Identification of flood area in the coastal region using remote sensing in Karawang Regency, West Java

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Abstract. Flooding often occurs in the lowlands, while the area is usually a rice production centres which affects the rice crop. Rice fields is generally located on fluvial plains and usually located in coastal areas, with relatively lower altitudes than roads or settlements. Physically wetland is an area flooding hazard and wetlands tend to longer floods than surrounding areas. Flood-hazard areas are formed due to sedimentation and usually at the confluence of river. This area is a fertile area for agriculture, has shallow ground water which is well suited for residential and urban areas. Karawang regency is one of the largest producers of rice commodities in West Java, therefore the Karawang regency government faces a challenge in maintaining the level of rice production due to global climate change that worsen the threat of flood hazard, in addition to land use change and increasing population. Based on the results of the spatial analysis from period of 2000 to 2006 the wetland area have been converted up to 7,493 ha. For the period of 2006 to 2015 wetland area have been converted up to 14,416 ha. Utilization of Geographic Information System with a model of Cellular Automata - Markov Chain is an appropriate method for studying the phenomenon of expansion of build ups land in coastal region. The primary data used in the research is a land cover map of 2000, 2006 and 2015, which were the results of the multispectral classification of Landsat. The prediction of land cover change for the next fifteen years shows a continuous increase in built up area. The expansion of built up area and the possibility of widespread flood hazard areas, have inverse relationship with the decreasing of agricultural land area.

1. Introduction
Flood disasters often occur in the rainy season, especially in coastal areas, this incident is a major issue in Indonesia. Flooding is an event where normally dry land becomes flooded by water, this is caused by high rainfall and lowland upland conditions and concave areas. Geomorphological phenomenon provides information that any landform of flood-formed can inform about flood vulnerability and its characteristic. Determining the zone of flood hazard areas using remote sensing satellite imagery can be done by combining the flood phenomenon and the ability of satellite data.
Delineation of flooded areas needs to be done quickly, as it is an important spatial information to support emergency response. The level of vulnerability of flood affected areas is identified from the character of its territory such as landform, river-side slopes, meandering, natural containment, and the presence of flood control building. Landforms such as alluvial plains, alluvial valleys, river bends, and swamps are areas susceptible to flooding because it is a low or hollow region with a slope of <2% [8]. The development of information technology presents a challenge in the distribution of spatial information of flood areas that can be determined more quickly, precisely and accurately. The parameters used are land form, land cover relief, slope, soil type and rock type which is analyzed by Geographic Information System and validated by using secondary data such as data of inundation area and field survey result data. The indicator variable that has a large influence on the occurrence of floods is land cover, which is an open field land conversion from the land used for recharge becomes built up area. The purpose of this study is to describe and map the flood-hazard areas, as well as the assessment of land cover changes using Landsat-8 satellite images of 2015 in Karawang regency.

Methods for identifying flood hazard areas using satellite imagery data can be done by identifying areas that have response to flooding. The Landsat-8 image is a multispectral image that can present the earth's surface physical information from a region, the information identified from the image using the regional wetness level parameter. Band 5 (NIR) is a useful channel in the manufacture of watersheds with land that produce very low reflections. Band 5 (NIR) and Band 7 (SWIR 2) are efficient in distinguishing wet and dry soil so that wetland boundaries can be delineated. Tasseled Cap Transformation (TCT) is a mathematical formula for calculating brightness, greenness, and wetness of digital numbers in each band (band 1 to band 5 and band 7) on Landsat images [6]. Calculation of greenness level by TCT method can only be applied using Landsat satellite image, TCT can also be used to analyze dry land, wetlands. The use of spectral value transformation is an attempt to refine objects in digital data satellite imagery that will generate new information. Transformation of spectral values can be divided into two, namely (1) sharpen information, (2) summarize information from the number of existing channels [7].

