



(RESEARCH ARTICLE)



## A spatial analysis of cropping intensity and canal proximity in Janjgir-Champa district using Sentinel-2 Imagery (2022-23)

Sudhanshu Yadav \*

*Independent Researcher, India.*

World Journal of Advanced Research and Reviews, 2026, 29(03), 1648-1662

Publication history: Received on 12 February 2026; revised on 22 March 2026; accepted on 24 March 2026

Article DOI: <https://doi.org/10.30574/wjarr.2026.29.3.0728>

### Abstract

The main objective of the present study is to determine the spatial relationships between crop intensity and canal proximity in the Janjgir-Champa district using Sentinel-2 Satellite Imagery (2022-23). This research utilized spatial techniques such as NDVI, QGIS-based multi-ring buffer analysis (500-2500 meters), and zonal histograms. According to the results of the analysis, the district's crop intensity is 108.16%, with agricultural intensity highest in the Nawagarh and Janjgir tehsils. The buffer analysis indicates that crop intensity is highest within 500 to 1500 meters of the canal network, while it gradually declines beyond 2000 meters. Comparing the Satellite-based data with district statistical data yielded an RMSE of 7.38 for cropping intensity index and 4799.73 hectares for the irrigated area, which is a testament to the high accuracy and scientific rigor of the study. In conclusion, this study certifies that the canal irrigation facility plays a key role in increasing crop intensity and provides a scientific basis for agricultural planning at a micro-level in the future.

**Keywords:** Crop Intensity; Canal Buffer; Sentinel-2; GIS; Remote Sensing; Spatial Analysis

### 1. Introduction

Crop intensity generally refers to the area of cropland on which more than one crop is sown in a year. In other words, the concept of crop intensity means the number of crops produced in a single field in one year. Crop intensity is a sign of the frequency of crops in a cropping year. Tripathi (1970) has argued that it is appropriate to use "agricultural intensity" instead of "crop intensity." He believes that agricultural intensity is related to double-cropped areas and is essentially the sum of physical (temperature, soil, and water), technical, management (irrigation and crop rotation), and biological factors [1, 2]. Sowing a crop more than once a year in any particular region indicates the advancement of that region's resources, such as irrigation, soil fertility, water management, etc. In a country like India, where most of the rainfall occurs from June to mid-September and the rest of the time (especially during the Rabi crop season) remains dry, taking two crops a year is not possible without adequate irrigation management and advanced technological development. The canal plays a primary role among irrigation means. In India, 22.85% of agricultural land is irrigated by canals [11, 17].

A canal is an important means for irrigation. Canal irrigation has been done since ancient times, but due to the food grain requirements of the fast-increasing population, the development of a modern canal system has become the necessity of the day. The main advantage of canal irrigation is that unirrigated wastelands can be developed by canal irrigation, which would increase the quantity of biomass in the area [18].

There is a close relationship between crop intensity and canal irrigation; therefore, in areas where canals are accessible, two to three crops can be grown per year. In the areas immediately adjacent to the canals, agriculture is more intensive. As the distance from the canal increases, its influence diminishes, and agricultural intensity also falls [7, 10]. Therefore,

\* Corresponding author: Sudhanshu Yadav

it becomes important to study the relationships between them on a quantitative basis. In the present study, a crop intensity index was derived from Satellite Imagery, and the relationships with the canal's buffer zone were explained.

Normalized difference vegetation index (NDVI) is a popular metric that analyses sensor data to assess vegetation density and health. It is primarily based on the difference between two specific bands of data to provide an accurate picture of the greenery on the ground. In this study, the crop intensity index was calculated using NDVI. NDVI is a technique that uses Satellite Imagery to monitor crop/plant health. It employs the red band and the near-infrared band. NDVI values range from -1 to +1. Values from -1 to 0 indicate water bodies, clouds, and non-vegetation elements, while values from 0 to 1 represent soil, grass, crops, and dense vegetation [20, 27].

### *Research objectives*

The objective of the present study is to obtain the following information:

- To create a map of the Kharif, Rabi, and Zaid crops using Sentinel-2 Satellite Imagery.
- To assess the cropping intensity at the district and tehsil levels.
- To examine the impact of canal irrigation to determine how agricultural intensity is affected as the distance from the canal increases.
- To validate the Satellite data by comparing it with government statistical data.

---

## **2. Material and methods**

### **2.1. Study area**

Janjgir-Champa district is located in the Indian state of Chhattisgarh. Its geographical extent is from 21°42'34" N to 22°15'48" N latitude and from 82°18'15" E to 82°50'33" E longitude. The total area of the district is 2,143.12 square kilometers (calculated using GIS-based vector shapefile). Janjgir-Champa district was established in 1998 by being separated from Bilaspur. Subsequently, in 2022, it was further divided, and the Sakti district was created out of it. The current Janjgir-Champa district has a total of 9 tehsils: Baloda, Akaltara, Janjgir, Champa, Pamgarh, Nawagarh, Shivrinarayan, Bamhanidih, and Saragaon. According to the 2011 census, the district's total population is 966,671. Of this, 803,118 are rural and 163,553 are urban. The total population is 83.08% rural and 16.92% urban. The number of farmers in the study area is 162,124, of which 97,000 are male farmers and 65,124 are female farmers [15, 23].

