# User Guidelines for Generating NDVI, Biomass, and Carbon Data in QGIS for Marine and Wetland Ecosystems

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## Introduction

This guideline provides step-by-step instructions for users to collect, process, and use remote sensing data for the implementation and monitoring of habitats.
In this guide, the technical staff can generate and interpret three key data outputs:

1. **Normalized Difference Vegetation Index (NDVI):** measures vegetation health, land cover changes, and wetland conditions over time
2. **Biomass Estimation (above-ground):** is an indicator of ecosystem health and is also used to quantify above-ground carbon stock
3. **Carbon Stock Estimation (above-ground):** Help determine the amount of carbon stored in above-ground vegetation, which is essential for carbon-based PES payments.

## Data Collection & Processing Steps

# Normalized Difference Vegetation Index (NDVI)

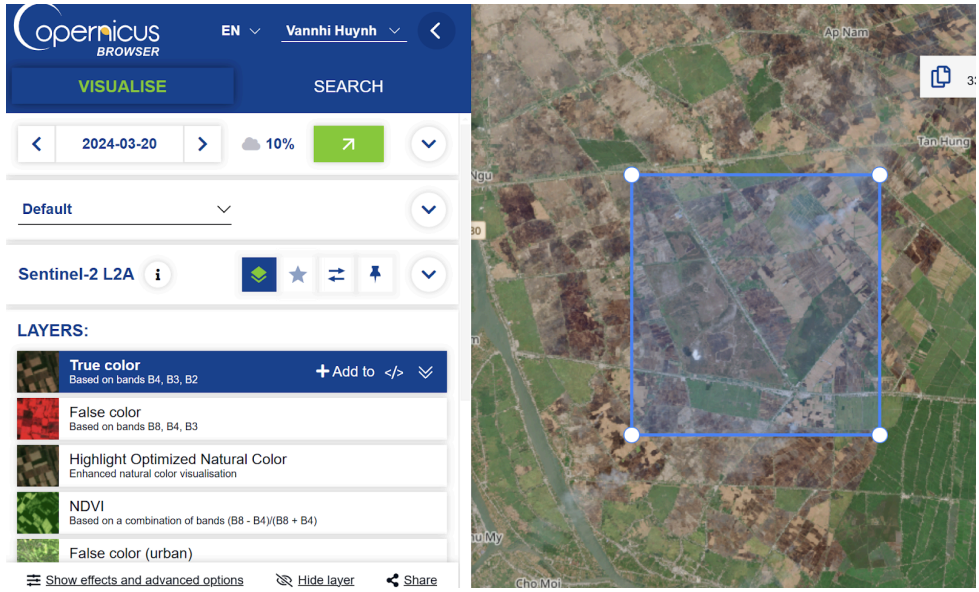
### Step 1: Acquiring Remote Sensing Data

| Satellite | Resolution | Price | Notes | Links |
|---|---|---|---|---|
| Sentinel-2 | 10m | Free | Good for vegetation monitoring but limited by cloud cover | https://dataspace.copernicus.eu/explore-data/data-collections/sentinel-data/sentinel-2 |
| Landsat 8/9 | 30m | Free | Good for long-term analysis but has a lower resolution | https://earthexplorer.usgs.gov/ |
| Planet | 3-5m | Paid | High resolution but requires purchase | https://www.planet.com/explorer/ |

- Seasonal Considerations
  - Depending on the site location, some habitats experience wet and dry seasons. Capturing ecosystems in both seasons would be a better analysis of ecosystem dynamics.
  - Free satellite data might contain cloud cover and provide limited data.
    - Adjust cloud cover to <5%, but can increase if needed.

### Step 2: Choose Data for Area of Interest

- Download the satellite images from one of the satellite data sites.
  - Example: Tram Chim National Park




- Once data is downloaded onto the computer, open the **QGIS** program to load band 4 and 8.
- Band 4 is the Red band, and 8 is NIR, which are needed for the NDVI calculation.

