Analysis of Distribution of Flood Disaster Hazard in Tangerang City

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Abstract. Tangerang City was largest city in Banten Province with total area of 184.23 km². Tangerang City was generally combination of coastal areas with lowlands condition which is located along Cisadane River. Mapping of flood-prone areas in Tangerang City aims to identify areas which have potential for flooding, so these areas can be analyzed for preventing action. In this research, flood-prone areas were identified using scoring method. The flood parameters consist of land height, slope, rainfall, soil type, land cover, and river range. Spatial information was represented in form of map, while attributes of spatial information were represented in tabular form using different parameters and weight values in mapping flood hazard in Tangerang City. The results show us that level of flood hazard in Tangerang City was divided into four classes of hazard, namely level of flood hazard “safe” in Benda District with area of 0.831 Ha, level of flood hazard “slightly vulnerable” in Jatiuwung District with area of 155.897 Ha, level of flood hazard “prone” occur in Pinang District, which has area of 1.360,161 Ha, while level of flood hazard “very vulnerable” was in Benda District, which has area of 1.358,454 Ha.

Keywords : Flood, Weighting, Mapping, Scoring, GIS.

1. Introduction
Tangerang City was generally combination of coastal areas with lowlands, and it was located along the Cisadane River which was located at an altitude of 10-18 meters above sea level. The slope of land in most areas of Tangerang City ranges from 0-3% [2]. On January 1, 2020, most of Tangerang City was flooded with a total of 934 houses submerged and 5 embankments broken [3]. The flooding that occurred was caused by very high rainfall so that many dikes and drainages in several rivers were unable to withstand heavy flow of river water. In an effort to anticipate, it is necessary to study the hazard of areas which are often affected by floods so that every year the community can better prepare themselves to cope this flood phenomenon. Floods can be analyzed with geographic information systems related to physical factors which produce potential areas. The method used in this study is a method of scoring and weighting, the greater the effect on the incident, the higher the score [5]. To get a total score, it was necessary to assign values and weights so that the multiplication between two can produce total value which was usually called a score. Results of this study were used to present information about mapping flood-prone areas in Indonesia. Tangerang City, so that flood area information and flood indicator could be used by government agencies and the community to anticipate the impact of flood disasters. This research aims to analyze distribution of flood-prone areas in Tangerang City using the scoring and weighting method.
2. Methodology

2.1 Study Area
This study located in Tangerang City, Indonesia. Geographically, it was located between 06°06’00” – 06°13’00” South Latitude and 106°36’00” –106°42’00” East Longitude. According to Badan Pusat Statistik Kota Tangerang year 2012 total area of Tangerang City was 184.23 km² Administratively, Tangerang City consist of 13 sub-districts and 104 sub-districts, with regional boundaries as follows:
- North side : Teluknaga District, Kosambi District and East Sepatan District (Tangerang Regency)
- Southside : Curug and Kelapa Dua sub-districts (Tangerang Regency), as well as North Serpong and Pondok Aren sub-districts (South Tangerang City)
- West side : Pasar Kemis Subdistrict and Cikupa Subdistrict (Tangerang Regency)
- East side: West Jakarta Administrative City and South Jakarta Administrative City (DKI Jakarta Province).

2.2 Data
The data used in this study are:
- a. Tangerang City administrative boundary data
- b. Tangerang City soil type data
- c. Tangerang City Landuse data
- d. Tangerang City river network data
- e. National Digital Elevation Model (DEMNAS) data for Tangerang City, 1209-41 and 1209-43.
- f. Tangerang City rainfall data

