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Spatial Analysis of Soil Texture and Peat Soil by NDSI method at Swamp Area of Banyuasin District, Indonesia

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ABSTRACT

Road construction in the swampy area should certainly face many problems related to the soil characteristics that are composed of soft soils. The understanding of soil condition to swamp areas is needed to determine the road trace and can be done using the remote sensing technology. The use of Normalized Difference Soil Index (NDSI) method is an alternative to the characterizing of the soil condition. The location of soil sampling is determined by NDSI, while the specific gravity, property index, and soil texture is analyzed by laboratory analysis. The classification of solid condition using NDSI method on composite band 65 obtained the range of reflectance values ranging (-1.0336) – (-0.4582) for water body, (-0.4582) – (-0.0645) for not open spaces and (-0.0645) – (0.4300) for open spaces. The classification of soil characteristics in the swamp area in Banyuasin regency consists of 3 classes, which are clay type with diameter <0.002 mm, medium soil with diameter 0.002 – 0.075 mm, and slightly rough for fine sandy soil with diameter 0.075 – 0.425 mm. In addition, in the study area, the peat depth is approximately measured as 50 – 100 cm and 100 – 200 cm.

Keywords: *Spatial analysis, Soil texture, Peatland, Citra Landsat 8, NDSI*

Introduction

The development of the swampy area continuously increases as a form of limited productive land used to fulfill the human needs. Some government efforts have been developed in the developing swamp areas included various sectors such as plantation, agriculture, and fisheries activities. To support the development of swamp areas, the construction of road infrastructure is a necessity, but the main problem faces in the implementation of road construction in the swamp area is the problem of soil characteristics which are generally soft soils and very soft soils which mostly consist of peatlands (Suriadikarta and Sutriadi, 2007; Arsyad *et al*., 2014). The road construction built on the expansive ground generates many problems such as the damaging to the road pavement which requires high cost during the construction, maintenance, and rehabilitation cost before the pavement reaches the age of the plan etc. (Harry, 2007; Suryoto *et al*., 2017). Furthermore, these problems are needed in consideration of road construction in the swamp area. In order to find out the condition of the land in the study field, it is necessary to investigate the soil characteristics where any investigation will require enormous costs. To reduce the cost, some technology can be used to help the field investigation such as Geographical Information System (GIS). GIS using remote sensing technology is one of the economic alternatives which can find out the potential land cover (Wondrade *et al*., 2014; Karakus *et al*., 2015). One of the remote sensing technologies that can be used for the recognition of soil characteristics is Landsat image 8 (Li and Chen, 2014).

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Landsat 8 in remote sensing technology has onboard operational land imager (OLI) and thermal infra red sensor (TIRS) sensor which have a total of 11 channels which consists of 9 channels (band 1-9) located on OLI and 2 channels bands 10 and 11 on TIRS (Lapan, 2015; USGS, 2016). Some methods are used in the interpretation of the image using the wavelength method such as Normallized Different Vegetation Index (Gandhi et al., 2015), Normalized Different Wetness Index-NDWI (Haikal, 2014), and Normalized Different Soil Index-NDSI (Deng et al., 2015). According to Deng *et al.,* (2015), The development of a spectral sample of vegetation and soil samples is conducted to distinguish normalized indexes for increasing soil information. These differences can be interpreted using the NDSI method. The study aimed to obtain the thematic map showing the location of soil and peat texture to facilitate the decision making in determining the road trace which traversed at a location in the swamp area.

Materials and Methods

Study Area

The study is located at Banyuasin regency which is between 1° 37′32.12″ to 3° 09′15.03″LS and 104° 02′21.79″ to 105° 33′38.5″BT. Banyuasin is one regency which has wide swamp area where the area has 1.183.299 hectares or approximately 12.18% of the total area of South Sumatera province (Kabupaten Banyuasin, 2011). Fig. 1 shows the administrative maps of Banyuasin regency.

