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The Spatial Pattern of Rice Productivity Using Sentinel-2A Image in Cariu and Tanjungsari District, Bogor Regency

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Abstract

Rice is known as substantial main foodstuffs of Indonesian people. According to the Report from Indonesia Centrer of statistic (BPS), of- West Java Province 2018, Bogor Region is one of lower-rice productions which was shown by decreasing value approximately 26,307 ton between 2014 and 2015. The increasing efforts of rice productivity is required to estimate and observe a rice-grain supplying in the market, especially in Cariu and Tanjungsari as the primary and specific city of rice production in Bogor Region. To gain an accurate data, remote sensing method is applied. The using of sentinel-2A image processing which has 10 m of spatial resolution is recommended to see the rice planting phase based on the age of planting. The study aims to analyze the spatial studying of rice production using Sentinel-2A image processing with Normalize Difference Vegetation Index (NDVI) method for to determine the age of rice plants starting from the beginning of planting to the end of the harvest and also help estimate the productivity of rice paddies. The results show that rice production estimation which is planted in the altitude of under 100 masl (mean sea level) have value 5,52 ton/ha, to the optimum altitude on the range of 100-500 masl the productivity increase become 6,31 ton/ha, and back down on the altitude more than 500 masl equal to 5,34 ton/ha.

Keywords: Altitude, NDVI, Rice Productivity, and Sentinel-2A Image

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1. Introduction

Indonesia is one of the most abundant rice (*Oryza sativa L.)* producing countries in the world ([1]. Based on data from [2], production of paddy field in West Java Province during a year, 2015, decreased from 11,085,544 tons to 10,856,438 tons. The declining of paddy production in Java led to a reduction of national stock [3]. The estimation of paddy productivity was considered from many aspects, such as the altitude of the place. Height of place is one of the critical factors which affects to climate condition relating to air temperature [4]. Based on the altitude influence on productivity, the rising of height

every 300 meters will be followed by a decreasing of air temperature about 1.6 ^{0}C so that it influences average productivity of rice plants [5].

Recently, to estimate the productivity of rice field can be observed by primary data obtained from field surveys and secondary data gained from the government by utilizing remote sensing imagery. The use of Sentinel-2A satellite imagery that has high spatial resolution completed by NDVI (Normalized Difference Vegetation Index) processing values can be applied to estimate the life period of rice from the initial planting to the end of the harvesting process. Moreover it was able to calculate the rice productivity [6]. Citra Sentinel-2A is remote sensing technology and part of earth observation satellite was initiated by the European Space Agency (ESA). Citra Sentinel-2A is equipped with multispectral instruments that have 13 spectral channels ranging from visible light to close by infrared shortwave with temporal resolution for five days [7].

Furthermore, Bogor Regency is one of the regions with quite low rice productivity in West Java Province. According to [8], rice production in 2014-2015 fell down around 26,307 tons. Cariu was the only sub-district in Bogor Regency which was supported by the Agriculture and Forestry Service to put CCTV (Close Circuit Television) and Integrated Planting Calendar, called KATAM, in order to observe the long period of paddy growth every month. Cariu Sub-district has a relatively low altitude which is dominated by the height between 50 and 100 masl. Whereas Tanjungsari Sub-district is a developed region of Cariu Sub-district which has a high altitude and it possesses the range of height around 300 to 500 masl. Both of them have different topography, namely the lowlands and highlands, although those sub-regions have similarities too, which utilizes planting rice on irrigated paddy fields. This study aims to assess distribution patterns of rice productivity spatially using Citra Sentinel-2A in Cariu and Tanjungsari Districts, Bogor Regency.

2. Materials and Methods

Cariu and Tanjungsari located on eastern of Bogor Regency were picked up as the sampling location which represented the most productive paddy field. CCTV and KATAM positioned in Cariu City at 6˚30'6" of South Latitude and 107˚7'17,8" of East Longitude. Citra Sentinel-2A as remote sensing technology was able to distinguish of paddy productivity described by altitude differences, low (<100 masl), medium (100-500 masl), and high (>500 masl). This study applied three steps for collecting the data, which were literacy studied, field investigation, and remote sensing activities.

Citra Sentinel 2-A program was downloaded from the United States Geological Survey (USGS) official website. The determination of sampling points for rice productivity was conducted by purposive sampling method [9]. The sampling points were decided by the long period of paddy growth between 8 and 13 of times periods and 30 samples of rice field population every sub-district therefore 90 sampling points obtained. Field surveyed method was done by plotting of sampling sources in each region which had convenience roadway.

