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Early estimation of sugarcane area of Uttar Pradesh using remote sensing and ground truth

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ABSTRACT

Uttar Pradesh contributes largest acreage of sugarcane (more than 40 per cent) to the national crop acreage; hence an early estimate of the crop acreage becomes paramount importance which was done using AWiFS data. Multi-date data of Resourcesat-2 AWiFS from February to November 2012 and January to November, 2013 for the 27 districts of Uttar Pradesh (U.P) was used to develop the procedure for early estimation of sugarcane acreage. The districts selected were having an area greater than 10 thousand ha and contribute 98.7 per cent of the state sugarcane acreage. The ground truth was collected during July/August and October 2012-13.The classification accuracy *vis-a-vis* critical data set requirement and identification of ratoon and freshly planted crop was also attempted. Early estimation of sugarcane acreage during month of June can be made possible by using multi-date AWiFS data upto May in case of Uttar Pradesh. The estimated acreage was 18.1 lakh ha which were 30 per cent underestimated in comparison to crop acreage estimation using data upto Nov. 3, 2012 which was 26.1 lakh ha. The error in early estimation of the crops was reduced by about 50 per cent as the estimated crop acreage during May was19.5 lakh ha whereas using AWiFS data upto Nov. 3, 2013 was 22.6 lakh ha. Therefore, on the basis of model output for two years, early estimation in June showed under estimation of 22 percent compared to final estimate in November.

Key words: *Sugarcane*, Early estimation, Acreage, Remote sensing, Ground trothing

Sugarcane is one of the most important cash crop in India with annual direct & indirect contribution of Rs.75, 000 crore to the Exchequer. The advance estimates of area and yield rates of sugarcane crop assume prime importance as 5 crore farmers and their families are directly dependent on this crops. Final estimates of production based on complete enumeration of area and yield through crop cutting experiments become available much after the crops are actually harvested. However, the government requires advance estimates of production for taking various policy decisions relating to pricing, marketing, export/import, distribution, etc. Considering the genuine requirement of crop estimates much before the crops are harvested for various policy purposes, a time schedule of releasing the advance estimates has been evolved (Anonymous, 2014). These estimates of crops are prepared and released at four points of time during a year as enumerated below. The earlier advance estimates of both kharif and rabi seasons are firmed up/ validated with the information available with State Agricultural Statistical Authorities (SASAs), remote sensing data, available with Space Application Centre, Ahmadabad as well as the proceedings of CWWG (Anonymous, 2008). Estimating sugarcane biomass is difficult to achieve when working with highly variable spatial distributions of growing conditions. Accurate and up-to-date land cover change information is necessary to understand and assess the environmental consequences of such changes (Kumar *et al.,* 2012). Various methods are employed to estimate the sugarcane acreage. Multi-temporal remote sensing data makes possible for monitoring the crop growth during its lifecycle and also to get anticipated information to forecast harvest (Fernando Benvenuti *et al*., 2010). Morel *et al.* 2014 and Mulianga *et al*. 2013 reported that empirical relationship method with a growing season-integrated Normalized Difference Vegetation Index NDVI produces best results over

others methods. With the higher resolution the detailed information could be obtained (Dadhwal *et al*., 2002). Remote sensing based crop discrimination and area estimation including single date approach based on maximum likelihood classification as well as hierarchical classification has been developed for major wheat-rice burning districts of Haryana using multi-date Resource sat AWiFS & LISS-III data for the year 2010 (Manjunath, 2006; Yadav *et al*., 2013).While remote sensing has the capability of capturing such changes, extracting the change information from satellite data requires effective and automated change detection techniques (Thenkabail *et al*., 2007 & 2012;Velpuri *et al*., 2009; Ozdogan *et al*., 2009). Advantages with GIS is that a few number of ground truth points (control points located on ground that reveals the true features and materials, and can be used as calibration in RS and GIS) may be collected, and then the same data can be interpreted over large areas (Mandal *et al*., 2014). From the year 2013-14 onwards, State and District Level forecasts are being generated for Cotton, Sugarcane and rabi Sorghum while multi-date SAR (Synthetic Aperture Radar) data of Indian SAR satellite RISAT-1is used for Rice (*kharif & rabi*) and Jute, multi-date Resourcesat-2 AWiFS (Advanced Wide Field Sensor) data, with 56 m spatial resolution, are being used for other crops. LISS III data, with 23.5 m resolution, is being also used for district level assessments. Hence sugarcane area estimation using remote sensing is the basic intention of the current study.

MATERIALS AND METHODS

Study area

The study area is located between 23.5^{o} and 30.5^{o} N and 76.5 ^{o} to 84.5 ^{o} E bordered by the Indo gangetic plains. It covers about 24093 km^{2} geographical area. The study area located within nine state and international border Nepal. There are many rivers lies in the study area and they are mostly Himalayan River. The study area was divided in two physiographic, highly fertile the *Gangetic plain*and smaller southern hill plateau. Due to fertile land and availability of irrigation facilities it comprised to highly productive area in the world.

