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Area estimating of cotton crop in major districts of Haryana using satellite data

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Abstract
Satellite remote sensing based crop monitoring has the advantage of synoptic, spatial and temporal coverage of an area Recent advances on the resolutions (*i.e.* spectral, spatial, radiometric, and temporal) and availability of remote sensing imagery have allowed us timely collection of information on the growth and development stages of the cotton crop. The aim of this paper was to review the applicability of the remote sensing-based imagery for cotton area mapping in Major Cotton growing districts of Haryana, India. Landsat 8 and images for *kharif* season 2019 used for analysis. Growing season of Cotton (April to May) coincides with monsoon season. These images were available on (www.usgs.gov) download portal. In ERDAS unsupervised classification was performed using Iterative Self-Organizing Data Analysis Technique (ISODATA) algorithm. Using this algorithm, the analyst input the number of clusters desired and a confidence threshold. In Haryana, cotton crop found concentrated in western parts of state. Fatehabd, Jind and parts of adjoining districts of Rajasthan had vast area under cotton. Landsat data gives good quality interpretation because of high resolution.

Keywords: cotton, remote sensing, GIS, landsat

Introduction
Agriculture is backbone of Indian economy providing livelihood to 67% population and contributing approx. 35%to Gross National Product. So keeping track of agricultural information is essential, remote sensing systems with their synoptic viewing capability and variety of temporal and spatial resolution helps in the same. Remote sensing methods are superior to conventional methods since it is fast and economic. Remote sensing plays significant role in agriculture and crop management applications such as crop inventory, crop production forecasts, drought, flood damage assessment and crop classification. We have mainly emphasized on crop classification using multispectral temporal data. In crop classification geographic area, crop diversity, field size, crop phenology and soil condition plays important role. Remote sensing has been emerged as one of the cost effective and time saving technology in many fields of Science. It has been matured and become operational for natural resources survey, monitoring and management (Joseph. 2013) [2]. Specially in the field of agriculture, it is being implemented to identify the location specific features for further interventions. Identification of different crop coverage is a very important technique, which provides vital information regarding the type and extent of crop cultivated in a particular area. This information has immense potential in the planning for further cultivation activities and for optimal land use planning (Karetal, 2008). Many studies have been carried out to develop the land cover classification in this regard.

All of the classification methods give varying results that depend on factors such as the type of satellite data and the subject of the classification. Factors such as the selected spectral bands, ancillary data, and the nature of the study area also affect the classification performance (Foody and Arora, 1997) [3]. Abundant research has tested numerous algorithms for land cover classification and compared the results, focusing on specific cases (Friedle and Brodley, 1997; Anderson, *et al.*, 1976) [4, 1]. Unfortunately, these studies have tended to give fragmentary information, from the point of view that they do not offer guidelines for general users regarding which classification scheme is optimal for given data and class conditions. As the increasing availability of satellite data makes their utilization more popular, guidelines have become necessary for the selection of the correct and optimal data and a corresponding classification scheme. Unsupervised classification is based on the exploitation of the inherent tendency of different classes to form separate spectral clusters in the feature space. Unsupervised classification uses algorithms that search for natural groupings of the spectral properties of the pixels. The computer selects the class means and covariance matrix to be used in the classification. Once the data is classified into clusters each clusters is then associated with a physical category (B.L. Deekshatulu and George Joseph, 1991) [2]. The object-oriented classification method was proved effective for separating vegetation types defined by life form, area, or shape without using additional remote-sensing data sources with different resolutions or any ancillary data such as digital elevation models (Li and Shao, 2013) [7]. Considering the consistent relationship between the crop nutrients, wheat yield and the wheat spectral parameters, satellite remote sensing shows promise as a tool for assessing the variation in soil properties and yield in arable fields. The results suggest that management zone delineation using RS (Remote Sensing) data was reliable and feasible (Xiaoyu *et al.*, 2009). Recent satellite sensors (e.g., Resourcesat-1, Cartosat-2, IKONOS-II, and RISAT-2), along with improved image processing techniques integrated with terrain and other spatial data using a geographic information system, are enabling mapping at large scale (Singh *et al.*, 2010) [10]. Studies also revealed that using remote sensing data along with field survey and laboratory analysis for assessing the potentials and limitations of soil. Using the basic information on soil, climate and topography based on the matching exercise between the growth and production requirements of the crop, suitability of soils for groundnut, paddy and finger millet was assessed as per FAO (Food and Agricultural Organization) land evaluation. The soil suitability maps have also been prepared by using Arc GIS software (Sathish and Niranjana, 2010) [9].

