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by Dinar Da Putranto

Spatial analysis of soil texture and peat soil by NDSI method at swamp area of Banyuasin District, Indonesia

Indrayani[1,2], Erika Buchari[3], Dinar D.A. Putranto[3*] and Edward Saleh[4]

[1]Environmental Science Postgraduate Program of Sriwijaya University, Palembang, Indonesia
[2]Civil Engineering Department, State Polytechnic of Sriwijaya, Palembang, Indonesia
[3]Civil Engineering Department, Faculty of Engineering, Sriwijaya University, Palembang, Indonesia
[4]Agriculture Engineering Department, Faculty of Agriculture, Sriwijaya University, Palembang, Indonesia

ABSTRACT

Road construction in the swamp yarea 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 – 200cm.

Introduction

The development of the swamp yarea 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 faced 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 re-

Corresponding author's email: iiend_sumantri@yahoo.com
*Corresponding author's email: dinar.dputranto@gmail.com

duce the cost, some technology can be used to help the field investigation such as Geographical Information System (GIS). GIS using remote sensingtechnologyisoneoftheeconomicalternativeswhichcan find out the potential land cover (Wondrade *et al.*, 2014;Karakus*etal.*,2015).Oneoftheremotesensing technologies that can be used for the recognitionof soilcharacteristicsisLandsatimage8(LiandChen, 2014).

Landsat 8 in remote sensing technology has onboardoperationallandimager(OLI)andthermal infra red sensor (TIRS) sensor which have a totalof 11 channels which consists of 9 channels (band1-9) 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 Normalliz Different Vegetation Index (Gandhi *et al.*, 2015), Normalized Different Wetness Index-NDWI (Haikal, 2014),and Normalized Different Soil Index-NDSI (Deng *et al.*, 2015).AccordingtoDeng*etal.*,(2015),Thedevelopment of a spectral sample of vegetation and soil samples is conducted to distinguish normalizedindexes for increasing soil information. These differences can be interpreted using the NDSI method. The study aimed to obtain the thematic mapshowing the location of soil and peat texture to facilitate the decision making in determining the road trace which traversed at a location in the swamparea.

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 thatdownloadedfromtheUnitedStatesGeological Survey on the scene: path 124/row 062 is used to obtained the classification of open area, unopened area,andwaters.Theimagedataprocessingisprocessed through stages: (i) pre-processing (cuttingthe imagethatservestolimittheareaofresearchand
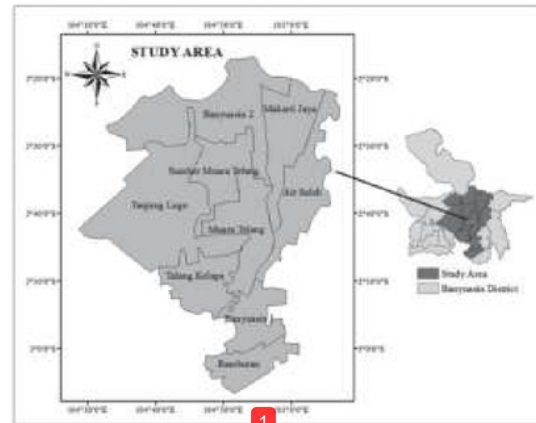

Fig. 1. Study Area

reduce the size of image files as well as geometric and radiometric correction; (ii) data processing (color composite, digital image interpretation for sharpening,smoothingfilter,contrast,multispectral classification on Landsat image 8) and NDSI transformation; and (iii) field test stages and laboratory teststoobtainthespecificgravity,propertiesindex, and soiltexture.

Soil texture and peat texture analysis are observed through soil moisture field by separating openareaandunopenedareabasedonNDSIvalue, 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 fornotifyingthesoilonthesurfaceconditionsofthe earth. The equation showed below.

NDSI= (SWIR – NIR) / (SWIR +NIR)

The characteristics of OLI sensor on satellite landsat8has9bandsnamelyband1(costalaerosol) withwavelength0.433–0.453;band2(blue)with wavelength 0.450 – 0.515; band 3 (green) withwavelength 0.525 – 0.600; band 4 (red) withwavelength 0.630–0.680;band5(NIR)withwavelength0.845– 0.885; band 6 (SWIR 1) with wavelength 1.560– 1.660; band 7 (SWIR 2) with wavelength 2.100– 2.300;band8(panchromatic)withwavelength0.500 –0.680;andband9(cirrus)withwavelength1.360– 1.390 (Lapan, 2015).

