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RESEARCH ARTICLE

Analysis of Land Cover Changing and Vegetation Index at Kuranji Watershed in Padang, West Sumatera, Indonesia

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Abstract

Various activities around Kuranji watershed included the land conversioncan be impacted to topographic condition and also contributed to altering the vegetation density. Remote sensing technology is an effective methodfor land cover mapping. The objectives of the present study were to analyze the changing of land cover and classifying the vegetation density index in the upstream Kuranji Watershed. This study was conducted at Kuranji Watershed in Padang, West Sumatera Province. Two Landsat images representing the changing of the watershed area during 2017 and 2018 as well as obtaining the classification of vegetation density during corresponding years.Landsat 8 OLI images were classified using a supervised classification technique, then computed the vegetation index using the Normalized Difference Vegetation Index (NDVI). The result showed that the extension of forest area, settlement area and paddy field (283.92; 35.06; and 27 Ha, respectively) and decline of mix dryland agriculture, shrub and garden area (93.68; 277.43; and 190.95 Ha respectively). Decreasing of dense vegetation found at lower dense class (6.47 Ha) and highest dense class (5535.35 Ha). Therefore, the increasing area found at the cloud, dense and higher dense class (93.17; 5525.1; and 109.94 Ha, respectively). So, it is highlighted that changing land cover and vegetation index happen during the only one-year period.

Keywords: *Land Cover, Landsat, Vegetation Index, Watershed*

1. Introduction

Land cover is affected by human activities, including agricultural, urban, settlement, and others. This conversion is one of the major environmental problem challenge all the countries over the world (Tadesse et al., 2017; Tiwari et al., 2017; Wissmar et al., 2004). It also impacts land cover change, watershed area, and vegetation condition due to the natural landscape conversion (Baker and Miller, 2013; Singh et al., 2016; Zaitunah 2018). Conversion to settlement and industrial land also occurred at Kuranj Watershed as many as 1030 Ha (Daus, 2005). Therefore, it impacted to watershed area flaw by high water flow debit on rainy and small in the dry season (Putri et al., 2018). Meanwhile, good watershed indicated if able to reduce surges in surface runoff fluctuations due to rain, stabilize the amount of discharge and extend the availability of surface runoff in the dry season. The more considerable change of land cover was directly proportional to total runoff. In a watershed with higher runoff and lower baseflow, the tendency may be causing the land cover change. Then resulting in runoff enhancement, so the soil infiltration as baseflow input was not optimal (Permatasari, 2017).

Remote sensing technique is one of the quick, easy, and effective methods for monitoring information about spatial diversity on the surface of the earth, especially in watershed conditions (Gillespie et al., 2019; Sampurno et al., 2016). The process of combining specific spectral bands from remote sensing imagery aims to get the vegetation index value. The vegetation index wave is obtained from the energy emitted by the vegetation in remote sensing imagery to show the size of life and the amount of a plant (Tiwari, 2017). To find out the distribution of vegetation in an area it is better to use the vegetation density index method because the photosynthetic activity of chlorophyll is more sensitive to read by the NDVI algorithm (Zaitunah, 2018). Therefore, this study aimed to analyze the land cover changing and vegetation density index in the upstream Kuranji Watershed.

2. Materials and Methodology

This research was located at upstream Kuranji Watershed in the Pauh District area, Padang, West Sumatera, Indonesia. Kuranji river lies in the mountainous region of the Bukit Barisan, which is a conservation and protection forest. The Kuranji upstream river network occupies an area of 8,000 hectares, at an elevation of ± 1,900 m above sea level (Fig.1).

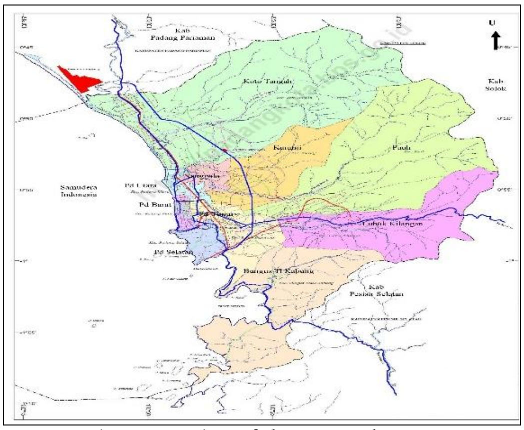

Fig. 1. Location of the research area.