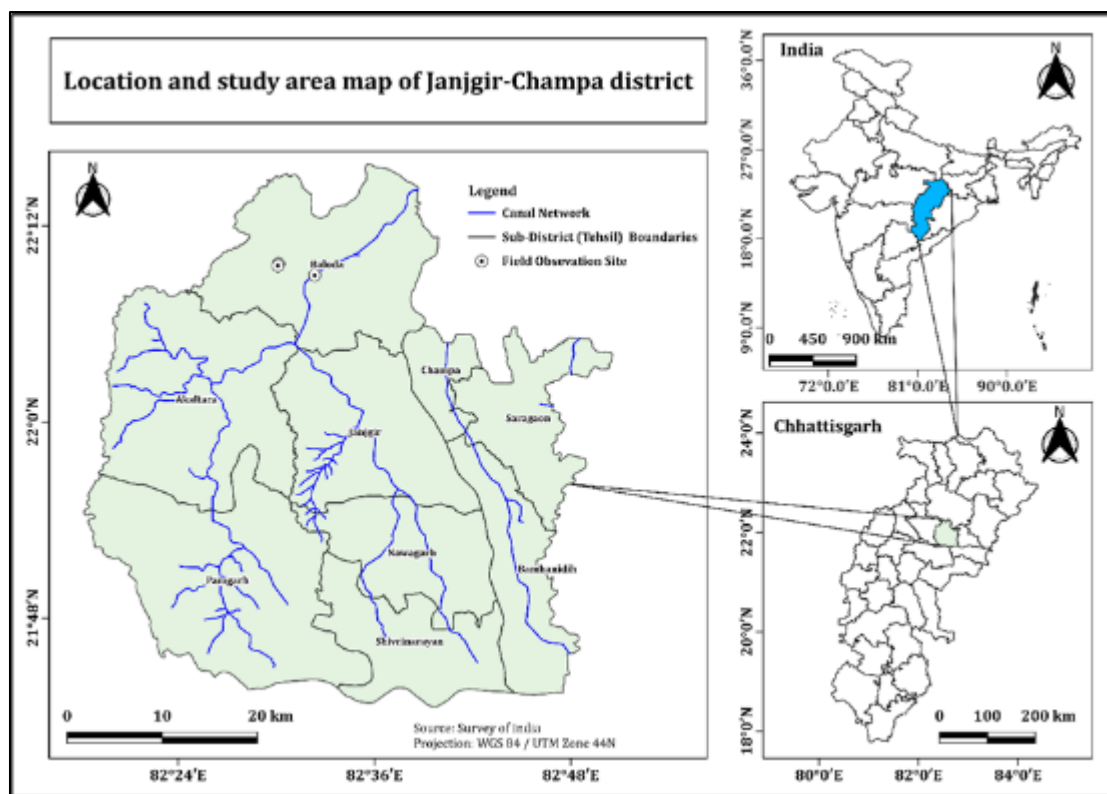
The study area located under the 'Chhattisgarh Basin', so from an elevation standpoint it is mostly flat, with an average elevation of 294.4 metres above sea level. Here, the fertile plains of the Hasdeo River and the Mahanadi River are found. The climate is tropical monsoon, and most of the rainfall here naturally occurs between June and September from the southwest monsoon winds. The average annual rainfall is 1252.3 mm. The district's minimum temperature is 12°C, and the maximum temperature is 44°C [15].

Owing to a favourable climate and flat, fertile plains, the area is well suited for agriculture. As a result, approximately 67.37% of the total land area is under cultivation. The predominant fertile soils are Kanhar(Black Soil), Dorsa(Clay-Loam Soil), and Matasi(Red and Yellow Soil). Two main crops are grown here: Kharif and Rabi. The principal crops include paddy, corn, black gram, sesame, groundnut, wheat, chickpea, pigeon pea, indigo/tivada, mustard, rapeseed, sugarcane, and others.

Irrigation for the kharif crop is provided by monsoon rainfall. In cases of low rainfall, irrigation is carried out through canals, groundwater, ponds, etc. The rabi crop is entirely dependent on canals and groundwater. In the Janjgir-Champa district, canal irrigation is the most important. A large network of canals is found here. In the Korba district, the large dam on the Hasdeo River, known as the Hasdeo-Bango Dam or the Minamata Dam, has its right-bank canal extended throughout Janjgir-Champa. This canal supplies water for irrigation to nearly every tehsil in the district [13].

### **2.2. Data acquisition and source**

For this study, multi-temporal Satellite Imagery from Sentinel-2 was acquired to conduct a spatial analysis of the crop intensity index in the Janjgir-Champa district. Level 1C (MSI) data, with a spatial resolution of 10 m, was acquired from the Copernicus Data Space Ecosystem [24].



**Figure 1** Location and study area map of Janjgir-Champa district, Chhattisgarh

Within the study area, it was essential to isolate non-agricultural zones to facilitate an analysis predicated solely on the purity of agricultural land. Consequently, the National Remote Sensing Centre's (NRSC) Land Use/Land Cover (LULC) data, obtained from ISRO's Bhuvan portal and characterised by a 10 m spatial resolution, was employed. The primary purpose of utilising this dataset was to construct a forest mask, which facilitated the identification and subsequent exclusion of forested regions from the analytical procedures [25].

The Survey of India shapefile was used to delineate the study area, specifically to show the district and tehsil boundary lines. Its objective was to obtain accurate data on crop intensities and canal impact areas at the tehsil and district levels [26].

**Table 1** Detailed description of Satellite Imagery and geospatial datasets

Satellite Product	Acquisition Date	Bands	Sensor	Spatial Resolution	Cloud (%)	Source	Purpose
Sentinel-2	2022-10-22	B04, B08	MSI	10m	10	Copernicus Data Space Ecosystem	Thematic Intensity Crop Map Generation
	2023-02-09	B04, B08	MSI	10m	10	Copernicus Data Space Ecosystem	
	2023-05-15	B04, B08	MSI	10m	10	Copernicus Data Space Ecosystem	
Bhuvan LULC (SIS-DP Phase-2)	2018-23	N/A	N/A	10m	N/A	NRSC, ISRO	Forest Mask

Survey of India Shapefile	N/A	N/A	N/A	N/A	N/A	Survey of India	District & Sub-District Boundary
---------------------------	-----	-----	-----	-----	-----	-----------------	----------------------------------

MSI= Multi-Spectral Instrument; LULC= Land use and Land Cover; NRSC= National Remote Sensing Centre; ISRO= Indian Space Research Organization

### 2.3. Software used

The following software packages were used for geospatial and statistical analysis in this study:

#### 2.3.1. QGIS (version 3.44.3 Solothurn)

This open-source software served as the primary tool for geospatial data processing. Image pre-processing, NDVI calculation, canal buffer zone/multi-ring buffer analysis, and the generation of the final thematic map were all accomplished using this software.

#### 2.3.2. Microsoft excel:

Statistical data derived from the zonal histogram, obtained through QGIS, was organized into a tabular format within this software. Furthermore, Excel was used to calculate the simple deviation, percentage deviation, and root mean square error (RMSE) to assess accuracy.

#### 2.3.3. Google earth pro:

It has been used to accurately delineate all agricultural land and the canal network in the Janjgir-Champa district. In addition, it has been used to verify the precise acquisition of NDVI values for crop greenness.

### 2.4. Satellite data pre-processing

After downloading band 4 (Red) and band 8 (NIR) of the Sentinel-2 image from Copernicus in .tiff file format, the image was first cleaned of atmospheric dust, and cloud using the semi-automatic classification plugin (SCP) in QGIS. It was then clipped to the administrative boundaries of the study area, Janjgir-Champa.

