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Estimation of rice yield and transplanting date by using satellite data in Karnataka state of India

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Abstract
Rice is a staple food in Asia and India is the largest rice growing country in world. The productivity and thereby productions vary within and among the state or regions. SAR based rice crop inventory is regularly carried out in India. The present study was aimed to estimate correlation between transplanting data and biomass derived from remote sensing data and observed field data in Shimoga district of Karnataka state for *kharif* rice. Shimoga is known as rice bowl of Karnataka.
The backscatter coefficient (σ°) derived from active C-band Synthetic Aperture Radar (SAR) data from MRS mode RISAT-1 satellite data was used, averaged for 3 x 3 pixel windows and used to estimate transplanting date and crop yield. The backscatter showed good relation with observed field yield obtained through study. The coefficient of determination (R^2) observed for the different model estimates based on RS data were 0.65, 0.90 and 0.45 for crop yield, transplanting date and rice dry biomass, respectively. It indicates that RS technology can estimate the yields at field level with certain accuracy. It was also observed that the number of sites (i.e. 30) were not sufficient to estimate yields of district, suggesting RS based sampling farm with larger sampling size to be included as future strategy.

Keywords: SAR data and rice, rice field backscatter, transplanting date and biomass

Introduction
Rice is of significant importance for many tropical countries, both as a staple food and as an agricultural product for international trading. Crucial parameters for yield forecasting are area of the rice fields and rice growth status. Asia accounts for 90% of the world's production and consumption of rice because of its favourable hot and humid climate. Two countries, China and India, produce 55% of the total crop. India covers 45 MHa paddy area according to the GoI statistics of 2013, which constitutes about second place in production and first place in area of world.
A major source of increase in rice yield in the past was public and private sector investment, flood control and drainage management that converted rainfed into irrigated ecosystems to facilitate the adoption of modern rice varieties and improved farming practices. Theoretically, the potential for further increase in rice yield is still large, as only 55% of Asian rice land is irrigated (IRRI, 2000). This situation leads to the need of an efficient monitoring system for areas under rice cultivation for economical use of resources and early forecasting of rice yield. The relevant organisations, mostly government institutions, require an easily applicable tool supporting decision making on well-timed food policy. The government spends lots of efforts to estimate the paddy field area and yields by field survey and to produce statistical data. Considering the time and budget required for the field survey, remote sensing techniques can be an attractive alternative to produce spatial distribution of rice plantation.
Most of the research has used C-band SAR, for example the Canadian Radarsat Earth observation satellite project or the European Space Agency's ERS system. In addition, a small amount of research has been carried out using L-band SAR, provided by aircraft based AIRSAR, Japan's JERS-1, and Pi-SAR systems, as well as NASA's shuttle based SIR system (Ferrazzoli *et al.*, 1997 and Ishitsuka *et al.*, 2004) [8, 4].
Kurosu *et al.* (1995) showed a clear relationship between the radar backscattering coefficient and crop parameters. Aschbacher *et al.* (1995) [1] have shown the usefulness of radar data for the detection of rice-growing areas. Le Toan *et al.* (1997) [11] used the multi-temporal information of ERS-1 C band SAR data for rice crop mapping and monitoring in Indonesia. Until date, there have been many studies carried out using SAR to monitor paddy fields (Kurosu *et al.*, 1997; Le Toan *et al.*, 1997; Ogawa *et al.*, 2002 and Okamoto and Fukuhara M., 1996; Ribbes 1999; Ishitsuka *et al.*, 2004; Li *et al.* (2005) and Ishitsuka *et al.*, 2003) [11, 13, 14, 16, 8, 1, 9].