Results

Classification of Open Spaces, Not Open Spaces, and Water Body

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 flandwhichisavegetatedswamparea. Theemitted wave will directly affect the vegetation and interrupt the process of classifying by NDSI. Soiland peatsoiltextureclassificationischaracterizedusing laboratoryanalysisandthenapproachedusingland 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 todistinguish unopened area (vegetation and settlement), open area (land), and waters area, thesamplesaretakeninLandsatimagewithacombination of 6 and 5 band composites, as in Fig, 2a. Fig.2bshowstheaveragereflectancevalueinband 5(NIR)andband6(SWIR).Furthermore,thereflectance value is used to determine the characteristics oflandastheopen,unopened,orwatersarea.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 and0.0444onNON.ThespectralvalueontheSWIR

spectruminband6tendstoriseinopenareaorifit 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 orif the object is hit by0.2195.

The NDSI value shows the difference between SWIR in band 6 and NIR in band 5. The negative averagevalueofNDSIindicatesthattheareaisunopened area whereas the positive average values indicate the open area (the object is exposed to the soil).Fig.3showedthevaluesofNDSIineachclassification.Furthermore,theclassificationofNDSIis dividedinto3classes.Thereflectancevalueofeach classificationcanbeseeninTable1.FromTable1,it canbeanalyzedthattheclassificationisbasedon

Table1. ClassificationoftheReflektanValuetodifferentiate open spaces, not openspaces, and water body

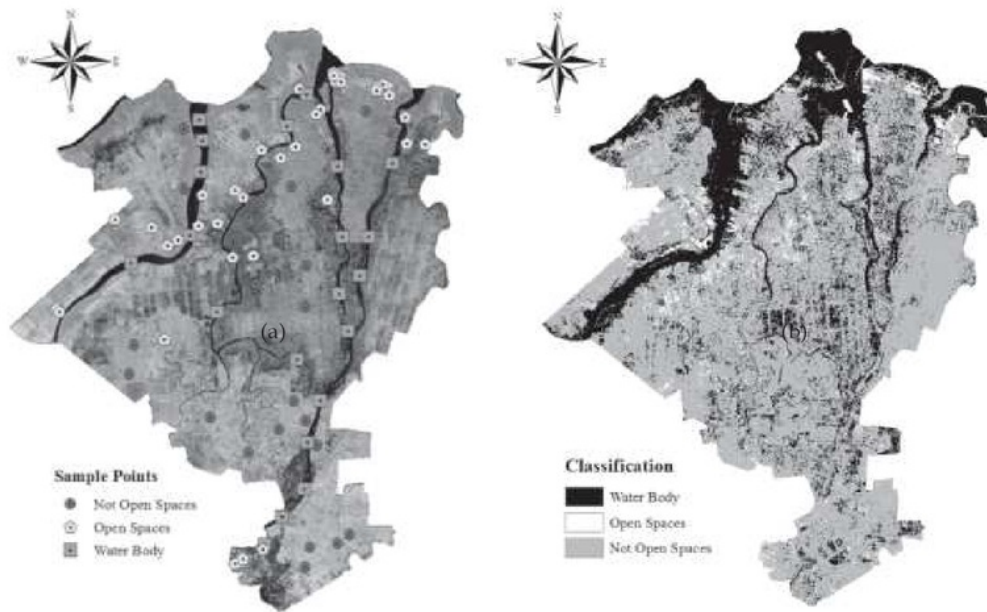| No.	Classification	Reflectance Value
1.	Water Body	(- 1,0336) – (- 0,4582)
2.	Not Open Spaces	(- 0,4582) – (- 0,0645)
3.	Open Spaces	(- 0,0645) – (0,4300)

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

the reflectance value of the waters area, the un-opened area (vegetation and settlement), and the open area (ground object), as in Fig.3.

