Change Detection Using Sentinel-2 Optical Data for Urban Area (Dehradun)

1. Data Description

Two Sentinel-2 Level-2A (surface reflectance) products were used to assess urban and land-cover changes in **Dehradun**, complementing the Sentinel-1 SAR analysis. The Level-2A products provide atmospherically corrected Bottom-of-Atmosphere (BOA) reflectance values suitable for land-cover interpretation and spectral analysis.

Acquisition Date	Product Level	Spatial Resolution	Bands Used	Purpose
5 February 2016	L2A	10 m / 20 m	B2–B12	Baseline land-cover
24 March 2025	L2A	10 m / 20 m	B2–B12	Recent urban scenario

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2. Data Preprocessing

Preprocessing was conducted in **ESA SNAP** to prepare the optical data for analysis and change interpretation.

2.1 Unzipping and Loading

The downloaded .zip Sentinel-2 L2A products were extracted and opened in SNAP. Metadata and individual spectral bands were inspected to confirm data integrity and cloud coverage.

2.2 Subset Extraction

A spatial subset was created using the **Region of Interest (ROI)** corresponding to the **Dehradun** This reduced data volume and ensured focused analysis over the area of interest.

2.3 Band Resampling

Sentinel-2 bands have varying spatial resolutions (10 m, 20 m, 60 m). All relevant spectral bands were **resampled to 10 m** using the SNAP **Resampling Tool** to ensure uniform pixel size for multi-band composites.

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3. Band Combination and Visualization

3.1 False Color Composite (FCC)

An FCC was created using **Band 8 (NIR)**, **Band 4 (Red)**, and **Band 3 (Green)** in the 8-4-3 combination.
This composite enhances vegetation and built-up contrast:

- **Vegetation** appears in **bright red** due to high NIR reflectance.

- **Urban/built-up areas** appear in **cyan to gray tones**.

- **Bare soil and open land** appear in **brownish hues**.

This visualization was particularly effective for identifying changes in vegetation cover and urban expansion across the 2016 and 2025 datasets.

3.2 Land/Water Composite

Another composite was prepared using **Band 8 (NIR)**, **Band 11 (SWIR1)**, and **Band 4 (Red)** in the 8-11-4 combination.
This FCC highlights surface moisture and built-up features:

- **Water bodies** appear **dark blue or black** (strong absorption in NIR and SWIR).

- **Built-up areas** show **light blue to gray** due to higher reflectance in SWIR.

- **Vegetation** appears **greenish** depending on chlorophyll intensity.

These composites were visually compared between 2016 and 2025 to detect major land-cover transitions.

4. Spectral Interpretation and Change Indicators

Spectral reflectance patterns were analyzed to differentiate land-cover types:

Land Cover Type	Typical Appearance in 8-4-3	Typical Appearance in 8-11-4	Interpretation
Vegetation	Bright red	Green	Healthy vegetation
Urban/Built-up	Cyan/Gray	Light blue/ gray	Impervious surfaces
Water Bodies	Cyan	Dark Blue	Surface water

In general, **urban or built-up areas exhibit higher reflectance in the SWIR and Red bands**, while **vegetation reflects strongly in NIR**.
By comparing 2016 and 2025 composites, the spread of **light blue/gray areas** (built-up) at the expense of **red/green areas** (vegetation) indicates **urban expansion**.

5. Change Observation and Analysis

Visual comparison of both years shows significant transformation in the land surface characteristics of Dehradun:

- **2016 Scene:** The core urban area was limited to the central valley, with extensive vegetation along the foothills and agricultural plains.

- **2025 Scene:** The extent of built-up regions increased markedly toward the **southern and eastern peripheries**, visible as expanded cyan and light gray zones in FCCs.

- **Decline in Vegetation:** Areas previously bright red (dense vegetation) in 2016 appears duller or replaced by gray tones in 2025, suggesting **loss of green cover** due to construction and development.

