

# Analysis of Land Use Changed in Ponorogo Based on Landsat 8 Imaginary using NDVI Classification

Arif Basofi\*, Nadia Widad Naufalita, Arna Fariza, Ahmad Syauqi Ahsan

Department of Informatics and Computer Engineering  
Politeknik Elektronika Negeri Surabaya  
Surabaya, Indonesia

Corresponding author e-mail: ariv@pens.ac.id

**Abstract.** Land use is a form of human intervention inland to meet the needs of both material needs and spiritual needs. Land use analysis is important for agricultural planning, urbanization and environmental studies. Remote-sensing data and GIS are an appropriate tool for the assessment of the global land-use change and environmental monitoring because of its spatial and temporal coverage capabilities. The change detection and assessment of land use using geospatial information allow the user to monitor land user over the large area and over a period of time. This study aims to classify land use in Ponorogo using Landsat 8 imagery. The normalized difference vegetation index (NDVI) is used for the mapping of changes in the land cover. In this study the NDVI based classification has indicated about significant change in land use between year 2015 and 2017. The major change has been found in areas with dense vegetation such as forest, farm, where about 4.22% of areas have been degraded between year 2015 and 2017.

## 1. Introduction

Land use is a form of human intervention inland to meet the needs of both material needs and spiritual needs [1]. The latest land use information in the form of maps can be obtained through remote-sensing techniques. Remote sensing has long been an important and effective means of monitoring land use with its ability to provide information on the spatial diversity on the surface of the earth quickly, widely, precisely, and easily [2][3][4][5].

Land-use analysis is important for agricultural planning, urbanization and environmental studies [6][7], and this information also helps to understand the relationship between cropland, forest land, settlement, etc. In recent times. The modernization and demographic pressure have increased the land use and simultaneously affected the land use [8]. Remote-sensing data and GIS are an appropriate tool for the assessment of the global land-use change and environmental monitoring because of its spatial and temporal coverage capabilities [9].

The change detection and assessment of land use using geospatial information allow the user to monitor land user over the large area and over a period of time. This study aims to classify land use in Ponorogo using Landsat 8 imagery. The normalized difference vegetation index (NDVI) is used for the mapping of changes in the land cover [10][11]. The classification results are maps of the latest Ponorogo land use that can be used for various studies, especially in identifying landslide prone areas in Ponorogo.



## 2. Related Works

In order to facilitate the process of land use classification in Ponorogo, theory and previous research is needed, which can be used as references in this study.

Singh et al. used the NDVI based classification has indicated about significant change in land use between a year 1990 and 2014 [11]. The Major change has been found in the forest cover area where about 113 km<sup>2</sup> (2.9%) of forest have been degraded, and about 115.4 km<sup>2</sup> area of wetland has been lost between year 1990 and 2014. Januar et al. carried out the identification of land cover in the Landsat 8 May 29, 2015 acquisitions of the city of Semarang [12]. The method used is the analysis of NDVI and combination of NDVI BSI, which later developed land cover classes consist of five classes, including water, barren. Settlements, rice fields and vegetation classification results are then compared with reference Maximum Likelihood classification. Results from this study at the level of accuracy obtained NDVI classification results amounted to 49.43% with the user's accuracy for the class of water by 76.15%, barren by 12.60%, settlements by 85.37%, rice fields by 25.44% and vegetation by 65.55%. As for the combination of NDVI BSI classification results obtained by 60.14% accuracy level with the user's accuracy for the class of water by 77.03%, barren by 8.07%, settlements by 82.47%, rice fields by 39.48% and vegetation by 65, 88%.

Arif et al. determined the change in the density of vegetation and extensive Jati forests in the KPH Randublatung [13]. The method used to determine the density of the forest vegetation to determine the identity that is based on the analysis of vegetation index NDVI (Normalized Difference Vegetation Index) using image Landsat 7 ETM + recording in 2000 and 2011. Based on the results of data processing, in 2000 area forest vegetation in the KPH Randublatung of 25.528,33 ha, with does not too heavy density has the highest value obtained from the analysis of vegetation index NDVI is an area of 10.815,33 ha. Meanwhile in 2011, area forest vegetation in the KPH Randublatung of 12.451,37 ha, with rare densities has the highest value area of 5.105,77 ha. Thus from 2000 to 2011, land covers Jati forest vegetation in the KPH Randublatung changing area of 13.076,96 ha. In this study, land-use classification in Ponorogo is carried out using Landsat 8 imagery, which later can be developed and used to analyze various events such as landslides, logging, etc.

