Pesanggrahan River Watershed Flood Potential Mapping in South and West Jakarta with LiDAR Data Segmentation

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Abstract. Most of large urban areas are historically grown around a river from small communities that eventually merge into present urban area. Area around the river, known as the watershed can be described as flood water catchment basin that hold water overflow from the river during rainy season. This condition is negligible at the beginning when most of these areas are farmlands or undeveloped, but as the area developed further, with more people reside in the area, this increasingly pose significant problem. Declining environmental quality in Jakarta is now the dominant factor of the recent natural disasters. This research is aimed to map the potential of areas around Kali Pesanggrahan in South and West Jakarta by LiDAR data-derived the Digital Elevation Model. The objective of this segmentation is to find the contour lines of the surface model data. Data processing in this research is using LiDAR data, after the digital surface model has been created, the data is then segmented beginning from the river surface to obtain the base area between the riverbanks. Subsequent step is to find the area increase corresponding to the elevation from the riverbank at 1m intervals. The result of this research is the flood potential area information, especially along the Pesanggrahan river in South Jakarta, ranging from the baseline river water level to 1 meters above normal level.

1. Introduction
Jakarta’s rapid growth without sufficient water supply system results in high sub-surface water usage, which in turn causes land subsidence. Degradation of the city’s drainage and sewer system, including downtown rivers further makes this complicated. Flood can be described as a water body in the flat area around the river resulted from overflow that cannot be accommodated by the river. Flood is a phenomenon that happens during rainy season every year in Jakarta. One aspect that is often overlooked is that the flood is closely related to the unity of the river watershed. Aside from flood due to heavy rain, sedimentation and erosion on the watershed also become a problem along with acceleration of land degradation and river water pollution [1-3].

Remote Sensing is a way of obtaining information about object or phenomenon through analysis of data obtained without directly in physical contact with the target [4]. The expected result is to produce Digital Surface Model (DSM) data segmentation on the flood prediction with 1 m resolution. Since floods in Jakarta occurs in rainy season, and most cases it happens during heavy rain with cloud coverage above the city, therefore, optical sensor observation for flood mapping is not possible. The alternative is to use radar sensor that can penetrate cloud cover, but it suffers from high speckle noise caused by the presence of buildings that tends to reflect the radar wave multiple times [5]. One of the most important stage in mapping inland water bodies is to obtain the surface shape model [6]. Other
research for disaster management in urban area mostly with resolution of over 2 meters [7-9] which is unsuitable for flooding in Jakarta with flood height mostly under 2 meters.

2. Materials and Methods

2.1. Digital Surface Model

DSM is a digital surface model or can be interpreted as a model of digital surface. DSM is also an elevation model that displays surface heights; DSM displays any existing surface shapes such as tree height, buildings and any objects on the ground. DSM is a system, model, method, and tool in collecting, processing, and presentation of terrain information. The arrangement of digital values representing the spatial distribution of the field characteristic, the spatial distribution represented by the values in the horizontal coordinate system x, y and the field characteristics are represented by the field altitude in the Z coordinate system [5].

2.2. Data preparation

The methods used in this study include surface height extraction from DSM data and object classification on the DSM data. The data in this research uses 2016 DSM model with 1-meter resolution. The DKI Jakarta administrations sub-district map are represented in Figure 1. This DSM data will be processed with each parameter, namely: contour data, ground surface height, slope. The surface contour has different color changes to determine the height of the surface so that the expected result will produce ground level data.

![Figure 1. DKI Jakarta Sub-District boundary map, each shade represents a District, with area of interest marked by a box](image)

