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Interpretation of land use and land cover at lowland area using by NDVI and NDBI

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ABSTRACT

Land use and Land cover is the key factor in the spatial planning. Remote sensing is one of the excellent ways that can be applied to determine the land use/land cover in the studied area. Tanjung api-api is one of the lowland areas that will be developed as the special economic area, so it is crucial to understand thoroughly the condition of land use/land cover that exists at this time. This study aimed to interpret the land use/ land cover in the Tanjung api-api wetland area using the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Built Up Index (NDBI) approaches. Using the NDVI approach, the results show that most of the Tanjung api-api area consist of vegetated areas with low densities up to high densities (approximately 97.18% of total area). The studied area has the mangrove forests, coconut plantations, rice fields, shrubs dryland farming and non-vegetation area of 2.82 %. In the other hand, using NDBI, the percentage of developed area is less than 3.34% of the total area, which consists of residential area and some separate infrastructure building and the rest is the vegetation area with an area of about 27.742 ha. The Approach of Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built Up Index (NDBI) are easiest, fastest and most effective to interpret vegetated and build up areas.

***Key words** : Land use and Land Cover, Lowland, NDVI, NDBI*

Introduction

To develop the lowland area into a built up area, it is essential to know some information about land use and land cover. In this time, the international port has been built in the exclusive region of Tanjung api-api in South Sumatera. Furthermore, Tanjung api-api has then planned to be built special economic zone and Tanjung Carat seaport. The total area of Tanjung api-api special exclusive zone is expected for 4.045 ha which consists of the industrial estate (2.030 ha) and reclaimed of Tanjung carat seaport (2.015 ha) (Peraturan Pemerintah RI No. 51, 2014). The development of lowland area into the developed area lead to the population growth and environmental degradation because the lowland plays an important role in the hydrology as water catchment areas, control systems, flood regulator fluctua-

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tions and preventing water salting (Muhammad and Pedia, 2012; Rieley *et al.*., 1997). In this time, the information about land use and land cover in Tanjung api-api is important to determine the development of the area and prevent the occurrence of land conversion function in the conservation area to avoid the environmental degradation due to the growth of industrial estates and other infrastructure buildings in Tanjung api-api. The results of research conducted by Eddy *et al.* (2017) showed that there had been a conversion of land use and land cover in Mangrove forest into the plantation and aquaculture areas in Tanjung api-api (Air Telang, Banyuasin) from 1989 to 2013. The changes of land use and land cover occurring due to increased built-up regions (settlements, infrastructure buildings, and waterproof structures) in the area which will cause the rise in the surface temperatures and cause the environmental degradation (Adeyemi *et al.*, 2015).

To determine the land use/land cover, the remote sensing is used through composite band method, Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built-up Index (NDBI) (Adeyemi *et al.*, 2015). Li *et al.* (2015) use NDVI to identify vegetation and the Normalized Difference Bare Land Index (NDBLI) to identify impermeable and vacant surfaces or open areas. To classify land cover, it can be done by using the characteristic spectral curve of Landsat 8 bands (Rahayu and Candra, 2014) while NDBI is used to detect the residential areas (Suwarsono and Khomarudin, 2014). Land use identification is carried out using three indices, namely NDBI, Modified Normalized Difference Water Index (MNDWI), and Earth-coated vegetation index (SAVI) to represent three classes of primary urban land use, built-up, open bodies of water, and vegetation (Xu, 2007). The relationship between NDBI, NDVI, and Land Surface Temperature values can be applied to identify land cover and urban areas (Ogashawara and Bastos, 2012; Luo and Li, 2014). The results show that NDVI and NDWI are negatively correlated with LST and NDBI are positively correlated with Land Surface Temperature. Land use change can be identified using NDVI approach on Landsat 7 and Landsat 8. The change of vegetation density due to the development activity influences the condition of the environment in the future, so it needs to control the land conversion (Wahyuni *et al.*, 2017). Using the vegetation indexes such as NDVI and EVI, the greenness of vegetation can be detected and used to evaluate the spatial of an area (Sudiana and Diasmara, 2008; As-syakur and Adnyana, 2009). Furthermore, the change of land cover and land use can be analyzed using Change Vector Analysis (CVA) covering component of NDVI and Bare Soil Index (BSI) (Si *et al.*, 2009).