## 3. System Design

In this study, we divided it into three parts, namely input, process, and output. figure 1 shows the design system in general.

The following is an explanation of the design system in general of this study:

### A. Input

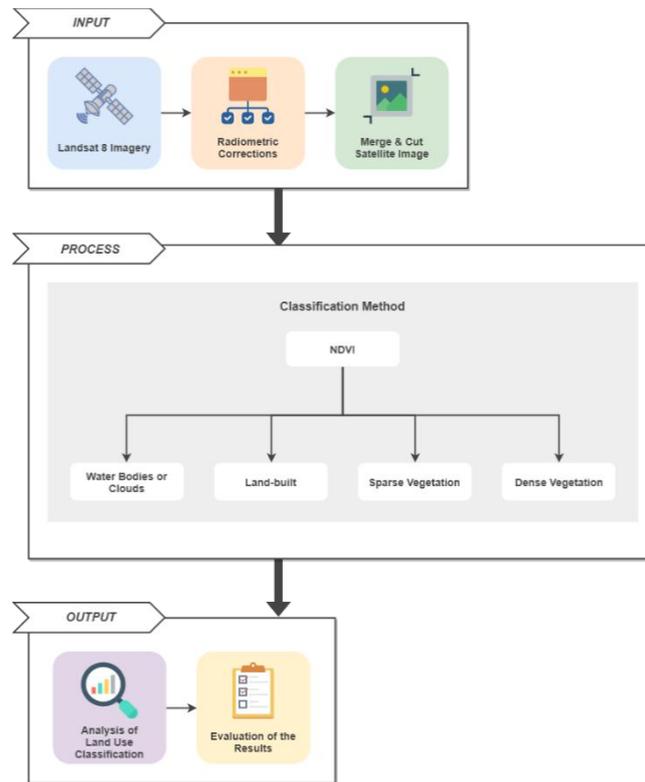
At this stage, Landsat 8 and SRTM satellite images were downloaded from USGS page <https://earthexplorer.usgs.gov/>. After that, radiometric correction is performed to correct the pixel value of the satellite image so that it matches the value it should, usually it considers atmospheric interference as the main source of error. It next is to cut the image using the ArcGIS software.

### B. Process

At this stage, classification is carried out using NDVI method. This method is using a combination of band 4 (red) and band 5 (NIR). The NDVI values itself is used to compare the greenness level of vegetation (chlorophyll content) in plants so that later land use can be known in Ponorogo. The output is divided into 4 classes of land use namely water bodies/clouds, land-built, sparse vegetation, and dense vegetation.

### C. Output

At this final stage, the result of classification is being analyzed and compared changes in each land use class per year. To evaluate the result of NDVI classification, confusion matrix is being calculated.



**Figure 1.** Design system in General

#### 4. Experiment And Analysis

##### A. Image Acquisition

The image of this study area was taken from 2015 to 2017. table 1 shows the details of the image used in this study.

**Table 1.** Detals of image used in this study

Path/Row	Date	Spatial Resolution
119/65 and 119/66	22/05/2015	30 meter
119/65 and 119/66	27/07/2016	30 meter
119/65 and 119/66	28/06/2017	30 meter