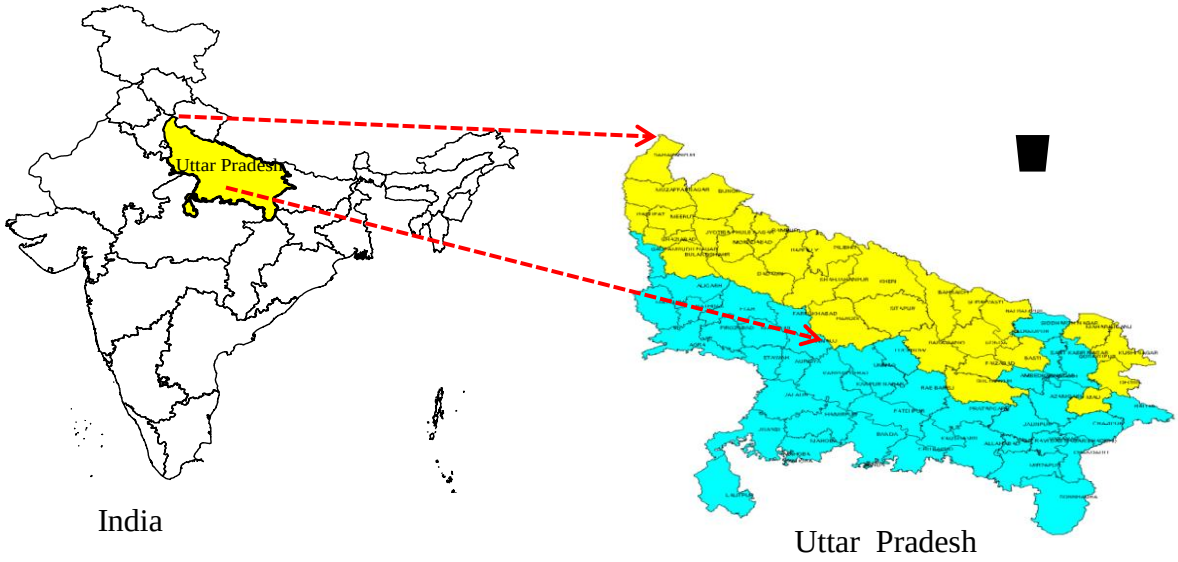

Fig.1: Study area or Location map

Database

Total 400 ground truth data was collected using the handheld GPS during the crop season in all the district of the study area. The satellite data of the same period consisted of 56 m spatial resolutions were used for the analysis (Table 1).

Table 1: Various dates of capturing the crop performance using Advance Wide Field Sensor (AWiFS) for estimating sugarcane yield under eastern and western agro climate of Uttar Pradesh

Forecast	Part	Dates
First Forecast	Eastern UP	Apr. 1, Apr. 15, Apr. 30, 2012-13
Second Forecast		Apr. 1, Apr. 15, Apr. 30, June 17, Oct.5, Oct.15, Oct.29, Nov.30, 2012-13
First Forecast	Western UP	Feb. 22, Mar. 4, Apr. 1,30, May 24, 28, 2012-13
Second Forecast		Feb. 22, Mar. 4, Apr. 1,30, May 24, 28, June 17, Oct. 5, 15, 29, 2012-13

Stratified sampling and collection of Multi-date AWiFS data was done as described in Fig.2. Tile-wise analysis was applied in 200x200 km of specific location. A stratified sampling scheme based on cumulative square root frequency distribution within segment size of 5x5 km using digital approach (Fig. 4) was implemented. The sampling fraction was kept at 20 per cent of the sub stratum. Ring crop season ground truth data was collected within selected sample segments.

