Participatory Mapping for Flood Disaster Zoning based on World View-2 Data in Long Beluah, North Kalimantan Province

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Abstract. Flood is one of the most frequent disasters in Indonesia. These conditions cause the necessary efforts to reduce the impact of these hazards. To reduce the impact of these hazards is to understand spatially the impact of previous disasters. Participatory mapping is one of the solutions to be able to assist in reducing the impact of flood disaster by conducting flood zoning so it can be known the range of the flood. The community plays an important role in participatory mapping because the experiences and mental maps of the community are the main sources of information used. North Kalimantan Province has a very large watershed area that is in Kayan watershed, there are several villages, one of them is Long Beluah Village. Kayan watershed has a flood problem annually that affects most of the areas including the Long Beluah Village. This study aims to map the zoning of floods in the village of Long Beluah in a participatory manner using remote sensing World View-2 data within community, so that people also understand the conditions they face. The method for achieving that goal is participatory mapping which means community involvement as well as the ability of community mental maps that will make an important contribution in this research. The results of this study show that flood zoning can be mapped based on experience and community mental maps that the greatest floods in February 2015 inundated most of the community settlements in Long Beluah Village. There are few places from the uninhabited areas of settlements and serve as refugee camps. The participatory zonation map of the participatory floods is quite appropriate with the situation at the time of the greatest flood that hit the village of Long Beluah, so that through the map can be drawn up plans to reduce the impact of such disasters such as evacuation routes and a more strategic refuge point.

Keywords: participatory mapping, flood, World View-2, North Kalimantan, disaster

1. Introduction
Flood is one of the most frequent disasters in Indonesia. These conditions cause the necessary efforts to reduce the impact of these hazards. Bulungan District, North Kalimantan Province is one of the areas with significant flood hazard. Judging from its territory, Bulungan District has two major watersheds, namely Kayan watershed and Sekatak watershed. Based on data from the Central Bureau of Statistics Bulungan District, Kayan watershed is the largest river basin system with 1,129,717 ha and 1,937,57 m3 / sec flow rate (Table 1).
Based on data from the National Disaster Management Agency, major floods have occurred in Bulungan district in February 2015, where initial information was obtained from the community of Long Beluah Village that the floods at the time were the greatest floods ever (Figure 1). The flood incident in Long Beluah Village in February 2015 was then used as the basis for collecting information on making the Flood Zoning Map of Long Beluah Village. For people with most of their property at home (no banks), flooding is a worrying thing. This shows that people need something that can help in preventing and even avoiding greater damage from floods [1].

Other studies have shown there is a way to estimate the damage from floods called stage-damage curves, which are seen by each type of land cover and have a scale of 0 (no damage) to 1 (complete destruction) which is also the influence of inundation depth [2]. One of the efforts in reducing the damage caused by flood, especially in keeping the property that is in the house is to keep the path or space that let the water flood into the house [1]. In fact, some indigenous houses in Indonesia have done that like traditional houses in Kalimantan. Another effort to be able to effectively stop flooding is a long-term solution. The deeper case of understanding how to cope with floods is not only through flood disaster experts but rather looking at the views of directly affected communities, so that decisions can be directed by understanding the real issues even though the technical measures have not been determined yet [1].

Overcoming flood problems cannot be done instantly so that in managing the flood problem it needs understanding and the steps of decision making and management both short and long term. Implementation of various policies will certainly have consequences on culture or habits that have lasted so long on the community, so this needs to be a particular concern in determining the strategy of flood risk reduction. Handling such vulnerabilities requires not only one concept to be applied in every place,

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**Table 1. Bulungan District’s Watersheds**

| Watershed | Areas (Ha) | Debit(m³/sec) |
|-----------|------------|---------------|
| Kayan     | 1,129.717  | 1.937.57      |
| Sekatak   | 198.212    | 371.0         |

Source: Badan Pusat Statistik Kabupaten Bulungan

![Figure 1. Latest flood after the biggest one (February 2015) on 2016.](image)
but it is necessary to prepare concept variations so as to fit issues in different places. The hereditary habits of the community can make the plan in dealing with the flood disaster to be ineffective so that the need for an approach that can provide different views and a more dynamic approach [3].

The spatial understanding of the historical impact of the recent floods is one way to reduce future disaster risks. The participation of flood-affected communities is indispensable in gathering spatial information on the distribution of puddles in the village of Long Beluah. The role of society is done through participatory mapping of flood zoning. Knowledge and experience of the community in dealing with flood disaster can provide accurate information in mapping distribution of puddle flood. The community has an important role in providing information related to the disaster, it shows people are able to survive and understand the potential of disaster with their understanding, and the better if able to master the existing technology and resources [4]. There have been several studies that utilize participatory mapping approaches and have proven effective in mapping floods especially in areas where data availability is incomplete [5].