Study Area

As per Planning Commission of India, the state comes under the 'VI' agro-climatic region (Trans-Gangetic plain region). It lies within the geographical coordinates from 27º39' N to 30º55' N latitudes and 74º27' E to 77º36' E longitudes (Fig.1). Total geographical area is 44212 Sq.km (1.37% of country's geographical area) and 85% of it is available for agricultural use. Rest of 15% is covered for non-agricultural purposes say built up, barren land or forests etc. The state has population of 25 million (2% of India's Population) as per census 2011. More than 70% of the population of Haryana is dependent on agricultural sector for their livelihood. Average annual rainfall of the state as a whole is 573 mm and below for arid/semi-arid regions. The net cropped area is 3.64 million hectares. About 86% of the area is arable, and of that 96% is cultivated. About 75% of the area is irrigated through tube wells and an extensive system of canals. Wheat is the major crop of state and grown in whole state in rabi season (October to March). In western ago climatic region of state (Fig. 1) mustard is also grown along with wheat. For rabi crops, the ground is prepared by the end of October or the beginning of November and the crops are harvested by mid of March to May

In the present study, spatial extent of wheat crop was analyzed for Haryana State (India) by remote sensing data. Haryana state lies in north-east agro-climatic zone of the country and humid to semi-arid type climatic conditions. Rainfall is very high in the eastern part compare to western part. The present research resulted that about 7.75 geographical areas of the state remains under wheat crop cultivation and it is grown more or less in all parts of state. The density of cotton sown area was found in north eastern parts of district.

