General Monitoring of Environmental Indices

Prepared By: Ms. Afrin Zaidi, Ms. Prisha Pareek, Mr. Sayanta Ghosh

Table of Content

Basic concept of Spectral indices

➢What is Remote sensing indices?

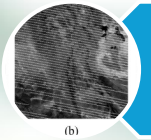
Remote sensing indices, also known as Spectral indices, are **mathematical formulas that combine reflectance values from multiple spectral bands to enhance and extract specific information about the Earth's surface**. These indices are used to distinguish different land cover types, monitor environmental changes, and assess conditions such as vegetation health and soil properties.

➢Importance of Indices

Correct atmospheric distortions affecting reflectance measurements.

Spectral indices are valuable tools for modeling, predicting, and interpreting surface processes

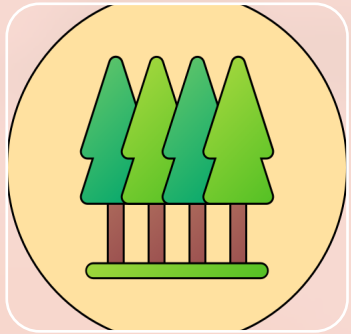
They are designed to assess and monitor a wide range of land change processes.



Reduce background influences, such as soil reflectance dominating over vegetation signals.

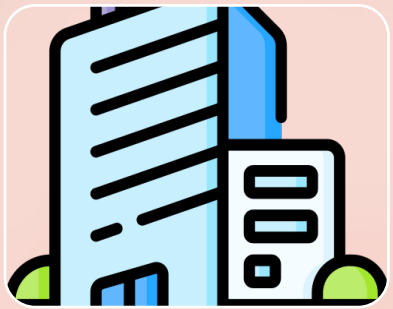
Remote sensing indices

Water Indices like **NDWI** highlight water bodies by suppressing other land features. Since water absorbs more energy in the NIR and SWIR bands, these are commonly used in water index calculations.



A Vegetation Indices like **NDVI** is a spectral transformation of multiple bands that highlights vegetation properties & health for accurate spatial and temporal comparisons.

Moisture index like **NDMI** is derived from remote sensing data to assess and monitor the moisture content of vegetation.



Built-up indices like **NDBI** are designed to highlight and differentiate built-up areas (like buildings and infrastructure) from other land cover using spectral information from satellite imagery.

Snow indices like **NDSI** are designed to highlight and differentiate snow-covered areas from other land covers using spectral information from satellite imagery.

Normalized Difference Vegetation index (NDVI)

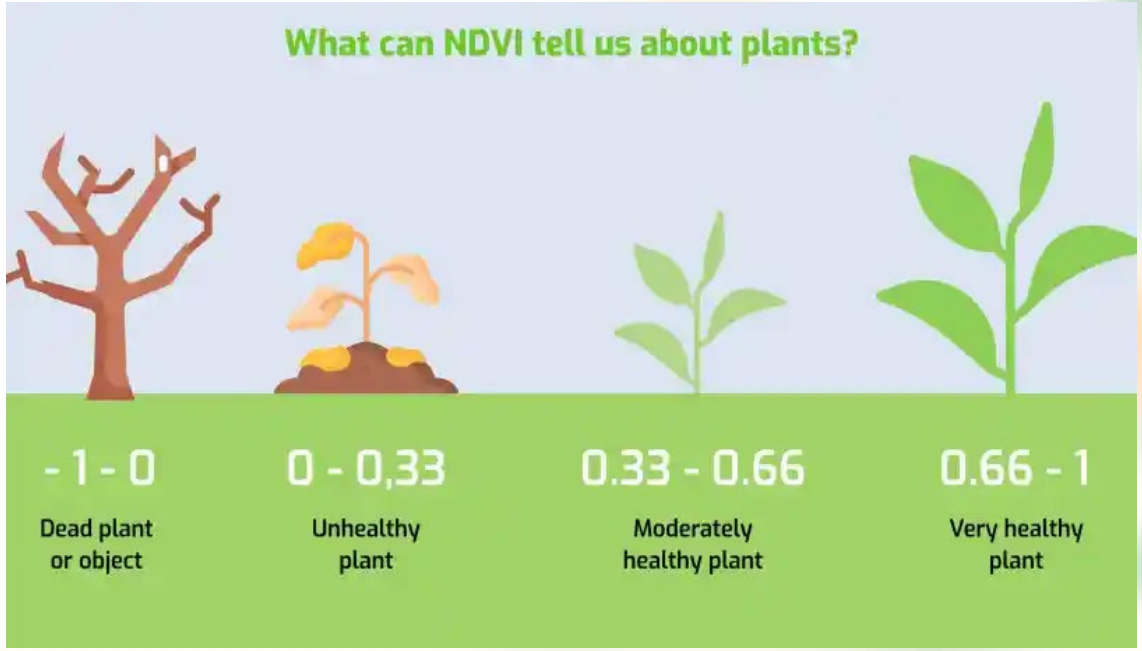
➢What is NDVI?

