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Analysis of the distribution of flood area in Karawang Regency using SAR Sentinel 1A image

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Abstract. Flood is one of the most frequent hydrometeorological disasters compared to other disasters. Floods cause more damage than other disasters. Karawang regency is one of the areas prone to national floods, due to floods that often hit the region. Detection of flood areas can be determined using multitemporal SAR Sentinel 1A image. Several factors can affect the occurrence of floods. The weighted index overlay analysis of each variable with the scoring method was done to construct a prediction model of flood hazard prone locations. Logistic regression analysis is used to analyze the variables that have the most significant effect on flood potential in Karawang. The result of analysis shows that flooding variable has significant correlation with the occurrence of flood inundation. Rainfall is the dominant factor of flood incident in Karawang regency that is in the class of 1500 - 2000 mm/yr, on the slope <2% and the type of flat entisol soil and the use of settlement land and rice field. The area is very vulnerable in the western part of central Karawang is a rice field area and close to the river flow in the District Rengasdengkol, Telukjambe Barat and Timur

1. Introduction

Flood is one of the most frequent disaster occurrences in Indonesia [1]. Floods can cause damage and cause loss of life, property, public facilities and critical facilities such as houses, shops, roads, bridges, markets and so on [2]. Material losses such as damage to health facilities, worship and education as well as lightly and heavily damaged houses are reported as impacts caused by floods. In addition to the material losses suffered by the community, floods also provide non-material losses, such as dengue diseases such as dengue fever, social vulnerability such as homes that are displaced when displaced, environmental degradation, and decreased convenience of life felt by the community [3]. Floods also cause more loss and damage than other disasters [4].

Karawang regency is one of the areas in West Java Province that are often affected by floods. According to the Environment Status (SLH) report in 2009 Karawang, floods hit 20 districts with a puddle of 21,071 ha. In 2010 hundreds of homes and rice fields were also flooded. Subdistrict of Telukjambe Barat, Cilamaya Wetan and Kulon inundated by Cibeet river flood and high rainfall in 2014. In 2016, West Karawang district, East Karawang, West Jambe Bay, East Jambe Bay, Batujaya, Pakisjaya, Cilamaya Wetan and Cilamaya Kulon is reported to be flooded In the same sub-district that is also hit by floods in 2017 [1]. Flood in Karawang regency needs to be wary because Karawang is one

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of the central areas of national rice barn. Moreover, Karawang regency has now developed rapidly into an industrial city, where many large companies are establishing new industrial areas that affect the wheels of the national economy.

Various scientific theories and studies have examined that flood disaster problems can cause climate change, high rainfall or flooding from other higher areas [5]. The high rainfall factor is one of the main indicators of flooding in Karawang [6]. In addition, flooding is also often with relatively flat topography as in the center of the city of Karawang. Karawang city center is located in a lowland area that continues to grow rapidly with an increasingly crowded population. Comprehensive disaster management efforts needed to cope with floods.

Rapid mapping is required for emergency flood mapping responses. Flood mapping methods based on surveys and airborne observations are difficult due to weather. Remote sensing has advantages ie the study is a large area, accuracy is relatively high and has a relatively low cost [7,8]. Synthetic Aperture Radar (SAR) data is one of the remote sensing systems that can generate important information as the impact of disaster, smoke and rain [9]. Remote sensing with active sensors is very much in the detection of events that can cause objects that are opposite to locations that intersect with satellite imagery [10]. Therefore SAR data are widely used to detect floods [11,12]. One of the most recent SAR data is Sentinel 1A. Sentinel 1A data has 20m spatial resolution and 12 days temporal resolution. With the ability that can be used to map the area of flooded puddles in Karawang regency.

The formulation of the problem in this study is to analyze the relationship or different test between the size of the flood area with the variables of rainfall, soil type, altitude, land cover, and land use. So that can be used as a warning of flood danger in Karawang regency.

2. Data and Methods

The data used in this study is Sentinel 1A image before flood on 04 October 2017 and flood date of 13 February 2018. *Infrared Climate Hazard Precipitation with Station data* (CHIRPS) is rainfall data utilizing infrared waves and rain stations with spatial resolution 0.05° (per pixel) to estimate the value of rainfall. Then DEM-SRTM data to find information height and other geomorphological information. Landsat 8 image to know the information of land use and also land cover at the research location.

