



International Journal of Engineering, Business and Enterprise Applications (IJEBA)

www.iasir.net

Application of remote sensing and GIS for acreage estimation of wheat

A.R. Pimpale¹, P.B. Rajankar², S.B. Wadkar³ and I.K. Ramteke⁴

¹Assistant Professor, Section of Agricultural Engineering, Dr. PDKV, Akola, Maharashtra, INDIA.

²Associate Scientist, Maharashtra Remote Sensing Applications Centre, Nagpur, Maharashtra, INDIA

³Head, Department of Irrigation and Drainage Engineering, Dr. PDKV, Akola, Maharashtra, INDIA

⁴Scientific Associate, Maharashtra Remote Sensing Applications Centre, Nagpur, Maharashtra, INDIA

Abstract: Reliable and timely estimates of crop area coverage is of great importance to planners and policy makers for efficient and timely agricultural development as well as making important decisions with respect to procurement, storage, public distribution, export, import and other related issues. Wheat is dominant crop grown in rabi season in Maharashtra, assuming greater importance in acreage estimation. Traditionally, the estimates of crop acreage are obtained through complete enumeration by revenue agencies (Giradwari system), sample surveys and by personal assessment of village patwari. Application of Remote sensing and GIS can provide more accurate and timely estimates of acreages. Present paper deals with the methodology adopted for classifying wheat crop using NDVI time series derived from multi-date IRS P6 AWiFS data. Study area covers the dominant wheat growing districts of Maharashtra state. Multi-date IRS P6 AWiFS data for rabi season of 2012-13 have been used. Two-stage classification of this dataset by unsupervised Iterative Self Organizing Data Analysis Technique, labeling of classes based on temporal spectral profiles of wheat and other competing crops, vectorisation of classified image, manual editing and labeling of mixed class polygons and decision rule based integration were followed to generate final classified image. This hybrid classification technique takes advantage of inherent clustering tendency of land use / land cover classes in feature space with temporal dimension added to it in terms of Normalized Difference Vegetation Index (NDVI) time series data. It also makes use of signatures of known crop classes for labeling the clusters. Wheat acreage estimated by this approach for the study area is found 189481 ha, which is deviating by 9.78 % from the reference data as reported by Government of Maharashtra. This technique is simple, time saving, less subjective and requires less expertise compared to hierarchical classification technique.

Keywords: AWiFS, wheat, NDVI, GIS

I. Introduction

Agriculture is an important sector of the Indian economy, accounting for 14% of the nation's GDP, about 11% of its exports, about half of the population still relies on agriculture as its principal source of income and it is a source of raw material for a large number of industries. Accelerating the growth of agriculture production is therefore necessary to meet the rising demand for food, but also to increase incomes of those dependent on agriculture to ensure inclusiveness. Climate change is a new challenge in agriculture. It has to face both the types of draughts i.e. excess rainfall and scanty rainfall conditions. In this situation it becomes necessary to know the acreage of particular crop sown in a particular area well in advance before harvesting which helps planners and policy makers for making important decisions with respect to procurement, storage, public distribution, export, import and other related issues and helps in proper planning of available resources and market situations. Traditionally, the estimates of crop acreage are obtained through complete enumeration by revenue agencies (Giradwari system), sample surveys and by personal assessment of village patwari which takes quite long time. Application of Remote sensing and GIS can provide more accurate and timely estimates of acreages which can help planners and policy makers. Multi-date, multi-spectral data in the form of several vegetation indices have been utilized for crop identification and area estimation world wide. Crop growth profiles, derived using spectral indices, have been modeled by (Badhwar, 1980) and by (Christ and Malila 1980) using multi-date Landsat – MSS data. Spectral yield models for corn and soybean based on growth profile for some selected time periods are studied by (Boatwright *et al.* 1988). The most commonly used classification methodologies used in remote sensing are unsupervised procedures such as Iterative Self Organizing Data Analysis Technique (ISODATA) and supervised methods, the most popular of which is the Maximum Likelihood (MXL) algorithm, where precise filtering of the information registered on imageries is carried out with image analysis algorithms. Researchers have used various classifiers for classifying the RS data for different applications (Tateishi *et al.*, 1991; Friedl and Brodley, 1997; Hastings, 1997; Friedl *et al.*, 1999). Multi-date IRS WiFS and AWiFS data have been used for various agricultural applications including cropping pattern change monitoring, crop yield modelling and crop classification (Rajak *et al.*, 2002; Rajak *et al.*, 2005;

Oza *et al.*, 2008). During rabi season, wheat is the one of the major crops and is cultivated in large contiguous areas in the study area. Monitoring of crop condition, development of crop growth profile and prediction of yield based on remotely sensed multi-spectral data hold great promise. In the present study, a hybrid technique of multi-date RS data classification based on two-stage ISODATA clustering and visual classification has been presented. It takes advantage of the natural groupings of pixels based on their spectral properties by way of ISODATA clustering and discrimination of spectrally similar classes by way of visual vector polygon analysis.

