COMPARATIVE ASSESSMENT OF VEGETATION CONDITION IN AGRICULTURAL LANDS OF FERGANA REGION USING SENTINEL-2 AND LANDSAT 8–9 NDVI

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Abstract

This paper compares vegetation condition in irrigated agricultural lands of the Fergana Region (Uzbekistan) using NDVI derived from Sentinel-2 MSI and Landsat 8–9 OLI imagery. NDVI maps were generated for June 2025, a key period of crop development in the valley. A unified processing workflow was implemented in ArcGIS Pro: scene screening for low cloud cover, radiometric conversion to reflectance (using Level-2 products where available), cloud/invalid-pixel masking, band compositing, and clipping to the regional boundary. The resulting NDVI rasters were compared visually and through simple spatial diagnostics to evaluate (i) the clarity of field boundaries, (ii) within-field heterogeneity, and (iii) consistency of high/low vegetation zones. Both sensors reproduce the regional pattern of vegetation vigor; however, Sentinel-2 provides substantially clearer field-scale detail due to its 10 m red and NIR bands, while Landsat 8–9 (30 m) shows smoother NDVI surfaces and is more suitable for retrospective and long-term analyses because of its long archive. The study confirms that a multi-sensor approach can improve operational agricultural monitoring in fragmented irrigated landscapes.

Keywords: remote sensing; NDVI; Sentinel-2; Landsat 8–9; Fergana Region; agricultural monitoring; vegetation index.

1. Introduction

Irrigated agriculture in the Fergana Valley is highly productive but also sensitive to water availability, soil salinity, and management practices. These factors can change rapidly during the growing season, making regular, spatially explicit monitoring important for decision-making. Field surveys provide detailed information but are costly and difficult to conduct frequently across large and heterogeneous areas.

Satellite remote sensing offers repeatable observations of crop canopies at regional scale. Vegetation indices computed from multispectral imagery are widely used to approximate canopy greenness, biomass development, and photosynthetic activity. Among them, the Normalized Difference Vegetation Index (NDVI) remains a standard indicator because it leverages the strong absorption of red radiation by chlorophyll and the high reflectance of near-infrared radiation related to internal leaf structure (Rouse et al., 1973; Tucker, 1979). NDVI theoretically ranges from −1 to +1, with negative values typically associated with water and clouds, values near zero with bare soil and built-up surfaces, and higher values with denser, healthier vegetation.

In the Fergana Region, croplands are often organized in narrow strips and fragmented field mosaics. Under such conditions, spatial resolution becomes critical: coarse pixels frequently mix vegetation and non-vegetation components, which can dampen NDVI extremes and blur field boundaries. Sentinel-2 provides 10 m sampling for the red and near-infrared bands used in NDVI, whereas Landsat 8–9 provides 30 m sampling for these bands. This study therefore focuses on how these resolution differences affect NDVI-based interpretation in irrigated agricultural lands.

The objective of this study is to compute NDVI from Sentinel-2 and Landsat 8–9 for June 2025 and to compare the resulting products in terms of spatial detail, within-field variability, and consistency of vegetation patterns. The findings are intended to support practical guidance on selecting satellite sources for agricultural monitoring in the Fergana Region.