##### B. Radiometric Corrections

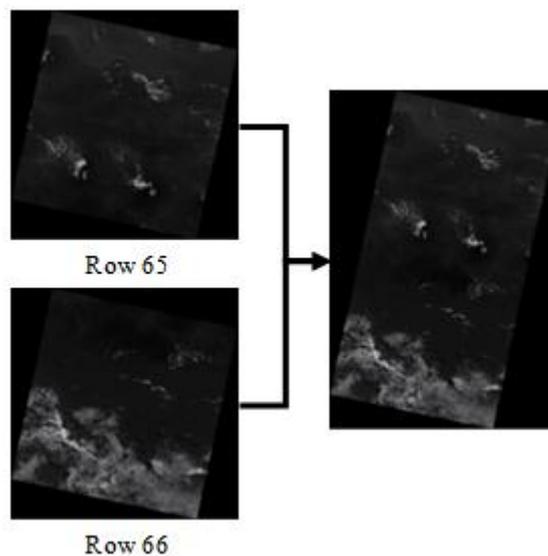
Before processing the satellite image, the first step to do is to do radiometric correction as shown in figure 2. This is because there are several variables that interfere with the quality of data such as reflecting sunlight, shifting latitude and longitude, etc. Landsat 8 satellite images used are at Level 1T (corrected terrain), so the image does not need to be corrected geometrically. This process is carried out using QGIS software.

##### C. Merging and Cropping

Geographically, Ponorogo is located at latitude -7.8685 and longitude 111,462 and for Landsat 8 is in Row 65 Path 119 and Row 66 Path 119 scene numbers and. Therefore, it is necessary to merge the two satellite image data as shown in figure 3.



**Figure 2.** Radiometric correction result



**Figure 3.** Merging satellite image

Cropping aims to cut the image in the research area using vector map of Ponorogo. The vector map contains latitude and longitude information from Ponorogo. Both merging and cropping are carried out using ENVI software. The result of the cropping process can be seen in figure 4.



**Figure 4.** Cropping satellite image

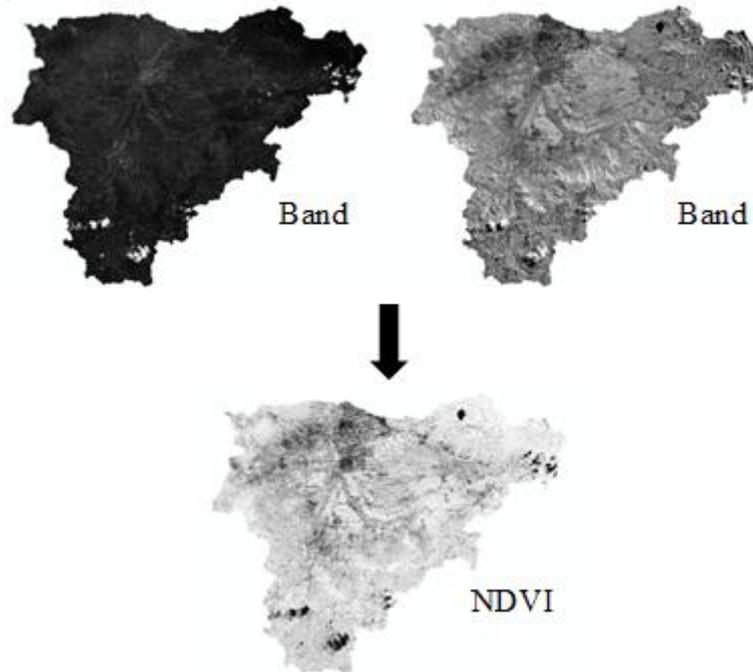
#### *D. NDVI Calculaion*

NDVI is an index based on spectral reflectance of the ground surface feature. Each feature has its own characteristic reflectance varying according to the wavelength. NDVI values ranges between -1 to +1. A Higher value of NDVI infers the presence of healthy vegetation in the area while its lower value is the indicator of sparse vegetation. NDVI has been used for analysis of change detection in many studies [14][15].

At this stage, NDVI calculation is used to determine the vegetation index in Ponorogo. NDVI values range from -1.0 to +1.0, where values close to -1.0 indicate areas with low vegetation and values, close to +1.0 indicate areas with high vegetation. In the NDVI calculation, band 4 (red) and band 5 (NIR) are used on Landsat 8 by dividing the reduction of the two bands with the addition of the two bands. The NDVI formula (1)

$$NDVI = \frac{NIR - red}{NIR + red} \quad (1)$$

After calculating the NDVI value using the formula above, the results are shown in figure 5.



