Assessment of Forest Change Using Normalized Difference Vegetation Index (NDVI) from Satellite Landsat 8 Imagery (Case Study at Garut, West Java)

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Abstract

Due to flood happened in Garut, September 20th 2016, the stakeholders need some assessment to know why this disaster can be happened. In the fact many factors can be caused flood like water rainfall, geology structure, and land cover change. In this research land cover area, especially vegetation, was generated using NDVI from Landsat 8 OLI Imagery. NDVI are used for the purpose detecting forest area change. NDVI (Normalized Difference Vegetation Index) is a numerical indicator that uses the visible and Near Infra-Red bands of electromagnetic spectrum, to analyze and assess whether the target being observed contain live green vegetation or not. In this study, the NDVI difference was generated for two different date acquisition data. First data is 2014 and the second is 2016. From the NDVI difference described that in 2014 forest area is about 68.52 %. In 2016 forest area change into 31.33 %. It means that in two years there are deforestation activities about 37.19 %. In purpose for rapid mapping Landsat 8 and remote sensing is good enough to detect the forest change.

1. Introduction

Flood is one of many natural disasters had been occurred since a long time ago. It is an extreme event cause death or injury for human, damage loss of valuable goods, ecosystem, infrastructure, communication system, agricultural land, forest, natural environment etc. For some country, flood is the most dangerous disaster causes huge economic loss. According Centre for Research on The Epidemiology of Disasters flood had caused the huge economic loss among other natural disaster (Figure).

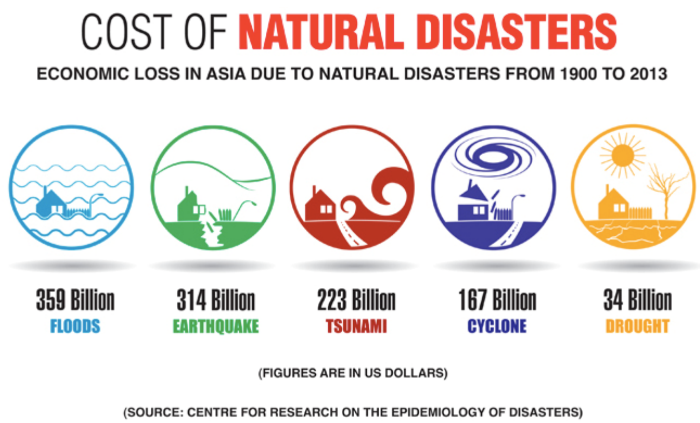


Figure 1. Cost of Natural Disaster

Natural disaster like flood can be occurred in everywhere including Indonesia. According to The Natural Disaster Hotspot: A Global Risk Analysis from The World Bank (Figure 1) Indonesia is the country that has high flood hazard decile.

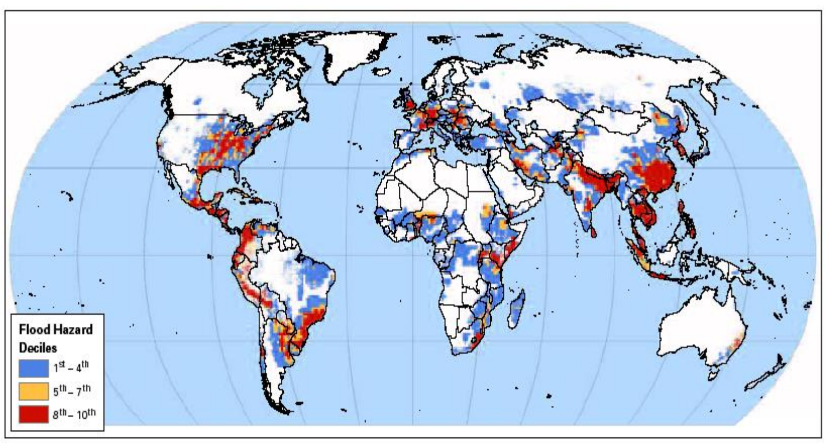


Figure 2. The Natural Disaster Hotspot: A Global Risk Analysis

Recently in September 20th 2016 there is a flood event in Garut, West Java. This flood caused death or injury to human and damage loss of valuable goods, ecosystem, infrastructure, communication system, agricultural land, forest, natural environment etc. According to Indonesia's National Agency of Disaster Mitigation there are 40 people died, 20 people missing, 6361 people evacuated and suffered loss for 288 billion rupiahs.

The high number of casualties and the amount of loss suffered due to the lack of preparedness and the anticipation of the public against the threat of flood. This is due to the lack of information about the disaster potential that is known by the public. In many areas people ignore disaster due to many reasons. Some people ignore it because the destructive disaster event happened a long time ago. It had been a story from the past. This people ignorance made them neglectful to the natural disaster occurrence potential.