II. Material and Methods

A. Study area:

This study was conducted in five districts situated in central part of Maharashtra *i.e.* Pune, Solapur, Ahmednagar, Beed and Osmanabad wherein spatially, extensive and contiguous sites contribute to wheat production (Fig.1). It covers an area of approximately 65,716 Km². It is located between 73°17'19"E to 76°47'42" E longitudes and 19°58'57" N to 17°03'56" N latitudes The average annual rainfall ranges between 500-700 mm with uncertainty and ill distribution. Rainfall pattern is bimodal. Droughts occur very often. The climate is hot and dry. General topography is having slope between 1-2 %. Most soils are vertisol and have montmorillonite clay, poor in nitrogen, low to medium in phosphate and well supplied in potash.

B. Remotely Sensed data:

Multi-date, multispectral satellite images of IRS- P6, AWiFS (Advanced Wide Field Sensor) Sensor for five consecutive months of wheat season (October/November/December /January/February) of the year 2012-13 were used for this study (Table 1). Rectangular subset images covering the study area were obtained and processed in ERDAS Imagine to generate Normalized Difference Vegetation Index (NDVI) images on all the dates of satellite pass.

Table 1. Multi-date IRS-P6 AWiFS data used for the study

Sr No	Satellite	Sensor	Path	Row	Date of Pass
1	IRS-P6	AWiFS	097	058	19-10-2012
2	IRS-P6	AWiFS	098	059	11-11-2012
3	IRS-P6	AWiFS	098	059	29-11-2012
4	IRS-P6	AWiFS	098	059	11-12-2012
5	IRS-P6	AWiFS	098	062	27-12-2012
6	IRS-P6	AWiFS	097	059	11-01-2013
7	IRS-P6	AWiFS	097	058	23-01-2013
8	IRS-P6	AWiFS	097	059	04-02-2013

C. Ground Truth data:

Ground truth work was carried out in December 2012. This time of ground truth coincides with the season of wheat crop in the study area. Data were collected from 82 sites of wheat and other crops in the study area. (Fig.1).

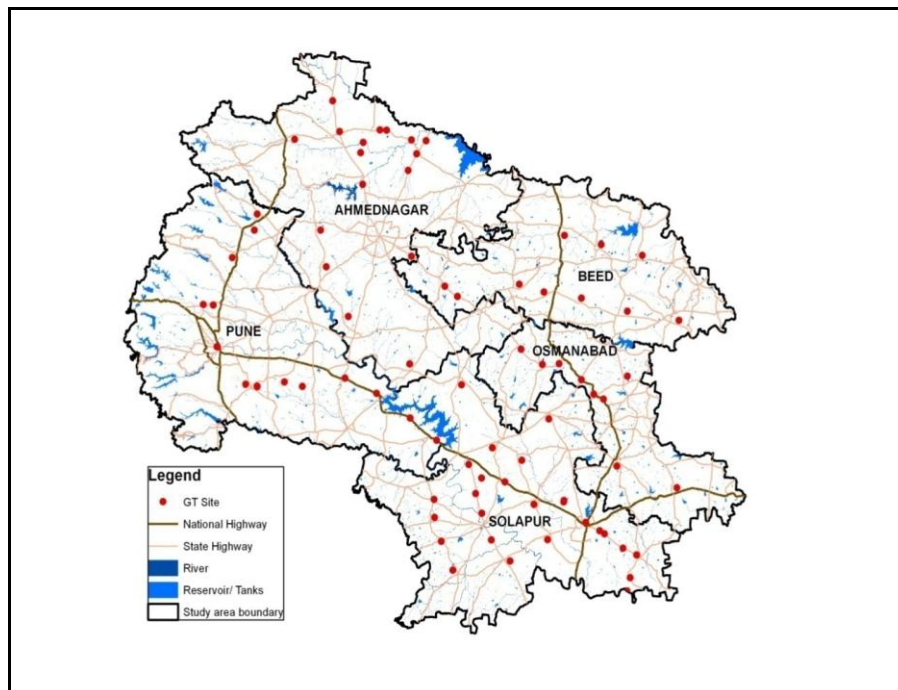


Fig. 1. The study area and location of ground truth stations

Handheld GPS device, geotagged camera and a mobile device with LOCATE software were used to obtain the locations and elevations of the sites. The information obtained from each site was recorded in ground truth proforma sheets.

