Digital Farming: Free Satellite Imagery & NDVI Maps

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The power of satellite imagery for modern farming

Generations of farmers have relied on keen observation, hard-earned experience, and instinct to cultivate the land. While those qualities remain important, the world of agriculture is changing fast. With rising input costs, unpredictable weather patterns, and increased demand for higher yields, new tools are emerging to support and strengthen farmers. For example, satellite imagery gives an overhead view of the entire field and reveals what human eyes on the ground may miss, enabling farmers to see exactly where crops are under stress related to water, soil issues, or pest at an earlier stage.

What is satellite imagery, and how does it work?

Satellite imagery captures Earth using sensors on orbiting satellites. These sensors collect data across the visible and infrared spectrum, which is processed into detailed images showing crop health, soil conditions, and more. These tools do not require technical expertise. Today, many satellite data providers, agricultural service providers and apps make these images available in user-friendly formats.

Why should you use satellite imagery?

Practical benefits of using satellite imagery include saving time and money, reducing chemical use by applying inputs only where needed, spotting stressed crops early and taking corrective action before it is too late. As agriculture becomes more data-driven, making better planting, fertilizing, and harvesting decisions based on real-time data, identifying drainage problems or overly dry areas quickly, comparing field performance and get insights on field variability with help of satellite imagery, will result in increased yields, improved soil and water management. Table 1 shows the several spectral band wavelengths and use in agriculture.

Table 1. Spectral band wavelength and use in agriculture.

Band	Wavelength (nm)	Use in Agriculture
Blue	450–495	Soil background, chlorophyll absorption
Green	520–560	Vegetation vigor, green biomass
Red	620–750	Chlorophyll absorption, plant stress
NIR	750–950	Vegetation structure, biomass

For example, a satellite derived metric product like NDVI (Normalized Difference Vegetation Index) is a numerical index that uses red and near-infrared (NIR) reflectance to determine vegetation greenness, to estimate plant health, vigor, and photosynthetic activity. NDVI is derived from the light reflected in the red and NIR bands as:

$$\mathrm{NDVI} = \frac{\mathrm{NIR}-\mathrm{Red}}{\mathrm{NIR}+\mathrm{Red}} \quad (1)$$

NDVI values close to +1 (e.g., 0.72) indicate healthy, green vegetation and close to 0 (e.g., 0.14) indicate stressed vegetation, bare soil, or other non-vegetated surfaces (Fig. 1).

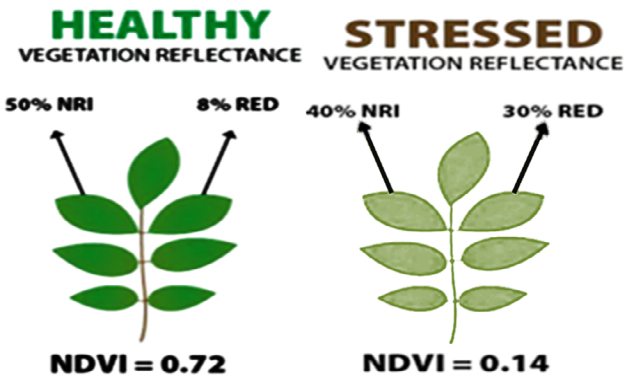

Figure 1. Left side (HEALTHY): 50% NIR and 8% Red reflectance with NDVI = 0.72 (healthy vegetation), Right side (STRESSED): 40% NIR and 30% Red reflectance with NDVI = 0.14 (stressed vegetation).

NDVI information has many applications in agriculture, including monitoring crop health, detecting drought stress, identifying disease in vegetation, and can be used to help farmers perform precision agriculture practices.

Getting started: Using resources more efficiently and sustainably.

