THE NEW METHOD FOR DETECTING EARLY PLANTING AND BARE LAND CONDITION IN PADDY FIELD BY USING VEGETATION-BARE-WATER INDEX

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Abstract. Rice (Paddy) plants is the most important food crop for the Asian population, especially in Indoseia. During the growth of rice plants have four main phases, namely the initial planting which is still dominated by water objects, the vegetative phase, the generative phase, and the postharvest phase or Bare land. Monitoring the condition of the rice plant needs to be done in order to know whether the rice plants have problems or not in its growth cause drought, floods, and pests and diseases. Application of remote sensing technology, which uses satellite data such as Landsat 8 which has a spatial and temporal resolution is high enough for monitoring the condition of crops such as paddy rice in a large area. In this study has been made an algoritm for monitoring rapidly of rice growth condition using combination between Vegetation-Bare-Water Index (EVI, NDBI, NDWI) with RGB Clustering in 766 partition of the band Blue, Red and Near Infrared. The results showed that the threshold values for objects cloud, cloud shadows, water, vegetation and bare relatively consistent for all date data using the method compared with other methods, such as the certain threshold value of band ratio method or only use vegetation index.

Keywords:Vegetation-Bare-Water Index,RGB, Clustering, paddy phase, EVI, NDBI, NDWI

1. Introduction

Paddy crop is the most important food crop for the Asian population, especially in Indonesia. Paddy is cultivated widely in Asian Region from tropical to cold-temperate climate zones which have variation depend on physical conditions each location. In the most tropical climate zone, temperature could be not as problem for cultivated paddy all the year.However, availability of water on planting time would be a important factor to conduct transplanting of paddy paddy. Therefore, some areas, where function of supplying water was not good condition,so the paddy growing seasons should be planned in planting time variation. Although there were several variation of planting time, but that phenomen can be used to understand how trend of paddy production at the study area. That condition could not be shown in detail from conventional statistics information. Based on background, it is necessary to consider a monitoring system of spatio-temporal characteristics of paddy planting. Beside that, it is useful to detect areas where time of planting paddy occur lately planting or not. Satellite remote sensing has been used extensively for these purposes. In order to know planting time of paddy through several year, high temporal resolution data very helpful for analysis. Some researchers have conducted research by using MODIS data to characterize the pattern of paddy planting for widely area in Asian region (e.g. Takeuchi and Yasuoka, 2004; Sakamoto et al, 2006; Xiao et al, 2006). Those studies have find that spatial distribution of paddy planted area and also cropping pattern in various areas can be detected. Uchida (2017)has examined capability of MODIS composite data to estimate paddy planted time in West Java, and he modified it to be adopted by 16-daycomposite MODIS data product (Uchida, 2010ab). Result of his researchshow that time of planting paddy could be identified and features of variation can be characterized properly. Results also find arelationship betweenrainfallpattern in early rainy season and variation of paddy planted time. Even though, his research has not been able to find out variation of spatial pattern in detail and only case in certain year. Therefore, further reserachshould be doneto know relationship betweenpattern of paddy planting time by using some parameter, which was obtainedfrom high temporal dan spasial resolution satellite, such as MODIS data aor Landsat. The purpose of this research is to detect rapidly growth phase of paddy by using Landsat 8 data based on NDWI (Water Index) , EVI (Vegetation Index) and NDBI (Bare Index) parameters.

2. Location of Research

The study site is Paddy field area belongs to PT Sang Hyang Sri, Subang, West Java. Why that location have decided as study area, because each block of paddy crop have known planting time, harvest time, and production. Geographically, the area is located between 787438 m and 794519m of easting NUTM Zone 48 and between -694463m and -704894 m of NorthingNUTM Zone 48 as shown in Figure 1. Planting Index of paddy per year exceeds twice or three times in extensive area.

Figure 1. Research location at Paddy area, Subang District, West Java

3. Methodology

Primary data used in this research is Landsat 8 data, Path 122/Row 064 that have been corrected of geometric and atmospheric became the surface reflectance. The data can be obtained form USGS situs or spcecial request from Remote Sensing Technology and Data Center. In order To obtain a rice plant growth profile, then use the data as much as twice the rice planting season, which is about 16 scenes in the period from May to August, 2015.Stages of research done can be seen in the flowchartin Figure 2.