Society participation has a great role for risk management as a complex network. Society participating has a great point and movement in resolving the problem of social science, communities, and decision makers. Information from the community on the extent of damage and perceived impact can be used as a source of information for governments and experts to analyse and measure disaster-related matters. In urban areas this can be assessed from the resilience of buildings that are tailored to the community's involvement with the disaster-related disaster they face [6]. Developed countries like Europe have even gone a long way in reducing flood disaster risk by making prototypes or equipment that will be useful in the future through the OSIRIS Project program [7].

The remote sensing image of Worldview-2 Panchromatic channel has a spatial resolution of up to 50 cm that is capable of displaying a detailed picture of the Earth's surface. The image of Worldview-2 was used in a participatory mapping process with the community so that the community also understood the condition of their area and the dangers they faced. In addition, the use of remote sensing imagery can help people to more easily perform zoning inundation based on mental maps that have been formed. The result of the flood zoning map is expected to form a better understanding for the people of Long Beluah Village in facing the threat of flood disaster that can occur in the future. The participatory map of the flood zoning is expected to provide more information and understanding for the community about spatial flooding spores so that it is expected to assist in further flood mitigation and disaster preparedness.

2. Method

Participatory mapping requires some data to provide an overview of the problem and also the conditions related to the location of the study area to be performed. Required data such as remote sensing imagery, maps that already exist and physical data. This activity also involves some people who better understand the conditions and understanding related to the area of study and flood events at that time. The communities involved provide information on the greatest floods that have occurred and assist in determining the boundaries or extent of the floods in the study area. Most of the communities involved were young villagers who participated in the evacuation process as well as some of the affected residents affected by the floods. Participatory mapping activities with discussions to determine the boundaries of puddles caused by floods, the extent of the affected area and the point of safe location as a place of evacuation.

The image data used is the 2012 View-2 Panchromatic imagery of 2012, so it is necessary to make adjustments related to the changes that occurred until 2015 where in that year the greatest flood occurred. The direct impact of the affected communities is a major source of data in creating a 2015 zoning map in the village of Long Beluah. Other information, such as the inundation depth, becomes additional data for subsequent analysis. Complete data limitations such as altitude data and rainfall data result in limited information that can complement the results of flood zoning maps, so that the public interest becomes the main data used for the preparation of flood zoning maps.
The result of participatory mapping is done by cartographic visualization so that it is more interesting and easy to understand. In addition, the zoning map of the flood becomes the main base in determining the point of evacuation location so that it can be prepared the route or the evacuation hammer to prepare for the possibility of disaster in the future. Simple participatory mapping methods can be a solution when the availability of limited data and limitations in data collection, so that the results of participatory mapping, especially for flood problems can be a reference flood mitigation policy (Figure 2).

Figure 2. Simple workflow of participation mapping.

3. Results and Discussion
Floods that occur in the village of Long Beluah almost every year hit. This is due to the morphology and morphometry of the Kayan watershed which covers most of North Kalimantan. The location of Long Beluah Village is located at the neck of the Kayan watershed, but floods in the upstream also affect the neck of the Kayan watershed. Accumulated rainwater received upstream can not be accommodated by the main river channel so that water overflows (Figure 3). This resulted in overflowing water, especially in the river channel that turned sharply due to geological fault. Soil conditions, which are mostly soil-type clays, make the water less receding quickly. Another factor that can flood the worse is the high rainfall intensity makes the water puddle more widespread. Climatic conditions in the North Kalimantan region, especially in the upstream is very uncertain so that floods can occur at any time.
The largest floods hit the village of Long Beluah occurred in 2015 in February. Almost the entire settlement area is submerged until the water level reaches 7 meters. Damage caused by the flood is large enough, especially on goods that have not been saved, so submerged and damaged. In addition, people become very susceptible to disease because the flood water also brings bacteria from unhealthy environments. All community activities are paralyzed so people can only rely on food aid from the government. Evacuation site points that have been built are very limited to meet the needs of refugees, especially clean water. Accessibility is also limited due to the high water inundation making land vehicles unable to pass the usual route and need to use small boats to reach the submerged areas.

3.1. Disaster Mitigation
Understanding of society in the face of flood is very less. The community anticipates after signs of flooding will occur, so it is quite late when the floods hit. Flooding symptoms or signs will most easily be observed by monitoring the intensity of the rain that occurred. If the intensity of rain is so high then the public is aware that it will happen that the flood will occur. In fact, the flood is caused by the upstream rain. The fact that data and also communications between regions resulted in very limited information for early warning. At the upstream almost no complete data available to be able to analyze the intensity of rainfall that occurred. The new Automatic Rainfall Logger tool is installed in Long Beluah Village one year after the great flood that occurred in February 2015. The tool is only one in one Bulungan District, so the data can only present the rain intensity locally only. Very limited inter-regional communication system due to inadequate telecommunication signal towers so that to be able to coordinate and early warning is also very difficult to do.

