Development of a Method to Estimate Distribution of Paddy Fields in Southeast Asia Using Terra/ASTER Data

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Abstract: In Asian countries, paddy field is indispensable for our lives not only as a source of food but also ecosystem, hydrology, landscape, culture and global warming. In this sense it is necessary to get the detailed spatial distribution of paddy field in Asian region. Remote sensing seems to be the most appropriate tool to estimate paddy field. In this study, two Terra/ASTER images acquired on different date were used to get a map of paddy field with different planting. ASTER's 15-m resolution was found to be enough to be recognize individual paddy field. Paddies with different planting stages were divided into five types using their spectral patterns. As a result a map of paddies with different planting was obtained with tolerably high accuracy.

Keywords: Spatial resolution, Paddy field, planting stage.

1. Introduction

In Asian countries, paddy field is indispensable for our lives not only as a source of food but also ecosystem, hydrology, landscape and culture. It is presumed to be one of the most likely sources of atmospheric methane and affects atmospheric phenomena in the local scale. In this sense it is necessary to get the detailed spatial distribution of paddy field in Asian region.

Field survey was conducted at paddy fields along Chaoplaya River near Bangkok city during 4-9 September 2003. In this area, rice planting is done twice or three times a year, and they have a variety of cropping patterns over extensive area. In this sense, it is difficult to investigate paddy field cropping stages by only field observation. Remote sensing seems to be the most appropriate tool to estimate paddy field considering their stages.

In this study, two Terra/ASTER images acquired on different date are used to get a map of paddy field including their stages. Spatial resolution of ASTER is 15m, and individual paddy could be recognized in images. Paddy fields were divided into four stages and the mage classification was carried out using spectral characteristics.

2. Study Area and Data Description

The ASTER image acquired on November 2, 2000 and December 4, 2000 were used to compare the spectral signature and spatial patterns. Both images were calibrated to radiance ($W/Sr/m^2$). Simple atmospheric correction was applied to both images with dark offset method. The coordinate was transformed from UTM to latitude-longitude coordinate system and images were resampled with the nearest neighborhood method. Two images were co-registered using the visible interpretation. Then the three band were chosen to investigate the spectral patterns of paddy fields; band 1(0.52~0.60μm), band 2(0.63~0.69μm) and band 3(0.76~0.86μm).

The test area was selected as a rectangular area covering paddy fields with a variety of cropping patterns The test area covers 512×512 pixels(about 7×7 km^2) and the geographical location is as follows; the upper left coordinate: 13° 47' 49.72'' N, 100° 49' 54.73'' E and the lower right coordinate: 13° 43' 40.32'', 100° 54' 10.59''. This area is located at the north of Bangkok. The area includes not only paddies but also open water, roods, forests, and other crop.

