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Determining the Area of Rabi Crops through Digital Image Processing: A Spatial Analysis of District Sirsa

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ABSTRACT
The study focuses on the spatial estimation of Rabi crops area in Sirsa District, Haryana, India, using Digital Image Processing techniques with Sentinel-2A satellite data. Sirsa, known for its agricultural productivity, especially in wheat, mustard, and other crops, presents a valuable case for crop area estimation during the Rabi season. The analysis utilized high-resolution imagery from the Sentinel-2A satellite, specifically targeting the Blue, Green, Red, and Near Infrared (NIR) bands to create a band stack and generate a False Color Composite (FCC) for better differentiation of agricultural areas. The image processing workflow involved data preprocessing, subsetting, masking, and unsupervised classification to identify agricultural regions and exclude non-agricultural land. Ground truth data was integrated to validate the classification results, improving accuracy. The findings revealed that wheat occupies the largest share of the cultivated area, covering 60.9% of the total agricultural land, followed by mustard at 26.1%, with other crops making up 13%. The spatial data analysis highlights the dominance of wheat in Sirsa's Rabi cropping pattern, reflecting the region's climatic suitability and agricultural priorities. This study demonstrates the potential of remote sensing and GIS technologies in precise agricultural monitoring, offering valuable insights into crop area distribution and enabling better agricultural management and decision-making.

Keywords:-Rabi Crops**,** Area Estimation, Sentinel-2, Digital Image Processing (DIP), GIS

I. INTRODUCTION

Crop area estimation is a vital component of agricultural monitoring, playing a key role in food security, resource management, and policy-making. Accurate data on crop acreage is crucial for understanding agricultural productivity, planning, and ensuring effective distribution of resources. Traditional field-based methods for crop area estimation, while valuable, are often resource-intensive, time-consuming, and limited by spatial and temporal constraints. To overcome these challenges, remote sensing (RS) and geographic information system (GIS) technologies have emerged as powerful tools for efficient, large-scale crop monitoring (Bisht et al., 2019; Kumar et al., 2022).

Remote sensing technologies, including satellite systems such as Landsat, Sentinel, and MODIS, provide valuable insights into the condition and extent of agricultural areas. These systems use various spectral bands to capture information about vegetation health, land cover, and other environmental factors that are essential for crop area estimation (Siyal et al., 2015; Guntamukkala et al., 2022). For instance, the Normalized Difference Vegetation Index (NDVI), which measures vegetation health, has been widely used in crop monitoring, as it offers a reliable indicator of plant vigor (Husak et al., 2008). Additionally, the use of multi-temporal satellite data allows for the tracking of crop growth cycles and changes in land use over time, further enhancing the precision of crop area estimates (Singh et al., 2024; Sailaja et al., 2019).

Studies have demonstrated the effectiveness of combining remote sensing with GIS techniques for crop area estimation. For example, Ahmed et al. (2015) used remote sensing and GIS to estimate Boro paddy acreage in Assam, India, utilizing methods like NDVI, RVI, and supervised classification. The study found supervised classification to be the most accurate method for estimating crop areas, which was validated using GPS and statistical records. Similarly, Adawadkar et al. (2023) applied hybrid classification techniques combining K-means clustering and supervised classification for wheat and onion acreage estimation in North Maharashtra, showing that remote sensing methods could achieve high accuracy in estimating crop areas with minimal deviations from official statistics.

The integration of GIS further enhances the capabilities of remote sensing, enabling spatial analysis and visualization of crop data. Geographic information systems allow for the fusion of satellite imagery with other data sources, such as topography and climate variables, which provides a more comprehensive understanding of crop distribution patterns and environmental influences (Bingfang et al., 2003; Singh et al., 2019). This integration has proven particularly useful in regions with complex agricultural landscapes, where traditional field surveys may struggle to capture the spatial heterogeneity of crop distribution (Pradhan et al., 2001; Singh et al., 2019).

In recent years, advancements in machine learning, artificial intelligence, and deep learning have further improved the accuracy and efficiency of crop area estimation. These technologies are being applied to process large volumes of satellite data, refine classification algorithms, and enhance predictions related to crop yields and land use changes (Guntamukkala et al., 2022). Moreover, the use of high-resolution satellite imagery, such as Sentinel-1A and Sentinel-2A data, has significantly improved the precision of crop monitoring, allowing for detailed analysis at the regional and district levels (Kannan et al., 2021; Thirumeninathan et al., 2022).