**Figure 5.** NDVI Calculation

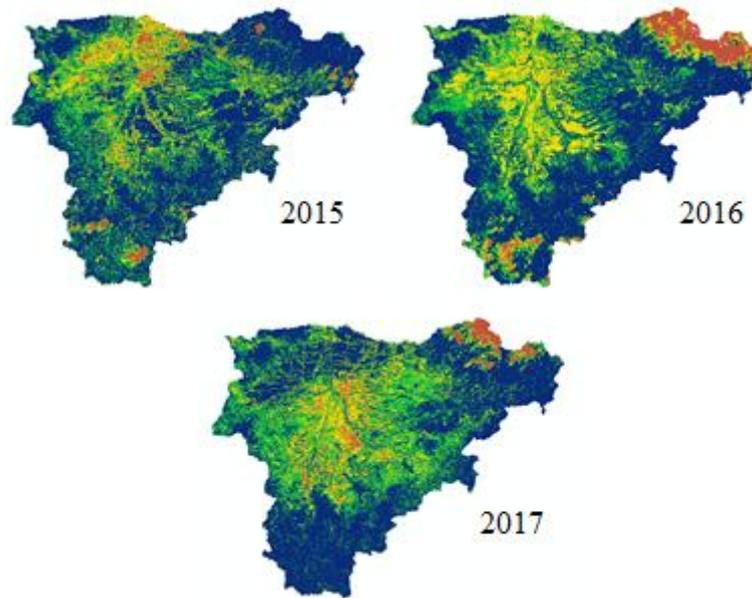
#### *E. Reclassification of Raster Data Based on NDVI Values*

Reclassification is a process of reclassifying input raster data into several classifications at certain intervals on output raster data. The reclassification process is divided into four land use classes that are water bodies and clouds, built-up land, sparse vegetation, and dense vegetation. The method used in this reclassification process is Natural Breaks (Jenks).

The results in figure 6 shows that the dominant blue color represents areas with dense vegetation, green represents areas with sparse vegetation. Yellow represents the built-up areas, and red represents water bodies and clouds. The following divisions of classification and range of NDVI values are shown in table 2.

**Table 2.** Legend of landuse classification results

Classification	Color	Range of Values
Water bodies, clouds	Red	< 0.0
Land-built	Yellow	0.0 – 0.5
Sparse vegetation	Green	0.5 – 0.7
Dense vegetation	Blue	> 0.7



**Figure. 6.** Landuse classification results

The value of NDVI indicates that raster data with values below 0 are identified as water bodies and clouds, raster data with values of 0 to 0.5 are identified as areas of built-up land, raster data with values of 0.5 to 0.7 are identified as areas with sparse vegetation, and data raster with values above 0.7 is identified as areas with dense vegetation.

#### *F. Classification Test*

To find out the level of accuracy of the mapping, a classification test must be done. Classification accuracy test is carried out using confusion matrix. Testing the accuracy of classification is performed by comparing the data training with classified image. In this study, 50 sample points are carried out for the entire area. The amount of data training can be seen in table 3.

**Table 3.** Amount of landuse data training

Classification	Total Data
Water bodies/clouds	2 data
Land built	11 data
Sparse vegetation	18 data
Dense vegetation	19 data
Total Data	50 data

Furthermore, data testing is obtained based on field data that can be checked by digital observation. Data testing is used as a reference for giving classification results and calculating true or false. The amount of data testing can be seen in table 4.

**Table 4.** Amount of landuse data testing

Classification	Total Data
Water bodies/clouds	2 data
Land built	9 data
Sparse vegetation	16 data
Dense vegetation	23 data
Total Data	50 data

From 50 sampling points in the field, the overall accuracy from 2015 was 84%, whereas in 2016, the overall accuracy was 80%, and in 2017, the overall accuracy was 82%. Overall accuracy is calculated as the sum of the diagonal divided by the total observation point. Image classification is considered correct if the results of the confusion matrix calculation  $\geq 80\%$  (Short, 1982), so that the classification results have met the requirements.

### G. Comparison Analysis of the Area

Based on the results of classification, the following is the comparison of the area of each land cover class of three years as shown in table 5.