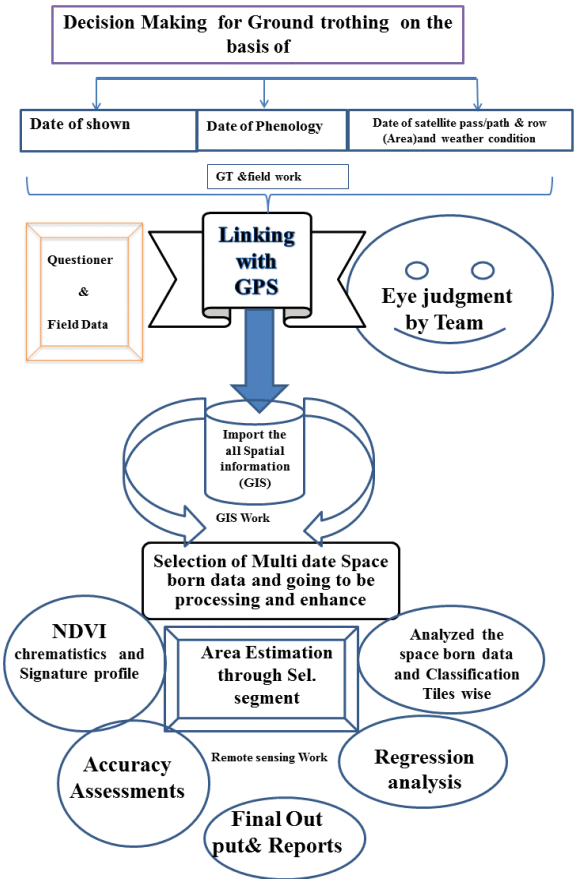

Fig. 2: Overview of Methodology

For early estimation of sugarcane acreage, the classification was based on the basis of NDVI profile from early growth stage of sugarcane using multi-date AWiFS data from February to November (Fig.6) and multi-date AWiFS data classification using K-mean clustering technique was used.

RESULTS AND DISCUSSIONS

Results revealed that using data up to May (2012) month, the total area under sugarcane was 18.1 lakhs ha which increased up to 26.1 lakhs ha by November 3, 2012. Therefore, early estimation in May 2012 showed under estimation of 30 per

cent compared to final estimate in November 2012. Similar result was obtained using stratification approach first forecast up to May 2013, area estimated was 22.3lakh (Fig.4).Using data up to May 2013, using stratification approach total area under sugarcane crop was 19.5 lakh ha. Area estimation using AWiFS data upto Nov. 3, 2013 the sugarcane acreage was 22.6 lakh ha. Therefore, early estimation in May 2013 showed under estimation of 14 per cent compared to final estimate in November 2013 (Table 3 and 4). Overall accuracy was found to be 90 per cent with sugarcane class accuracy of 91 per cent. The results of sample segments are shown in Table 1 for data used up to May 2013 and table 2 for data used up to November 2013. So about 14-15 per cent of extrapolation should be used to May estimate to arrive at final estimate which is expected in November

Table 2: Confusion matrix of blind sites in UP taken from validation ground truth

	Sugarcane	Rice	sorghum	Other	mentha-rice	popular	total	Ommission error
Sugarcane	11			1			12	91.67
Rice	1	7					8	87.5
sorghum			4				4	100
Other				4			4	100
Mentha-rice				1	3		4	75.0
popular						4	4	87.5
Total	12	7	4	6	3	4	36	90.28
commission error	91.67	100	100	66.67	100	91.67		

Overall accuracy: 90 percentSugarcane class accuracy: 91 percent

In the part of eastern Uttar Pradesh some farmers grow plantation (poplar) with sugarcane which create analytical problems to get the actual sugarcane signature. Differentiation of NDVI of sugarcane and ratoon should be done on tiles wise and variety wise to avoid the overlapping of the actual crop signature.

Table 3: Sugarcane acreage of UP using sampling approach and data up to May 2013

Strata	Nh	nh	%cover	Area ‘000 ha
D	1409	282	15.97	562.79
C	997	199	21.97	547.75
B	619	124	24.44	378.22
A	338	68	43.27	365.61
Total	3363	673		1854.37

Correction factor: 1.05263 correctedtotal: 1951.97

Table 4: Sugarcane acreage in UP using sampling approach and data upto November 2013

Strata	Nh	nh	%cover	Area ‘000 ha
D	1409	282	20.56	724.12
C	997	199	25.75	641.77
B	619	124	29.17	451.44
A	338	68	39.88	336.98
Total	3363	673		2154.30

Correction factor: 1.05263 correctedtotal: 2267.688

Table 5: Regional proportion of area and production of sugarcane in Uttar Pradesh

State	Meteorological Sub-division	Area ('000 ha)	Production ('000 tons)	Yield (t/ha)	Proportion to State (%)	
					Area	Production
Uttar Pradesh	10-East UP	817.92	41954.03	51.29	38.58	34.69
	11-West UP	1302.24	79002.77	60.67	61.42	65.31

Sugarcane Yield

As per the availability, district-wise area, production and yield data for sugarcane crop were collected from two sources i.e. from Indian Harvest, CMIE (Centre for Monitoring Indian Economy, Mumbai) for the period from 1987-88 to 2005-06 and from Department of Agriculture and Co-operation, New Delhi for the period from 1998-99 to 2010-11. The district-wise sugarcane area and production data were aggregated to meteorological sub-division level to develop the yield models at regional scales. The meteorological sub-division level yields were computed using these production divided by area. The proportion of area and production at meteorological sub-division level for the Uttar Pradesh were given in (Table 5).The weekly weather data available at meteorological sub-division level from India Meteorological Department (IMD) were converted to fortnightly form for the period from 1990 onwards. Considering the crop calendar and availability of data, the yield models were developed using data from March Ist fortnight to December IInd fortnight for the period from 1990 to 2010. It was observed that there was no trend in the yield data in any of the regions. The agro-meteorological yield models were developed based on normalized correlation weighted weather parameter indices. The yields predicted at meteorological sub-division level, using data from March Ist fortnight to December IInd fortnight for the year 2013, The Yield forecasts (2013-14) for Uttar Pradesh were 55.30 t/ha respectively.