Normalized Difference Vegetation Index (NDVI) is a remote sensing method that uses the reflectance of light in the visible and near-infrared (NIR) wavelengths to **determine the amount and health of vegetation in an area**.

High reflectance in NIR and high absorption in Red spectrum, these two bands are used to calculate NDVI. So, following formula gives Normalized Difference Vegetation Index (NDVI).

- NDVI = (NIR – Red) / (NIR + Red)

The NDVI value varies from -1 to 1. Higher the value of NDVI reflects high Near Infrared (NIR), means dense greenery.



The Normalized Difference Vegetation Index can be used to:

- NDVI of a crop or a plant calculated regularly over periods of time can reveal Plant health remotely.
- It can be used as a drought indicator.
- NDVI is used to estimate crop yields, pasture performance, and rangeland carrying capacities

Normalized Difference Moisture Indices (NDMI)

➢What is NDMI?

Normalized Difference Moisture Index (NDMI) is **used to determine the water content of vegetation**. This formula uses shortwave infrared (SWIR) and near infrared (NIR) to capture moisture variations in vegetated areas. NDMI is applicable in applications that monitor drought and changes in vegetation moisture conditions. NDMI is useful for fire hazard assessment.

- NDMI = (NIR - SWIR) / (NIR+SWIR)

NDMI ranges from -1 to 1, with values near -1 indicating water stress and values near +1 suggesting waterlogging.

NDMI INTERPRETATION
-1 – -0.8 Bare soil,
-0.8 – -0.6 Almost absent canopy cover,
-0.6 – -0.4 Very low canopy cover,
-0.4 – -0.2 Low canopy cover, dry or very low canopy cover, wet,
-0.2 – 0 Mid-low canopy cover, high water stress or low canopy cover, low water stress,
0 – 0.2 Average canopy cover, high water stress or mid-low canopy cover, low water stress,
0.2 – 0.4 Mid-high canopy cover, high water stress or average canopy cover, low water stress,
0.4 – 0.6 High canopy cover, no water stress,
0.6 – 0.8 Very high canopy cover, no water stress,
0.8 – 1 Total canopy cover, no water stress/waterlogging

The Normalized Difference Moisture Index can be used to:

- Regularly monitor water content in crops,
- Determine field/farm zones with water stress,
- Improve tree harvest logistics planning,
- Determine the combustibility levels in fire-prone areas.

Normalized Difference Water Indices (NDWI)

➢What is NDWI?

The NDWI is used to monitor changes related to water content in water bodies. As water bodies strongly absorb light in visible to infrared electromagnetic spectrum, NDWI uses green and near infrared bands to highlight water bodies.

- NDWI = (Green – NIR) / (Green + NIR)

NDWI values range from -1 to +1, with higher values indicating greater water content. Water bodies have values above 0.5, while vegetation exhibits much lower values, facilitating differentiation. Built-up areas fall within the range of 0 to 0.2.

The NDWI values correspond to the following ranges:

- 0.2 – 1 – Water surface,
- 0.0 – 0.2 – Flooding, humidity,
- -0.3 – 0.0 – Moderate drought, non-aqueous surfaces,
- -1 – -0.3 – Drought, non-aqueous surfaces

The Normalized Difference Water Index can be used to:

- Water Resource Management: Monitoring water bodies, droughts, and conservation.
- Flood Monitoring: Mapping flood-affected areas.
- Agriculture: Assessing crop health and water stress.
- Ecosystem Studies: Tracking wetlands and aquatic health.
- Urban Planning: Managing waterlogging in built-up areas.
- Climate Change Studies: Analyzing long-term water body changes.

Normalized Difference Built-up Indices (NDBI)

➢What is NDBI?

The Normalized Difference Built-up Index (NDBI) uses the NIR and SWIR bands to emphasize manufactured built-up areas. It is ratio based to mitigate the effects of terrain illumination differences as well as atmospheric effects.