Although some may be hesitant about adopting new technologies, getting started using satellite imagery is now a simple process. Data providers like Sentinel Hub offer free trials suitable for farms of any size. Many smallholder farmers are already using this type of information to combat drought and increase yields, often with just a smartphone. Free and open-access Sentinel-2 data is publicly available, supporting a wide range of global research and practical applications in agriculture, environmental monitoring, and more. The Sentinel-2 mission, launched by the European Space Agency (ESA), provides high-resolution multispectral images of Earth's surface through its Multispectral Instrument (MSI). The captured images with different spectral bands, including visible, near-infrared (NIR), and shortwave infrared (SWIR) wavelengths, allow us to observe vegetation health, soil moisture, and crop conditions that are invisible to the human eye. Sentinel-2 (A and B) provide high-resolution (10 m, which refers to a pixel size of 10 × 10 meters) images, where individual Sentinel-2 revisits the same spot about every 10 days. However, Sentinel-2A and Sentinel-2B work together and revisit the same location approximately every five days, enabling continuous surface monitoring. Sentinel-2A and Sentinel-2B with MSI key spectral bands (10 m) for calculating NDVI offer repeated, wide-area observations using specific wavelengths of light.

Step-by-Step Guide to Download Sentinel Satellite NDVI Images

1. Visit the Copernicus Open Access Hub website
    - To download the sentinel satellite images, go to the website by clicking on this link: browser.dataspace.copernicus.eu/
    - This website provides free access to European Space Agency (ESA) satellite images.
2. Sign-up and log-in
    - Click on green color Register option to create an account if you are a new user (Fig. 2).
    - Fill in your details (name, country, email, password, etc.) on the popped form and create a username and password.
    - Check your email for a confirmation link and verify your account and return to the website and click on Log In. Enter your username and password to enter in the main environment (Fig. 3).

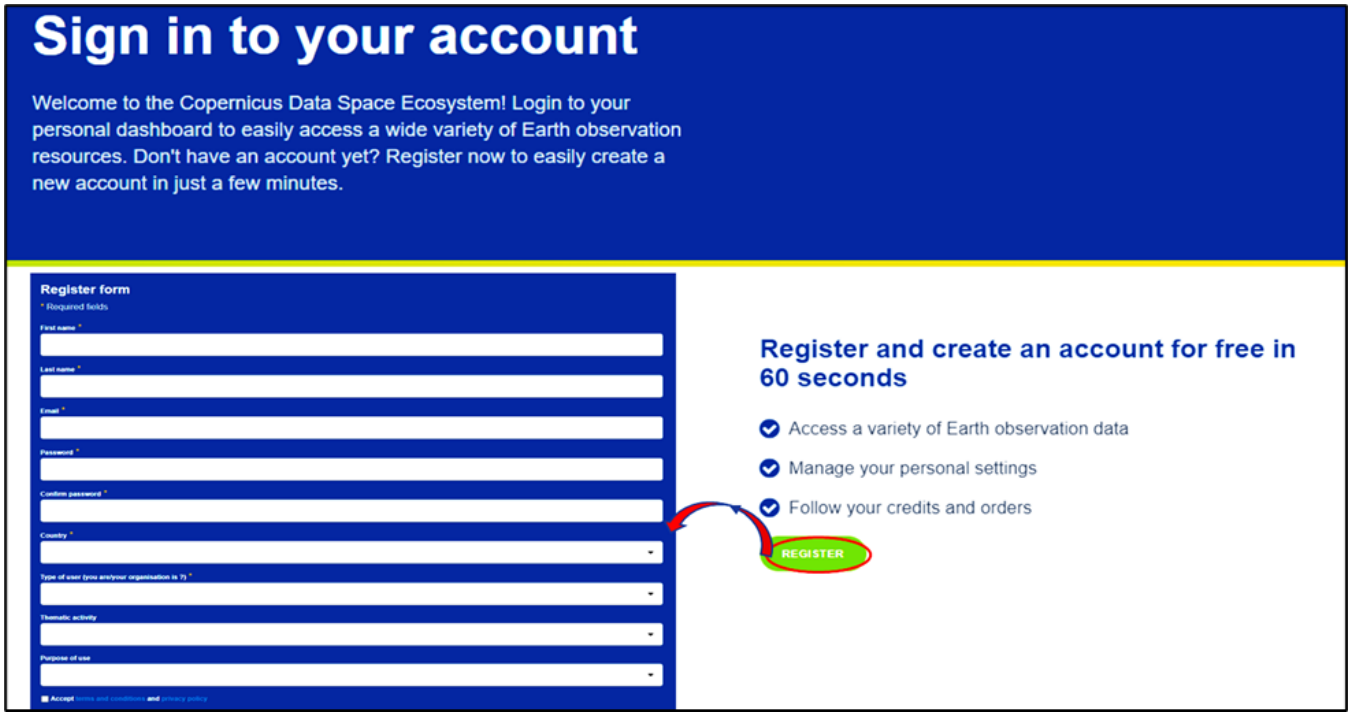

Figure 2. Registration page to create account.