- **Stable Water Features:** Water bodies (dark blue) showed minimal spatial change, indicating consistent hydrological conditions over the period.
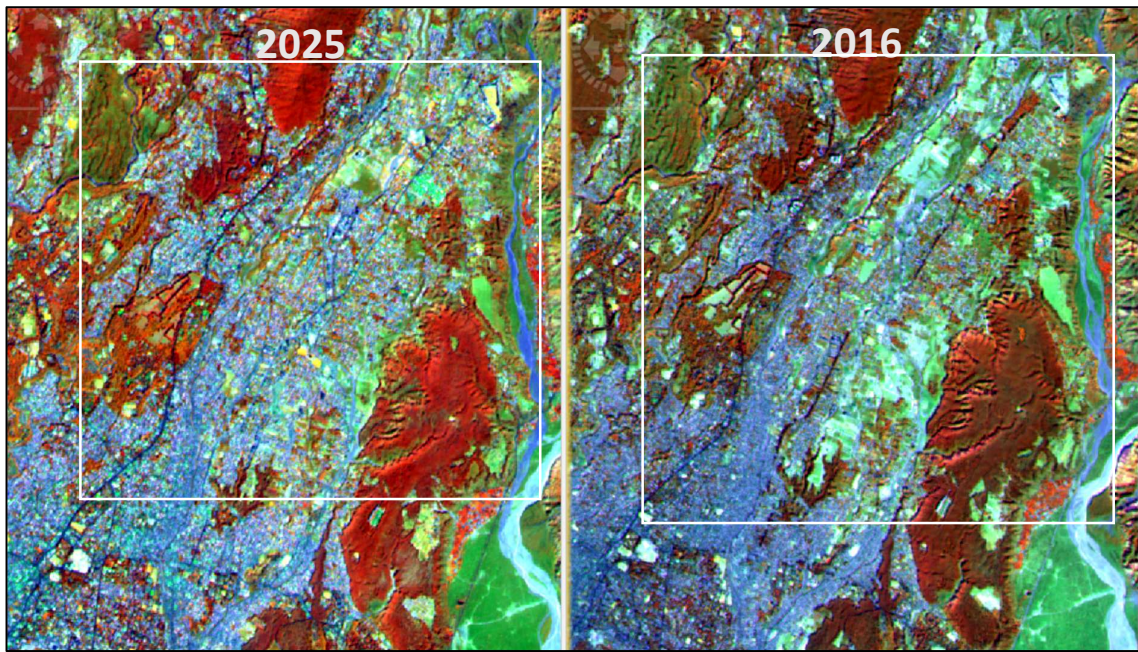
The combination of **8-4-3** and **8-11-4** composites