Precise Estimation Method for Rice Planted Acreage using Accurate Agricultural Plot Vector Data and Moderate Resolution Satellite Raster Data

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Abstract: In the rice planted acreage estimation, high precise measurement and laborsaving are required by using satellite data. A method referring accurate agricultural plot vector data was used in this paper which improves the estimation accuracy of rice planted acreage compared with conventional methods. In this method, satellite data are not used for totalization, although they are used to discriminate whether the fields are rice planted or not. This paper described the result of the above method using to ASTER-VNIR data.

Keywords: Agricultural Plot, Rice Planted Acreage Estimation

1. Introduction

The crop acreage estimation of agricultural products is an important subject on agricultural administration. Especially, rice is one of the most important agricultural products in Japan. It is desired to estimate the rice planted acreage accurately as possible. There are some pixel based methods to estimate the rice planted acreage using the optical or radar satellite data [1], [2]. In the pixel based methods, the estimated acreage is calculated to totalize the rice planted pixels on satellite data. The size of the paddy fields in Japan is small compared to estimate by satellite data, therefore pixels are mixed with many land use covers which decreases the estimation accuracy. In order to improve the estimation accuracy, high ground resolution satellite data are needed. However, there are problems in frequent use of high ground resolution satellite data due to its narrow observation area, requiring a fair weather at time of acquisition and high cost. The other hands, in order to reduce the estimation cost and improve the estimation accuracy, an integrated method which combined the satellite data and GIS data was proposed [3]. In the integrated method, the pixels are divided into an individual segment using the agricultural plot vector data. Then the individual plot was distinguished whether the either rice planted plot or not. In this study, the integrated method called “Outline Referring Method” was improved in discriminating whether the agricultural plot was rice planted or not by considering the registration gap between the agricultural plot vector data and satellite data. This paper described the result of the above method using ASTER-VNIR data.

2. Rice Planted Acreage Estimation

The rice planted acreage estimation process is divided as follows:

1) Discrimination of the rice planted area
2) Totalization of the discriminated area acreage

In the pixel based methods, the actual rice planted plots shown in Fig.1a are discriminated by satellite image pixel shown in Fig. 1b. Then totalizing these pixels area, the rice planted acreage is estimated. In this estimation process, discrimination and totalization of rice planted area are carried out by the pixel of satellite data. However, these discriminated pixels are mixed with many land use covers including the actual rice planted field, which causes the totalization error.

On the other hand, in the outline referring method, the rice planted fields are discriminated by plot referring the accurate agricultural plot vector data after the rice planted pixels discriminated as shown in Fig.1c. And the estimation acreage is obtained by totalizing the discriminated plots acreage which is provided from the existing acreage data for each paddy plot. In this method, satellite data are not used for totalization, although they are used to discriminate whether the fields are rice planted or not. Therefore the highly precise estimation is expectable using moderate ground resolution satellite data.

