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ORIGINAL ARTICLE

REMOTE SENSING AND GIS BASE CROP ACREAGE ESTIMATION OF THE SUGARCANE FOR SOLAPUR DISTRICT, MAHARASHTRA

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Abstract:

Accurate and faster estimation of crop area is very essential for projecting yearly agriculture production for formulating national budget and deciding agriculture policies. The present investigation deals with the estimation of sugarcane crop acreage of Maharashtra state. The cultivation of sugarcane crop in Maharashtra has been increasing steadily because of the increasing irrigation facilities. In the present study, comparison was carried out between conventional (field data) and remote sensing data for the estimation of accuracy about the sugar cane crop area. Tahsils wise data was analyzed from last 30 years for all the tahsils of Maharashtra state. This data used for the analysis and calculation of maximum and minimum concentration of sugar cane crops using Bhatia crop concentration Index and statistically improvised with t – test method. On this basis Western part Maharashtra depicted maximum increase in area and concentration of sugarcane crop. IRS P6 LISS – III multispectral data was used for the determination of total area under crop with the spectral reflectance of sugar cane crops in selected region of maximum concentration in Western Maharashtra. On the of basis spectral responses, appropriate signature of sugar cane was detected and analyzed. The analysis show that the maximum increase in acreage was in Solapur district. Moreover, Digital Image Process for various algorithms was analyzed and compared to the crop data of conventional ground based surveys. J48 algorithm was found to be more accurate 125 percentages and this helped in establishing the accuracy of Remote Sensing data in estimation of crop acreage for high density crop like sugarcane along with being more accurate, cost effective, reliable, timely and faster than the conventional ground based surveys.

KEYWORDS:

Crop acreage, Algorithms, Crop concentration index and remote sensing, GIS.

INTRODUCTION

Agriculture in developing countries will be confronted with three major challenges in the decades to come (i) increasesing food demand from rapidly growing population as well as economic growth, (ii) stagnating or declining productivity in high productivity region, often described as “green revolution fatigue” and (iii) increasing vulnerability of agriculture to potential climate change (Deosthali et al., .2000.) It is not conceivable that agriculture can deliver the expected output without modern technologies such as genetic engineering, biotechnology and geo-environment technology.

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Estimating of crop production in advance of the harvest is the great utility in the farming such as implementing appropriate agriculture management and pricing of export/import of agriculture commodities (Deosthali et al 2000.). Crop production estimation involves determination of total area under crop and prediction of the yield per unit area.

Remote sensing technology have demonstrated its potentiality in providing information of the characteristics and spatial distribution of nature resources including agriculture resources because of their unique advantage of providing multitemporal and multispectral resolution. Use of satellite remote sensing data has also provide to be more cost effective, reliable ,timely and faster then the conventional ground based surveys of agricultural resources. Spectral reflectance data obtained from remote sensing is a manifestation of integrated effect of weather, soil, cultural practices and crop characteristics that can be used in identifying and monitoring crop growth and for estimating crop yield.

Since 1980s, remote sensing technology has been used different part of the world. A series of controlled ground experiment were conducted in different agro climatic region of India to understand spectral behavior of variety crop and to relate remote sensing derived spectral indices especially(NDVI) Normalized Difference vegetation index and (RVI) Ratio vegetation index with growth and yield attributes. Identification crop type using remote sensed data requires understanding of the spectral behavior of the crop in different part of electromagnetic spectrum and at different level such as a single, leaf, crop canopy and in actual field condition because many variables operate at various levels and influence spectral response. Such understanding of the spectral response helps in interpretation of data collected by various sensors.

The choice regarding spatial resolution, time of acquisition of digital RS data determined by the cropping pattern, field size, crop distribution pattern and crop calendar of region of study. For large mono-cropped area with uniform crop distribution, coarser resolution data such as IRS LISS I and LISS II with 72.5 and 36.25 meter spatial resolutions respectively would be adequate. Whereas in multi-cropped region characterized by small field size and scatted crop distribution, higher spatial resolution data such as from LISS III (23 m) would be desirable. Satellite data should be acquired at maximum vegetation growth stage of crop because early and late season, crop are characterized by larger heterogeneity. The optimum acquisition period can be based on crop calendars of the area and information collated during pre-field surveys. Crop Calendar differences needs to be adjusted to enable direct comparison of time series NDVI (Murthy C.S. and Roy P.S. 2007).

