Detection of preparatory water in paddy irrigation area using RADARSAT/SAR-C and Landsat/ETM+

Shigeo Ogawa [a,*], Takeo Shima [a], Hisashi Takeichi [b]

NIRE, Department of Regional Resources, 2-1-6, Kannondai, Tsukuba, Ibaraki, Japan – sogawa@affrc.go.jp

MAFF, Kisogawa Management Office, 3-11-16, Shirogane, Showa, Nagoya, Aichi, Japan – takeichi_hisashi@tokai.nn-net.go.jp

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ABSTRACT:

Paddy rice is one of the most important crops in Japan and it needs much water to grow, especially for water reserves for paddy irrigation. The test site "Owari Seibu" doesn't have enough irrigation water and the water reserves are rotated for a period of about one month in this area. In order to monitor the water reserves condition, we use four satellite data sets (RADARSAT/SAR-C, Landsat/ETM+) and a digital land use map (10m mesh). Relationship between total of estimated paddy field area from satellite and statistical value is very high (n=32, y=1.12x, r^2=0.999). The results of detecting transplanted paddy field area accurately correspond to statistical data (n=18, r^2=0.990) at the local level. The distribution map of water reserves made from this analysis shows a rotation pattern over a wide area.

1. INTRODUCTION

Paddy rice needs much water to grow and farmers derive water in rotation rule that has established from ancient period. Preparatory water in paddy irrigation is needed much water in short time. Rotation rule is strict in preparatory water term.

Irrigation water is rotated in test site "Owari seibu area" for preparatory water. The term of preparatory water in paddy irrigation is about one month. Distribution of paddy field is decreasing by the construction of building or the control of production by the government. It takes many costs to monitor the distribution of water irrigation in wide area. In order to monitor the water reserves condition, we use four satellite data sets (RADARSAT/SAR-C, Landsat/ETM+) and a digital land use map (10m mesh).

There are many papers on the detection of paddy field area. Nageswara and Rao (1987) estimated the paddy area and yields in India using Landsat/TM. Otsubo and Iida (2001) made time series flood map in lower Mekong area using RADARSAT/SAR data. But, they didn't validate the amount of area. Fujiki et al. (2001) analyzed water management of paddy field based on field survey and hearing on upper east bank of Thao Phraya Delta, Thailand.

Yamagata et al. (1988) analyzed paddy field area by the methods of most likelihood classification and filtering. Estimation of paddy field area is in 52ha (2.5%) RMSE. Ogawa et al. (1990) got high accuracy of paddy area estimation by calculating the percentage of branch road, farm ditch, ditch border and levee area. Okamoto et al. (1996) estimated paddy field area from the relationship between band5 of Landsat/TM and RVI.

There are few papers on preparatory water in paddy irrigation, because it takes some time series satellite data to monitor preparatory water in preparatory water season.

We estimated preparatory water distribution and area based on field survey and characteristics of back scatter coefficient. We validated then from statistical data.

2. TEST SITE AND USED DATASETS

Test site "Owari seibu" is located center of Japan and its center position is East 136° 45', North 35° 12' (40km X 50km, Fig.1) .