III. Image processing

The image data was processed in the sequence (Fig.2) as follows:

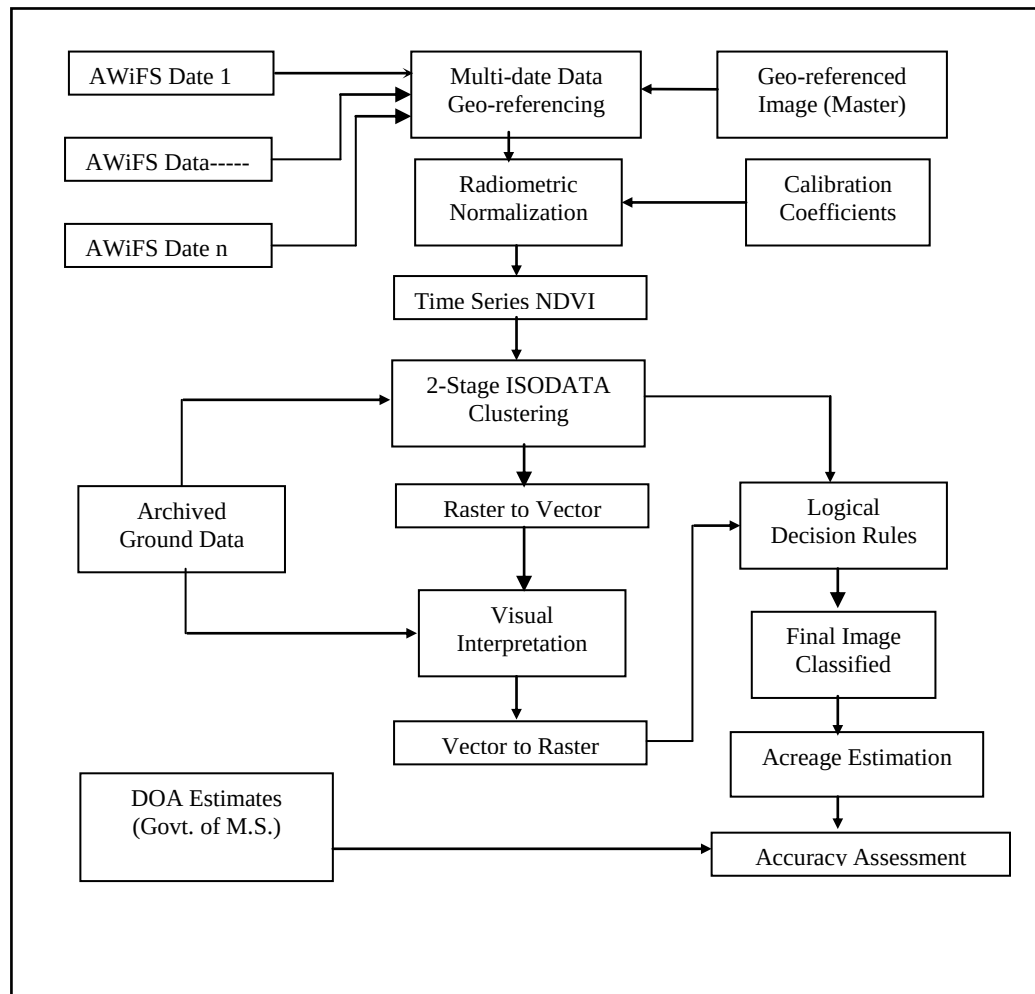


Fig. 2 Flow diagram of methodology adopted for acreage estimation

A. Preparation of Reference temporal spectral profiles:

Images of Normalized difference Vegetation Index (NDVI) on all the dates of pass were generated using ERDAS Imagine software and stack was prepared. The geographical locations of GT field sites were transferred on the images. The average NDVI values of rabi sorghum, wheat and sugarcane fields, water bodies and built up land for all the dates of satellite pass were obtained. Graphs of NDVI values for different dates of satellite image acquisition were plotted for rabi sorghum, wheat, sugarcane and other areas. These plots represent Reference Temporal Spectral Profile (RTSPs) of the respective class. General RTSPs of sorghum and wheat crops and RSTPs reflecting different dates of sowing were also prepared.