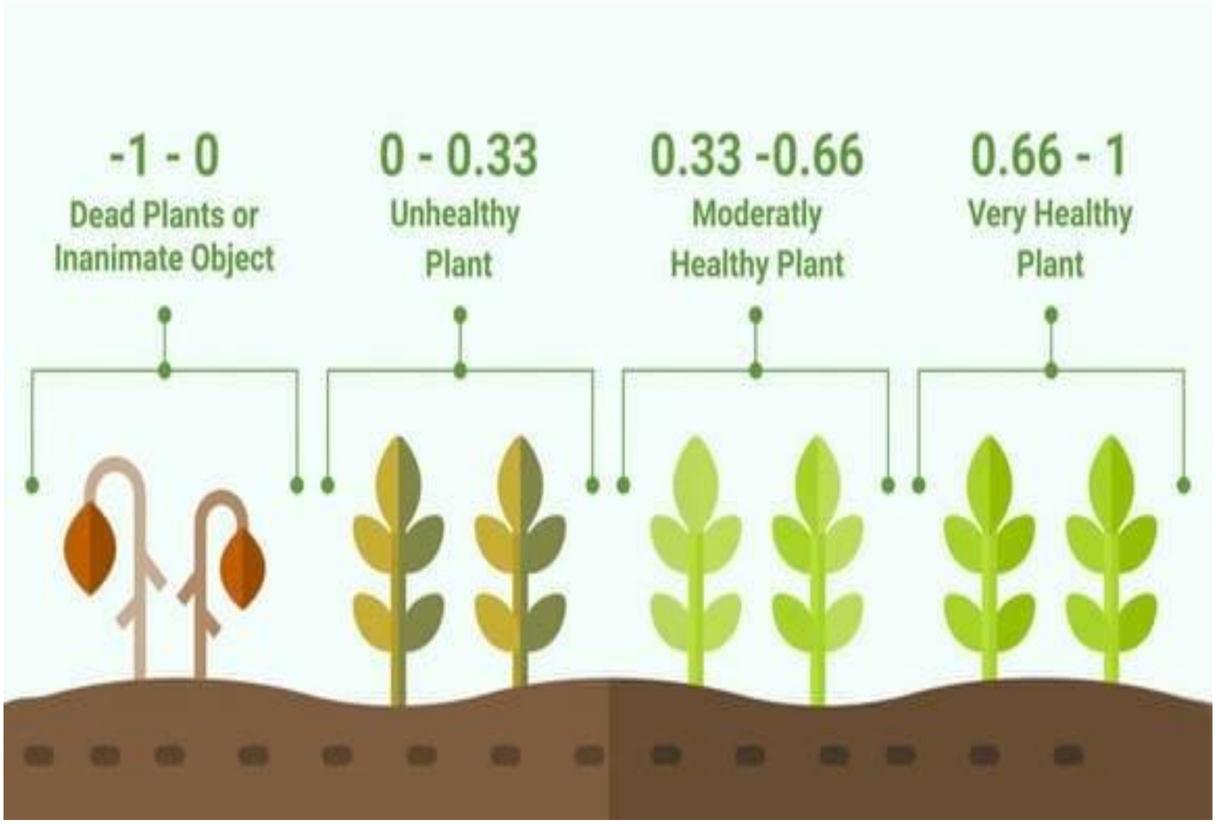

Figure 1. Conceptual interpretation of NDVI values.

2. Materials and Methods

2.1. Study area

The study area covers the Fergana Region in eastern Uzbekistan. The region is bordered by Namangan and Andijan Regions and shares international boundaries with the Kyrgyz Republic and the Republic of Tajikistan. Agriculture is dominated by irrigated cropping systems (e.g., cotton, cereals, maize, and horticultural crops), supported by major canal networks and the Syr Darya basin. Climatic conditions are continental with hot, dry summers; irrigation is therefore a key driver of vegetation development during the peak season (June–July). Soil types include sierozem (gray desert) soils and alluvial deposits, with local salinization affecting crop vigor in some areas (Kuziev & Sektimenko, 2009).