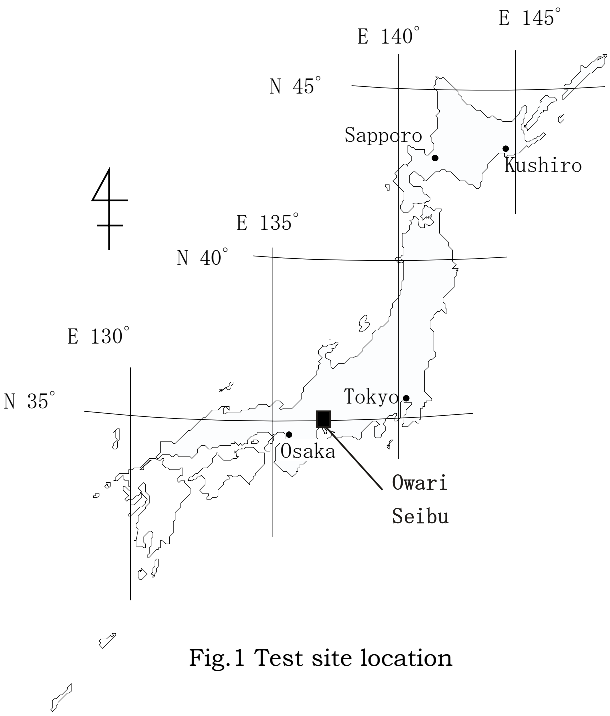

Fig.1 Test site location

Paddy field is main land use in this area. Nowadays, agricultural land is decreasing by the urbanization and yield control of the government. Cultivating pattern changes by the farmer's oldness and the concentration of working day (especially holiday). The term of transplanting is from 1 May to 10 June. It is divided three terms, early term (from 1 to 10 May), standard I (from 20 to 31 May), standard II (from 1 to 10 June).

Time series satellite images are two RADARSAT/SAR-C and two Landsat/ETM+ data (Table 1). We used 10m digital map (land use map in Nagoya area, 1977) to select the paddy area. We also used 25000 digital map (1:25000 scale) for the reference of geo-metric correction. We compared estimated paddy area to statistical data in districts level.

Table 1 List of used satellite data for flooded paddy fields in Owari Seibu.

Acquisition date, time	Satellite	Sensor	Resolu tion(m)	Orbit	Beam Mode
2002/May/17	RADARSAT	SAR-C	8	Descend	Standard 1
2002/May/20	Landsat-7	ETM+	30	Descend	-
2002/May/26	RADARSAT	SAR-C	3.125	Ascend	Fine 3
2002/June/5	Landsat-7	ETM+	30	Descend	-

3. ANALYSIS METHODS

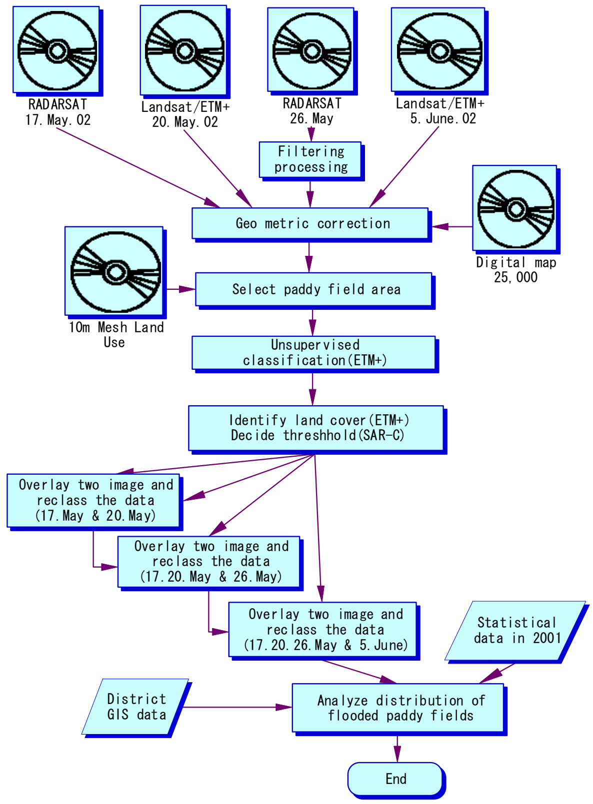

Fig.2 Diagram of monitoring preparatory water in paddy irrigation

The outline of analysis is shown in Fig.3 and details are as follows.

(1) Each images is cut from original. Landsat/ETM+ is used seven bands (band1-5 and band7). RDARSAT images are translated from original digital number to back scatter coefficient (dB). We processed the RADARSAT image acquired on 26 May 2002 using filtering methods (Gamma-MAP filter, widow size 7X7, coefficient of variation 0.2) to reduce the speckle noise.

(2) Each images is geo-corrected referring to 25000 digital map (mesh size 2.5m) by the Polynomial, most neighborhood. Geo-corrected pixel sizes are 30m in Landsat/ETM, 8m in RADARSAT (17 May), 3m in RADARSAT (26 May). Ground control points are selected and RMSE is within 0.5 pixel size.