In 2006, the Japan Aerospace Exploration Agency (JAXA) launched the Advanced Land Observing Satellite (ALOS). The C-band and shallow incidence angle (31-46u) have been found suitable for identification of rice crops (Chakraborty *et al*., 2005 and Panigrahy *et al*., 1999) [2, 15]. The sensitivity of water surface roughness created by a wind-induced ripple to SAR backscatter is reduced by using HH polarization and a large incidence angle (Chakraborty *et al*., 1997, Panigrahy *et al*., 1999 and Chakraborty *et al.*, 2005) [3, 15, 2].

Site and data

Study area for rice crop monitoring, Shimoga district of Karnataka state, India was selected from 2014-2015. Shimoga is known as Rice bowl of Karnataka state. Area having water as gift and favourable climatic condition so, Paddy is the predominant crop in both the seasons. The crop is transplanted during end of July to early August in *Kharif* season and during February-March in *Rabi* season. Shimoga having area, production and productivity 131070 ha, 313243 t and 2516 kg ha^{-1}, respectively under *Kharif* Shimoga district having latitude 13.9333° N and 75.5667° E longitude.

Data

RISAT-1 MRS SAR data was used for analysis for paddy crop study. The acquisitions of data on dates were as 10th July, 2014, 04th August, 2014 and 29th August, 2014 data at 25 days interval acquired three scenes. The first date data (10th July, 2014) was acquired coinciding with the puddling/transplanting stage. The other two dates were acquired at 25 day intervals i.e. on 04th August and 29th August, 2014, which covered growth until the peak vegetative stage of the crop. The three-date data were co-registered into single multi-temporal dataset, which reflects the variation in rice planting of the study area.

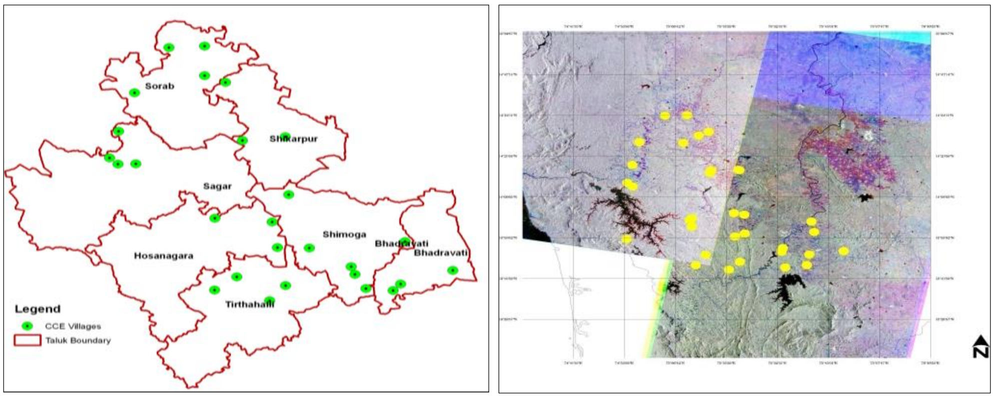

Fig 1: Map of study area and Three date FCC of Shimoga (10th July, 04th Aug and 29th Aug_2014-15) showing the study Points

Methodology

Data analysis done in two steps as:

1. Field data collection
2. SAR data analysis

Field data collection

For study, different 30 villages from seven taluka's of Shimoga district of Karnataka were selected. Field work was undertaken during 21st November – 3rd December, 2014 at the time of crop harvesting stage.

Field experimental data for rice growth and economical parameter such as Crop varieties, sowing time, spacing, crop stress, crop water condition, pests and diseases, weight of biomass, weight of grain and test weight were collected. In this area, most of the paddy crop was transplanted in the first fortnight of August.

SAR data analysis

SAR Data used for analysis was in medium resolution mode having ascending pass, incidence angle 36º, dual polarization (HH, HV), swath 115 m with spatial resolution 18 m and temporal resolution 25 days.