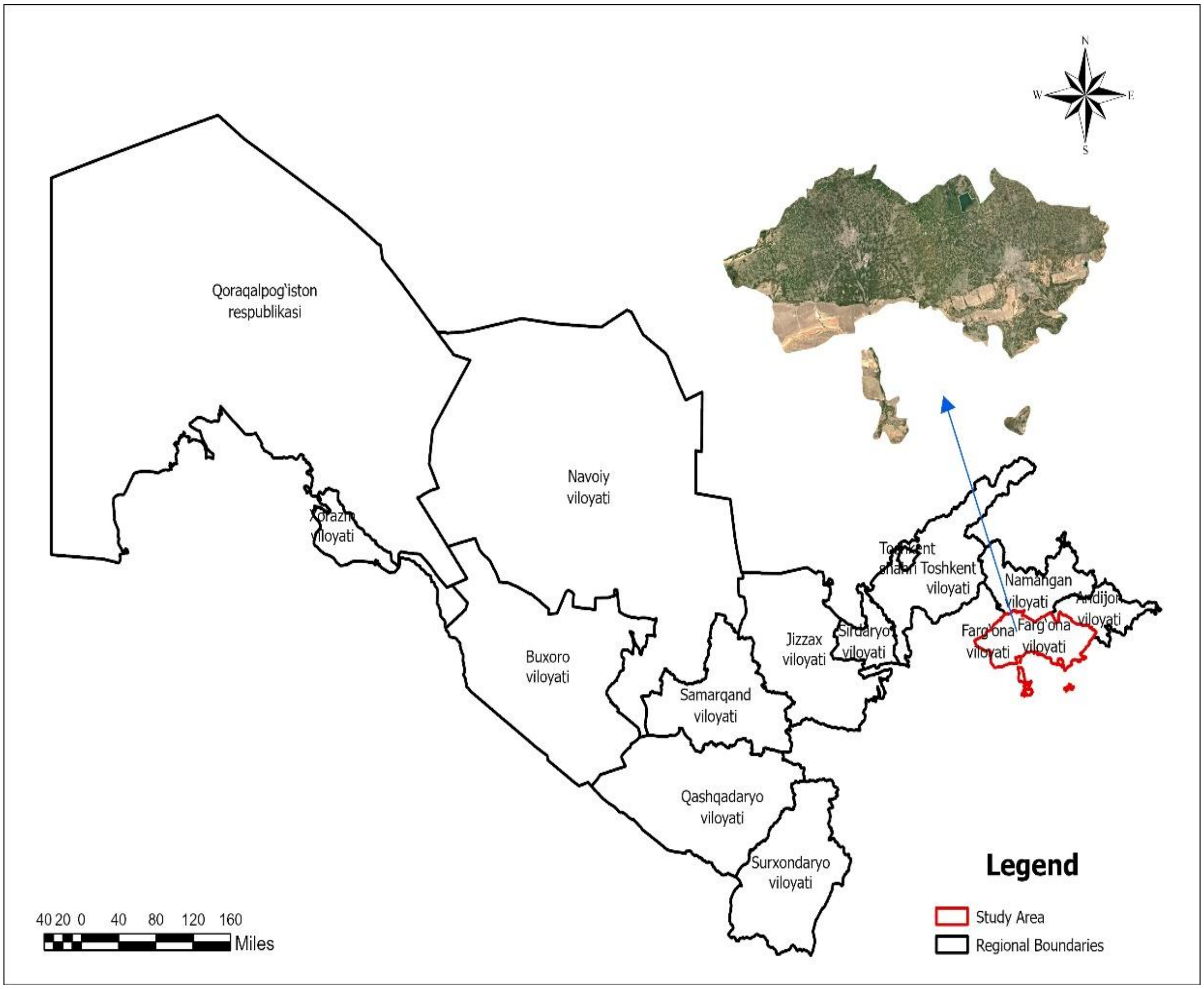

Figure 2. Study area (Fergana Region, Uzbekistan).

2.2. Data sources and preprocessing

Multispectral imagery from Sentinel-2 (MSI) and Landsat 8–9 (OLI) was used to assess vegetation condition in June 2025. For Sentinel-2, NDVI-relevant bands were the red band B04 and the near-infrared band B08 (10 m). For Landsat 8–9, NDVI was computed using the red band (Band 4) and near-infrared band (Band 5) (30 m). Scenes were selected to minimize cloud contamination and to represent comparable phenological conditions within the month (USGS, 2015; ESA, 2021).