Moreover, data were processed using ArcGIS 10.4 and ENVI 5.1, while to calculate tabular data was executed by Microsoft Excel. To display the distribution of cultivating phase throughout 2018, the interpretation results from Citra Sentinel-2A was transformed and determined by NDVI (Normalized Difference Vegetation Index) method. Subsequently, the outcomes were described spatially and computed analyzing statistically. According to the regression line between paddy productivity and NDVI values in the Cariu and Tanjungsari, an equation was resulted and formed the basic estimation of rice production.

Table 1: The Range of NDVI Values for The Ages of Rice Plant.

NDVI Values	Vegetation Density	Ages of Rice Plant (week)	Ages of Rice Plant (days)
< 0.170	Non Vegetation/water	< 3	< 20
0.170 -- 0.310	Very Low	3-< 4	20-30
0.310 -- 0.450	Low	4-6	30- 40
0.450 -- 0.520	Medium	6-8	40- 60
0.520 -- 0.884	High	8-13	60- 90
0.450 -- 0.520	Medium	13-16	90-110
0.310 -- 0.450	Low	> 16	> 110

After the optimum vegetative, the NDVI values will decrease according to the grain maturity level

Source: Modification from Pradipta, 2012 [10]

3. Results and Discussions

3.1. NDVI Values Of CCTV And KATAM

Figure 1 showed NDVI values of Citra Sentinel-2A at CCTV and KATAM located through 2018. According to the graph, the highest point peaked in June. NDVI values grew gradually in the initial time of planting period to optimum vegetation and dropped in the harvesting session. At Figure 1 the graph displayed parabola curve was matched to CCTV and KATAM data that described the paddy field dominated with water during

planting periods. The planting periods in Cariu and Tanjungsari occurred from Mei to August and December to March. Besides, rice filed was dormant phase to maintain soil fertility for next planting periods; at this time. NDVI results tend to high values.

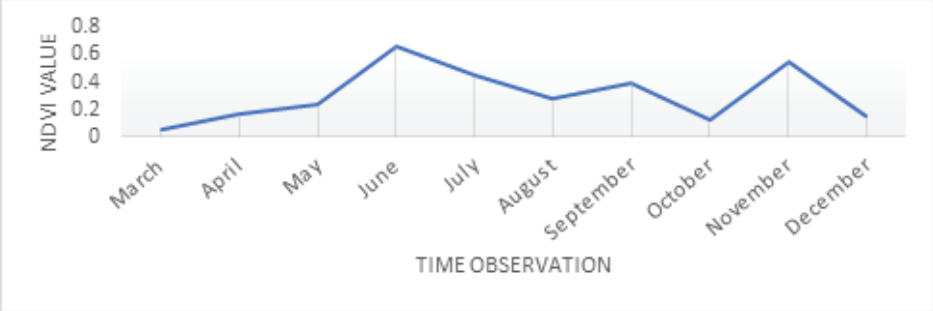

Figure 1: NDVI values of CCTV and KATAM in Cariu.

3.2. NDVI Mapping Of Cariu And Tanjungsari Regions

NDVI determination was known after calculated to NDVI algorithm equations of Citra Sentinel-2A. As lower NDVI points showed small rice vegetation factor. NDVI had ranged between -1 and +1. The change and distribution of NDVI in Cariu and Tanjungsari were displayed in Figure 2. On May, in the middle of the region, NDVI arranged slight vegetation density. Contrary, in northern of the city, NDVI experienced the opposite. For two months later, vegetation density was found not significant changes. Neveruthless on August, the vegetation density was spread fully across all regions in Cariu and Tanjungsari.