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

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| Sentinel-2 Bands | Central Wavelength (µm) | Resolution (m) |
|---|---|---|
| Band 1 - Coastal aerosol | 0.443 | 60 |
| Band 2 - Blue | 0.490 | 10 |
| Band 3 - Green | 0.560 | 10 |
| Band 4 - Red | 0.665 | 10 |
| Band 5 - Vegetation Red Edge | 0.705 | 20 |
| Band 6 - Vegetation Red Edge | 0.740 | 20 |
| Band 7 - Vegetation Red Edge | 0.783 | 20 |
| Band 8 - NIR | 0.842 | 10 |
| Band 8A - Vegetation Red Edge | 0.865 | 20 |
| Band 9 - Water vapour | 0.945 | 60 |
| Band 10 - SWIR - Cirrus | 1.375 | 60 |
| Band 11 - SWIR | 1.610 | 20 |
| Band 12 - SWIR | 2.190 | 20 |

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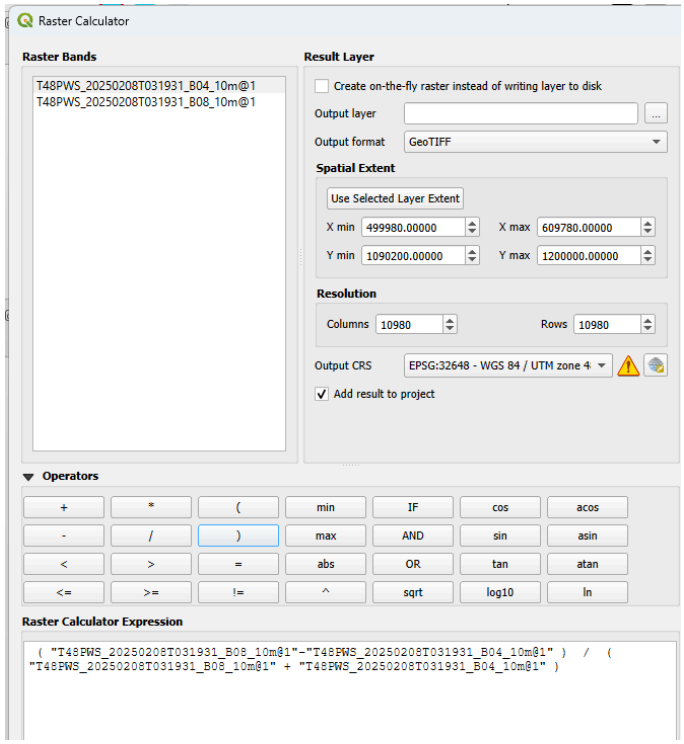
    - Sentinel 2 Bands

### Step 3: Generating Data for NDVI

- Upload the 2 bands to QGIS and open up ‘Raster Calculator’
- Plug in the band for the NDVI equation
    - Example:

- 


- Save the file and run the equation
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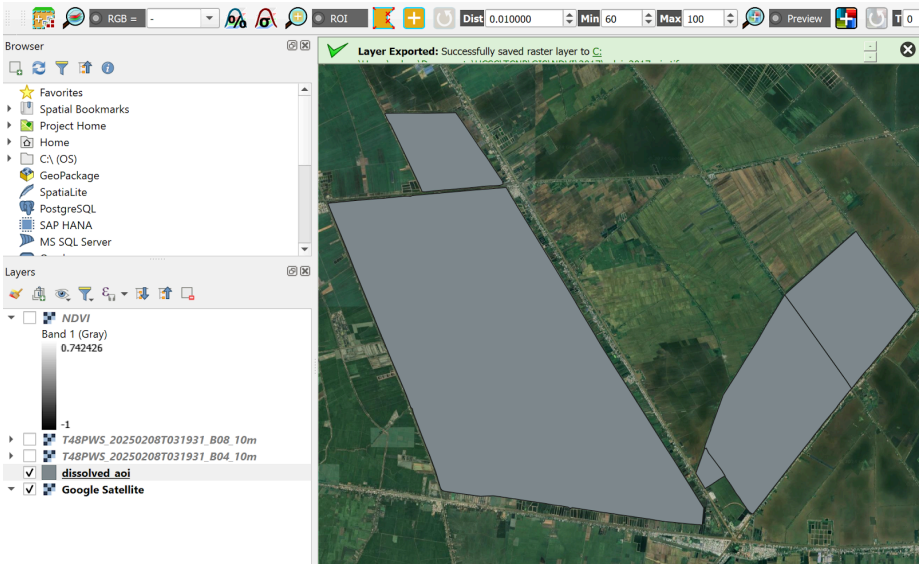
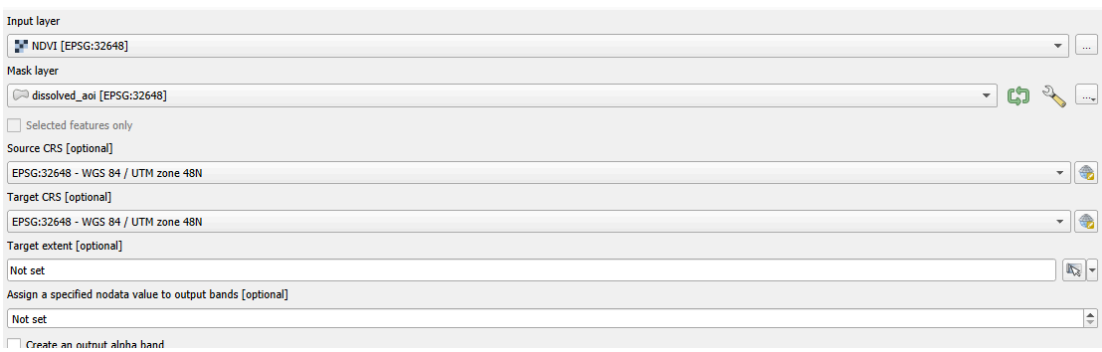
- If only interested in a specific area, then NDVI needs to be cropped/clipped. Create a vector layer and draw the polygon to the area of interest.

