Vegetation Change Detection Using Multi-Temporal Sentinel-2 NDVI (Punjab–Haryana Agricultural Region)

1. Introduction

Vegetation monitoring is a key application of Earth observation for agricultural assessment. Satellite-derived vegetation indices such as NDVI enable consistent and large-scale monitoring of crop health and seasonal dynamics.
This study demonstrates vegetation change detection using multi-temporal Sentinel-2 imagery over the Punjab–Haryana agricultural belt.

2. Study Area

The study area covers cropland-dominated regions of Punjab, Haryana, and the western Delhi NCR. This region exhibits strong seasonal crop cycles dominated by rabi crops such as wheat, making it well-suited for NDVI-based analysis.

3. Data Used

Sentinel-2 Level-2A

- Spatial resolution: 10 m (Red, NIR)
- Dates selected based on minimal cloud cover:
  - **23 Feb 2023** – peak vegetative growth
  - **22 Apr 2023** – maturity / harvest stage
- Bands:
  - Red (B04)
  - Near Infrared (B08)
  - Scene Classification Layer (SCL)

Only required bands were downloaded to optimize data volume and processing.

4. Methodology

4.1 Preprocessing

- Scene Classification Layer was resampled from 20 m to 10 m using nearest-neighbor resampling.
- Clouds, cloud shadows, and invalid pixels were masked using SCL.

- Less than **0.1%** of pixels were masked, ensuring high data reliability.

4.2 NDVI Computation

NDVI was computed as:

NDVI = (NIR − Red) / (NIR + Red)
Cloud-masked NDVI maps were generated for both dates.

4.3 Change Detection

Vegetation change was assessed using NDVI differencing:

ΔNDVI = NDVI (April) − NDVI (February)

A threshold of **±0.15** was applied to classify:

- No significant change
- Vegetation increase
- Vegetation decrease

4.4 Geolocation Accuracy

Sentinel-2 Level-2A products are orthorectified and georeferenced with sub-pixel positional accuracy. All derived NDVI and change products retain the original spatial reference and alignment, making them suitable for GIS-based analysis and visualization.

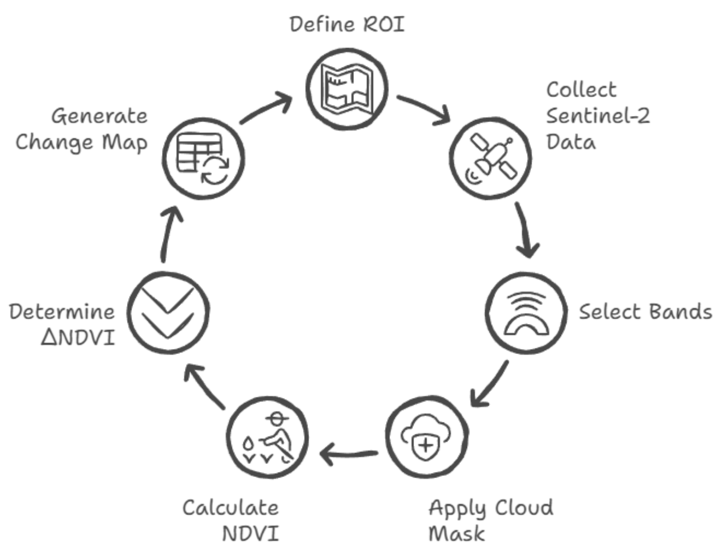

Figure 1. Methodology

5. Results

- Mean NDVI decreased from **~0.66 (February)** to **~0.16 (April)**.
- ΔNDVI maps show widespread negative change across croplands.
- Classified change mask highlights dominant vegetation decrease, consistent with harvesting activity.