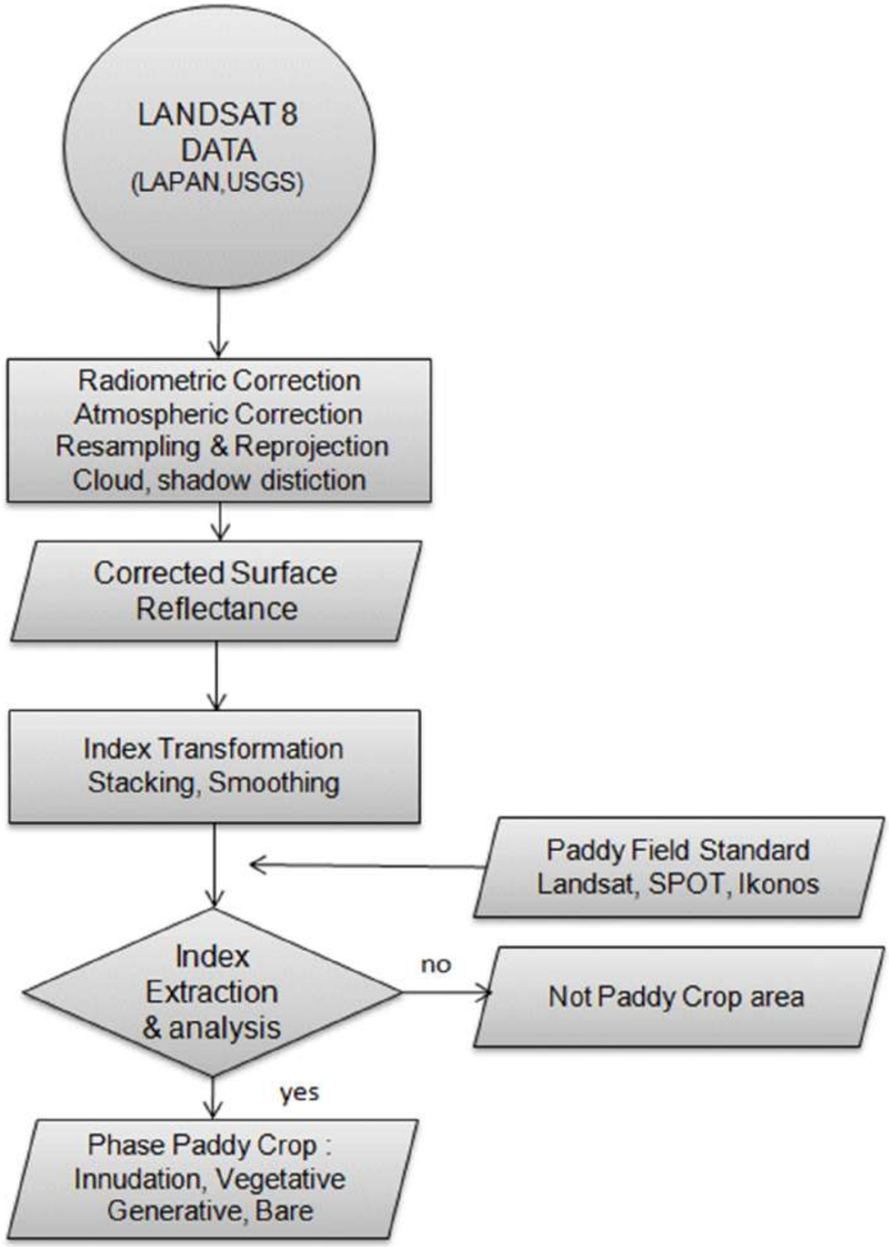

Figure 2. The Flowchart of Research Stage

Three indices that can represent of land and paddy crop condition (wet, dry, bare or vegetated) are NDWI(Normalize Difference Water Index), NDBI(Normalize Difference Bare Index), and EVI(Enhanced Vegetation Index). Those indices are influenced by land moisture condition on surface (0 – 20 cm soil depth). Like as NDVI, so NDBI and NDWI can be derived based on peak value of spectral response onto general objects (water, bare, vegetation) at wavelength variety which can be shown on Figure 3.

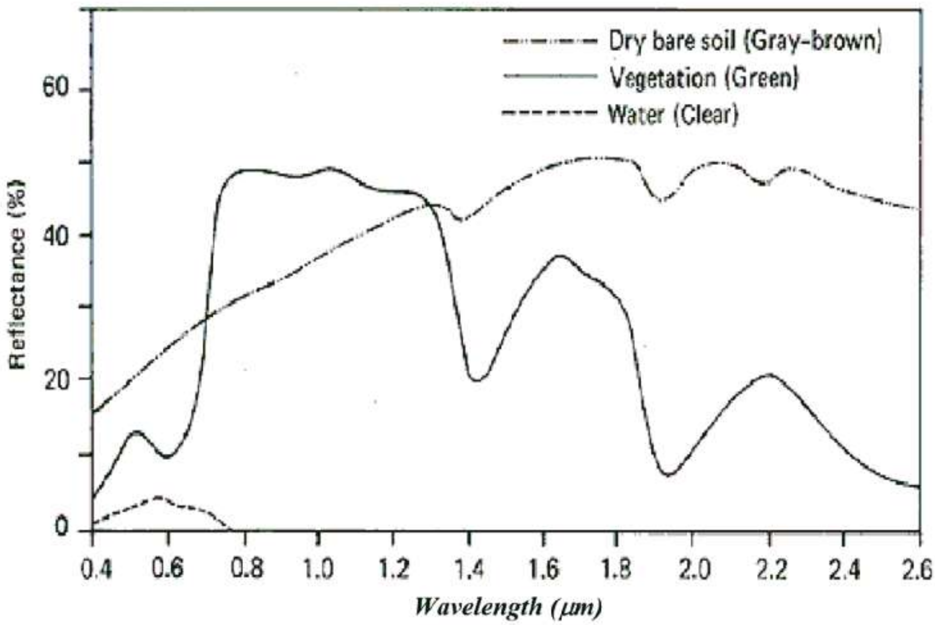

Figure 3. General Spectral Response of Water, Bare Soil, and Vegetation object

Peak values for vegetation object is shown contrastly at wavelength 0.6 µm (red) and 0.8 µm (near infra red). Peak values for water object is shown contrastly at wavelength 0.4 µm (blue) or 0.5 µm (green) with 0.8 µm and 0.6 µm or 2.1, while peak values of open area or bare soil lies at 0.8 µm and 1.8 µm (SWIR = short wave infra red). Research result by Dirgahayu (2013) obtain the best of 3 reflectances of MODIS data for estimating land mositure. Those are Red (R4), NIR (R5), and SWIR1 (R6), SWIR2 (R7) reflectances. Based on that result, so NDWI and NDBI can be created like as computing NDVI by using the following formula below