(3) Paddy field in each satellite images is picked up using digital land use map. Other land use area is replaced by 0 value.

(4) Paddy field image of Landsat/ETM+ is classified 40 classes (20 May) and 60 classes by unsupervised classification method (ISO DATA method). We set 60 classes because Landsat image (26 May) is covered with thin cloud in some parts. We made land cover map from classified image and ground survey. Flooded paddy is detected by RADARSAT images.

(5) At first, we decide flooded and non-flooded paddy field from classified RADARSAT image (20 May) and Landsat/ETM+ image (16 May). Flooded paddy at 17 May and non-flooded paddy means flooded paddy. Next, we decide flooded and non-flooded paddy using classified image from two images and RADARSAT image (26 May). Decision role is same above. Finally, we decide flooded and non-flooded paddy using classified image from three images and Landsat image (5 May).

(6) We calculated paddy field area and flooded paddy field area in each district. Comparing the total of paddy field and statistical value, we estimate flooded paddy field area.

4. RESULTS AND DISCUSSIONS

4.1 Characteristics of paddy field reflectance

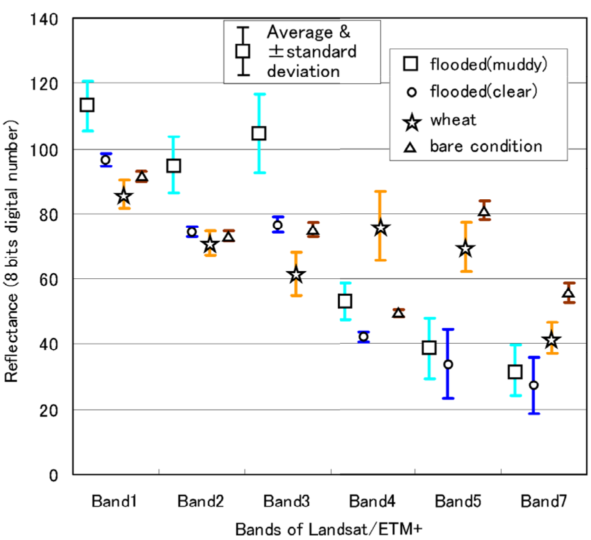

Fig. 3 Reflectance in different paddy field condition(20 May, 2002)

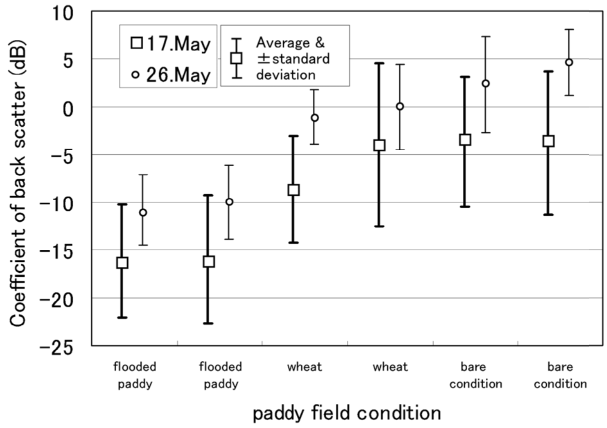

Fig. 4 Coefficient of back scatter in paddy field

Characteristics of Landsat/ETM+ image (20 May) are shown in Fig.3. Flooded paddy fields are clearly identified by band5.

Characteristics of RADARSAT images (16 and 26 May) are shown in Fig.4. Backscatter coefficients acquired on 26 May are relatively higher than that on 16 May. This reason depends on observing sensor angle and deference of beam mode. Standard deviation of each land cover is higher than that of Landsat image. Flooded paddy field is identified to others.

