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Assessment of land use change in Bedadung Jember watershed using landsat-8 satellite imagery

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Abstract. Increased population growth will impact on changes in land use for human settlements and other living needs. It is caused to land use change that negatively impacts the environment if it is not managed properly. Therefore, the information regarding to land use map is essentially needed. This research aims to asses land use change in Bedadung Jember watershed using a remote sensing technology as Bedadung watershed is one of the largest watersheds through the settlement areas of Jember regency. Remote sensing technology is widely used to provide any information such as land use changes without having an immediate monitoring in site. Therefore, it can be used to monitor land use changes in an area regularly. Landsat-8 has 30x30 m resolution is one of remote sensing technologies which is suitable for this research. The method of classifying land use change used supervised classification with Normalized Difference Vegetation Index (NDVI) analysis approach in Geographic Information System (GIS). The results showed that within 16 years from 2001-2017, Bedadung Jember watershed had increased its settlement areas to 36,79 km^2 or 2,66%, forest areas are decreased to 47,98 km^2 or 3,47%, paddy field areas are decreased to 122,33 km^2 or 8,84%, open areas are increased to 3,86 km^2 or 0,28%, shrub areas are increased to 37,68 km^2 or 2,72% and plantation areas are increased to 90,82 km^2 or 6,57%. Simulation results with daily rainfall plans on land use in 2001 and 2017 show that the peak discharge generated in 2001 was 68.8 m3/s, while in 2017, it was 103.9 m3/s. Peak discharge in 2017 is higher than in 2001. This simulation shows that the condition of land use in 2001 is better than in 2017.

1. Introduction

Population growth rates highly impacts the land use changes as it increases the land necessity for human life. It's resulted to nature imbalance that we need to address with planning and development to lands that their function has changed. In regard to plan and develop an area, accurate data is required to support such as land cover map.

The identification of land cover map which is conducted directly in site requires fund, time and energy which resulted to the monitoring of land use changes that can't be conducted regularly. Therefore, it requires a technology which is able to identify the entire or some objects on the earth surface regularly. Remote sensing technology is able to identify objects on the earth surface that can be used to monitor the land use changes in an area. Many researchers have stated that remote sensing technology can be used to detect the land use changes and have been proven widely and accurately in providing the information regarding to land use changes and monitor it periodically. [1][2] The information regarding to land use changes is essentially needed due to its impacts to hydrological characteristic of watersheds [3].

Landsat-8 is one of remote sensing technologies which has 30x30 m resolution that is suitable for this research [4]. Land use changes use supervised classifications with Normalized Difference Vegetation Index (NDVI) approach in Geographic Information System (GIS). classification has widely used since 2010 [2].

Meanwhile, the composition of forest areas in Bedadung watershed has decreased which was once as a catchment to agricultural land. The upstream areas which turned into agricultural land caused the water to flow immediately to river along with soil without being absorbed. The impact of forest areas

reduction is flood in Bedadung watershed [5]. National Agency for Disaster Management (BNPB) of Jember regional in 2016 recorded that 17 districts in Jember were prone to flood and landslides during rainy season. Bedadung watershed is one of three biggest watersheds through the settlement areas of Jember regency. Therefore, monitoring to land use change is needed in Bedadung watershed.

2.   Methods
2. 1 Study area
The research sites (S 70 58' 8" – S 80 23' 31,872" and E 1130 35'– E 1130 28' 26,514") is Bedadung watershed in Jember regency. (Figure 1).
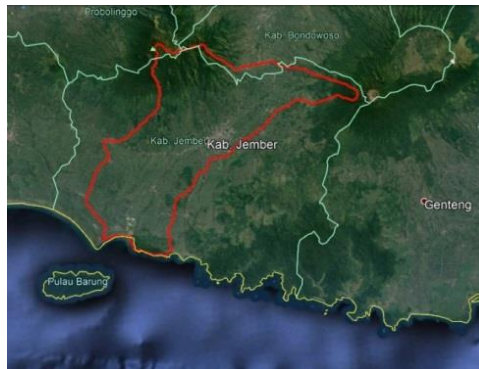
Figure 1. Reaserch Site.