$$\mathbf{NDWI = (R3 - R7)/(R3 + R7)} \quad (1)$$

$$\mathbf{NDBI = (R6 - R5)/(R5 + R6)} \quad (2)$$

Vegetation Index to detect land greeness with equation:

$$\mathbf{EVI = 2.5*(NIR - Red)/(1+NIR+6*Red-7.5*Blue)} \quad (3)$$

Not visible bands was used to reduce the influence of the atmospheric effect which very significant towards the visible bands, so in this research was used SWIR1 (R6) and SWIR2 (R7) band of Landsat 8. Information data about crop calendar of planted paddy was obtained from PT Sang Hyang Sri, Subang District of West Java. Paddy field distribution data was obtained from Ministry of Agriculture, Indonesian Goverment. This data was produced trough manual interpretation and digitizing on screen using IKONOS imagery 2010 years. Figure 4 shows spatial distribution of paddy field at PT Sang Hyang Sri and its surround belong to part of Subang district. In the previous research (Uchida, 2010ab), has been indicated that the maximum of NDWI was reached at the time of transplanting paddy paddy and EVI value was sharply increased after the time of transplanting.

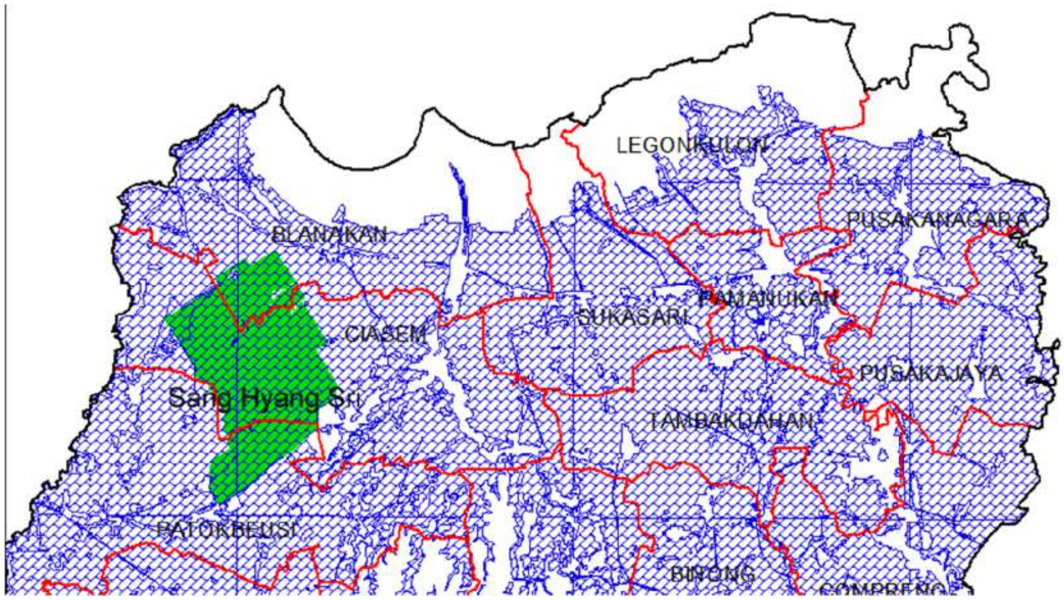

Figure 4. Spatial Distribution of Paddy field at Sang Hyang Sri and its surround, Subang District

4. Results and Discussions

4.1. Investigation of objectcs based on Color Composite Image of Landsat 8

Based on RGB color composite image 653 dated August 31, 2015 (Figure 6) and previously dated August 15, 2016 (Figure 5) shows most of the paddy fields in the district of Subang still appeared of rice crops and which have occurred harvesting crop. Object water showed early treatment and early rice planting is also seen in some areas. While object wetland in paddy field looks vary from dark green to light green and mixing with yellow color.