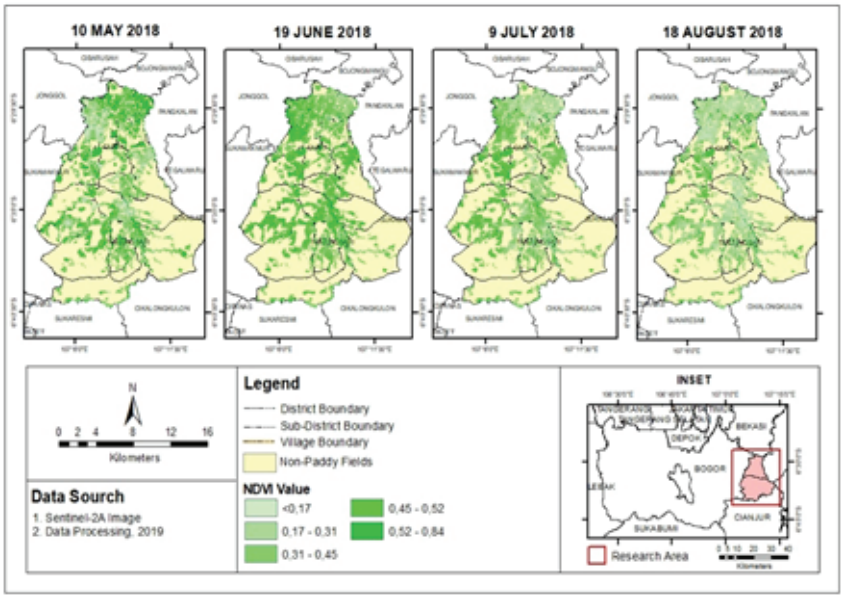

Figure 2: NDVI mapping of paddy through May to August 2018 in Cariu and Tanjungsari.

3.3. The Length Periods of Paddy Plant

To identify the age of rice plants accordance to NDVI classification modified [10] identified that the optimum vegetation phase pointed at 8 to 13 weeks after cultivation periods. Then, NDVI was going to decrease which indicated the maturity of rice grains until to be readily harvested informed by Figure 3. On May, paddy ages were dominated by less than 3 to 4 weeks when on those stages the soil was filled by water. A month later, the optimum age of paddy was about 8 to 13 weeks, and in July, paddy approached the maturity stage.

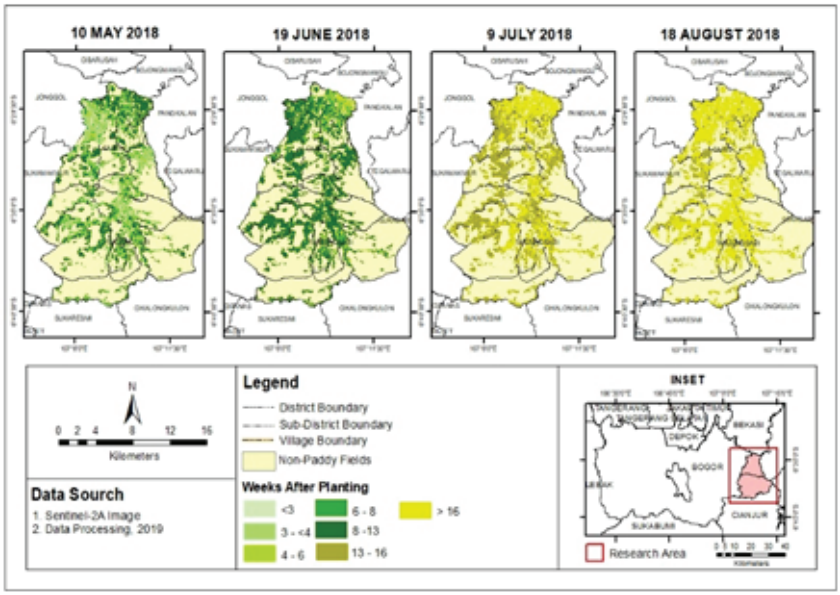

Figure 3: The length periods of paddy plant through May to August 2018 in Cariu and Tanjungsari.

Figure 4 reported the determinant values as R^2based on regression model between NDVI values and paddy productivity in the elevation of (a) <100, (b) 100-500, and (c) >500 msal, respectively. Those equations proposed estimation values of rice productivity according to the age of paddy around 8 to 13 weeks after planting. Coefficient determinant (R^2) confirmed the strength interpretation relationship among the variables. Coefficient determinant (R^2) between 0.70-0.90 possessed strong and positive linear relationship [11]. Furthermore, the estimation of paddy productivity was calculated using the regression equations which described on Table 2.

In the lowland, less than 100 masl, mainly located on Cariu City, Bogor Regency produced about 5.52 ton/ha of paddy productivity. Lower height of place was supported by maximum light exposure and a single irrigation system from Cikumpeni line. Additionally, the middle height was dominated by Tanjungsari City, Bogor Regency. Paddy productivity estimation was more significant than the former around 6.31 ton/ha.