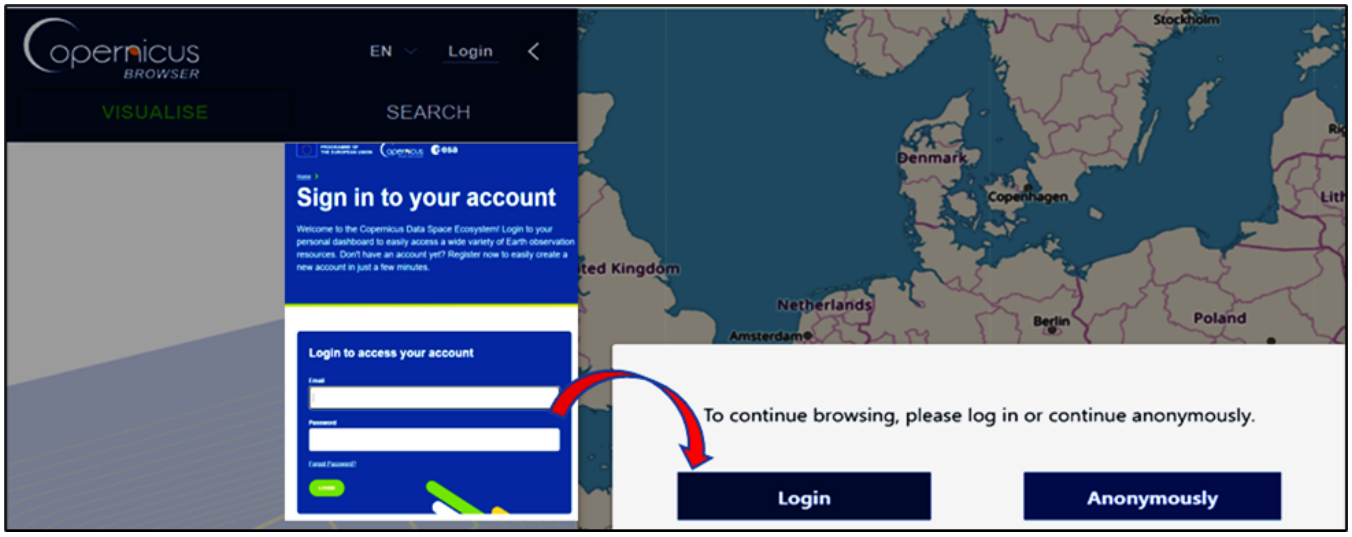

Figure 3. Page to sign in to your account.

3. Choose your area of interest (AOI)
    - Once logged in, use the mouse to pan and zoom to your area of interest AOI (Fig. 4).
    - Draw the rectangle over the area of interest by clicking on polygon symbol