Indian agriculture, in general and agriculture of the Deccan plateau, in particular characterized by fragmentation land holdings. Above 56% of the land, holding in India are less then 1ha size the size is going to diminish further in further in future of late intensive cultivation is practiced in India maximizing the profits by introducing the multiple crop systems. Agro-ecosystems present a higher level of complexity due to small field size, diversified cropping pattern and field-to-field variability in crop phonology and management practices. Thus obtaining reliable information on various crop growths in the mixed cropping situation is the paramount important for framing policies regarding import/ export, procurement, storage etc. Remote sensing technology, as mentioned earlier, as well established to provide pre-harvested crop information on operation basic for major crop growth under dominantly monocroppipg situation occupying larger contiguous areas. However ,the use of satellite data for identification of various crop under multiple cropping system is limited, this type of studies necessitate finer spatial resolutions data, IRS- P6 LISS III sensor with spatial resolutions 23.5 meters provides an opportunity to derive information on crops growth under multiple cropping situation.

Against this backdrop, the present study is undertaken to evaluate the feasibility of utilizing the current available moderately high IRS- P6 LISS III data for crop inventory in Solapur District Maharashtra. Sugarcane is a sixteen-month crop and is planted in the month of July - August. The sugarcane lands are ploughed across seven or eight times, green manured with sann-hemp, and if not green manured forty carts of farm-yard-manure per acre are applied. The land is once again ploughed and it is then flooded with water. When the surface begins to dry it is leveled with the beam harrow and then the sugarcane is planted. Again at the time of earthing up, nitrogen is supplied in the form of groundnut oilcakes and sulphate of ammonia in equal proportion, as top dressing. The layers are set in deep furrows drawn by the bullock-plough. Sugarcane thus planted is called nangria oos (plough cane) to distinguish it from pavlya oos (trodden cane) which is pressed on by foot after the land has been ploughed, broken fine and irrigated. The treading system is usually followed with the poorer canes or in poor soil and it requires manuring after ten or twelve days of planting. The trodden cane sprouts a month after planting, but the plough cane, being deeper set, takes a month and a half to sprout but suffers less from any changes in climate, supply of water, etc., and reaches greater perfection. Sugarcane is either eaten raw or is made into sugar or gur.

The local variety of sugarcane is known as pundya and is grown throughout the district. It is a soft cane and is mainly used for chewing and extracting juice for drinking. Improved varieties such as C.O.-740,

C.O.-419 and C.O.-775 have been introduced by the department of agriculture in the district. These varieties give a better yield. Sugarcane is a crop which exhausts the soil and, therefore, it is not grown in the same field from year to year but is rotated in alternate years with food-crops. It is the major cash crop in the region and it is increasing as co- operative farming and sugar factories are increasing in the area.

REVIEW OF LITERATURE

Three experiments were conducted to achieve the present global agriculture program.

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In early 80s, the commission of European communities in collaboration wit seven specialized national institutes conducted the project to identify and estimate the acreage under rise using LANDSAT-MSS data.

Currently major programs are underway in Africa under global information and Early Warning system of FOA (GIEWS) and Europe under monitoring of Agriculture through Remote sensing (MARS). The mars project over the decade has developed rapid crop survey producers, crop condition assessment through NOAA-AVHRR and employs crop simulation model and real time data for forecasting and assessment

In India since 1986 agriculture crop (wheat, paddy, oilseed, cotton etc) are being investigated at regional level using satellite RS data. Digital supervised classification of LANDSAT MSS data was used for identification and acreage estimation of kharif paddy (kalubarme et al 1986). A two stage of stratified sampling approach and supervised classification of LANDSAT–MSS and TM and IRS 1A and 1B LISS 1 data give batter estimation of paddy crop acreage in large study area such as group of district or state

DATA AND METHODOLOGY

Location: Solapur District is located western part of Maharashtra plateau with the 17.10 to 18.32 degrees North Latitude and 74.42 to 76.15 degrees East Longitude. Covering area 14,895 (sq km)

