Identification of flood potential in Rawa Danau, Banten Province based morphometry and satellite image analysis

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Abstract. The Quaternary Volcanic Rawa Danau, Banten Province has a unique characteristic. Their deformed morphology reflects those unique characteristics. A physical characteristic of deformed morphology is able to describe the morphometry parameters of a subwatershed. It also can be analyzed using the Digital Elevation Model (DEM) obtained from satellite imagery. The lineament of geological structure can be observed from satellite images through their colour, shape, texture, and pattern. Subwatershed characteristic data can be used to calculate the flood discharge using morphometry. Some morphometry parameters can be used are river dimension, an azimuth of river segment, an azimuth of terrain lineament, river length, drainage density, and bifurcation ratio. This research can be used to identify flood potential at Rawa Danau–Banten Province. The result of the research shows that the value of Rb is less than 3, it means all of the subwatershed has deformed. At the Cidano, Ci Kaduan, Ci Bulakbaru, Ci Tawing, Ci Cangkepan, Ci Pasauran, Ci Sangkuy, Ci Carung value of Rb increased so it indicates that the deformation is quite substantial and also potentially flood.

Keywords: Deformation, flood, morphometry, rawa danau, satellite image

1. Introduction
Potential disaster can be known by analyzing the recent geological data [1]. The most important geological data that be used is geomorphology. For the latest update of geomorphology data can be accessed with remote sensing and field observation [2, 3]. Remote sensing techniques will be compared with geomorphological parameters and GIS tools and analyze the information of DEM for the determination of evolution of river and their lineament. So, we can identify their potential disaster [3, 4].

Research area were located in Rawa Danau, Serang Regency, Banten Province or geographically in 6º7'0.51''S until 6º14'16.31''S and 105º53'23.56''E until 106º2'38.74''E. Rawa Danau area contains volcanic rocks, pyroclastic rocks, colluvium, and swamp deposit as shown in figure 1. Rawa danau is one of quaternary volcanic terrain that has deformed morphology. The quaternary volcanic rawa danau has uncompacted lithology and rawa danau has high rainfall so it has potentially flooded. In Banten province, specially Rawa Danau there is no research about potential disaster with morphometry analysis. The result of analysis can be used for identification potential disaster and used as reference developing area-based mitigation [5-8].
2. Methodology
Methods that used in this research are field works and remote sensing, laboratory analysis, and studio analysis.

2.1. Field works and remote sensing
As the first method, field works is used to collect field data like lithology, structure and find out the geological history of the Rawa Danau which is used for supporting the morphometry and satellite image analysis. The 30 m spatial resolution Digital Elevation Model (DEM) data, obtained from the satellite image, was utilized to know lineament of geological structure, to develop river network mapping, an area of subwatershed and determine their boundary subwatershed boundary before field work was conducted. Tools and materials used in this study are map with 1:25.000 scale, ArcGis and field tools. GIS has been known as a powerful tool to assess the risk and natural hazards management (e.g. flood prone areas delineation).

The DEM was used to extract the drainage networks and subwatershed boundaries. The drainage networks are determined by Strahler stream order. The Strahler stream order defines two of first-order streams that come together, they will form a second order stream. Third order stream will consist of two second-order streams that come together and so on (figure 2) [9].

![Figure 1. Location of research area in Peta Geologi Lembar Anyer and Peta Geologi Lembar Serang.](image1)

![Figure 2. Strahler stream order](image2)
2.2. Studio analysis
After determining the boundary of subwatershed we need to classify order of river, river length, and subwatershed area.

2.2.1. Bifurcation ratio [6]. Bifurcation Ratio is used to define the ratio between number of streams of N order and N + 1 order of a drainage network that is written as,

$$Rb = \frac{N_i}{N_i + 1}$$  \hspace{1cm} (1)

where $Rb$ is bifurcation ratio, $N_i$ is the number of streams of $i$ order, and $N_i + 1$ is the number of streams of $i + 1$ order. This dimensionless ratio looks into the relationship between streams of different orders. The relation with the flooding probability is positive, where higher bifurcation ratio will lead into more prone of flooding area.

2.2.2. Drainage density [3]. Drainage density is calculated by measuring the total stream length and dividing by drainage area. A high density may indicate surface runoff moves rapidly from hillslopes to channels, thin or deforested vegetation cover, infiltration rate, and also describes the texture of a stream network. The drainage density (Dd) is written as,

$$Dd = \frac{L_s}{A}$$  \hspace{1cm} (2)

Here, $L_s$ is the number of all streams in the unit of km while $A$ is the area of subwatershed in the unit of (km$^2$).

To identify their potential disaster, the study compared field works and remote sensing data with laboratory analysis data.

- If the value of $Rb < 3$ and or $Rb > 5$ it means the subwatershed has been deformed [10], and if $Rb < 3$ it means low probability of flooding, $3 < Rb < 5$ it means moderate probability of flooding, and $Rb > 5$ it means greater the probability of flooding.
- If the value of drainage density is low, it means the lithology is resistant, high rate infiltration, and range of their streams are wide apart. If value are high it means lithology are less resistant, lower rate infiltration and range of their streams are close (table 1) [3].

