Estimation of rice production based on LAI images by MODIS data in West Java

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ABSTRACT: Rice is one of the most important agricultural crops in Indonesia and also a primary food resource for more than three billion people in the world. However, because of a worldwide serious problem on food shortages due to climate change, it is necessary to evaluate the potential of rice production and estimate rice yield in Indonesia. Cianjur, a study area, is located in the West Java, Indonesia, at 7°03' S latitude and 106°60' E longitude. This area is famous for the rice production and is one of areas where the decrease of agricultural productivity is much concerned. Satellite remote sensing has been used widely and extensively and is now recognized as a powerful and effective tool for monitoring rice growth and the rice production.

In this study, images of leaf area index (LAI) by Moderate Resolution Imaging Spectroradiometer (MODIS) acquired from 2003 to 2008 were used to evaluate the rice growth and also construct an equation of the rice yield per unit of a paddy field in Cianjur. As a result, it is suggested that a weekly change of LAI indicates two times of rice production in a year, and the average LAI of the 2 times production is correlated with the rice yield per unit ($r=0.527$, $p<0.05$). Thus, this indicates that the rice yield per unit can be estimated through the following equation: $y = 0.632479x + 3.049962$, where y is the rice yield per unit size of a paddy field and x is the average LAI of 2 times production, and the standard error of estimation is 0.77.

1. INTRODUCTION

The environmental conservation and food production is one of the most critical issues that we have to make best efforts to solve from now on in every country. The remote sensing agricultural research, especially related to rice production and rice field management is very important for Asian countries, because rice is the staple food for the people and, on the other side, Asian agriculture frequently suffers from heavy losses caused by meteorological events. Considering these matters, it is a good idea to develop an efficient rice cultivation support system based on a concept of the precision agriculture which can effectively increase the rice production and also realize the environmental conservation.

In this study, to assess the feasibility of the estimating rice yield using remotely sensed data, the investigation of the relation between annual rice production from the agricultural statistical data and cumulative LAI derived from MODIS LAI 8days composite data was carried out in west Jawa, Indonesia.

2. METHOD

2.1 Study site

The study was conducted in 6 sub-districts (Kecamatan Cilaku, Sukaluyu, Bojongpicung, Ciranjang, Karangtengah, and Cianjur) located in the north east of Kabupaten Cinajur, west Jawa, Indonesia (longitude 106°21'E-107° 22'E, latitude 6°42S-7°25'S) (Fig. 1).

2.2 Data for analysis

(1) MODIS/Terra＋Aqua Leaf Area Index/
FPAR8-day L4 Global 1km SIN Grid V005 (2003-2008) （46 composite data）
(2) Aqua/Terra MODIS and SPOT VEGETATION rice paddy map at IIS, U-Tokyo, Japan (1999-2007, 1km resolution)
(3) Administrative boundary GIS data
(4) Agricultural statistics data from 2003 to 2008 which was published by BPS

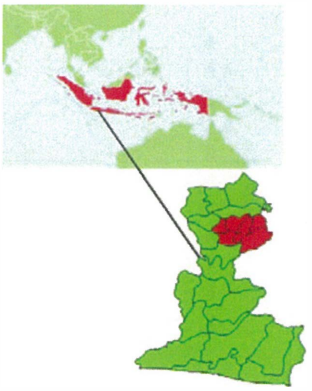

Fig. 1 Study site

2.3 Procedure

Figure 2 show that the procedure of data analysis.

First, the leaf area index composite data (LAI), the SPOT data and the ASTER data were rectified using the administrative boundary GIS data by the nearest neighbor resampling algorithm using the selected ground control points. Secondly, a supervised classification was applied to these rectified images to distinguish the paddy fields, and the mask file of paddy fields was created. Data on cumulative LAI value of paddy fields from October, 2001 to September, 2008 were calculated, and the data was added to the GIS of administrative boundary. Finally, the tabulate area analysis was executed using the LAI data and the agricultural statistic data to analyze the seasonal trend of LAI and the relationship between the annual rice production and LAI.