**Table 5.** Change in landuse of study area in 2015

Land Use	Pixels	Area	Percentage
Water bodies/clouds	57053	49.80 km <sup>2</sup>	3.63%
Land built	195956	171.20 km <sup>2</sup>	12.48%
Sparse vegetation	425101	371.34 km <sup>2</sup>	27.07%
Dense vegetation	892308	779.45 km <sup>2</sup>	56.82%
Total	1570418	1371.79 km <sup>2</sup>	100%

In the table 5, it shows that in 2015, there were 3.63% of satellite imagery is red indicating water bodies or clouds, 12.48% are yellow indicating land built, 27.07% are green indicating areas with sparse vegetation, and 56.82% is blue indicating areas with dense vegetation.

**Table 6.** Change in landuse of study area in 2016

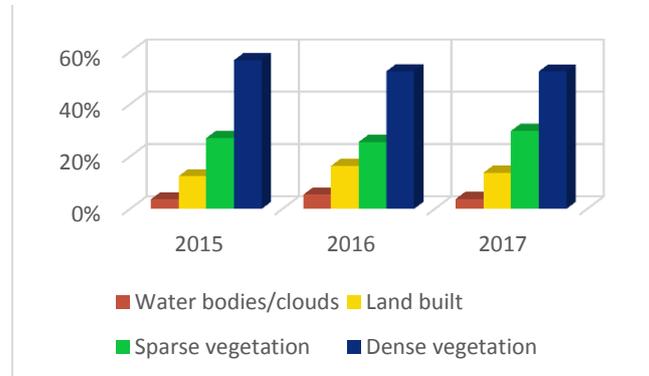
Land Use	Pixels	Area	Percentage
Water bodies/clouds	85201	74.49 km <sup>2</sup>	5.43%
Land built	257377	224.97 km <sup>2</sup>	16.40%
Sparse vegetation	401373	350.76 km <sup>2</sup>	25.57%
Dense vegetation	825479	721.56 km <sup>2</sup>	52.60%
Total	1569430	1371.78 km <sup>2</sup>	100%

**Table 7.** Change in landuse of study area in 2017

Land Use	Pixels	Area	Percentage
Water bodies/clouds	59386	51.85 km <sup>2</sup>	3.78%
Land built	216913	189.44 km <sup>2</sup>	13.81%
Sparse vegetation	468633	409.34 km <sup>2</sup>	29.84%
Dense vegetation	825401	721.01 km <sup>2</sup>	52.56%
Total	1570333	1371.64 km <sup>2</sup>	100%

In the table 6, it shows that in 2016, there were 5.43% of satellite imagery is red indicating water bodies or clouds, 16.40% are yellow indicating land built, 25.57% is green indicating areas with sparse vegetation, and 52.60% is blue indicating areas with dense vegetation.

In the table 7, it shows that in 2017 there were 3.78% of satellite imagery is red indicating water bodies or clouds, 13.81% is yellow indicating land built, 29.84% is green indicating areas with sparse vegetation, and 52.56% is blue indicating areas with dense vegetation. The transformation of land use from 2015 to 2017 can be seen in figure 7.



**Figure 7.** Graphical Presentation of Change in Land Use of the Study Area

From the figure 7, it shows that area with dense vegetation such as forest, farm, and other areas with high level of greenness is dominating Ponorogo. It also can be seen that the percentage of areas with dense vegetation has decreased from year to year. This shows that land conversion occurs in Ponorogo such as logging, making rice fields, etc.

## 5. Conclusion

Comparison of the 2015 and 2017 classification result show a significant change in land use. In recent times the modernization, increasing demographic pressure, and over-exploitation of natural resources have become a major threat for degradation of forest cover. The total of forest cover 57.89 km<sup>2</sup> have been lost between the year 2015 and 2017 due to agricultural intensification and human encroachment. This alarming condition is required a scientific management of land use for sustainable development in the area.