Classification Method

In this study, the interpretation of Landsat 8 image that downloaded from the United States Geological Survey on the scene: path 124/row 062 is used to obtained the classification of open area, unopened area, and waters. The image data processing is processed through stages: (i) pre-processing (cutting the image that serves to limit the area of research and reduce the size of image files as well as geometric and radiometric correction; (ii) data processing (color composite, digital image interpretation for sharpening, smoothing filter, contrast, multispectral classification on Landsat image 8) and NDSI transformation; and (iii) field test stages and laboratory tests to obtain the specific gravity, properties index, and soil texture.

Soil texture and peat texture analysis are observed through soil moisture field by separating open area and unopened area based on NDSI value, by combining band 5 (NIR) at wavelength 0.845 – 0.885 and band 6 (SWIR) at length 1.560 – 1.660 waves which are shortwave infrared can be useful for notifying the soil on the surface conditions of the earth. The equation showed below.

$$NDSI = (SWIR - NIR) / (SWIR + NIR)$$

The characteristics of OLI sensor on satellite landsat 8 has 9 bands namely band 1 (costal aerosol) with wavelength 0.433 – 0.453; band 2 (blue) with wavelength 0.450 – 0.515; band 3 (green) with wavelength 0.525 – 0.600; band 4 (red) with wavelength 0.630 – 0.680; band 5 (NIR) with wavelength 0.845 – 0.885; band 6 (SWIR 1) with wavelength 1.560 – 1.660; band 7 (SWIR 2) with wavelength 2.100 – 2.300; band 8 (panchromatic) with wavelength 0.500 – 0.680; and band 9 (cirrus) with wavelength 1.360 – 1.390 (Lapan, 2015).

Results

Classification of Open, Unopened, and Water Area

In this study, the NDSI method is used to classify unopened area which is the vegetation and settlement areas), open area (land), and waters area. The main problem occurred in the study area is the type of land which is a vegetated swamp area. The emitted wave will directly affect the vegetation and interrupt the process of classifying by NDSI. Soil and peat soil texture classification is characterized using laboratory analysis and then approached using land map from Landsystem (Sukarman *et al*., 2013), Sumatra Peat Map from Wetland Indonesia (Wahyunto *et al*., 2003), and peat area map of Banyuasin regency (Kabupaten Banyuasin, 2017).

In order to distinguish unopened area (vegetation and settlement), open area (land), and waters area, the samples are taken in Landsat image with a combination of 65 band composites, as in Fig, 2a. Fig. 2b shows the average reflectance value in band 5 (NIR) and band 6 (SWIR). Furthermore, the reflectance value is used to determine the characteristics of land as the open, unopened, or waters area. Both SWIR band spectrum 6 with wavelength 1.560 – 1.600 µm and NIR spectrum on band 5 with wavelength 0.845 – 0.885 µm have low reflectance value when exposed at water area, that is 0.0161 at SWIR and 0.0444 on NON. The spectral value on the SWIR spectrum in band 6 tends to rise in open area or if it is exposed to a ground object, ie, equal to 0.2735. While the spectral value in band 5 rises in the unopened area (vegetation and settlement) that is equal to 0.2815 and decreased in the open area or if the object is hit by 0.2195.

The NDSI value shows the difference between SWIR in band 6 and NIR in band 5. The negative average value of NDSI indicates that the area is unopened area whereas the positive average values indicate the open area (the object is exposed to the soil). Fig. 3 showed the values of NDSI in each classification. Furthermore, the classification of NDSI is divided into 3 classes. The reflectance value of each classification can be seen in Table 1. From Table 1, it can be analyzed that the classification is based on the reflectance value of the waters area, the unopened area (vegetation and settlement), and the open area (ground object), as in Fig.3.

Fig 3 shows that the highly vegetated area tends to classified into the waters area because in the areas with dense vegetation, there will have a high wetness level due to water level contained in the leaf. Furthermore, the spectrum in band 6 reflects the small spectral value if it is exposed to water. The accuracy in the interpreting of the condition of open area is carried out using confusion matrix. The method will compare the matching data result of classification of open area with the result data of inspection directly in the field.

