The use of airborne Lidar data to analyze flood disaster area: case study of Sekarbela Subdistrict, Mataram

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Abstract. Lidar is a remote sensing technology that is developing and widely used today. This data has the advantage of having a very high spatial accuracy so that it is very supportive of mapping with detailed accuracy. There are various benefits of lidar data, one of which is for risk analysis of natural disasters. The purpose of this study is to use lidar data to analyze flood disasters in an area. The method uses information derived from the Lidar data, namely the Digital Surface Model (DSM) and the Digital Terrain Model (DTM), which results from ground and non-ground classification. From this data, topographical analysis is carried out, especially the river flow area and its influence on the surrounding area. The research location is the City of Mataram, Lombok, Indonesia. This location is a coastal area and the location through which the river flows into the sea. The results of the analysis of this study were compared with data on flood disasters that had occurred in that location as comparative data. The results showed that the analysis using Lidar data has excellent topographic accuracy as an approach in the analysis of flood disasters towards an area.

1. Introduction
Flooding is the most common natural disaster in Indonesia, and it can be considered an annual disaster. Preparation of flood hazard and floodplain maps is an example of the readiness phase in a disaster management cycle, which is extensively used to decrease the effect of disasters, react during the occurrence, and take action to recover after a catastrophe, particularly flood disasters, happens.

Lidar (Light detection and ranging) is a remote sensing product currently being developed. It is widely used in various studies, such as land cover classification [1,2,3,4], topographic mapping [5], extraction of vegetation [6]. Lidar data in its development has been used to support mapping at a detailed scale. In its use, the data is generally classified into two classes, namely ground and non-ground, from the data it can be used to support topographic maps, to make contour lines and break lines. For environmental analysis lidar data can be derived into Digital Elevation Model (DEM) data.

DEM are used for various applications, such as for a civil engineering project or modelling natural disasters. DEM data has an important role in flood disaster modeling, affecting the accuracy of the model results, especially the extent and depth of floods [7] as well as for making hydrological simulations for watershed modeling [8]. DEM from lidar provides detailed and accurate information,
with a resolution of 0.5 m can be used to provide an overview of the earth's topography, besides that it is used in geosciences, such as forestry, geology, oceanography, hydrology [9], detecting slopes fine faults and detection of small tectonic-geomorphic features [10], obtaining topographic data of the earth's surface by filtering vegetation or other objects on the surface [11].

The purpose of this study is to use lidar data to analyze flood disasters in an area. Lidar is mostly obtained through airborne laser scanning (ALS). An ALS survey is usually aimed to have an evenly distributed lidar points over a large area. The distance between a lidar sensor and a target is measured based on half the elapsed time between the release of a pulse and the detection of an echo [12]. The DEM accuracy produced by ALS depends on a variety of factors, such as flight altitude, flight speed and scan angle. A thick vegetation cover such as forest can reduce the infiltration rate of lidar pulses to the ground and thus also affect the accuracy of DEM [13].

2. Material and Methods

2.1. Study Site

Sekarbela Subdistrict is a subdistrict located on the western most part of Nusa Tenggara Barat Province (NTB), this location is in the City of Mataram, Lombok, Indonesia. Areas that are prone to flooding on a yearly basis (BPBD Kota Mataram). Sekarbela Subdistrict has an area of 10.31 km² by having 5 (five) villages (Table 1), namely Kelurahan Kekalik Jaya, Tanjung Karang, Tanjung Karang Permai, Karang Pule, and Jempong Baru (Figure 1).

| No | Village          | Area (km²) | Percentage |
|----|-----------------|------------|------------|
| 1  | Kekalik Jaya    | 1.35       | 13.10      |
| 2  | Tanjung Karang  | 2.57       | 24.91      |
| 3  | Tanjung Karang Permai | 0.67 | 6.57 |
| 4  | Karang Pule     | 1.07       | 10.34      |
| 5  | Jempong Baru    | 4.65       | 45.08      |
|    | Total           | 10.31      | 100        |

Source: BPS-Statistic of Mataram Municipality 2020

Data used in this research is lidar data (Figure 2) from Geospatial Information Agency of Indonesia (BIG), acquisition in 2016. The point clouds density of the lidar data is in average 10 points per square meters (ppm), which is compliant for maps scale of 1: 5,000. Point cloud density for the study area can be seen in figure 2. The research site is located in a coastal area with light building density.
Figure 1. Location site, Sekarbel Subdistrict

Figure 2. Sekarbel Subdistrict lidar data
2.2 Filtering and Create DTM

The method used to analyze the flood disaster in the research location is creating a DEM using Lidar dataset. The process of filtering ground and non-ground lidar data using Global Mapper software. Only ground data needed to create DTM. The filtering process selects ground features when entering the LAS data from the classification results (Figure 3). Interpolating the ground point clouds data was done to generate the DTM. The interpolation aimed to close empty areas formerly filled by non-ground data, carried out using gridding method (Figure 4).

![Figure 3. Filtering Lidar point cloud](image1)

![Figure 4. Gridding](image2)
3. Result and discussion

3.1 DTM from Lidar

The algorithms or parameter values that were used at the time of classification would affect the results of the filtering process and DTM formation that was carried out using Global Mapper. Classification results performed to get ground and non-ground could fairly represent the real conditions of the field study area. The visual of the DTM generated from LiDAR was quite good with a point density of 10 ppm (Figure 5).

![Figure 5. DTM of study area](image)

3.2 Flood Analyze using Lidar

![Figure 6. DTM of river estuary area in Tanjung Karang Village](image)
Figure 7. 3D of estuary area

Districts Sekarbela has the potential for flooding every year resulting in material loss. With flat physical condition of urban areas and drainage conditions that are currently not functioning optimally, every time it rains more than 3 hours resulted in a number of roads and areas flooded housing. Tanjung Karang Village is one of the one village in Sekarbela District, Mataram City. The results of the initial observations carried out in the village of Tanjung Karang show that the Village is flood-prone, every rainy season arrives. Tanjung Karang Village and its surroundings or some of the area can certainly be flooded. Floods must be of different intensities every year. We can see the DTM of the river estuary area (Figure 6) and the 3D model of estuary area (Figure 7).

Based on BPBD data from Mataram City in 2020 Mataram City has a flood subscription area every year, one of which is Sekarbela Subdistrict. According to BPBD Mataram City from 2020, Sekarbela Subdistrict is faced with flooding problems every year, resulting in material losses. With the flat physical condition of urban areas and drainage conditions that are currently not functioning optimally, every time it rains in Sekarbela Subdistrict for more than 3 hours, a number of roads and residential areas in that location are inundated and floods occur.

To overcome this problem and carry out disaster mitigation activities, especially flood disasters, efforts are also needed to map the Vulnerability of Flood Disaster Areas. One of the efforts to map the vulnerability of flood-prone areas is to map areas that are indicated to be prone to flooding through Digital Mapping Based on Lidar System.

4. Conclusion
Based on the results of spatial analysis, it shows that lidar data can be used to analyze flood-prone locations. This can be seen from the DTM data, which is a derivative of lidar data, showing the relatively flat topography of the research site. In addition, from the topographic profile obtained, it can be analyzed that the location of the settlement is relatively close to a large river, this is quite dangerous if there is an overflow of river water, this problem is mainly found in Tanjung Karang Village which is passed by a large river.

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