B. Data Load reduction:

In order to reduce data load Non Crop Mask (NCM) of wasteland, forest, large water bodies, built up areas was overlaid on the NDVI stack and output multilayer dataset representing cropped area was used for further processing.

C. Isodata Clustering and Labelling (Stage I and Stage II):

The multilayer dataset obtained was subjected to unsupervised classification with 20 iterations and 0.950 coverage threshold with skip factor $X=1$ and $Y=1$ which resulted in raster image containing 100 classes of clusters. The signature file so generated was used to obtain Temporal Spectral Profile (TSPs) for each class. These TSPs were compared visually with RSTP of wheat crop and the related classes were assigned as wheat crop. The process was repeated for unclassified pixels to get classes representing wheat crop. Finally classified image was obtained.

IV. Result and Discussion

The classified image obtained after unsupervised classification is shown in Fig.3. It was found that TSP of 15 classes was matching with RTSP of wheat. The images showing only wheat crops (recoded images) in the subset area were obtained. The district wise pixel count of wheat crop was obtained by applying zonal attributes/majority count function of ArcGIS. For this process, option of intersection /union and ignore zero values was selected.

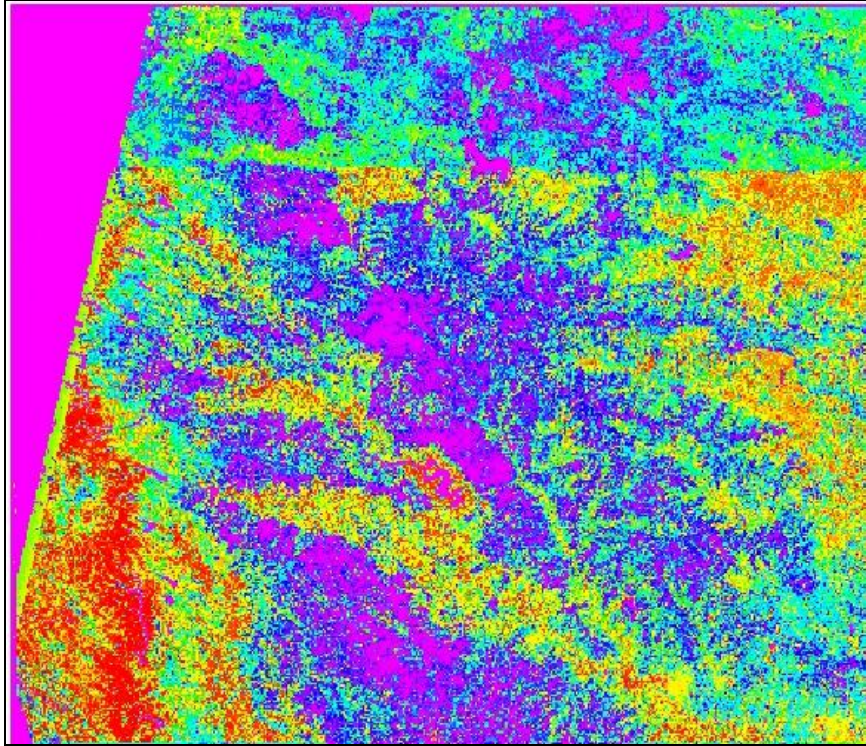


Fig. 3 Classified Image after unsupervised classification

After running the process, the attributes of the vector layer show the majority count i.e. number of pixels of wheat in each district. The area under the wheat crop in each district was obtained by multiplying these number of pixels by resolution of the data i.e. 56x56m and converted. The wheat acreage estimated from the final classified image for the study area comprising five districts of Maharashtra state was estimated to 189481 ha. More than 95 percent pixels classified as wheat were correctly classified using the hybrid technique. It is observed that many linear features like canals and roads were correctly classified as non crop class in the present analysis. The results of acreage estimation and its comparison with the reference figures received from crop statistics by Department of Agriculture, Government of Maharashtra are given in Table 2 Relative deviations in terms of % variation are estimated district-wise.