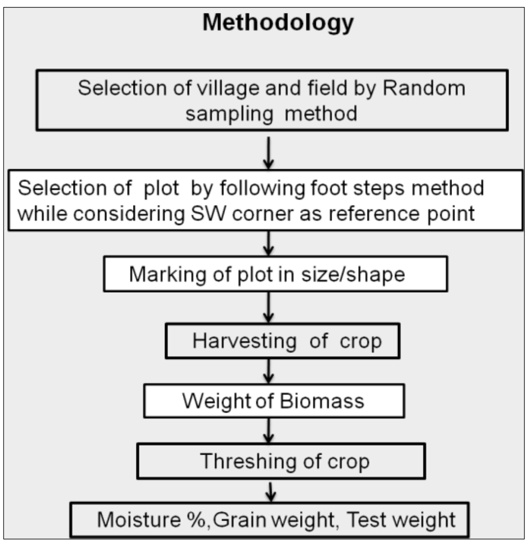

Fig 2: Flow chart for *In situ* data collection

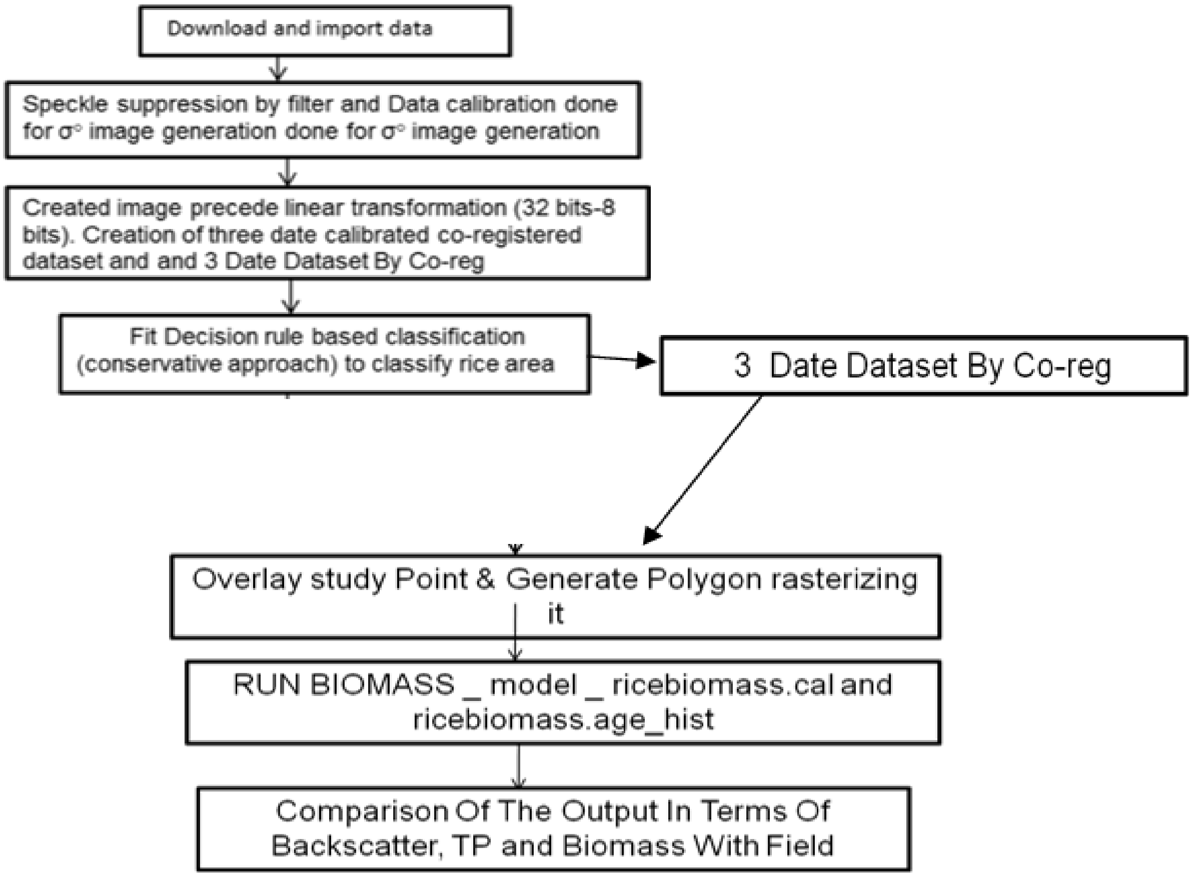

Fig 3: Flow chart for SAR Data processing methodology

Formulae used

1. Convert green biomass to dry biomass

Dry Biomass = (Mean biomass) × (Moisture const) × (Lag factor)

Where, Moisture const = 0.25-0.3

Lag factor = 1.1-1.2

2. dB to DN

dB = (DN/10)-25.5

3. Convert dry biomass to yield

Yield= Dry biomass × Harvest index

Result and discussion

Rice area classification was done by using rice biomass model on the basis of backscatter. The analysis of temporal backscatter of the SAR data was based on the understanding of the scattering of radar from rice fields. Besides this, knowledge of plant morphology, cultivation practices and rice field environment are required. In the case of rainfed low land rice field, the freshly transplanted rice plant gives a very low backscatter value due to specular reflection from standing water present in the field. As the plant grows and develops tillers, the radar backscatter increases until the plant reaches the reproductive stage. This is due to volume scattering from the vegetation and multiple reflections between the plants and water surface. Beyond this stage, the radar backscatter remains nearly constant (Aschbacher *et al.*, 1995, Chakraborty *et al*., 1997, Ribbes *et al*., 1999 and Panigrahy *et al*., 1999) [1, 3, 16, 15].