This paper provides a detailed review of various studies that have employed remote sensing and GIS techniques for crop area estimation, highlighting their methodologies, findings, and potential for improving agricultural planning and food security. By synthesizing these efforts, the paper aims to underscore the importance of leveraging these technologies for sustainable agricultural practices and informed policy-making, particularly in the face of growing global food demand and environmental challenges. The integration of remote sensing and GIS holds the promise of transforming agricultural monitoring into a more efficient, scalable, and precise endeavor, which is essential for addressing the complex challenges of modern agriculture (Abdul-Jabbar et al., 2023).

STUDY AREA

Sirsa is located in the south-western part of Haryana, India. It is part of the Hisar division and lies close to the Punjab and Rajasthan borders **Latitude:** 29°14′ N to 29°59′ **Longitude:** 74°27′ E to 75°18′ E (Fig.1). The area of Sirsa district is approximately **4,277 square kilometers**.The districts bordering Sirsa are Punjab: Firozpur (in the state of Punjab) lies to the north-west of Sirsa.Moga (in the state of Punjab) is also located to the nth. Rajasthan: Ganganagar (in the state of Rajasthan) lies to the south-west of Sirsa.Churu (in the state of Rajasthan) is to the south of Sirsa. These neighboring districts in Punjab and Rajasthan, along with Sirsa, form a region where agricultural activities, especially wheat, cotton, and rice cultivation, play a significant role in the economy.