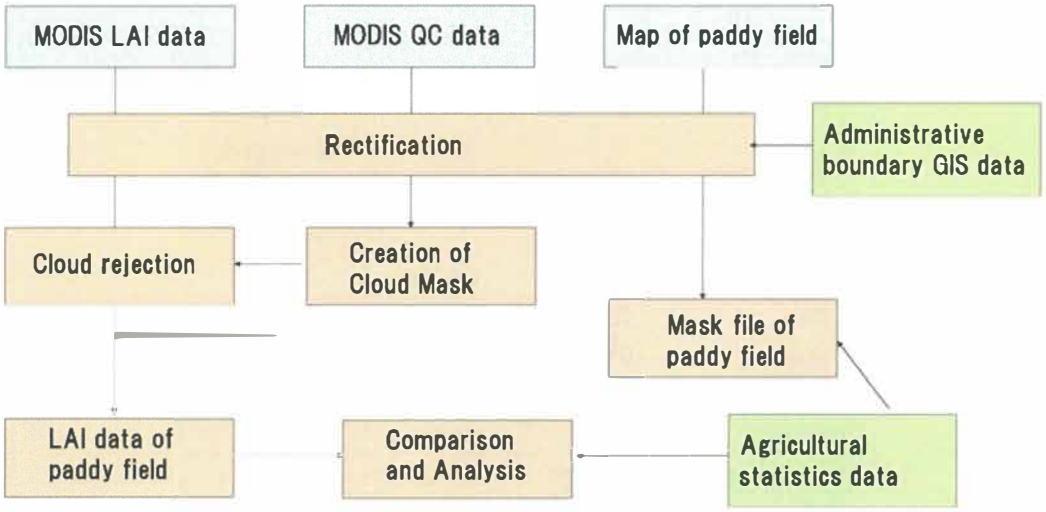

Fig.2 Procedure

3. RESULTS AND DISCUSSION

The seasonal trend of averaged LAI in all sub-districts (Kecamatan) is shown in Figure 3. There are two minimum values in a year. These seasons correspond to the harvesting season of rice crop around the test site. Table 1 shows the relationship between annual rice production per unit and the average LAI of 1st and 2nd cultivation period. The result shows significant positive correlation between the annual rice production and the cumulative LAI of the first cultivation period and the second cultivation period($n=36$)($p<0.01$ and $p<0.05$). The correlation coefficient of the first cultivation period is higher than the second cultivation period. As a result, it is suggested that a weekly change of LAI indicates two times of rice production in a year, and the average LAI of the 2 times production is correlated with the rice yield per unit ($r=0.527$, $p<0.05$).

Figure 4 shows the relationship between the average LAI and the annual rice production per unit. The rice yield per unit can be estimated through the following equation:

$y = 0.632479x + 3.049962$

where y is the rice yield per unit size of a paddy field and x is the average LAI of 2 times production
The standard error of estimation is 0.77.

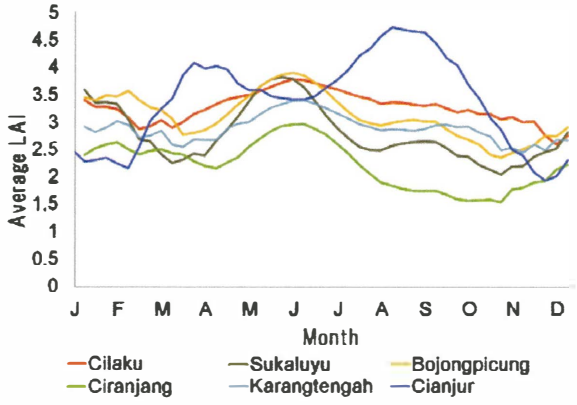

Fig. 3 Seasonal trend of averaged LAI

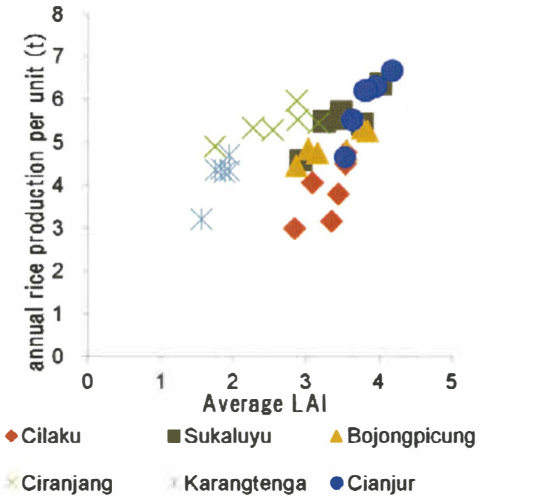

Fig. 4 Relationship between the average LAI and the annual rice production

Table 1 Relationship between annual rice production per unit and the average LAI of 1st and 2nd cultivation period

sub-districts (Kecamatan)	1st cultivation period	2nd cultivation period	Average of 1st & 2nd cultivation period
All sub-districts	0.576**	0.449**	0.527**
Cilaku	0.707	0.466	0.693
Sukaluyu	0.823*	0.710	0.872*
Bojoingpicung	0.804	0.893*	0.891
Ciranjang	0.788	0.673	0.753
Karangtengah	0.949**	0.649	0.883*
Cianjur	0.867*	0.764	0.901**

(* :p<0.05 ** :p<0.01)

4. CONCLUSION

It was possible to estimate the annual rice production of 2008 using the average LAI of 1st and 2nd cultivation period from 2003 to 2007. This study indicates that the cumulative LAI of remotely sensed data is applicable to the estimation of rice production amount in wide areas, and the creation of each estimation equation for the irrigated paddy fields and the rain fed paddy fields will contribute to improvement of the estimation accuracy of the annual rice production.

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