Radar backscatter coefficients of rice have been expressed as a function of time (Fig. 4). Backscatter coefficient (so) of time-series radarsat data shows the increasing trend as growth advances. At the rooting stage after transplanting, backscatter coefficients of paddy fields are ranged from -22dB to -20dB. Then, at late reproductive stage, they reach -9dB to -8dB. The temporal variation (>11dB) of backscatter coefficient may be significant to interpret rice growth. In comparison with previous studies, Hong *et al.*, (2004) [6] reported that backscatter coefficients of Monitoring of Rice Growth by radarsat fields were ranged from -16dB to -13dB at the rooting stage after transplanting and then they reached -4.4dB- to -3.1dB at the end of reproductive stage and showed plateau until the end of the ripening stage, with RADARSAT. Ribbes and Le Toan (1999) [16] reported by using radarsat S1 mode showed that at the beginning of the cycle, flooded fields provide low backscatter (-14 to -12dB) and then at the end of the reproductive stage, so values reach -6dB and remain stable until the end of the cycle. Temporal variation were more than 7dB (-15--20dB to -8--6dB) by Le Toan *et al.*, (1997) [11] by using ERS-1 SAR (C band; 5.3 GHz, VV polarization) and around 6dB (-13--12 to -6dB) by Ogawa *et al.* (2002) [13] report by using RADARSAT data. Panigrahy *et al.*, (1999) [15] (ADRO Project ID 349) reported that rice crop showed the largest dynamic range of backscatter of -18-to-8dB during the study period. During this study, reported rice crop range of backscatter was -16 to -4dB from study sites.