Flood area research can be done using remote sensing data, climate data, flood data and other factors that are integrated using geographic information systems. The methods used include hydrological analysis of rain and river data, flood incidence analysis and relation to rainfall conditions, and then flood hazard mapping based on geomorphology approach of remote sensing data [13,14].

In this research, used multi-criteria analysis by looking at the main factors causing flood in Karawang (Figure 1). Where variables used include rainfall variables, elevation, soil type, land use, landform, and inundation area information. After each variable has a weight then the weighted overlay method / overlapping system variabe flood hazard. The weight calculation of each variable is done by using composite method is Composite Mapping Analysis or CMA [15]. The CMA analysis is a commonly used method for applications in the environmental field of [16,17]. CMA utilizes a polygon overlay or exploits the cell manipulation capabilities (raster) of GIS .

This method is done by assigning weight to the scaled variable, so the total score is a linear combination. Determination of this level of weight depends on the needs of the scope of the problem to be solved with complete knowledge [14]. The CMA combines factors related to disasters and humans [16].

Characteristics location are based on the spatial relationship of the factors that trigger an observed event. Spatially the CMA method utilizes the overlay function of polygon or raster manipulation of SIG. There is an inettraction between the flood event and the factors that affect the flood by providing weighting and scoring factors so as to produce a linear combined index.

$$C_n = \sum_{i=1}^n w_i x_i \text{ or } C = w_1 x_1 + w_2 x_2 + \dots + w_n x_n \quad (1)$$

where C is a composite index representing a class status that has been scaled, w_i is the weight of parameter i, x_i is the criterion of parameter parameter i and n is the number of parameters.

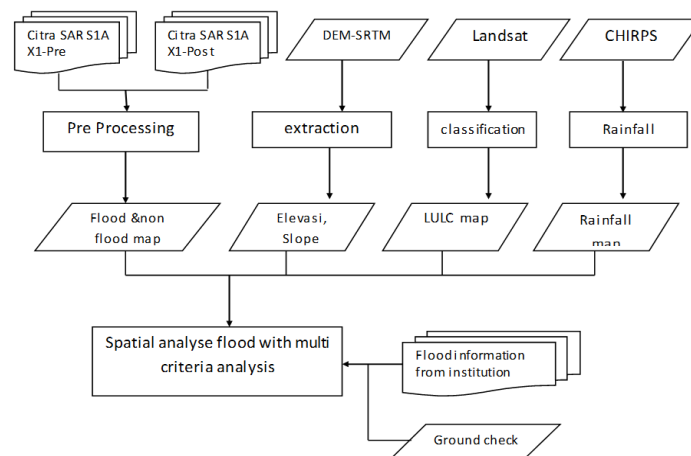


Figure 1. flow diagram of research

3. Results and Discussion

3.1 Geographical of research area

Most of Karawang regency consists of lowland with variation between 0-5 m above sea level. The northern part of Karawang regency is dominated by a wide coastal plain stretching from the eastern to the western end. Only a small part of the southern part of the plateau is bumpy and hilly with altitude between 0-1200 m above sea level.

Elevation between 0 to 7 mdpl is located in most of the northern part of Karawang regency ie in Pakisjaya, Batujaya, Tirtajaya, Cibuaya, Jayakarta, Pedes, Cilebar, Tempuran, Cilamaya Kulon, Cilamaya Wetan and Kutawaluyo subdistricts. This altitude area covers almost the majority of Karawang regency which is 48.18%. While areas with altitudes between 7 to 50 mpdl are mostly in Rengasdengklok, Rawamerta, West Karawang, East Karawang, Talagasari, Majalaya, Lemahabang, Banyusari, Tirtamulya, Jatisari, Purwasari, Klari, Telukjambe Timur and Telukjambe Barat subdistricts. The elevation of Pangkalan and Ciampel sub-districts is between 50 and 150 mdpl. While the height above 150 mdpl is in the district Tegalwaru.

Karawang regency has a slope varies between 0 - 40%. Based on the result of image processing of DEM SRTM resolution 30 m, it is found that Karawang regency with slope 0 - 2% and 2 - 8% slope with area of 139,129,58 ha and 39,286,51 ha respectively. The slope of 0-2% covers almost 73% of the total area of Karawang regency. With the distribution of its territory include Pakisjaya, Batujaya, Tirtajaya, Cibuaya, Jayakarta, Pedes, Cilebar, Tempuran, Cilamaya Kulon, Cilamaya Wetan, Kutawaluy, Rengasdengklok, Rawamerta, West Karawang, Karawang Timur, Talagasari, Majalaya, Lemahabang, Banyusari, Tirtamulya, Jatisari, Purwasari, Klari, Telukjambe Timur. While the slope of 2 - 8% covers 20.54% of Karawang regency, mostly in the district of West Telukjambe, Ciampel and Pangkalan. The slope of the slopes above 8% is located in the southern part of Tegalwaru subdistrict which is directly adjacent to Bogor and Purwakarta Regency.