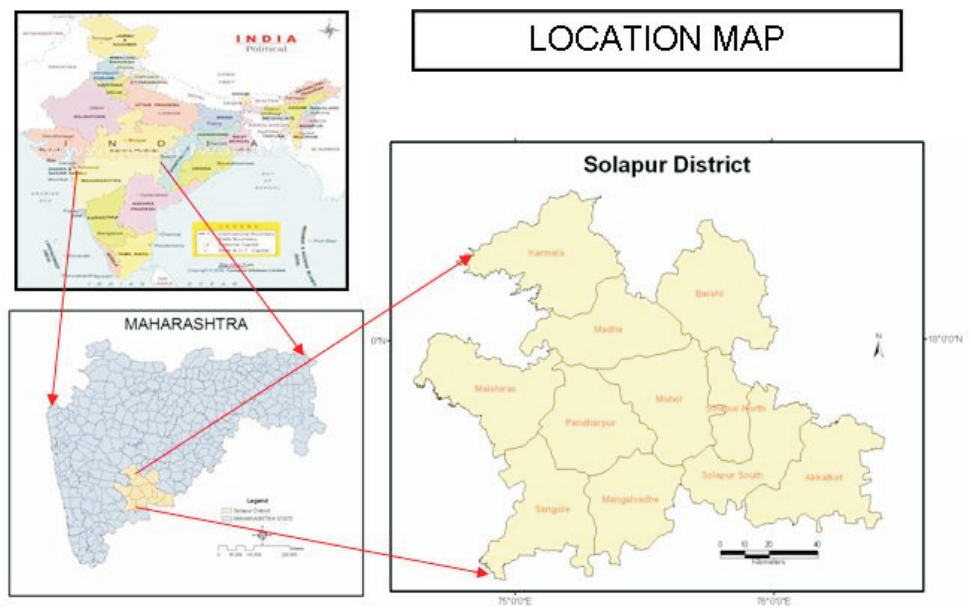


Figure 1: Study area – Solapur district

Topography: The Balaghat mountain ranges' flank the district on the north, north-east and the east side, whereas to the South and the south-west parts of the district stand the Mahadeo Hills. The rest of the district is mostly flatlands and plateau as river Bhima and Sina drain the area.

Climate: Generally the climate of Solapur is extreme, hot and arid. In some parts, the maximum

temperature in the summer touches 42-45 degrees Celsius. Most of the district falls in the rain shadow region and thus is deprived of adequate amounts of rainfall. The average amount of rainfall here is as low as 500 to 750 mm. The distribution of rainfall is very uneven.

Data:

Sources of data: To achieve the object of crop inventory in the in the mixed cropping of solapur district the data from various sources were collected: Spatial and Non-spatial data

Remote sensing data:

Multi-sensor digital data of Indian Remote Sensing Satellite used for digital analysis is given below Table.1 satellite data

Satellite data	Sensor	Path/row	Date
IRS-P6	LISS III	97/60 96/60	14 Jan 2008 02 Feb 2008

Field Data: Primary level survey was carried out in the study area for collection of ground truth for the available crops and farmers were interviewed for the farming systems and management techniques for the crops.

Agriculture data: Agriculture data of the taluka viz., crop pattern, crop calendar, crop phonology and historical crop yield was collected in hard copy from central office of Agriculture Department, Pune, and Govt. of Maharashtra.

Collateral Data: Survey of India topographical maps on 1:250,000 (27sheets) were used to prepare boundary map of solapur district.

METHODOLOGY

The Methodology adopted in this study incorporate both the Digital Image Processing (DIP) and GIS based analysis show on (Figure 2).

Crop Concentration Index: Crop concentration means the variation in the density of any crop in an area/region at a given point of time. Location Quotient Method - The location quotient technique has also been applied by geographers for the determination of the regional character of the cropping patterns. In this technique the regional character of the crop distribution is investigated and determined, first by comprising the proportion of sown area under different crop and ranking them, and secondly, by relating the crop density in each of the component areal units of the region/country try to corresponding density of the region/county as a whole this approach makes it possible to measure the regional concentration of the crop objectively. It also helps to identify and differentiate areas that have some significance with regard to the crop distribution within the region (Majid Husain 2001).

The location quotient method i.e. crop concentration index (Bhatia 1965) is expressed as below:

$$\frac{\text{Area of } \mathbf{x} \text{ crop in the component Areal unit (Tahshil)}}{\text{Area of all crops in the component Areal unit (Tahshil)}} \Big/ \frac{\text{Area of } \mathbf{x} \text{ crop in the entire region (State)}}{\text{Area of all crops in the entire region State}}$$

(1970-71 to 1998-99) collected from Agricultural department of Maharashtra State, concentration index was calculated for each year and the temporal trend was checked for statistical significance.

PREPARATION OF THEMATIC MAPS

Base maps: Road, River, Settlement and other important land feature from survey of India Toposheet were traced onto a polyester tracing film. Tie point of the topsheets were marked also.

Preparation of crop inventory: Preparation of land use / land cover map consisted following steps:

Prefield work: A base map at 1:50000 scales illustrating major cultural feature (village, roads, river, railway network etc.) was victories from the topographical map survey of India. The study of area demarcated on the hard copy of IRS-P6 LISS III FCC corresponding to the base map. The various image characteristics of Land use / land feature were visually interpreted.

Fieldwork: During the fieldwork, ground truth data were collected for inventory of the study area. The observation sites were marked on the top maps as well as FCC (IRS-P6 LISS) on 1:50000 scale. For ground truth sides of various crops, information with reference to crop type, growth stage was noted in the preformed of ground truth data collection.

