Identification, Discrimination and Classification of Cotton Crop by Using Multispectral imagery using complete enumeration approach over Haryana state

Om Pal[1], Hemraj[1]

[1]*Haryana Space Application Centre, Hisar, India*

---***---

Abstract - *The accurate and timely crop production forecast plays a pivotal role in management for taking the decision related to import, export etc. by the policy makers which may be very helpful for enhancing productivity, resource allocation, and sustainable land management. The crop production forecast comprises mainly crop area and yield assessment. In recent years, crop classification and area assessment using remote sensing and GIS techniques have gained prominence due to their non-invasive and cost-efficient nature. The use of multi-spectral data operating in the visible and near infrared region of electromagnetic spectrum is widely used for the crop area, health and condition assessment. This research paper presents an in-depth exploration of cotton crop classification and area estimation using single date multi-spectral imagery by employing complete enumeration approach in major cotton growing districts of Haryana. The study investigates the potential of optical data for accurate cotton crop identification and monitoring. The paper discusses the methodology, data acquisition, feature extraction, classification algorithms, and showcasing their applicability in different agricultural contexts. Through an extensive review of existing literature and empirical analysis, the study suggests the implication of supervised classification technique and the role of remote sensing and GIS based technology in enhancing agricultural crop management.*

Key Words: Agriculture, Cotton crop, Optical data, Supervised Classification, GIS, Area estimation

1. INTRODUCTION

Cotton, a vital cash crop, plays a crucial role in the global economy by providing raw material for the textile industry. Temporal monitoring the growth stages and crop health assessment of cotton crop is essential for optimizing yield and resource utilization. Traditional methods of crop assessment using field survey is labour-intensive and often may be lacking of accuracy due to human intervention. In recent years, remote sensing technologies coupled with advanced machine learning techniques have emerged as powerful tools for crop classification and monitoring. Optical data from satellite and drone-based sensors provide valuable information about the spectral reflectance of crops. These temporal data sources offer insights into various physiological and biochemical changes within the plants. Multispectral and hyperspectral data, as well as vegetation indices such as NDVI (Normalized Difference Vegetation Index), have been widely utilized in crop classification studies [1], [2].

Machine learning algorithms have shown remarkable success in analysing optical data for crop classification. Maximum Likelihood, Convolutional Neural Networks (CNNs), Random Forest, Support Vector Machines (SVMs), and k-Nearest Neighbors (k-NN) are commonly employed for feature extraction and classification [3], [4]. Accurate identification of cotton growth stages is crucial for timely crop assessment. Optical data can assist in distinguishing between stages such as planting, emergence, flowering, boll development, and senescence. Machine learning models trained on annotated datasets can accurately classify these stages [5]. Early detection of pest infestations and diseases is vital for preventing yield losses. Optical data can reveal stress indicators and anomalies in cotton fields. Integration of spectral data with machine learning algorithms enables the assessment of health conditions, facilitating targeted treatment [6].

Geographical information system and satellite-based imageries are helpful for identification and demarcation of cotton crop from other associated land cover features thus capable of generating the crop map which is used as basic input for further crop health and yield assessment. This study demonstrates the potential of using high resolution imagery of Sentinel-2 for the identification, discrimination and demarcation of cotton crop from other associated land cover classes.

2. STUDY AREA AND DATA

2.1 Study Area

The study area is situated in the extreme west and southern part of Haryana state consisting of major cotton growing districts viz., Bhiwani, Charkhi Dadri, Fatehabad, Hisar, Jind and Sirsa (**Figure 1**) and covering total geographical area around 18,278 Kilometre square. The study area lies between the 27 degree 37' to 30 degree 35' latitude and between 74 degree 28' to 77 degree 36'' longitudes. The mean elevation of the area is 190 to 210 above sea level with annual precipitation of 32-53 mm. The climate of study area is semiarid, sub-tropical and continental in monsoon. The soil texture of the study area varies from sand to sandy loam and silt clay loam along the ghaggar river belt. The study area has a diverse topography ranging from plains, alluvial bed of ghaggar belt to sand dunes. The study area comprises of types of unconsolidated alluvial deposits of Quaternary age geographical formations. The 70% of total geographical area of the study area is covered by the agricultural fields. The major crops grown in study area are Wheat, Mustard, Gram, Paddy, Cotton, Citrus, Guava and Indian Jujube. The study area covers almost 80 % of total cotton crop area of the entire state. The Cotton crop is grown during kharif season having paddy and bajra as the main associated crops. Do not use abbreviations in the title or heads unless they are unavoidable.