provided a strong visual and spectral basis for differentiating **urban, vegetation, and water surfaces**, enabling reliable interpretation of land-cover change.
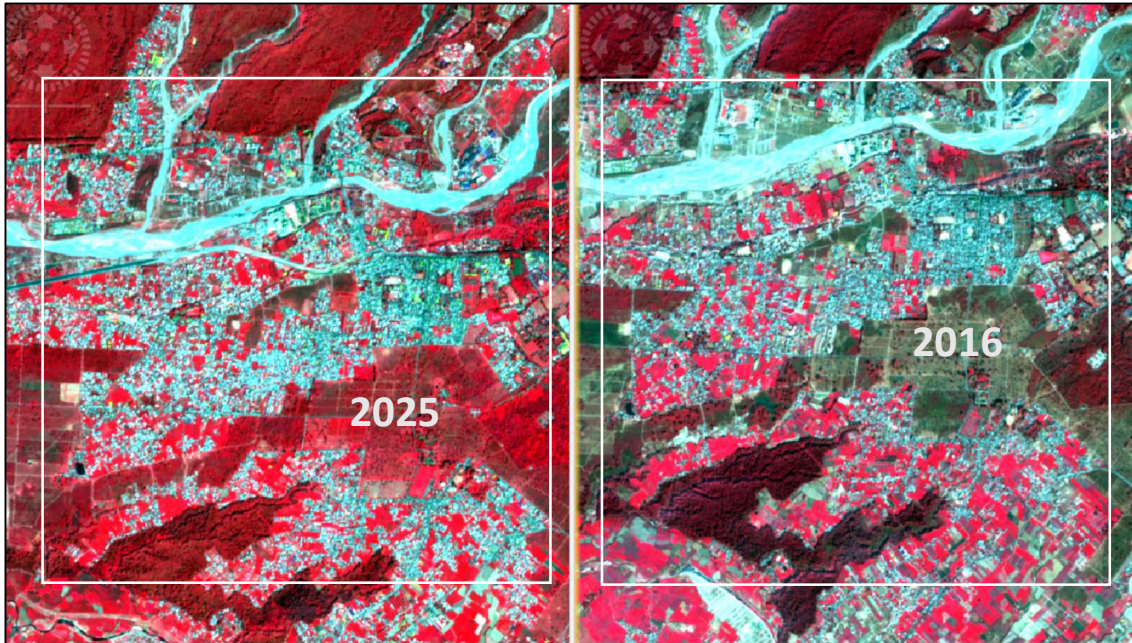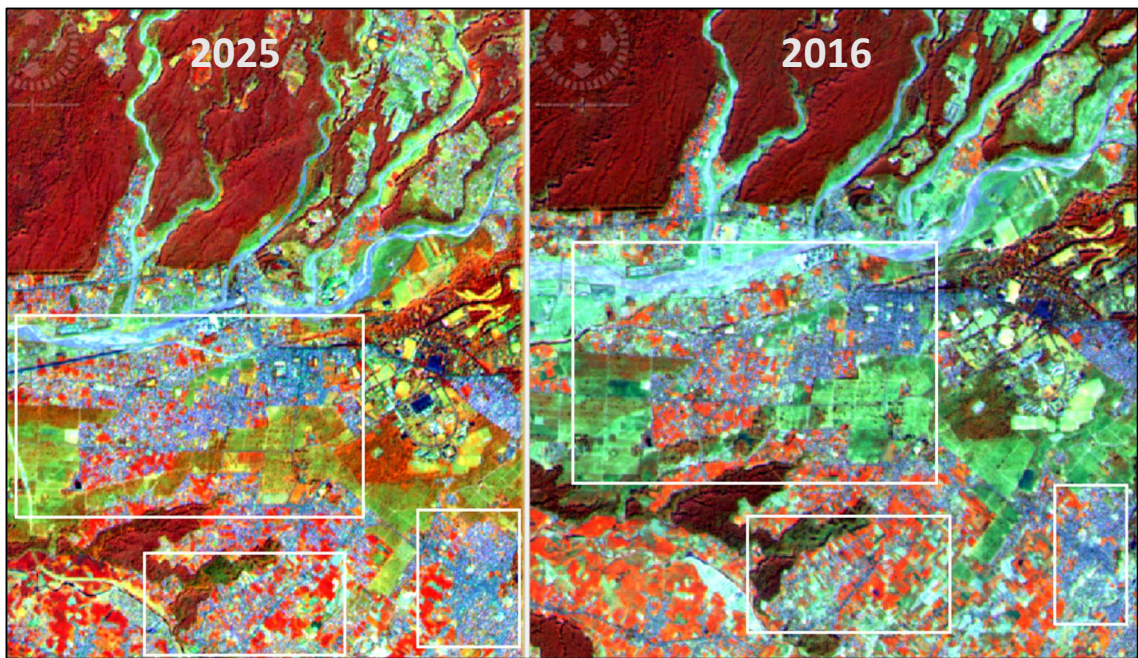