Nowadays there are a lot of technology and methods for natural disaster management. One of technology and method for natural disaster management is remote sensing. Remote sensing is the acquisition of data, remotely acquired without any physical contact.

Remote sensing is among many tools available to natural disaster management. This tools is the effective tool for many decision makers to provide an accurate information for disaster management planning. Remote sensing uses satellite for the basic tools to get information about disaster. This satellite has various spectral bands that can be used for the purpose of observing natural hazard like visible bands, NIR (Near Infra-red), IR (Infrared), SWIR (Shortwave Infrared), TIR (Thermal Infrared), and SAR (Synthetic Aperture Radar). These spectral bands provide different quality and coverage information for natural disaster management. Beside that, remote sensing also provides information in multi temporal coverage. It can make easier to observe natural phenomena in various dynamic periods.

Many factor can cause flood like monsoon season, high level or precipitation, geological situation, and land use cover detection. Those factors are connecting each other. If monsoon season comes the rain will come down heavily then surface water will be raise. So there will need more land surface that can store water from the rain. Due to the change of land cover because building development in many area, the vegetation area that can hold water is decreasing. As a result, the water from the headwater directly flow to the estuary and overflowed.

So for the purpose of mitigation and preparedness, it is important to have one of many information, temporal and spatial, about forest or vegetation change area. Knowing the forest change area can make the decision maker and the other stakeholders easier to make planning for disaster mitigation.

2. Material and Method

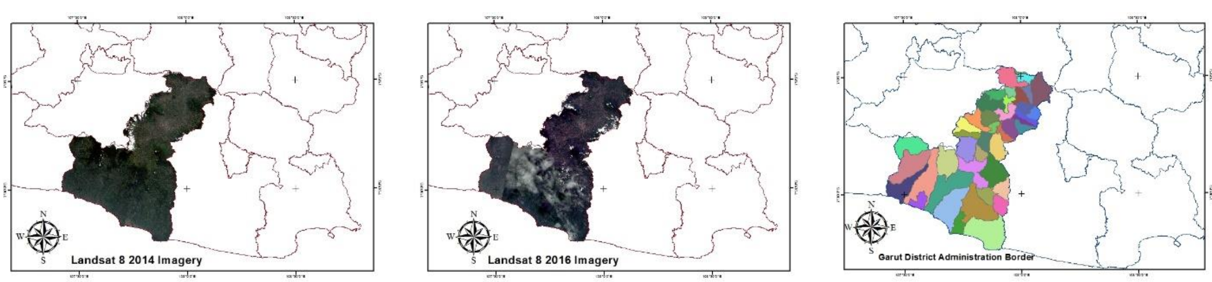
2.1. Location

The research was performed as a case study of flood at Garut, West Java, in 20th September 2016. Garut is located at 7°13′S and 107°54′E. This city is a valley surrounded by various volcanoes like Mount Galunggung, Moung Guntur, Mount Talagabodas and Mount Cikuray (Figure 3).

Figure 3. Garut surrounded by volcanoes

2.2. Spatial Dataset

The data used for this research are Landsat 8 OLI imagery in 2014 and 2016. These data used for detecting forest change in study area. Those data were radiometrically and atmospherically corrected using FLAASH, method that embedded in ENVI.



(a) (b) (c)

Figure 4. Spatial Dataset

This research required spatial data set such as (a) Mosaic image of Landsat 8 image path 122 row 65 acquired in June 9th 2014 and Landsat 8 image path 121 row 65 acquired in August 5th 2014 (b) Mosaic image of Landsat 8 image path 122 row 65 acquired in September 2nd 2016 and Landsat 8 image path 121 row 65 acquired in June 7th 2016 (c) Garut district administrative boundary with scale 1:25000 produced by Geospatial Information Agency of Indonesia in 2009.

2.3. Process Flow

The process flow of this research described in Figure 5 where all of data will be contained by administrative boundary. Commonly there are three main processes which are image processing, determining NDVI, and image detection.

The first process is mosaicking two Landsat 8 images in same year. The purpose of this process is to get full area of research. After mosaicking, performing preprocessing of Landsat 8 imagery which are acquisition in 2014 and 2016. Preprocessing consist of radiometric and atmospheric correction. After getting corrected imagery, clipping by administrative boundary was performed. This step aims to get imagery based on research area.

The second process in this research is performing NDVI analysis. NDVI are used for the purpose detecting forest area change. NDVI (Normalized Difference Vegetation Index) is a numerical indicator that uses the visible and Near Infra-Red bands of electromagnetic spectrum, to analyze and assess whether the target being observed contain live green vegetation or not.