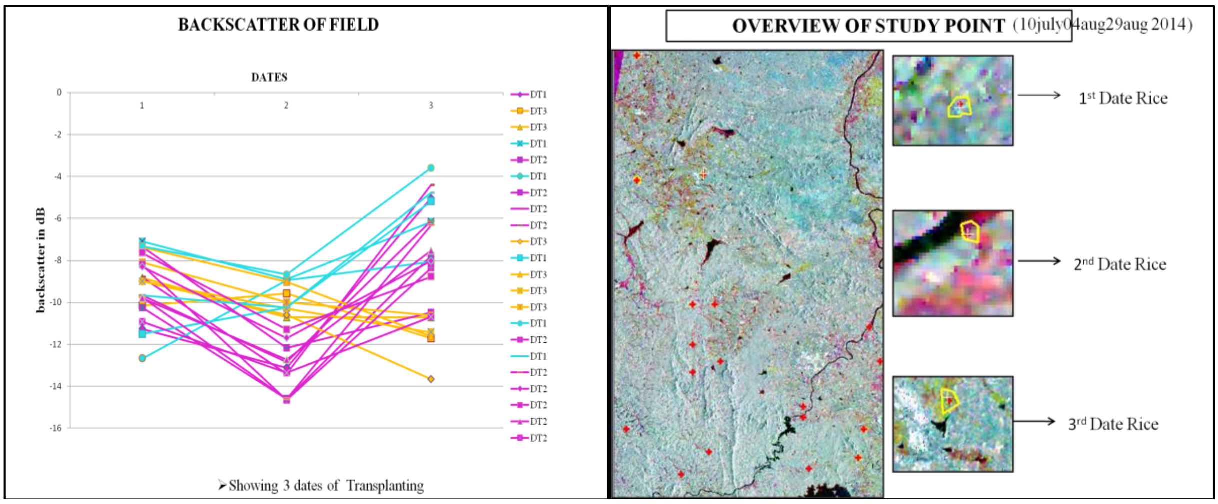

Fig 4: Rice area classification and backscatter from study sites

Transplanting data and peak biomass

The soil backscatter plays dominant role near the harvesting stage. While inverting, a cut-off was laid to take account of the soil/ crop backscatter when the canopy starts drying up. Biomass was estimated at flooded fields or smooth fields near field capacity soil moisture and the model was re-run for varying soil moisture content. The radiative transfer model based inversion of biomass from backscatter was directed for the first rising portion of the curve. From this, we retrieved the mean biomass, mean TP date and corresponding frequency for all the series of transplantation in 5 days interval. This information was used for fitting growth curve. The sigmoid growth curve was fitted using Monte-Carlo simulation with least square error. From the fitted curve we derived the peak age, peak biomass, peak transplantation date corresponding age of the crop and the inflection points as reported by Haldar D. *et al.* (2013) [5].

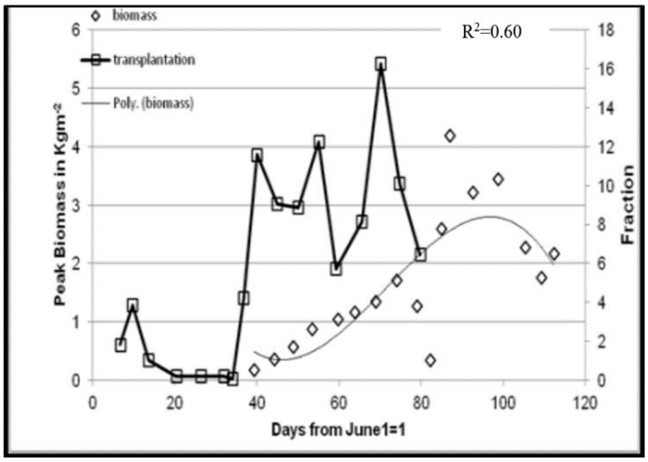

Fig 5: Transplanting date, peak biomass of *Kharif* paddy and crop growth pattern

Graph shows 4.5, 70 days (1june=1 i.e. 70=August) peak biomass and transplanting date, respectively and R^2 value is 0.60 (Fig. 5).