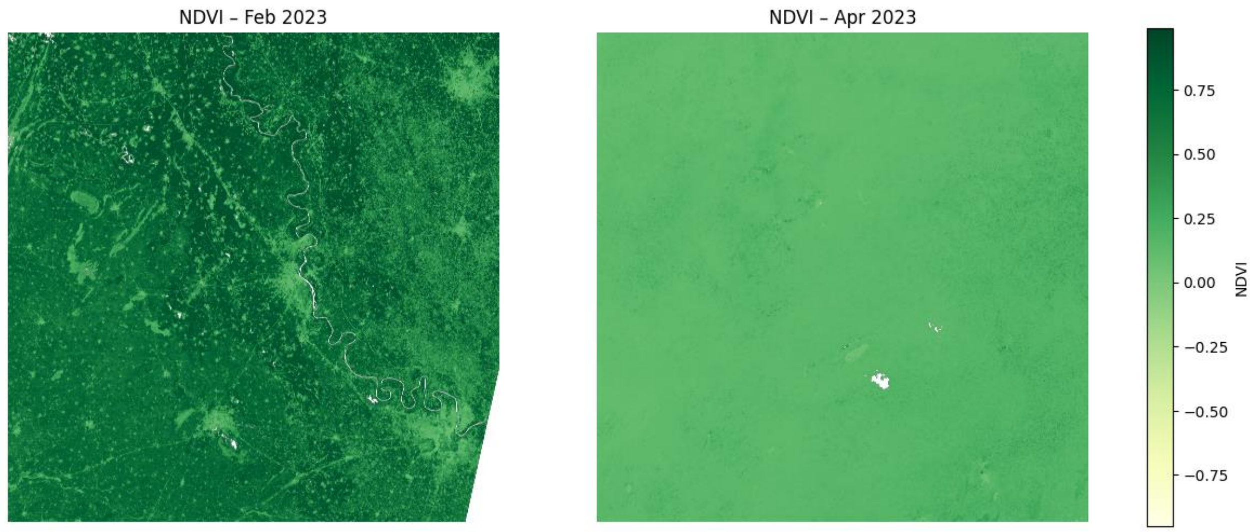

Figure 2. NDVI map for February 2023 showing dense and healthy vegetation during peak rabi growth,NDVI map for April 2023 showing reduced vegetation greenness due to crop maturity and harvesting.

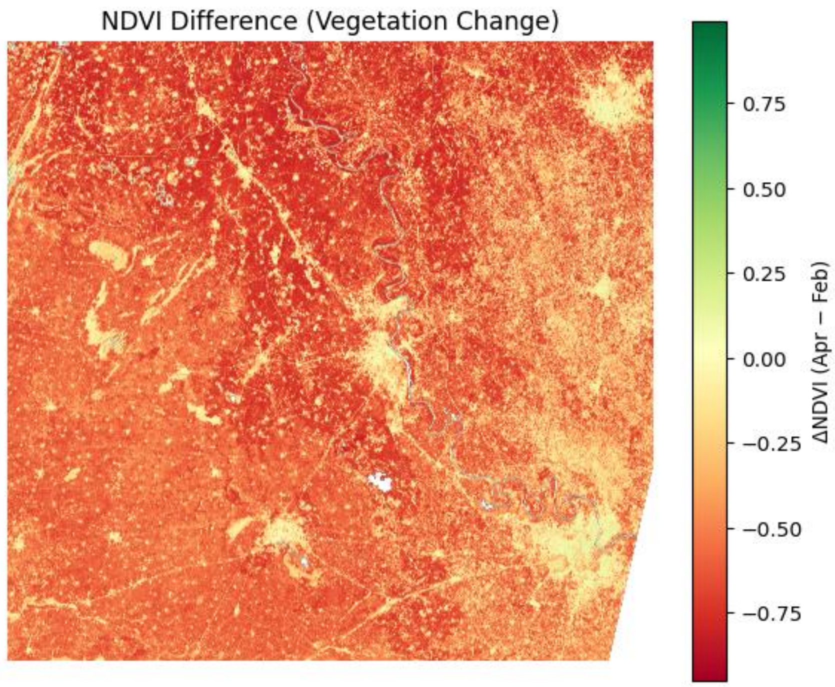

Figure 3. NDVI difference (April − February) highlighting widespread vegetation decline across croplands.