Satellite image data was downloaded from the United States Geological Survey (USGS) website. Landsat OLI (Operational Land Imager) 8 analyzed using image data on path 127 and row 61. The image data for 2017 and 2018 with less cloud covering was chosen to analyze and extract into 11 bands. In this study, land cover classification is carried out by a supervised classification method using Quantum GIS software, where for each land cover class is obtained by identifying the sample training area.

The user or image analyst was processed and "supervises" the pixel classification as the step of the supervised method. Then, the specification of various pixels values or spectral signatures were associated with each class. This is done by selecting representative sample sites of a known cover type called "training areas". The computer algorithm uses spectral signatures from these training areas to classify the whole image. Ideally, the classes should not overlap or should only minimally overlap with other classes. Each pixel is assigned to the class that has the highest probability.

The land cover group in this study refers to the classification of SNI 7645-2010 regarding land cover classification and divide into several types. Forests referred to the thrive in dryland habitats in the form of lowland forests, mountainous hills, highland tropical forests that are still compact, and never experienced human intervention or have experienced like logging. The mixed dry land is planted land with more than one type of non-uniform tree plantations that produce flowers, fruits, gums, and reap a nice profit, not by felling trees. The bare land called the land with no activity on it either naturally or semi-naturally. The settlement directs to the undergone natural or semi-natural land cover substitution with the artificial land cover, which is usually waterproof and relatively permanent. Paddy fields lead to agricultural areas that are flooded or watered with irrigation technology, rainfed, which is characterized by the pattern of dike planted with rice. Shrub is a dry land area that has been overgrown with a variety of heterogeneous and homogeneous natural vegetation with a density level of sparse to dense with low vegetation. Then, garden leads to farming with temporary or shifting cultivation crops other than rice that do not require extensive irrigation. Moreover, the group of water bodies is the appearance of waters that exist on the earth surface, including the rivers.

Table1. Multispectral bands of Landsat 8 (USGS, 2013)

	Landsat 8 OLI	Spectral Range (μm)	Spatial Resolution (m)
Coastal/Aerosol	Band 1	0.433-0.453	30
Blue	Band 2	0.450-0.515	30
Green	Band 3	0.525-0.600	30
Red	Band 4	0.630-0.680	30
Ner - IR	Band 5	0.845-0.885	30
SWIR-1	Band 6	1.560-1.660	30
SWIR-2	Band 7	2.100-2.300	30
Panchromatic	Band 8	0.500-0.680	30
Cirrus	Band 9	1.360-1.390	15
LWIR-1	Band 10	10.30-11.30	30
LWIR-2	Band 11	11.50-12.50	30

Vegetation Index is one of the parameter to analyze the vegetation area which has a variety of algorithm variations. The use of digital data in the forestry sector also enables tapping data on the distribution of vegetation density on land surfaces more easily and quickly. The Normalized Difference Vegetation Index (NDVI) is an indicator of the greenness of the biomes and rewarding to know the density of vegetation in the study area. Calculation of NDVI values at upstream Kuranji Watershed by Quantum GIS software was used band 4 (red) and band 5 (Near Infra-Red/NIR) ratio using the formula [1].

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

Theoretically, the values of the NDVI vary between −1.0 and +1.0 range. The appearance of the NDVI image after processing by the quantum GIS software (raster image)was changed to vector for getting NDVI value. The results of the classification of each vegetation index transformation were divided into several classes, namely; clouds/shadow clouds, lower dense, dense, higher densities, and the highest dense vegetation.

3. Result and Discussion

3.1 Land Cover Changes

The estimation of the training area also can be quick and effective, measured by remote sensing. Based on the Landsat 8 OLI interpretation using the Quantum GIS software. The upstream Kuranji watershed area was classified into several types; each color describes the land cover type (Table 2).

The upstream Kuranji watershed is part of the protected forest area has undergone a change in land cover. Such as becoming a farming area, an indication of illegal logging, and residential area development. Land-use change is an important phenomenon that must be aware (Tadesse et al., 2017; Tiwari et al., 2017; Wissmar et al., 2004).