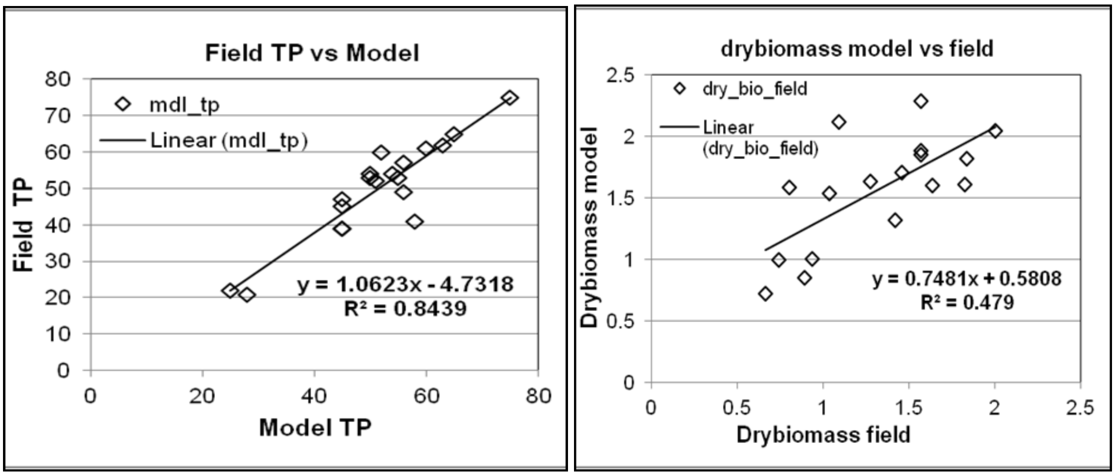

Fig 6: Correlation between model and field transplanting data of drybiomass

Above graph (Fig. 6) shows very good relation between field transplanting dates (TP) with model estimated TP i.e. R^2 value is 0.8439. Another graph shows near about 50% correlation between dry biomass observed on field with model estimated drybiomass having R^2 value 0.479.

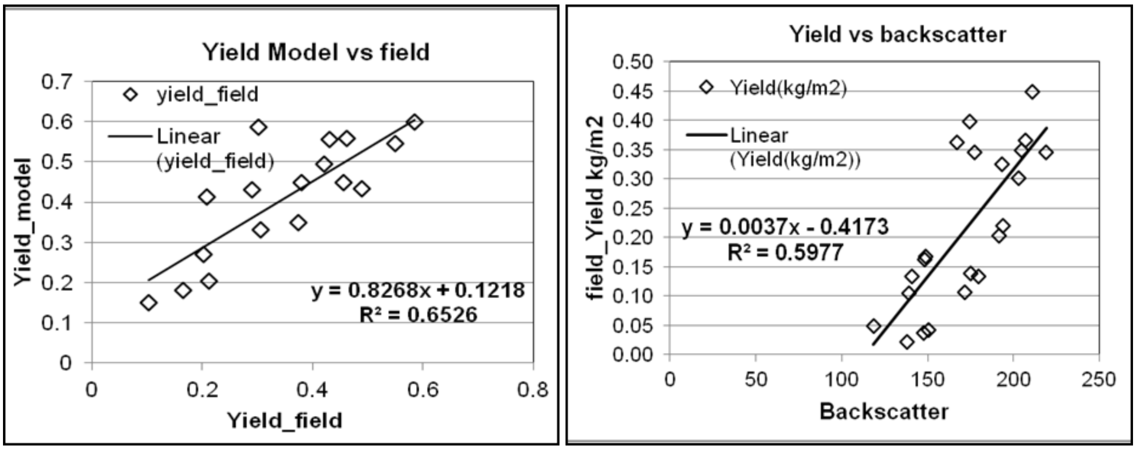

Fig 7: Correlation between backscatter with field yield and field yield vs model yield

Above graph (Fig. 7) shows correlation between field yield with Model Yield having R^2 = 0.652 and correlation of backscatter with field yield having R^2= 0.597. It shows good relation between field yield with backscatter obtained from study sites from Fig. 4. Maximum deviation occure because of unavailablity of June data.