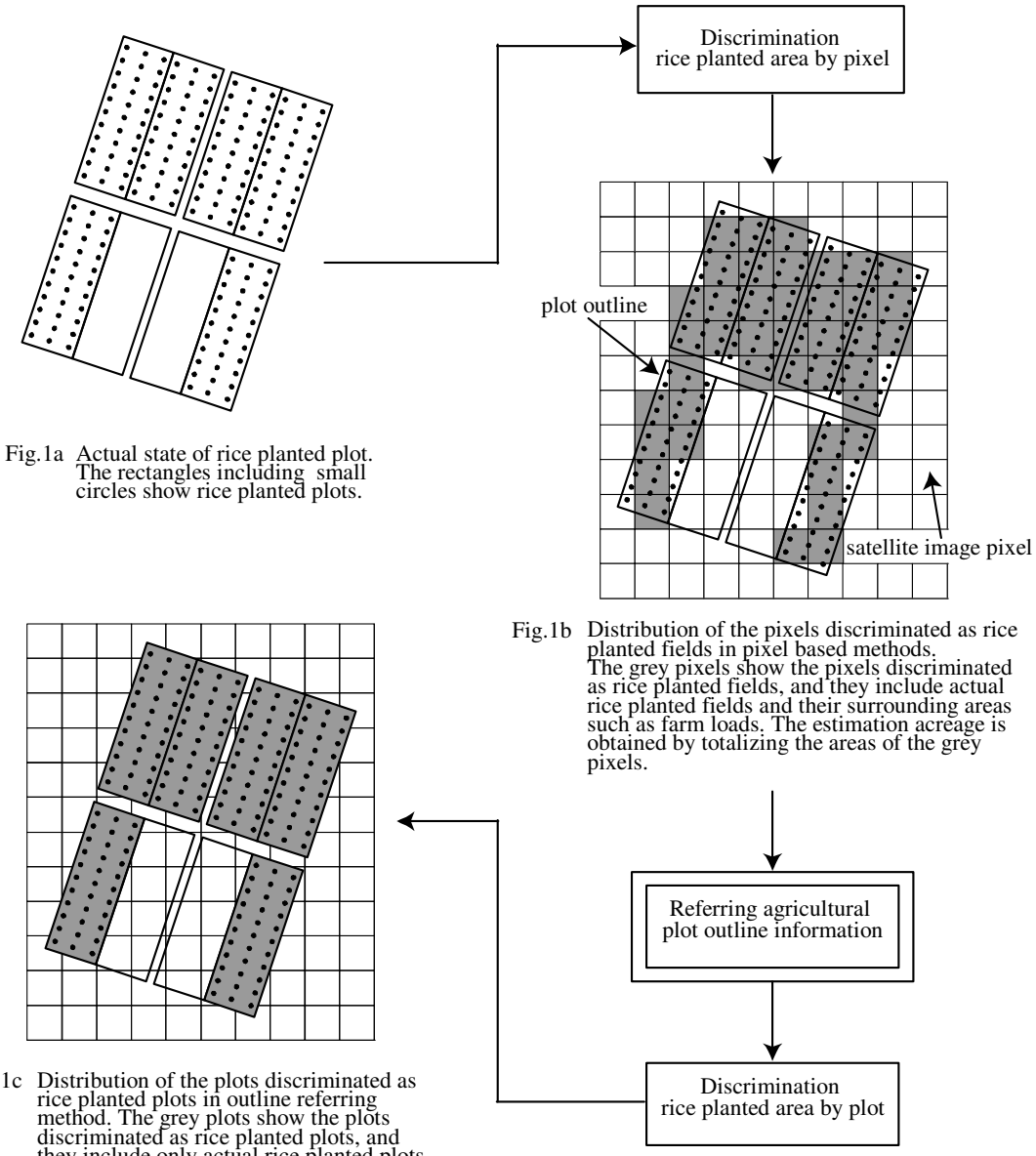

Fig.1a Actual state of rice planted plot. The rectangles including small circles show rice planted plots.

Fig.1b Distribution of the pixels discriminated as rice planted fields in pixel based methods. The grey pixels show the pixels discriminated as rice planted fields, and they include actual rice planted fields and their surrounding areas such as farm loads. The estimation acreage is obtained by totalizing the areas of the grey pixels.

Fig.1c Distribution of the plots discriminated as rice planted plots in outline referring method. The grey plots show the plots discriminated as rice planted plots, and they include only actual rice planted plots. The estimation acreage is obtained by totalizing the areas of the grey plots.

Fig. 1 Flowchart of estimating rice planted acreage

3. Test Site and Data Description

The test site is located at Koshiji town in Niigata prefecture, centered at latitude 37.41ºN, longitude 138.80ºE as shown in Fig.2. Niigata prefecture is well known as the best quality rice production in Japan. Therefore, the pilot studies of high precision agriculture are carried out actively, using satellite remote sensing and GIS analysis. The test site area is 2.7km from east to west, 4.0km from north to south. In the area of the test site, Japan agricultural cooperatives (JA) Echigo-Santo has been inquiring several data of cultivation in almost paddy plots since 2001 and managing their data by unique paddy plot number. In this paper, the inquiring cultivation data were used as ground truth data. The agricultural plots vector data was extracted by delineating the paddy plot outline on the IKONOS data acquired on 25 August 2001. Before extracting vector data, the IKONOS data was projected onto the Japan plain coordinate system, zone eight using the 1:10000 topographical maps. The extracted agricultural plots vector data was shown in Fig. 3.The ASTER-VNIR data acquired on 14 August 2001 was used to estimate the rice planted acreage in the test site, shown in Fig. 4. In the preprocess of the estimating, the ASTER-VNIR data was

