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Use of satellite data to improve damage assessment process for agricultural insurance scheme in Indonesia

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Abstract.

Goal is to develop new method utilizing satellite data for assessment of damage in paddy field which can contribute toward substantial reduction of the damage assessment time and costs in framework of agricultural insurance in Indonesia. For the damage assessment, estimation of yield in each paddy plot is a key, so the research on the estimation of rice yield was carried out using satellite data which was acquired in harvesting season. Multiple linear regression analysis was conducted for the estimation of yield using 7 predictors, which are digital values of visible and infrared bands, NDVI, GNDVI and NDWI.

As the result, the estimation equation was created at a level of 1 % significance using predictors of near infrared and NDWI derived from satellite data in 2014, and the 10-fold cross-validation result was 0.7t/ha. Finally, the paddy plots where the indemnity shall be paid were identified by calculating the reduction ratio using the estimated rice yield and the average yield of the past 10 years. The results out of this research suggest that satellite data can be effectively used for estimation of yield and also assessment of damage at lower costs to calculate indemnity in agricultural insurance.

Keywords. *estimation of rice yield, agricultural insurance, food security, adaptation to climate change*

Introduction

Agricultural insurance is expected to play an important role in stabilizing the agricultural production through compensating the losses caused by the climate change, which means the agricultural insurance can be a key adaptation to the climate change and also can contribute the stability in food security as one of 4 pillars defined by FOA of the United Nations. The Government of Indonesia through the Ministry of Agriculture has launched several pilot projects of agricultural insurance to minimize the risk in production failure particularly rice farming. Indonesia is currently in the middle of efforts to boost food production, specifically focusing on rice. The main objective is to achieve self-sufficiency in rice.

A key in agricultural insurance is the damage assessment which is required to be as precise, quick, quantitative and inexpensive as possible. As an approach to meet such requirements, introduction of innovative technology including remote sensing technology into the insurance procedures is expected to try with high priority. From several years ago, for the purpose to reduce the costs for the damage assessment, the new assessment process incorporating our developed method utilizing satellite data and GIS has been actually implemented in Japan. Indonesian Government is planning to introduce this assessment process to Indonesian agricultural insurance scheme through some modifications necessary to fit the specific situation in Indonesia. Considering the plan, we conducted a pilot study where research on estimation of rice production on each individual plot basis was made using satellite data and GIS data in West Java province for dry season. The estimation of production can be used for the assessment of damages in the agricultural insurance.

Methodology

Study site

Cianjur, West Java of Indonesia (long.106°21′E ~107°25'E, lat. 6°42′N～7°25'N) was selected as the study site.This area is one of the major rice production areas in Indonesia and is located in between Cisokan river and Citarum river from east to west both of which flow from the southern mountains down to the northern Cirata reservoir. Since this area is just under the equator with torrid climate, they have temperate climate throughout the year and also have the dry season from May to October and the rainy season from November to April. Because of this climate, harvesting is 2 to 3 times a year, and at the 3rd time some farmers cultivate soy beans as field rotation instead of rice. In this area, with support of JICA, a large scale of irrigation system was constructed before, but there is still about 20% of rain-fed paddy field which is influenced by the change of precipitation.

Satellite data and rice yield data

For this study, SPOT 5 data obtained on August 17, 2014 was used to estimate rice production and damage assessment. The resolution is 10 m for visible and near infrared band and 20 m for short-wavelength infrared band. From August 28 through 29, 2014, the investigation and sampling of rice was conducted in the study area. Selection of the specific location for the investigation and sampling was made in paddy fields of which situation were just before the harvesting. The sampling was made on each individual field, and total 9 rice plants (3 x 3 plants) per each location were harvested as the study sample. The fresh weight of rice grain was measured after the threshing.

Procedure

At first, an image classification using ISO cluster method was executed to extract paddy fields from the satellite data. The classified paddy fields included various different growth stages of paddy field such as seedling, heading and harvesting. In order to extract only paddy fields ready for harvesting, the supervised classification method using the investigation location data was applied to the classified paddy fields.