Utilization of satellite imagery for flood identification has advantages compared with conventional methods, because by using the image of early delineation activity of flood and puddle areas can be done before it is validated. The wet / flooded region has a spectral response that looks darker than the unflooded area that looks bright / red. This flooded and puddle-hazard map when overlaid with river hydrological network maps will be more attractive because it can therefore be monitored for areas with the potential to experience subsequent flooding if river flow or rainfall continues to increase. The accuracy of land cover information will facilitate the analysis of the planning and development of a region. The Landsat Image 8 of 2015 in this study is used to identify current land cover conditions and wet areas indicated as flooded areas, has a resolution of 30 m and 12 bit pixels, this image data can be accessed for free, and is an opportunity for maximum utilization.

1.1. Landsat-8 Imagery

The Landsat-8 satellite (Table.1.) used on this project, has an On-board Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) sensor with 11 bands, among these bands, 9 bands (bands 1-9) are in OLI and 2 others (Bands 10 and 11) on TIRS [1].

| Sensor         | Band | Wavelength (µm) | Resolution (m) | Sensor                   |
|----------------|------|-----------------|----------------|--------------------------|
| 1. Operational Land Imager (OLI) | Band 1 | 0.43 - 0.45     | 30             | Visible (Coastal aerosol) |
|                | Band 2 | 0.45 - 0.51     | 30             | Visible (Blue)           |
|                | Band 3 | 0.53 - 0.59     | 30             | Visible (Green)          |
|                | Band 4 | 0.64 - 0.67     | 30             | Visible Red (Red)        |
|                | Band 5 | 0.85 - 0.88     | 30             | Near Infrared            |
|                | Band 6 | 1.57 - 1.65     | 30             | SWIR 1                   |
2. Thermal

Infra-red Sensor (TIRS)

| Band   | Range               | Units |
|--------|---------------------|-------|
| Band 7 | 2.11 - 2.29         | 30    |
| Band 8 | 0.50 - 0.68         | 15    |
| Band 9 | 1.36 - 1.38         | 30    |

2.11-2.29 SWIR 2
0.50-0.68 Panchromatic
1.36-1.38 Cirrus

Source: Butler, 2013 (Obtained from USGS website)

2. Method

This research applies descriptive qualitative method based on the evaluation of the existing condition, research variables include the spatial extent obtained from the results of spatial analysis with multi time. Classification of spatial analysis of land use change using topography map of year 2000, satellite image of Landsat year 2006 and year 2015. Result of extraction of topographic map of 2000 scale 1: 25,000 as reference in analysis of land use change. The steps to be implemented in this study are presented in the flow chart of the research method attached to (Figure.1).

For the purposes of identifying flood-hazard areas the Tasseled Cap Transformation (TCT) method is used, the transformation of spectral values is an attempt to sharpen objects in digital data satellite imagery that will generate new information. The new coefficients are analyzed in detail to confirm Landsat-based imagery 8, TCT indicating that the new set comes from the Landsat 8 OLI coefficient. This process as a continuation of data continuity through TCT since 1972 re-formulated TCT for OLI on Landsat 8, this technique will be very useful to study the estimated land cover for the future [2].

Land surface objects have varied spectral responses in wet / waterlogged and dry / unfertilized areas.

In the vegetated areas, during floods there is an increase in reflectance values in visible channels (band 1 - 4 OLI). In contrast to Infrared channels (NIR, SWIR, MIR) decreased. This condition is different for soil objects (open land), where both the visible and infrared spectrum decreases.

The Tasseled Cap Transformation counting procedure based on [2] is:

\[
i_1 * 0.1511 + i_2 * 0.1973 + i_3 * 0.3283 + i_4 * 0.3407 + i_5 * 0.7117 + i_6 * -0.4559 \text{ (wetness)}
\]

\[
i_1 * -0.2941 + i_2 * -0.2430 + i_3 * -0.5424 + i_4 * 0.7276 + i_5 * 0.0713 + i_6 * -0.1608 \text{ (greenness)}
\]

\[
i_1 * 0.3029 + i_2 * 0.2786 + i_3 * 0.4733 + i_4 * 0.5599 + i_5 * 0.5080 + i_6 * 0.1872 \text{ (brightness)}
\]