After that, a forest mask was created from the image obtained using Bhuvan LULC data, excluding forests, built-up areas, water bodies, and so on from the analysis so that only the agricultural area could be counted.

### 2.5. NDVI and CII calculation

To understand the process of Normalized different vegetation index (NDVI) and Crop intensity index (CII) calculation, we have divided it into four sections:

#### 2.5.1. NDVI generation

First, by adding bands 4 and 8 of the Sentinel-2 Satellite image as layers in QGIS and using the raster calculator to apply the following formula, the NDVI value was calculated:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

**Table 2** Seasonal Satellite data and NDVI thresholds

Season	Acquisition date	NDVI threshold	Remarks
Kharif	2022-10-22	>0.4	Peak growth stage with high biomass
Rabi	2023-02-09	>0.4	Active growth period for winter crops.
Zaid (summer)	2023-05-15	>0.38	Adjusted for heat stress and dry conditions

In Table 2, areas with NDVI values below the threshold are classified as non-agricultural. Meanwhile, forest areas were removed using the Bhuvan LULC map to accurately calculate the agricultural area.

### 2.5.2. Map integration using raster calculator

The binary maps of the three seasonal crop map (Kharif, Rabi, Zaid) were combined using the QGIS Raster Calculator to create an integrated annual map. The following logical equation was used in this process:

$$CII\_map = Kharif\_raster + Rabi\_raster + Summer\_raster$$

### 2.5.3. Area extraction and statistical calculation

After combining the three seasonal raster images, we used a zonal histogram in QGIS to convert the visual data on the map into numerical data. We used the tehsil-wise administrative boundaries of Janjgir-Champa as zones. This tool accurately counted the tehsil-wise crop area in pixels. It includes pixels with NODATA HISTO, HISTO 0, HISTO 1, and HISTO 2 and HISTO 3 were obtained. Of these, only the HISTO 1, HISTO 2, and HISTO 3 were included in the crop area calculation, as they represent single-crop, dual-crop, and triple-crop areas, respectively. Therefore, only these were included in the calculation. Since the spatial resolution of Sentinel-2 is 10 m, the following formula was used to convert it to hectares:

$$Area(Ha) = Total\ Pixels \times 0.01$$

### 2.5.4. Calculation of cropping intensity index (CII)

After converting the pixel data into hectares, we calculated the crop intensity index for the Janjgir-Champa district and all its tehsils using Microsoft Excel. The total Kharif area has been considered as NSA (Net sown area).

$$CII(\%) = \left( \frac{Gross\ Cropped\ Area(GCA)}{Net\ Sown\ Area(NSA)} \right) \times 100$$

## 2.6. Buffer and proximity analysis

To assess the effect of canal irrigation on crop intensity, this study employed proximity analysis. This approach facilitated a precise examination of the canal's spatial impact. The impact area was delineated using the multi-ring buffer tool within QGIS.

Specifically, five buffer zones were established around the canal, at distances of 500, 1000, 1500, 2000 and 2500 meters. The primary aim was to ascertain how crop intensity varied with increasing distance from the canal.

Subsequent to the creation of the canal buffer zones, the Zonal Histogram tool was utilized to extract crop area data for each zone. The mean (weighted) crop intensity index was then calculated using the following formula, based on the acquired data:

$$Mean\ CII = \frac{(1 \times HISTO_1) + (2 \times HISTO_2) + (3 \times HISTO_3)}{HISTO_1 + HISTO_2 + HISTO_3}$$

where  $HISTO_1$ ,  $HISTO_2$ , and  $HISTO_3$  represent the counts of single, double, and triple crop pixel classes.

## 2.7. Accuracy assessment and validation

In this study, we used official statistical data to validate the data obtained from Satellite Imagery. Although the district statistical data do not provide canal-buffer-based figures, we calculated the area by adding the canal impact zones falling between 500 m to 2,500 m compared it to the total canal-irrigated area in the statistical data.

The following statistical formula was used for accuracy assessment:

Simple Deviation (D)-

$$D = S_i - O_i$$

Percentage Deviation (PD)-

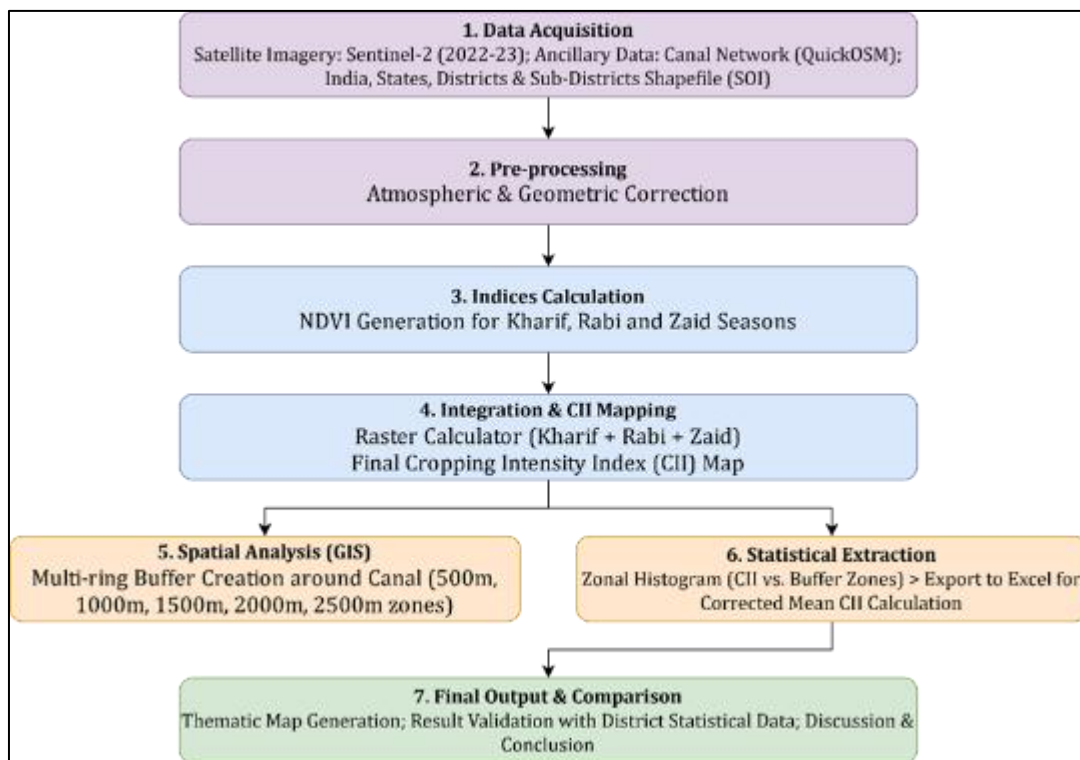
$$PD = \left( \frac{S_i - O_i}{O_i} \right) \times 100$$

$S_i$ = Satellite data,  $O_i$ = Official/Statistical data

Root mean square error (RMSE)-

$$RMSE = \sqrt{\frac{\sum(S_i - O_i)^2}{n}}$$

$S_i$ = Satellite data,  $O_i$ = Official/Statistical data,  $n$ = Total number of sub-districts (tehsil)



**Figure 2** Flowchart representing of research methodology

The values of RMSE and deviation for both crop intensity and irrigated area are shown in Table 5 and Table 6 in the results and discussion sections.

