Rice crop phenology analysis during *rendeng* season using remote sensing data: an EVI-2 ratio approach of Aceh Besar regency rice field

S Sugianto\textsuperscript{1*}, R Adinda\textsuperscript{1}, M Rusdi\textsuperscript{1}, H Basri\textsuperscript{1}, Syakur\textsuperscript{1} M Iqbal\textsuperscript{2}

\textsuperscript{1}Soil Science Department, Agriculture Faculty, Universitas Syiah Kuala, 23111 Darussalam, Aceh, Indonesia, 
\textsuperscript{2}Remote Sensing and Cartography Laboratory, Agriculture Faculty, Universitas Syiah Kuala

*E-mail: sugianto@unsyiah.ac.id

**Abstract.** Information about rice phase growth is essential for predicting of rice production, and to ensure food security program, especially during *Rendeng* season of rice field. The use of remote sensing data is very helpful in the process of determining the phases of plant growth. Information about the condition of the rice plant is very important to be able to estimate the growth phases and the planting season that fitting within the control of the production results of the rice field. This research aims to analyze phenology of rice crops during *Rendeng* season using remote sensing data by utilizing EVI-2 ratio. The methods used in this research is a descriptive method of quantitative interpretation with Landsat 8 OLI data. Classification on phenology phase was carried out fro the selected area of Aceh Besar District, Aceh. Results show that phenology cycle of rice crop during *Rendeng* season vary, ranging from low greenness to high greenness. The total area for each phase of growth also varies, with peak area occur in January. There are cyclical differences of different rice plant phenology in the *Rendeng* in Aceh Besar District. The differences of planting times by the farmers resulted in the existence of the value of the EVI-2 ratio variation in the area. January is the higher values of the greenness of rice crop then drop to February to March. The value of the ratio of EVI-2 experience increases with the total area of rice plant in accordance with the phases of growth of the rice plant.

1. Introduction

Rice is an important food crop for Indonesia. In the year 2015, Indonesia alone produced up to 75.40 million tonnes, making Indonesia as an agricultural country with the main staple crop is rice. Information about the condition of the rice plant is very important to be able to estimate the growth phases and the planting season that fit within the control of the production results. The challenge facing Indonesia is a large number of land-use changes from paddy fields to the building so that the results of the production in some area is declining, including for Aceh.

Aceh is one of the provinces produce more rice than for their own consumption, a surplus
production each year. Aceh is one of the province's rice production centers in Indonesia to be able to perform targeted rice self-sufficiency and become national food mainstay. The Aceh province which consists of 23 regencies and 22 of them are rice-producing regencies. One of them is Aceh Besar. Aceh Besar regency is the fourth largest rice-producing area with total area reached 43,096 hectares and total production as much as 258,969 tons [1].

Aceh Besar Regency is one of regency contributing rice production to Banda Aceh and its surroundings. The planting system used is the double cropping system (two times the harvest in a year). Season the rice planting season is Rendeng at the time of the rainy season which ranges between the months of October - March. Time of planting at this season are likely to have the risks against the flooding problem and high crop failures. Obtaining data directly during the Rendeng season is a difficult task, however remote sensing data can be utilized to obtain data even though the harvest time has been done. During the last two decades, remote sensing data have been widely used in mapping the rice cultivated areas. The most commonly used methods have been developed is based on exploiting the optical remote sensing-based spectral indices [2]. Remote sensing provides full information, fast, accurate-time alignment in showing data that can be analyzed to show the condition of the rice plant. The collection of images and information by using the image retrieval technique using unmanned aerial satellite that can be obtained the images with high resolution periodically, with lower costs. Thus, the distribution of area and the condition of paddy fields can be known by analyzing the spread and the rate of the rice plant greenness [3]. This is usually known as the growth cycle called phenology. The growth cycle of the phenology is one of the most important components of model plants to the prediction of growth and yield [4].

Monitoring of the condition of the plant and to estimate potential crop yields as a seasonal production potential. Utilization of Enhanced Vegetation Index against the rice plant phenology for Rendeng season was conducted to find out the monitoring of the phase-phase growth of rice plant. The ratio of EVI-2 provides enhanced sensitivity at high biomass area to minimize the influence of the soil and the atmosphere. The biomass prediction supports the cropping system estimation and monitoring of phenology rice in providing important information for rice growth monitoring and prediction results. This research was conducted on the analysis of the rice plant phenology at the time of season Rendeng through ratio approach EVI-2. [5]. The specific objectives included the: (i) determination of rice signatures in temporal dimension during phenology cycle; (ii) delineation of the spatial distribution of paddy rice for each growth phase cycle.

