Planning (Tondobala, 2011). The Intervention on the disaster problem is accommodated in the planning stages,

utilization and control of space. The perspective shows that the problem of disaster requires an arrangement or careful, focused and integrated planning as well as on PERKA BNPB 4, 2008 (Hutabarat, 2008).

Post-flood, plans and patterns of utilization of space which is relatively safe from the possibility of a similar disaster had been

prepared by the central or local governments. Currently, the government is in there vision arrangement step of the RTRW Hulu Sungai Tengah regency 2010 - 2030 which is listed in local regulation (Perda) No. 5 of 2011. The plans and spatial development prioritize to ensure the attachment and consistency between planning, budgeting, and controlling as well as the public has a right to be involved to give oral and written input into development planning arrangement through aspiration. Plan and spatial utilization of post disaster in Hulu Sungai Tengah both macro and micro refers to the rule of spatial utilization that the use of space for the cultural region and non-cultivation region and supported by utilization of disaster mitigation space.

The pattern of spatial utilization that occurred in Hulu Sungai Tengah regency, particularly in Barabai sub-districts can be seen by the development of settlement area that occurred in some areas affected by the flood or physical damage. The development of settlement areas can be seen from the image map and the result of land use. The area with the highest population density is the primary focus of its spatial planning, especially, if the area has a high population density and are located in areas of high and medium vulnerability. Consequences of the existing plan not is implemented due to the unaccomplished of the data collection of plot boundaries of individual property; the destruction of agricultural cultivation areas will lead to changes in land use that is out of control because it happened in the temporary shelter areas of. It can be seen in the study that the area of temporary housing or shelter is still located around high and medium prone areas.

The development of settlement areas gets priority in determining the land use. The development of settlement areas is to anticipate the population growth and dismissed the tendency of land use which only focuses on the settlements that already exist. As a result, the area is difficult to develop because it is far from adequate facility and infrastructure. Post-flood, in fact

the evaluation is needed for the settlement development by considering some criteria such as physical criteria. Physical criterion is required for the construction of the settlement area which is far from the river, slope, and an area which lies in the low hazard or no hazard, and gooderodibility, free from flood or water puddles. According to the General Directorate of Spatial Planning (2003) in Hartono (2015) the great terms of slope that is recommended for housing / settlements with maximum slope (20-25%). Most study areas of settlements (99.32%) are on the slope below 20-25% so it is still suitable for housing / settlements.

Based on the map of vulnerability level that has been generated, it can be seen the safest location to build settlements (see Figure 1). The safe location for settlement should utilize the land in accordance with the settlement's criteria which are safe and appropriate spatial. By knowing the condition of land use in study area as well as the vulnerability map of in the study area, it can be known the right direction of the settlement. If the whole area get flood, the region with low vulnerability and not vulnerable should be selected for the location of the evacuation. The allocation of the settlement is also placed in areas that have a low vulnerability and not vulnerable according to vulnerability maps that have been created. It is to avoid the worst impact that would be caused by the flood in the study area.

CONCLUSIONS

1. The results of the flood prone mapping in the study area of research shows that most of the study areas are flood prone;
2. The main focus of spatial planning lies in an area with a high and medium level of floodprone; it is related with the determination of a safe location for residential development;
3. The safe location for residential use the land is in accordance with the criteria of a safe and appropriate spatial for settlement, low prone area, and not prone can used for

the allocation of residential development space.

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Legislations

- Law No. 1 of 2011 on Housing and Settlement Region.
- Law No. 24 of 1992 on Spatial Planning.
- Law No. 24 of 2007 on Disaster Management
- Law No 25 Year 2004 on National Development Planning System.
- Law No. 26 of 2007 on Spatial Planning
- Local Regulation (Perda) No. 5 of 2011 on Spatial Planning ofHulu Sungai Tengah 2010-2030