Ground Truth: Sites for the other Land use/land cover type's viz., water body, wasteland with/without grass, current fallow, and various rabbi crops were well distributed and precisely marked with its surrounding object on the FCC and topographic maps.

DIGITAL IMAGE ANALYSIS:

Digital images processes used various Algorithms Supervised classification mainly maximum likelihood, mahalonobis distance, texture based knowledge based, artificial neural network. This process was down in digital image. The procedure followed is presented schematically;

Image Enhancement: The contrast stretch image enhancement was applied to original image to be used as reference for the visual interpretation.

Identification of the different thematic classes: Based on the field visit to the study area a classification scheme for the digital analysis was determined. Brief descriptions of tile categories are presented in Table 2.

Training Signature Generation: The training sites such as sugarcane, other agricultural crops, fallow land, wasteland, waterbody, Built-up-land were identified with help of ground truth sites marked on the topographical map and the visually interpreted FCC maps. The training class various classes of various crop covers and land use class in the form of mean, variance and covariance matrix were generated by masking homogeneous training site area on the FCC displayed on the computer.

Table 2 Classes identified from visual interpretation.

Level I	Level II
Agriculture	Sugarcane other Agriculture
Water body	River Reservoir
Built-up-area	Settlement
Follow land	Fallow land
Wasteland	Wasteland