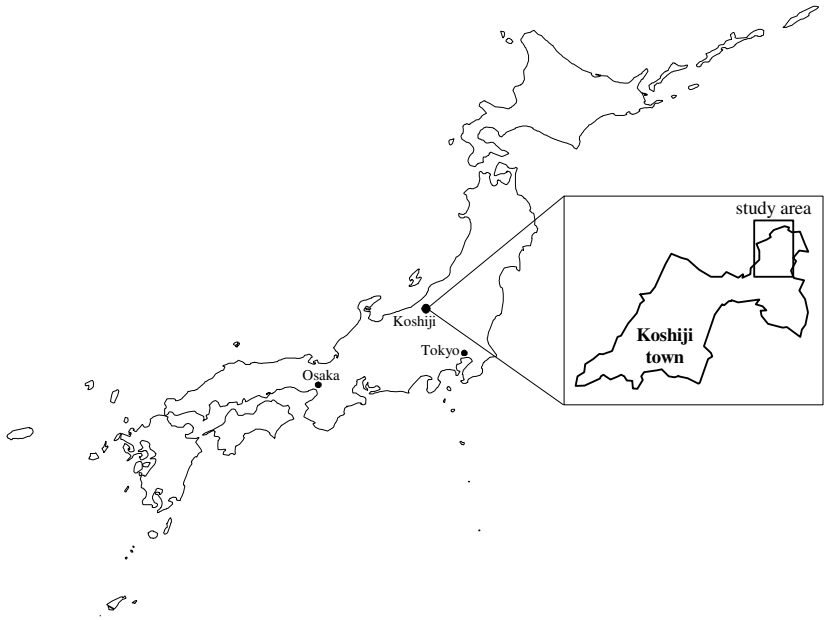

Fig.2 Location of the test site

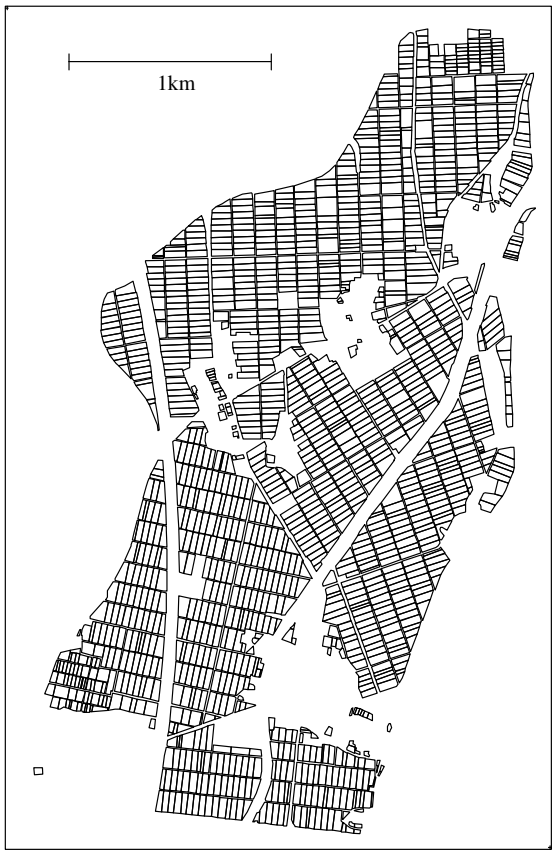

Fig. 3 Extracted agricultural plots vector data.

Fig. 4 ASTER-VNIR data of the test site. The area insides the thick black line is the comparison area.

projected onto Japan plain coordinate system, zone eight using the agricultural plot vector data. The RMS error of the rectification of the ASTER-VNIR data was 0.3 pixels. In order to compare the acreage between pixel-based methods and outline referring method, the comparison area was established in the test site. The border line of the comparison area was visually selected avoiding the cloud area. Also the border line of the comparison area was delineating not to cross the

agricultural plot vector data as shown in Fig. 4. Then the IKONOS data was used to determine the rice planted acreage in the test site and used as the truth data in this study.

4. Determination of Rice Planted Acreage of the Comparison Area using IKONOS data

In preprocess an agricultural land mask data was generated from the agricultural plot vector data by vector to raster transformation process. The agricultural land mask data has a paddy plot number as pixel value and ground resolution of 1m. At first, the IKONOS data was classified two crop types and one is the rice and the other is the soybean. Inside the agricultural land mask, the crop type was classified by a supervised method with training data generated from the inquired data of the cultivation. In the classification, the IKONOS band 1 to 4 and NDVI ((Normalized Difference Vegetation Index) data were used. NDVI was calculated by Eq. (1).

$$NDVI = (NIR - VIS)/(NIR + VIS) \quad (1)$$

Where NIR is the Near Infrared band data and VIS is the Red band data. Next, the rice planted plots were determined, assuming that only one crop type is planted in one plot. The unclassified plots were not used to compare the acreage of the rice planted fields. By totalizing the rice planted plot acreage, the rice planted acreage in the comparison area was 211.7 hectares.

5. Estimation of Rice Planted Acreage

5.1 Pixel Based Method

Estimating the rice planted acreage, the ASTER-VNIR image band 1 to 3 and NDVI were classified by the supervised method using Maximum Likelihood classifier. The training data were selected referring the inquired cultivation of crop kind. The classification was carried out inside the agricultural land mask. This mask is the same mentioned above expect that the spatial resolution is 15m. By totalizing the discriminated pixels as rice planted, the rice planted acreage was 193.1 hectares.