Preprocessing was conducted in ArcGIS Pro and included: (i) conversion to reflectance and use of surface-reflectance products where available, (ii) masking of clouds and invalid pixels using quality information, (iii) band stacking/compositing for NDVI input bands, and (iv) clipping to the administrative boundary of the Fergana Region. All rasters were handled in a common projection for mapping. To avoid misleading visual differences, NDVI rasters were displayed using a harmonized color scheme and fixed value range during side-by-side comparison.

2.3. NDVI computation

NDVI was computed per pixel using the standard expression:

NDVI = (NIR − Red) / (NIR + Red).

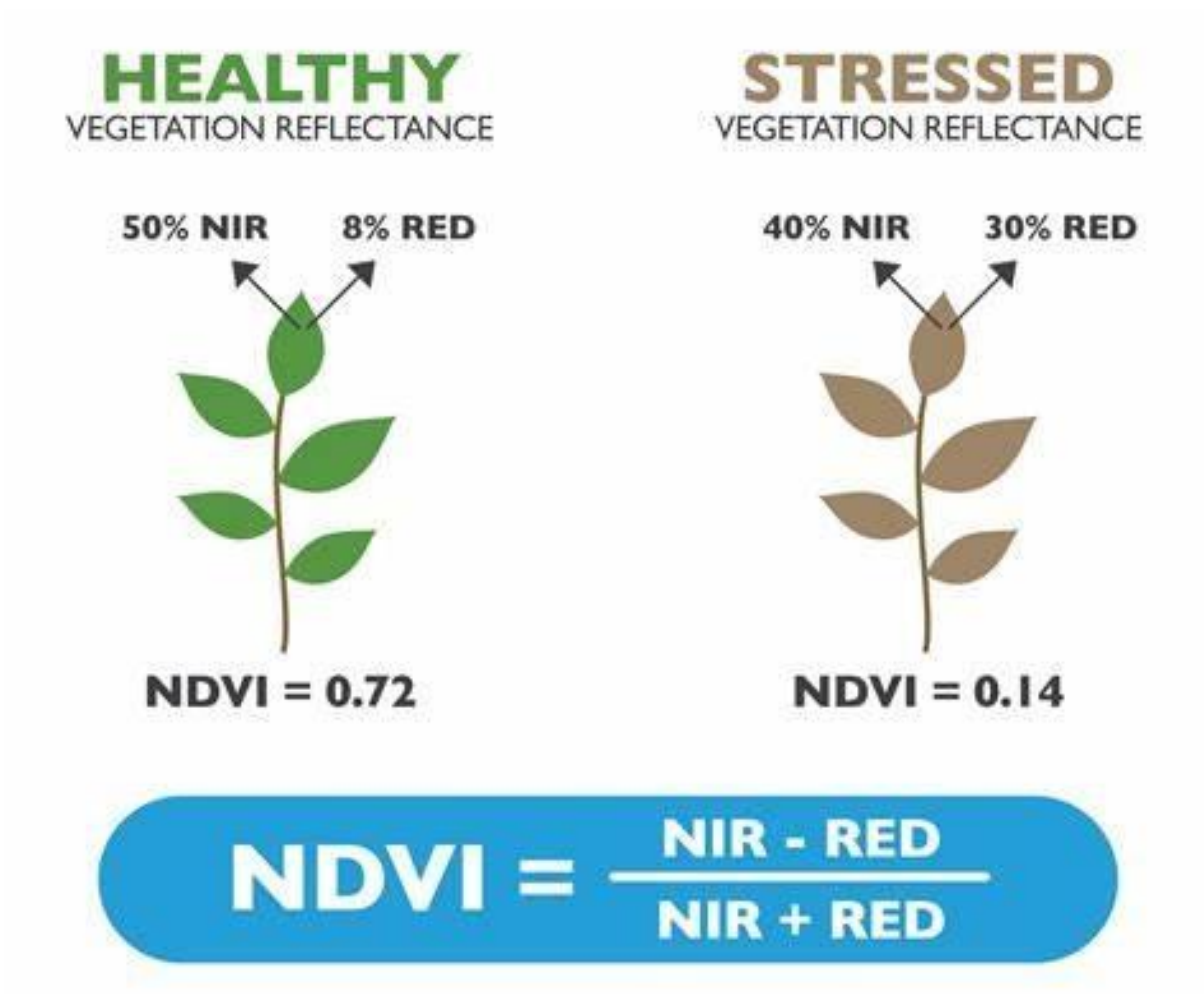

Figure 3. NDVI formula used in this study: NDVI = (NIR - Red) / (NIR + Red).

In ArcGIS Pro, the Raster Calculator (Spatial Analyst) was used to implement the equation and generate continuous NDVI rasters for each sensor. Sentinel-2 NDVI used B08 (NIR) and B04 (Red); Landsat 8–9 NDVI used Band 5 (NIR) and Band 4 (Red).

2.4. Thematic mapping and comparative assessment

For interpretation and reporting, NDVI values were grouped into five classes: water/non-vegetated (−1.0 to 0.0), sparse vegetation (0.0 to 0.2), moderate vegetation (0.2 to 0.4), high vegetation (0.4 to 0.7), and very high vegetation (>0.7). Comparative assessment focused on: (a) delineation of field boundaries, (b) visibility of within-field variability, and (c) spatial agreement of high and low NDVI zones between sensors. Differences were interpreted in relation to pixel size, spectral response, acquisition timing, and preprocessing choices.

3. Results and Discussion

3.1. Spatial patterns of NDVI in June 2025

Both Landsat 8–9 and Sentinel-2 NDVI maps show pronounced spatial differentiation across the Fergana Region. High NDVI values cluster in irrigated croplands with active canopy development, while lower values occur over bare soil, recently harvested or fallow fields, and non-agricultural surfaces such as settlements and transport corridors. The observed pattern matches the biophysical interpretation of NDVI, where healthy vegetation combines strong NIR reflectance with low red reflectance (Rouse et al., 1973; Tucker, 1979).