Distribution of soil types in Kabupaten Karawang dominated the order Entisol from alluvium parent material. Most of this type of land is located on the northern coast to the center of Karawang regency. Coastal areas, and northern ponds are predominantly hydraquent, endoaquents and udipsamments included in wet entisols. The distribution area includes Pakisjaya, Batujaya, Tirtajaya, Cibuaya, Jayakarta, Pedes, Cilebar, Tempuran, Cilamaya Kulon, Cilamaya Wetan, Kutawaluya, Rengasdengklok, Rawamerta, Karawang Barat and Talagasari. While Karawang Timur, Majalaya, Lemahabang, Banyusari, Tirtamulya, Jatisari, Purwasari, Klari, Telukjambe Timur, Ciampel and Pangkalan belong to the order Inceptisol with great groupnya Eutrudept. Hapludox soil types included in the order of oxisols

are in most subdistricts of Cikampek, Kotabaru and Purwasari. Tegalwaru sub-district is dominated by hapludults soil type belonging to Ultisols order.

Annual rainfall in Karawang regency is dominated above 1500 mm/yr. Only a small part of the subdistrict of Cilamaya Wetan and Cilebar has annual rainfall below 1500 mm/yr. District of Pakisjaya, Tirtajaya, Cibuya, Pedes, Jayakarta Rengasdengklok, Kutawaluya, Tempuran, Cilamaya Kulon and most of Cimalaya Wetan have annual rainfall 1500 - 2000 mm/yr. While the rainfall 2000 - 2500 mm/yr is located in the district of Batujaya, East Karawang, West Karawang, Rawamerta, Talagasari, Lemahabang, Banyusari, Jatisari, Kotabaru, Tirtamulya, Purwasari, Majalaya, most of Telukjambe Timur and Telukjambe Barat. Sub-districts of Pangkalan, Ciampel, Klari, Cikampek and Tegalwaru have annual rainfall above 2500 mm/yr.

Karawang regency land cover is obtained from Landsat 8 OLI path / row.122 / 064 image processing with recording date July 19, 2017. The land cover classification is based on Indonesian National Standard on land cover. Based on the classification, Kabupaten Karawang has 12 types of land cover, among others: (1) Settlement, (2) Swamp, (3) Plantation, (4) Rice Field, (5) Pond, (6) Shrub, (7) Garden Mixed (8) Plant forest (9) Mooring, (10) Secondary dryland forest (11) Water body (12) Open land. Rice field is the most dominant land use in Karawang regency which is about 55% of the whole area of Karawang regency. Further settlement ranks second with a range of values 13% of the area of Karawang regency.

Rice fields are scattered in the north to west and east of Karawang regency covering most of the districts of Pakisjaya, Batujaya, Tirtajaya, Pedes, Jayakarta, Kutawaluya, Tempuran, Rawamerta, Talagasari, Lemahabang, Banyusari, Tirtamulya, Jatisari Majalaya, West Karawang, Cilamaya Kulon and Cilamaya Wetan. While the settlements are spread evenly and generally extends along the main road. The area of residential area with an area of 25,813.8% is seen widely in the districts of Ciampel, Telukjambe Timur Cikampek, Kotabaru and Klari which part of its territory is included in the industrial area (Figure 2).

3.2 Detection flood area using Sentinel 1A SAR image

Detection of flood areas is a further step in analyzing spatial flooding in Kabupaten Karawang. Sentinel 1A SAR image used is level 1 GRD (Ground Range Detected) ie SAR data that has been projected by using ellipsoid model of earth. At this level, it has dual polarization (HH + HV, VV + VH, HH, VV) and Interferometric Wide swath (IW) acquisition mode. IW mode has a sweep width of up to 250km with a geometric resolution of 5m x 20m. IW mode captures three sub-swaths using Terrain Observation with Progressive Scans SAR (TOPSAR). With TOPSAR technique, in addition to directing rays in range as in SCANSAR, the rays are electronically directed from the rear forward in the azimuth direction for each burst, resulting in higher image quality. IW mode is an acquisition mode for ground-level observation.