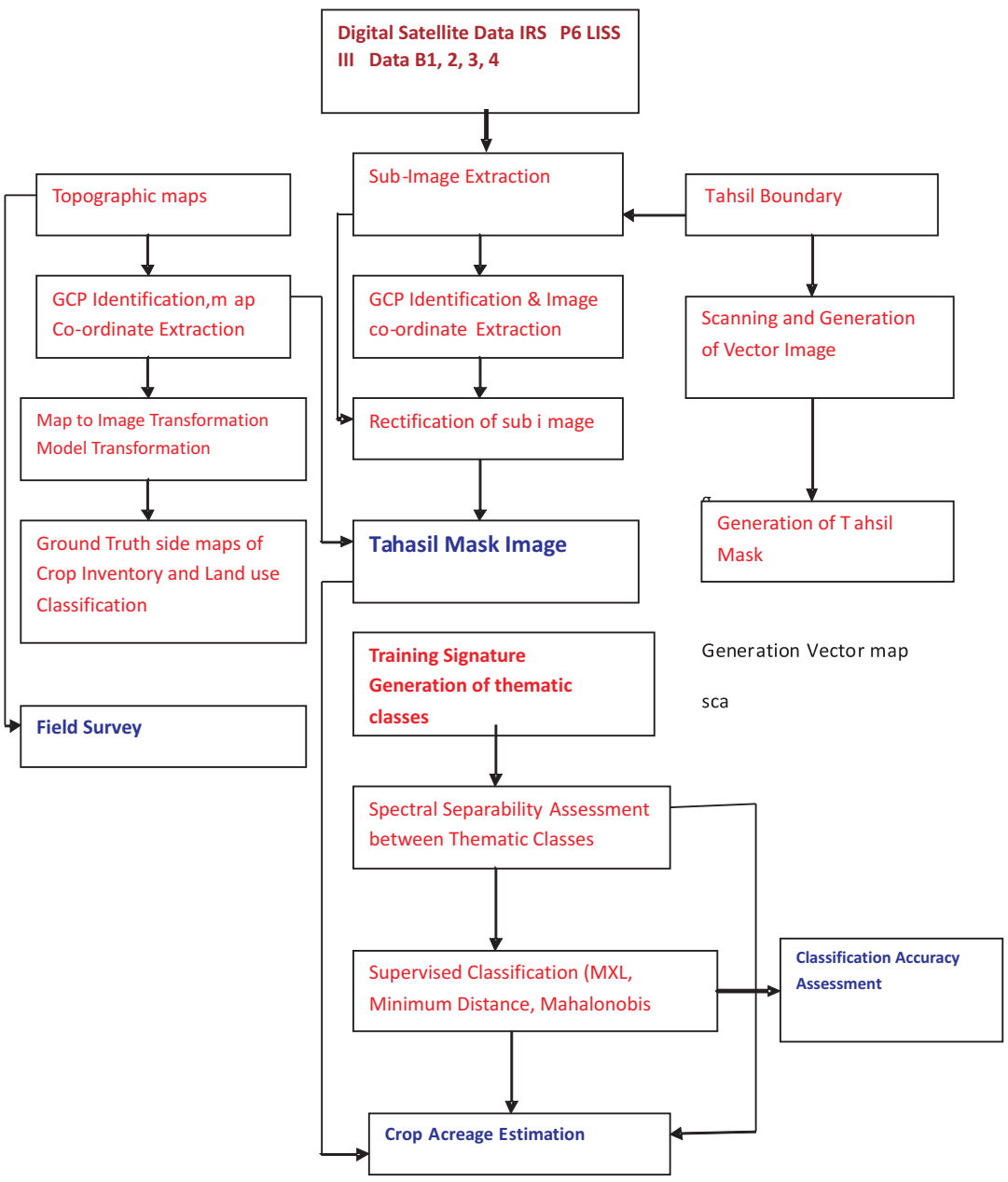
SUPERVISED CLASSIFICATION

Supervised classification can be defined normally as the process of the sample know identity to classify pixel of unknown identify. Sample of know identity are those pixels located within the training area. Pixel located within the training area called as the training sample used to guide the classification algorithm to assign specific spectral values to appropriate information class. He basic steps involved in a typical supervised classification procedure are following Training stage, Feature selection, Selection of appropriate classification algorithm Post classification smoothening, Accuracy assessment.

Decision Trees for Supervised learning (knowledge based): Decision trees represent a supervised approach to classification. A decision tree is a simple structure where non-terminal nodes represent tests on one or more attributes and terminal nodes reflect decision outcomes. J.R. Quinlan has popularized the decision tree approach with his research spanning more than 15 years. The latest public domain

implementation of Quinlan's model is C4.5. The Weka classifier package has its own version of C4.5 known as J48 (Witten IH and Frank E 2005)

Figure 2 Flowchart of Methodology



RESULTS AND DISCUSSION

Crop Concentration Index

Crop concentration means the variations in the concentration of any crop in tahsil in comparison to the state's concentration. Using this technique, concentration for sugarcane crop of the Maharashtra state. In Solapur district, Malshiras and Pandharpur are located in north-western part which has very high sugarcane concentration; it might be due to perennial rivers bhima and nira river flowing north part of tahsil along with their fertile black soils and their canal network. In contrast to that, north-eastern part of the

district, Barshi taluka is showing very low concentration index value; as it is far from any river as well as artificial reservoir dam and it is comparatively at higher altitude. Mohal, Sangole, Mangalwedha, Solapur North and Solapur South tehsils show moderate concentration index value for sugarcane as river Sina and Bhima flows through these tahsils and different irrigation facilities are available.

Table 3 Solapur district - Concentration index for Sugarcane

Taluka	Concentration Index	Class
Mangalvedha	1.34	Moderate
Sangola	2.35	High
Akklkot	0.80	Low
Solapur South	1.66	Moderate
Pandharpur	4.75	Very High
Solapur North	1.39	Moderate
Mohol	1.46	Moderate
Malshiras	7.34	Very High
Madha	0.69	Low
Karmala	0.87	Low
Barshi	0.39	Low

Crop Inventory

Crop Identification and Discrimination using remote sensed data is based in the fact Each Crop has unique spectral signature. Typical spectral reflectance of a crop show absorption due to pigment in visible region (0.62 -0.68um).High reflectance in show the near infrared region (0.7 to1um) is because of internal cellular structure of the leaves vigour of crop is manifest by ratio of absorption in red and the reflectance in the near infrared region (Dadhwal V.K.. et al., 2000).Crop Discrimination and acreage estimation using IRS P6 LISS III Data.

Spectral characteristics and spectral separation of crops: Identification and discrimination of existing crops during the winter (rabbi) season Sugarcane and other agriculture from other land use and land cover in the study area were carried out following digital supervised classification using FCC of the Band 3,2,1 as RGB of the IRS P6 LISS III data . The spectral characteristics of the crops along with other land cover presented in (figure 10), in the form of the mean gray values (DN) as a function of spectral band. All this classes of land use/land cover have distinct spectral responses in four band of IRS P6 LISS III data Barren land show highest reflectance in green and swir band. Sugarcane indicated higher reflectance in NIR and lower reflectance in red band compared to other agriculture crop. Sugarcane crop has high biomass; open cover canopy high chlorophyII content per unit area gives higher reflectance in NIR band and absorption RED and SWIR band. Other agriculture crop reflects low in NIR and high in red compared to sugarcane. Reflectance of other agriculture crops class appeared as dull red color in visual interpretation. Fallow land areas appeared dark gray color in the image. This class shows similar reflectance in NIR and red band. It is very difficult to distinguish between fallow and newly planted areas as they reflect same in NIR and red bands. Built up land and barren land classes were very difficult to discriminate as at some places these classes get mixed may be due to open bare rock and blank spaces between built up land reflects same.