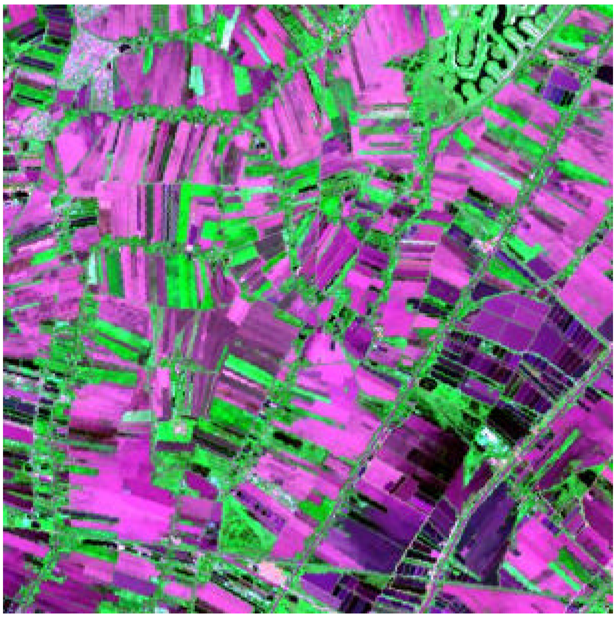
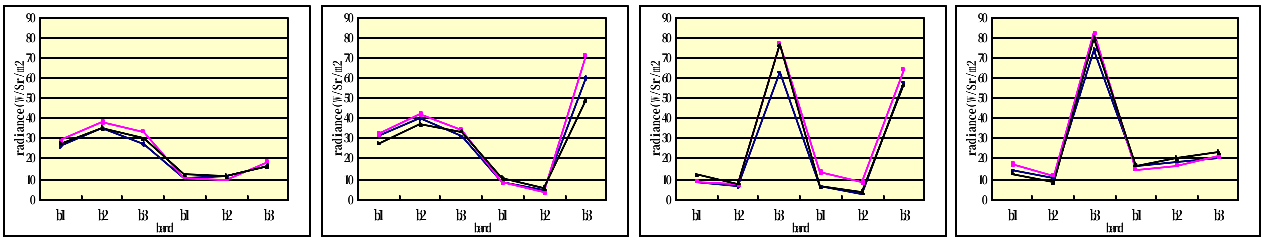
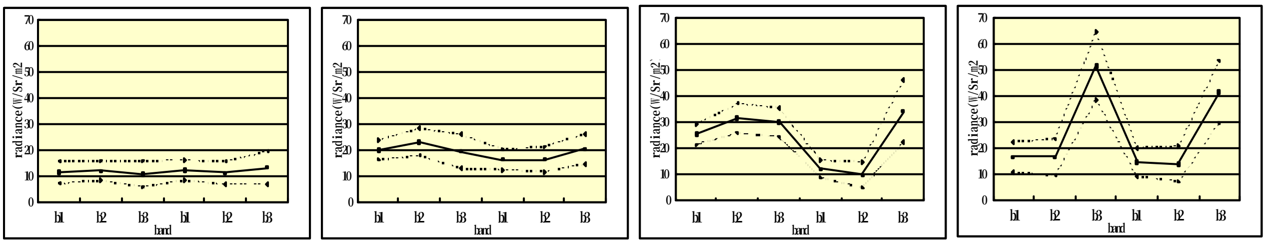


Fig. 1. Terra/ASTER true color composite acquired on December 4, 2000. The area covers 7×7 km^2 including paddies with different planting stages.



(a) Before transplanting (b) Transplanting (c) Growing (d) Harvesting

Fig. 2. Spectral signatures of four types of paddy fields with different planting stages.



(a) class1 (b) class2 (c) class3 (d) class4

Fig. 3. Each figure shows spectral statistics of each class.

3. Methodology

1) Definition of paddy fields with different planting stages

In order to make paddy field map with a variety of cropping patterns it is necessary to divide rice cropping to some stages.

Spectral patterns change notably before and after transplanting and harvesting. If transplanting occurs in this one-month, spectral patterns change from non-vegetation to vegetation. Simply if harvesting occurs, spectral patterns change form vegetation to non-vegetation. Figure4 shows the schematic growing behavior of rice plant after planting [1],[2].

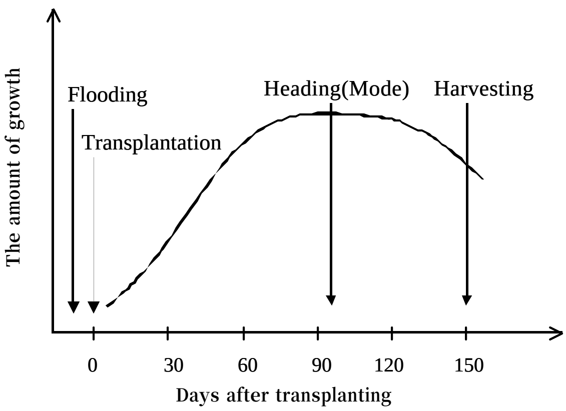


Fig. 4. The amount of growth of rice plant as a function of time.

2) Image classification and paddy field mapping

Visual interpretation found that ASTER's 15-m resolution was enough to recognize individual paddy field. In this study, the time lag of two data was about one month, paddy fields were divided into four stages; as shown in figure2, (a) before transplanting, (b) transplanting, (c) growing and (d) harvesting.

Figure2-(a) shows the spectral patterns of "before transplantation stage". It shows a change from soil to water. So it is thought in these paddies water were lead and preparation for transplantation were done during this one-month.

Figure2-(b) shows the change of "transplantation stage". The spectrum shows soil (or mixture of soil and water) on November 2 and vegetation on December 4. So these paddies were panted during this one-month.

Figure2-(c) shows the change of "growing stage". The spectrum of both days shows vegetation. These paddies had been already planted on November 2 and rice was growing during this one-month.