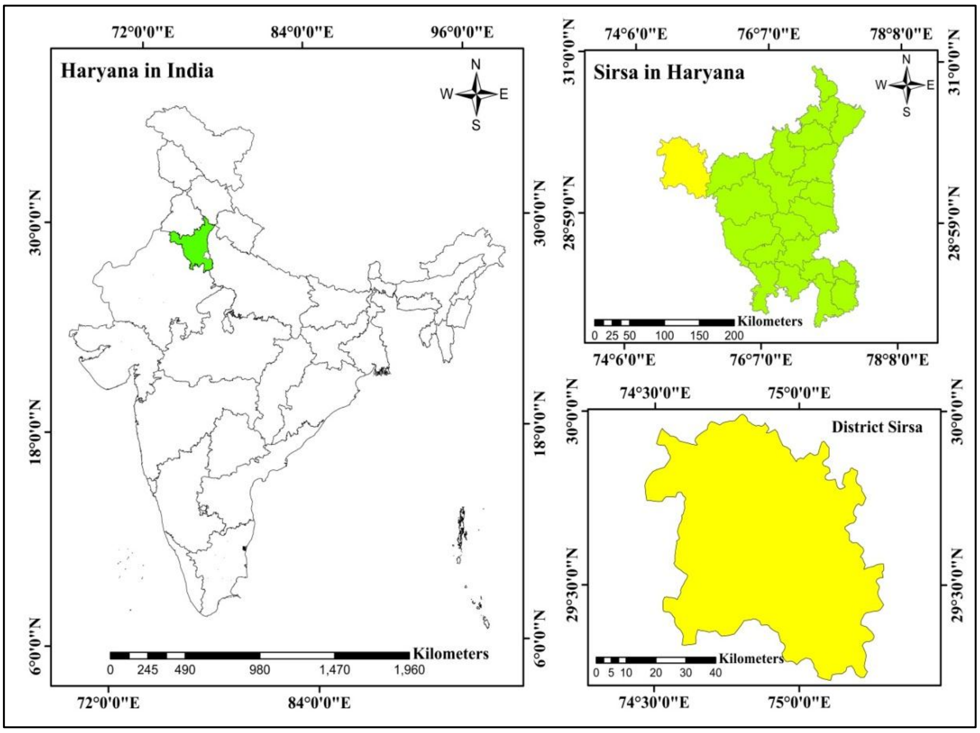

Fig.-1: Location Map of the Study Area

Geography & Soil:
Soil Type: The soil in Sirsa district is primarily sandy, loamy, and clayey, with high fertility in some areas. The region has alluvial soil suitable for growing various crops. The soil is rich in nutrients, making it ideal for agriculture.
Climate: Type Semi-arid climate.
Temperature: Summers are extremely hot, with temperatures soaring above 40°C. Winters are cooler, with temperatures dropping to around 5-6°C.
Seasons: The region experiences three main seasons: Summer (March to June): Hot and dry, Monsoon (July to September) Moderate rainfall, Winter (October to February) Cool and pleasant
Rainfall: Sirsa receives moderate rainfall, with an annual average of 350-500 mm. The monsoon season (July to September) is the primary period of rainfall, but droughts and irregular rainfall patterns are common.
Agricultural Activity: Sirsa is an agriculturally rich district, known for its fertile land and irrigation infrastructure, which support a wide range of crops. The major crops grown include: Wheat Predominantly grown in the Rabi (winter) season. Cotton A significant crop in the Kharif (summer) season, contributing to the region's economy.Rice Grown in areas with sufficient irrigation. Sugarcane, mustard, and barley are also cultivated.

II. MATERIAL AND METHODOLOGY:-

Satellite Data: Sentinel-2A is a satellite mission under the European Space Agency's (ESA) Copernicus program, specifically designed for Earth observation. Sentinel-2A is equipped with a MultiSpectral Instrument (MSI) that captures high-resolution optical imagery in 13 spectral bands, ranging from the visible to the shortwave infrared spectrum. This satellite operates in a sun-synchronous orbit, offering revisit times of 5 days at the equator, which is ideal for

Band	Wavelength Range (nm)	Resolution (m)	Swath (km)	Description
Band 1	443	60	290	Coastal Aerosol
Band 2	490	10	290	Blue (for water bodies, vegetation, soil analysis)
Band 3	560	10	290	Green (for vegetation, chlorophyll content)
Band 4	665	10	290	Red (for vegetation, soil)
Band 5	705	20	290	Red Edge (for vegetation, detecting chlorophyll)
Band 6	740	20	290	Red Edge (for vegetation, detecting chlorophyll)
Band 7	783	20	290	Red Edge (for vegetation, detecting chlorophyll)
Band 8	842	10	290	Near Infrared (NIR) (for vegetation, land cover)
Band 8A	865	20	290	Narrow Near Infrared (NIR)
Band 9	945	60	290	Water Vapour
Band 10	1375	60	290	Shortwave Infrared (SWIR)
Band 11	1610	20	290	Shortwave Infrared (SWIR)
Band 12	2190	20	290	Shortwave Infrared (SWIR)

METHODOLOGY:-

This flowchart describes the process for estimating crop area in District Sirsa during the Rabi season of 2024 using Sentinel-2A satellite data. of 16 feb 2024, downloaded it from Copernicus browser, then unzipped the zip file and open in Arc

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10.8 sofftware, then Satellite data from Sentinel-2A, specifically focusing on Blue,Green,Red and NIR bands (bands 2,3, 4, and 8), is used and creat **Band Stack**. Then FCC (false color Composite gave red to NIR, green to red, blue to gree.