## References

- [1] M.S.S. Ali, M. Arsyad, A. Kamaluddin, N. Busthanul, and A. Dirpan, "Community based disaster management: Indonesian experience", In IOP Conference Series: Earth and Environmental Science, Vol. 235 No. 1, pp 012012), IOP Publishing, 2019
- [2] S. E. Franklin, E. E. Dickson, M. J. Hansen, D. R. Farr, and L. M. Moskal, "Quantification of landscape change from satellite remote sensing", The Forestry Chronicle, Vol. 76 No. 6, pp. 877-886, 2000
- [3] X. Xu and X. Min, "Quantifying spatiotemporal patterns of urban expansion in China using remote sensing data", Cities, Vol. 35, pp. 104-113, 2013
- [4] C. Gong, S. Yu, H. Joesting, and J. Chen, "Determining socioeconomic drivers of urban forest fragmentation with historical remote sensing images", Landscape and urban planning, Vol. 117, pp. 57-65, 2013
- [5] P. S. Thenkabail, M. K. Gumma, P. Teluguntla, and I. A. Mohammed, "Hyperspectral remote sensing of vegetation and agricultural crops", Photogrammetric Engineering and Remote Sensing (PE&RS), Vol. 80 No. 8, pp. 697-723, 2014
- [6] S. Huang, F. Siegert, J. G. Goldammer, and A. I. Sukhinin, "Satellite - derived 2003 wildfires in southern Siberia and their potential influence on carbon sequestration", International Journal of Remote Sensing, Vol 30 No. 6, pp. 1479-1492, 2009
- [7] J. P. Nunes, J. Seixas, and J. J. Keizer, "Modeling the response of within-storm runoff and erosion dynamics to climate change in two Mediterranean watersheds: A multi-model, multi-scale approach to scenario design and analysis", Catena, Vol. 102, pp. 27-39, 2013

- [8] G. C. Myers and C. G. Muschkin, Demographic consequences of migration trends in Puerto Rico: 1950-1980, *International migration* (Geneva, Switzerland), Vol. 22 No. 3, pp. 214-227, 1984
- [9] R. P. Singh, N. Singh, S. Singh, and S. Mukherjee, "Normalized difference vegetation index (NDVI) based classification to assess the change in land use/land cover (LULC) in Lower Assam, India", *International Journal of Advanced Remote Sensing and GIS*, Vol. 5 No. 10, pp. 1963-1970, 2016
- [10] Y. Shao, R. S. Lunetta, J. Ediriwickrema, and J. Iiames, "Mapping cropland and major crop types across the Great Lakes Basin using MODIS-NDVI data", *Photogrammetric Engineering and Remote Sensing*, Vol. 76 No. 1, pp. 73-84, 2010
- [11] R. P. Singh, N. Singh, S. Singh, and S. Mukherjee, "Normalized difference vegetation index (NDVI) based classification to assess the change in land use/land cover (LULC) in Lower Assam, India", *International Journal of Advanced Remote Sensing and GIS*, Vol. 5 No. 10, pp. 1963-1970, 2016
- [12] D. Januar, A. Suprayogi, dan Y. Prasetyo, "Analisis Penggunaan NDVI dan BSI untuk Identifikasi Tutupan Lahan pada Citra Landsat 8 (Studi Kasus: Wilayah Kota Semarang, Jawa Tengah)", *Jurnal Geodesi Undip*, Vol. 5 No. 1, pp. 135-144, 2016
- [13] A. Witoko, A. Suprayogi, and S. Subiyanto, "Analisis Perubahan Kerapatan Vegetasi Hutan Jati Dengan Metode Indeks Vegetasi NDVI (Studi Kasus: Kawasan KPH Randublatung Blora)", *Jurnal Geodesi Undip*, Vol. 3 No. 3, pp. 28-43, 2014
- [14] S. Huang and F. Siegert, "Land cover classification optimized to detect areas at risk of desertification in North China based on SPOT VEGETATION imagery", *Journal of Arid Environments*, Vol. 67 No. 2, pp. 308-327, F. 2006
- [15] D. E. Ahl, S. T. Gower, S. N. Burrows, N. V. Shabanov, R. B. Myneni, and Y. Knyazikhin, "Monitoring spring canopy phenology of a deciduous broadleaf forest using MODIS", *Remote Sensing of Environment*, Vol. 104 No. 1, pp. 88-95, 2006

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