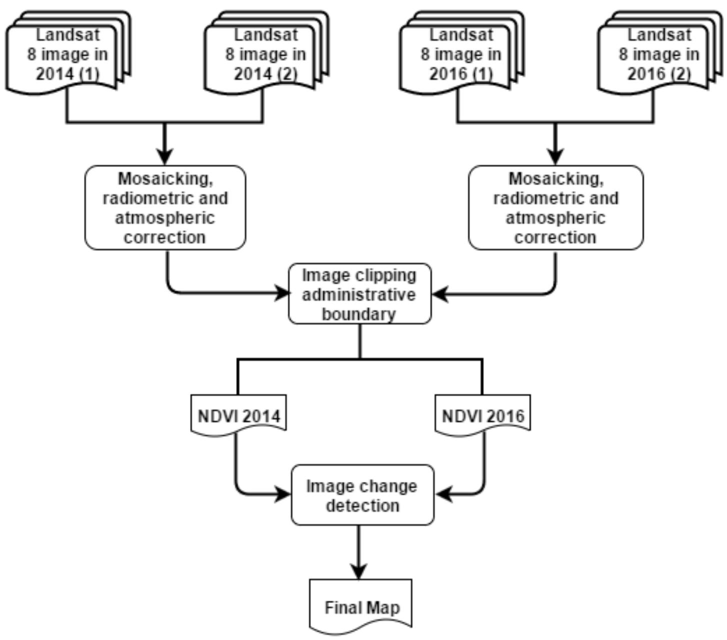


Figure 5. Data Processing Flow

Generally, healthy vegetation will absorb most of the visible light that falls on it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. Bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum (Holme *et al* 1987).

Since we know the behavior of plants across the electromagnetic spectrum, we can derive NDVI information by focusing on the satellite bands that are most sensitive to vegetation information (near-infrared and red). The bigger the difference therefore between the near-infrared and the red reflectance, the more vegetation there has to be.

The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

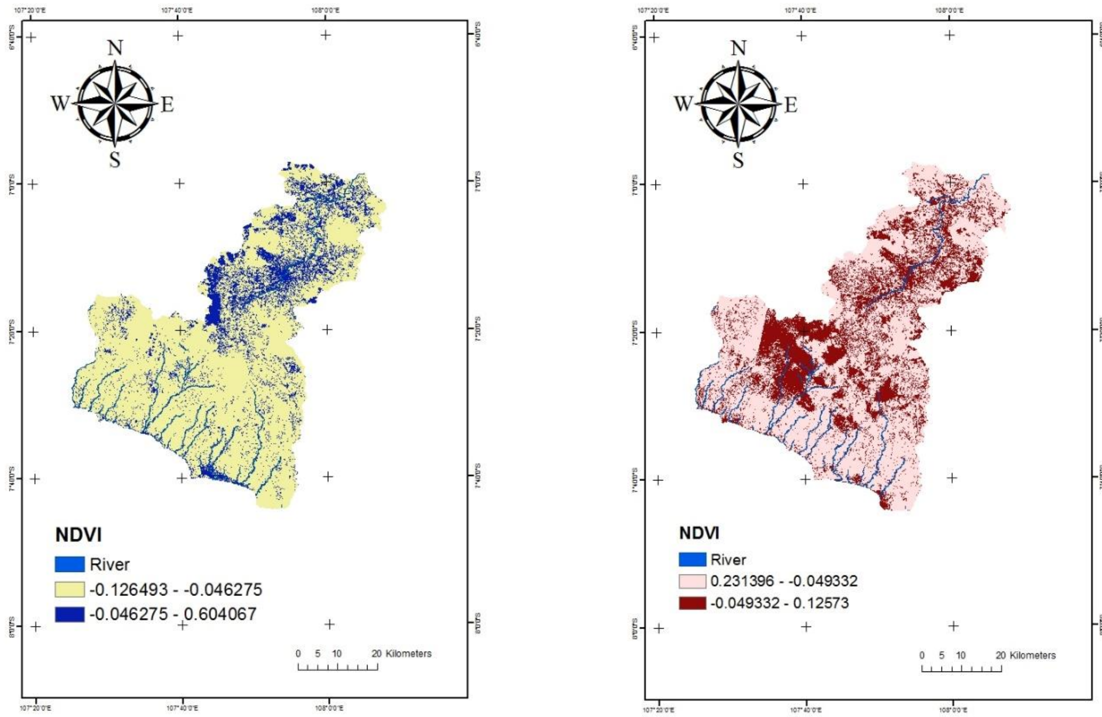
This formulation allows us to cope with the fact that two identical patches of vegetation could have different values if one were, for example in bright sunshine, and another under a cloudy sky. The bright pixels would all have larger values, and therefore a larger absolute difference between the bands. This is avoided by dividing by the sum of the reflectance.