2. 2 Tools and material
Data used is landsat-8 satellite imagery in 2017 on path/row 118/066 and 117/066, was obtained from www.earthexplorer.usgs.gov and RBI maps from Indonesian Geospatial Information Agency. This research also used ArcGIS 10.3 software and Er Mapper 7.1

2. 3 Methods
There are 2 steps in creating land cover map as follows:
1.   Pre-Processing
     a. Geometric correction, correct image data to geographic information system so that image information follows the actual existence on earth [6]. It's also called as "Rectidication" (the process of geometric correction between images that haven't been fixed with the map)
     b. Radiometric correction, to improve the visual quality and reduce errors which are caused by atmospheric disturbance during the recording [7].
     c. Cut image, to create Bedadung watershed border and reduce the image size.

2.   Data Processing
     a. IImage Enhancement, a step to clarify the appearance of image by displaying the color compositions of red, green and blue (RGB) [8] and manipulate spectral image to sharpen the image of certain object [9]. It's used ArcGIS 10.3 software.
     b. NDVI Transformation, to modify "band" to discover several aspects that determine the level of greenness as the distribution of vegetation areas [10]. All Bedadung watershed areas is differentiated into 7 classes which are forests, plantations, settlement areas, agriculture, bush, water body and open field.
     c. Image classification, to classify the similar display. This classification used supervised classification, a grouping process of various pixels into groups based on the similarity of

pixel spectral values [11] as well as used classification of remote sensing data based on numbers (digital numbers).

2. 4   Accuracy assessment

Accuracy assessment, to correct the interpretation results with Google earth based on accuracy test by using confused matric and then calculates the accuracy of "Kappa" equation. Kappa equation can be calculated by the equation of 1 [12] [13] [14]:

$$Kappa\ (K) = \frac{N \sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r} X_{i+} X_{+i}}{N^2 - \sum_{i=1}^{r} X_{i+} X_{+i}}\ 100\ \% \tag{1}$$

Where :

Xii = observation in row i and column i

Xi+ = marginal total of column i

X+i = marginal total of row i

N   = total number of observation, r = number of rows and columns in error matrix

## 3. Results and Discussion

3. 1   Image mosaic

Landsat 8 is one of imagery satellite in remote sensing that is used to monitor land use change without a direct observation in site and also can be used to differentiate forests, plantations and agriculture. Mishara et al., Alam et al and Juliev et al stated that landsat-8 can differentiate forests, water body, buildings, vegetation and open fields [15][16][17]. Image mosaic is an action combining image between path/row 118/066 (acquisition date June 5th 2017) and 117/066 (acquisition date July 16th 2017) which are cut based on the boundary of Bedadung watershed.
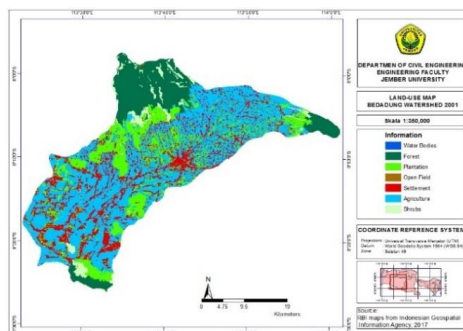

Figure 2. Reaserch site

3. 2   Land cover classification

Classification result of land cover in Bedadung watershed in 2017 from Landsat-8 is explained on Figure 3.
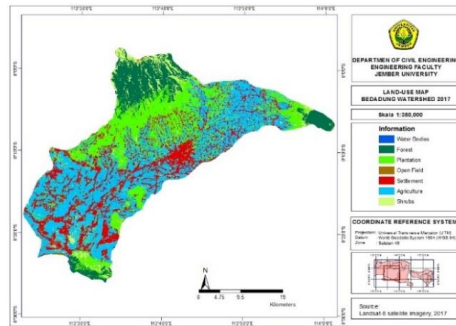
Figure 3. Land cover map of Bedadung watershed 2017.

Classification result of land cover in Bedadung watershed in 2017 from RBI maps is explained on Figure 4.


Figure 4. Land cover map of Bedadung watershed 2001.

The classification result, from 2001 to 2017 showed that Bedadung watershed has be altered in their land use for 16 years. The classification result is explained on Table 1 and Figure 5.
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Table 1. Land use change of Bedadung watershed.