The test accuracy of open spaces, not open spaces, and water body

Field measurements are conducted from February to April 2017 at several locations in the study area, namely Tanjung Lago sub-district, Talang Kelapa sub-district, Muara Telang sub-district, Banyuasin I sub-district and Rambutan sub-district. Fig. 4 represents the description of the condition of the open area. The accuracy of the classification results is tested using a confusion matrix, as in Table 2. From table 2, it can be seen that the percentage of the overall rate is 95.00 % which indicates that the classification results of not open spaces (vegetation and settlement), open spaces (land), and

water body can be used in the making of soil condition thematic maps in the swamp areas based on the reflectance value classification.

Soil and Peat Soil Texture Tests

Soil and peat soil texture classification are carried out by taking some soil samples in the open and unopened areas. Soil samples are taken at 10 locations in which each location is taken 3 points in several study area using hand bore. Furthermore, the property index testing is performed to determine the soil type and soil texture based on AASHTO classification. The location point of soil sampling is presented in Fig. 5. The results of properties index testing and filter analysis are shown in table 3.

According to wetland map (Wahyunto *et al*., 2003), location 6 is a peat area with a depth of <50 cm, whereas at location 1 and location 5 are peat soil with a depth of 50-100 cm. The laboratory analysis shows that the soil characteristics at location 1, and location 5 are clay grayed soil whereas at location 6 shows the clay type soil. Laboratory tests are also done by measuring the soil density. The results show that the density of soil at location 1, and location 5 and 6 are 2.66 and 2.46, respectively. Based on the soil density, it can be concluded that in the study area, the existing soil type is not kinds of peat soil because the peat soil has a low soil density.

Soil and Peat Texture Classification

The classification of soil texture in the study area is divided into 3 classes: fine soil for loamy soil, fine soil for dense soils (based on laboratory test results showing that in swamp areas consisting of clay and clay soil), and peat. The peatland classification is taken from Wetland Peatland Data of Indonesia in Sumatera region (Wahyunto *et al*., 2003) which has a depth of 100 – 200 cm. Peat depth specifications are based on unused depths in agricultural and plantation activities. While the classification of soil texture is determined based on the results of research in the laboratory and compared with the landscape map (Sukarman *et al*., 2013). The results show that the texture of the soil present in the swamp area consists of fine structure and slightly fine, so the classification of soil is only divided into 3 classes: fine texture for clay soil with grain size <0.002 mm, slightly smooth texture for soil with grain size of 0.002 - 0.075, and peat soil. The delineation of soil texture is based on the river boundary. The classification of soil texture and peat soil can be seen in Fig. 6.

Discussion

Potithep et al., (2005) calculated NDSI to find the relationship between groundwater and soil contents from infrared waves and near infrared waves. Two shortwave infrared channels and long waves from MODIS on channels 5 and 6 are selected. The results show that groundwater content at 10 cm depth has the best linear relationship with channel 6 based NDSI.

The NDSI method can not determine the soil texture and peat soil classification because the wavelength is not directly exposed to the soil object. According to Deng et al., (2015), the development of spectral values of vegetation and soil is carried out to distinguish the normalized index of the soil. These differences can be interpreted using the NDSI method but the classification can only be determined for identification the open area, unopened area, and waters. The recognition of soil and peat texture are conducted by laboratory tests based on samples which are taken in the open areas obtained from the results of classification. Based on the classification obtained from the laboratory test, the texture of the soil in the swamp area in Banyuasin regency consists of the clay; clay greyed soil and fine sand. From the classification of soil conditions using the NDSI method, the composite band 65 obtained the range of reflectance values (-1.0336) – (-0.4582) for waters, (-0.4582) – (-0.0645) for the unopened area and (-0.0645) – (0.4300) for open area. The soil classification in swamp area is divided into 3 classes: soft for clay type with diameter <0.002 mm, medium for soil with diameter 0.002 – 0.075 mm, and rather rough for sandy soil with diameter 0.075 – 0.425 mm. While the peat soil has a depth between 50 – 100 cm and 100 – 200 cm.