- 


- In the Processing Toolbox, open up ‘Clip raster by mask layer’
- Input layer is the NDVI layer and the mask layer is the polygon of the area of interest.
- Make sure to have the right coordinates (CRS), then run to see the results.
- 

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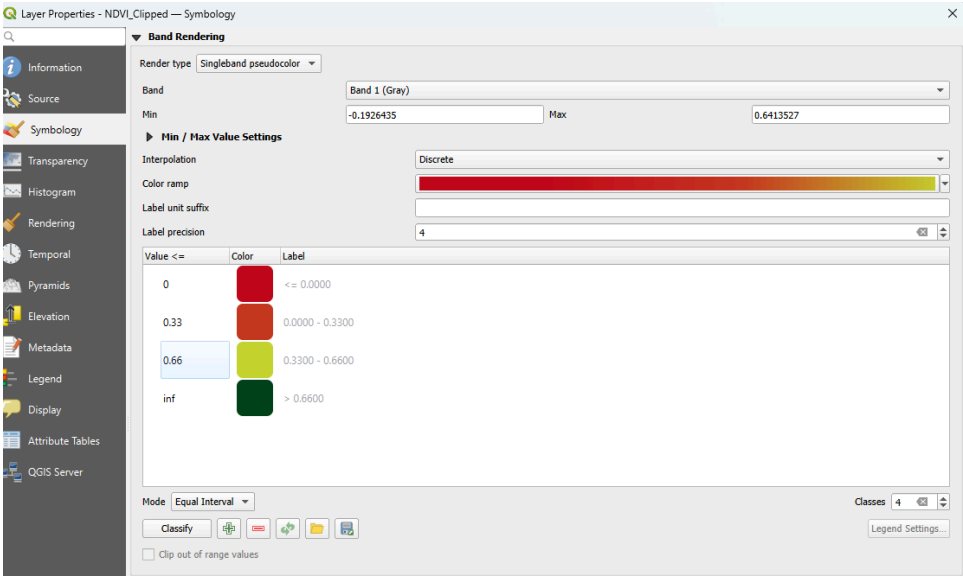
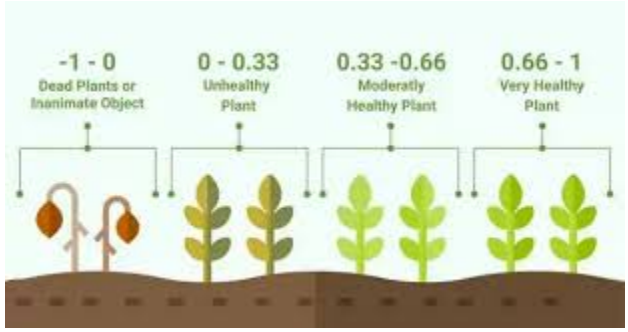
    - This is the NDVI clipped to the area of interest.
- Go to the layer properties and symbology