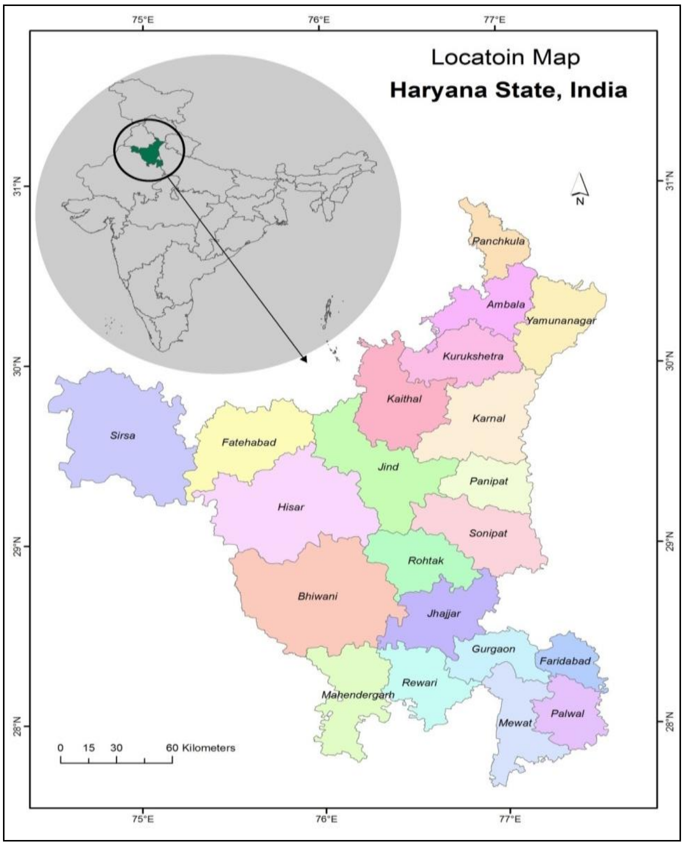


Fig 1: District map of Haryana

Data and Methodology

A study was carried out on Cotton crop area estimation using remote sensing and GIS techniques. India the Landsat 8 data (free source) scene acquired from Landsat site was used for analysis. Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9 (Table 1). The resolution for Band 8 (panchromatic) is 15 meters. Thermal bands 10 and 11 are useful in providing more accurate surface temperatures and are collected at 100 meters. Approximate scene size is 170 km north-south by 183 km