- NDBI = (SWIR - NIR) / (SWIR + NIR)

The Normalize Difference Build-up Index value lies between -1 to +1. Negative value of NDBI represent water bodies whereas higher value represent build-up areas.

The NDBI values correspond to the following ranges:
-1 to -0.5 - Water bodies
-0.5 to -0.2 -Dense vegetation
-0.2 to 0.0 - Sparse vegetation, bare soil, or mixed land cover
0.0 to 0.2 - Low built-up density
0.2 to 0.5 - Moderately built-up areas
0.5 to 1.0 - Highly built-up areas

The Normalized Difference Built-up Index can be used to:

- Urban Planning: Analyzes growth, development, and environmental impact.
- Land Use Mapping: Differentiates land cover and tracks changes.
- Environmental Monitoring: Evaluates impervious surfaces and heat islands.
- Built-up Area Identification: Maps urban infrastructure.
- Urban Expansion Monitoring: Tracks city growth trends.
- Heat Island Assessment: Detects heat-retaining surfaces.
- Impervious Surface Extraction: Aids hydrological modeling.

Normalized Difference Snow Index (NDSI)

➢What is NDBI?

NDSI is a measure of the relative magnitude of the reflectance difference between visible (green) and shortwave infrared (SWIR). It is used to detect and map snow-covered areas in satellite imagery.

- NDSI = (Green – SWIR1) / (Green + SWIR1)

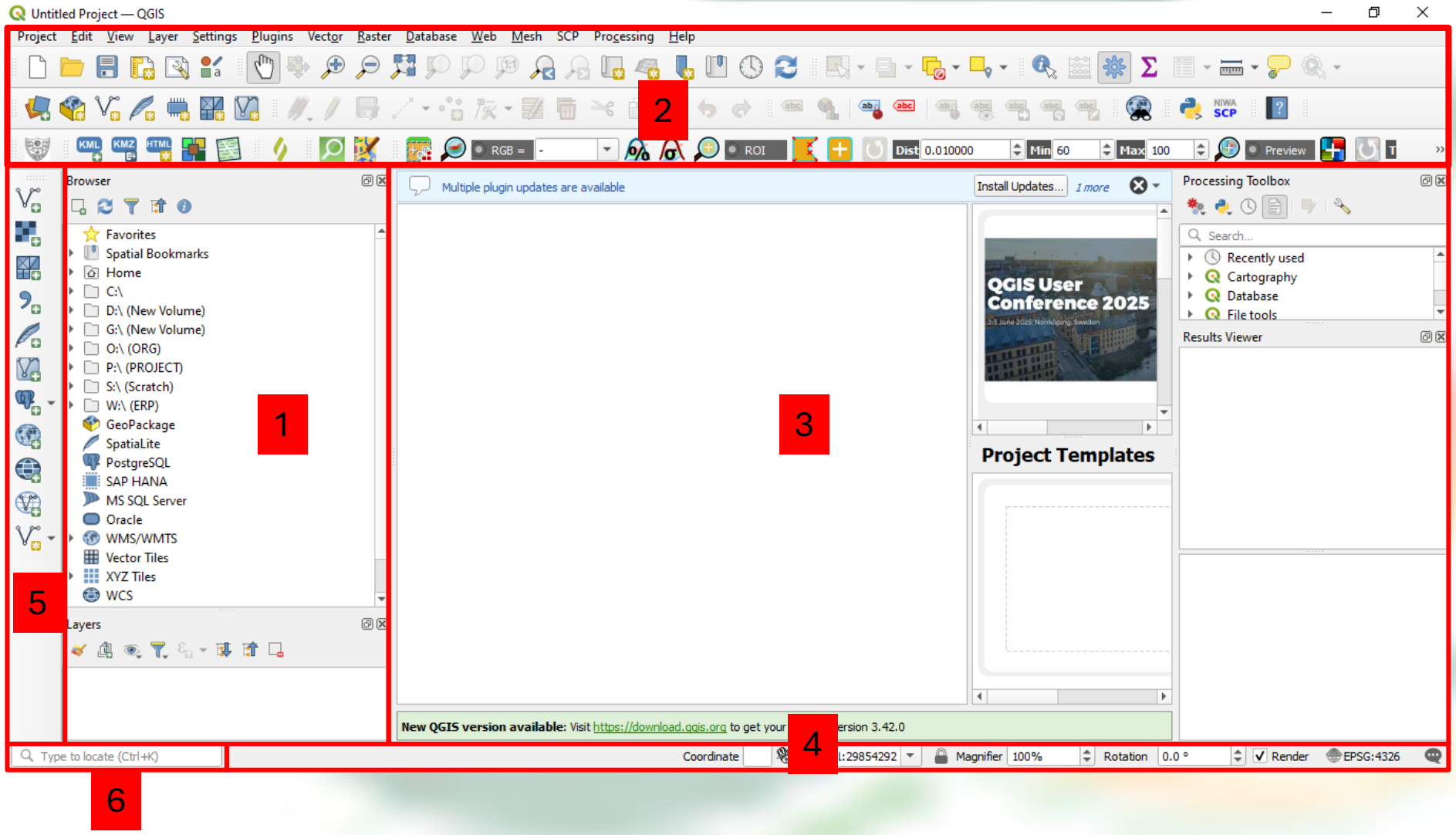
The values of snow index are ranged between -1 to +1. Negative values are indicating snow free areas & positive values are indicating snow covered areas.