4.2 Relationship between the total of estimated paddy field area and statistical value

Estimated paddy field sum up on district unit is very high

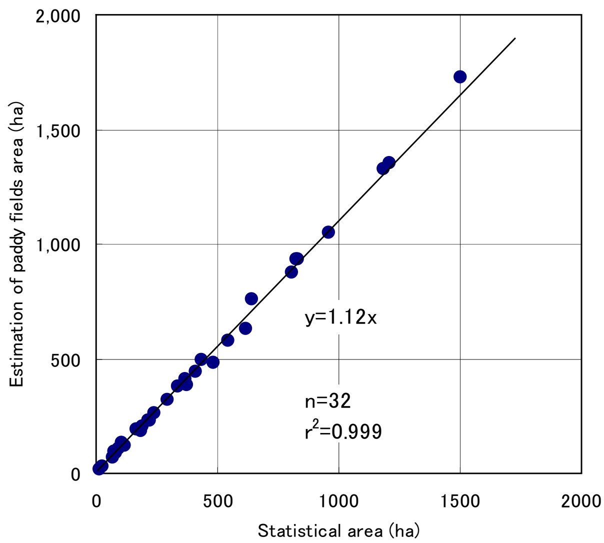

Fig.5 Comparison between estimated paddy fields area from satellite data and statistical data

relationship with statistical value (shown in Fig.5, number of districts are 32, r^2=0.999, RMSE=21.5ha, y=1.12x). Though land use map shows in 1997, there is no reclamation of paddy fields in Japan recent years. Referred to Ogawa et al. (1990), classified paddy fields from Landsat/TM are contains branch road, farm ditch, ditch border and levee area. Simply sum up of paddy fields pixel results over estimate. In this classified image classified paddy contains these land use.

4.3 Estimation of flooded paddy field area

We summed up flooded paddy field and estimate the area using relationship got from Fig.5. We selected districts in which transplanting would be finished (shown in Fig.6, number of districts are 20, r^2=0.968). There are two parenthetic points and these districts contain lotus field. Lotus field cover with water in this season and is classified as flooded paddy field. If two districts are removed, estimation of flooded paddy field area becomes higher (number of districts are 18, r^2=0.990, RMSE= 29.7ha).

4.4 Identification of paddy field

Fig.7 shows distribution of preparatory water in district unit. This percentage shows flooded paddy / total flooded

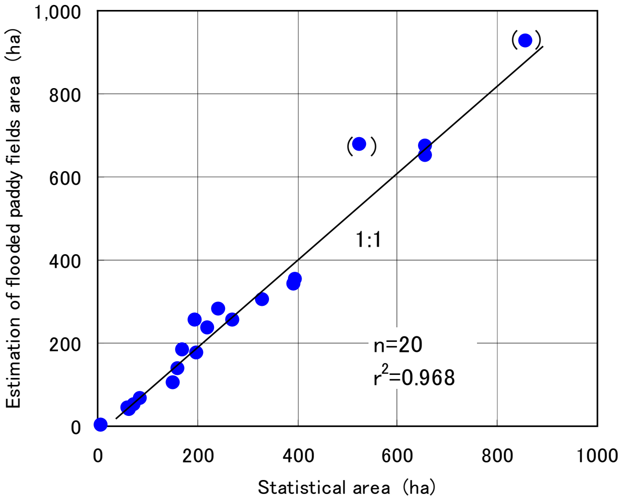

Fig.6 Comparison between estimation of flooded paddy fields area of districts and statistics