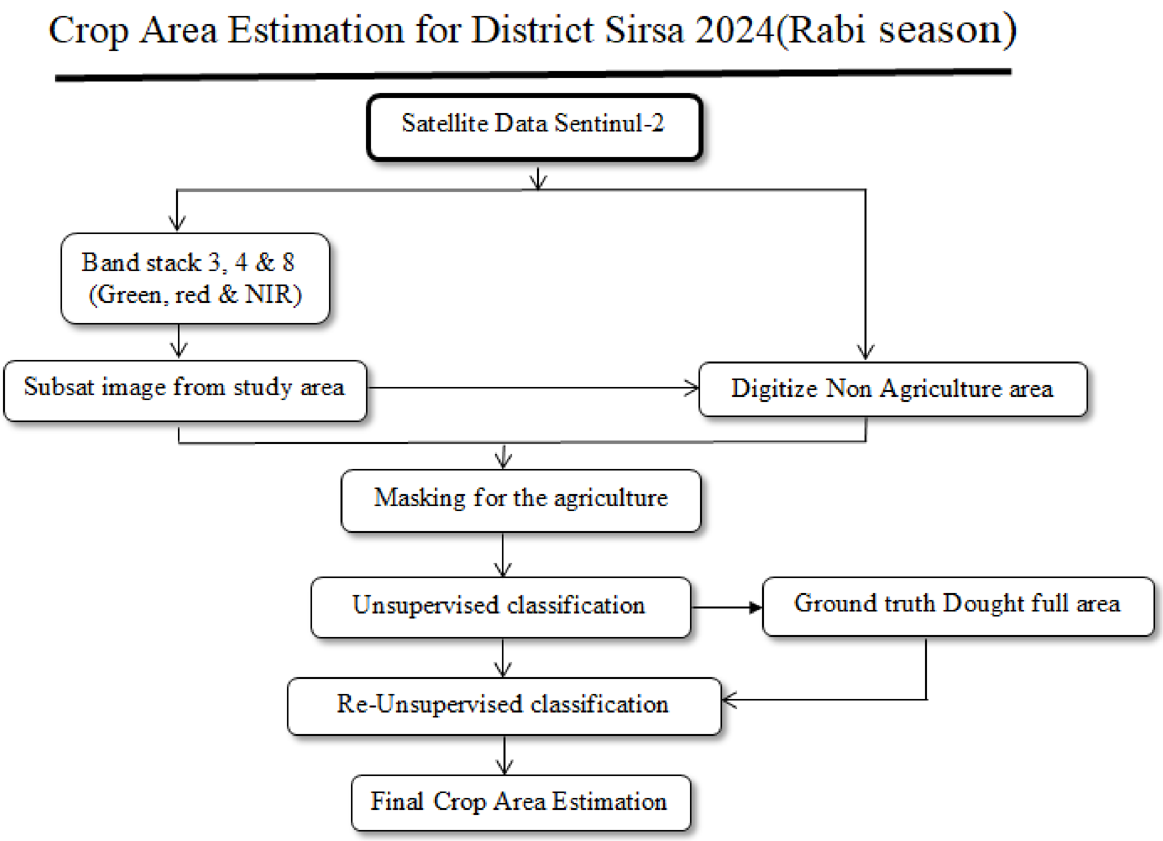

Fig.2: Methodology flow chart.

- **Subset Image**: This involves extracting a specific Area of Interest (AOI) from a larger satellite image or GIS dataset using tools like "Clip" or "Extract by Mask." It focuses the analysis on a smaller region, such as an administrative district, improving efficiency by reducing the dataset's size and narrowing the focus to the relevant area.
- **Digitizing Non-Agricultural Areas**: This step involves identifying and mapping non-agricultural regions (e.g., urban areas, water bodies, forests) using high-resolution satellite imagery, such as Sentinel-2A. These areas are digitized manually by tracing polygons around them in GIS. The digitized features are stored in a shapefile to create a non-agriculture layer, which can be used to mask out irrelevant areas in agricultural studies.
- **Masking Agricultural Areas**: In this process, agricultural areas are isolated from the rest of the land using satellite imagery and classification techniques like unsupervised classification. A binary mask is created, distinguishing agricultural regions (1) from non-agricultural ones (0). This mask is applied to the original data to retain only the agricultural areas for further analysis, such as crop area estimation or productivity monitoring.
- **Unsupervised Classification**: This technique automatically groups pixels in satellite images based on their spectral properties without prior knowledge of the data. The imagery is classified into clusters that represent different land cover types, such as crops or water. Ground truth data or visual interpretation is then used to label each cluster, resulting in a classified image that provides insights into land cover or vegetation types.
- **Ground Truth**: This involves collecting field data to validate satellite-based assessments, such as drought severity. The process includes defining the AOI, collecting real-world observations using GPS, mobile GIS apps, and drones, and interviewing local stakeholders. This field data helps enhance the accuracy and reliability of remote sensing analyses, such as drought monitoring.