Jakarta is categorized as a delta city, a city located at the mouth of a river that is generally below sea level, and quite vulnerable to climate change. Proximity to rivers causes a delta city to have a strategic advantage in terms of water transport, it is generally below sea level, and quite vulnerable to climate change. The Watershed Map and Flood Way through Jakarta Region, can be seen in Figure 2. Pesanggrahan River originates from Bogor and Depok in West Java Province and passes South, West and North Jakarta. All Pesanggrahan River basin has a flat and elongated shape with several tributaries entering the main river. Kali Pesanggrahan has a river area of 142,500 km2 with a length of 11,400 km. The original flow capacity of Pesanggrahan River is 210 m3/s but currently only 75 m3/s, while the flow that must be accommodated by Pesanggrahan River for the current 25-year period is 198.9 m3/s [11, 12]. Water runoff occurs mainly due to backwater from Cengkareng Drain and overflow at Pesanggrahan River and Angke River confluence.
2.3. Mapping method
Flood mapping method is by DKI Jakarta DSM data which is result of contour data processing of Jakarta. DSM data is segmented by watershed segmentation method to get predicted flood potential. After obtaining the DSM segmentation result, then the data is registered to coordinate the corresponding position so as to facilitate further processing. The registered data is then cropped to determine the area of interest before conducting the analysis. The expected output of this process is information on potential floods along the Pesanggrahan River Basin located in South Jakarta Municipality [10].

DSM data is processed from LiDAR data by using QGIS application to get contour data and ground surface height. The expected output of this process is information on potential flooding along Pesanggrahan River Basin located in Pesanggrahan Sub district. The method results in DSM contour data in Pesanggrahan District as well as the ground surface height of the local area.

2.4. Elevation and gradient
Higher ground elevation has less chance of flooding compared to lower regions because water runs on the surface tends to flow to lower regions where the accumulation takes place. The slope is determined where the steeper slope of the area will cause less time for the rainwater to be filtered so that it will easily flowing over the surface. While less steep surface will cause the water to have a lot of time to absorb water into the soil so that the capacity more quickly fulfilled.

2.5. Land cover
Different type of land cover has different water capacity figures. It shows how much the portion of the rainfall will flow as the capacity of the stream surface. The growing number of vegetation will increase soil ability to absorb rainwater. The surface of the built area in urban environment is covered by many buildings and roads resulted in high capacity water flow that supports the occurrence of floods.

3. Results
Description of land surface elevation around Pesanggrahan area is obtained from LiDAR data processing. Figure 3 shows the results of the altitude data processing. The elevation of the surface in Pesanggrahan River is relatively homogeneous because it is a flat area. From the results of the
processed data, Pesanggrahan area is classified into classes with 1 m interval in the elevation. The resulting classification of the LiDAR is the Digital Surface Model (DSM) which shows the elevation ranges from -4 m at the northern edge to 29 m at most of the southern edge of the observation area.

![Figure 3. Pesanggrahan River: (a) LiDAR data, (b) color-coded Elevation data from LiDAR, and (c) detailed area Digital Surface Model (DSM)](image)

The DSM from Figure 3(c) is transformed into contour lines and the area of the Pesanggrahan river is marked as a polygon. Figure 4 shows the baseline contour is derived from the riverbank and some of its catchment basins which is marked in brown.

![Figure 4. Contour lines derived from the DSM superimposed on the DSM](image)

4. Discussion
The baseline is considered as the normal water level of the river and the next contour line outside the baseline is 1 meter higher than the riverbank height. As the simulated flooding occurs when the water level exceeds the baseline and because the resolution of the data is 1 m, then the potentially flooded area in Figure 4 is marked with green color. Preliminary area plotting with GIS software resulted in two categories, namely: baseline elevation with height of 0 m from the riverbank, and area with elevation of 1 m above the normal baseline. Area calculation for the two plots is shown in Table 1.
Table 1. Elevation-based flood-potential area calculation

| Elevation from river (m) | Area (hectares) |
|-------------------------|----------------|
| 0                       | 78.05          |
| +1                      | 148.00         |

As can be seen in Table 1, rising river water level of 1 m causes the potentially flooded area immediately close to the riverbanks increase significantly from 78 hectares to 148 hectares. Areas north of the toll road is a flat lowland which could disperse the water overflow onto significantly greater area.

5. Conclusion

From the DSM obtained from LiDAR data results in 1 m contour lines that can be used to calculate the potentially flooded area along the Pesanggrahan River Watershed. This mapping result shows that when the river water level is rising by 1 m, then the potentially flooded area next to the riverbanks grows to almost twice as great as the original river. This work is still continuing to map further extent of the inherently dangerous area with elevation of 1 m or lower under normal river level (baseline) and further extent of potentially flooded area on the northern flatland area.

6. References

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