Snow Detection Threshold:
NDSI > 0.4 → Generally considered snow
NDSI < 0.4 → Non-snow surfaces (e.g., vegetation, soil, water, or clouds)

The Normalized Difference Snow Index can be used to:

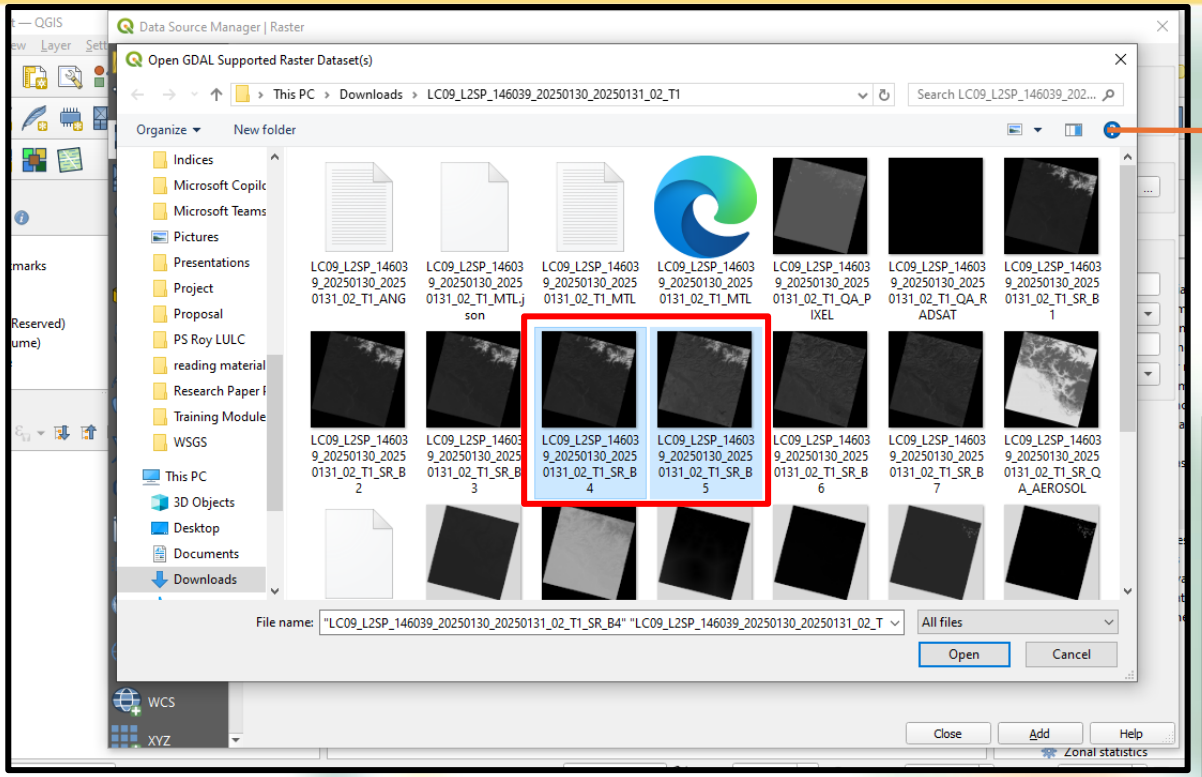
- Snow cover Detection
- Snow Mapping
- To discriminate snow and clouds
- To accurately detect glacier ice in complex shadowed terrain
- To detect the frozen lake
- Glacier mapping