east-west (www.usgs.gov). Multispectral images (band 2-7) were extracted from scenes for classification. Details of Landsat 8 scene are given in table 1. Landsat OLI records data in different bandwidths. These bandwidths are broken down into portions of the visible, NIR and SWIR infrared regions of the electromagnetic spectrum. From these various bandwidths, a great deal of information about the land cover can be displayed and analyzed. Haryana state falls under 147 - 148 paths and 39 - 40 rows.

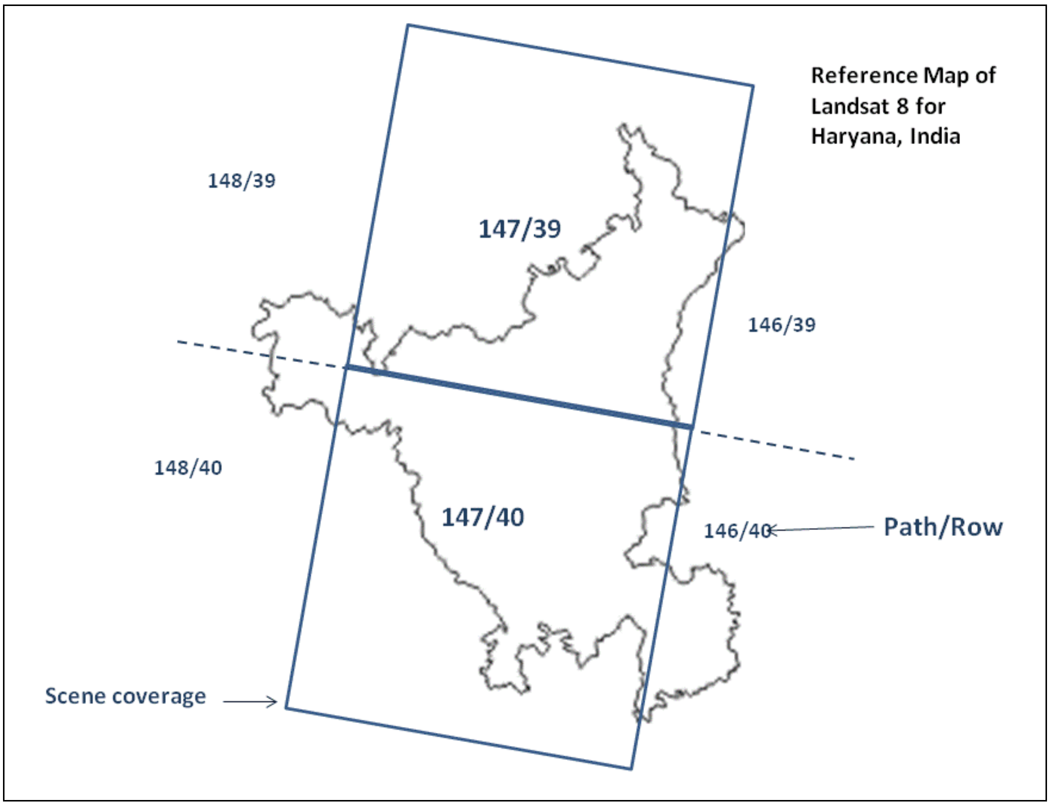
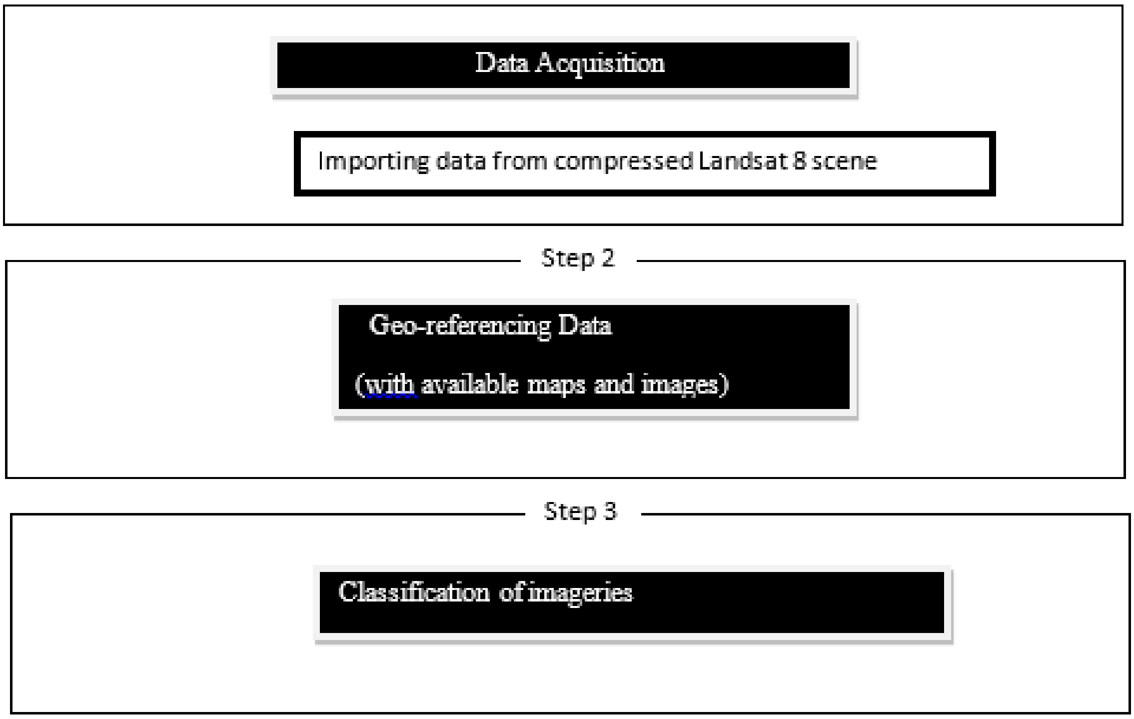