Table 2. Estimated acreage of wheat crop

Crop	District	RS Estimates (ha)	DOA estimates (ha)	Deviation (%)
Wheat	Ahmednagar	41357	38900	6.31
	Pune	59708	53000	12.66
	Solapur	30861	28800	7.16
	Beed	31805	27700	11.21
	Osmanabad	26750	24200	10.53
	Total	189481	172600	9.78

Area under wheat crop in the study area was estimated by remote sensing as 189481 ha against actual area of 172600 ha reported by Department of Agriculture showing 9.78 percent over estimation. This may be because of similar spectral profiles of coexisting crops like oats. Wheat being irrigated crop, soil moisture affects the reflectance of crop. Lowest variation of 6.31% was observed in Ahmednagar district whereas highest variation 12.66% was observed in Pune district.

The similar results related to accuracy of acreage estimation were found by Dua *et al.* (2007) for potato and Goswami *et al.* (2012) for wheat.

V. Conclusion

The hybrid technique demonstrates the utility of multi-date RS data classification, integrated two-stage ISODATA clustering and visual classification of unknown vector polygons. The two-stage ISODATA clustering yielded in a classified image having 93 to 98 percent pure-class pixels and 2 to 7 percent mixed-class pixels. It is observed that many linear features like canals and roads were correctly classified as non-wheat classes in the present study. Such a holistic approach where multi-date RS data is fed to rigorous and repetitive analysis, makes it conceptually sounder than those methods, involving single-date spectral indexes which rely solely on spectral data within a narrow critical period maximum vegetative growth phase.

References

- Badhwar, G.D., (1980), Crop emergence date determination from spectral data, Photogramm. Eng. Remote Sensing, 46, 369-377.
- Boatwright, G.O., Badhwar, G.D. and Johnson, W.R., (1988), An AVHRR spectral based yield model for corn and soybeans. Final Report, Project No. 8103, USDA-ARS. Beltsville, Maryland, USA.
- Christ, E.P. and Malila, W.A., (1980), Temporal spectral analysis of technique for vegetation applications of Landsat, 14th Int. Sym. on Remote Sensing of Environment, San Jose, Costa Rica, Apr, 23-30, 2, 1031-1041.
- Friedl, M.A., and Brodley, C.E., 1997. Decision tree classification of land cover from remotely sensed data. Remote Sensing of Environment. 61, 399-409.
- Friedl, M.A., Brodley, C.E., and Strahler, A.H., 1999. Maximizing land cover classification accuracies produced by decision tree at continental to global scales. IEEE Transactions on Geoscience and Remote Sensing. 37, 969-977.
- Hastings, David A., 1997. Land cover classification: some new techniques, new source data. Proceedings, 18th Asian Conference on Remote Sensing, Tokyo, Asian Association of Remote Sensing. Pp. JS-2-1 to JS-2-6.
- Manakos L., Schneider T. & U. Ammer, 2000. A comparison between the ISODATA and the eCognition classification methods on basis of field data. Poster at the XIXth ISPRS Congress, Amsterdam, Presentation number: TP VII-09-22, Netherlands.
- Oza M P, Pandya M R and Rajak D R, 2008. Evaluation and use of Resourcesat-I data for agricultural applications. International Journal of Applied Earth Observation and Geoinformation 10, 194-205
- Rajak D R, Oza M P, Bhagia N and Dadhwal V K, 2002. Monitoring Cropping Pattern Changes Using Multi-temporal WiFS Data. Geocarto International, 17(2), 51-56.
- Rajak D R, Oza M P, Bhagia N and Dadhwal V K, 2005. Spectral Wheat Growth Profile in Punjab Using IRS WiFS Data. Journal of the Indian Society of Remote Sensing, 33(2): 345- 352.
- Tateishi, R., K. Kajiwar, and T. Odajima, 1991. Global land cover classification by phenological methods using NOAA GVI data. Asian-Pacific Remote Sensing Journal. vol. 4, no. 1, pp. 41-50.
- Dua VK, Sushma Panigrahy, Mehta RL, Lal SS, Govindakrishnan PM, Singh JP, Arora RK, Kumar M, Kumar P, Rawat S, Bhatt N and Ahmad I (2007). Estimation of potato acreage in the Indo-Gangetic region using IRS AWiFS data. *J. Potato.*, 34 (1-2) : 123-124
- Goswami SB, Saxena A and Bairagi GD 2012. Remote sensing and GIS based wheat crop acreage estimation of Indore district, M.P. International Journal of Emerging Technology and Advanced Engineering.2(3):200-203