Fig.3showsthatthehighlyvegetatedareatends toclassifiedintothewatersareabecauseintheareas with dense vegetation, there will have a high wet-ness 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 accuracyintheinterpretingoftheconditionofopen area is carried out using confusion matrix. The method will compare the matching data result of classificationofopenareawiththeresultdataofin-spection directly in thefield.
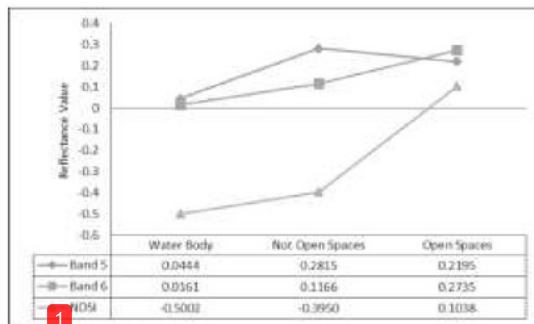

Fig. 3. The Reflectance value in Band 6 (SWIR), Band 5 (NIR) and NDSI

The test accuracy of open spaces, not openspaces, andwaterbody

Field measurements are conducted from Februaryto April 2017. The measurements are conducted at 30 sample points which determined by direct landuse andinundationchecks.Fig.4representsthedescrip-tionoftheconditionoftheopenarea.Theaccuracy of the classification results is tested using a confu-sion matrix, as in Table 2. From Table 2, it can be seenthatthepercentageoftheoverallrateis86.67%

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 swampareasbasedonthereflectancevalueclassifi-cation.

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 loca-tionsinwhicheachlocationistaken3pointsinsev- eral study area using handbore. 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 Table3.

According to wetland map (Wahyunto *et al.*, 2003), location 6 is a peat area with a depth of <50 cm,whereasatlocation1andlocation5arepeatsoil with a depth of 50-100 cm. The laboratory analysis shows that the soil characteristics at location 1,and location5areclaygrayedsoilwhereasatlocation6 shows the clay type soil. Laboratory tests are also done by measuring the soil density. The results showthatthedensityofsoilatlocation1,andloca-tion5and6are2.66and2.46,respectively.Basedon thesoildensity,itcanbeconcludedthatinthestudy area, the existing soil type is not kinds of peat soil because the peat soil has a low soildensity.

Soil and Peat Texture Classification

The classification of soil texture in the study areais divided into 3 classes: fine soil for loamy soil, fine soil for dense soils (based on laboratory test results showingthatinswampareasconsistingofclayand clay soil), and peat. The peatland classification is taken from Wetland Peatland Data of Indonesiain

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

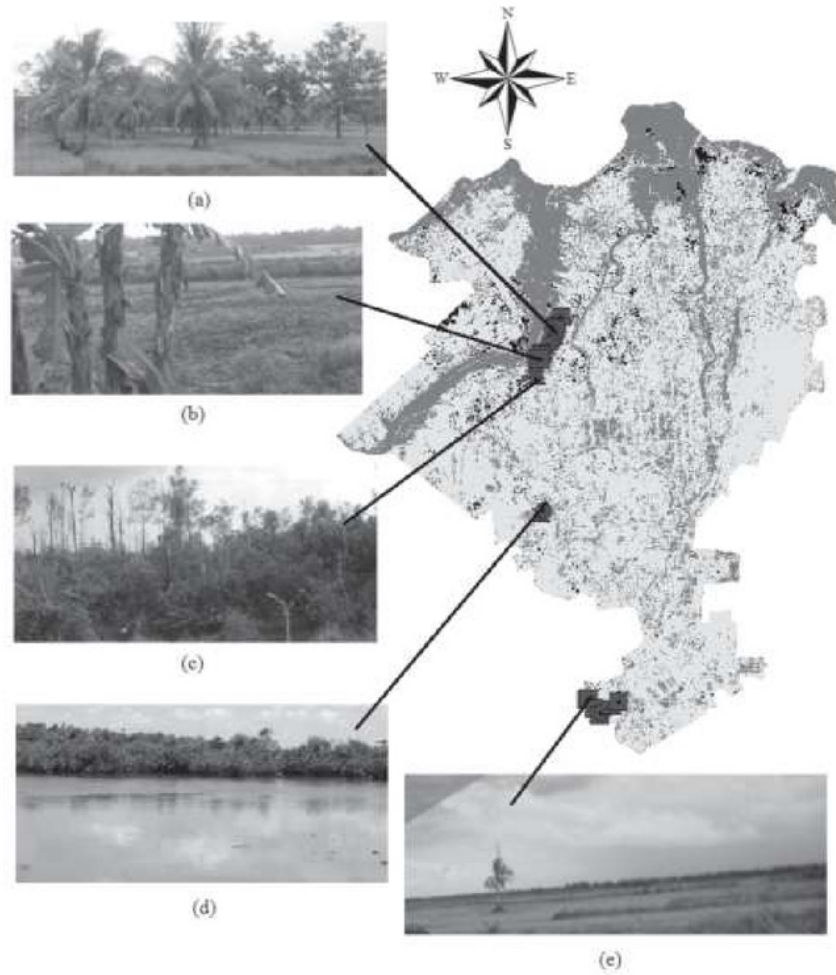|	Description	Reference Data(FieldData)			Sum	User Accuracy
		Not Open Spaces	Open Spaces	Water Body		
	Not Open Spaces	13	1	1	15	86,67
Classification	OpenSpaces	1	10	0	11	90,91
Data	WaterBody	1	0	3	4	75,00
	Sum	15	11	4	30	
	Produser's Accuracy	86,67	90,91	75,00		86,67