Table 2. Land Cover Changes based on color classification

Land Cover Types	Color Class
Cloud	
Waterbody	
Cloud Shadow	
Forest	
Mix dry land agriculture	
Bare Land	
Settlement	
Paddy field	
Shrub	
Garden	

The enhancement of population, level of socio-economic activity, and infrastructural accessibility result rapidly in land cover change. Earthquake activity and the issue of the tsunami in Padang city also impacted the community moved to the safety zone settlement included in the upstream Kuranji Watershed. The detail distribution of land use was performed in Table 3.

Table 3. Land Cover Changes at Upstream Kuranji Watershed.

Land Cover Types	2017 Area (Ha)	2017 %	2018 Area (Ha)	2018 %
Cloud	0.00	0.00	161.96	1.32
Waterbody	73.24	0.59	110.41	0.90
Cloud Shadow	0.00	0.00	28.27	0.23
Forest	10011.84	81.79	10295.76	84.05
Mix dry land agriculture	181.15	1.48	87.47	0.71
Bare Land	213.39	1.74	210.23	1.71
Settlement	257.54	2.10	292.60	2.39
Paddy field	29.90	0.24	56.90	0.47
Shrub	1228.38	10.03	950.95	7.76
Garden	244.73	1.99	53.78	0.44

Table 3 described that the settlement area in 2018 increase as many as 35.1 Ha along with the community's need for housing, the development of educational facilities, and the construction of public infrastructure. Almost allof the community's livelihoods are planters with Banana, Durian, Rambutan, Papaya, and Mango as the commodities. The mixed garden cover in 2017 is 181.15 Ha with a percentage of 1.48%, but it declined in 2018 due to satellite imagery show factors. So, it may be correlated to forest area change that shows the amount of forest area in 2018 as many as 283.92 Ha.

Bare land cover in 2018, having no significant decrease (only 3,16 Ha), means that the watershed area is still optimal untapped (Table 2).Table 2 describe that the paddy field in 2018 has a significant escalation area around 27 Ha, in that most of the community's livelihoods in Pauh District are farmers. On the other hand, shrub cover of 1228.38 Ha with a percentage of 10.03% spread over areas of protected forest and conservation forest; this is indicated due to illegal logging by the local community and former logging no longer reforestation. Then, shrub cover is also scattered around the riverbanks due to the former fields untilled anymore.

The mapping of land cover change was interpreted from OLI 8 Landsat. Satellite imagery results in 2017 recording in good atmospheric conditions at the review location, so only a little few clouds and cloud shadows were displayed (Fig.2). The difference in land cover change at upstream Kuranji Watershedin the years 2017 and 2018 can be shown in Figures 2 and 3.