Conclusion

Based on the classification of soil conditions using the NDSI method, the composite band 65 obtained the range of reflectance values (-1.0336) – (-0.4582) for water body, (-0.4582) – (-0.0645) for not open spaces, and (-0.0645) – (0.4300) for open spaces. The soil classification in the swamp area is divided into 3 classes based on the diameter of soil: soft for clay type with diameter <0.002 mm, medium for soil with diameter 0.002 – 0.075 mm, and rather rough for sandy soil with diameter 0.075 – 0.425 mm. The peat soil has a depth between 50 – 200 cm.

Acknowledgements

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Table 1. Classification of the Reflektan Value to differentiate open spaces, not open spaces, and water body

No.	Classification	Reflectance Value
1.	Water Body	(- 1,0336) – (- 0,4582)
2.	Not Open Spaces	(- 0,4582) – (- 0,0645)
3.	Open Spaces	(- 0,0645) – (0,4300)

Table 2. The confusion matrix on the classification of open spaces, not open spaces, and water body

	Description	Reference Data (Field Data)			Sum	User Accuracy
		Not Open Spaces	Open Spaces	Water Body		
Classification Data	Not Open Spaces	152	2	2	156	97,44
	Open Spaces	4	27	1	32	84,38
	Water Body	0	1	11	12	91,67
	Sum	156	30	14	200	
	Produser's Accuracy	97,44	90,00	78,57		95,00

Table 3. Test results and analysis of Filter Properties Index based on AASHTO classification.

No	Description	Score Avarange			
		Specific Gravity	Soil Classification (AASHTO)	Soil Type Classification (AASHTO)	Granules Size (mm) (AASHTO)
3					
1	Location 1	2,66	A-4	Silty Soil	0,002 - 0,075
2	Location 2	2,59	A2-4	Silty or clayey gravel and sand	0,075 – 0,425
3	Location 3	2,68	A-4	Silty Soil	0,002 - 0,075
4	Location 4	2,60	A-6	Clayey Soil	< 0,002
5	Location 5	2,46	A-4	Silty Soil	0,002 - 0,075
6	Location 6	2,46	A-7	Clayey Soil	< 0,002
7	Location 7	2,42	A-4	Silty Soil	0,002 - 0,075
8	Location 8	2,53	A-7	Clayey Soil	< 0,002
9	Location 9	2,21	A-7	Clayey Soil	< 0,002
10	Location 10	2,17	A-7	Clayey Soil	< 0,002