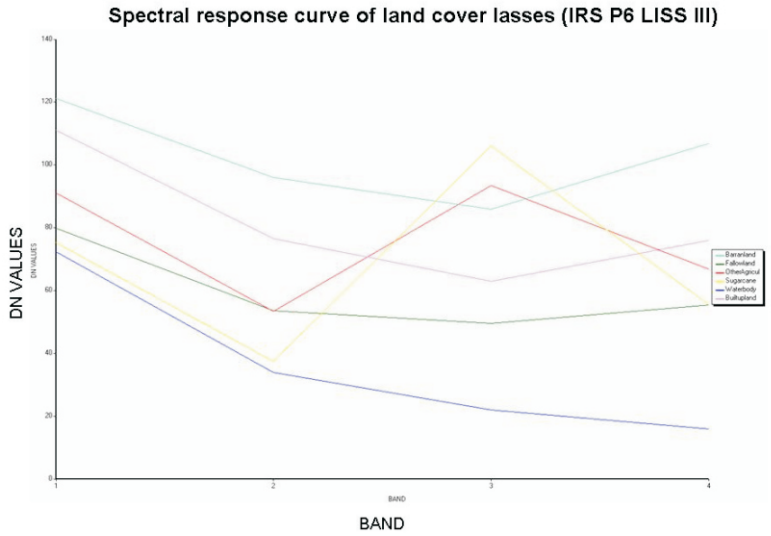


Figure 3 Spectral Seperability

Crop acreage Estimation

Crop and Other Land use Inventory of Solapur District Obtained through Complete Enumeration Digital Classification Technique of IRS P6 LISS III Data Performance of the various Classification approaches. To evaluate the result of the classification and to verify the degree to which the land cover maps derived would meet user's need, classification accuracy assessment was done through machine-assisted procedure. Accuracy assessment is based on spectral analysis of the digital data. The derivation of accuracy figures are based on the following definition

Supervised (Traditional) Classification Approaches: Various Traditional classifications algorithms are used to assign an unknown pixel to one the classes. Training site know pixel classifier unknown pixel. In this study, among the most frequently used classification algorithms, Maximum Likelihood and Mahalonobis distance were used (George Joseph 2008). Six thematic classes were identified based on the supervised classification scheme for IRS-P6 LISS III using above mentioned classification algorithms rectified digital data was classified. The classified output by MXL and Mahalonobis methods are shown. The overall accuracy of the classified image as shown in the table the MXL. Derivable class with original 4 bands like NDVI and Slope were also taken and classification was carried out but gave extremely low results. Overall accuracy for Mahalonobis is highest in traditional classifiers as well as machine learning classifiers i.e. 95%. And it is lowest for MXL classifier i.e. 86%. MXL with NDVI and raw bands were also taken for analysis, but due to its accuracy getting lower than 80% it was not considered for further analysis.

Table 4 Accuracy table for different classification techniques

Thematic Classes	**Maximum Likelihood**		**Mahalonobis distance**	
	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy
Sugar cane	94.40%	97.10%	97.50%	97.50%
Other Agriculture	84.40%	77.10%	97.50%	97.50%
Water body	100%	94.30%	97.60%	100%
Built-up land	100%	45.71%	100%	77.50%
Fallow land	66.70%	97.30%	100%	97.60%
Barren land	80%	91.40%	81.6	100%
Overall Accuracy	86.12%		95.00%	
Overall Kappa Statistics	0.8382		0.94	

	4-Layer Texture		8-Layer Texture		J48 4band		J48 4band + NDVI	
Thematic Classes	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy	Producer's Accuracy	User's Accuracy
Sugar cane	100.0%	91.4%	100.0%	97.1%	93.3%	80.0%	80.5%	91.7%
Other Agriculture	100.0%	91.4%	84.6%	94.3%	71.8%	80.0%	91.7%	91.7%
Water body	100.0%	100.0%	97.2%	100.0%	100.0%	91.3%	100.0%	100.0%
Built-up land	100.0%	85.7%	100.0%	62.8%	96.5%	80.0%	100.0%	66.7%
Fallow land	100.0%	97.1%	77.3%	97.1%	76.7%	94.3%	80.9%	94.4%
Barren land	97.1%	94.3%	100.0%	88.6%	89.5%	97.1%	94.6%	97.2%
Overall Accuracy	94.29%		91.43%		87.76%		91.67%	
Overall Kappa Statistics	0.9335		0.9001		0.8571		0.9028	