Fig. 3: Sugarcane districts (yellow) Selected sample segments in UP

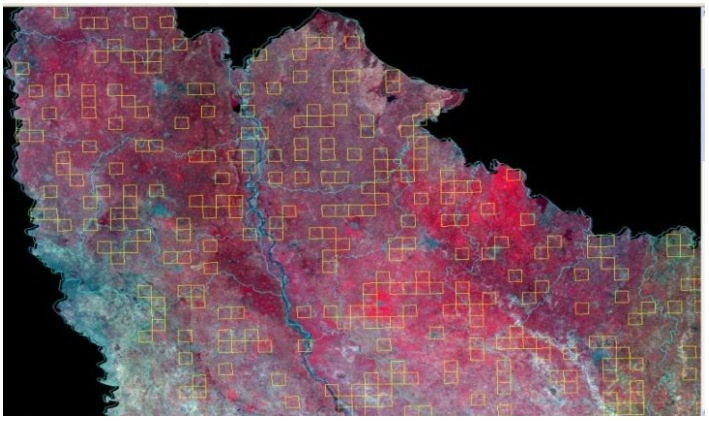

Fig. 4: AWiFSData (FCC) with sugarcane sample segments

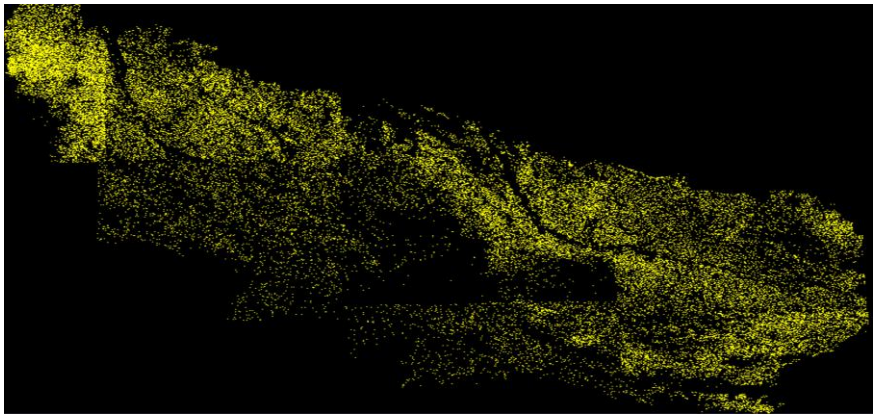

Fig. 5: Classified image under Sugarcane area and forecast area 2013

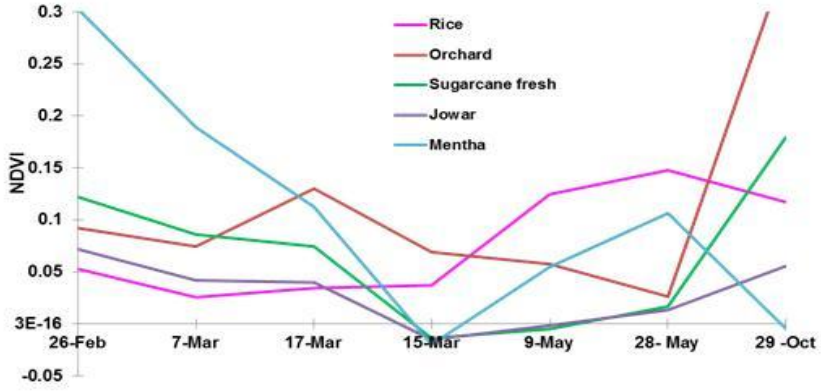

Fig.6: NDVI profile and signature value of multi date AWiFS data

CONCLUSION

The sugarcane grown area shifting the Mentha crops of some districts of Uttar Pradesh. Early estimate of sugarcane acreage in June can be made possible by using multi-date AWiFS data upto May in all the three states studied. UP contributes largest acreage contribution more than 40 per cent of national crop acreage. Here, early estimate could be possible which contribute about 86 per cent of the final acreage obtained in November. So an extrapolation factor of 14-15 percent can be added to May estimate to arrive at the final estimate which is carried out in November. Similarly in Maharashtra, about 10 per cent extrapolation factor can be added to the May estimate to arrive at the final estimate which is obtained in November.

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