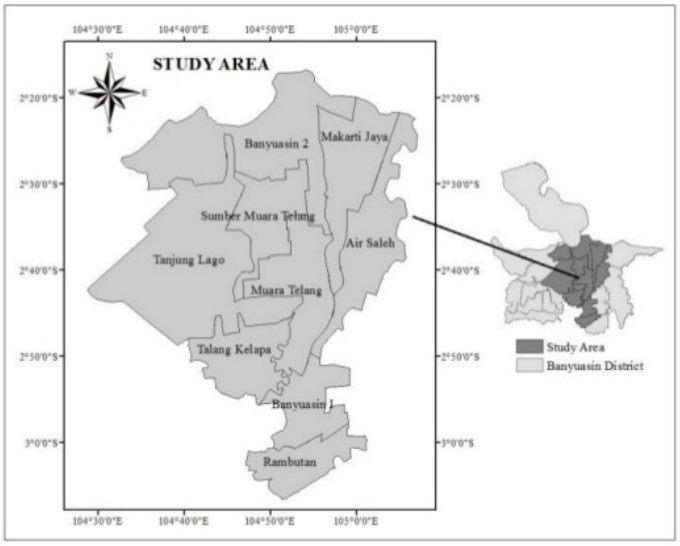
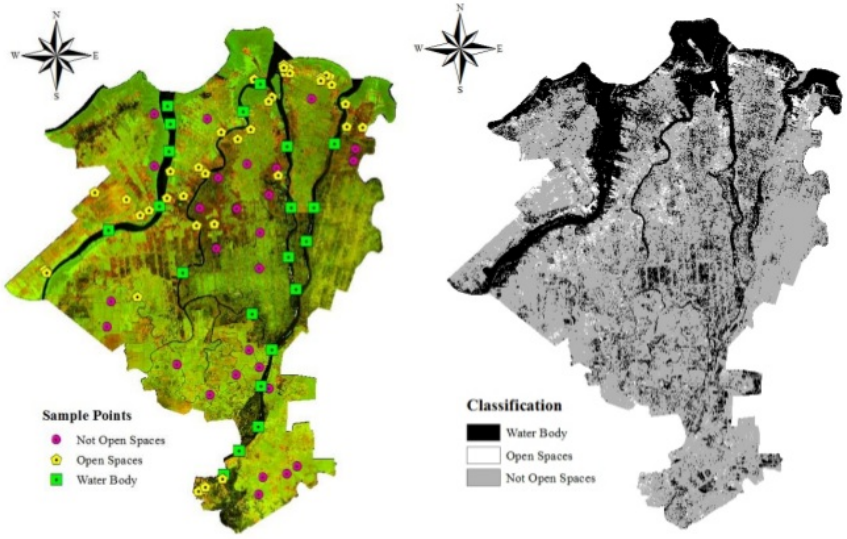
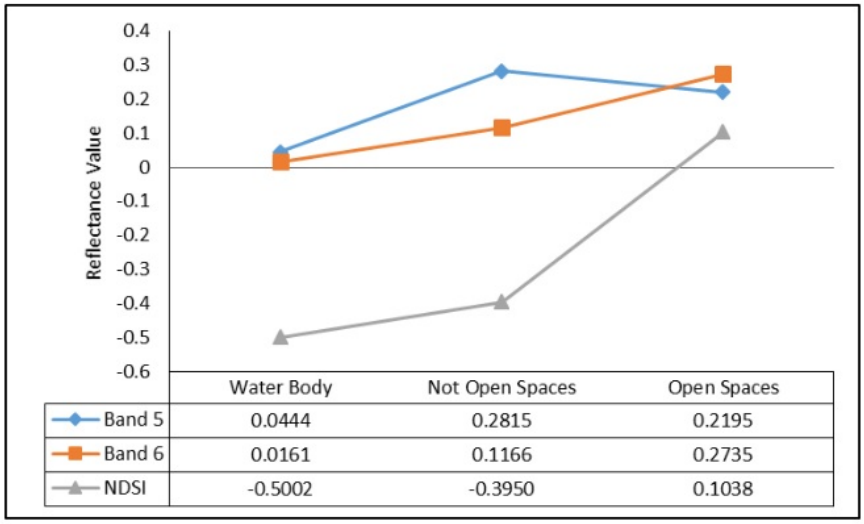


Fig. 1. Study Area



(a) (b)

Fig. 2. Soil conditions identification on the composite Band 65. (a) sample point of the determination of Reflectance Value, (b) classification result of open spaces, not open spaces, and water body.



	Water Body	Not Open Spaces	Open Spaces
Band 5	0.0444	0.2815	0.2195
Band 6	0.0161	0.1166	0.2735
NDSI	-0.5002	-0.3950	0.1038