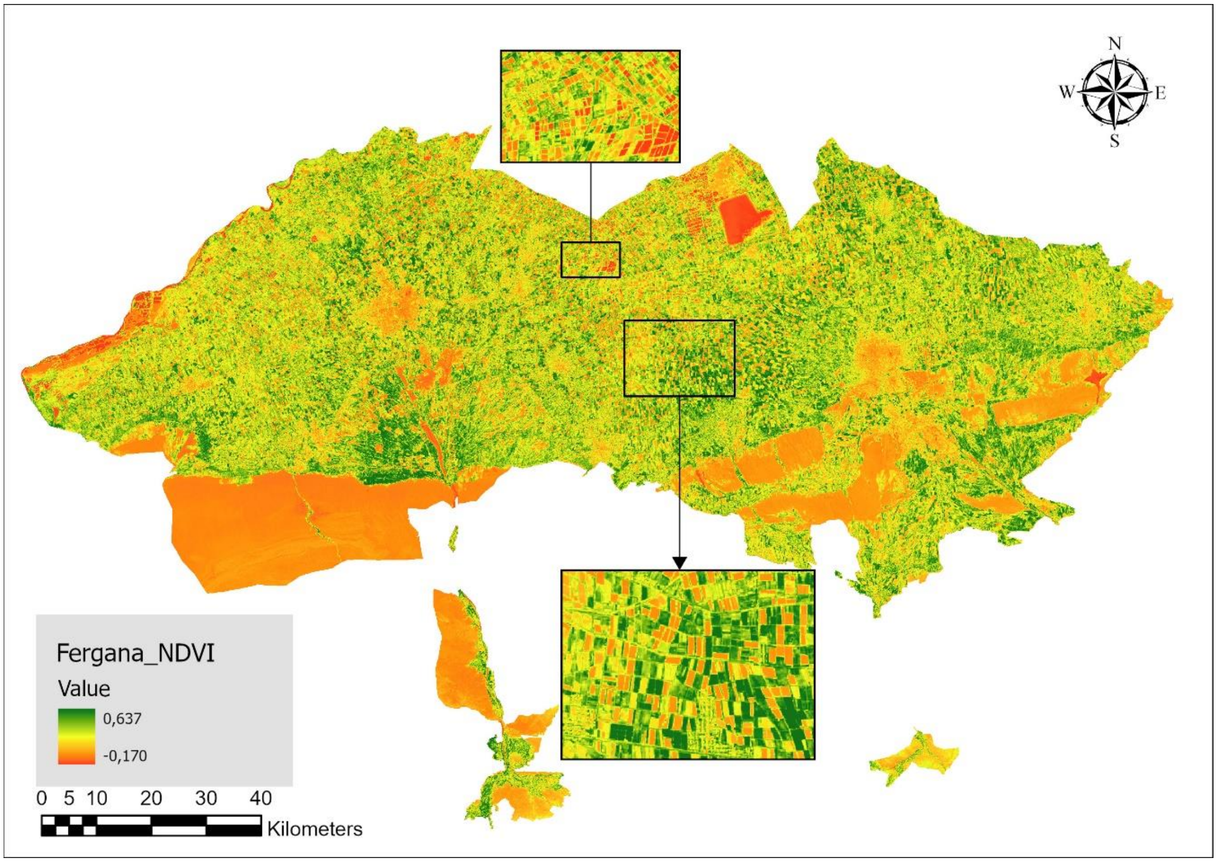

Figure 4. NDVI map derived from Landsat 8-9 imagery for June 2025 (study area subset).

3.2. Comparison of Sentinel-2 and Landsat 8–9 NDVI products

Despite overall agreement in the regional distribution of vegetation vigor, the two sensors differ in the level of spatial detail. Sentinel-2 NDVI reveals clearer field boundaries and internal gradients within fields. This is primarily a resolution effect: 10 m pixels reduce mixing between vegetation and adjacent features (field edges, irrigation ditches, narrow roads), whereas 30 m Landsat pixels more often contain a mixture of land-cover components. As a consequence, Landsat NDVI appears smoother and may underestimate local extremes in fragmented cropland mosaics typical of the Fergana Valley.