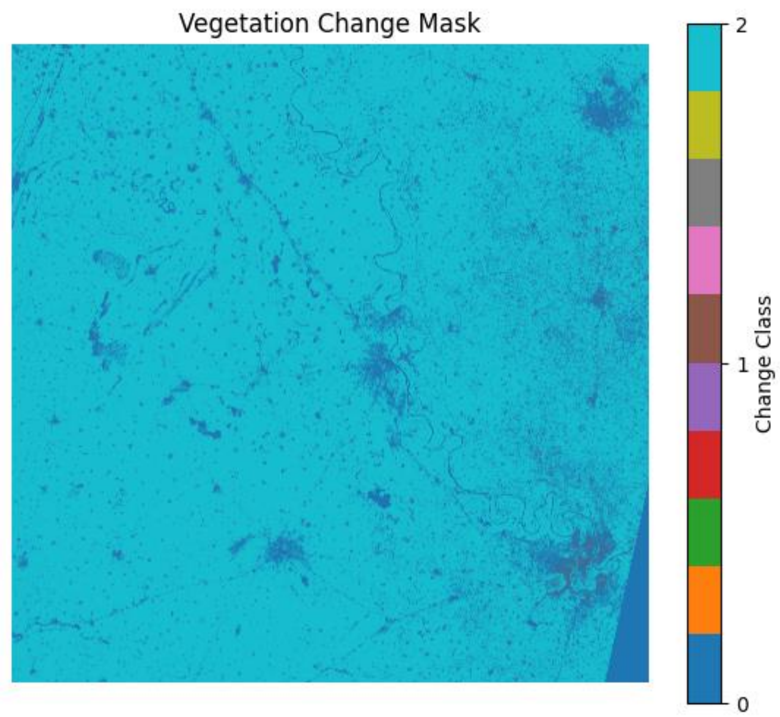

Figure 4. Classified vegetation change mask showing dominant vegetation decrease across the study area.

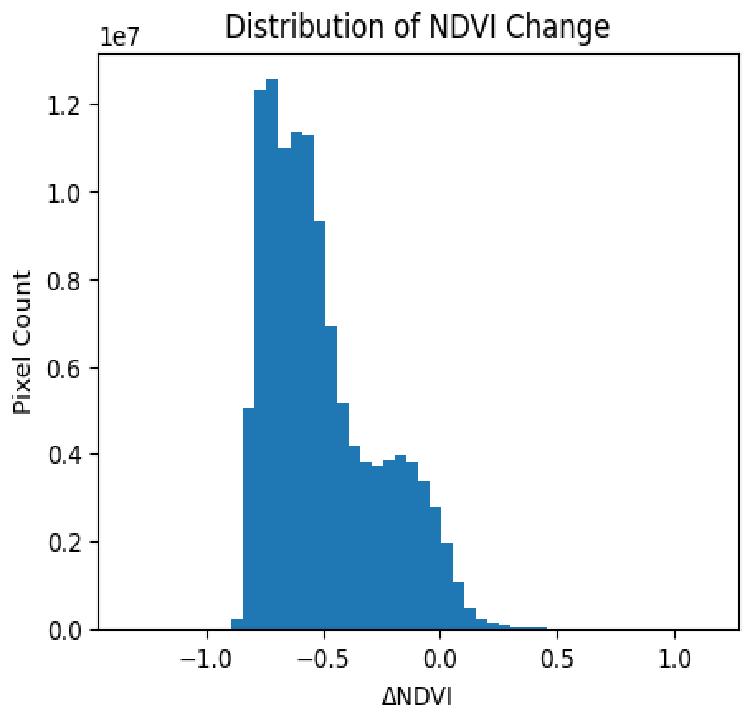

Figure 5. Distribution of NDVI change values indicating dominance of negative vegetation change.

Potential false detections may occur due to crop rotation, mixed pixels at field boundaries, or soil exposure after harvest. However, minimal cloud masking (<0.1%) and consistent seasonal patterns reduce the likelihood of spurious change detection.

6. Discussion

The observed NDVI decline reflects crop maturation and harvesting cycles typical of the Punjab–Haryana region. The results highlight the importance of phenological context when interpreting vegetation indices. NDVI differencing proved effective for detecting large-scale seasonal vegetation change.

7. Conclusion

This study presents a simple, interpretable, and efficient workflow for vegetation change detection using Sentinel-2 NDVI. The approach generates GIS-ready outputs suitable for agricultural monitoring and can be extended to multi-sensor or multi-temporal analysis.

While this study focuses on optical NDVI-based change detection, the workflow can be naturally extended to incorporate SAR backscatter for cloud-robust multi-sensor analysis.