Fig 2: Reference map of Landsat 8 for Haryana

Step by step methodology starting from importing of data to classification is presented in following flow chart (Fig. 3).



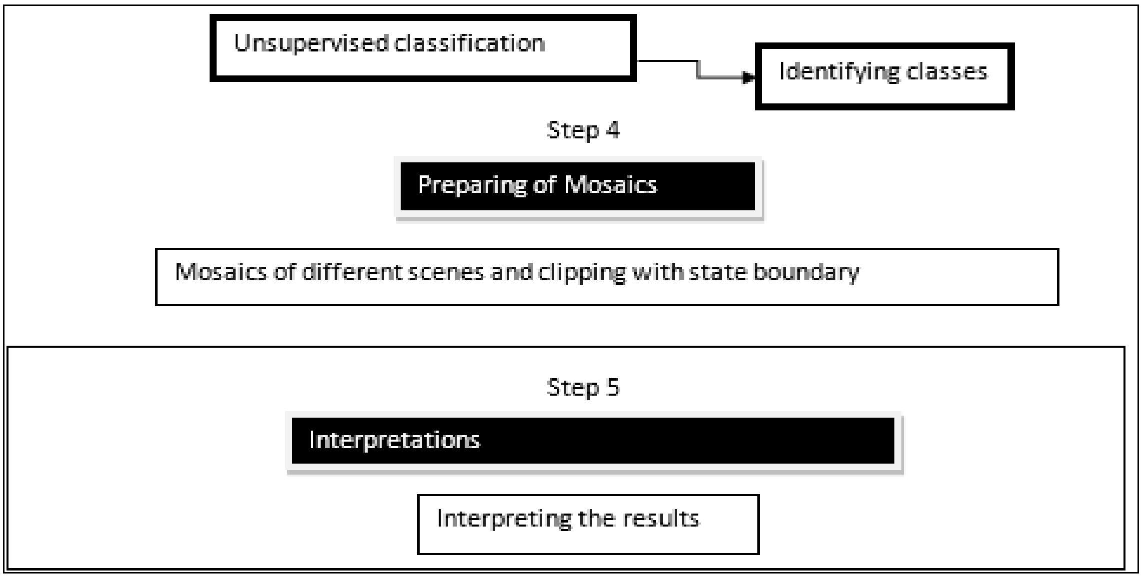


Fig 3: Flow chart for methodology

Digital image analysis was carry out in Erdas imagine and Arc GIS software, the Geotiff data was import to Erdas imagine format. Best cloud-free Landsat were selected for analysis and study area extracted. Landsat operates in 8 multispectral bands. These multispectral regions can bring more information that can differentiate in crops. In SWIR region, better crop discrimination using band 5 (1.55µ-1.75µ) in comparison to TM band 7 (2.08 µ -2.34µ) was observed. The SWIR is particularly significant in the vegetation canopy cover. Inclusion of SWIR band increases the overall accuracy and increased in the accuracy of the specific crops. Cotton crop in September is discernible mostly in red tone on image. The unsupervised classification for single date data was carried out. This date was selected on the bases of the difference in reflection by different crops grown during the khrif season.

Results and Discussion

Unsupervised Classification

In a multispectral image, each pixel has a spectral signature determined by the Reflectance of that pixel in each of the spectral bands. Multispectral classification is an information extraction process that analyzes the spectral signatures and then assigns pixels to classes based on similar signatures (Sabins, 2007). For example, all of the pixels which represent an area of forested land on a TM image should have roughly the same spectral signature. Classification procedures attempt to group together such similar pixels.

This way, a layer can be generated with each land cover type represented by a different class. The detail of the classes depends on the spectral and spatial resolution characteristics of the imaging system. Landsat imagery is usually good for creating a general land cover classification map. Unsupervised classification is a method in which the computer searches for natural groupings of similar pixels called clusters (Jensen, 2009) [5].

In ERDAS unsupervised classification is performed using an algorithm called the Iterative Self-Organizing Data Analysis Technique (ISODATA). Using this algorithm, the analyst input the number of clusters desired and a confidence threshold. The computer or software, then builds clusters iteratively, meaning that with each new iteration, the clusters become more and more refined. The iterations stop when the confidence level (or a maximum number of iterations specified by the user) is reached (Jensen, 2009) [5]. For example, if the user wants 30 clusters at 95% confidence, the computer will iteratively build the clusters until it is 95% confident has attained the best distribution of pixels into 30 clusters. For identifying the classes, each class was highlighted at a time and then determines which of the land use it belonged to by interpreting the original multispectral image. Fig. 4, 5 and Fig. 6 present the Landsat scene 147,148-39, 46 of Haryana before and after classification, respectively. In addition to MSS, NDVI of the image was also prepared and compared with each class to identify vegetation. Then each class was given a color such as water as blue. Finally, the image was exported to map as shown below. To get the results for Haryana, an AOI layer was created in ERDAS and final classified image was cropped (subset) for Haryana Fig.3.