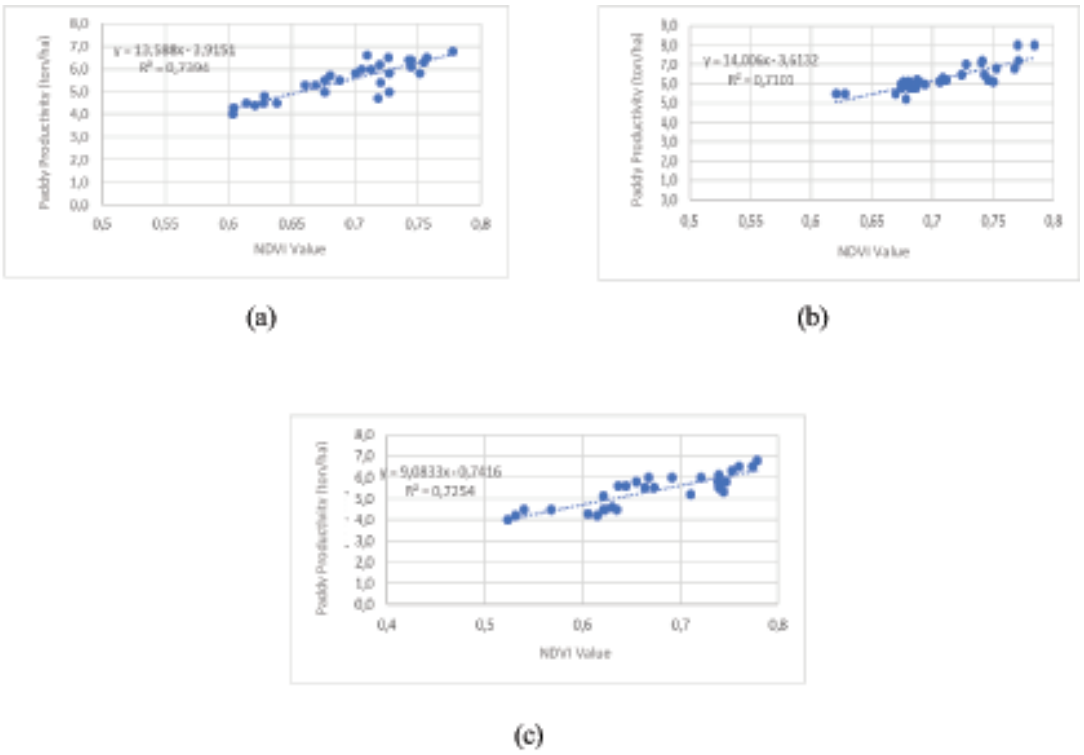

Figure 4: Determinant values (R^2) of NDVI and paddy productivity in (a) <100 masl; (b) 100-500 masl; (c) >500 *masl*.

Table 2: The Estimation of Paddy Productivity in the Varieties of Elevations.

Difference of Altitude (masl)	NDVI Values (8-13 weeks after planting)	Mean values of Paddy Productivity Estimation (ton/ha)
<100	0.6944	5.52
100-500	0.7090	6.31
>500	0.6695	5.34

By comparing Cariu, Tanjungsari obtained several irrigation systems and better light exposure. More importantly, the kind of soil in the middle elevation was mostly formed by latosol soil that type of fertile soil containing high organic humic acids [12]. The characteristics of latosol solid texture were clay and crumbly in order to store much water inside the pores. Those physical factors affected the productions significantly. Based on the findings of field surveying, rice production was reported as the smallest values only 5.34 ton/ha that caused by slight light penetration hidden by trees and scrubs and also was gained little watering systems due to obstruction of the height slope. Also, the type of rice plant were lived in the highland named Gogo required much more water consumption. Moreover, regosol and andosol had coarse grain and sand fraction which not much appropriate to support the growth of paddy plant.

4. Conclusions

The results of the study showed that Citra Sentinel-2A could identify the rice planting phase based on the vegetation index value of the NDVI algorithm in Cariu and Tanjungsari districts. The optimum NDVI values of the vegetative phase estimating the rice productivity are 0.84. On February during the first planting period and June in the second planting period. The estimation model of paddy productivity in Cariu and Tanjungsari was lowlands (<100), medium (100-500), highlands (> 500) masl, pointed at 5.52, 6.31, and 5.34 tons/ha, respectively. Therefore, rice plants are mostly suitable to be planted on moderate plains which have an altitude of 100-500 masl. Several substantial factors that influenced the paddy growth and increase rice productivity highlighted on types of soil, irrigation channels, and solar exposure.

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