## 2.8. Field observation

The results obtained from Satellite data in the Janjgir-Champa study area were verified by conducting a field survey. The main objective was to understand the degree of correspondence between the remote sensing maps and the on-the-ground reality.

During the visit, it became clear that the presence of a canal alone is not enough, the soil composition and its slope also have a significant impact on farming. We observed that the fields near the canal that are on the slope or downhill easily receive water without any machinery. On the other hand, The fields that are slightly higher still require pumps or

machines for irrigation today. This micro-relief has a direct impact on crop intensity. Only observations were made during the visit, no quantitative data were collected.



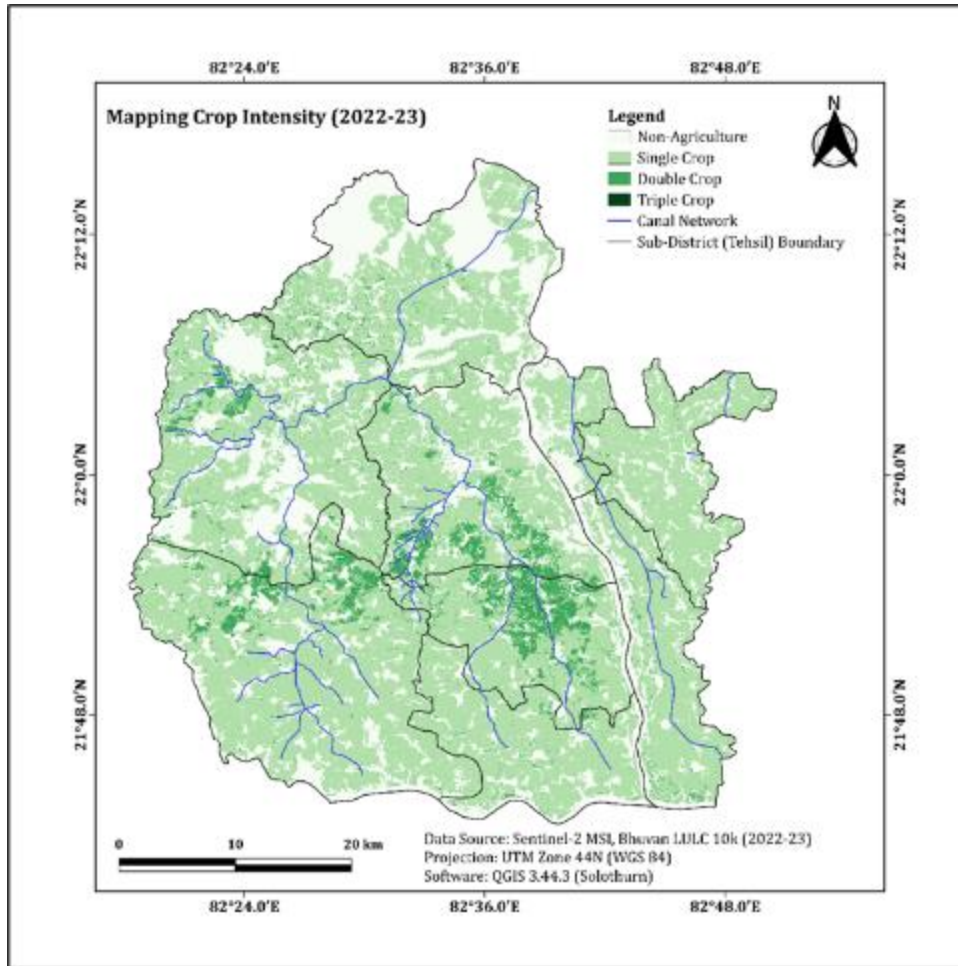
**Figure 3** Field observation photographs from different locations in Janjgir-Champa district. (a) Kharif crop (22°9'40.5828"N, 82°30'8.48088"E), (b) Rabi crop (22°9'36.51336"N, 82°30'6.2316E), (c) Canal infrastructure (22°8'58.52004"N, 82°32'20.79312"E), (d) Buffer zone agriculture

### 3. Results and discussion

The results of this research indicate a strong relationship between canal irrigation and crop intensity. The study found the following result of canal irrigation and crop intensity:

#### 3.1. Analysis of cropping intensity (CII)

Figure 4 shows the distribution of crop intensity in the Janjgir-Champa region. Table 3 provides the district's total Kharif area at 144,382.96 hectares, in which paddy is the main crop this season. In Rabi, a total of 11,777.2 hectares of land are under cultivation. The main Rabi crops are wheat and rice. Thus, the study found a crop intensity of 108.16% for the entire district, indicating that double cropping is practiced over a very small area. However, differences in crop intensity are observed at the tehsil level.



