

Determining the Spatial Distribution of Rabi Crops through Remote Sensing and GIS Technology: Selected villages of Hisar (Haryana)

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Abstract

This study employs Sentinel-2A satellite imagery and GIS techniques to estimate the Rabi crop area in selected villages of Hisar, Haryana, for the 2024–25 season. The research focuses on wheat and mustard cultivation, utilizing high-resolution multispectral data and supervised classification methods. Ground truth data, collected from 25 locations using GPS and SW Maps, was used to validate the classification process. The results indicate that wheat is the predominant crop, covering 65.4% of the total cultivated area, primarily in regions with canal irrigation. Mustard, occupying 4.6% of the area, is more prevalent in water-scarce regions. The study highlights the impact of irrigation availability on crop distribution and demonstrates the effectiveness of remote sensing in agricultural monitoring. These findings provide crucial insights for policymakers to optimize agricultural resource management and improve food security in semi-arid regions.

Keywords: Rabi Crops, Remote Sensing, GIS, Spatial Distribution, Satellite Data.

I. Introduction

The introduction highlights the extensive use of remote sensing and GIS technologies in agricultural monitoring and crop area estimation. Researchers have particularly favored the high-resolution Sentinel-2 satellite imagery for its effectiveness in crop classification, especially for Rabi crops like wheat and mustard. Digital Image Processing (DIP) techniques, such as supervised and

unsupervised classification, and the integration of spectral indices like the Normalized Difference Vegetation Index (NDVI) and False Color Composite (FCC), have proven to enhance classification accuracy significantly. Ground truth data validation plays a crucial role in improving the reliability of these classification outputs. By integrating remote sensing approaches with ground truth data and advanced classification techniques, the accuracy and reliability of agricultural monitoring are greatly enhanced. This provides valuable insights for policymakers, aiding in efficient agricultural planning and resource management. The dominance of wheat as the primary Rabi crop in Northern India, especially in regions with favorable climatic conditions, is consistently highlighted across various studies. Overall, these methods support better decision-making for resource allocation and agricultural planning, contributing to sustainable agriculture and food security.

Study Area :- The selected study area is located in Hisar, Haryana. The total geographical area of the selected study region is 45 km². The selected Study area of Hisar district located in 29°2'0" to 29°6'0"N latitude and 75°42'0" to 75°48'0"E longitude. (Fig:1) This selected area Situated to the south direction of the Hisar city. The selected villages of Hisar (Harikot, Mangali Brahman, Dhani Jatan, Mangali Mohabat, Mangali Aklan, Mangali Jhara and Mangali Surtia) covering the major crops wheat and mustard growing zones have been chosen for the study.