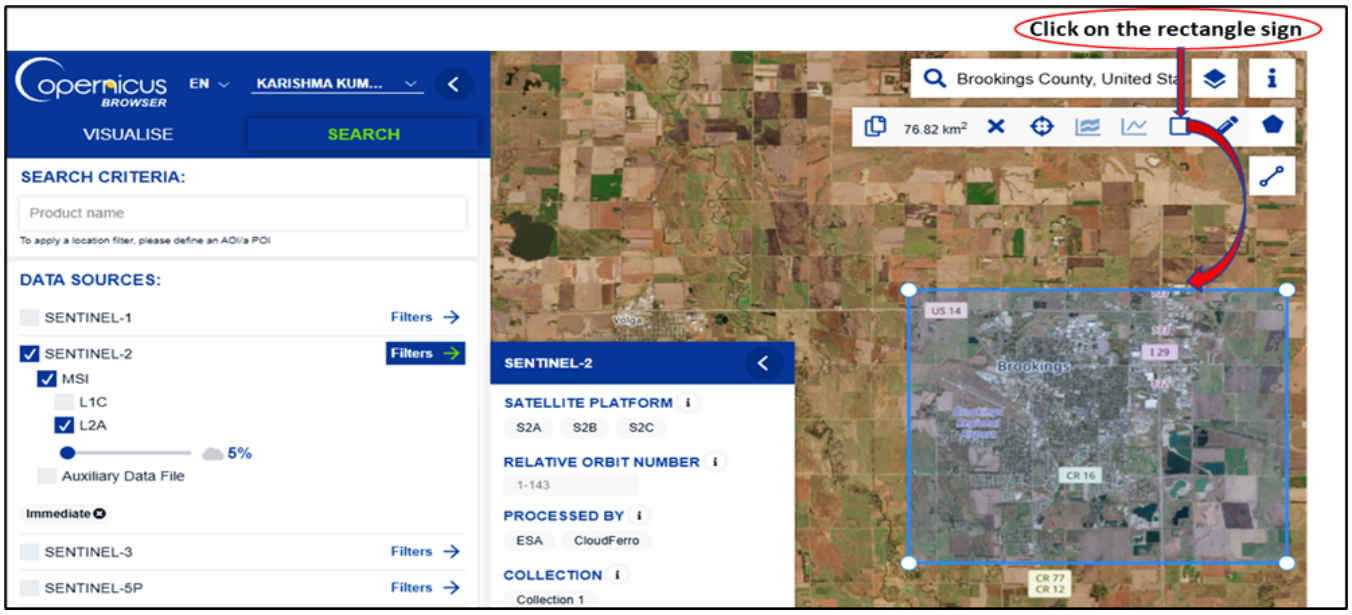

Figure 4. Page to search for images for a specific location by defining an Area of Interest (AOI).

4. Search for images
    - Click on the Search tab in the top menu (Fig. 5).
    - Use the filters (Data sources tab) on the left side of the screen to refine your search:
        - Time Range: Select a date range (from and until) to find recent images.
        - Mission: Choose Sentinel-2 (NDVI) for land images.
        - Cloud Cover: Set it to 5% for clear images.
    - Click the Search button, and a list of available images will appear.