Fig.4. CrossCheckofClassification(a)NotOpenSpaces(FieldRiceandPlantation);(b)OpenSpaces(Prepa- ration for Field Rice); (c) Not Open Spaces (Shurb); (d) Water Body (River); (e) Open Spaces(Field)

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

No	Description	Score Avarange			
		Specific Gravity	Soil Classification	Soil Type Classification	Granules Size (mm)
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-5	Silty Soil	0.002 - 0.075
6	Location 6	2.46	A-7	Clayey Soil	< 0.002
7	Location 7	2.42	A-5	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

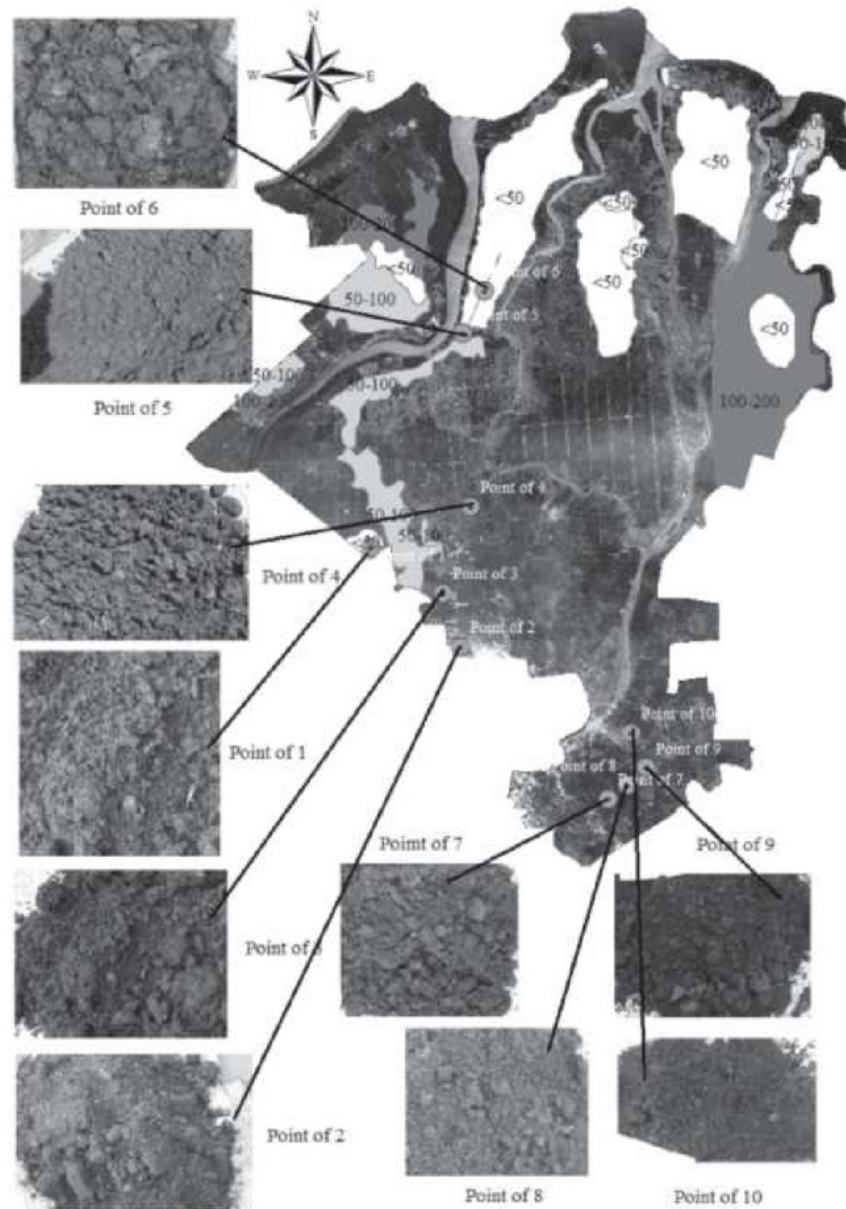**Fig. 5.** Soil Sampling Locations

Sumateraregion(Wahyuntoetal.,2003)whichhas depthof100–200cm.Peatdepthsspecificationsare basedonunuseddepthsinagriculturalandplanta- tionactivities.Whiletheclassificationofsoiltexture isdeterminedbasedontheresultsofresearchinthe laboratory and compared with the landscapemap