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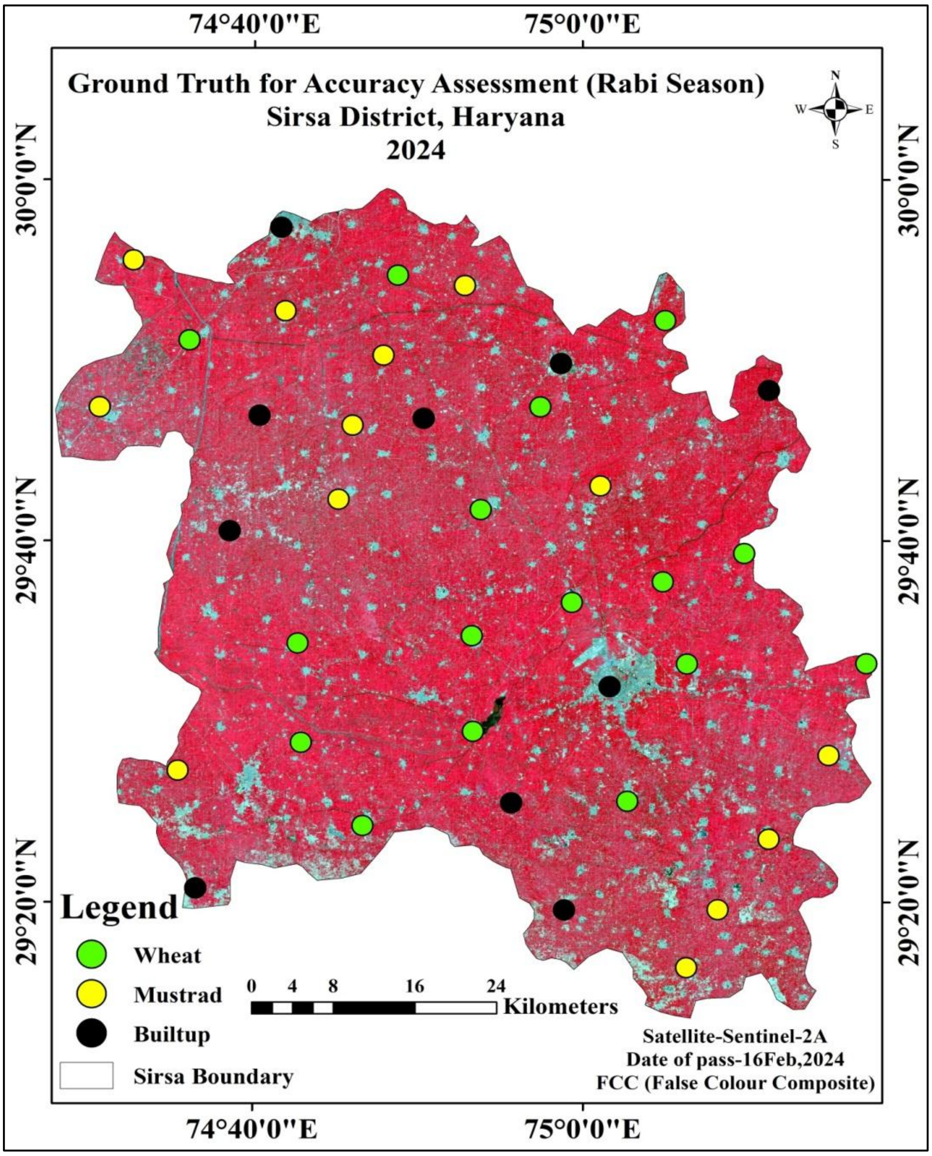

Fig.3: Ground Truth for Accuracy Assessment Map Rabi Season 2024 of Sirsa District Haryana.

Unsupervised Classification with Ground Truth Integration: Integrating ground truth data into unsupervised classification improves the accuracy and interpretability of land cover or drought assessments. The process starts with unsupervised algorithms like K-Means grouping pixels by spectral similarity. Ground truth data is then used to validate these clusters, assigning meaningful labels (e.g., "Severe Drought" or "Water Bodies"). Accuracy assessments are conducted using metrics like Overall Accuracy and User's Accuracy. Finally, the classification is refined using contextual knowledge and spatial pattern analysis, enhancing interpretation and providing actionable insights for decision-making.