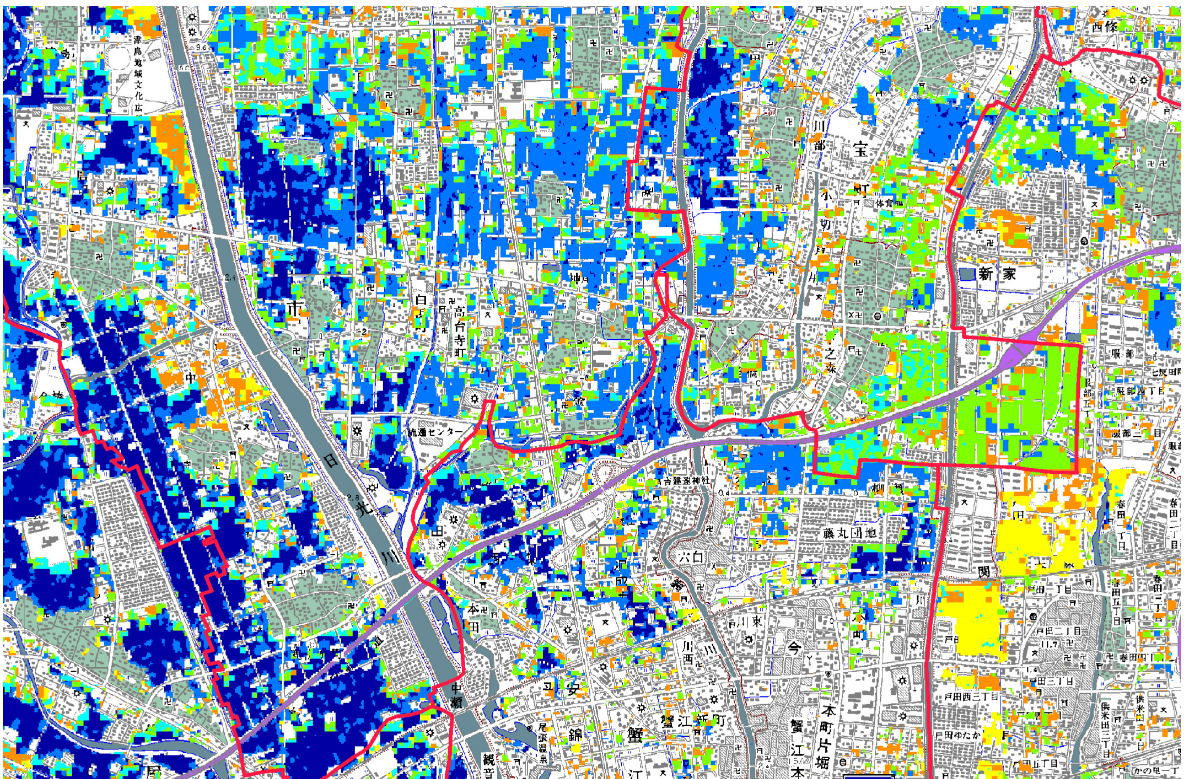

Fig.8 Distribution of preparatory water in paddy irrigation

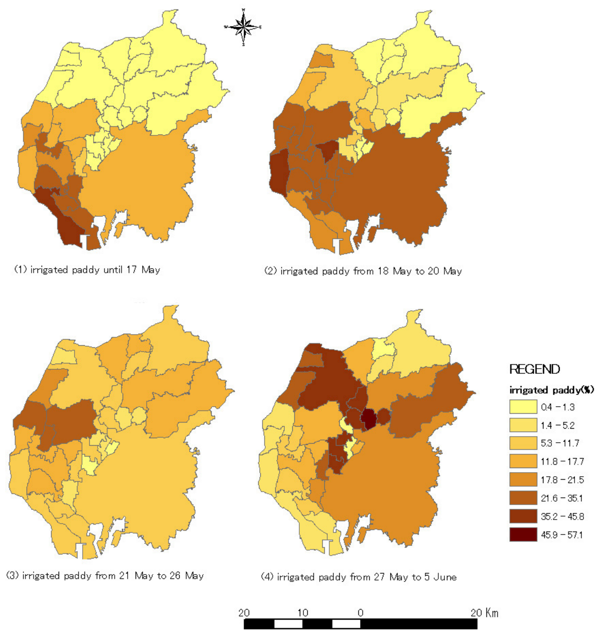

Fig.7 Distribution of preparatory water in paddy irrigation

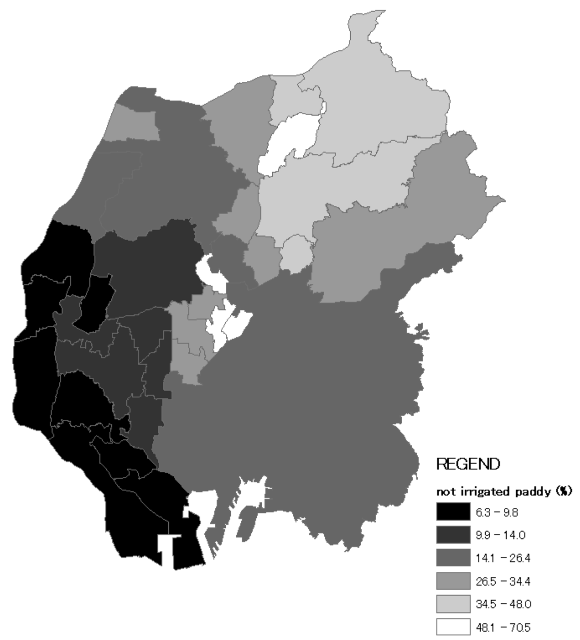

Fig.9 Percentage of paddy field before preparatory water on 5 June, 2002.
(Percentage = not irrgated paddy / no vegetation paddy * 100)

paddy * 100 (%). Flooded paddy fields start from south (low and flat area) and shift to north (upper area).

We can know the details of preparatory water in field level (Fig.8). It is easy to understand the position overlaying the map image.

Fig.9 shows percentage of paddy field before preparatory water on 5 June 2002. Transplanting is earlier in lower and west side area and transplanting is not finished in upper area.

Total area of paddy fields and flooded paddy fields are corresponding to statistic value. Flooded paddy fields didn't verify in each term. Ogawa et al. (1998) estimated flooded paddy field area using RADARSAT image and mask of paddy field area and the area estimation is corresponds to statistic data. Considering these references, this map would be high accuracy.

5. CONCLUSION

In this paper, we estimate the distribution of preparatory water in paddy irrigation using RADARSAT/SAR-C and Landsat/ETM+ data (four data sets) and 10m digital land use map. Estimated paddy field sum up on district unit is very high relationship with statistical value (number of districts are 32, r^2=0.999, RMSE=21.5ha, y=1.12x). Using this relationship, estimation of flooded paddy field area becomes higher (number of districts are 18, r^2=0.990, RMSE=29.7 ha).