Classification	Area			
	Km^2		%	
	2001	**2017**	**2001**	**2017**
Forest	206,6	158,6	14,9%	11,5%
Settlement	223,7	260,5	16,2%	18,8%
Agriculture	656,8	534,5	47,5%	38,6%
Shrubs	51,5	89,2	3,7%	6,4%
Water Bodies	3,5	4,6	0,3%	0,3%
Plantation	240,7	331,5	17,4%	24%
Open Field	0,5	4,4	0,0%	0,3%
Total	**1383,196**	**1383,196**	**100%**	**100%**
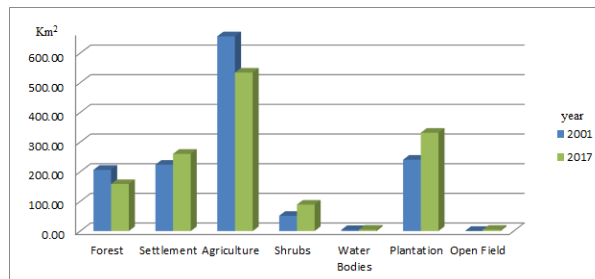
Figure 5. Land use change of Bedadung watershed.

3. 3   *Accuracy assessment*

Accuracy calculation result with confused matrix is explained on Table 2.

Table 2. Confused matrix.

Reference Data	Classification							Total
	Open Field	Shrubs	Water Bodies	Settlement	Forest	Agriculture	Plantation	
Open Field	0					1		1
Shrubs		4			1	3	5	13
Water Bodies			1					1
Settlement				34		1	5	40
Forest					23			23
Agriculture						73	9	82
Plantation					2	2	46	50
Total	0	4	1	34	26	80	65	210

Accuracy result for land cover landsat-8 2017:

Overall Accuracy = 86%

Kappa Accuracy = 81%

The classification result is correct if its accuracy is ≥ 80%. According to another research, Rwanga et al and Borana et al stated that Kappa statistical ranking criteria have ≥ 80% of kappa accuracy, it shows a useful classification [13][18].

Furthermore, this research compared interpretation result with the site condition which is explained on Table 3:

Table 3. Suitability of classification.

No	Coordinate Point		Object		Location
	X	Y	Interpretation Results	Field Condition	
1	793454.407	9096593.409	Shrubs	Shrubs	Mujahir Street, Sukorambi, Jember District
2	794175.745	9094426.087	Settlement	Settlement	Imam Bonjol Street, Kaliwates, Jember District
3	801339.264	9099087.79	Water Bodies	Water Bodies	Baratan, Patrang, Jember District
4	781587.289	9087036.341	Agriculture	Agriculture	Gumelar, Balung, Jember District
5	793022.264	9101268.683	Plantation	Plantation	Karangpring, Sukorambi, Jember District
6	771970.95	9073055.458	Open Field	Open Field	Puger kulon, Puger, Jember District
7	786593.06	9107150.94	Forest	Forest	Pakis Atas, Panti, Jember District

3. 4   Changes in land cover of Sub-District Government (IKK)
District government center of Jember regency is in Patrang, Kaliwates and Sumbersari.
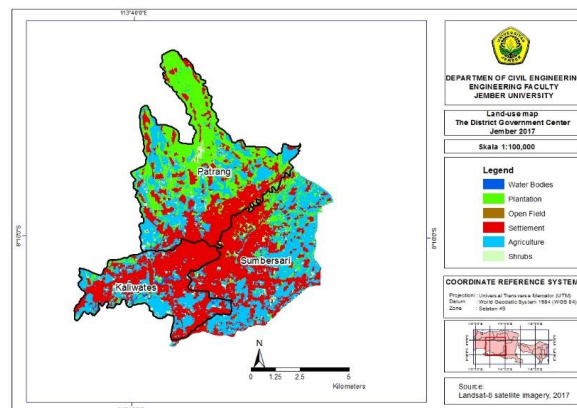

Figure 6. Land use change in district government center of Jember regency.

Map of land use in the district government center area in Jember 2001 to 2017 is explained on Table 4-6 and Figure 7-9.

Table 4. Land use change in Patrang district

| Classification	Area			
	Km^2		%	
	2001	**2017**	**2001**	**2017**
Forest Settlement	9,8	11,59	23,5%	27,8%
Agriculture	20	10,8	48%	25,9%
Shrubs	0,12	1,32	0,3%	3,2%
Water Bodies	0,16	0,16	0,4%	0,4%
Plantation	11,57	17,72	27,8%	42,5%
Open Field	0,0	0,08	0,0%	0,3%
Total	**41,654**	**41,654**	**100%**	**100%**
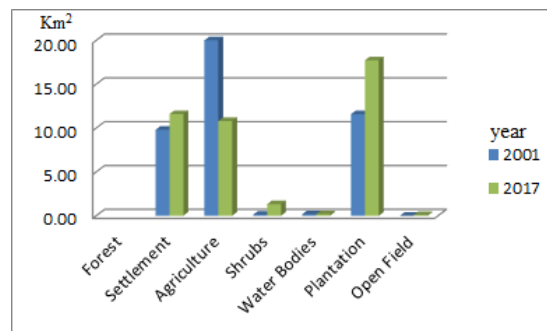
Figure 7. Land use change in Patrang district.