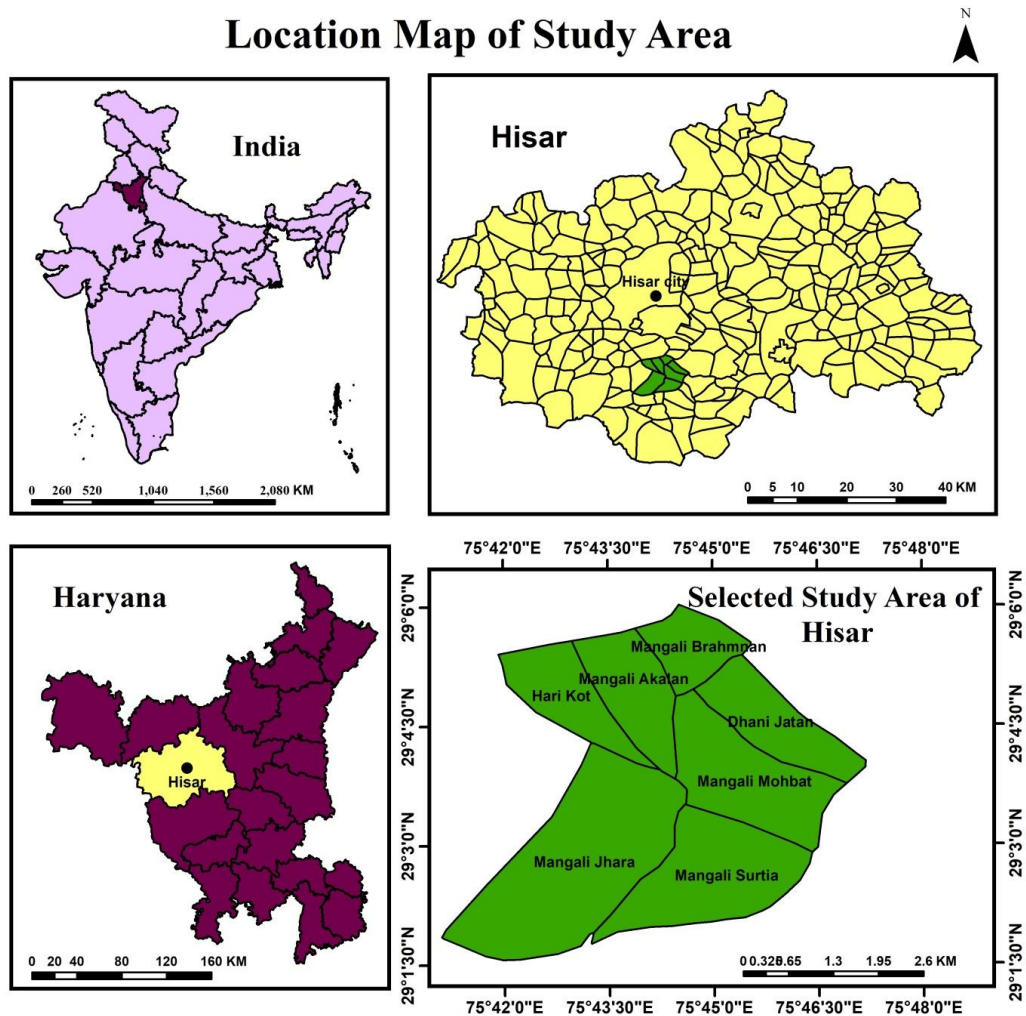


Fig.-1: Location Map of the Selected Study Area in Hisar District, Haryana

Climate, Temperature and Rainfall:

Hisar, located in the northern Indian state of Haryana, experiences a semi-arid climate.

The average annual temperature is around 25°C (77°F), but this varies significantly between seasons. Summers are intensely hot, with May and June being the peak months, often seeing temperatures soar above 40°C (104°F) and frequent heatwaves. In contrast, winters are relatively cool, with January being the coldest month, when nighttime temperatures can drop to around 5°C (41°F) or lower.

Rainfall is sparse and irregular, with most precipitation occurring during the monsoon season (July to September) and averaging between 300 and 400 mm annually. The stark contrast between scorching summers and milder winters highlights Hisar's semi-arid climate, making the region prone to droughts and heat stress during the hot months,

while winters remain relatively pleasant and manageable.

Soil Texture:

The soil type is primarily alluvial, with sandy, loamy, and clayey types. Sandy loam is the most common, offering good drainage but low water retention, requiring frequent irrigation. Loamy soil is more fertile, suitable for crops like wheat, mustard, Bajra, and cotton. Clayey soil, found in some areas, retains moisture but can cause waterlogging.

Irrigation and agriculture activity:

The region depends on irrigation for agriculture. The main irrigation sources in this area include the Western Yamuna Canal, tube wells, bore wells, and rainwater reservoirs. Farmers rely on groundwater extraction and modern techniques like drip and sprinkler irrigation to conserve water. Due to the

semi-arid climate and low rainfall, irrigation is crucial for sustaining agriculture.

In this area, agriculture is organized by three main seasons. In the Rabi season (October–March), major crops like wheat, mustard, barley are grown with irrigation due to low rainfall. The Kharif season (June–September) relies on monsoon rains, supplemented by irrigation, for crops such as bajra, cotton, and paddy. During the Zaid season (April–June), short-duration crops like vegetables and melons are cultivated using modern techniques like drip irrigation

II. Materials and Methodology

Data Collection:

Administrative Boundary:

The administrative district village boundary of the study area is obtained from the Survey of India.

Satellite Data collection:

The satellite data we used in this study is the Sentinel-2A 10 meter resolution blue, Green, Red and NIR bands image. Sentinel-2A launched on 23 June 2015, as part of the Copernicus Programme by ESA, provides high-resolution multispectral imagery for agriculture, land cover mapping, and environmental monitoring. It carries a Multispectral Instrument (MSI) with 13 spectral bands and spatial resolutions of 10m, 20m, and 60m. It used to visit locations every 10 days initially, but its revisit period improved to 5 days with Sentinel-2B in 2017.