**Figure 4** Janjgir-Champa district & Sub-district (Tehsil) wise Cropping Intensity Index (CII) derived from Sentinel-2 Satellite Imagery

**Table 3** Satellite-derived (Sentinel-2) Estimation of Seasonal Crop Area and Cropping Intensity Index (CII)

Sub-District (Tehsil)	Kharif (Ha)	Rabi (Ha)	GCA (Ha)	CII %
Nawagarh	14801.7	3550.75	18352.45	123.99
Janjgir	18562.46	2721.62	21284.08	114.66
Pamgarh	31557.1	2477.88	34034.98	107.85
Akaltara	23472.99	1605.35	25078.34	106.84
Baloda	16923.3	579.78	17503.08	103.43
Shivrinarayan	12913.49	366.36	13279.85	102.84
Bamhanidih	11207.99	315.06	11523.05	102.81
Saragaon	11672.87	140.5	11813.37	101.20
Champa	3271.06	19.9	3290.96	100.61
<b>District</b>	<b>144382.96</b>	<b>11777.2</b>	<b>156160.16</b>	<b>108.16</b>

GCA= Gross crop area; CII= Crop intensity index; Ha= Hectare; In Table 3 Satellite data for the rabi season includes both rabi and zaid (summer) crop area to ensure consistency with the district statistical data format

An observation of Table 3 reveals that there is a significant difference in the cropping intensity of each tehsil. The tehsils with high cropping intensity are Nawagarh (123.99%), Janjgir (114.66%), and Pamgarh (107.85%). Are Champa (100.61%) and Saragaon (101.20%) among the tehsils with lowest cropping intensity. This indicates that Nawagarh,

Janjgir and Pamgarh have adequate irrigation facilities and greater awareness among farmers about dual-cropping. In Champa and Saragaon, the practice of dual cropping is almost nonexistent.

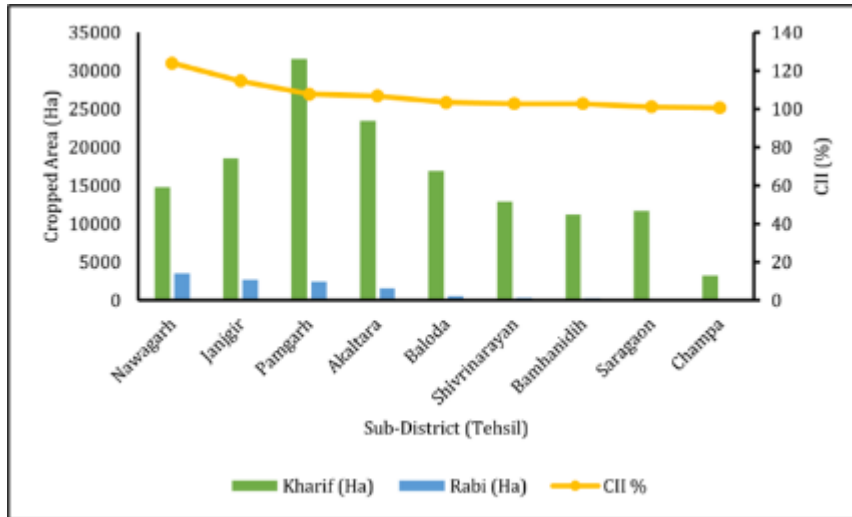


Figure 5 Sub-district (Tehsil) wise cropping intensity graph

### 3.2. Impact of canal irrigation and buffer zone analysis

To understand the impact of crop intensity on the canal network as it expands, a buffer zone analysis was conducted, yielding positive results. The details are provided in Figure 6.

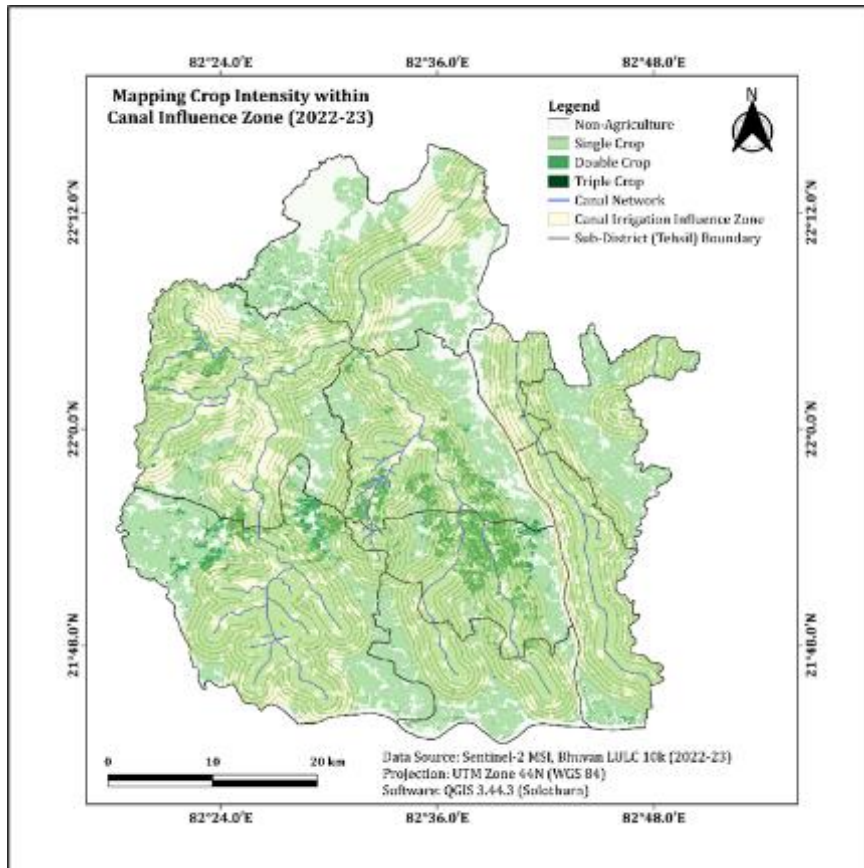


Figure 6 Spatial mapping of canal irrigation reach and its influence on Sub-district (Tehsil) level cropping patterns in Janjgir-Champa district

To understand the relationship between canal buffer zones and agricultural productivity, a buffer zone ranging from 500 m to 2500 m was established, with the primary objective of determining how much quantitative change occurs in crop patterns as the distance from the canal to the fields increases. An observation of Table 4 clearly shows that there is a direct and deep relationship between irrigation accessibility and the mean crop intensity index.

Analysis of the given data makes it clear that the agricultural response is strongest in the Nawagarh tehsil, where the mean (weighted) crop intensity index is 1.30 in the 1000–1500 m buffer zone. Next, in the Janjgir tehsil, the mean (weighted) crop intensity index was found to be 1.25 in the 1,500 m buffer. This value indicates that here the main canal and its smaller branches are also more extensive, which is clearly visible when looking at Figure 6. Due to the ample availability of canal water, farmers have successfully shifted from single-crop to double-crop agriculture. The total irrigated agricultural area identified based on the buffer zone at the district level is 98,844.95 hectares. An observation of the data also makes it clear that as the canal's distance increases beyond 2000 m, the crop intensity begins to decrease and approaches the district average of 1.08. In the data from the Pamgarh tehsil, the mean (weighted) crop intensity index increases from 1.11 to 1.15 at distances between 2000 m and 2500 m from the canal buffer zone.