Materials and Methods

Study area dan data collection

Tanjung Api-Api is a lowland area located at Banyuasin district, South Sumatera. It geographically located at coordinates between 104° 45′ to104° 55′ E Longitude and 2° 17′ to 2° 24′ S Latitude (Fig. 1). The interpretation of land use and land cover in Tanjung api-api is necessary because it will be developed as a special economic area in South

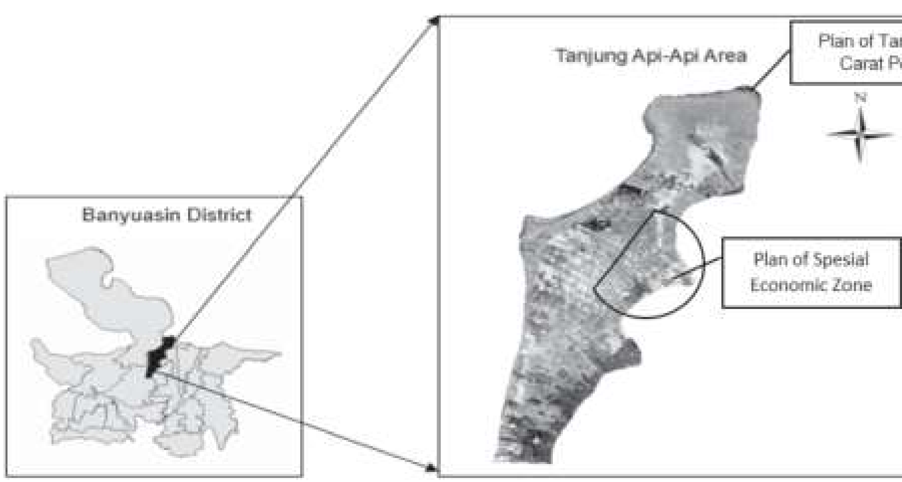


Fig. 1. Location of Study Area.

Sumatera to interpret the studied area, we used Landsat 8 data on path/row 124/062 location. The data was taken in December 2016. The data was downloaded for free from United States Geological Survey (USGS) and the resolution used is 30 m. All the data was processed using GIS software.

Image Processing

Before interpreting land use and land cover (LULC), all the bands used in Landsat 8 will be georeferenced on UTM WGS 1984 coordinate system (Zone 48 S). Furthermore, the bands will be cropped and convert from the digital number (DV≥DN) into the reflectance value of each band. Equation 1 and 2 are used to convert the digital number (DN) to Reflectance value.

$$\rho\lambda' = M\rho * Qcal + A\rho \quad .. (1)$$

note:

$\rho\lambda'$: TOA reflectance, without correction for the sun angle

$M\rho$: Reflectance Multi Band_x , where x is the band number

Añρ : Reflectance Add Band _x, where x is the band number

Qcal : Digital Number Value (DN)

The equations for correction with the angle of the sun i.e:

$$\rho\lambda = \rho\lambda'/(\cos(\theta_{SZ})) = \rho\lambda'/(\sin(\theta_{SE})) \quad .... 2)$$

where:

$\rho\lambda$: ToA reflectance

θ_{SE} : sun elevation

θ_{SZ} : sun zenith angle

θ_{SZ} : 90 ° - θSE

Furthermore, the value of NDVI is calculated using equation 3 while the value of NDBI is calculated using equation 4.

$$NDVI = \frac{NIR - RED}{NIR + RED} = \frac{B5 - B4}{B5 + B4} \quad .. (3)$$

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR} = \frac{B6 - B5}{B6 + B5} \quad .. (4)$$

Land use classification and land cover are done by supervised classification method on the value of NDVI and NDBI. Ground check to the field is carried out to obtain the validation of land use and land cover from interpretation result of NDVI and NDBI value. Identification of land use and land cover are based on the result obtained from NDVI and NDBI reflectance value.

Results and Discussion

Classification Land Use and Land Cover (LULC) with NDVI

The NDVI approach is the simplest way to identify the level of vegetation density in the area. There is the specific wavelength used in the NDVI approach in which the red wavelength is 0.630 µm -0.680 µm (at band 4) and the near-infrared wavelength 0.845 µm - 0.885 µm (at band 5). The presence of near-infrared spectra (NIR) and red spectrum (RED) in Landsat 8 make the identified easier to determine the vegetation on the land cover by using vegetation index (NDVI). NDVI has the values range from -1 to 1 and the value of NDVI < 0 indicates the non-vegetated area whereas the value of NDVI > 0 indicates the vegetated area. The higher of NDVI values indicates the denser of vegetation.