III. RESULT AND DISCUSSION:

The crop area of major Rabi crops in Sirsa District was successfully estimated using Sentinel-2A satellite data and GIS technology. The study focused on key Rabi crops like wheat, mustard,etc.The satellite imagery, with a spatial resolution of 10 meters, provided detailed and accurate information for mapping and classification of crop areas. The results of this topic are displayed using maps and tables. The data is visually represented through maps, allowing for an easy understanding of spatial relationships. Additionally, detailed information is provided in the form of tables, offering a more structured and comprehensive presentation of the data.

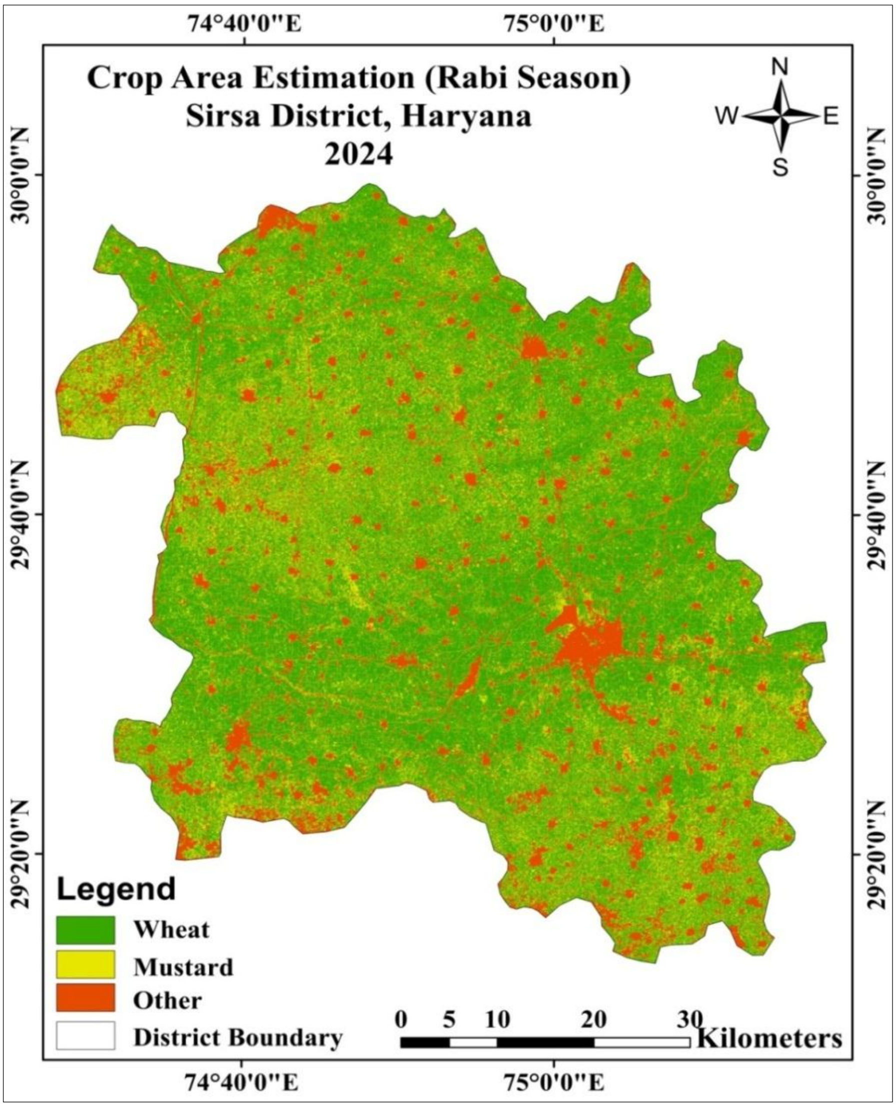

Fig.4: Crop Area Estimation Map of Rabi Season Sirsa District Haryana 2024.

The table presents a detailed analysis of the crop area distribution in Sirsa during the Rabi season of 2024, shedding light on the allocation of agricultural land among major crops. The total cultivated area is reported as 422,973.4 hectares.

Table-1: Estimated Area of Rabi Crops 2024 of Sirsa District Haryana.