2.3 Methods
a. Land Elevation
Map of land elevation or elevation obtained from the results of the DEMNAS classification with the following steps:
- i. Mosaic
  DEMNAS data obtained from tides.big.go.id was DEMNAS 1209-41 and 1209-43 in mosaic. Mosaic dataset used to store, manage, view, and query small to vast collections of raster and image data [6].
- ii. Cropping
  Mosaic DEMNAS data must be cut to fit the Tangerang City administrative
- iii. Land Elevation Classification
  DEMNAS data which has been cropped was reclassified using the Reclasiffy to obtain land elevation data with the desired classification
- iv. Scoring
  Data on land elevation results were given a score for each class

b. Land Slope
Map of land slope obtained from the results of the DEMNAS classification with the following steps:
- i. Slope
  DEMNAS data which has been cropped in previous elevation processing was used again in this processing to get a comparison of the values of elevation and distance or slope.
- ii. Slope Classification
  The results of the slope data were reclassified to obtain slope data with the desired classification.
- iii. Scoring
  The data on results of the slope was given a score for each class

c. Rainfall
Rainfall map was obtained by processing rainfall data from Central Statistics Agency, by interpolating using IDW tools in ArcGIS to obtain a rainfall level polygon in Tangerang City. After that, a score was given to each class.
d. Type of soil
Map of soil types were obtained from classification of soil types in Tangerang City, where soil types were divided into several classes according to their ability to absorb water, then a score was given for each class.

j. Land Cover
Land cover map was obtained from results of the Tangerang City land cover classification, where land cover was divided into several classes according to its effect on the flow of water as cause of flooding, then a score is given to each class.

k. River Range
River range map was obtained by processing the Tangerang City river using the Multiple Ring Buffer tool by entering a buffer distance of 25, 100, and 250 meters to get a river buffer with that distance. After that, a score is given to each class.

l. Overlays
The data for the six flood parameters in form of slope, elevation, rainfall, soil type, land cover, and river range which have been processed and scored were overlayed into one new ArcGIS file, then combined using Union tools in ArcGIS to create a new feature class. By combining the features and attributes of each feature class.

m. Weighting
The overlay data of the six parameters that have been combined using the Union tool was given weight by adding a new field to the attribute, with the title weighting, then given the weighting value using the Field Calculator tool and entering the formula \(0.1*\text{Elev\_Score} + 0.2*\text{Rainfall\_Score} + 0.1*\text{Soil Type\_Score} + 0.2*\text{LandCov\_Score} + 0.2*\text{BuffS\_Score} + 0.2*\text{Slope\_Score}\) to get the weight value according to the journal that has been determined.

n. Reclassification of Flood Hazard Level
After obtaining the flood susceptibility weights, a reclassification of the flood susceptibility level was carried out in order to obtain a flood-prone map with a classification method.

3. Results and Analysis

3.1 Mosaic
Digital Elevation Data (DEM) are used to determine terrain attributes such as elevation at any point, slope and aspect [4]. Tangerang City was located on two DEMNAS data, namely DEMNAS_1209-41 and DEMNAS_1209-43, so two data need to be merged first before further process. Results of mosaic can be seen in the following figure.
3.2 Cropping

Cropping was process of cutting an image or raster data at certain coordinates in image area [8]. In this study, cropping was carried out to cut DEMNAS according to the administrative boundaries of Tangerang City. In addition, in process of making slope class used, cropping will also speed up computer work in the data processing process. For this reason, the mosaic map must be cut so that the results can be seen in the following figure.

3.3 Analysis of Land Slope Map

The largest land slope in the sloping category, which is 13,784,457 Ha or about 76% of Tangerang City area has a sloping slope, and smallest in the very steep category, which was only 17,221 Ha or only about 0.1% of the area in Tangerang City which has very steep slopes. While an area of 903,655 Ha or about 5% of the area in Tangerang City has a flat slope, 2,923,960 Ha or around 16.1% of the area in Tangerang City has a rather steep slope, and 498,210 Ha or about 2.7% of the area in Tangerang City has a slope steep.
Parameter of scoring method for land slope classification can be seen in the following table.