Land use change in Patrang district is explained on Table 4 and Figure 7 which is showed that shrubs, plantations, open lands and settlement areas were increased. While agricultural areas were decreased.

Table 5. Land use change in Kaliwates district..

| Classification	Area			
	Km^2		%	
	2001	**2017**	**2001**	**2017**
Forest Settlement	7,81	11,99	37,6%	57,6%
Agriculture	10,59	6,82	50,9%	32,8%
Shrubs	0,05	0,73	0,2%	3,5%
Water Bodies	0,4	0,5	1,9%	2,4%
Plantation	1,95	0,76	9,4%	3,7%
Open Field	0,0	0,01	0,0%	0,1%
Total	**20,8**	**20,8**	**100%**	**100%**
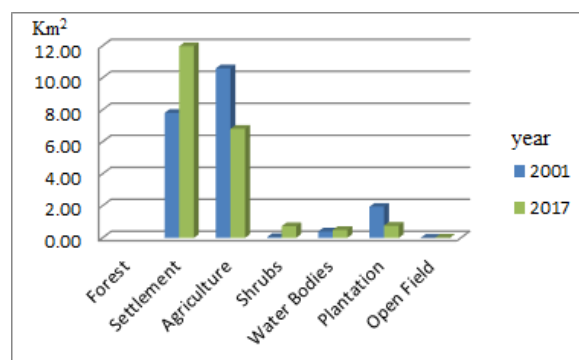
Figure 8. Land use change in Kaliwates district..

Land use change in Kaliwates district is explained on Table 5 and Figure 8, which is showed that shrubs, open fields and settlement areas were increased while plantation and agricultural areas were decreased..

Table 6. Land use change in Sumbersari district.

Classification	Area			
	Km^2		%	
	2001	**2017**	**2001**	**2017**
Forest				
Settlement	10,47	15,39	30,8%	45,3%
Agriculture	16,77	13,74	49,3%	40,4%
Shrubs	0,19	1,04	0,6%	3,0%
Water Bodies	0,26	0,28	0,8%	0,8%
Plantation	6,32	3,50	18,6%	10,3%
Open Field	0,0	0,06	0,0%	0,2%
Total	**34,01**	**34,01**	**100%**	**100%**
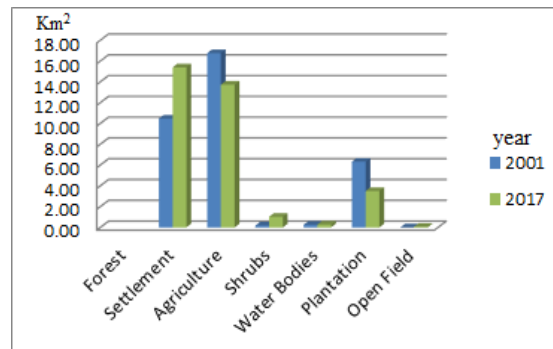
Figure 9. Land use change in Sumbersari district.

Land use change in Sumbersari district is explained on Table 6 and Figure 9, which is showed that shrubs, open fields and settlement areas were increased while plantation and agricultural areas were decreased.

Rain simulation conducted using HEC-HMS shows that the peak discharge generated in 2001 was 68.8 m3/s, while in 2017, it was 103.9 m3/s. This simulation aims to determine the effect of land-use change on peak discharge volumes.

4. Conclusions

According to the result and discussion, it can be concluded that Bedadung watershed experienced land cover changes within 16 years with the following explanation:

a. forest areas were decreased to ± 3,47%
b. plantation areas were decreased to ± 8,84%
c. agriculture areas were decreased to ± 6,57%
d. settlement areas were increased to ± 2,66%

Kaliwates district is the center of sub-district administration in Jember which the most significant settlements growth. The results show that forest area is always decreasing. Meanwhile, the peak discharge in 2017 is higher than in 2001, and this shows that the condition of land use in 2001 is better than in 2017. Therefore, the government must implement a conceptual plan based on a minimum percentage of future vegetation cover. Furthermore, replanting must be carried out immediately and introduced to the community.

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