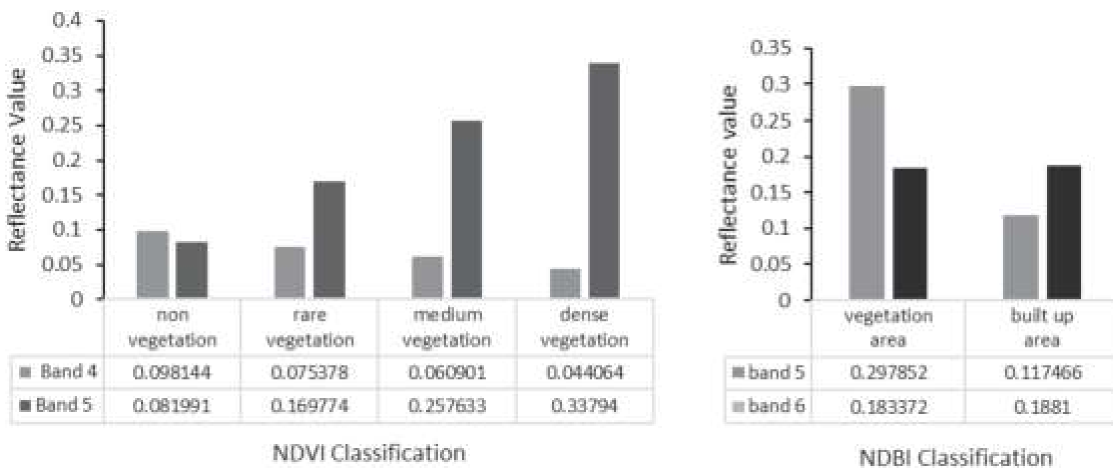
The response and characteristics of an object will vary when approached with a certain wavelength. In Fig. 2 in non-vegetation area, the reflectance value in band 4 is bigger compared to band 5, whereas in the vegetated region, the reflectance value in band 5 is greater than that of band 4. The higher level of vegetation density is caused by the reflection of the mesophyll tissue which contained in the leaf on near-infrared waves while the absorption of chlorophyll by band 4 was smaller. It is caused that the ratio between band 5 and band 4 became high. While in the non-vegetation area, the ratio between reflectance band 5 and band 4 is very small because the absorption of chlorophyll by the red wavelength (band 4) is greater than the reflection at the near-infrared light wavelength (band 5). In the vegetated area, there will be the maximum reflection by near-infrared wavelength whereas the absorption of light at the red wavelength will be minimum (large ratio so that the NDVI value is high). In the non-vegetation areas (settlements, water bodies, and infrastructure buildings), the ratio values of band 5 and band 4 are minimum. The reflectance values of the vegetation spectral are influenced by leaf structure including leaf shape and extent, pigment content, and organic material (Huete and Glenn, 2011). The maximum reflection will occur in near-infrared waves caused by leaf structure (mesophyll) which increase the reflection of near-infrared while at the red wavelength will occur maximum absorption caused by green leaf substance (Chlorophyll) (Molidena and As-syakur, 2012). To determine the density of vegetation, the vegetation index is used to measure the green canopy, chlorophyll canopy, leaf area, canopy cover, and structure (Huete and Glenn, 2011).

Band 5 and 4 ratios will be maximized in the vegetated regio due to the energy reflected by the 5 more bands on the broad leaf/plant canopy cover so that the reflected energy is greater than the absorbed energy.

The results show that Tanjung api-api area has -0.39512 and 0.86324 as the minimum and maximum value of NDVI, respectively. Supervised classification is done to interpret the land use and land cover in Tanjung api-api (Table 1). Table 1 shows that the developed area in Tanjung api-api is located in the coastal area (Sungsang) with a value of NDVI 0.0843 up to 0.1597 while in the other area, it can be seen that land use is still dominated by vegetation with NDVI value between 0.1598 up to 0.86324. The settlement of residence or the other infrastructure buildings in Tanjung api-api is very difficult to be detected because it has approximately 2.82% of total area (810 ha) with NDVI value between -0.3951 up to 0.08421, while the NDVI value of plantation and mangrove forest has a maximum value of 0.64778 up to 0.86324 with an area of 97.18% (27.890 ha).