Fig. 3. The Reflectance value in Band 6 (SWIR), Band 5 (NIR) and NDSI

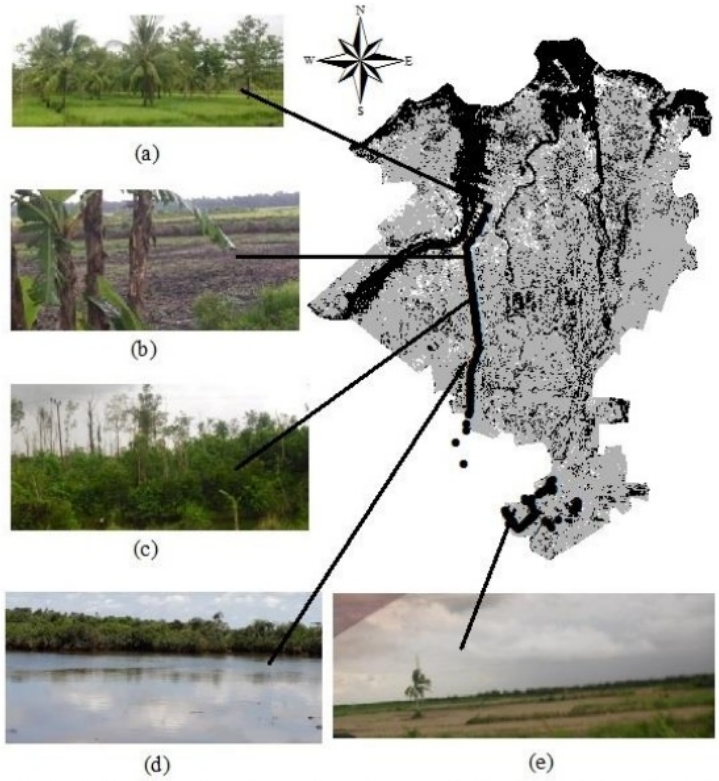


Fig. 4. Cross Check of Classification (a) Not Open Spaces (Field Rice and Plantation); (b) Open Spaces (Preparation for Field Rice); (c) Not Open Spaces (Shurb); (d) Water Body (River); (e) Open Spaces (Field)

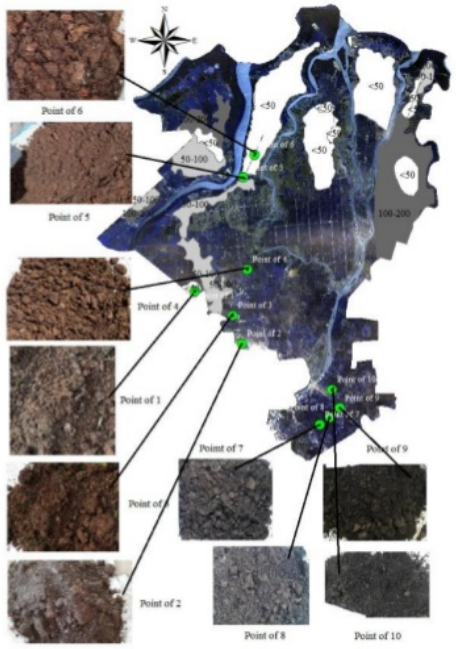


Fig. 5. Soil Sampling Locations

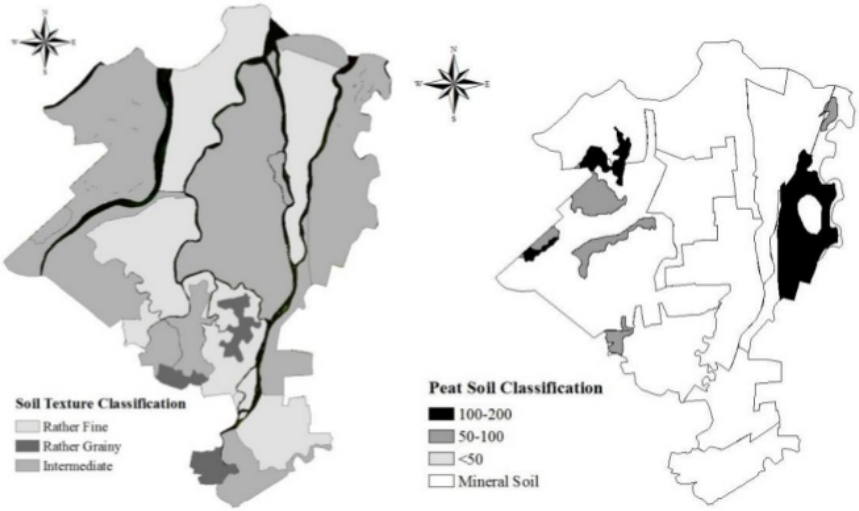


Fig. 6. Result of classification. (a) Soil texture, (b) Peat soil.

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