Prevention action by the community is not much done, but the culture of the community house in the village of Long Beluah has characteristic of Dayak house culture that is House Stage. Stage House has a shape like an ordinary house made of ulin wood (the best wood that is waterproof) and has a buffer or poles under it so that the average stage house is high so it is not easily flooded by water. The culture has existed long ago that indicates that people are already aware how to cope with floods by making their homes higher. In the event of regular flooding (not extreme) the house of the stage is very effective to protect the residence from the puddle, although the flood can close the access of transportation. In the
occurrence of extreme floods as happened in February 2015, the stage house is still not enough to prevent water puddles that reaches 7 meters high, so at that time almost the entire settlement area was inundated. Preparation in building the point of evacuation location is done suddenly so that the evacuation process is less coordinated and spontaneous.

The unique morphological and morphometric conditions of the Kayan River make people unable to do much to prevent them. The need for building engineering such as dams to prevent flood disasters occur very effectively. Viewed from the side of society, what they can do is learn the characteristics of the flood disasters they face and prepare solutions to reduce vulnerability to flood hazards. Understanding spatial flood characteristics is important for the community, because by understanding spatially people can determine the right decision to take evacuation measures and disaster risk reduction efforts (Figure 4).

Figure 4. Activity of participation village boundary mapping to understand spatial thinking.

3.2. Community Participation Flood Zoning

The flood zoning mapping aims to identify the extent of the impact of the greatest flood that once hit the village of Long Beluah. This activity is one solution of data limitations to do mapping with complete data. Limitations of supporting data to create a complete flooding model are the main reasons for participatory mapping involving communities to be very important. The community has experience and understanding related to the condition and environment of their residence. In addition, mental maps of society are sufficient to describe the situation at the time of the flood. Community involvement can also generate spatial thinking or understanding in tackling disasters.

The communities involved in participatory mapping of the flood zone are the people involved in the evacuation process and also the communities directly affected by the floods. Most of those involved were village youths who were still very well aware of the flood conditions at the time. Any place in Long Beluah Village can be explained in great detail through high-resolution black and white imagery. Simply put, the community can explain through the image to where the water inundated the area of Desa Long Beluah. The image provided has been added to the description of public facilities which are also through participatory village office management. Participants are very helpful in recognizing the area of Desa Long Beluah with the attributes of public facilities. Technically, the delineation is done simultaneously with the explanation of the participants directly directing the flooded points. The results of the flood zoning showed almost all the settlements were submerged in floods.

The shortcomings of the resulting results are the lack of supporting data such as contours, making it difficult to validate by height or topography. Supporting data such as village maps are also not available
so that in comparison to village size it is not known what percentage of the submerged villages. It can be calculated only the area of submerged and visually submerged residential areas. The results of the initial delineation still need to be improved so that visualization can be done well.

The visualization of participatory mapping data is made as interesting and clear as it is easily understood by the community (Figure 5). Visualization is more emphasized on the selection of symbol warrants that are shuffled with the existing image so that still looks submerged settlements. The results of the flood zone mapping can also be analyzed as appropriate places for evacuation when floods occur.

![Participation Flood Zone Map of Long Beluah Village](image)

**Figure 5.** Participation Flood Zone Map of Long Beluah Village.

### 3.3. Making Evacuation Route

Based on the disaster management system, determining the evacuation route is very important to facilitate the process of disaster evacuation more systematically. The determination of the evacuation route is based on the result of the flood zoning map and the local wisdom of the community in facing the previous flood. The location of evacuation sites as evacuation sites is determined based on location height data, evacuation location information from people experiencing previous flood events, consideration of availability of water supply and electricity, consideration of easy access of aid delivery, and weather security.

Directions for evacuation routes have an important role in the evacuation process. This is to facilitate the community through the nearest route to the safe location of the pool, of course in addition to local wisdom of people who are accustomed to face the flood disaster. The installation of evacuation route directions is placed at strategic points that are easily visible.

### 4. Conclusions

Floods that occurred in the Long Beluah Village is a flood that routinely occurs due to morphology and morphometry Kayan watershed. Total precautions require an infratucture engineering capable of
withstanding large water accumulations. What can be done now is to reduce the risk of flood hazard and reduce the level of flood disaster. Cultural understanding of society has existed long ago with the existence of traditional houses that have the function of avoiding the house from standing water. The extreme floods that hit indigenous houses were not enough to mitigate the effects of floods, so another precaution was needed. The greatest flood disaster in February 2015 became the basis of reference in preparation for the subsequent floods through spatial understanding of the flood zone maps.

Incomplete supporting data for more detailed mapping makes participatory mapping a prime solution. Community understanding is important information as the main data in the preparation of flood zone maps. Community involvement will fill the space between experts and non-experts so the results will complement each other. The resulting flood zone maps can be used as a possible historical data in the preparation of plans and policies in addressing future flooding problems. Further analysis by using flood zoning can yield some other supporting information in relation to disaster mitigation such as making evacuation routes.

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