Table 1. Land Slope Classification [8]

| No | Land Slope (%) | Description     | Score |
|----|----------------|-----------------|-------|
| 1. | 0-3            | Flat            | 9     |
| 2. | >3-8           | Sloping         | 7     |
| 3. | >8-15          | Slightly Steep  | 5     |
| 4. | >15-30         | Steep           | 3     |
| 5. | >30            | Very Steep      | 1     |

3.4 Analysis of Land Elevation Map

Land height or elevation in Tangerang City with largest area at elevation of 10 – 25 m, which is 13,008,534 Ha or about 71.5% of Tangerang City area has elevation of 10 – 25 m, and the smallest at elevation of 25 – 50 m, which is only 280,653 Ha or only about 1.5% of Tangerang City area which has elevation of 25 – 50 m. Meanwhile, area of 4,912,331 Ha or about 27% of Tangerang City area has elevation less than 10 m.
Figure 4. Land Elevation Map

Parameter of scoring method for land elevation classification can be seen in the following table.

| No | Elevation (m) | Score |
|----|---------------|-------|
| 1. | <10           | 9     |
| 2. | 10-25         | 7     |
| 3. | 25-50         | 5     |
| 4. | 50-75         | 3     |
| 5. | 75-100        | 1     |
3.5 Analysis of Soil Type Classification Map

The type of soil in Tangerang City with the largest area was latosol soil type, which is 12,276,325 Ha or about 67.4% of Tangerang City area has latosol soil type, and the smallest was pandsolic soil type which is only 1,402,633 Ha or only about 7.7% of Tangerang City area which has pandsolic soil type. While an area of 4,523,470 Ha or about 24.9% of Tangerang City area has alluvial soil types.

![Soil Type Classification Map](image)

Figure 5. Soil Type Classification Map

Parameter of scoring method for land elevation classification can be seen in the following table.

| No | Soil Type                                      | Infiltration          | Score |
|----|-----------------------------------------------|-----------------------|-------|
| 1. | Alluvial, Planosol, Gray Hydromorph, Groundwater Lateric | Insensitive           | 9     |
| 2. | Latosol                                       | Slightly Sensitive    | 7     |
| 3. | Brown Forest Land, Mediterranean Land         | Moderate Sensitivity  | 5     |
| 4. | Andosol, Laterik, Grumosol, Podsol, Padsolic  | Sensitive             | 3     |
| 5. | Regosol, Litosol, Organosol, Renzina          | Very Sensitive        | 1     |

3.6 Analysis of Rainfall Classification Map

Rainfall in Tangerang City was obtained by processing rainfall data from the Central Statistics Agency of Tangerang City using IDW tools, obtained rainfall of 4,350 mm/year for all areas in Tangerang City, with rainfall of 4,350 mm/year, the rainfall class is 4,350 mm/year. Rainfall in Tangerang City is classified as heavy because it is more than 3000 mm/year.
Parameter of scoring method for land elevation classification can be seen in the following table.

| No | Description | Rainfall Average (mm/tahun) | Score |
|----|-------------|-----------------------------|-------|
| 1. | Heavy       | >3000                       | 9     |
| 2. | Medium      | 2000-3000                   | 5     |
| 3. | Small       | <2000                       | 3     |

3.7 Land Cover Classification Map Analysis

Land cover in Tangerang City with largest area was land cover with building type, residential area which is 9,627,934 Ha or about 53.0% of Tangerang City area has settlement class, and smallest land cover with plantation type which is only an area of 810,395 Ha or only about 4.5% of Tangerang City area which has a plantation class. While an area of 4,076,919 Ha or about 22.4% of Tangerang City area has a type of land cover of shrubs and grasslands, and area of 3,666,03 Ha or about 20.2% of Tangerang City area has paddy fields, lakes, swamps, and open ground classes.
Parameter of scoring method for land elevation classification can be seen in the following table.