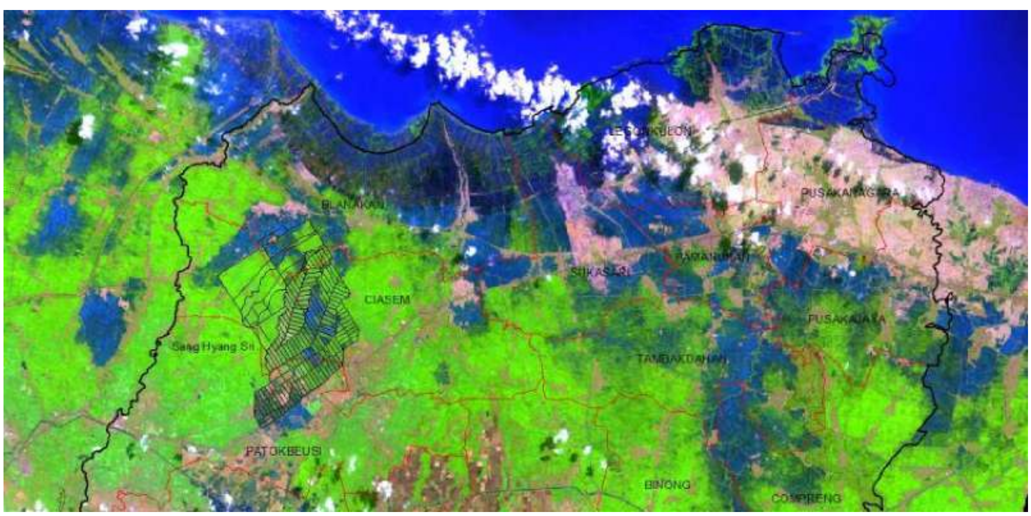

Figure 5. Natural Color Composite band 653 (SWIR1,NIR, Green) of Landsat 8 on August 15, 2015

Figure 6. Natural Color Composite band 653 (SWIR1,NIR, Green) of Landsat 8 on August 31, 2015

The condition paddy fiels has been harvested land is shown by the appearance of the object of open area (bare land) in paddy fields with gradation of dark brown and magenta to light gradation. Vegetation cover of rice crop in paddy is still visible in PT Sang Hyang Sri and on August 31, 2016. In order to know the rice plant is undergoing a vegetative or generative growth phase, then it must be known change of the vegetation index (EVI) compared with the previous 16 days of data. Vegetative phase is indicated by the increase in the vegetation index or a trend of positive changes. While the generative phase occurs otherwise is indicated by negative changes or a trend of decline in the vegetation index. Changes in the vegetation index from the date of August 15 to 31 are shown in Figure 7.

Water object boundary indicated by the value of vegetation index < 0 with the changes varied, while the object of open area (bare land) indicated by EVI between 0.22 to 0.33 with the vegetation index changes largely negative. Based on the analysis of the vegetation index change, so rice plants that are experiencing generative phase is indicated by the bright green color. While the rice plants that are natural vegetative phase indicated by the appearance of green color a bit darker. The condition occurs because the paddy field during the vegetative growth of the rice plant is still in the wet condition until moist.

4.2. Spectral Characteristics of Water, Bare, and Vegetation object based on Landsat 8 Data

The initial step to determine the characteristics of the object water, open land, settlement or bare land in paddy field, vegetation, clouds and its shadow, then taken sampling represents the condition of these objects. For this purpose have been taken samples as many as 64 samples. Furthermore, the extraction of value surface reflectances of Landsat 8, then plotted the results in graph form for further analysis. The results of extraction surface reflectance of Landsat 8 data can be shown in figures below (Figure 8 – 12).

Based on those figures can be shown that peak of surface reflectance for open area or bare land (Sugarcane, Paddy field, settlement) occurs in SWIR1 band of Landsat 8 Data. The peak of surface reflectance for vegetation object occurs in NIR band.

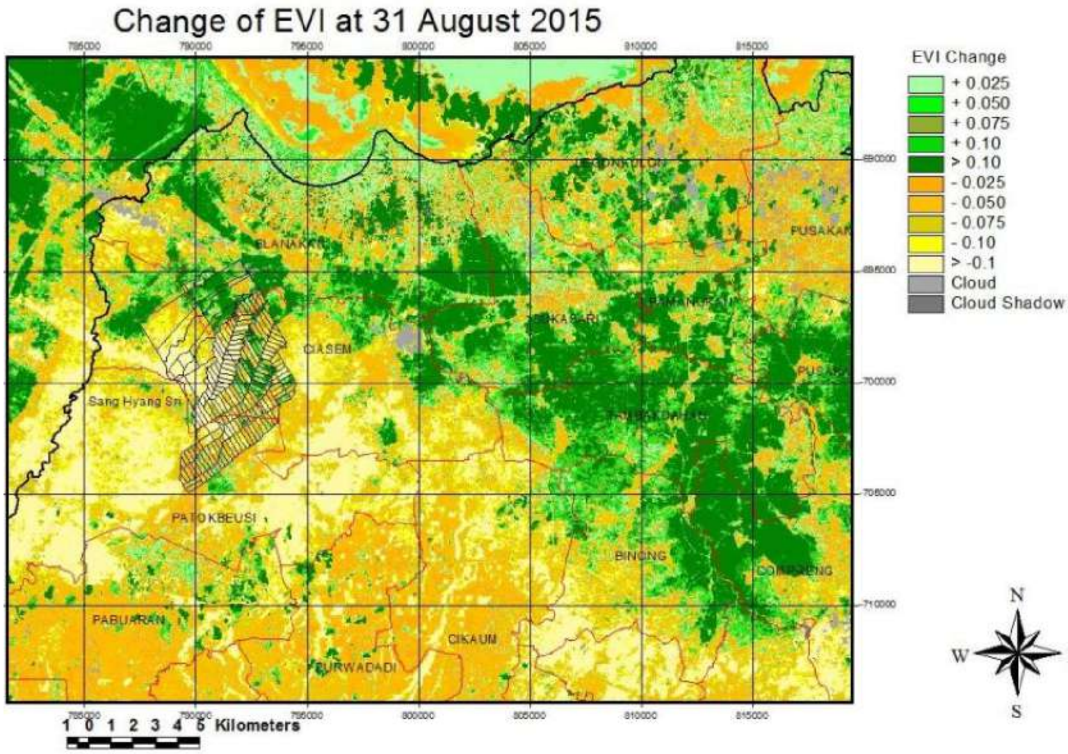

Figure 7. Spatial Distribution of The Change of EVI at Subang District, West Java