Accuracy of crop area estimated versus reported by the statistical abstracts for Solapur district and verified with district agricultural office is given in table Among the three Supervised classification (traditional techniques) i.e. MXL and Mahalonobis algorithms, MXL gave higher accuracy (87%) in sugarcane class based on reported area classification overall accuracy 86% and kappa statistic 0.83. Mahalonobis give 83% accurate area

Table 5 Reported and classification area

Classes	Reported Area in (ha)	MXL %	Mahalonobis %
Sugarcane	154530	87.36	83.75
Agriculture	434313	97.77	100.79
Barranland	223423	106.17	97.26
Fallow land	486845	99.34	96.24
Built-up-and	236987	83.54	95.42
Water body	26567	94.37	91.87

Data mining algorithm (J48)

The knowledge based data mining algorithm (J48) was used. In this J48 algorithms have weka software selected training classes taken pixel value. In machine learning algorithms, more mixing of classes was observed in J48 for 4 raw bands and NDVI band. Bordering of 2 classes resulted in unclassified class as a result of mixing. It is more observed in built-up-land and barren land.

Figure 4 Result of the Data mining (J48 algorithm) machine base classification

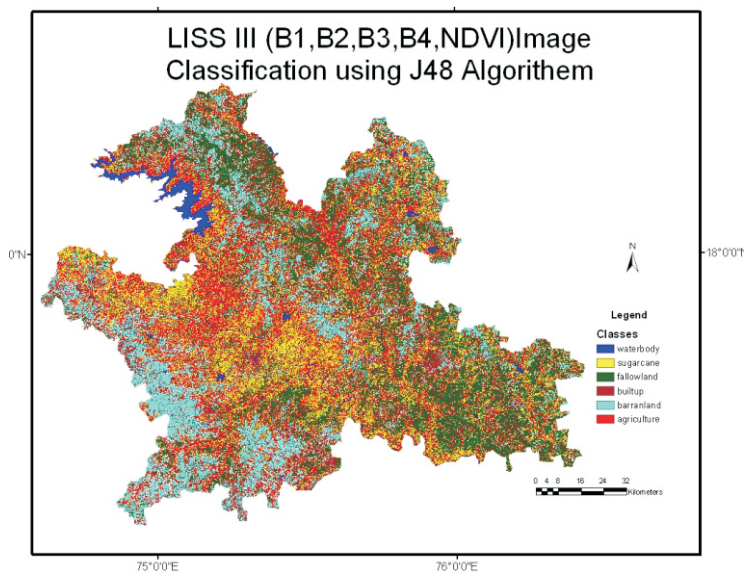


Table 6 Separability between training site signature.

No	Classification Algorithms	Euclidean Distance			Divergence Distance			Transformed Divergence Distance		
		MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG
1	MXL	136	28	70	3055	31	610	2000	1961	1997
2	MXL+NDVI	135	28	70	123923	82	15348	2000	2000	2000
3	Mahalonobis	136	28	70	3055	31	610	2000	1961	1997
4	4-layer Texture	169	39	103	2509	5	395	2000	918	1790
5	8-layer Texture	137	47	93	3184	64	1560	2000	1999	2000

The 4 layer texture based classification depicted very precise discrimination between sugarcane and other crops class. But eight layer texture classifications gave less sugarcane and extrapolated the other agricultural class. Both the texture based classification gave good results for water and fallow land. There was mixing observed between built-up-land and barren land for four layer texture.

Table 7 Comparison of reported versus estimated area for advanced algorithms.

Classes	Reported Area (ha)	8 layer texture %	4 layer texture %	J48-4 band %	J48- 4 band + NDVI %	ANN %
Sugarcane	154530	101.07	110.06	92.87	125.25	71.66
Agriculture	434313	98.75	75.08	76.64	80.50	87.36
Barranland	223423	108.13	147.46	64.58	77.33	155.51
Fallow land	486845	82.78	95.69	79.89	75.91	108.22
Built-up land	236987	107.74	82.40	80.93	107.79	76.05
Water-body	26567	84.24	77.59	115.67	105.64	75.85

In all the advanced algorithms, except ANN, all other techniques were able to precisely discriminate between Sugarcane and other agriculture. And all these machine learning techniques were

giving more or less accurate areas for all classes. Of all J48 with 4 raw band and NDVI band gave better results compared to J48 and ANN. Texture base classification gave good results for sugarcane in both the techniques. ANN gave extrapolated results for barren and fallow land and other classes were very low when 1 hidden layer is given for analysis. It gave mixed classification when given 2 hidden layers.

SUMMARY AND CONCLUSIONS

In order to assess crop acreage estimation in mixed cropping region. It is essential to use advanced techniques of digital image processing algorithm. Remote sensing is a powerful technique for surveying, mapping monitoring and can be put to best use if it is incorporated with GIS. Crop discrimination and area estimation can be possible by Digital Image Processing Classification Algorithms.