During the field visit, it was observed that crop intensity is influenced not only by canal expansion but also to a large extent by the local topography. It was noted that on the side of the canal where the slope is steep, water reaches the fields without the aid of any machinery. Conversely, where the slope is gentle, other auxiliary devices must be used. However, more intensive farming is taking place in the steep-slope areas, while relatively less intensive farming is occurring in the high-slope areas.

**Table 4** Sub-district (Tehsil) wise variation of Mean (Weighted) Cropping Intensity Index (CII) across different Canal Buffer Zones

Sub-District (Tehsil)	Buffer Zone (Meter); Mean (weighted) CII					500m to 2500m Total Irrigated land (Ha)
	500m	1000m	1500m	2000m	2500m	
Nawagarh	1.29	1.3	1.3	1.23	1.16	20362.09
Janjgir	1.2	1.16	1.25	1.23	1.12	18724.53
Akaltara	1.09	1.07	1.08	1.06	1.05	13152.99
Pamgarh	1.03	1.04	1.08	1.11	1.15	12096.06
Baloda	1.03	1.02	1.02	1.02	1.04	9787.33
Shivrinarayan	1.02	1.04	1.04	1.03	1.02	8632.81
Bamhanidih	1.01	1.03	1.03	1.03	1.03	7147.15
Saragaon	1.01	1.02	1.02	1.02	1.01	5914.06
Champa	1	1	1	1.01	1.02	3027.93
District	1.094	1.088	1.108	1.096	1.081	98844.95

CII= Cropping intensity index; Ha= Hectare.

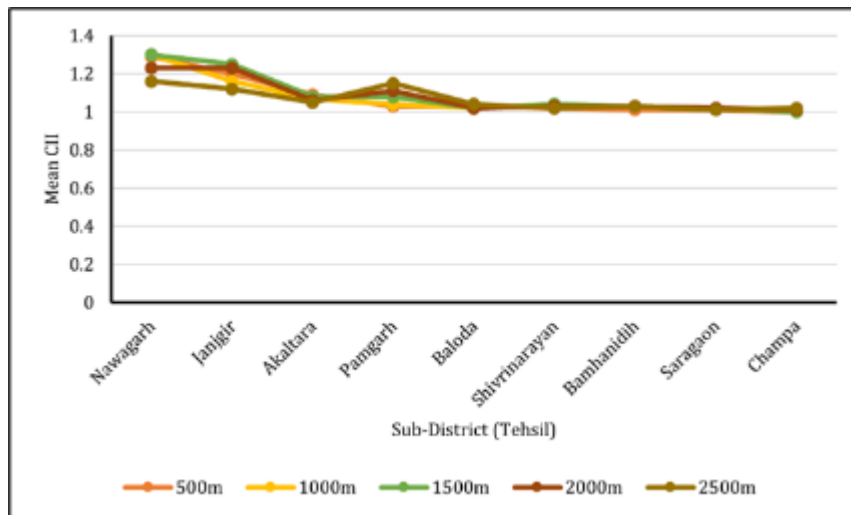
### 3.3. Accuracy assessment and validation

In the present study, to ensure the reliability and accuracy of the data obtained from Sentinel-2, the crop areas were compared with those in the District Statistical Handbook (2022-23).

It has been explained in the following points:

#### 3.3.1. Cropping intensity index accuracy & validation

When comparing the crop intensity index derived from Satellite Imagery with statistical data, we observed excellent accuracy and correlation. We used RMSE (Root Mean Square Error), which yielded 7.38, a very low error. This proves that the data obtained from Satellite Imagery are entirely accurate .



**Figure 7** Sub-district (Tehsil) wise canal buffer zone graph

Table 5 presents a comparison of Satellite and statistical data. When comparing the cropping intensity index derived from Satellite data with the statistical data across different tehsils of the district, it was found that in some tehsils such as Janjgir (10.86%), Pamgarh (4.31%), and Akaltara (4.23%), a positive deviation was shown, indicating that the Satellite image recorded more crops than the statistical data. These could include fruits and vegetables that are not recorded in the government figures. In addition, in some tehsils such as Nawagarh (-12.3%), a negative deviation was observed in Bamhanidih (-4.2%).

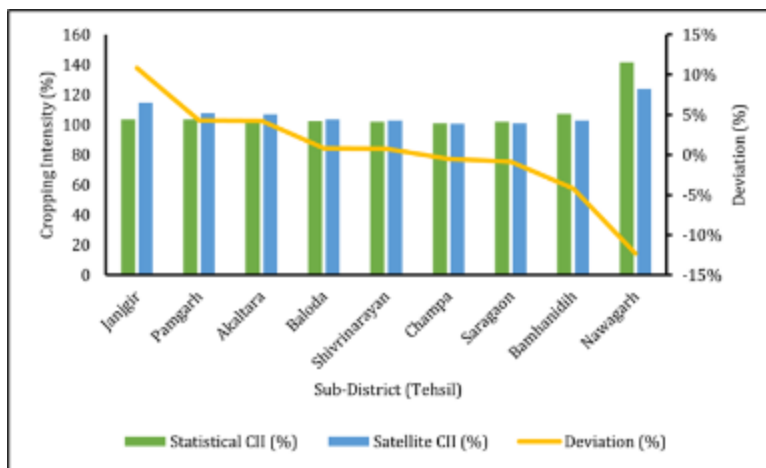
**Table 5** Statistical comparison and sub-district level validation of Satellite-driven CII against district statistical data (2022-23)

Sub-District (Tehsil)	Statistical CII (%)	Satellite CII (%)	Deviation	Deviation (%)
Janjgir	103.43	114.66	11.23	10.86
Pamgarh	103.4	107.85	4.45	4.31
Akaltara	102.5	106.84	4.34	4.23
Baloda	102.6	103.43	0.83	0.8
Shivrinarayan	102.06	102.84	0.78	0.76
Champa	101.1	100.61	-0.49	-0.49
Saragaon	102.08	101.2	-0.88	-0.86
Bamhanidih	107.32	102.81	-4.51	-4.2
Nawagarh	141.38	123.99	-17.39	-12.3
District	107.02	108.16	1.14	1.065
RMSE	7.38			

Source: Sentinel-2 Satellite data; District statistical handbook (2022-23)