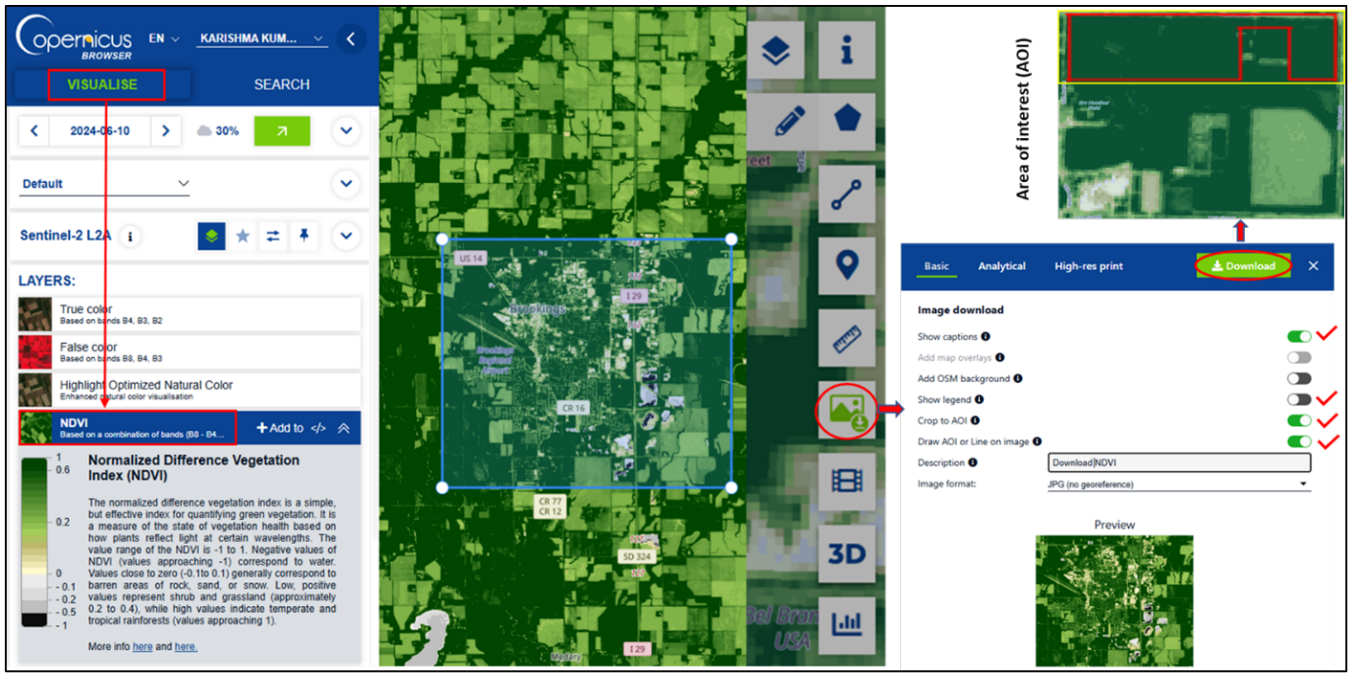

Figure 5. Page to filter and select images based on several criteria.

5. Select the best image
    - Look through the results and pick an image with <5% cloud cover.
    - Click on the view options to see its preview and metadata
    - Check the Product Info and ensure the image meets the needs.
6. Visualize and download the direct NDVI Image
    - Click on the Visualize tab to access the NDVI layer option.
    - Check the NDVI image while focusing on the Area of Interest (AOI).
    - Click on the Gallery icon with the Download symbol.
    - Enable all relevant options to ensure high-quality output and select the file format.
    - Finally, click on the Download button to save the image.
7. Steps to process indirect NDVI using MSI bands
    - Load the data: Open QGIS and import the Red and NIR bands of your satellite data (Fig. 6).
    - Access the raster calculator: Navigate to the raster calculator tool within QGIS. This tool allows you to perform mathematical operations on raster datasets.
    - Enter the NDVI formula: In the raster calculator, input the NDVI formula using the Red and NIR bands. Ensure the order of bands is correct for subtraction.
    - The formula for input is: (NIR - Red) / (NIR + Red)
    - Save the result: Designate an output file for your NDVI result, preferably saving it as a TIFF file for optimal compatibility.