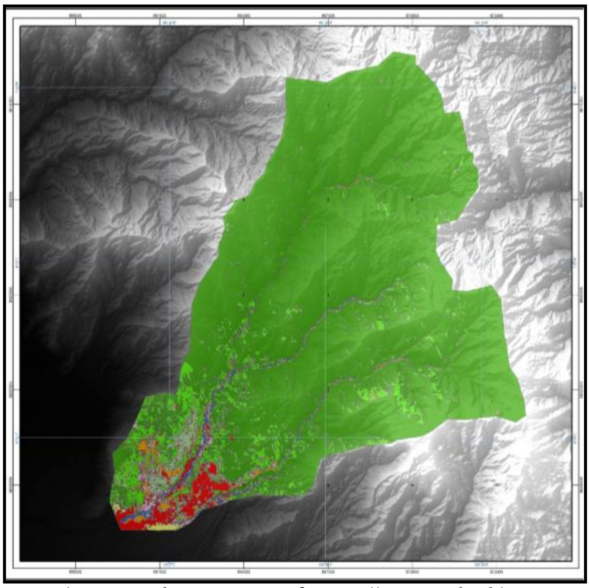

Fig. 2. Land Cover Map of Kuranji Watershed in 2017

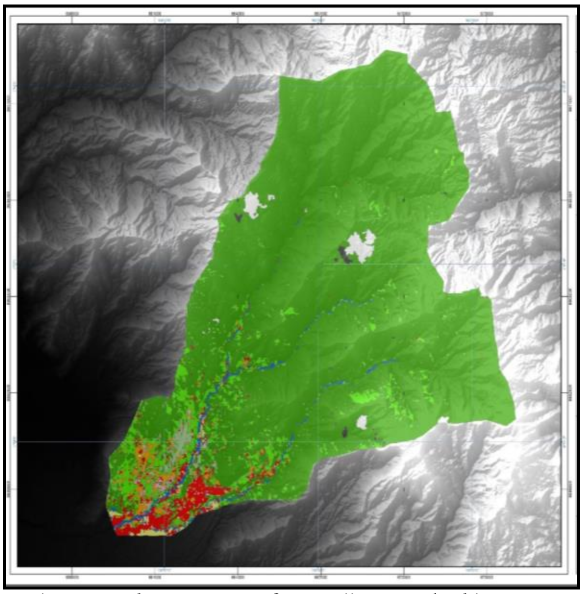

Fig. 3. Land Cover Map of Kuranji Watershed in 2018.

3.2 Vegetation Index

Figure 4 and 5 is a Normalized Difference Vegetation Index map of the Landsat Image of OLI 8 in 2017 and 2018.The NDVI analysis in 2017in the Kuranji watershed showed that “orange” representing the dense vegetation, “red” the higher dense vegetation group (Fig. 4). At the top of the watershed was founded the dense vegetation with NDVI value range 0.55-078; further, the highest dense vegetation with NDVI values range 0.78-1. It is due to sections are protected by forest areas and conservation forests. Furthermore, the bottom of the watershed was more dominating lower dense vegetation and relatively dense vegetation groups consist of developed land, paddy fields, fields, and shrub.

The results of the 2018 NDVI analysis show that the dense vegetation represented by orange and the higher dense vegetation represented by red still dominate in the upper watershed. The NDVI method is more sensitive to photosynthetic activity by chlorophyll, so plants with high canopy densities and greener leaf conditions will increase the vegetation index value. The NDVI index of higher dense vegetation class decrease in 2018 (2,778,093 Ha), meanwhile the highest dense vegetation increased (9,103,334 Ha). It indicates an increase in the growth of forest areas with high canopy densities (Table 3).

At the bottom of the watershed was founded the lower vegetation in range 0-0.25, experiencing an increase in expansion due to increasing of developed area around 38.89 Ha. At the top,the NDVI value with cloud cover and cloud shadow as many as 93.193 Ha. It caused by the satellite recording imagery, the spot having cloud exposure. However, the extent of clouds and cloud shadow did not significantly influence(Fig. 5).

The results in the year 2017 are classified based on the density of vegetation index. The amount of the area with lower dense vegetation is 32.442 Ha, dense vegetation is 321,925 Ha, higher dense vegetation is 8,303,196 Ha and very dense vegetation of 3,567,982 (Table 4).

Table 4. NDVI Changes at Upstream of Kuranji Watershed.

Dense Class	NDVI Value	Area (Ha) 2017	Area (Ha) 2018
Cloud, Cloud Shadows	-1 – 0	0.023	93.193
Lower Dense	0 – 0.25	32.423	38.899
Dense	0.25 – 0.55	321.925	211.985
Higher Dense	0.55 – 0.78	8303.196	2778.093
Highest Dense	0.78 – 1	3567.982	9130.334