Figure2-(d) shows the change of "harvesting stage". Spectrum shows vegetation on November 2 and non-vegetation on December 4. So it is thought harvest were done in these paddies during this one-month.

At first, the ASTER data set was classified into 15 classes with unsupervised classification method (ISO-Data method). Then 15 classes were merged to 4 classes by comparing their spectral patterns and statistic value (mean and standard deviation of the spectrum).

4.Results and discussions

Figure3 shows the statistical result of image classification including four types of cropping patterns. According to fig.3, class1 corresponds to water surface, class2 to "before plantation stage", class3 to "plantation stage" and class4 to "growing stage". But "harvesting stage" wasn't found. There, only class4 were extracted with segmentation method and spectral patterns of paddy field were checked again. In result, paddies that belonged to "harvesting stage" were present in dass4. This is because 6 bands were used to classify the image with unsupervised method and if the band3 of December 2 were a little different, it was classified as class3. There, to divide paddies of "growing stage" and "harvesting stage" spectral patterns of paddies that belonged to each stage were selected and class3 were classified again with supervised method using the spectral patterns selected above.

To consider the amount of growth shown in figure3, "growing stage" were divided into 2 classes; "before heading stage" and "after heading stage". As figure3, vegetation continues to increase till heading and keeps the same amount and then decreases. So it is thought NDVI of paddy increases till heading and doesn't change or decreases after that. There, NDVI of "growing stage" area were calculated and the difference of NDVI ((NDVI of 12/4)-(NDVI of 11/2)) was calculated. The area where difference of NDVI was positive was defined as "before heading stage" area and the area where that was zero or negative was defined "after heading stage" area.

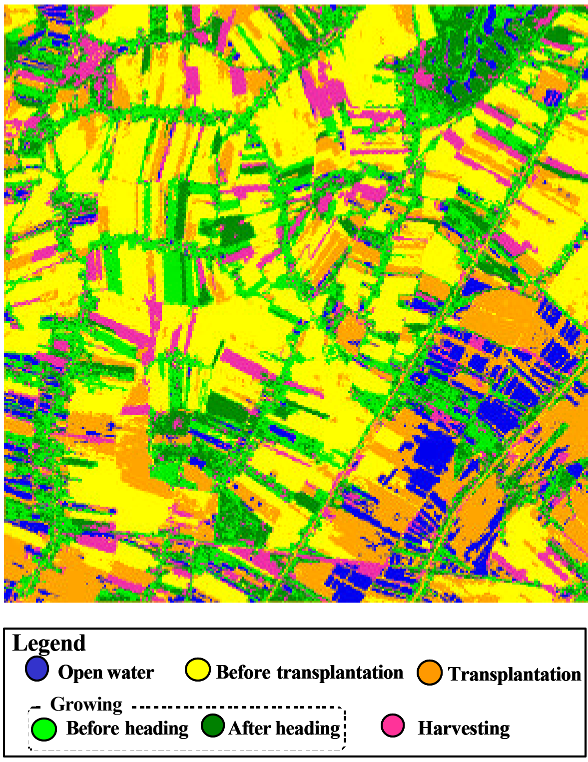


Fig. 5. Classification result of paddy field map with different planting stage.

Figire5 shows the map of paddy fields and the distribution of each stage. According to figure5, a map of paddies with different planting stages was obtained with tolerably high accuracy. But paddies that include in "growing" stage were not separated from other vegetation. For example, there is a temple at the upper right of the image, but this is misclassified.

5.Conclusions

Field investigation of paddy field was done at the north of Bangkok in September 2003. Some paddies were identified with GPS digital camera. By comparing the location of these paddies and the ASTER image, ASTER's 15m spatial resolution was found to be enough to recognize individual paddy field.

Using two ASTER images acquired different date (the time lag is about one month) and comparing the spectral patterns of three bands (band 1, 2 and 3), paddy field could be divided into four stages. As a result a map of paddy field with different planting was obtained. ASTER's two data was found to be enough to recognize the different stages of each paddy. But it was impossible to divide paddies that were in the "growing" stage and other vegetation. In addition, it was also impossible to determine how many times a year rice planting are done in each paddy with only two ASTER images. To recognize the crop cycle and divide growing paddy and other vegetation, more images acquired in different season are necessary.

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