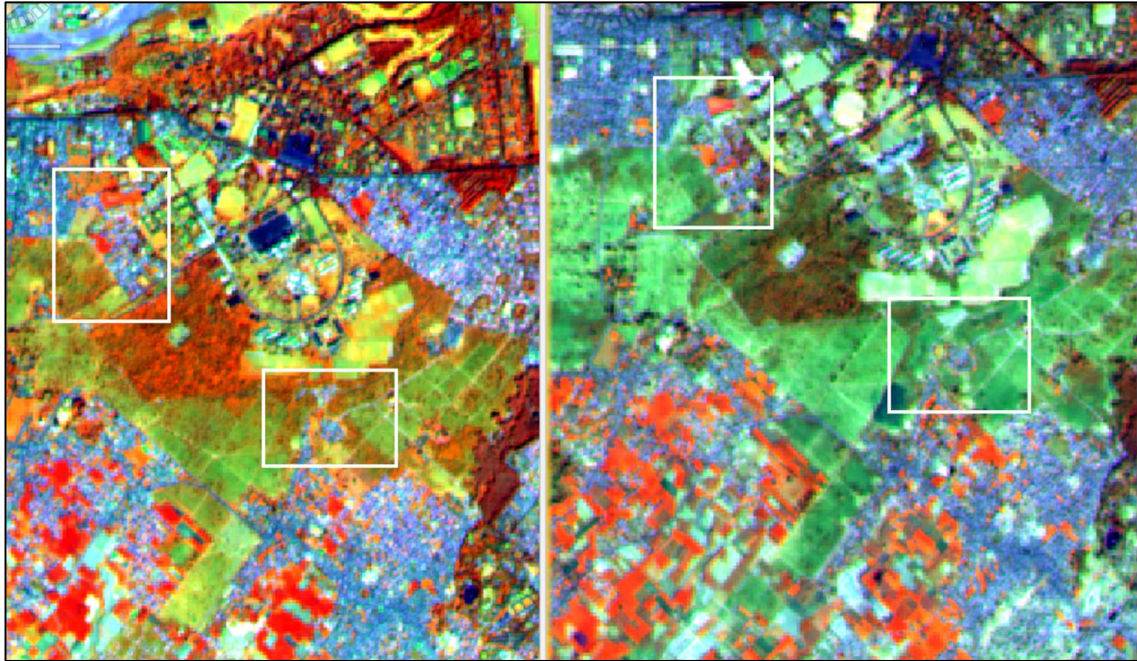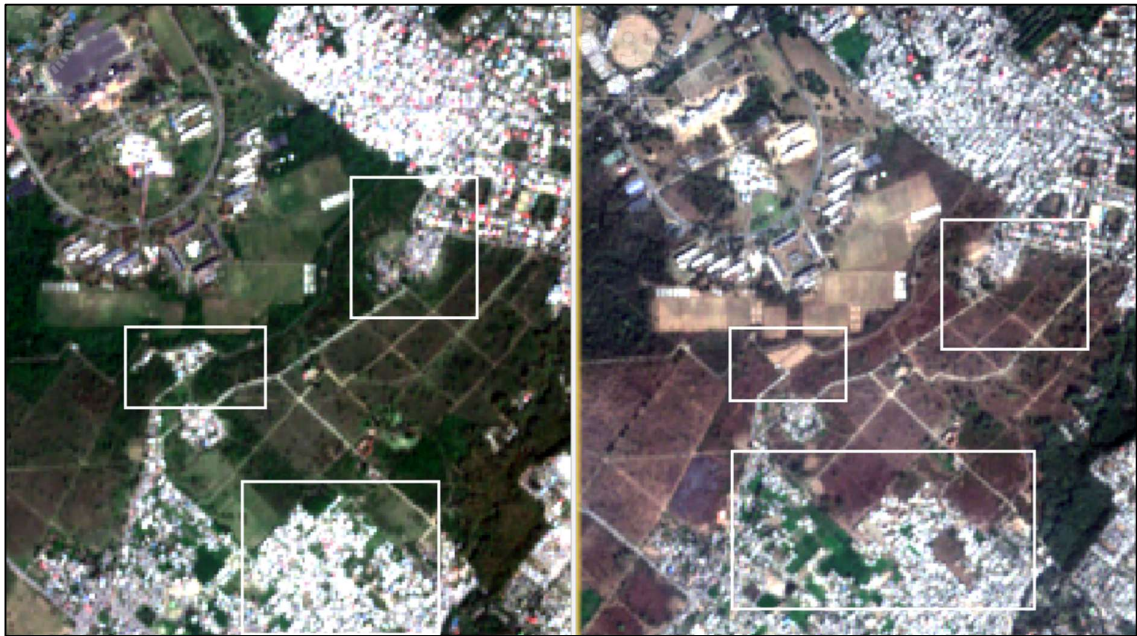FCC 1- R-Band8, G-Band4, B-Band3
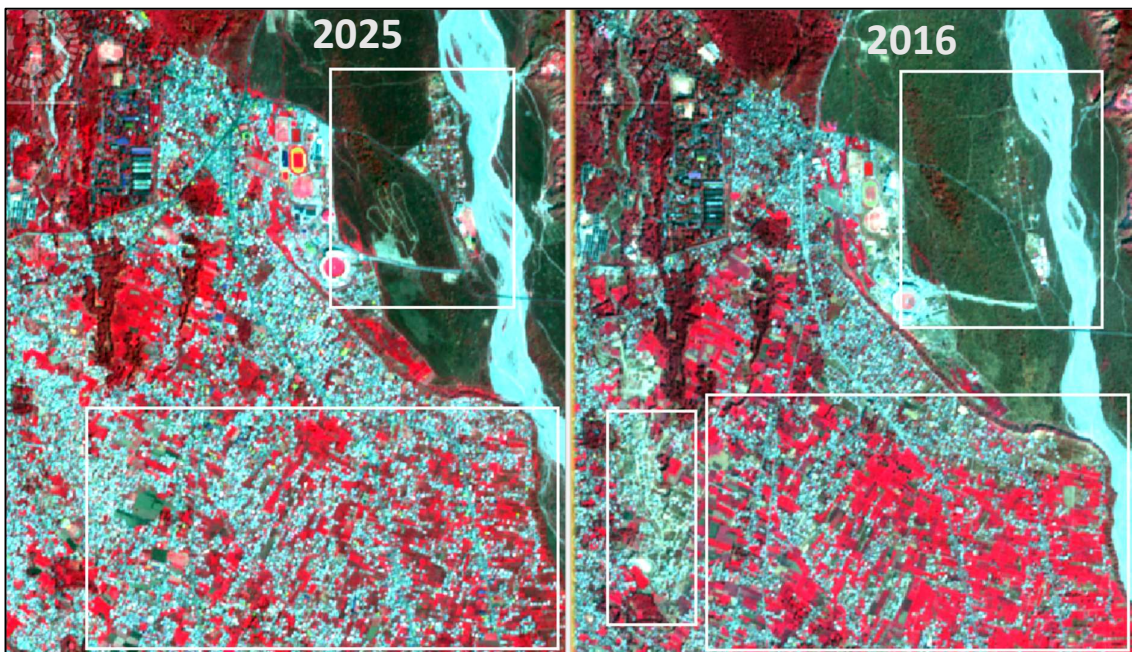
FCC 2- R-Band8, G-Band4, B-Band3

FCC 3- R-Band8, G-Band11, B-Band4

FCC 4- R-Band8, G-Band11, B-Band4

FCC 5- R-Band8, G-Band11, B-Band4

RGB 4- R-Band4, G-Band3, B-Band2

6. Interpretation Summary

From the Sentinel-2 analysis, it was observed that:

- **Built-up reflectance increased** significantly in the NIR–SWIR bands between 2016 and 2025, confirming **urban growth**.

- **Vegetation reflectance (NIR)** declined in peripheral areas, consistent with **loss of green cover**.

- The FCC comparison revealed **expansion of impervious surfaces**, especially along **transport corridors and new residential zones**, mirroring the patterns detected in the Sentinel-1 SAR analysis.