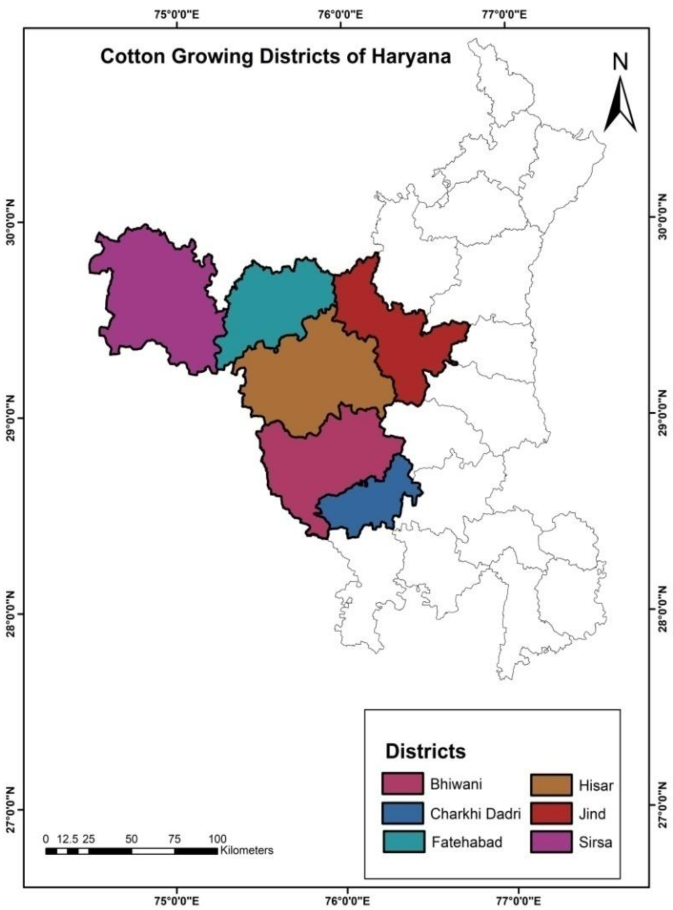

Figure 1: The major cotton growing districts of Haryana

2.2 Data Used

Sentinel-2A MSI data is used for the identification and discrimination of cotton crop in the major cotton growing districts of Haryana viz., Bhiwani, Charkhi Dadri, Fatehabad, Hisar, Jind and Sirsa. This data was downloaded from the Copernicus website (https://scihub.copernicus.eu/dhus/#/home) from September to October, 2022. Sentinel-2A having optical data at temporal resolution of 5 days with spatial ground resolution of 10 meter. Ground truth data was also used to identify the signature of cotton and associated land cover features for discriminating and classification.

3. METHODOLOGY

3.1 Selection of Optimum Data

As classification of a particular crop requires majorly its differentiation from associated crops. So differentiation of particular crop with high accuracy requires the selection of optimum data. The ancillary data related to cotton crop phenology and multi-date high resolution satellite data covering the all-main phenological stages of crop was used to select the optimum data for the discrimination and delineation of the cotton crop from other geo-spatial features. Multi-date Sentinel-2A data for the study area was also used to monitor the dynamics of vegetation areas like forest, paddy and cotton crop and to select the optimum bio-window for cotton crop identification. After the analysis of multi-temporal satellite data, it is observed the data acquired in the month of September was the most appropriate for identification and delineation of cotton crop from the other land cover classes and also to derive vegetation vigour variation within the cotton crop. The district boundary was overlaid on the image to extract the crop mask. The supervised classification technique was performed to delineate the cotton crop.