Based on the NDVI value, the land use in Tanjung api-api is classified into 7 classes: ponds/water body, settlement area, shrubs, rice fields, dry farms mixed with shrubs, mangrove forest and plantation. According to Holben (1986), NDVI values which are greater than 0.500 indicate densely vegetated areas whereas the negative NDVI values indicate non-vegetated areas such as water and snow, for NDVI values between 0.002 to 0.025 indicating the open land and settlements. Meanwhile, according to Sudiana and Diasmara (2008), the area which has the NDVI values smaller than 0.2 is a territorial water or rocky soil, and the NDVI values which is greater than 0.4 indicates a vegetated and fertile vegetation.

Fig. 3 shows the land use and land cover in the area of Tanjung api-api lowlands dominated by vegetation. The non-vegetation area has a lighter colors than vegetated areas, and the more dense vegetation



(a) (b)

Fig. 2. Classification Land Use and Land Cover (LULC) using by Reflectance Value, (a) NDVI and (b) NDBI.

Table 1. Classification of Land Use and Land Cover (LULC) using by NDVI Value.

	Land Use and Land Cover	NDVI Value	Area (ha)	Percentage(%)
Non Vegetation Area	Ponds area / water body	-0. 3951 - 0.08421	810	2.82
	Settlement area and Bare soils	0.0843 - 0.1597		
Rarely Vegetation	• Rice fields	0.1598 - 0.4545	4.016	13.99
	• Shrubs			
Medium Vegetation	dry farms mixed with shrubs	0.4545 - 0.64778	6.346	22.11
Dense Vegetation	• Mangrove forests	0.64778 - 0.86324	17.528	61.07
	• Plantations			
	Total Area		28.700	100

will show the darker of color. The reflection of the near-infrared spectrum will occur significantly in dense vegetation, and only a little energy is absorbed by the leaves so that the brightness that occurs will vary in band 4 and band 5. It will affect the brightness value at NDVI value. Purwanto (2015) reported that the area with vegetation rarely has lighter shades than in vegetated areas. It is caused that the reflection on the near-infrared spectrum is higher than absorption by the red spectrum. From fig. 3, it can be seen that the dark areas are the area with the density of dense vegetation consisting of mangrove forest, coconut plantation, and oil palm plantation. At the location of the Tanjung Carat port plan, land use is dominated by dense vegetation consisting of mangrove forests. While on the plan of the location of special economic zone plan, it can be investigated that current land use consists of a small amount of mangrove forest, coconut plantation, and dry land agriculture. There are many coconut plantations in the location of the special economic area plan, Teluk Payo village, and Muara Sungsang. The studied area is inhibited by the migrants of Bugis who lived and planted coconut as their livelihood. Furthermore, the settlement area is still in a small number. In the area with medium density, the agricultural land is dominated by dryland agriculture mixed with shrubs.

The areas with sparse vegetation and non-vegetated areas are indicated by areas of bright color. The area consists of the settlements, open land (bare soils), and ponds/water body. In this research, it is very difficult to distinguish the spectral values of mangrove forest, and coconut plantation due to the dense density whereas in the newly opened coconut plantation area, the spectral value is smaller than the mangrove forest because the leaf cover is not dense. Using NDVI approach, it is difficult to detect the settlements in the studied area because the small number of settlement area and the high coconut trees covers the roof of the house. The reflection received is a reflection derived from the coconut crown.