Figure 1. Flow chart of research methods

The spectral that can be used to assess the temperature conditions in an object on the Earth's surface is the thermal spectral. This thermal spectral usage can be done with brightness temperature analysis. Brightness and Greenness are considered to be vegetation visions, whereas between Brightness and Wetness is considered a plot of land for Landsat TM [4]. The vegetation and water
indexes derived from satellite reflection data are the two main sources of information for monitoring land cover. Land surface objects have varied spectral responses in wet / waterlogged and dry / unfertilized areas [4]. In the vegetated areas, during floods there is an increase in reflectance values in visible channels (band 1 - 4 OLI). In contrast to Infrared channels (NIR, SWIR, MIR) decreased. This condition is different for the object of land (open land), where the visible spectrum and infrared decrease [2]. From field test to NDVI spectral transformation process result gives 68.17%; The process of transformation of Principal Component Analysis (PCA) spectral value of 96.13%; And Tasseled Cap Transformation (TCT) provide an accuracy of 92.44% [7]. The result of accuracy of the process of merging the transformation of spectral values (Principal Component Analysis + NDVI + Tasseled Cap Transformation) then done the process of supervised classification gives accuracy value 92.61%, not proven to give addition of better accuracy [2].

Multicriteria analysis for flood hazard mapping, in determining flood hazard area using rainfall parameter, altitude data, slope map, soil type, geological data, land cover data, and landform. Rainfall is the main source causing flooding, areas with high rainfall have the possibility of greater flood events compared to areas with lower rainfall. In this study, rainfall data used obtained from the Meteorology Climatology Agency and Geophysics Agency. Flood events are more common in lowland areas and have flat slopes because the water tends to be slow to flow, compared to areas that are at high altitudes. Slope and elevation parameters are made using contour data from topographic maps. Different types of soils have different levels of infiltration and water holding capacity, soils with coarse textures have higher infiltration capacity than fine textured soils. But in this study, the classification of land used in the Order category [10]. Geological conditions directly affect the rate of infiltration of water in the form of deep permeation, geological data for this study obtained from geological map on a scale of 1: 100,000 Karawang Sheet, which will be used as secondary data.

Geomorphology, type of main rock, soil type, slope and rainfall as the main inputs, to recognize flood-hazard areas can be analyzed by overlaying various parameters that result in flooding. Physical characteristics of the land as inputs play a role in determining the level of flood vulnerability, therefore the form of land has an important role in this research. Because the form of land is one place where the process of running water that comes from the input of rain to the sea. A review of landforms can also represent slope conditions, drainage conditions and in general can also concern existing soil conditions. Another factor that also gives a great influence on the occurrence of flooding is the land cover that serves as a parameter against water to flow. In making the map of flood hazard to implement the overlay of the five parameters trigger the occurrence of floods, of the five factors is a big enough role is on the level of rainfall that exists.

3. Result and discussion
The result of transformation process of spectral value with Tasseled Cap Transformation (TCT) gives three bands created are commonly held to represent Brightness, Greenness and Wetness. The result of transformation process of multi-temporal colour composite spectroscopy (RGB) value can separate the appearance of rice field / wetland area with non-rice field can be seen clearly. Blue colour associated with water, red colour associated with open area / settlement / dry land / open land . For green colour associated with vegetation (Figure.2.a).

The analysis of spectral pattern can be explained briefly in (Figure.2.a.), analysis of satellite data of Landsat colour composite with RGB TCB (Tasselcap brightness) -TCW (tasselcap wetness) -TCW (tasselcap greenness) composition, giving red appearance to non-vegetated, green on areas with vegetation, and blue or dark on the appearance of waters or wet objects. The gradations of redness depend on the level of vegetation and water shortages, the less the vegetation gets wetter and the TCW gets wetter the blue or darker the colour.
Figure 2. (a) TCT RGB
Figure 2. (b) TCT Brightness
Figure 2. (c) TCT Greenness
Figure 2. (d) TCT Wetness

Result of brightness, light / white colour is dry land / open area / roof / road etc. Water gives a dark colour, while vegetation follows the density of plants with grey colour (Figure 2.b). The greenness results show the light / white colour of the vegetation, for dark colour is the wet / water area (Figure 2.c). The result of wetness of water appearance is white / bright. The darker the grey scale, for vegetation following the density if the vegetation is denser lighter if it is wet. The open area gives a darker spectral display (Figure 2.d).