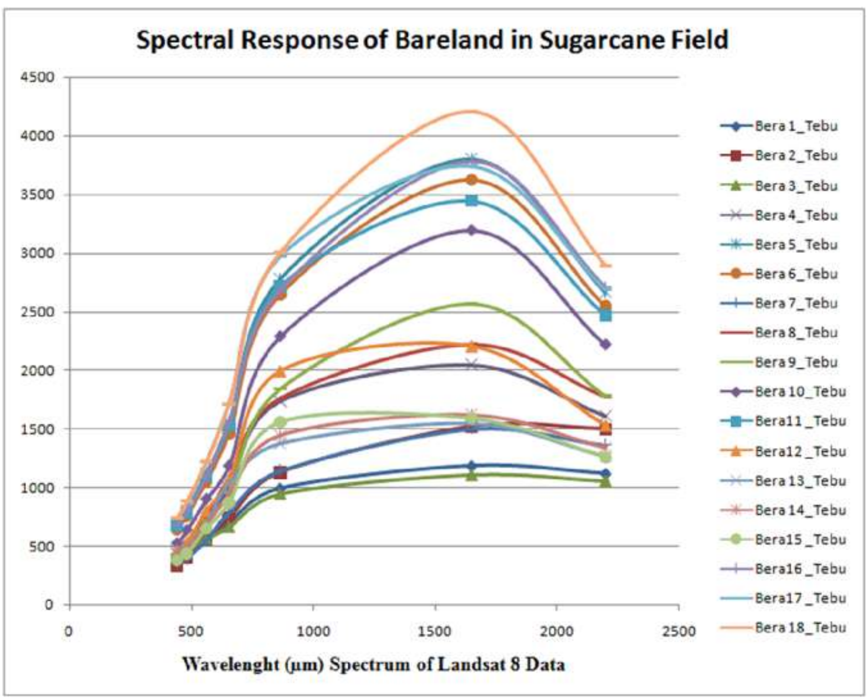

Figure 8. Spectral Response of Bare Object in Surgarcane Field Based on Landsat 8 Data

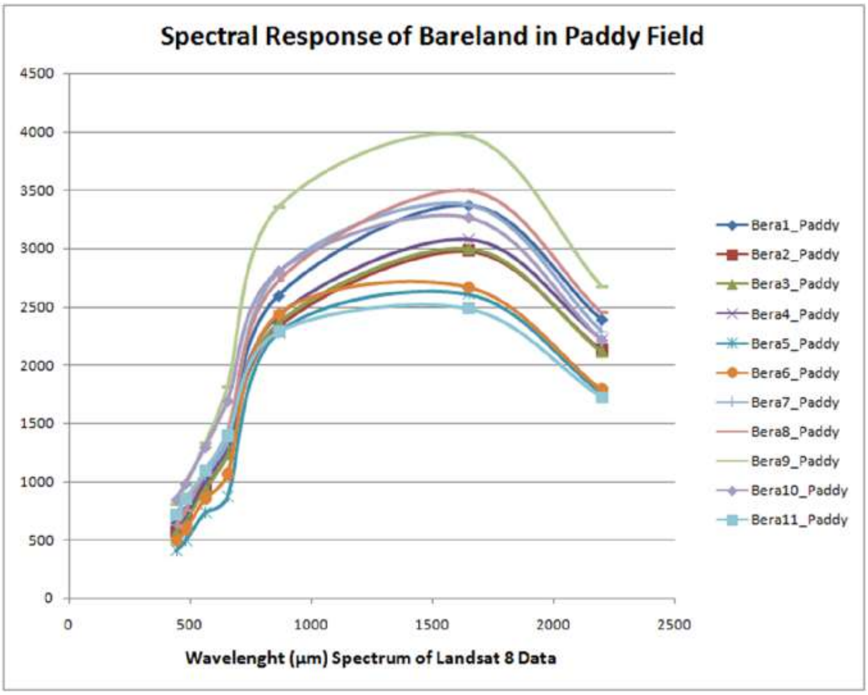

Figure 9. Spectral Response of Bare Object in Paddy Field Based on Landsat 8 Data