(Sukarman *et al.*, 2013). The results show that the textureofthesoilpresentintheswampareaconsists of fine structure and slightly fine, so the classifica- tionofsoilisonlydividedinto3classes:finetexture for clay soil with grain size <0.002 mm, slightly smoothtextureforsoilwithgrainsizeof0.002-0.075,

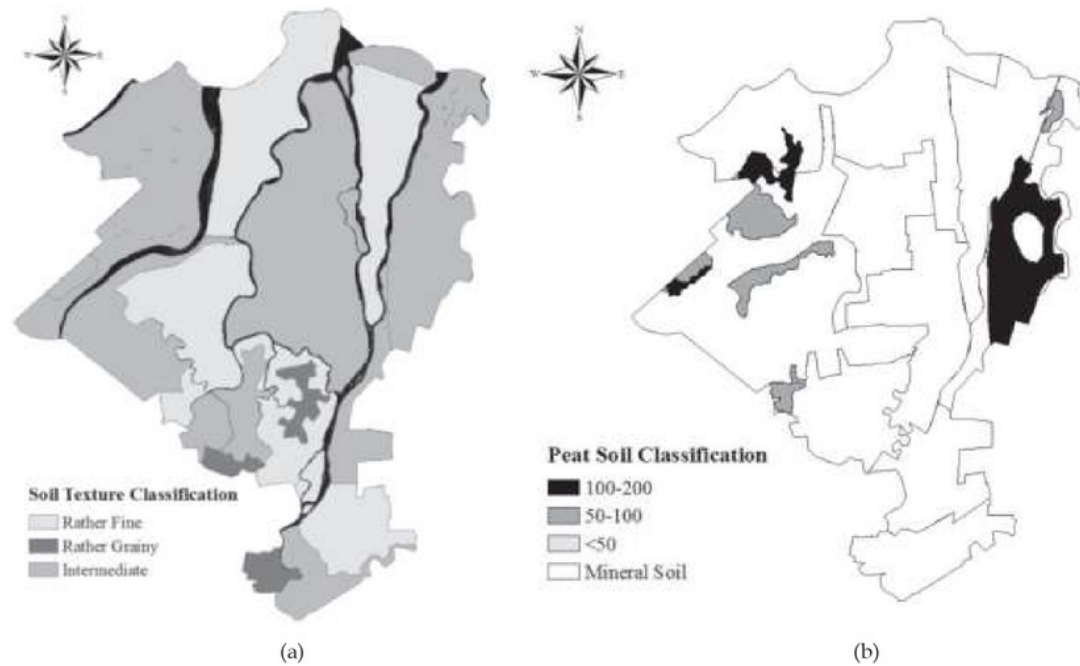(a)   (b)

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

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 cannot 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 area as 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)foropenspaces.The soil classification in the swamp area is dividedinto 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.

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