2. Research Method
This study is a descriptive method quantitative interpretation with Landsat 8 OLI. Spatial data analysis using remote sensing data analysis with the concept of vegetation index value calculation of the EVI-2. Satellite analysis of stages ranging from pre-image processing image data, calibration, geometric transformation and the transformation of radiance to the reflectance. We sampled one of the sub-district with the highest and homogeneous rice field during Rendeng season of Blang Jaroe of Indrapuri Sub-district. The selection of the area was based on the creterian of irrigation rice field and 2 times planting season a year, that is Rendeng and Gadu season (wet and dry season). The satellite data used is from October 2014 till March 2015.

Satellite data processing was carried out in the remote sensing and cartography laboratory, Faculty of the Agriculture University of Universitas Syiah Kuala. Geographically the area of study is located at 95° 24' 40" - 95° 26' 40" E and 5° 27' 10" - 5° 25' 0" N (Figure 1).

The parameters of the rice plant phenology in use against the vegetation index of rice crops are rice the phase of plant growth. The phase of growth (phenology) can be grouped into 5 categories, namely water phase, vegetative phase, generative phase, harvest phase and phase fallow [6]. For monitoring of vegetation, the benchmarking process conducted between brightness level Red and the near-infrared channel
The EVI-2 can be calculated using the following formula [7].

\[
\text{EVI-2} = G \times \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + 2.4 \times \text{RED} + 1)}
\]

where:
- \(L\): Calibration factors from the effects of canopy and soil (value 1)
- \(G\): Gain factor (value 2.5)
- \(\text{NIR}\): The value of a near-infrared spectral band
- \(\text{RED}\): The value of the red spectral bands

The results of the calculation of the value of the formula 2 next-EVI is classified according to the number of the desired classes. In this study used 5 classes. Formula to mathematically determine the interval (distance) between the classes of density as follows:

\[
\text{Classification} = \frac{(\text{Maximum Value} - \text{The Value Of Minimum})}{(\text{Number Of Classes})}
\]

The value range EVI-2 has been reclassified can be grouped according to the criterion of rice growth as shown in table 1.

| No | Value EVI-2 | Greenness level / Land condition | The age of rice plant week after planting (WAP) |
|----|-------------|----------------------------------|-----------------------------------------------|
| 1  | <-0.03      | Non vegetative area/ fallow/water | < 3                                           |
| 2  | -0.03 – 0.15| Very low greenness               | 3 – 4                                         |
| 3  | 0.15 – 0.25 | Low greenness                    | 4 – 6                                         |
| 4  | 0.25 – 0.35 | Medium greenness                 | 6 – 8                                         |
| 5  | 0.35 – 1    | Contrast greenness               | 8 – 13                                        |

After the value of the EVI-2 obtained, the next step is to create a scale of colors (color folder) level of vegetation in order to be retrieved more information. NASA classifies the level of green vegetation EVI-2 using the scale as shown in Figure 2.
3. Results and Discussion

3.1 The Cycle of Rice Plant Phenology Using Ratio EVI-2 Approach.

EVI-2 have a greater dynamic range than the NDVI and therefore more suitable to capture the phenology dynamic plant without saturation. The results of the analysis of the rice plant phenology using cycle EVI-2 approach ratio generates a different variation of growth phase on each month. Variations of the phase of growth and the results of calculation of the ratio of EVI-2 can be seen in Figure 3, 4, and 5.
Figure 4. Distribution of phase 1 and phase 2 for Rendeng season of rice crops

Figure 5. Distribution of phase 3, 4 and 5 of the rice plant on the Rendeng Season

Based on Figure 3 and 4 can be seen that the ratio of EVI-2 lowest occurs in October. As it known to the early planting Rendeng season happen in October or November, so that the result values range from -0.1 to -0.03. However, the results obtained show that the lowest vegetation index values obtained ranged from 0.1. This happens due to the difference between the time of the data collection and the planting field. While in November the ratio of EV-2I ranged between 0.21, these values indicate the month including vegetative growth phase into the category with a range value of EVI greenish low. The value of the ratio of EVI-2 in December amounting to 0.27 greenness with a level of medium, including into the primordial phase. The highest value obtained in January contains the generative phase criteria range value of EVI-2 high level of 0.69 greenish. Generative growth phases, shown with harvest [8].