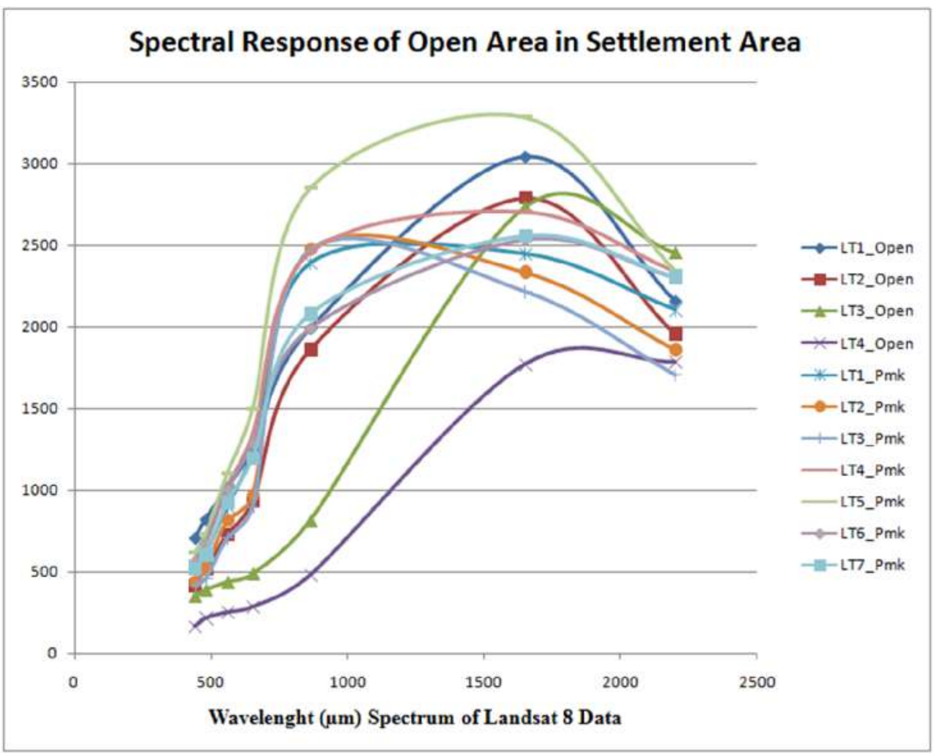

Figure 10. Spectral Response of Bare Object in Settlement Region Based on Landsat 8 Data

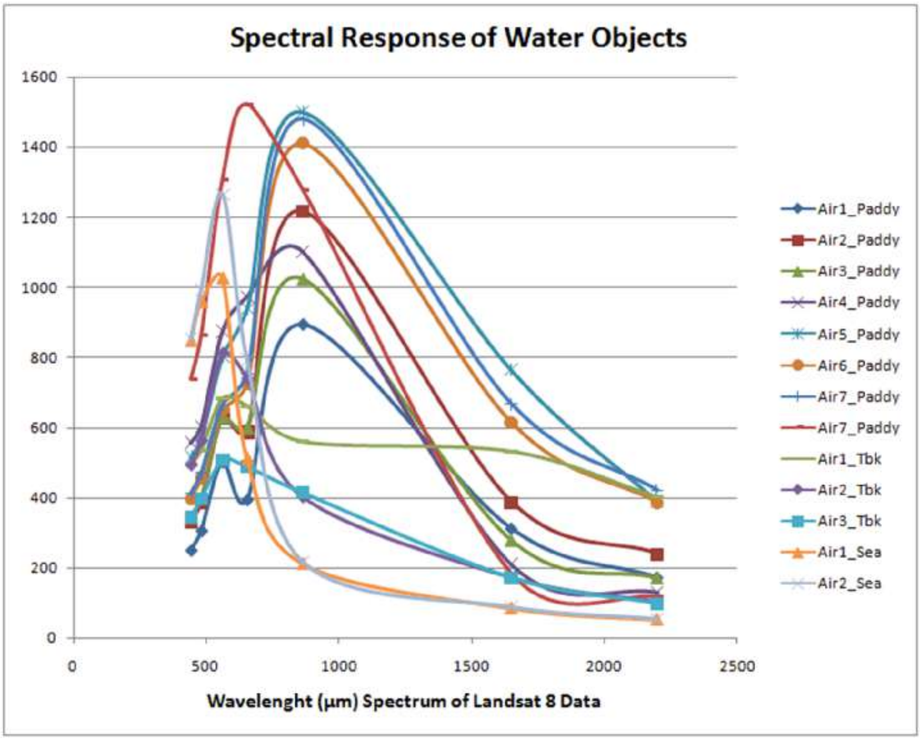

Figure 11. Spectral Response of Water Object in Paddy Field, Fishpond, and Sea Based on Landsat 8 Data