Theoretically, NDVI values are represented as a ratio ranging in value from -1 to 1 but in practice extreme negative values represent water, values around zero represent bare soil and values over 6 represent dense green vegetation.

The last process of this research is generating image change detection. This process aims to calculate the different area of forest between 2014 and 2016.

3. Result

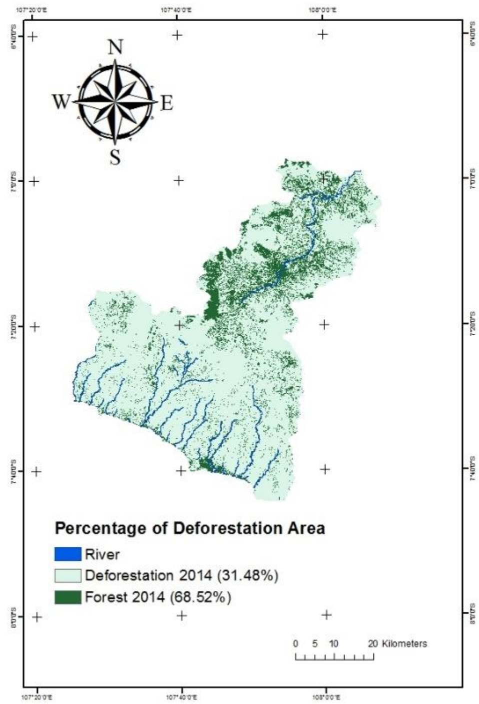
NDVI generating in this research has 2 classes such as forest and deforestation area. In Figure 6 we can see that in 2014 Deforestation area and forest area have vegetation index consecutively between -0.126493 - -0.046275 and -0.046275 - 0.604067. In 2016 Deforestation area and forest area have vegetation index consecutively between -0.231396 - -0.049332 (a) and -0.049332 - 0.12573 (b).



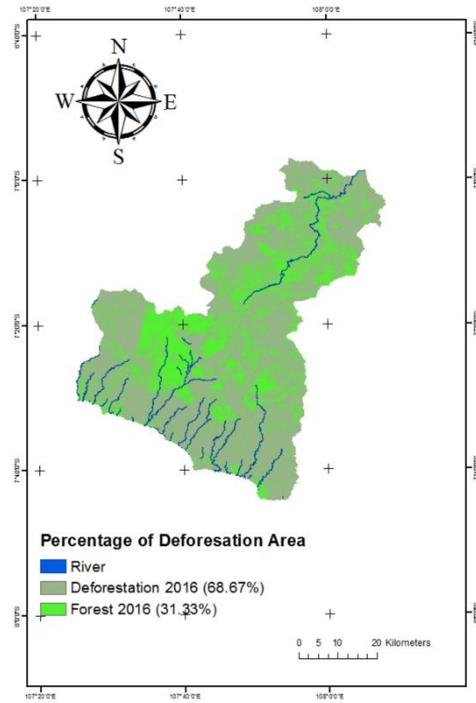
(a) (b)

Figure 6. NDVI

From that NDVI the other parameter we can also see how much deforestation happened in 2 years. In Figure 7, In 2014 deforestation area reach 31.48 % and forest area reach 66.52 % (a). In 2016 there is 66.67 % of deforestation area and 31.33 % forest area (b). It means that in recent two years had happened deforestation for 37.19 %.



(a)



(b)

Figure 7. Percentage of Deforestation Area

Deforestation in this area can be affected by the change of land use and land cover due to the raising of population.

4. Discussion

This research is presented for detecting change area of forest in Garut due to flood happened on September 20th 2016. From the research we can get the rapid result about forest area. This research can be useful for stakeholders to make decision about disaster management. From the result they can make planning for mitigation, emergency response, and recovery.

In remote sensing, Landsat 8 imagery is useful technology to make rapid assessment for disaster management purpose. It is widely available imagery, free cost, and can be downloaded every time we need. The spatial resolution of Landsat 8 image of 30 m is good enough to make an initial assessment of natural disaster.

In further research we can make others analysis from other bands in Landsat imagery like surface temperature, flood water, soil moisture etc. The more information we get more easy to make decision about natural disaster management activities. Also, in further research we can use higher resolution imagery like SPOT, Pleiades, Quickbird, and others. Even we can use imagery from an active sensor like Radar for night measurement purpose.

5. Conclusion

This study explores a commonly used approach of Landsat 8 OLI imagery for detecting the change area of forest. In this study, the NDVI difference was generated for two different date acquisition data. First data is 2014 and the second is 2016. From the NDVI difference described that in 2014 forest area is about 68.52 %. In 2016 forest area change into 31.33 %. It means that in two years there are deforestation activities about 37.19 %. In purpose for rapid mapping Landsat 8 and remote sensing is good enough to detect the forest change.

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