3.2 Image Stacking and Database

The Sentinel-2A data was downloaded. After layer stacking district boundary was overlaid for sub-setting the study area. The ground truth data recording the information of all land cover features was collected using GPS and the collected locations overlaid on satellite imagery were used to identify the signature of crops. **Figure 2** show the flow chart depicting the methodology.

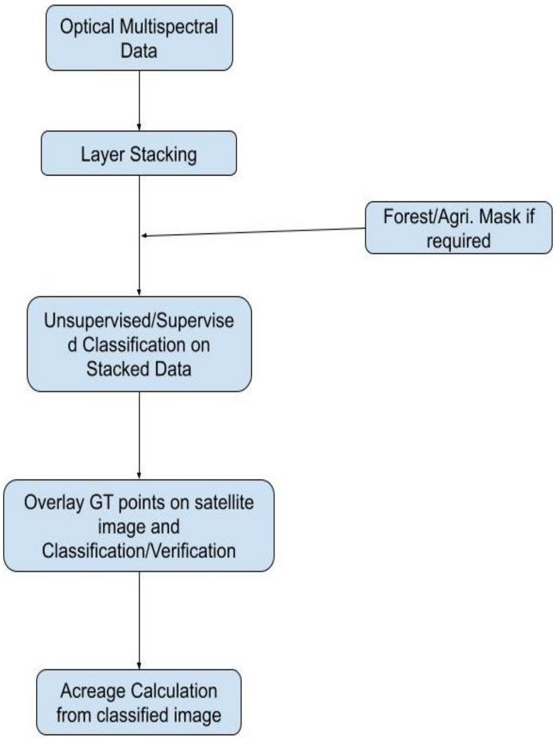

Figure 2: Methodology for crop classification and area assessment

4. RESULT AND DESCUSSION

As mentioned in the Methodology crop identification and classification was carried out using multi-spectral satellite imagery. The collected Ground truth data was used to identify the signature of cotton and associated crops and also for checking the accuracy of classified mask.

After analysing the crop pattern and crop phenology the satellite imagery acquired in the 1st fortnight of September was selected for the crop identification and classification. Firstly, unsupervised classification technique was carried out on the multi-spectral dataset to identify the land use classes and the agricultural crop mask was generated for the study area. Within the crop mask, the signature of the cotton and associated crops were identified using the ground truth sites and then supervised classification approach by selecting maximum likelihood classifier was followed for the classification of imagery. The spectral profile of the Cotton crop and associated land cover features is depicted in the **Figure 3**. The Cotton crop can easily be discriminated from the land cover classes like settlement, fallow land, water bodies etc as illustrated in the spectral profile depicted in the **Figure 3**.

In the study area Bajra and Paddy are the main associated crops. As the selected imagery coincides with the peak vegetative stage of the Cotton crop so as depicted in the fig, the cotton crop has high reflectance in the NIR region as compared to its associated crops. The bajra crop has low reflectance which further decreases in the imagery acquired in 2nd fortnight of September. On the other hand Paddy crop also has low reflectance (**Figure 3**) which further may increase slightly in the imagery acquired in the 2nd fortnight of September. The analysis shows that using the single date multispectral imagery the desired crop can easily be discriminated with its associated crops with acceptable accuracy.