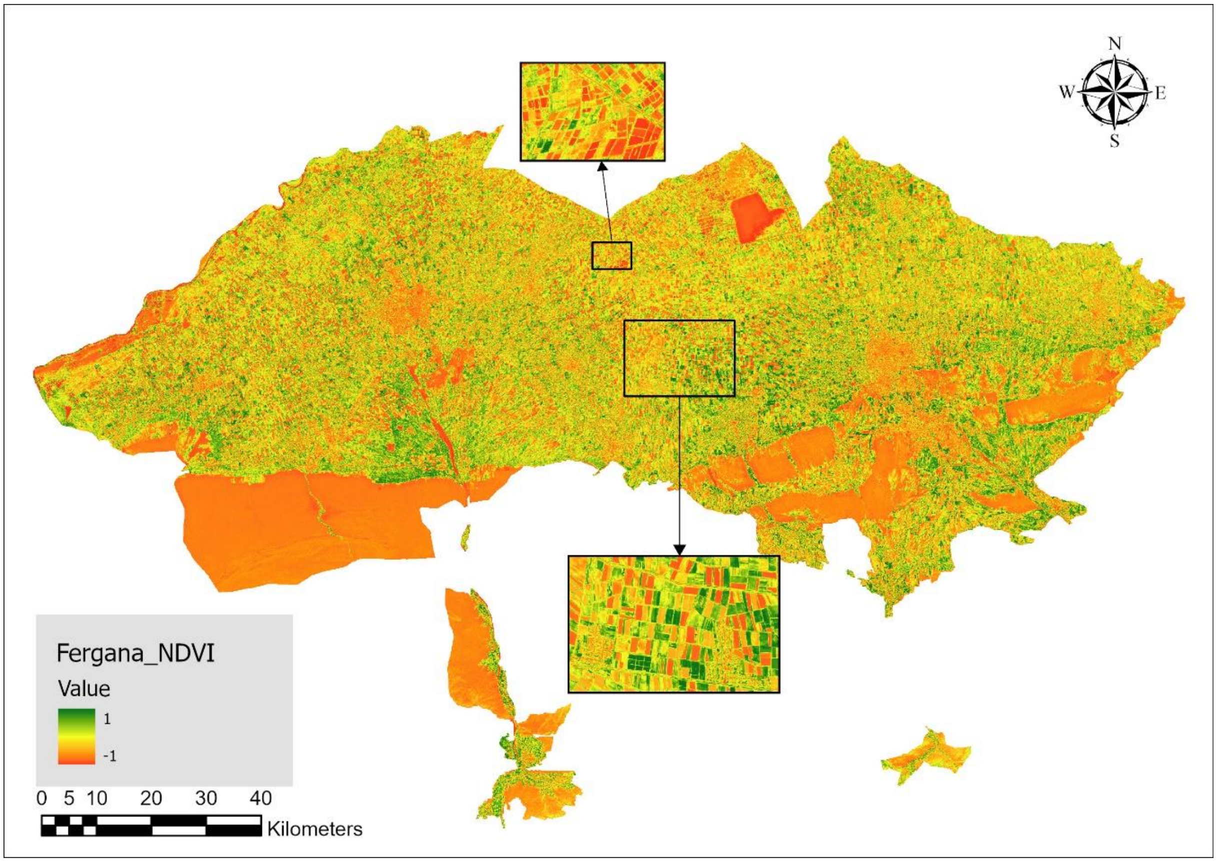

Figure 5. NDVI map derived from Sentinel-2 imagery for June 2025 (study area subset).

Differences in NDVI values between sensors are expected even over the same location. The red and NIR bands are not spectrally identical across missions (central wavelength and bandwidth differ), which can introduce small but systematic deviations in the ratio. In addition, exact acquisition dates within June 2025 may not coincide, and short-term changes in irrigation, crop development, or management can alter canopy reflectance. Finally, the choice of atmospheric correction level, cloud masking, and raster display settings (stretching and value range) can influence the appearance of NDVI maps. Therefore, strict quantitative inter-comparison should rely on harmonized surface reflectance products, temporally matched scenes, and standardized resampling and visualization procedures.