Identification of flood areas is done by extraction from SAR image Sentinel 1A. The method of change detection is used to know the flood area by using pre (before) image and post image (after) the occurrence of flood. The stages of the processing process begins with the initial processing of calibration, speckel filtering, geometric correction, classification and analysis. Sentinel 1A image processing process is done based on the application platform of ESA is SNAP (Sentinel Application Platform) version 2.0 beta-07 64bit.

After the data processing is obtained the distribution of flood area from Sentinel 1A image. The flood of area mostly occurs in the annual rainfall class of 2000 - 2500 mm and 1500 - 2000 mm. Only a small part of the flood area was detected in rainfall class above 2500 mm. While on slope class, flood area is more visible on slope class <2% and 2 - 15% while in slope class above 15% no flood is detected. The flood area is mostly located at an altitude of less than 50 meters above sea level, only a small part of the flood area is detected at an altitude of 50-150 meters above sea level. At an altitude above 150 m above sea level no flood area was detected.



Figure 2. classification of land cover in Karawang

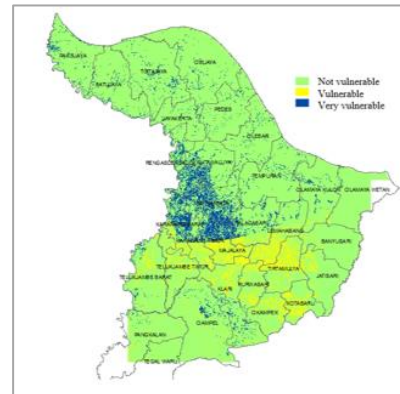


Figure 3. Potential flood hazard in Kabupaten Karawang

Entisol and alluvial flat soil type is the dominant soil type in Kabupaten Karawang. In this type of soil is also seen a lot of flood areas in 2017. In addition to the type of soil entisol, inceptisol orders with subclasses of corrugated eutrudepts also detected flood areas, although not as much as in the order entisol. While in land use class, flood area is detected in residential area, rice field and moor. Class of settlement, rice field, and mooring is the dominant class in Karawang regency. Flood areas were also detected in plantation classes, mixed gardens, open fields, swamps and rivers even in small percentages. However, in the plantation and dryland forest classes, floods are detected in very small percentages.

Flood weight calculation using Composite Mapping Analysis (CMA) based on identification of flood from Sentinel 1A SAR image, average rainfall, height, slope, soil type and land use. From the calculation of flood variables, we get the average weight of each of these variables. From the result of calculation of average weight of each flood variable, the average weight for rainfall is 0.50. While the mean weights for slope and elevation are respectively 0.30 and 0.23. The average weight of soil type and class of land use is 0.61 and 0.30. Below is the calculation of the average weight of each flood variable against the flood of 2017 area.

The highest relative weights are in soil type variables followed by rainfall variables. Land use variables and slopes have similar relative weight. While the smallest weight is found in the variable height of the region. Furthermore, from the calculation of relative weights and scores of each variable obtained the value of each variable. Variable value is obtained from the multiplication of the score with the relative weight of the flood variables.

Based on the result of flood spatial scoring analysis in Kabupaten Karawang, the potential flood hazard maps are categorized into 3 ie not vulnerable, prone and very vulnerable. The distribution area is not prone to floods in the southern part which is a highland area and the northern part of which is dominated lowland, ponds and rice fields. While the vulnerable area is in the middle of the east of Karawang. This area is dominated by settlements and also industrial estates. The existence of land use change in the area makes the area prone to flooding. While the area is very vulnerable in the middle of the western part of the district of West Telukjambe, Telumjambe East, Rengasdengklok.

4. Conclusion

The pattern of distribution of flood areas in Karawang regency in 2017 spreads in the middle group spread to the west. The flood areas are mostly dispersed in the rainfall class of 2000 -2500 mm / year and 1500 - 2000 mm/yr. While on the slope less than 3% many detected flooding. Almost half of the 2017 flood area is located at slope level of less than 3%. The flood area is mostly spread at 750 mdpl altitude, only a small area of flood spread over less than 7 m above sea level and above 50 mdpl. Inceptisol and undulating soil types as well as land use of settlements and rice fields detected the most dominant flood areas. The potential flood hazard in Karawang regency shows that flood-prone areas are in the central part of the east which is dominated by residential and industrial areas. While the area is

very vulnerable in the western part of central Karawang is a rice field area and close to the river flow in the District Rengasdengklok, Telukjambe Barat and Timur.

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