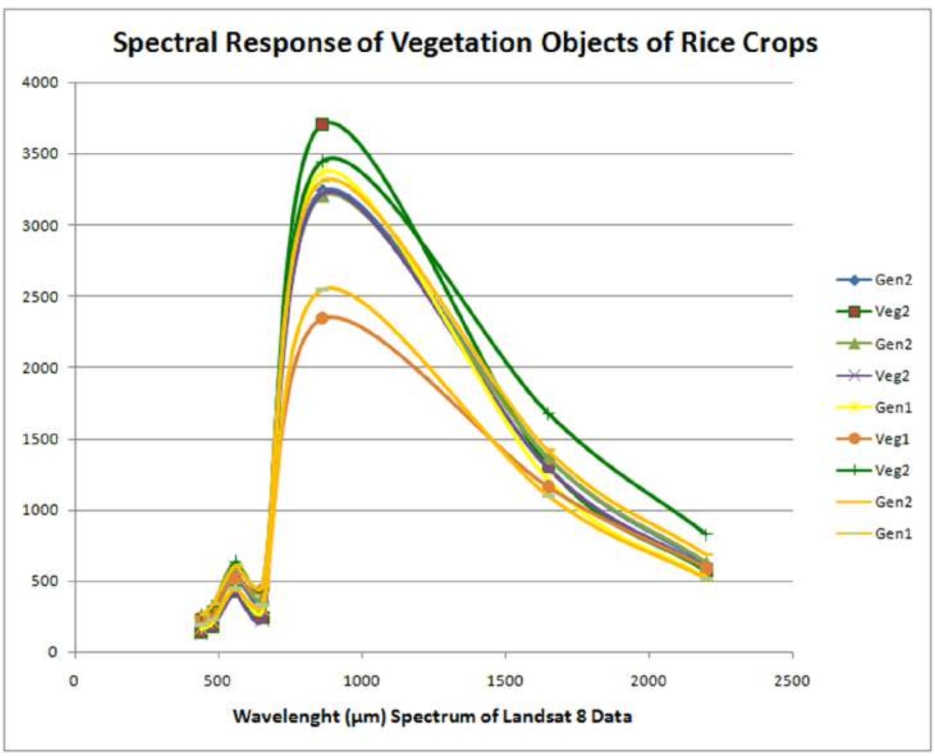

Figure 12. Spectral Response of Rice Crop in Paddy Field Based on Landsat 8 Data

While it happens interesting things in the paddy field, which indicates that there were some objects of water that have the peak value in the Green channel and also in NIR band of Landsat 8 data reflectances (see in Figure 11). The logical thing to happen, because there were already the object of the rice plant during the innudation in early planting.

4.3. Determining the growth phase of rice crop in paddy field

Rice growth profile can be viewed by using the 16 days data from multitemporal vegetation index (EVI). As an example of the extract of the vegetation index from early planting to harvest can be seen in Figure 13. Based on Figure 13 shows the peak value of vegetation index occurred at about the middle of growth, that is when the rice plant ages ranged between 60-64 days after planting (DAT). Early planting is characterized by EVI value lower than at the time of harvest and bare land. Based on the changes in vegetation indices, it can be made the spatial distribution of the growth phase of rice at a time or a certain period, for example in 5 or 8 daily. For example, the growth phase of rice standing crop in the study site on August 31, 2015 based on change of EVI can be seen in Figure 14.

When compared with natural color composite image or RGB 766 clustering result on the same date, then the image of the paddy phase occured mixing between the initial class of early planting which is still dominated by water and bare in some locations. To resolve the mistake in determining class of early planting and bare object, then in determining the initial planting and bare class should be based on changes EVI, in addition to using a range of values EVI. In general, the initial phase of planting marked by positive changes, otherwise the harvest and bare condition marked negative change of EVI. Based on the analysis in this study showed the combination use of NDWI for early planting class, and NDBI for bare class be optimized to determine the grade rice growth phase using Landsat 8. The results can be shown in Figure 15.

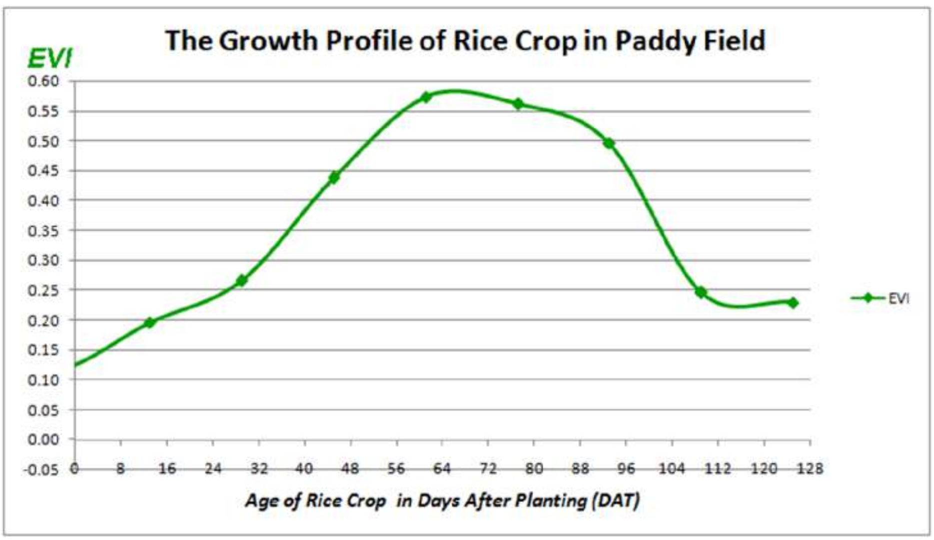

Figure 13. The Growth Profile of Rice Cropin Paddy Field (EVI Maximum 0.55-0.60)