To derive the rice yield estimation equation, the multiple linear regression analysis was executed using the data on digital values of visible and infrared bands, NDVI(Normalized Difference Vegetation Index :(NIR-R)/(NIR+R)), GNDVI(Green Normalized Difference Vegetation Index : (NIR-G)/(NIR+G)) and NDWI (Normalized Difference Water Index : (SWIR-R)/(SWIR+R)). Then, the comparison of prediction errors of each model and satellite data was performed using the 10-fold cross-validation by random data partitioning. Finally, the decrease in yield which was estimated from satellite data against average yield of last 10 years was calculated for evaluating the damage ratio of rice production by area.

Result and discussion

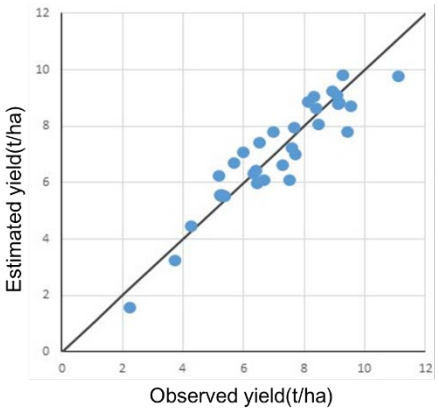
The regression equation was created using all combinations of 7 predictor valuables given by the multiple regression analysis. Among the equations, the following equation has the least error of the yield estimation at a level of 1 % significance, using NIR (near infrared) and NDWI as the predictor.

$$\text{Rice yield (t/ha)} = -6.69 + 90.15 \times \text{NIR} + 20.45 \times \text{NDWI} \quad (r=0.85, \text{significant at 1\% level})$$

Then, a comparison of the estimated yield with the investigated yield by 10-fold cross validation method was made with the result that the estimation error was 0.7(t/ha) (Fig.1). The formula was applied to the SPOT data in order to assess the regional characteristics. Finally the result was visualized. As a result of comparing the rice yield and the irrigation canal in West Java, the yield varies by paddy field unit and becomes lower toward downstream.

The reduction ratio of rice production was calculated using the estimated result and the average production of the past 10 years. Finally the visualization map of the reduction ratio in rice production was created (Fig. 2). According to the Indonesian agricultural insurance, if the damage of rice crop reaches 75% or above, the indemnity shall be paid to farmers having such paddy field. In our pilot site in West Java, our study result made it clear through study of visualization of the reduction ratio shown in the map that about 80 paddy fields in low production area of lower irrigation region would be the area to be paid by the insurance.

This damage assessment method is such a method that the assessment by human and the assessment through utilization of spatial information such as satellite data should be well integrated with the result the method could enable people to assess the damage more efficiently and more quantitatively. Through this study it is suggested that the spatial information such as satellite data can be potentially used as a powerful tool to make the assessment of damage effectively and quantitatively covering wide area in the agricultural insurance in Indonesia.



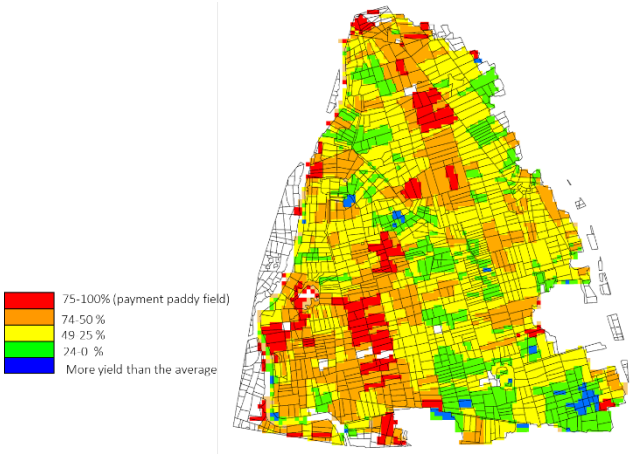


Fig 1 Verification by 10-fold cross validation method

Fig.2 Decrease in yield of 2014 against average yield of last 10 years