Its data is freely available on platforms like Copernicus Open Access Hub (<https://browser.dataspace.copernicus.eu/>). It is widely used for crop monitoring, land mapping, and disaster management, and thus it is a valuable tool for GIS and remote sensing applications.

Ground Truth data collection:

In this study, we used primary Data. Ground truth data represent the precise geographic location of an earth feature in the global coordinate system. In this study, ground truth data were collected via Base map, Global Positioning System (GPS) device and the SW Maps mobile app to ensure accuracy.

From this study area, 25 ground truth points are collected for the data. These GT points are used by us as signatures of Rabi crops (wheat and Mustard). Data collection was done in selected study area, Hisar district, during Rabi season 2024–25. This is concurrent with the satellite imagery time period that has been acquired. The principal crops cultivated during the Rabi season in this region are mustard and wheat, which are typically marked between November and December and harvested between March and April. All cultivated Rabi crops were taken into account for acreage estimation in this study. The ground truth data gathered helps in validating remote sensing analysis and improving crop estimation accuracy.

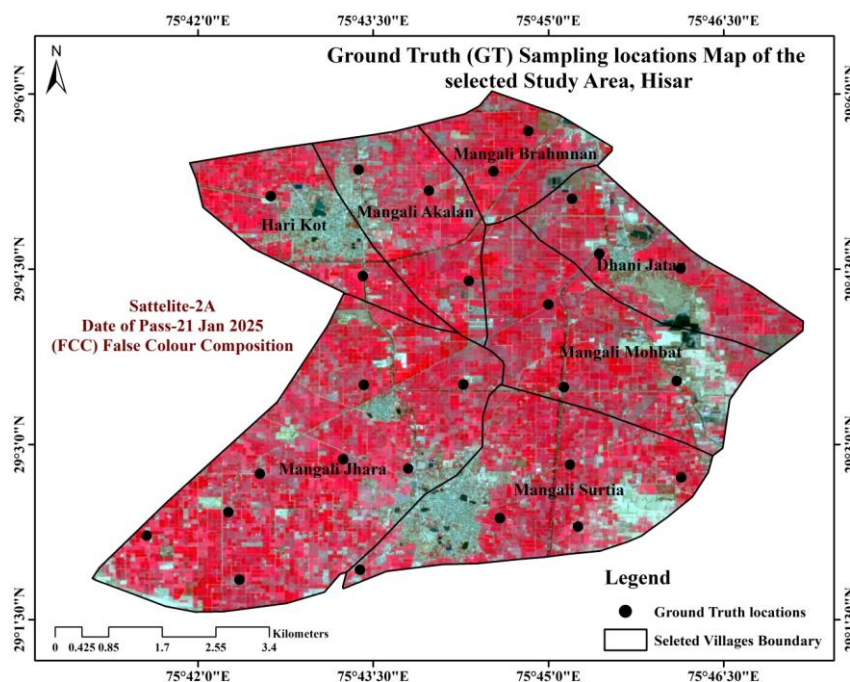


Fig.-2:Ground Truth (GT) Sampling locations Map of the selected villages, Hisar

The following flowchart illustrates the step-by-step methodology, beginning with data import and progressing to classification.

Area Estimation of selected villages, Hisar (Rabi season) 2024-25

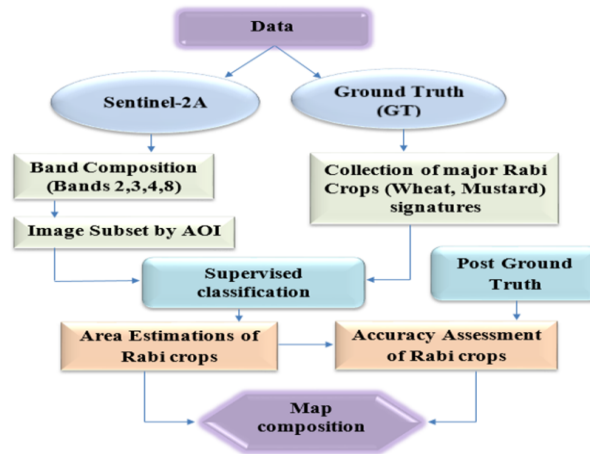


Fig-3:Methodology Flow Chart.

