The method for detecting biological parameter of rice growth and early planting of paddy crop by using multi temporal remote sensing data

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Abstract. Rice crop is the most important food crop for the Asian population, especially in Indonesia. During the growth of rice plants have four main phases, namely the early planting or inundation phase, the vegetative phase, the generative phase, and bare land phase. Monitoring the condition of the rice plant needs to be conducted in order to know whether the rice plants have problems or not in its growth. Application of remote sensing technology, which uses satellite data such as Landsat 8 and others which has a spatial and temporal resolution is high enough for monitoring the condition of crops such as paddy crop in a large area. In this study has been made an algorithm for monitoring rapidly of rice growth condition using Maximum of Vegetation Index (EVI Max). The results showed that the time of early planting can be estimated if known when EVI Max occurred. The value of EVI Max and when it occurred can be known by trough spatial analysis of multitemporal EVI Landsat 8 or other medium spatial resolution satellites.

1. Introduction
Application of Remote Sensing (RS) activities for monitoring the growth conditions of rice paddy fields in Java – Bali have undertaken since 2005 by RS Application Center, LAPAN, because Java and Bali island still contribute ± 55 % of Indonesian rice production. Monitoring about growth condition of main crop need to be done by using satellite technology. Like as reported by some research, ie Takeuchi [1], Sakamoto [2], Xiao [3] and Uchida [4,5] about ability of low or medium spatial satellite data, such as MODIS and Landsat for monitoring rice growth. While Dirgahayu [6] has been provided about useful of soil moisture in paddy field which can be derived from MODIS data for predicting drought condition. Now, the activity is part of research focus in the field of food security in Indonesia has be done operationally for whole Indonesian area by cooperating between LAPAN with ministry of Agriculture. Factors that affect food security in a region associated with spatial aspects such as: food availability and vulnerability. Spatial information that shows the actual condition of the indicators of food availability and vulnerability can be derived from RS data which has high spectral and temporal resolution, like as Landsat 8, MODIS data. Spatial information include, ie the greenness rice crop, rice growth phase, early growing season, rice crop growth stage, harvest failures caused by drought, flood, pets and diseases in the paddy field, harvest area, and productivity can be estimated by RS data. Those information are needed to predict the rice production. Based on the background above, the purpose of research are to estimate when EVI maximum as one of biological parameter of rice growth occurred and the early planting time of rice crop in paddy field.
2. Materials and Method
The study site is Paddy field in Subang District, West Java. Geographically, the study area is located between 787438 m to 794519 m of easting and between -694463 m to -704894 m of Northing with NUTM Zone 48 projection as shown in Figure 1. Primary data used in this research is surface reflectance of Landsat 8 data, P/R 122/064. In order To obtain a rice plant growth profile completely, so needed multitemporal data as many as 16 scenes in the period from May to August, 2015. Stages of research done can be seen in the flowchart in Figure 2. Two parameter will be used in this research based on result by Dirgahayu [7], ie NDWI and EVI. NDWI (Normalize Difference Water Index) to detect wetness condition can be created by using the following formula:

\[ NDWI = \frac{(R3 - R7)}{(R3 + R7)} \]  

This formula is different from the method used by Uchida [8] and also Li, et all [9], Zhou, et all [10], because based on investigation result by Dirgahayu [7] show that peak high value of water body generally occur at Green Reflectance (R3) of Landsat 8 data, while SWIR2 (R7) reflectance always the lowest value for water body. Vegetation Index to detect land greeness using Enhanced Vegetation Index (EVI) equation:

\[ EVI = \frac{2.5 \times (NIR - Red)}{(1 + NIR + 6 \times Red - 7.5 \times Blue)} \]  

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

3. Results and Discussions

3.1. Visual Interpretation based on Colour Composite Image of Landsat 8
Most of the paddy area shows still look of rice crops based on RGB color composite image 653 dated August 31, 2015 (Figure 3) and some areas occurred harvesting. Object water showed is also seen in some areas. While vegetation object in paddy field looks dark green to light green and yellowish green colour.
The condition paddy field has been harvested 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. In order to know the rice plant in 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.

3.2. Extraction of Maximum EVI as Biological Growth Parameter of Rice Crop
Statistical analysis of EVI multitemporal using Landsat 8 from January to September 2015 is shown in Image Composite RGB (Mean EVI, EVI Max and Min EVI) in Figure 4. The paddy field area in Subang appear light green with a smooth texture that is different from the object of other land cover. While the spatial distribution of paddy field classification based on Maximum of EVI in the region can be seen in Figure 5. Based on the spatial distribution of the maximum EVI in Figure 5 shows that the dominant class is the class that has the EVI Maximum range: 0.55-0.60. The next occurred in class 5 and class 3.
The percentage of rice area in Subang based on EVI maximum grade is shown in Table 1 and the graph in Figure 6.

**Table 1. Distribution of Paddy Field Area in Subang District**

| Class | EVI Max    | Area (Ha) | Area (%) |
|-------|------------|-----------|----------|
| 1     | 0.40-0.45  | 1,832     | 2.5%     |
| 2     | 0.46-0.50  | 5,741     | 7.7%     |
| 3     | 0.51-0.55  | 15,551    | 20.9%    |
| 4     | 0.56-0.60  | 29,943    | 40.2%    |
| 5     | 0.61-0.65  | 17,356    | 23.3%    |
| 6     | 0.66-0.70  | 3,789     | 5.1%     |
| 7     | > 0.70     | 237       | 0.3%     |

**Figure 4.** Color Composite RGB (EVI Mean, Max, EVI Min) of EVI Multitemporal
3.3. Determining the Early Planting of Rice Crop in Paddy Field

Rice growth profile can be known by using the 16 days data from multi temporal vegetation index (EVI). For an example of the extraction result of the EVI Multi temporal Landsat 8 from early planting to harvest time can be viewed in Figure 7. Based on Figure 7 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 (≤ 0.188) lower than at the harvest time (100-120 days) and bare land. Based on the time when EVI Maximum has occur ($t_{EVI Max}$, in Julian date), so it can be created the spatial distribution of the planting time of rice and also can be predicted when and how amount area of harvesting. Early planting with still inundation of water can be decided by the value of EVI ≤ 0.188 and NDWI ≥ 0.226. When the early planting occurred (TEP) can be estimated by using the equation:

$$TEP = t_{EVI Max} - \frac{1}{2} \times \left( \frac{LP}{Period} \right)$$  (3)
Where LP is length period (120 days). Period is temporal resolution of Landsat 8 (16 days). The implementation result can be seen in Figure 8.

![The Growth Profile of Rice Crop in Paddy Field](image1)

**Figure 7.** The Growth Profile of Rice Crop in Paddy Field (EVI Maximum 0.55-0.60)

![Spatial Distribution of The Early Planting Time of Rice Crop in Paddy Field at Subang District, from February to July 2015](image2)

**Figure 8.** Spatial Distribution of The Early Planting Time of Rice Crop in Paddy Field at Subang District, from February to July 2015
4. Conclusions
The research has successfully demonstrated the ability of Landsat 8 to estimate when the early planting time of rice crop have been occurred. The early planting can be determined based on the maximum of EVI as biological growth parameter and using combination EVI and NDWI parameters.

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