Guide to Calculating Indices in QGIS

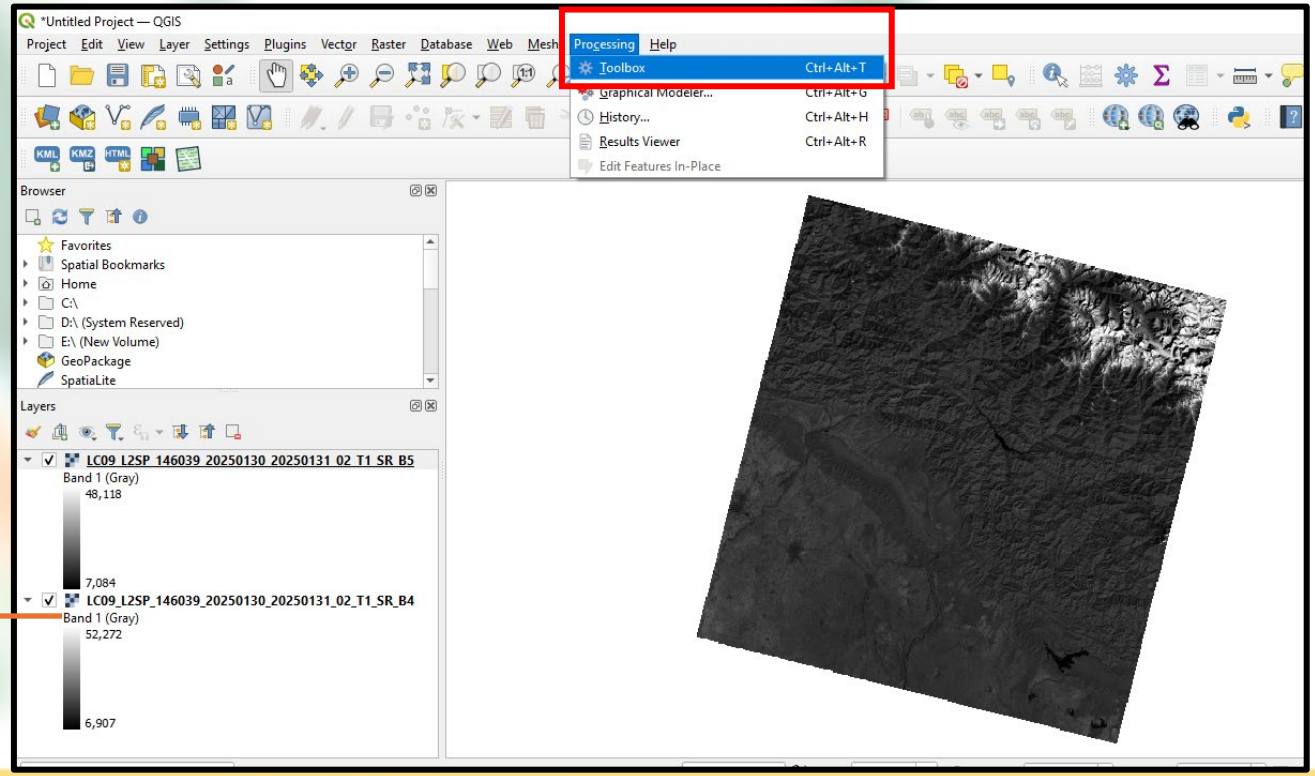


The elements Identified in the figure are:

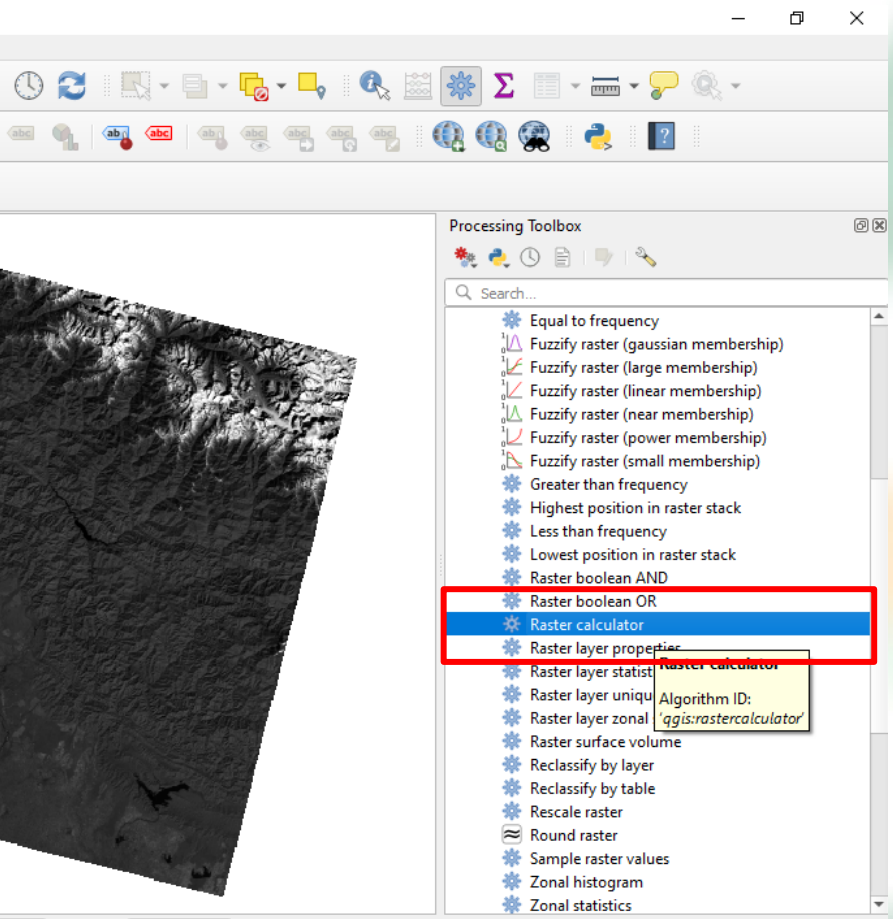
1. Layers List / Browser Panel
2. Toolbars
3. Map canvas
4. Status bar
5. Side Toolbar
6. Locator bar