3. Results and discussion
SRTM is Shuttle Radar Topography Mission that obtained digital elevation models that used in geographic information systems. SRTM data is interpreted and compared its hill shades (figure 3). By this method a lineament of river for each subwatershed. And we can decide the order of river (first order-fourth order) and devided into 17 subwatershed (figure 4). To determine for each subwatershed only use Strahler stream order.

| Dd (km/ km$^2$) | Category |
|-----------------|----------|
| < 0.25          | Low      |
| 0.25–10         | Moderate |
| 10–25           | High     |
| > 25            | Very high|

Table 1. Classification drainage density [3]
Figure 3. DEM SRTM Data (left side) and area subwatershed (right side) with river order.

Figure 4. DEM data and subwatershed that overlayed.

Subwatershed magnitude was employed along with drainage density, first order stream frequency, relief ratio. Drainage density was not employed in the equations with first order stream frequency, as they are highly correlated [11]. Drainage density will indicate their deformation stage. From this calculation, drainage density showed low improvement of deformation. It indicates deformation has formed before deposition of Rawa Danau Volcano’s eruption products.

The morphometric calculation is given in table 2. The table shows that most of value subwatershed’s drainage density is less than 0.25 km/ km². The highest value of drainage density is in Cicarung subwatershed (Dd = 0.31 km/ km²) and the lowest value is in Ci Herang subwatershed (Dd = 0.04 km/ km²). Some subwatersheds have’s drainage density in moderate values (e.g. Ci Suwar subwatershed, Ci Dani subwatershed and Ci Carung Subwatershed). The moderate value suggests moderate rate infiltration and potentially to flooding. In general, bifurcation ratios (Rb) range between 3.0 and 5.0 for subwatersheds when the influence of geological structures on the drainage network are
negligible. The mean bifurcation ratios in the subwatershed of the study area range from 1.5 to 5.17. The highest value of \(R_b\) are located in Ci Kaduen subwatershed and the lowest value of \(R_b\) are located in Ci Carung. The subwatershed that has \(R_b\) value less than 3 are potentially to flood and \(R_b\) value more than 5 are deformed subwatershed (figure 5).

### Table 2. Calculation result from the drainage density value and bifurcation ratio.

| Subwatershed  | \(L_s\) (km\(^2\)) | \(A\) | \(D_d\) | \(R_b\) 1-2 | \(R_b\) 2-3 | \(R_b\) 3-4 | \(R_b\) |
|---------------|---------------------|-------|---------|------------|------------|------------|------|
| Ci Kadueun    | 10.71               | 65.88 | 0.16    | 9          | 4.5        | 2          | 5.17 |
| Ci Herang     | 7.14                | 171.26| 0.04    | 4.6        | 3.75       | 4          | 4.12 |
| Ci Balagendong| 13.40               | 34    | 0.11    | 3.78       | 4.5        | 2          | 3.43 |
| Ci Sukamala   | 6.55                | 48.45 | 0.14    | 4.25       | 6          | 0          | 3.42 |
| Ci Kalapa     | 7.74                | 55.25 | 0.14    | 4.5        | 4          | 3          | 3.83 |
| Ci Bulakbaru  | 4.76                | 22.1  | 0.22    | 4          | 3          | 0          | 2.33 |
| Ci Kalahi     | 10.66               | 98.6  | 0.11    | 5.16       | 3.8        | 5          | 4.65 |
| Ci Paseh      | 4.17                | 27.2  | 0.15    | 3.75       | 8          | 0          | 3.92 |
| Ci Koneng     | 8.34                | 35.7  | 0.23    | 5          | 6          | 0          | 3.67 |
| Ci Tawing     | 4.11                | 42.5  | 0.10    | 5.44       | 3          | 0          | 2.81 |
| Ci Suwar      | 39.27               | 136   | 0.29    | 3.56       | 3.6        | 5          | 4.05 |
| Ci Kumbueun   | 10.12               | 57.8  | 0.18    | 3.91       | 3.67       | 3          | 3.53 |
| Ci Dano       | 22.61               | 72.25 | 0.31    | 6.28       | 6          | 3          | 5.09 |
| Ci Cangkepan  | 1.79                | 14.88 | 0.12    | 3.67       | 3          | 0          | 2.22 |
| Ci Pasauran   | 2.38                | 11.05 | 0.22    | 4          | 4          | 0          | 2.67 |
| Ci Sangkuy    | 1.78                | 14.45 | 0.12    | 3.4        | 5          | 0          | 2.80 |
| Ci Carung     | 1.59                | 5.1   | 0.31    | 4.5        | 0          | 0          | 1.50 |

**Figure 5.** Result area that potentially to flood has red zone.
4. Conclusion

This study showed the impact of geological structure on some subwatersheds (e.g. Ci Dano and Ci Kaduan). The decreasing runoff potential was caused by the suitable condition for infiltration that is caused by the low values of drainage density. In contrary, high stream frequency was caused by the sparse vegetation and the impermeable sub-surface material causing low infiltration capacity (e.g. Ci Suwar subwatershed, Ci Dano subwatershed, and Ci Carung subwatershed), So, Cidano Subwatershed, Ci Kaduan subwatershed, Cibulakbaru subwatershed, Ci Tawing subwatershed, Ci Cangkepan subwatershed, Ci Pasauran sub watershed, Ci Sangkuy subwatershed, Ci Carung subwatershed that has $R_b$ more than 5 and/or $R_b$ less than 3 and Moderate $D_d$ value are greater probability flooding.

These result conclude there are three subwatershed that potential to flood which are Ci Dano, Ci Suwar, and Ci Carung subwatershed. The result of this study could be used as basic framework in assisting flood mitigation or in land use planning. However, we should fully aware about the scale that was used in the study while using this result for developing area.

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