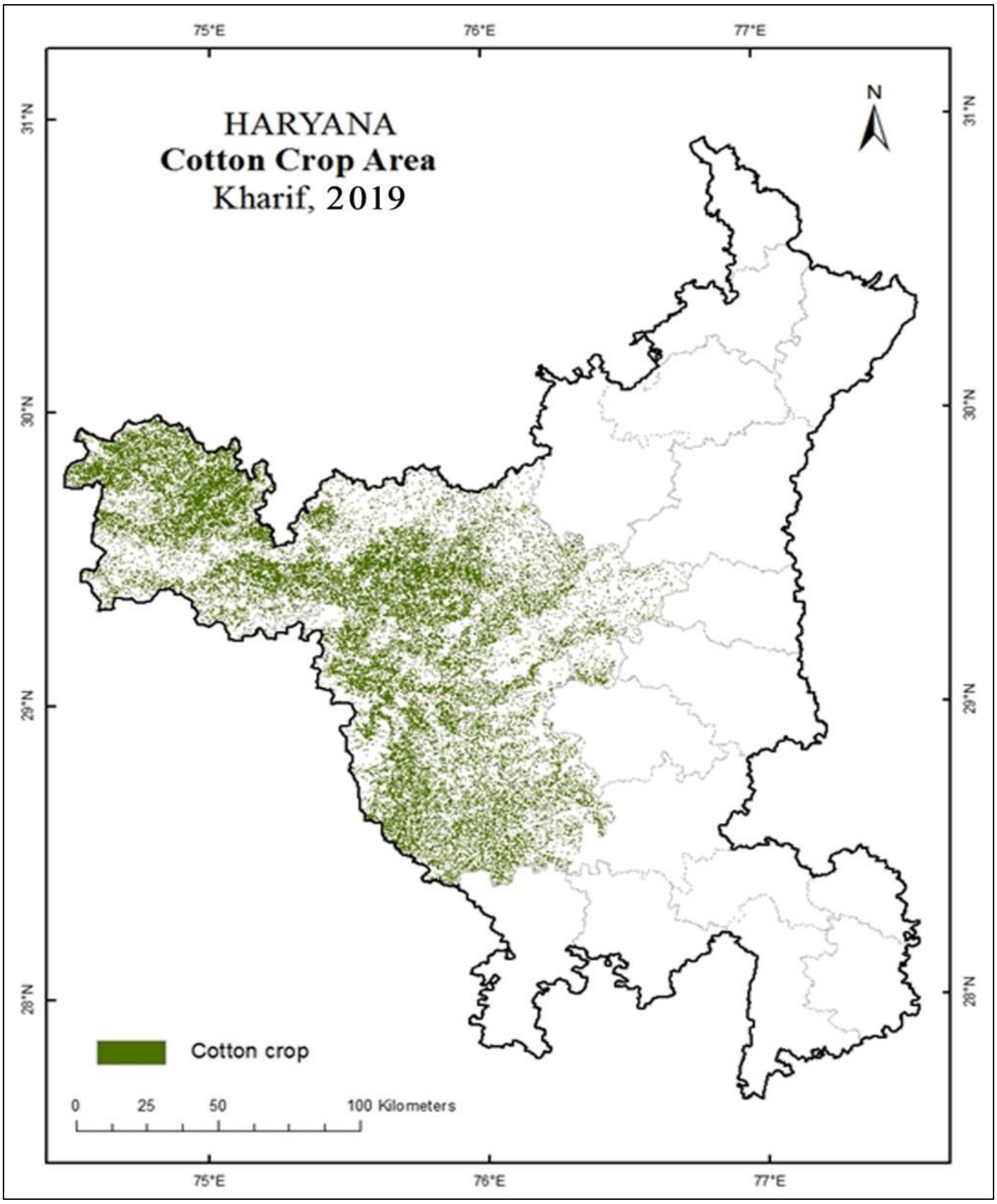


Fig 4: Cotton Crop area in major Districts of Haryana depicted satellite image.

The Landsat 8 data has resolution of 30 meters. Therefore each pixel cover ground area measuring 30x30 meter or 900 sq. meters or 0.09 hectare or.0009 sq. km. By adding the all-cotton classes (i.e. class cotton 1 to cotton 2) the total cotton pixel in the image were 8117375 cotton pixels x 0.0009= 7305.63sq. Km. Total classified area: 5194829 pixels x 0.0009= 4675.35 sq. km. This is 91.7% of total geographical area of Bhiwani district (5099 sq. kms???)

Conclusion

Cotton in Haryana is mostly concentration in the western part of the state mostly Sirsa Fatehabad, Jind, Hisar and Bhiwani and Charkhi Dadri Districts of Haryana. Rainfall is low but irrigation facility is better owing to which Cotton is grown in some parts of this zone. There has been a sharp shift in area under the Cotton crop.

Remote sensing technique is very helpful for spatial analysis of crops. In the present study it not only revealed the area under cotton crop in Haryana but also showed its distribution over the region. It further can help in finding out densely cropped cotton area and sparsely cropped area and many more analysis.

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