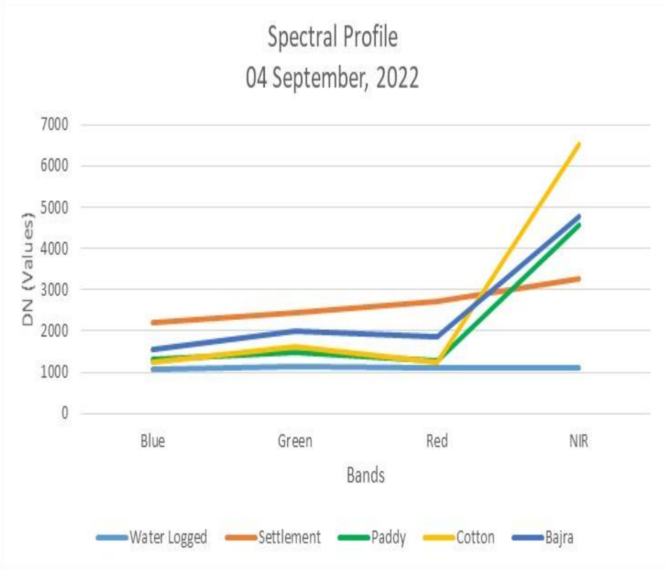

Figure 3: Mean DN values of different crops as seen in multi-spectral data

After classification district wise area under the cotton crop was estimated as depicted in table 1. The crop classified mask overlaid on the satellite imagery is depicted in **Figure 4**. The present study emphasis the potential of single date multispectral data for crop discrimination, classification and area estimation.

The district wise estimated cotton area is given in Table 1.

Table 1: District-wise Cotton Area of Year 2022-23

Sr. No.	District	Area (000' ha)
1	Bhiwani	67.09
2	Charkhi Dadri	25.32
3	Fatehabad	50.28
4	Hisar	105
5	Jind	49.56
6	Sirsa	130.2
Total (6 District)		427.45