CONCLUSIONS

Crop concentration values for Malshiras and Pandharpur talukas are very high and Barshi taluka shows very low concentration for sugarcane crop. Spatio temporal trend shows significant increase in 6 talukas out of 11 talukas of Solapur district.
In all traditional as well as advanced classifiers, Mahalonobis classification gave highest overall accuracy i.e. 95% and MXL resulted lowest accuracy of 86.1%.
In machine learning algorithms, more mixing of classes was observed in J48 for 4 raw bands and NDVI band.
ANN and J48 algorithm gave better results when compared with traditional algorithms.
Limitations:
The number of ground control points was inadequate to cover such a large extent of the area.
The results presented here are specific to the moderate resolution imagery and may or may not be applicable to other resolution data.
The results are also area specific and may or may not be applicable to other areas with same resolution image data.

Future Work: The present study deals with the use of various traditional classification algorithms and ancillary layers in addition to spectral bands. The future work may include advanced classification techniques like, Fuzzy logic based classification, Genetic classifiers, etc., which may help in improving the classification accuracies.

REFERENCES

Bezdek, J., Ehrlich, R., Full, W. (1984) FCM: *the fuzzy c-means clustering algorithm. Computers & Geosciences 10, pp. 91-203.*
Deoshali, V.(2000). *Application of Remote sensing and GIS for crop inventory in a mixed cropping system Karveer tahshil Kolhapur District, Maharashtra, Unpublished report, CSSTE-AP, IIRS*
Dadhwal, V.K. (2000). *Crop Assessment using remote sensing – Part II: Crop condition and yield assessment. Indian J. Agric. Economics, 55 (2), pp.55-67.*
Dadhaval, V.K., Singh P, Dutta, S. and Parihar, J.S., (2002) *Remote sensing based crop inventory: A review of Indian experience.Tropical Ecology, 43(1) pp.107-122.*
Dwivedi, R.S., T. Ravi, S., Venkataratnam, L., *The inventory and monitoring of eroded lands using remote sensing National Remote Sensing Agency, Balanagar, Hyderabad-500037, India.*
Eastman, J.R, (2001).*Idrisi 32 release 2, guides to GIS and Image processing two, Clark labs.*
Erdas Imagine Tour Guides and field guid, (2001) ERDAS Atlanta V8.5
Gonzalez, R. S., and Woods, R.E.,(1999)Digital image processing IInd Pearson Education
George Joseph 2008 *Fundamental of Remote sensing, Universities press (India) Private Limited*
Han, J., Kamber, M., (2006) *Data Mining: Concepts and Techniques, Second edition,Morgan Kaufmann.*
Kiema, J.B., (2002) *'Texture analysis and data fusion in the extraction of topographic objects from satellite imagery', International Journal of Remote Sensing, 23:4 pp.767 -776*
Kalpana, R., Natarajan, S., Mythili, S., Shekinah, D.E., and Krishnarajan, J.,(2003) *Remote Sensing for Crop Monitoring - A Review, Agric.Rev, 24(1), pp.31-39.*
Kashid, D.L, and Kashid, N.D., (2010) *Crop concentration in Sindhudurg district. A Geographic Anaysis.GeosciencesResearch, 1(2), pp.28-33.*
Lillesand, T.M., and Kiefer R.W., (1987) *Remote Sensing and Image Interpretation, John Wiley and Sons*
Majid Husain (2001), Systematic Agriculture Geography, Ravat Publication New Delhi, 3th edition

Murthy, C. S., Sai, M.V.R., Sesha, K., Bhanuja, V., and Roy, P. S. (2007)*Agricultural drought assessment at disaggregated level using AWiFS/WiFS data of Indian Remote Sensing satellites',Geocarto International, 22(2), pp.127- 140*

Sárközy (1994) *The GIS concept and the 3-dimensional modeling, Computers, Environment and Urban Systems, 18(2), pp.111-121.*

Venkataram, L., Ravi Shankar and Sudharshan, (2004). *Soil & Crops status, issues and prospects Remote Sensing application, NRSA Hyderabad*

Witten IH, Frank E. (2005).*Data mining: Practical Machine Learning Tools and Techniques. Second edition, 2005. Morgan Kaufmann.*

Yadav, I.S., Sreenivasarao, N.K., Reddy, B.M.C., and Rawal, R.D. (2002) *Acreage and production estimation of mango orchards using Indian Remote Sensing (IRS) satellite data. Scientia Horticulturae. 93, pp.105-123.*

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