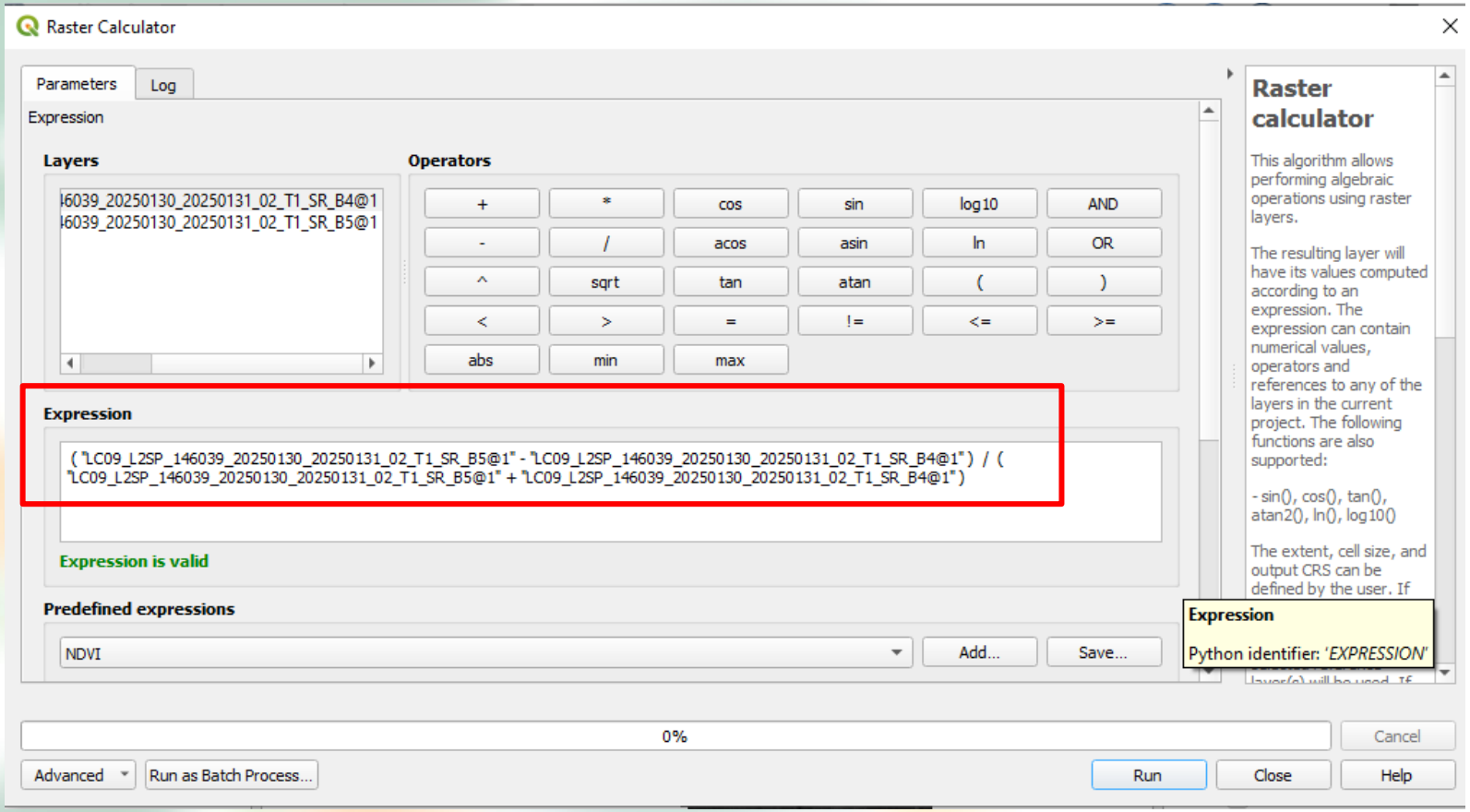


Step 1: Once the download is complete, Open the GeoTIFF file on QGIS Software.
Layer > Add Layer > Add Rater Layers > Add these two bands NIR and red

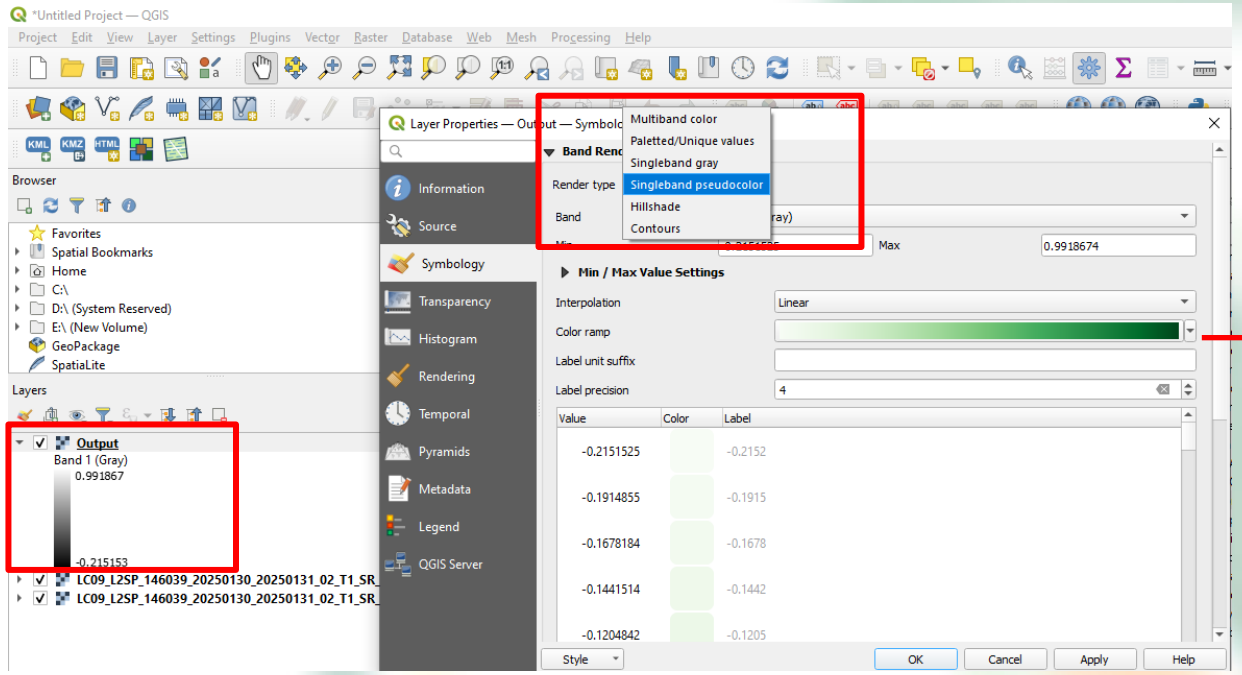


Step 2: Once bands are added, In toolbar area click > Processing > than select toolbox