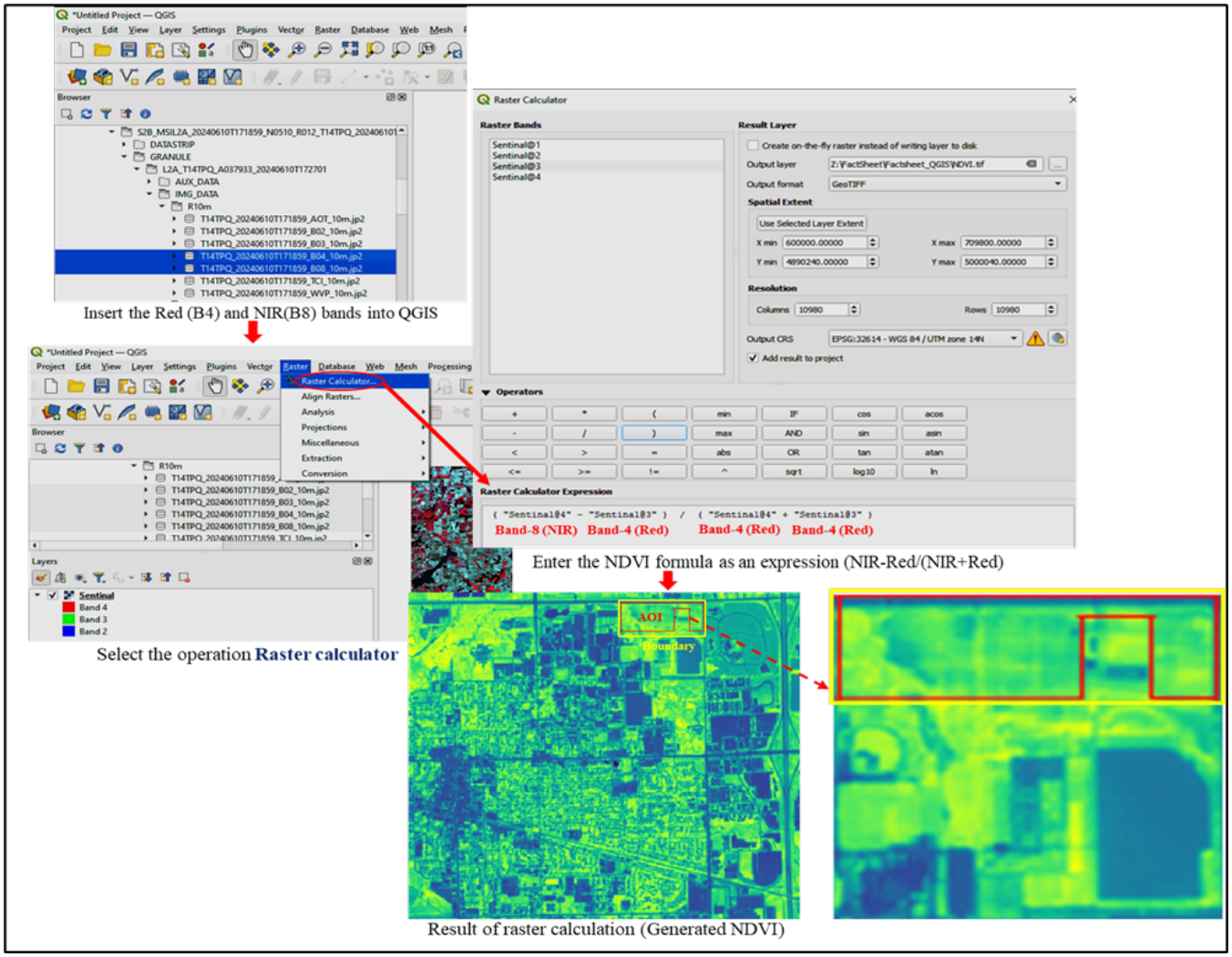

Figure 6. Using QGIS to create an NDVI map.

Visualizing the NDVI Result in QGIS

Adjust symbology and interpret the results: Once the NDVI calculation is complete, you can adjust the symbology to better visualize the values. Use color ramps to differentiate between high (healthy vegetation) and low (sparse or no vegetation) NDVI values. Areas with high NDVI values indicate healthy, green vegetation. Low NDVI values, especially those close to -1, often represent water bodies, as water absorbs near-infrared light (Fig. 7).