Figure 4 shows that on February is coming into the harvest phase where the value of the ratio of EVI-2 acquired for 0.65 of the greenness at a high level. This value decreased from January was caused by the process of harvesting is done the farmer does not simultaneously so there are still some paddy fields which are still not in the harvest so that it emits light spectrum. This is in accordance with the opinion of the[9] that the ratio of EVI-2 will increase after the planting, and will continue to increase compliance with the growth phase, and start to diminish before harvesting because the leaves wither.
3.2 Total Area of Rice plant using EVI-2 Ratio approach.

The total area of the rice plant is calculated using Digital Number (DN) with pixel size 30 x 30 meter for each plant growth phase of rice in each month on the Rendeng season. The existence of a different area of growth phases each month of the Rendeng season with a total area of rice plant in accordance with the cycle of phenology used EVI-2 is shown in Table 2. This can be attributed to the higher value of the ratio of EVI-2 of the surface area of the rice plant in accordance with the intended phase. Every month on phase 1 has the distinction in low intensity, but not comparable to January, in which this month has a vast area. This can be attributed to the next phases of increasingly broad up to phase 3. Significant differences can be inferred because of the planting is not the same time by farmers as well as the presence of interference of clouds at the time of collecting the data of satellite images Landsat 8 OLI as shown on Table 2.

Table 2. Total Area of Rice plant at different phenology cycle (Ha)

| Month  | n   | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 |
|--------|-----|---------|---------|---------|---------|---------|
| October| 36.96 | 43.90  | 311.89  | 108.58  | 34.65   |
| November| 49.89 | 336.42 | 95.51   | 45.62   | 8.55    |
| December| 48.33 | 313.39 | 117.16  | 42.47   | 14.64   |
| January | 131.63| 138.74 | 175.50  | 81.82   | 8.30    |
| February| 10.68 | 24.93  | 147.80  | 272.45  | 80.13   |
| March   | 0    | 24.71  | 265.68  | 44.79   | 200.80  |

Landsat satellite data collection has limitations such as removing cloud disruption in presenting appropriate vegetation index level. Blanketed-cloud to the satellite image data will cause the red and near-infrared will be back reflecting off into space and captured by the satellite sensor, This phenomenon will affect the value of the ratio of vegetation index EVI-2 [10]. The use of EVI-2 ratio help in very minimizes disturbance of clouds, resistant to atmospheric disturbances as well as resistant to disturbance of soil color [11]. In addition to the presence of cloud disruption that affects the vast difference of rice crops spread difference can reflect data is already passed to predict the phenology of the basic cycle associated with the planting season and cropping patterns that match the climate changes use climate data of the area [12].

The distribution of the value of the ratio of EVI-2 ratio spatially displayed by representing each phase-phase growth that showed a rice plant phenology for the Rendeng season for the year 2014 up to 2015 can be seen in Figure 5, 6 and 7. This result has shown that there is a relationship between greenness and production. It can reflect the health and the maturity of the crops. It could be related to the production of rice.

Figure 6. The Spatial distribution of the ratio of EVI-2 to Phase 1 to Phase 5 of the growth of the rice plant in October 2015 and November 2015
Figure 7. The Spatial distribution of the ratio of EVI-2 to Phase 1 to Phase 5 of the growth of the rice plant for December 2014 (a) and January (b) 2015

Figure 8. The Spatial distribution of the ratio of EVI-2 to Phase 1 to Phase 5 of the growth of the rice plant for February 2015 (c) and March (d) 2015

Figure 6 and 7 show variation of the total area occupied for each phenology phase of rice crop. In figure 6 a dominated by phase 2, in January is dominated by phase 3 (6b), for February is dominated by phase 4 (7c) and in March is dominated by phase 5 (7d)

4. Conclusion
In this paper, we demonstrated the use of remote sensing data for calculating the phenology cycle of rice crops in Aceh Besar District. The value of EVI-2 ratio showsthat the occurrence of cyclical differences of different rice plant phenology in the Rendeng season for the selected location in Aceh Besar District. The differences of planting times by the farmers resulted in the existence of the value of the EVI-2 ratio variation in the area. January is the higher values of the greenness of rice crop, then drop to February to March. From this result, it can be inferred that in February and March is harvest season in Aceh Besar District. The value of the ratio of EVI-2 experience increases with the total area of rice plant in accordance with the phases of growth of the rice plant.

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