The results of the analysis of flood hazard areas with multicriteria method referring to [9] (Table 1). The coastal flood hazard area can be calculated using the formula in Table 2 using the formulation of parameter 1 and parameter 4 in Table 1.

Table 2. Calculation of flood hazard class

| No. | Parameter                           | Scoring | Weighting | Value |
|-----|-------------------------------------|---------|-----------|-------|
| 1   | Calculation of flood hazard class for rainfall (30%) |         |           |       |
|     | ≥ 200 mm                            | 3       | 30        | 0.90  |
|     | 50 – 200 mm                         | 2       | 30        | 0.60  |
|     | ≤ 50 mm                             | 1       | 30        | 0.30  |
| 2   | Calculation of flood hazard classes for landcover (70%) |         |           |       |
|     | Settlements                         | 3       | 50        | 1.05  |
|     | Shrub/Farm                          | 2       | 50        | 0.70  |
|     | Rice field/ forest                  | 1       | 50        | 0.35  |
| 3   | Calculation of flood hazard characteristic of slope land (70%) |         |           |       |
|     | 0%- 2%                              | 3       | 50        | 1.05  |
|     | 2%- 4%                              | 2       | 50        | 0.70  |
|     | >4%                                 | 1       | 50        | 0.35  |
| 4   | Calculation of flood hazard coastal of slope land (70%) |         |           |       |
|     | 0%- 2%                              | 3       | 70        | 2.10  |
|     | 2%- 4%                              | 2       | 70        | 1.40  |
|     | >4%                                 | 1       | 70        | 0.70  |

Source: SNI 8197, 2015 [9]

Slope maps are processed using contour altitude and spot height data on a 1: 25,000 scale topography map. That research area has slope <2% with area 75.61%, slope 16-25% with wide 13,43%, slope 2-8% with wide 5,24% and slope> 40% with wide 5,61%. Landforms in areas susceptible to flooding due to low areas or basins with slopes <2%, or having high flood vulnerability (Table 2.), (Figure 3.) are maps of spatial assessment of flood hazard areas [9]. The average rainfall condition is 1,100 - 3,200 mm / year with the highest rainfall in January to April and December with rainfall of ≥200 mm [3].
Table 3. Calculation of coastal flood hazard class

| Weighting value (1+4) | Class interval | Hazard classes |
|-----------------------|----------------|---------------|
| 0.90+2.10=3.0         | 2.10 – 3.00    | High          |
| 0.60+1.40=2.0         | 1.10 – 2.00    | Medium        |
| 0.30+0.70=1.0         | 0.10 – 1.00    | low           |

Source: SNI 8197, 2015 [9]

Figure 3. Flood hazard map
Figure 4. TCT Analysis overlay with Flood hazard map

Landsat 8 Image Data Recordings dated October 18, 2015, transformed spectral Tasseled Cap Transformation (TCT) spectral values that can provide information on wetland conditions as an early indication of low areas and will often be inundated (Figure 4).

Projected future land cover changes will be made with the predicted changes in the present approach through spatial modelling. The prediction model uses CA-Markov, to predict future land cover changes of 16 years or in 2031, this software has the ability to simulate land cover changes with Markov chain procedures [5]. The CA-Markov model is run by using IDRISI software, the 2000 data input, 2006 data is used as the basis for projected 2015. The projected land cover change for 2031 uses 2000 data, 2006 data and 2015 data. Data used in this process is raster format data with pixel size 30x30 meter.
Indication of the result of the analysis is the decrease of wetland area and the widening of the developed land, the widened land expansion has reduced the wetland area from 51.41% of area by 2015 (Figure.5) to 45.81% from the area in 2031 (Figure.6.) And the expansion of wake land is in flood-hazard areas.

4. Conclusion
The benefits of identification of flooded and inundated areas can be used to alert communities living in the region about the dangers of flooding and puddles. Transformation of Tasseled Cap Transformation (TCT) spectral values can provide information on wetland conditions as an early indication of low areas and will often flooded. The analysis of land use change using the land transition change matrix in 2000-2015 to predict land use change in 2031 suggests that there is a significant change from converted agricultural land to built up area. Projected land use changes in 2031 indicate an increase in the build up area that converts rice fields, and in general the expansion of build up areas occupies flood-hazard areas.

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