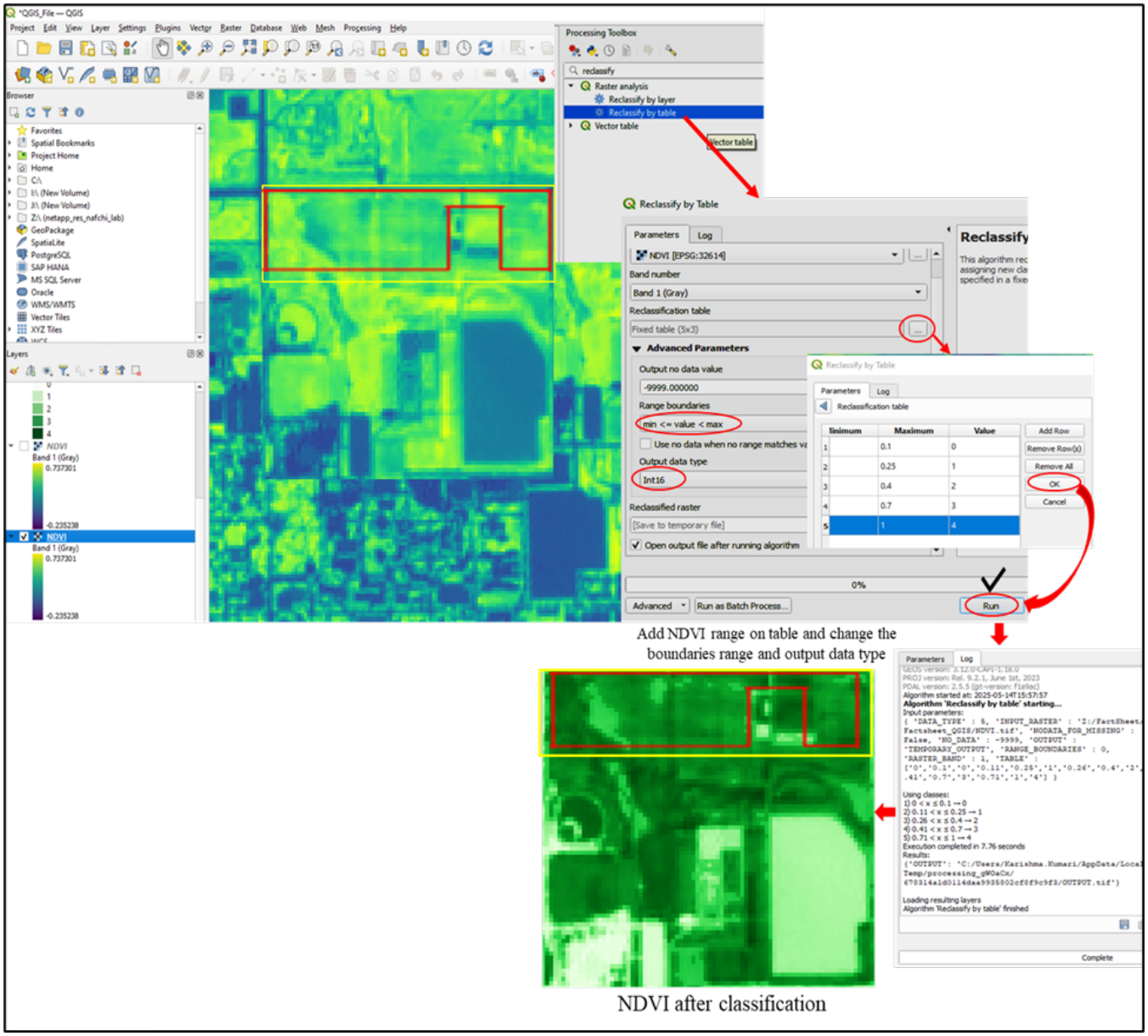

Figure 7. Example of using QGIS to visualize and adjust the NDVI results. The study area (28 acres) is located at South Dakota State University (Plant Path North/P1-P4) in Brookings County, South Dakota (coordinates: 44.325482 to 44.323224 N, -96.776982 to -96.768311 E).

Example 1: Direct download of NDVI from the Sentinel Hub

NDVI was directly downloaded from Sentinel Hub EO Browser using pre-processed Sentinel-2 NDVI imagery (10 m resolution) (Fig. 8).