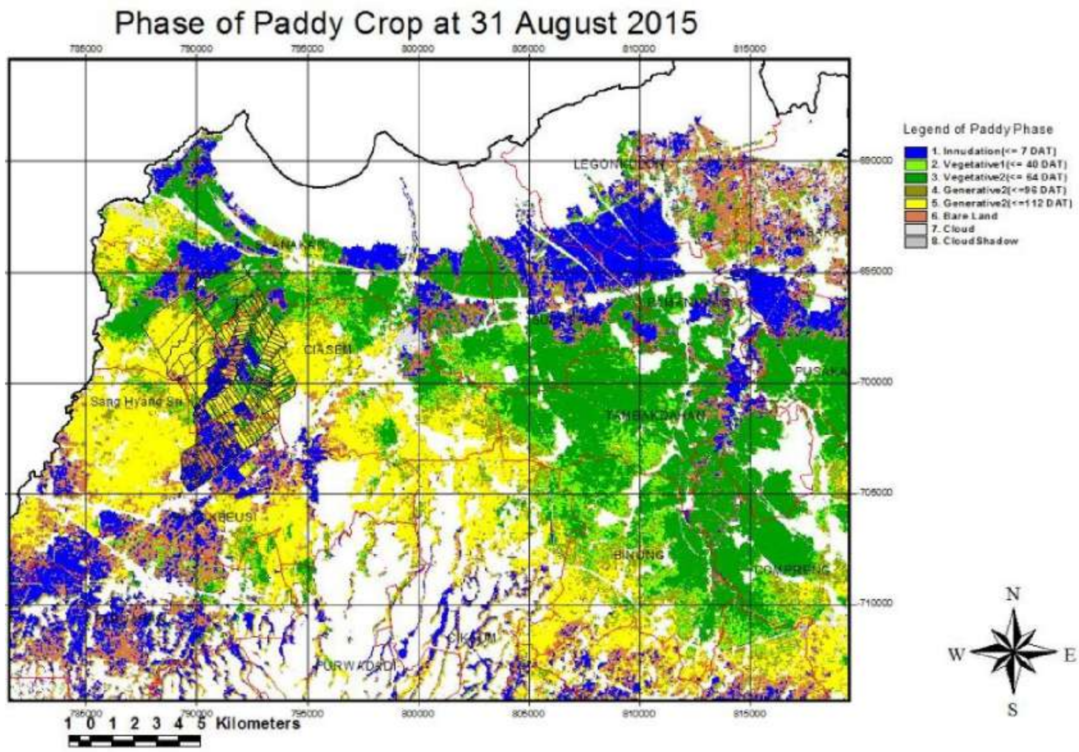

Figure 14. The Standing Rice Crop in Paddy Field at 31 August 2015, Subang District Based On EVI

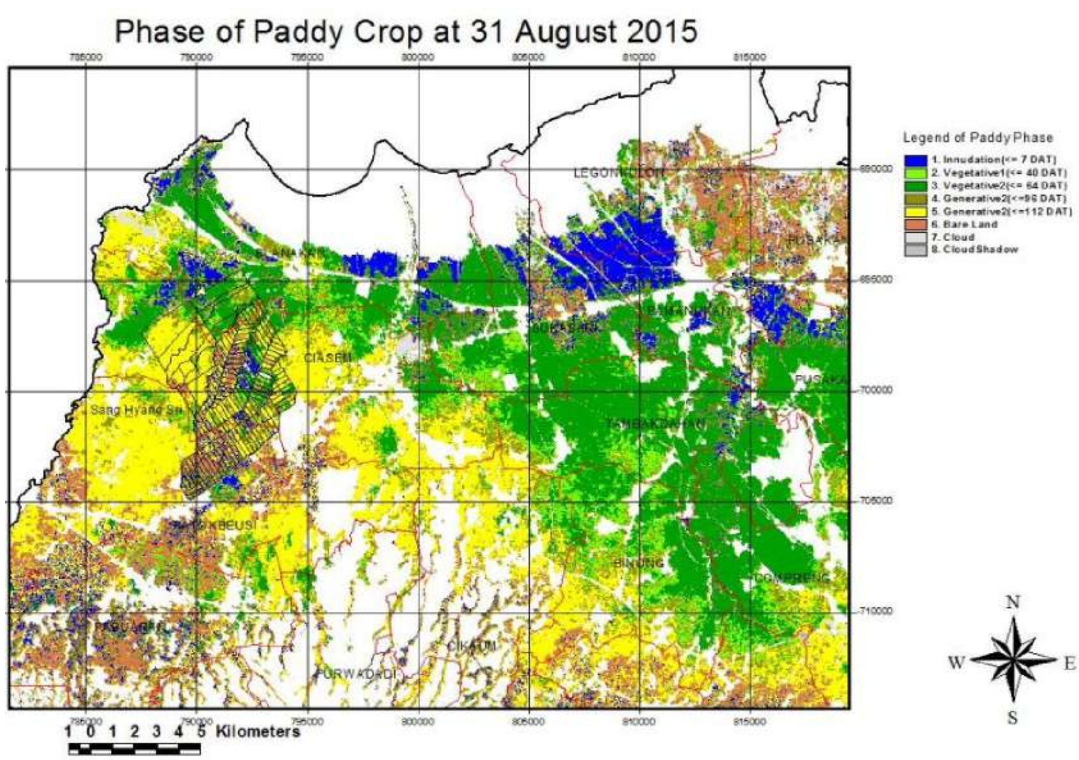

Figure 15. The Standing Rice Crop in Paddy Field at 31 August 2015, Subang District Based on Index Combination (EVI-NDWI-NDWI)

5. Conclusions

The existence of the standing rice crop in the paddy field in various phases, namely early planting predominantly water, vegetative, generative and bare land can be determined by the range of values EVI and its change. The research has successfully demonstrated the ability of Landsat 8 to determine the growth stage of rice plants use change and combination index EVI EVI, NDBI, and NDWI. The combined use of EVI, NDBI and NDWI be optimized to determine the growth phase and age of the rice crop in the paddy field.

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