Yield Estimation of Paddy Rice using High Spatial and Temporal Satellite Data in Indonesia

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Although Indonesia is one of the world's leading rice producers, it suffers from weather conditions such as precipitation, pest and disease. Therefore, it is important to conduct a quantitative damage assessment and utilize the agricultural insurance system. In quantitative damage assessment, it is essential to understand rice yield per field, however, the work to take yield data per field consume time and intensive labor. To solve this problem, we aim to reduce the time, labor, and cost in the field by estimating rice yield using remote sensing data.

In West Java, Indonesia, scale of paddy fields is small and paddy rice per field with different growth stages are mixed because transplanting date varies from field to field. Therefore, to better understand and estimate yield per field, time series data with high spatial and temporal resolution is required. In this study, an enhanced spatial and temporal adaptive reflectance fusion model (ESTARFM) was employed to combine 250-m Moderate Resolution Imaging Spectroradiometer (MODIS) and Sentinetl-2 data to generate a synthetic Sentinel-2 time series data for estimation of rice yield. The blue, green, red, near infrared and short wave infrared were chosen for this processing.

Normalized Different Vegetation Index (NDVI) was calculated, and defined heading stage at maximum NDVI of NDVI curve. It is clarified that the rice yield has a high relationship with some vegetation indices and reflectance at heading stage and after the stage in previous studies. These differences are considered to be due to environmental factors in the study area and differences in rice varieties. Based on these conclusions of previous studies, this analysis included the period from the heading period estimated by time-series NDVI to 40 days. For this period, synthetic Sentinel-2 time series data was used with original Sentinel-2 data to create time-series data of reflectance, NDVI, Green Normalized Difference Vegetation Index (GNDVI) and Normalized Different Water Index (NDWI). Then, yield estimation model was created based on these data every 5 days. Finally, the model which has GNDVI and NDWI as parameters was chosen based on AIC and RMSE.

The results showed that ESTARFM could be used to combine time series MODIS and Sentinel-2 data with a correlation coefficient from 0.77 to 0.92. The model could estimate yield per field with correlation coefficient of 0.6 and RMSE was about 1.30 t/ha. Therefore, it is considered that this methodology can be used for this study area to estimate rice yield.

Keywords: Data fusion, Sentinel-2, MODIS, Time-series