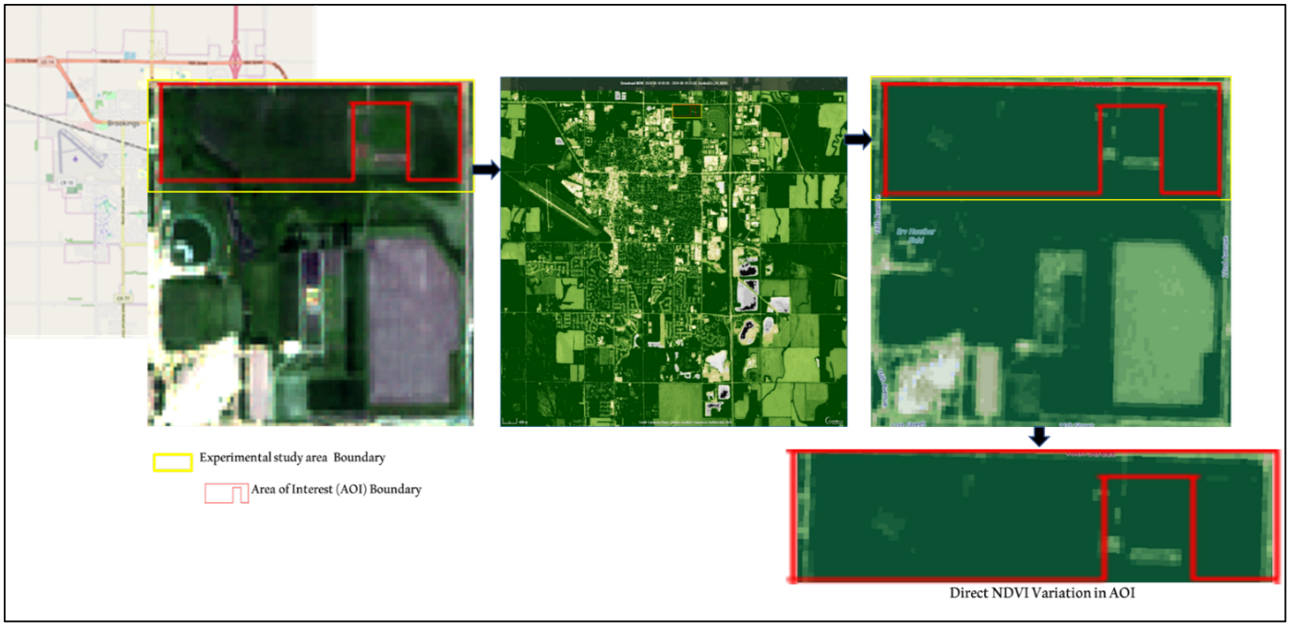

Figure 8. Results of example 1 (Direct download of NDVI from Sentinel Hub).

Example 2: NDVI processed from bands using QGIS

NDVI was derived using the Red (Band 4) and Near Infrared (Band 8) bands with the formula:

$$\mathrm{NDVI} = \frac{\mathrm{B8}-\mathrm{B4}}{\mathrm{B8}+\mathrm{B4}}$$

This processed NDVI helped assess the crop health variability across different field management zones (Fig. 9).

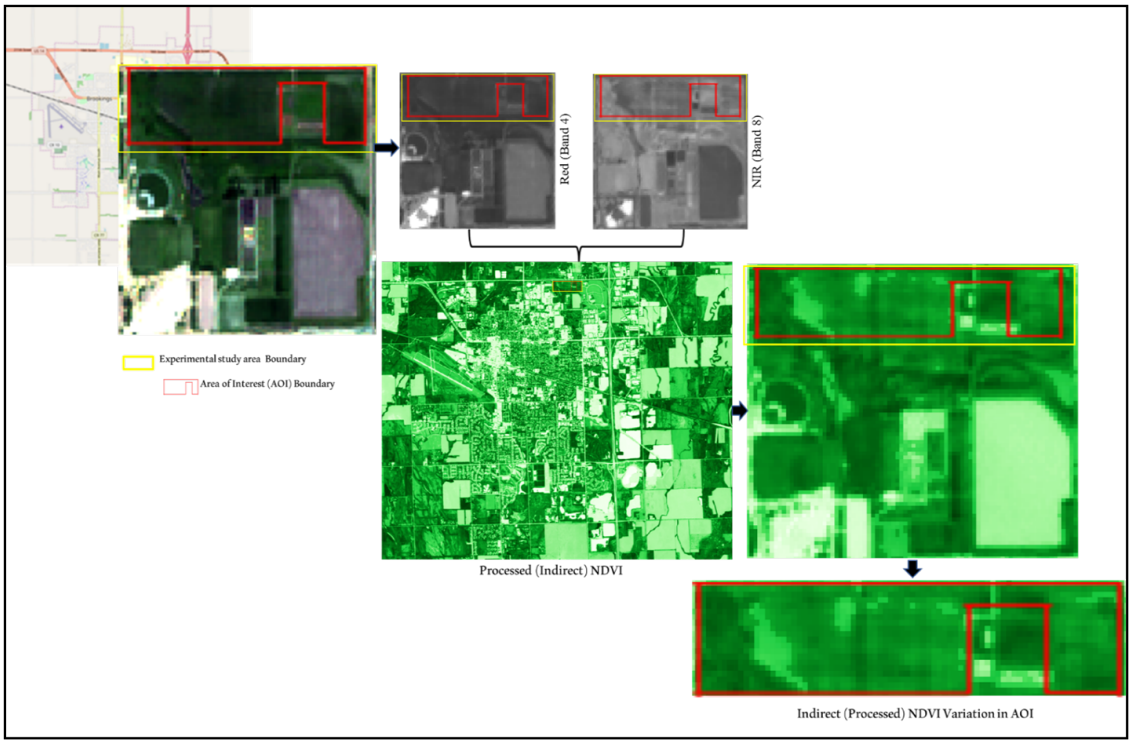

Figure 9. Results of example 2 (NDVI processed from bands using QGIS).

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