Classification Land Use Land Cover (LULC) with NDBI

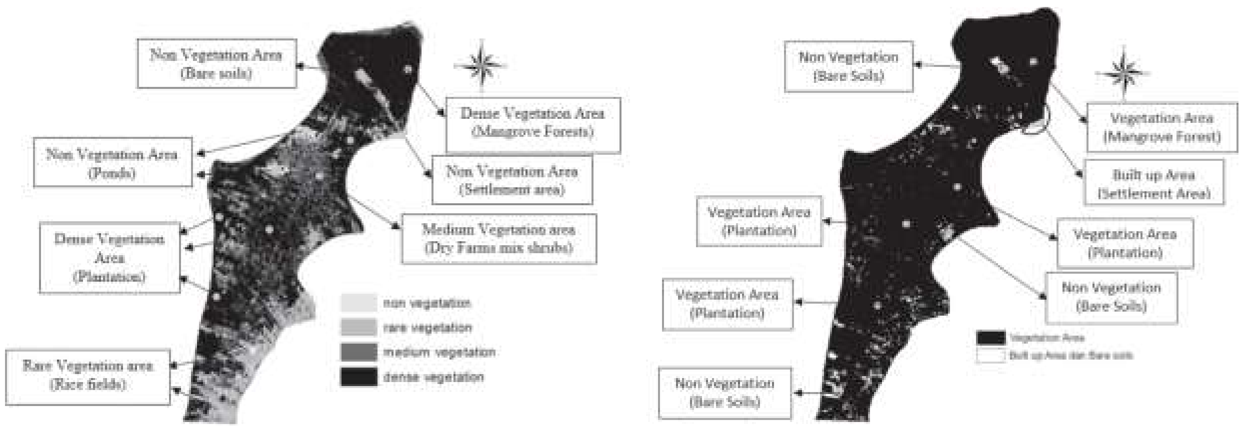
To investigate the developing area, it can be done with the NDBI approach using wavelength 1.560 µm -1.660 µm on infrared /SWIR shortwave spectrum (band 6) and wavelength 0.845 µm – 0.885 µm in near-infrared spectrum (band 5). The SWIR spectrum (band 6) can detect geological, soil and rock condition while the near-infrared spectrum (band 5) is used to identify the biomass/vegetation content. The negative NDBI shows the unopened area/vegetation area whereas the positive NDBI indicates the open area. When the SWIR spectrum concern the settlement object, the reflected reflectance value will be large in which when it comes to the plant as the object, the reflectance value indicated by the small SWIR spectrum will be small.

Fig. 3 shows that the developed area has the greater reflectance value on band 6 compared to band 5. Band 6 will reflect maximally when reflected by settlements or open area. By using NDBI, it is difficult to distinguish the settlement area from the open area because each object has a waterproof surface that reflects almost the same reflectance. The data is supported by Zha *et al.*. (2003) who mentioned that the NDBI method was the effective and profitable to map the built area so that it can be an alternative to map the rapid development of the city. However, the NDBI can not separate the types of areas such as settlements, industrial estates, and other commercial areas.

In addition, NDBI also can not separate the open ground because it has the same spectral response on the SWIR and NIR spectra. To distinguish buildings and bare or empty area, open waterbody, and vegetation can be done by extracting the built-up area

Table 2. Classification of Land Use and Land Cover (LULC) using by NDBI Value.

Land use and Land Cover		NDBI Value	Area (ha)	Percentage(%)
Vegetation Area	• Mangrove forest • Plantation • Rice field • Shrubs • Dry farms mixed shrubs	-0.6794 - 0.00001	27.742	96.66
Built up area	• Settlement area and Bare Soils	0.00001 - 0.4300	958	3.34
	Total Area		28.700	100



(a) (b)

Fig. 3. Classification Land Use Land Cover (LULC) using by (a) NDVI Value and (b) NDBI Value.

with EBBI, SAVI, and MNDWI. The supporting program will separate the built-up area from non-urban built-up land (Bhatti and Tripathi, 2014; Sinha *et al.*., 2016).

According to the result of the analysis, the value of NDBI in Tanjung api-api is -0.6794 up to 0.4300. Table 2 shows that the area of developing and bare soils in Tanjung api-api is approximately 958 ha (3.34%). The dense settlements and developed areas are mostly located in the coastal areas of Sungsang where the vegetation area mostly located in Tanjung api-api. The vegetation area has an area of about 27.742 ha (96.66%) consisting of mangrove forest, coconut and oil palm plantation, agriculture, and others

In general, using NDVI and NDBI approaches, it is seen that Tanjung api-api area mostly consists of vegetation area and slightly built area. Land use/ land cover in Tanjung api-api area is dominated by mangrove forest, plantation, dry farms mixed with shrubs, rice fields, settlement, bare soils and fish pond.

Conclusion

The analysis using NDVI and NDBI can be used to interpret land use/land cover in Tanjung api-api. Using the NDVI approach, the results show that the land use/land cover in Tanjung api-api is dominated by vegetation area. The vegetation area has 97.18% of the total area consisting of mangrove forests, plantations, dry farms mixed shrubs, rice fields, and shrubs. In the other hand, the non-vegetation area has 2.82% of total area which consists of settlement area, fish pond, and open land. Using NDBI, the results of the built area is 3.34% of the total area consisting of settlement and bare soils area whereas the undeveloped area is 96.66% of the total Tanjung api-api area.

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