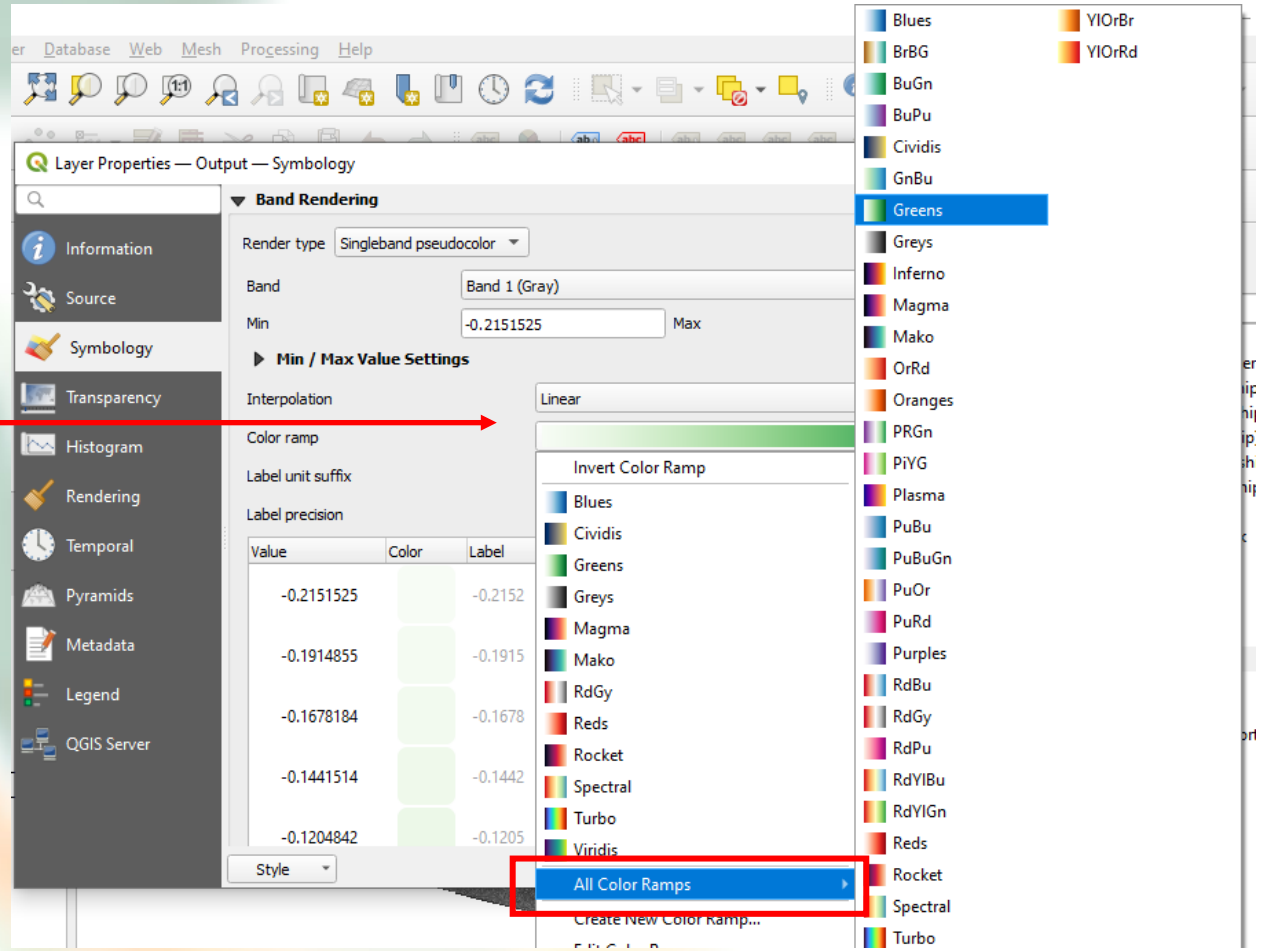


Step 3: In Processing Toolbox Search Raster calculator > In Expression box write the formula and select the layer from layers box > Run



Step 4: Right click on layer>Properties>Symbology

Step 5: Click the ‘singelband grey’ option > In the drop down, select ‘singleband pseudocolor’ > select the color palette of your choice in color ramp



Step 6: Explore Other options of Visual Representation by clicking ‘All Color ramps’

Final Output here dark green shows high NDVI Value while the Lower NDVI Value represent no vegetation area.