Crop area Estimation of Sirsa 2024 (Rabi season)			
Sr. No.	**Crop name**	**Area in Hac.**	**Area in %**
1	Wheat	253379.8	60.9
2	Mustard	107431.0	26.1
3	Other	62162.6	13.0
Total		**422973.4**	**100.0**

which is divided into three main categories: Wheat, Mustard, and Other crops. Wheat dominates the agricultural landscape with 253,379.8 hectares under cultivation, accounting for a substantial 60.9% of the total area. This indicates that wheat is the staple crop and forms the backbone of Rabi season farming in Sirsa.

Following wheat, mustard emerges as the second most significant crop, covering 107,431.0 hectares, or 26.1% of the cultivated area. This highlights its importance as a major oilseed crop in the region, contributing significantly to the agricultural economy. The remaining 62,162.6 hectares, comprising 13% of the total area, are dedicated to other crops, which could include a mix of pulses, barley, or other minor crops. While these "other crops" occupy a smaller share of the total area, they may still play a vital role in diversifying the agricultural output of the region.

Overall, the data reflects the predominance of wheat cultivation in Sirsa during the Rabi season, supported by mustard as a key secondary crop. This distribution is indicative of the agricultural priorities and climatic suitability of the region, where wheat thrives as a winter crop, and mustard serves as an essential oilseed. The allocation of a smaller percentage to other crops suggests a limited diversification in cropping patterns, potentially hinting at the need for further exploration of sustainable and diverse farming practices. This table effectively provides insights into the cropping trends and agricultural dynamics of Sirsa in the Rabi season of 2024.

IV. CONCLUSION:

The study on crop area estimation for the 2024 Rabi season in Sirsa District using Sentinel-2A satellite data and GIS technology provides key insights into the region's agricultural landscape. By utilizing high-resolution imagery and geospatial tools, accurate estimates of major crops, particularly wheat (60.9% of cultivated area) and mustard (26.1%), were obtained. These results reflect local agricultural practices where wheat is the primary winter crop, and mustard is a key oilseed crop.

The integration of remote sensing with GIS proved effective in providing precise, spatially-explicit data for crop area estimation, critical for agricultural planning and resource management. The study employed Sentinel-2A imagery, unsupervised classification, and ground truthing for validation, making it applicable to similar agricultural regions. The research also highlights the potential of satellite imagery and GIS in enhancing crop monitoring, particularly in semi-arid areas like Sirsa, where traditional methods can be resource-heavy. The findings underscore the importance of technology in improving crop diversification and supporting sustainable agricultural practices, ultimately contributing to better resource allocation and food security.

REFERENCES:

[1]. Adawadkar, M., et al. (2023). Estimation of wheat and onion acreage in North Maharashtra during the 2020-21 Rabi season using Sentinel 2A satellite data.
[2]. Ahmed, R., et al. (2015). Estimating Boro paddy acreage in Nagaon district, Assam, using remote sensing and GIS techniques.
[3]. Bisht, S., et al. (2019). Application of Sentinel-2A satellite data for crop acreage estimation using NDVI and Iso-data clustering techniques.
[4]. Bingfang, W., et al. (2003). Crop area estimation in China using stratified sampling and remote sensing data.
[5]. Guntamukkala, S., et al. (2022). Remote sensing and GIS for crop yield estimation: Recent advances and future trends.
[6]. Husak, G. J., et al. (2008). Estimating cropped area using satellite data for food security in Central Ethiopia.
[7]. Kannan, S., et al. (2021). Estimating paddy area in Nagapattinam district, Tamil Nadu, using multi-temporal Sentinel-1A SAR data.
[8]. Kumar, H., et al. (2022). Estimating fodder crop area in West Bengal using Sentinel-2A/B data.
[9]. Pradhan, S., et al. (2001). Development of a GIS-based system for crop area estimation and forecasting.
[10]. Sailaja, B., et al. (2019). Rice area estimation at the mandal level in Nalgonda district using NDVI and unsupervised classification.
[11]. Singh, M., et al. (2019). Remote sensing techniques for estimating mustard crop acreage in Haryana, India.
[12]. Singh, S., et al. (2019). Crop acreage estimation using Landsat 8 imagery in Haryana, India.
[13]. Thirumeninathan, S., et al. (2022). Groundnut acreage estimation in Tamil Nadu using Sentinel-1A SAR data.
[14]. Abdul-Jabbar, T. S., et al. (2023). Remote sensing technologies for crop yield estimation and monitoring.