Methods-

Software used:

QGIS was used for Band composition, for Image clipping and supervised classification.

Band composition/layers stack:

Band combination is the process of overlaying different satellite spectral bands for the purpose of highlighting specific characteristics. In the present research work, Sentinel-2 bands 2 (blue), 3 (green), 4 (red), and 8 (NIR) were utilized and combined to get a better outlook of crops, land use, and land cover characteristics.

Subset/Image clipping:

Image clipping is the separation of a specific area of interest from a large satellite image or raster data set. It is a valuable method in remote sensing applications, as it reduces data size, enhances processing efficiency, and focuses analysis on a given study area. In this study we subset the sentinel image by using administrative boundary (Hisar villages Boundary) of AOI.

Ground Truth Technique (GT):

Ground truth data are used for collecting original data. We have used the ground truthing method (GTM) in this study for recording spectral signatures of main crops, i.e., wheat and mustard. For that purpose, we created a base map containing 25 tentative points. These tentative points were indicated while performing the field survey for achieving maximum accuracy in the process of satellite image classification. Ground truth information is valuable in supervised classification, improving the accuracy of satellite crop mapping and acreage estimation.

Supervised classification:

Supervised classification is a GIS technique used to analyze satellite imagery by training the model with labeled data to recognize land characteristics like forests, water bodies, and cities. Common techniques are MLC, SVM, and Random Forest, which categorize pixels based on patterns. The results are refined with post-processing and validated using real-world data. Though useful in crop estimation and land mapping, its accuracy demands quality training data and is therefore time-consuming. In this paper, we used supervised classification for area estimation of big Rabi crops like mustard and wheat.

Accuracy assessment:

Post the area estimation, post-ground truth (PGT) points are utilized in measuring area estimate accuracy or classified data relative to field measurements or reliable reference data. It begins with acquiring ground truth points, which are accurate real-world coordinates obtained through field surveys, high-resolution images, or GPS. These ground truth points are compared with the classified data to measure how well estimated areas match with conditions on the ground. We collected 18 ground truth points for accuracy measurement in this study area.

III. Result and Discussion:

This selected study area was estimated using Sentinel-2A satellite images and GIS technology. Major Rabi crops such as wheat and mustard were researched in this article, with satellite 10-meter high-resolution data employed for accurate mapping and classification.