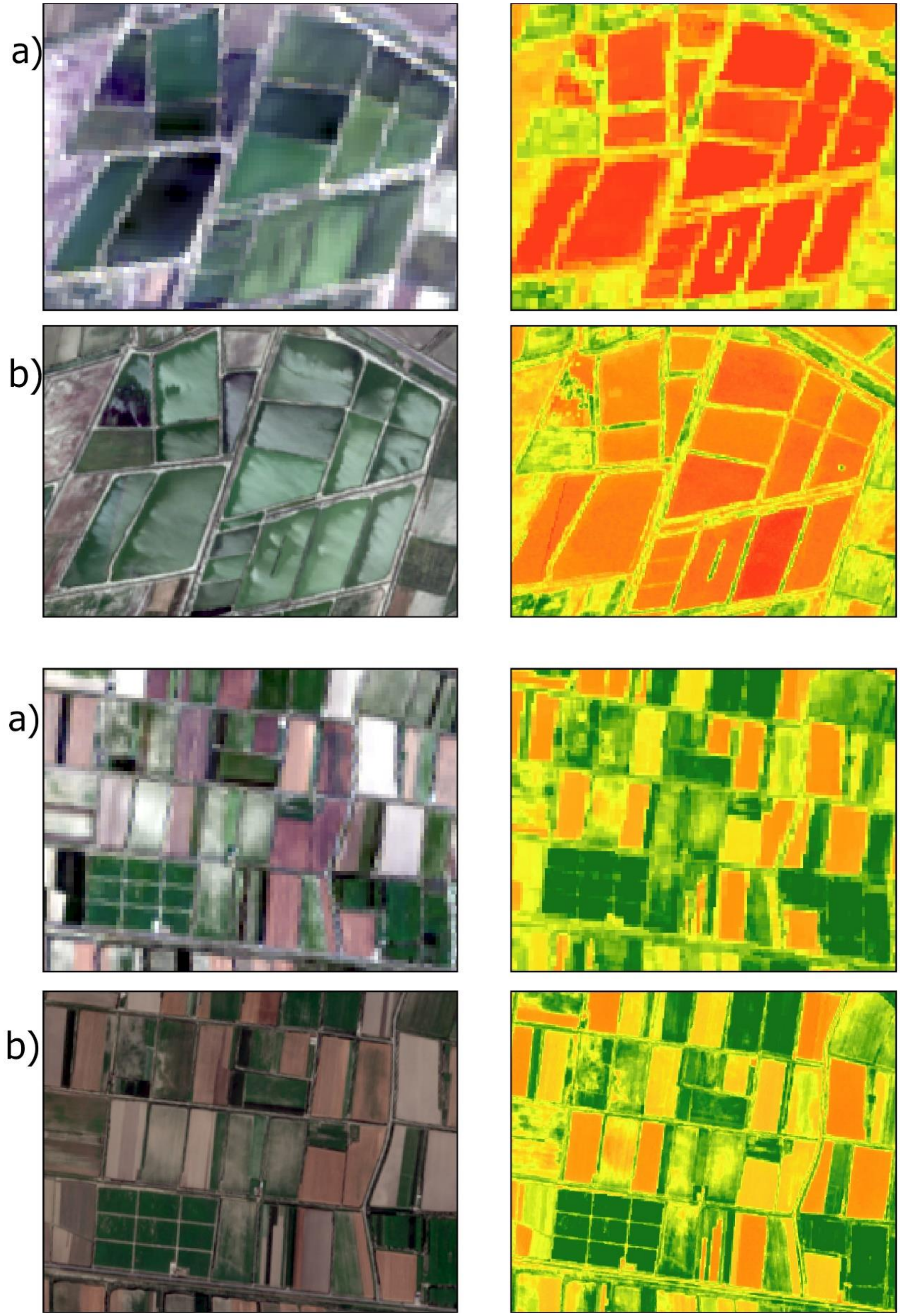

Figure 6. Side-by-side comparison of RGB and NDVI visualizations for Landsat (a) and Sentinel-2 (b).

4. Conclusion

NDVI-based assessment of irrigated agricultural lands in the Fergana Region for June 2025 shows that both Sentinel-2 and Landsat 8–9 are capable of capturing the main spatial pattern of vegetation vigor. Sentinel-2 provides superior field-scale representation due to 10 m sampling in the NDVI input bands, which improves delineation of fragmented cropland mosaics and within-field heterogeneity. Landsat 8–9 products are spatially coarser but remain highly valuable for retrospective studies and long-term vegetation dynamics because of the continuity of the Landsat archive. Future work should strengthen sensor comparability by using harmonized surface reflectance data, selecting temporally matched acquisitions, and reporting quantitative statistics (e.g., mean/median NDVI by district or crop type) alongside maps. In the fragmented irrigated landscape of the Fergana Region, the choice of sensor materially affects field-scale NDVI patterns. Sentinel-2 (10 m) resolves sharper NDVI gradients at field boundaries and small parcels and therefore tends to preserve more within-field variability and extreme values, whereas Landsat 8–9 (30 m) more often mixes vegetation with bare soil, canals/roads, and built features within a single pixel, leading to smoother NDVI surfaces. For operational crop-condition screening and short-term management, Sentinel-2 is therefore preferable, while Landsat 8–9 remains essential for consistent multi-year baselines and long-term trend analyses (ESA, 2021; USGS, 2015).

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