### 3.3.2. Canal irrigation area accuracy & validation

To assess the accuracy of the canal impact area, we relied on district statistical data. Since the statistical handbook does not provide data for buffer zones (500 m, 1000 m, etc.), only the total irrigated area of the canal is given, so we have taken the buffer zones to be (500 m to 2500 m) calculate the canal's irrigated area. Based on this, the following data were obtained:

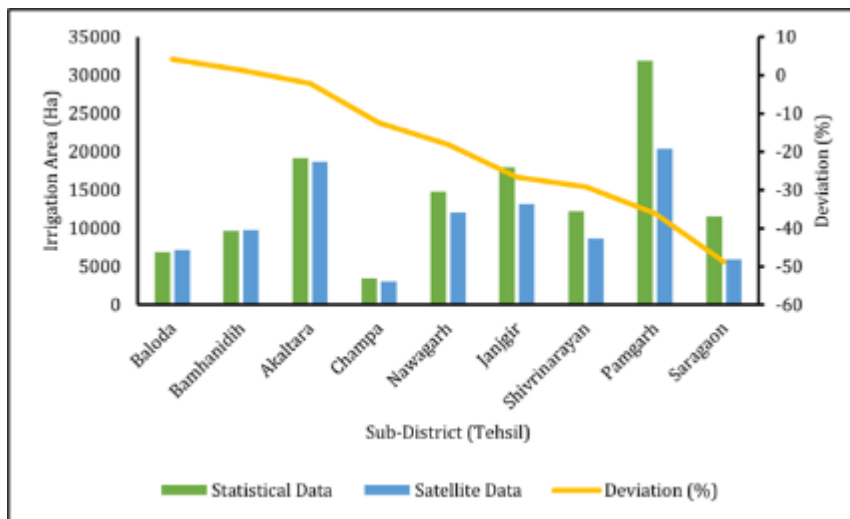


**Figure 8** Statistical data and Satellite data comparison/accuracy graph for cropping intensity index

**Table 6** Validation of Satellite-derived total canal irrigation extent against district statistical data (2022-23)

Sub-District (Tehsil)	Statistical Data (Ha)	Satellite Data (Ha)	Deviation	Deviation (%)
Baloda	6865	7147.15	282.15	4.11
Bamhanidih	9657	9787.33	130.33	1.35
Akaltara	19141	18724.53	-416.47	-2.18
Champa	3460	3027.93	-432.07	-12.49
Nawagarh	14791	12096.06	-2694.94	-18.22
Janjgir	17933	13152.99	-4780.01	-26.65
Shivrinarayan	12206	8632.81	-3573.19	-29.27
Pamgarh	31863	20362.09	-11500.91	-36.1
Saragaon	11547	5914.06	-5632.94	-48.78
District	127463	98844.95	-28618.05	-22.45
RMSE	4799.73 (Ha)			

Source: Sentinel-2 Satellite data; District statistical handbook (2022-23)



**Figure 9** Statistical data and Satellite data comparison/accuracy graph for canal irrigation area

Table 6 compares Satellite and statistical data, yielding an RMSE (Root Mean Square Error) value of 4799.73 hectares. This value is good in terms of accuracy and reliability. Since the total irrigated area is 1.27 lakh hectares, an RMSE of 4799.73 hectares amounts to just 3.7% relative error, which confirms the high trustability of the Satellite data.

At the district level, the deviation is -22.45%, which shows that Satellite data is capable of providing a reliable estimate of the actual irrigated area. At the tehsil level, Baloda (4.11%) and Bamhanidih (1.35%) have the lowest deviation, where the Satellite and statistical data are almost the same. The tehsils with negative deviations are Saragaon (-48.78%) and Pamgarh (-36.1%), which is due to the small size of the fields, as the Satellite image has a 10 m spatial resolution, so it is possible that it has included bunds and small roads, which has led to an underestimation of the net crop area.

---

#### 4. Conclusion

In the present study, the impact of crop intensity and proximity to canals in the Janjgir-Champa district was analyzed based on data obtained from Sentinel-2 Satellite Imagery. The results indicate that the district total crop intensity is 108.16%, which is clearly reflected, indicating that the district primarily grows a single crop, with two crops sown only in a few limited areas. The data obtained at the tehsil level shows considerable variation, with a crop intensity of 123.99% in Nawagarh tehsil and 101.20% observed in Saragaon. A look at Figure 6 reveals that the canal network is more extensive in Nawagarh and Janjgir, and the farmers there are more aware of the dual-crop pattern. The dual-crop pattern is negligible in Champa and Saragaon. The most important conclusion of this study is the strong spatial relationship between canal proximity and agricultural intensity. Analysis of the buffer zone shows that in the range of 500 to 1500 meters from the canal network, the mean (weighted) CII values are high, reaching up to 1.30 within a 1,000 m radius in Nawagarh. However, as the distance from the canal increases (from 2000 m to 2500 m), the CII value decreases. When compared with district statistical data, the RMSE value for crop intensity is 7.38, and for canal-irrigated area, it is 4799.73 hectares, confirming the high accuracy and scientific rigor of the geospatial analysis.

This study is quite different from existing research in many respects because it provides information on the impact of canal irrigation and agricultural productivity at a micro-spatial level. This will help policymakers in the future with irrigation management and agricultural planning. This study has observed that in Baloda, in tehsils such as Champa, the area irrigated by canals is very small due to the limited expansion of canal sub-branches. If canals were expanded in these tehsils, two-crop cultivation would increase. Currently, irrigation here relies mainly on groundwater, which is limited and under significant pressure.

---

#### Compliance with ethical standards

##### *Disclosure of Conflict of interest*

No conflict of interest to be disclosed.