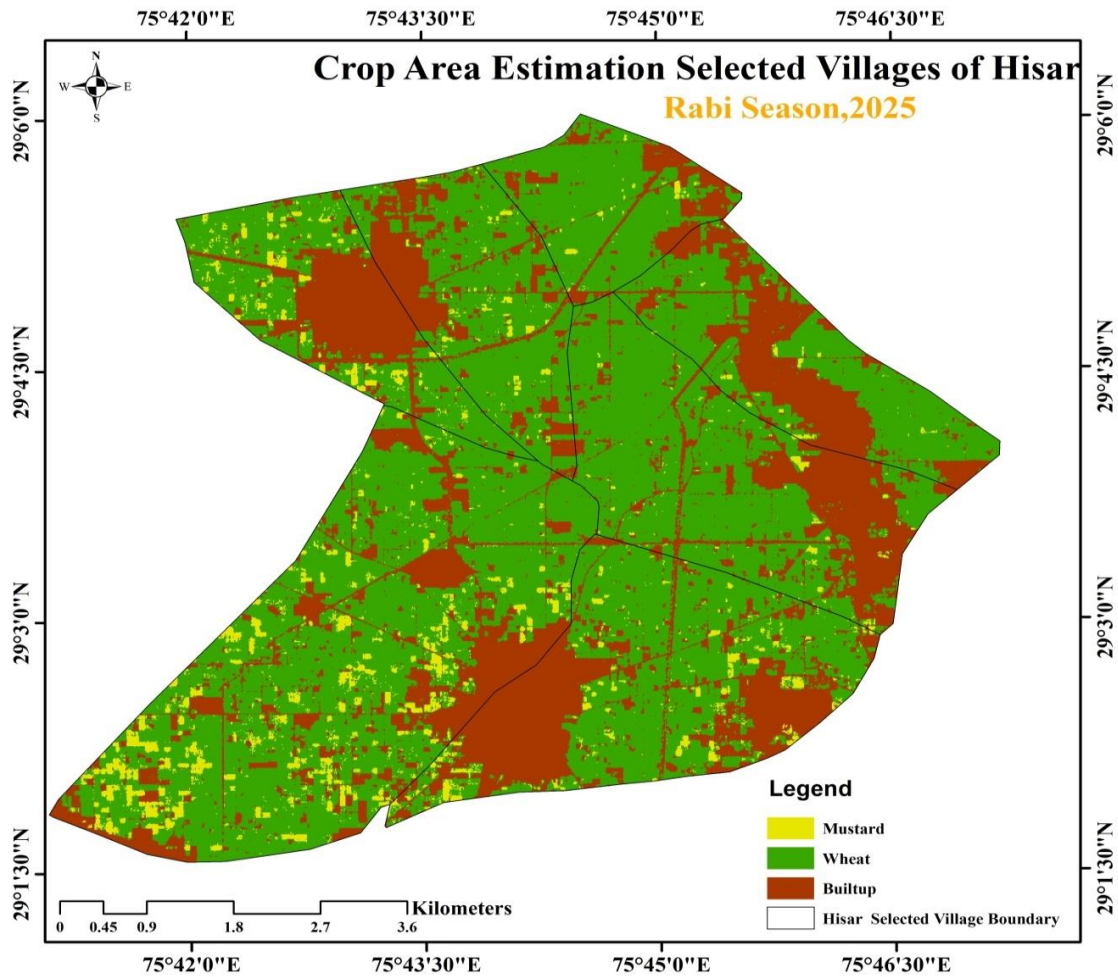


Fig.-5 : Crop Area Estimation Selected Villages of Hisar Rabi Season, 2025.

The crop area estimation map of the chosen villages of Hisar for 2025 Rabi season shows a widespread cover of wheat (green) across most of the region, indicating extensive farming. Mustard (yellow) is in patches of smaller and dispersed size, frequently mixed with wheat fields, showing mix cropping patterns. The built-up areas (brown) are concentrated along roads and villages and indicate settlements and infrastructure. The spatial distribution is a reflection of an intensively linked agricultural landscape with a recognizable road network and village edges, exhibiting the association of agricultural land with human settlements.

We noticed in our research that key Rabi crops, namely wheat and mustard, are cultivated in the area. Classification results revealed that wheat

dominates in areas of good irrigation, and mustard dominates in dry areas.

In this selected area of study, wheat is more cultivated than mustard, mainly due to the system of irrigation. Wheat is mainly cultivated in the northern, northeast, and center parts of the region because all these areas are irrigated by canal and Tube wells and so become suitable to cultivate wheat. Wheat requires higher water than mustard, and for this reason, these irrigated lands are found to be suitable for cultivating wheat. But areas lacking canal irrigation, where water supply is scarce, are most suitable for mustard growth. In the south, southwest, and northwest, about, mustard is grown in greater quantities since canals do not exist and water supply is poor. The inclusion of ground truth data significantly improved the accuracy of classification, proving the utility of field verification in remote sensing studies.

Table 1: Rabi Crop Area Distribution in Selected Villages of Hisar (2025)

Rabi Crop Area Estimation of selected villages, Hisar(2025)		
Class	Area	Area in Percentage (%)
Mustard	209.6	4.6
Wheat	2995.1	65.4
Other	1376.72	30.1
Total	4581.37	100.0

This table-1 indicates the Rabi crop area estimation of selected villages of Hisar for 2025. It categorizes the sown area into three major crop groups: Mustard, Wheat, and Other crops. Wheat occupies the majority with 2995.1 hectares, which is

65.4%, while other crops occupy 1376.72 hectares (30.1%), with Mustard occupying the lowest space at 209.6 hectares (4.6%). The cultivated areas total 4581.37 hectares, expressed as percentages in terms of contribution of each crop to the overall.