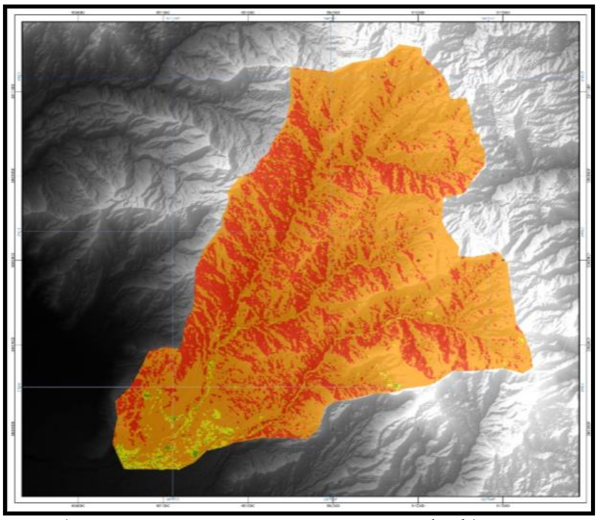

Fig. 4. NDVI Maps at upstream Watershed in 2017

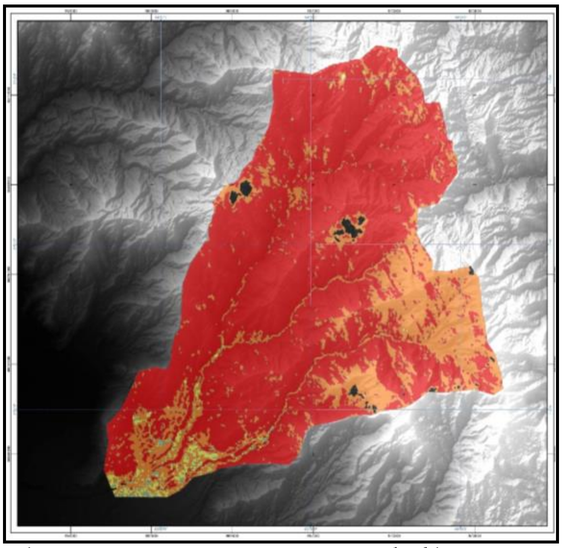

Fig. 5. NDVI Maps at upstream Watershed in 2018

4. Conclusion

This research provides information about changing of the land cover and the vegetation index happen during an only one-year period in 2017 until 2018.

Land cover in the upper watershed of Batang Kuranjiis dominated by the forest cover class of 10,011.84 Ha (81.79%) in 2017 and 10,295,759 Ha (84.05%) in 2018. The highest dense class of vegetation density index also dominates at the upstream watershed. So, it highlighted that the analysis of land cover changing and vegetation index using remote sensing (Landsat 8 OLI) helpful to get more accurate results and classification of image data.

References

Baker TJ and Miller SN, 2013.Using the Soil and Water Assesment Tool (SWAT) to Asses Land Use Impact On Water Resources in An East African Watershed. Journal of Hydrology. 486: 100-111.

Daus, S., 2005, *Kaji Ulang Debit Banjir Rencana Sungai Batang Kuranji Terhadap Daerah Korong Gadang Kota Padang*. Institut Teknologi Bandung, Bandung. (thesis).

Gillespie TW, Madson A, Cusack CF, Xue Y. Changes in NDVI and Human Population in Protected Areas on the Tibetan Plateau. Arctic, Antarctic, and Alpine Research, 51 (1): 428-439, DOI: 10.1080/15230430.2019.1650541.

Permatasari, R., 2017, Pengaruh Perubahan Lahan terhadap Rezim Hidrologi DAS (Studi Kasus: DAS Komering), *Jurnal Teknik Sipil*ITB Vol.24 No.1, p91-98, ISSN: 0853-2982.

Sampurno, R. M., dan A. Thoriq, 2016, Klasifikasi Tutupan Lahan Menggunakan Citra Landsat 8 Operational Land Manager (OLI) di Kabupaten SUmedang, *Jurnal Teknotan* Vol.10 No.2, p61-70, P-ISSN: 1978-1067, E-ISSN: 2528-6285.

Singh RP, Singh N, Singh S, Mukherjee S. 2016. Normalized Difference Vegetation Index (NDVI) Based Classification to Asses the Change in Land Use/Land Cover (LU/LC) in Lower Assam, India. International Journal of Advanced Remote Sensing and GIS. 5 (10): 1963-1970.

Tadesse, L.,Suryabhagavan KV., Sridhar G., LegesseG. 2017. Land use and Land Cover Change and Soil Erosion in Yezat Watershed, North Western, Ethiopia. International Soil and Water Conservation Research. Vol 5 (2): 85-94.

TiwariJ., Sharma SK, A., Patil, RJ. 2017. Land use andLand cover Mapping Based on Normalized Difference Vegetation Index using Remote Sensing and Geographical Information System in Banjar River Watershed of Narmada Basin. Current World Environment. Vol.2(3): 680-686.

USGS (United States Geological Survey) Landsat 8 product, 2013. (accessed 01.01.19)

Wismar, RC., Timm RK. 2004. Effect of Changing Forest and Impervious Land Covers on Discharge Characteristics of Watershed. Environmental Management. Vol 34 (1): 91-98.

Zaitunah A, Samsuri, Ahmad AG, Safitri RA. 2018. Normalized Difference Vegetation Index (NDVI) Analysis for Land Cover Types Using Landsat 0 OLI in Besitang Watershed, Indonesia. IOP Conf. Series: Earth and Environmental Science 126.