**Table 5. Land Cover Classification [8]**

| No | Classes                  | Score |
|----|--------------------------|-------|
| 1. | Rice fields, ponds, open land | 9     |
| 2. | Agriculture, settlement  | 7     |
| 3. | Bushes, shrubs, reeds    | 5     |
| 4. | Plantation               | 3     |
| 5. | Forest                   | 1     |

3.8 Analysis of River Range Classification Map

The results of river buffer in Tangerang City with a buffer distance of 25 m has total area of 1.373,197 Ha or only about 7.5% of Tangerang City area, while buffer with a distance of 100 m has total area of 3.224,246 Ha or about 17.7% of Tangerang City area, and buffer with a distance of 250 m has total area of 4.816,678 Ha or about 26.5% of Tangerang City area.
Parameter of scoring method for land elevation classification can be seen in the following table.

| No. | Buffer (m) | Description | Score |
|-----|------------|-------------|-------|
| 1.  | 0-25       | Near        | 7     |
| 2.  | 25-100     | Medium      | 5     |
| 3.  | 100-250    | Far         | 3     |

### 3.9 Analysis of Tangerang City's Flood Prone Map

The level of flood susceptibility in Tangerang City was obtained from results of data processing of six flood hazard parameters, namely slope, elevation, soil type, rainfall, land cover, and river range. Level of flood hazard in Tangerang City was divided into 4 classes, which can be seen in table 8. Those six parameters used in this study have been conducted by using scoring and weighting methods in order to get the distribution of flood prone map. The scoring and weighting data can be seen in table 1 to table 7.

#### Table 7. Weighting Factors for Each Flood Hazard Parameter [8]

| No. | Parameter       | Weight |
|-----|-----------------|--------|
| 1.  | Land Slope      | 0.20   |
| 2.  | Elevation       | 0.10   |
| 3.  | Soil Type       | 0.10   |
| 4.  | Rainfall        | 0.20   |
| 5.  | Land Cover      | 0.20   |
| 6.  | River Range     | 0.20   |

#### Table 8. Flood Hazard Level Value [9]

| No. | Flood Hazard Level | Total Score |
|-----|--------------------|-------------|
| 1   | Very Prone         | 6.75-9      |
Tangerang City was included in flood-prone city category because about 64.5% or an area of 11,737,956 Ha of Tangerang City area and about 29.7% or an area of 5,409,097 Ha of Tangerang City Area was included in very low level prone of flood, while only about 0.03% or area of 5.459 Ha of Tangerang City area which was included in safe level, and about 5.8% or area of 1,054,956 Ha of Tangerang City area which was included in level of slightly flood prone.

The largest area of "very vulnerable" level of flood hazard was located in Benda District, of 1,358,454 Ha, while the smallest area for the "very vulnerable" flood hazard level was located in Larangan District of 67,855 Ha. The largest area for "vulnerable" flood hazard was located in Pinang District of 1,360,161 Ha, while the smallest area for "vulnerable" flood hazard was in Batu Ceper District of 542.259 ha. The largest area for the "slightly vulnerable" level of flood hazard was located in Jatiuwung District of 155,897 Ha, while the smallest area for "slightly vulnerable" flood hazard was located in Neglasari District, of 13,482 Ha. Meanwhile, the largest area for the “safe” level of flood hazard was located in Benda District of 0,831 Ha, and there are two districts in Tangerang City which do not have “safe” level of flood hazard, which means that they only have a slightly vulnerable, vulnerable, and very high level of flood hazard, namely Karawaci District and Tangerang District.

![Flood Prone Map](image)

**Figure 9.** Flood Prone Map

4. **Conclusion**

The level of flood hazard in Tangerang City is divided into four classes of hazard, namely the level of "safe" flood hazard in Benda District covering an area of 0.831 ha, a "slightly vulnerable" flood hazard level in Jatiuwung District covering an area of 155,897 ha, and a "hazardous" flood hazard level occurring in Jatiuwung District. Pinang District has an area of 1,360,161 ha, while the level of flood hazard is "very vulnerable" in Benda Subdistrict with an area of 1,358,454 ha. Benda district which has an area of 2,845,639 ha is an area in Tangerang City that has the greatest flood-prone potential. In
addition, the slope in Benda District was 3-8% and most of soil types were alluvial which was susceptible to soil changes so that it has the potential to become a disaster-prone area.

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