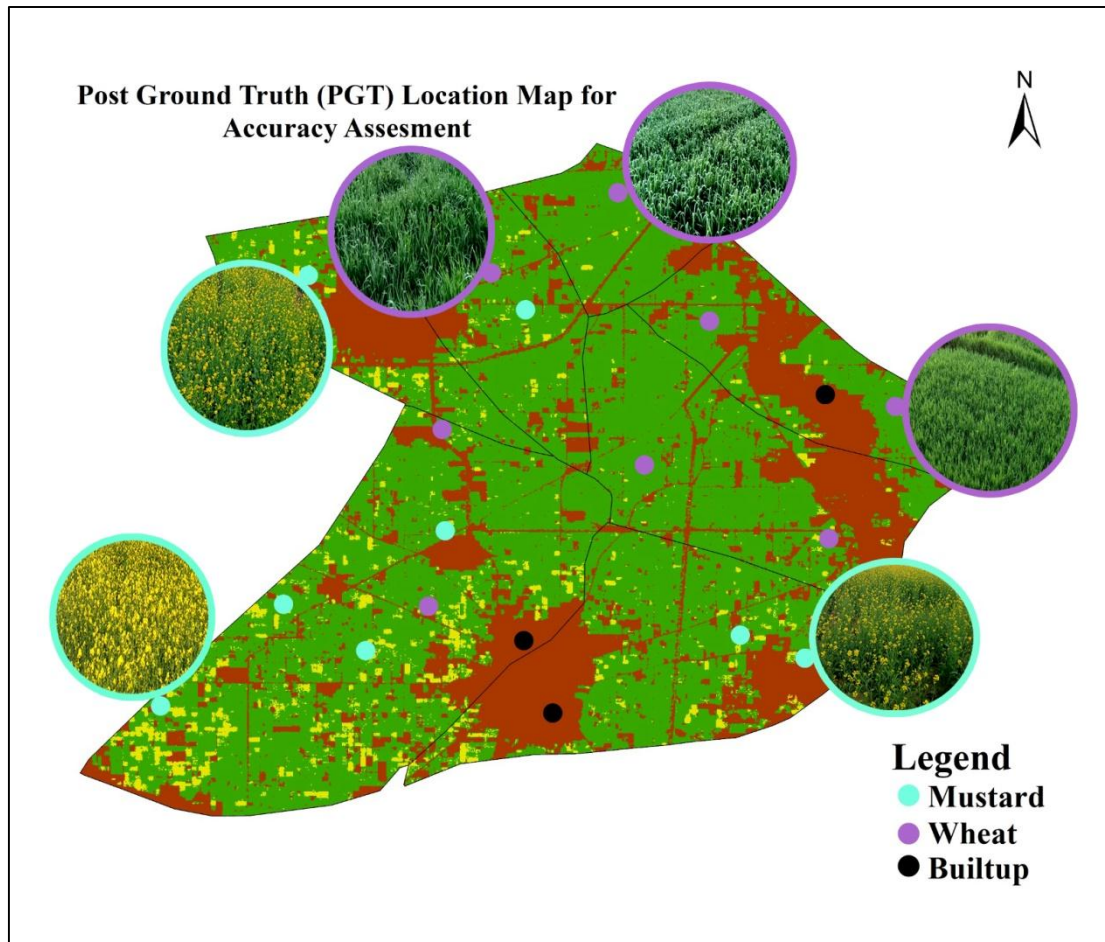


Fig.-4: Post Ground (PGT) Location Map for Accuracy Assessment.

The accuracy assessment of this map involves verifying the classification of different land cover classes—mustard, wheat, and built-up urban—against post-ground truth (PGT) data. The map has some points shaded differently for mustard

(cyan), wheat (purple), and built-up (black) areas, which are verified with field observations. The inclusion of real-world images at sample points also assists in verifying the accuracy of classified areas. By cross-matching these ground truth points with

the mapped classes, the assessment helps in verifying the reliability and accuracy of the classification process, where the data mirrors the actual land cover distribution. Through the procedure we employed to conduct accuracy assessment, we were able to achieve 95% accuracy.

IV. Conclusion:-

This study used Sentinel-2A satellite images and GIS techniques to estimate the Rabi crop area in the selected villages of Hisar, Haryana. Results show wheat dominates (65.4%) with enhanced irrigation cover, and mustard (4.6%) is grown in areas with scarce water. Ground truth validation enhanced the accuracy in classification using remote sensing methods. The results point towards the importance of irrigation in the distribution of crops and yielded useful information to the policymakers for enhanced agricultural planning, resource utilization, and food security in the semi-arid regions.

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