5.2 Outline Referring Method

After classifying the rice planted pixels, the rice planted plots was discriminated by referring the agricultural plot vector data shown in Fig. 5. As the technique of referring the agricultural plots vector data from the satellite data, the pixel spacing of the classification image was changed to 1m same as the agricultural land mask data. Combining the agricultural land mask image and the classified image, the pixels of the ASTER-VNIR and NDVI image data inside the same plot was identified using the paddy plot number. For discriminating the rice planted plots, it is

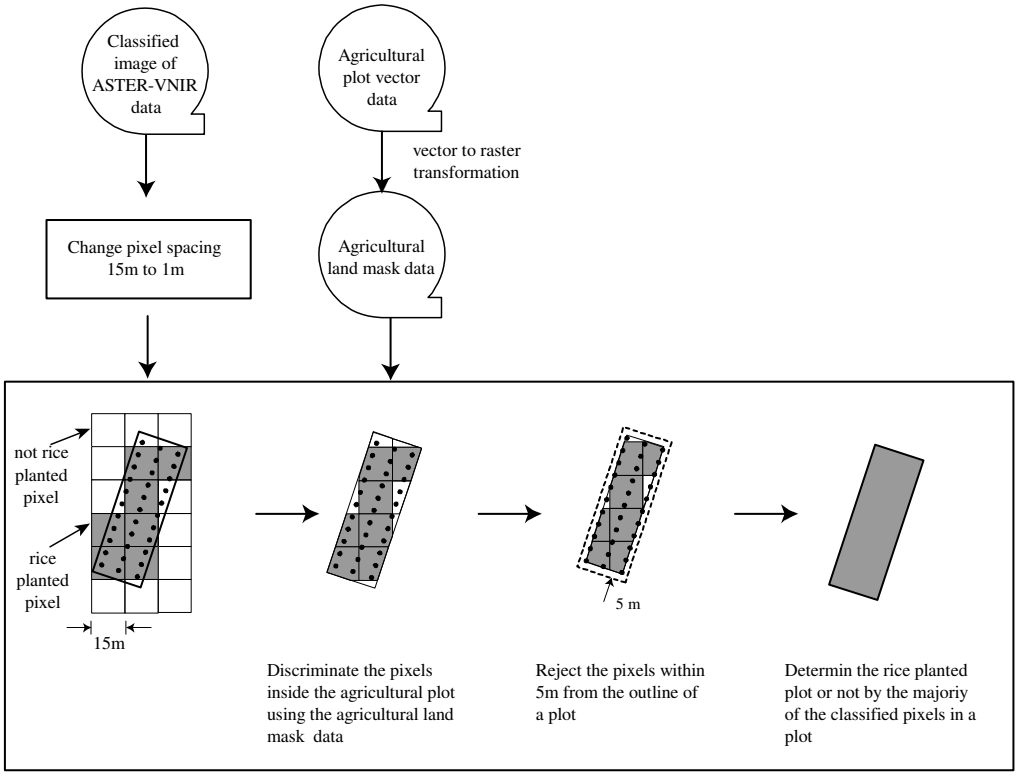

Fig. 5 Flowchart of discriminating rice planted plots by referring the agricultural plot vector data

important to adjust the registration gap between the satellite data and the agricultural plot vector data. In this study, the pixels around the centere of plot were used to discriminate whether the plot is rice planted or not. The pixels within 5m from the outline of a plot were rejected. By the assumption that only one crop type is planted in one plot, the rice planted plots were determined by the majority of the classified pixels in a plot. The discrimination result of crop type was shown in Fig. 6. By totalizing the discriminated plot acreage as rice planted, the rice planted acreage was 200.0 hectares.

6. Comparison of Rice Planted Acreage

In the comparison area, the acreage between the pixel-based methods and outline referring method were compared. The estimation error ratio *Er* was calculated by Eq. (2).

$$Er = (Ae - A)/A \qquad (2)$$

Where *Ae* is the estimated acreage, *A* is the base acreage calculated using the IKONOS data. The comparison result is shown in Tab. 1. The estimation error ratio of the conventional method and the outline referring method were -8.8 % and -5.5 %, respectively. The estimation error was decreased about 3% using the outline referring method.

7. Conclusions

This paper shows the integrated method called "Outline Referring Method" improved the estimation accuracy of the rice planted fields using the moderate ground resolution satellite data which considered the registration gap between the agricultural plot vector data and satellite data. By using the multi-temporal satellite data to discriminate the rice planted fields; the estimation accuracy will be improved more.

Acknowledgement

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Fig. 6 Discriminated result of the rice planted plots

Tab. 1 Comparison result of the rice planted acreage

	Rice planted acreage (ha)	Estimation error ratio (%)
Pixel based method	193.1	-8.8
Outline referring method	200.0	-5.5
IKONOS	211.7	—

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