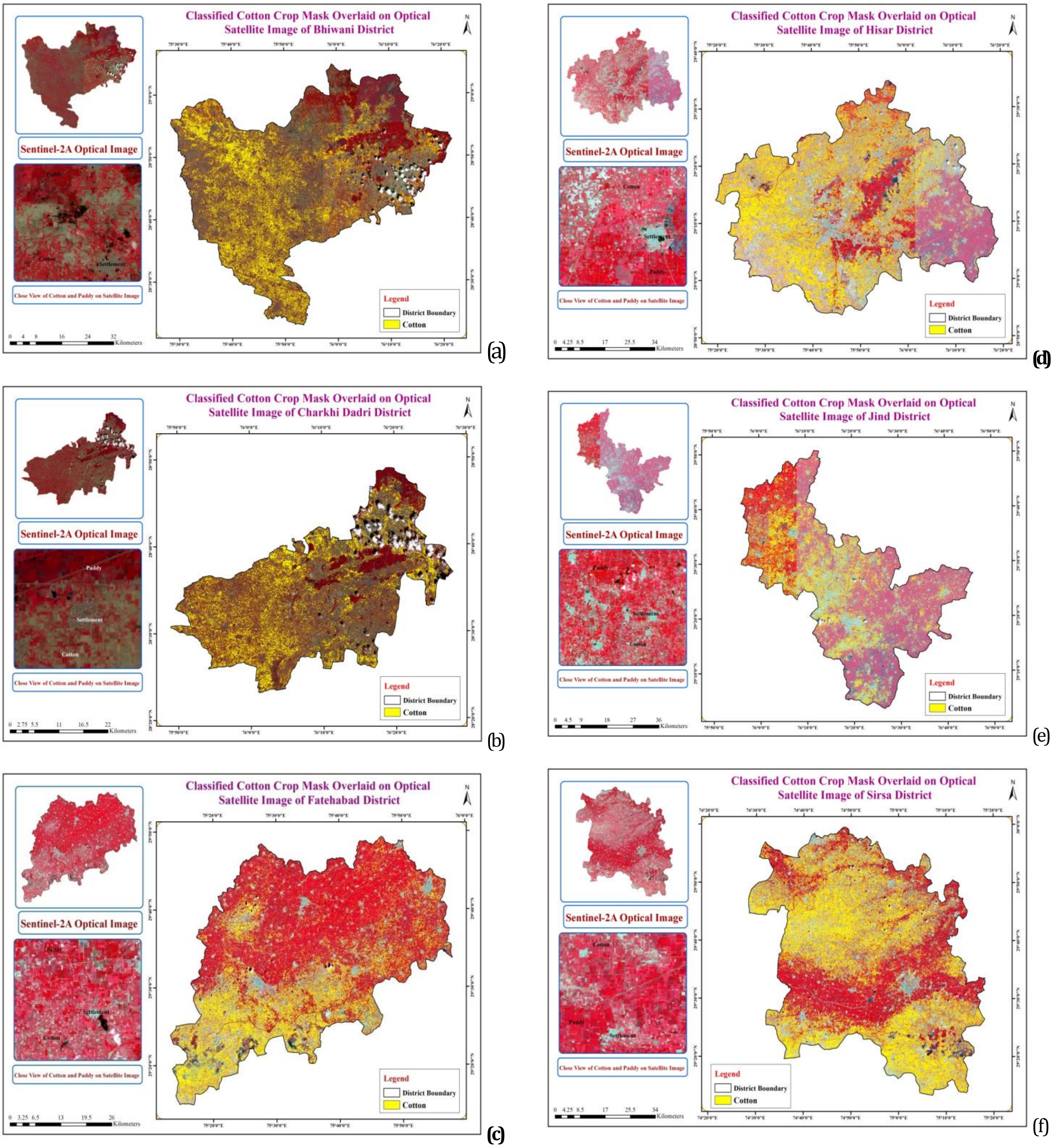

Figure 4: Cotton crop mask Overlaid on the satellite Imagery

5. CONCLUSIONS

The present study emphasis the potential of single date multi-spectral data for the crop identification and classification. As Each agricultural crop has the variations in its growing pattern and in phenological stages thus showing the wide variation in the reflectance values in the NIR and visible region. This characteristic generates distinct signature of each crop in the multi-spectral data. After analysing the crop phenology and reflectance in multi-spectral data the crops can easily be discriminated and classified. The results of the study indicates that the cotton crop area can easily be estimated using single date multispectral data for the major growing districts covering around 85% of the total cotton crop area of the state.

The generated crop map may be very helpful for making assessment regarding the crop condition and health by using temporal satellite data using various vegetation indices. The accurate crop mask will be very helpful for making the crop loss assessment in any natural weather calamities.

ACKNOWLEDGEMENT

The authors acknowledge European Space Agency (ESA) for satellite data and Director HARSAC for lab facility.

REFERENCES

[1] Chu, T., Chen, R., Landivar, J. A., Maeda, M. M., Yang, C., & Starek, M. J. (2016). Cotton growth modeling and assessment using unmanned aircraft system visual-band imagery. Journal of Applied Remote Sensing, 10(3), 036018-036018.

[2] Ma, Y., Zhang, Q., Yi, X., Ma, L., Zhang, L., Huang, C., ... & Lv, X. (2021). Estimation of cotton leaf area index (LAI) based on spectral transformation and vegetation index. Remote Sensing, 14(1), 136.

[3] Kussul, N., Lavreniuk, M., Skakun, S., & Shelestov, A. (2017). Deep learning classification of land cover and crop types using remote sensing data. IEEE Geoscience and Remote Sensing Letters, 14(5), 778-782.

[4] Li, M., Zang, S., Zhang, B., Li, S., & Wu, C. (2014). A review of remote sensing image classification techniques: The role of spatio-contextual information. European Journal of Remote Sensing, 47(1), 389-411.

[5] Jamuna, K. S., Karpagavalli, S., Vijaya, M. S., Revathi, P., Gokilavani, S., & Madhiya, E. (2010, June). Classification of seed cotton yield based on the growth stages of cotton crop using machine learning techniques. In 2010 International Conference on Advances in Computer Engineering (pp. 312-315). IEEE.

[6] Kamilaris, A., & Prenafeta-Boldú, F. X. (2018). Deep learning in agriculture: A survey. Computers and electronics in agriculture, 147, 70-90.