We verified the high accuracy of estimation and very useful methods. Each stage could not evaluate the flooded paddy area, but it would be high accuracy from the total accuracy and study reports.

REFFERENCE

Fujiki T., Satoh M., Sopaphun P. and Vudhivanich V., 2001. Water Management Practice in Upper Chao Phraya Delta, Thailand - Analysis of water use in the Borommathad Irrigation Project-, Transactions of the Japanese Society of Irrigation, Drainage and Reclamation Engineering, No.216, pp. 1-7.

Nageswara P.P. and Rao V.R., 1987. Rice crop identification and area estimation using remotely-sensed data from Indian cropping patterns., Int. J. of Remote Sensing, 8, pp. 639-650.

Ogawa S., Inoue Y., Mino N. and Tomita A., 1998. Monitoring of Rice Field using SAR Data and Optical Data, Proc. 2nd International Workshop on Retrieval of Bio- & Geo-physical Parameters from SAR Data for Land Applications, pp.155-159.

Ogawa S., Miyama K. and Fukumoto M., 1990. Study on land use classification using remote sensing images. Transactions of the Japanese Society of Irrigation, Drainage and Reclamation Engineering at Hokkaido region, No.216, pp. 1-7.

Okamoto K. and Fukuhara M., Estimation of paddy field area using the area ratio of categories in each mixel of Landsat TM, International Journal of Remote Sensing, 17,9, pp1735-1749, 1996.

Otsubo Y., Ito T. and Iida H., 2001. Time-series Inundation Mapping in the Lower Mekong Basin Using RADARSAT-SAR Images, Rural and Environmental Engineering No.41, pp. 57-69.

Yamagata Y., Ishida K., Fujita Y., 1988. Estimation of planted paddy field area using Landsat/TM image, Transaction of Japan Society of Photogrammetry and Remote sensing, pp.163-168.