Conclusion

It shows that R^2 values for TP, dry biomass, yield and yield Vs backscatter is 0.8439, 0.479, 0.652, and 0.597, respectively. This, result says that RS data gives better relation with field data and it may be usefull for different government and private sectors to improve procedure and reliability of crop yield forcasting.

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References

1. Aschbacher J, Pongsrihadulchai A, Karnchanasutham S, Rodprom C, Paudya DR, Le Toan T. Assessment of ERS-1 SAR data for rice crop mapping and monitoring. IEEE T Geosci Remote. 1995; GE-23:2183-2185.
2. Chakraborty M, Manjunath KR, Panigrahy S, Kundu N, Parihar JS. Rice crop parameter retrieval using multi-temporal, multi-incidence angle Radarsat SAR data. ISPRS J Photogramm. 2005; 59:310-322.
3. Chakraborty M, Panigrahy S, Sharma SA, Kundu N, Ghose SC, Pal M. Early estimation of rice area using temporal ERS-1 synthetic aperture radar data-a case study for the Howrah and Hughy districts of West Bengal, India. Int. J Remote Sens. 1997; 18:1827-1833.
4. Ferrazzoli P, Paloscia S, Pampaloni P, Schiavon Sigismondi S, Solimini D. The potential of multifrequency polarimetric SAR in assessing agriculture and arboreous biomass. IEEE Trans. Geosci. Remote Sensing. 1997; Ge35:5-17.
5. Haldar D, Chakraborty M, Jain V, Parihar JS. BGREI paddy monitoring status in Orissa-comparative evaluation of 2011 and 2012, 2013. SAC/EPSA/FASAL-R&D/ATDG/SR/01/2013.
6. Hong Y, Hsu KL, Sorooshian S, Gao X. Precipitation estimation from remotely sensed imagery using an artificial neural network cloud classification system. Journal of Applied Meteorology. 2004; 43:1834-52.
7. International Rice Research Institute, http://www.cgiar.org/irri/Riceweb/, 2000.
8. Ishitsuka N, Saito G, Ouchi K, Uratsuka S. Observation of Japanese rice paddy fields using multi wavelength and full polarimetric SAR -Remote sensing sensor on next generation satellite. Advances in Astronautical Sciences. 2004; 117:565-575.
9. Ishitsuka N *et al*. Methodology Development for Area Determination of Rice Planted Paddy Using RADARSAT Data. Journal of The Remote Sensing Society of Japan. 2003; 23(5):458-472. [In Japanese].
10. Kuroso T, Suitz M, Fujita K, Chiba Moriya T. Rice Crop Monitoring with ERS-1 SAR - A First Year Result, Proceedings of 2nd ERS-1 Symposium, Hamburg, Germany, October 11-14, ESA SP-361. 1995; (1):97-102.
11. Le Toan T, Ribbes F, Floury N, Wang L, Kong JA, Kurosu T *et al.* Rice crop map ping and monitoring using ERS-1 data based on experiment and modeling results, IEEE T Geosci Remote. 1997; 35(1):41-56.
12. Li J, Chen W. A rule-based method for mapping Canada's wetlands using optical, radar and DEM data. International Journal of Remote Sensing. 2005; 26:5051-5069.
13. Ogawa K, Schmugge T, Jacob F, French A. Estimation of broadband land surface emissivity from multispectral thermal infrared remote sensing. Agronomie: Agriculture and Environment. 2002; 22:695-696.
14. Okamoto K, Fukuhara M. Estimation of paddy field area using the area ratio of categories in each mixel of Landsat TM. Int. J Remote Sens. 1996; 17:1735-1749.
15. Panigrahy S, Manjunath KR, Chakraborty M, Kundu N, Parihar JS. Evaluation of Radarsat standard beam data for identification of potato and rice crops in India. ISPRS J Photogramm. 1999; 54(4):254-262.
16. Ribbes F, Toan TL. Rice field mapping and monitoring with RADARSAT data. International Journal of Remote Sensing. 1999; 20(4):745-765.