---

#### References

- [1] Singh UB. Agriculture Geography. 5th ed. Merath: Rajiv Prakashan; 2021.
- [2] Gautam A. Agriculture Geography. 2nd ed. Prayagraj: Sharda Pustak Bhavan; 2024.
- [3] Hegde AS, Ranjan R, Hegde SS. Crop classification and cropping intensity estimation using geospatial technology in the upper Gangetic plains of Uttarakhand. *Heliyon*. 2024; 10(22):e36364. Available from: [https://www.cell.com/heliyon/fulltext/S2405-8440\(24\)12395-X?](https://www.cell.com/heliyon/fulltext/S2405-8440(24)12395-X?)
- [4] Ravishankar, Pandey D, Pali AK, Sahu AK. Simulation modelling of canal irrigated command area: A case study. *International Journal of Fauna and Biological Studies*. 2018; 5(2):14-16.
- [5] Ravikumar R, Ezhilarasan G, Dacruz N. Cropping Intensity, Irrigation, and Fertilizer Consumption: An Analysis. *International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences*. 2024; 12(6):1-7.
- [6] Choudhury BU, Sood A, Ray SS, Sharma PK, Panigrahy S. Agriculture Area Diversification and Crop Water Demand Analysis: A Remote Sensing and GIS Approach. *Indian Society of Remote Sensing*. 2013; 41(1):71-82. Available from: <https://link.springer.com/article/10.1007/s12524-011-0194-z>
- [7] Heller E, Rhemtulla J, Lele S, Kalacska M, Badiger S, Sengupta R, Ramankutty N. Mapping Crop Types, Irrigated Areas, and Cropping Intensities in Heterogeneous Landscapes of Southern India Using Multi-Temporal Medium-

Resolution Imagery. *Photogrammetric Engineering & Remote Sensing*. 2012; 78(8):815-827. Available from: <https://www.ingentaconnect.com/content/asprs/pers/2012/00000078/00000008/art00002;jsessionid=5de2bg0ptjc0s.x-ic-live-03>

- [8] Kumar B, Aashish, Manisha, Beniwal S, Rani N. Spatial Analysis of Cropping Patterns Using Digital Image Processing: A Case Study of Sirsa District Haryana. *IOSR Journal of Applied Geology and Geophysics*. 2025; 13(2):10-20.
- [9] Hosseini MM, Zoej MJV, Dehkordi AT, Ghaderpour E. Cropping intensity mapping in Sentinel-2 and Landsat-8/9 remote sensing data using temporal transfer of a stacked ensemble machine learning model within google earth engine. *Geocarto International*. 2024; 39(1):2387786. Available from: <https://www.tandfonline.com/doi/full/10.1080/10106049.2024.2387786>
- [10] Deshmukh MS, Tanaji SV. Cropping Intensity Index and Irrigation Intensity in India. *North Asian International Research Journal Consortium*. 2017; 3(2):1-11.
- [11] Negi G, Ballabh C. A Study on Cropping Intensity Index and Irrigation Intensity in District Dehradun. *International Journal of Creative Research Thoughts*. 2018; 6(1):150-156.
- [12] Yadav PK, Singh P, Kumar N, Upadhyay RK, Jadaun SPS. Impact of canal restructuring on agricultural land use in 23 down Haidergarh canal command system, Uttar Pradesh, India. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. 2019; XLII-3/W6:345-350. Available from: <https://isprs-archives.copernicus.org/articles/XLII-3-W6/345/2019/>
- [13] Shrivastava SK, Verma MK, Devatha CP. Optimization modelling for crop planning of Hasdeo Bango command. *International Journal of Engineering Research & Technology*. 2012; 1(9):1-13.
- [14] Prathyusha I, Ragunath KP, Pazhanivelan S, Kumaraperumal R, Selvakumar S, Sivamurugan AP. Geospatial assessment of cropping intensity: Advances, challenges and future directions . *Plant Sci. Today [Internet]*. 2025 Oct. 8 [cited 2026 Mar. 2];12(sp1). Available from: <https://horizonpublishing.com/journals/index.php/PST/article/view/11351>
- [15] Directorate of Economics & Statistics. District Statistical Handbook: Janjgir-Champa [Internet]. Raipur: Government of Chhattisgarh; 2022-23 [Updated 2024; cited 2026 Mar 02]. Available from: <https://des.cg.gov.in/>
- [16] Cropin. NDVI (Normalized Difference Vegetation Index): All You Need To Know [Internet]. Bangalore: Cropin Technology Solutions; 2023 Feb 15 [Updated 2023 Feb 15; cited 2026 Mar 02]. Available from: <https://www.cropin.com/blogs/ndvi-normalized-difference-vegetation-index/>
- [17] Directorate of Economics and Statistics. Land Use Statistics 2022-23 [Internet]. New Delhi: Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India; 2024 [cited 2026 Mar 4]. Available from: <https://desagri.gov.in/wp-content/uploads/2024/09/Final-file-of-LUS-2022-23-for-uploading.pdf>
- [18] Gurjar RK, Jat BC. *Geography of water resources*. Jaipur: Rawat Publication; 2008.
- [19] Dey A, Sarkar S, Mondal A, Mitra P. Spatio-temporal NDVI prediction for rice crop. *SN Computer Science*. 2025;6(3):241.
- [20] Wikipedia. Normalized difference vegetation index [Internet]. San Francisco: Wikimedia Foundation; 2026 Mar 4 [updated 2026 Mar 4; cited 2026 Mar 7]. Available from: [https://en.wikipedia.org/wiki/Normalized\\_difference\\_vegetation\\_index](https://en.wikipedia.org/wiki/Normalized_difference_vegetation_index)
- [21] Yadav S. Baloda Tehsil ke bhumi upayog evam bhumi aavaran mein parivartan ka bhaugolik soochana pranali dvara vishleshanatmak adhyayan. *International journal of novel research and development*. 2025Dec24;10(12):c106-12
- [22] Guria N, Tiwari G, Namdeo R, Yadav AS. Land use change, cropping pattern and productivity of major crops in Janjgir-Champa(C.G). *World journal of advanced research and reviews*. 2025;25(1):1764-1774
- [23] Office of the Registrar General & Census Commissioner, India. Census of India 2011: Chhattisgarh - District Census Handbook - Janjgir-Champa [Internet]. New Delhi: Ministry of Home Affairs, Government of India; 2011 [cited 2026 Mar 11]. Available from: <https://censusindia.gov.in/nada/index.php/catalog/45256>
- [24] European Space Agency. Sentinel-2 [Internet]. Frascati: Copernicus Data Space Ecosystem; 2024 [cited 2026 Mar 12]. Available from: <https://dataspace.copernicus.eu/data-collections/copernicus-sentinel-missions/sentinel-2>

- [25] National Remote Sensing Centre (NRSC). Bhuvan Thematic Services [Internet]. Hyderabad: Indian Space Research Organisation (ISRO); 2024 [cited 2026 Mar 12]. Available from: <https://bhuvan-app1.nrsc.gov.in/thematic/thematic/index.php>
- [26] Survey of India. Survey of India Official Website [Internet]. Dehradun: Department of Science & Technology, Ministry of Science & Technology, Government of India; 2024 [cited 2026 Mar 12]. Available from: <https://surveyofindia.gov.in/>
- [27] Prasad D. Text book of remote sensing GIS and GPS. 1st ed. Rajesh publication; 2026.