- 

  - 


- Create a similar symbology with 4 categories
- Apply the symbology > OK
- The visualization should look similar to this.
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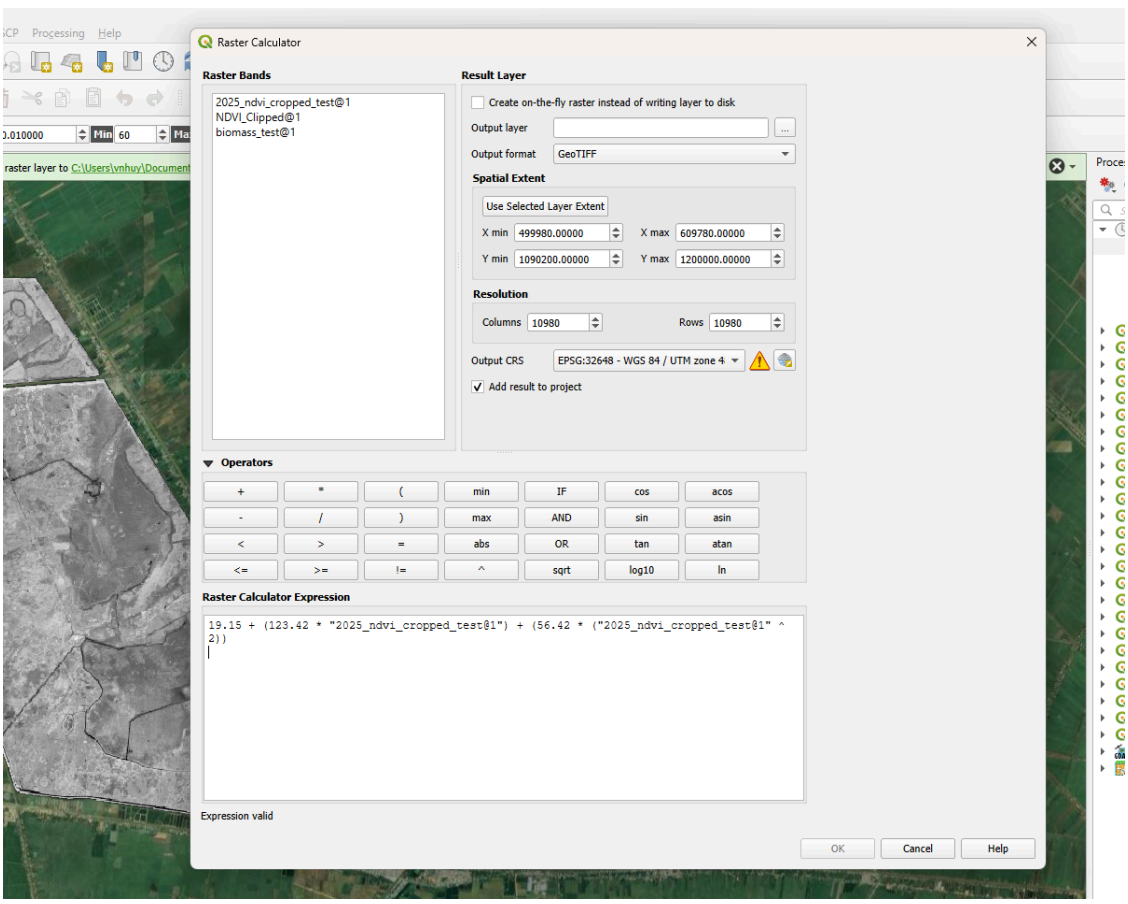
# Above-ground Biomass

## Step 1: Apply the specific above-ground biomass allometric equation to NDVI data to create above-ground biomass data

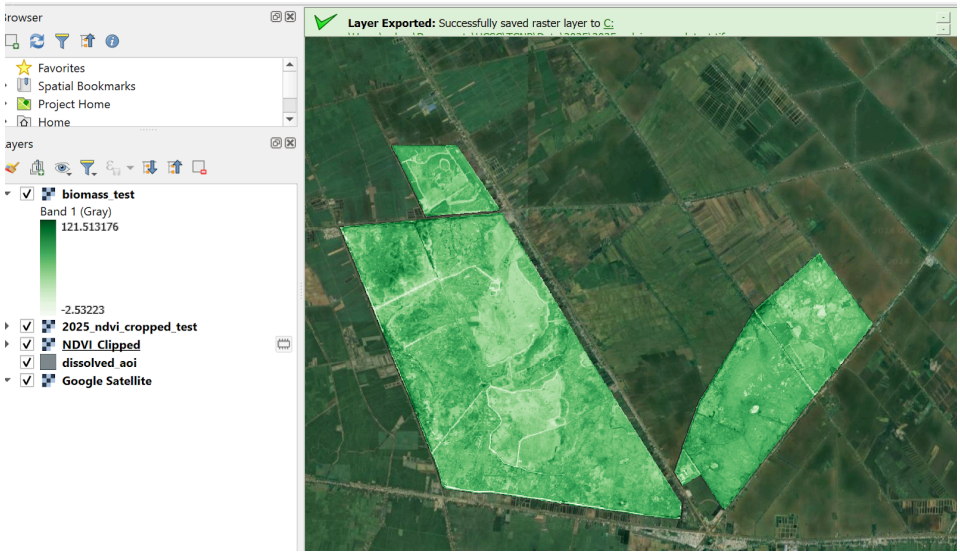
Each specific ecosystems have its own allometric equation for NDVI to above-ground biomass. in this example, the equation is for the melaleuca forest (example:

AGB=19.15+(123.42×NDVI)+(56.42×(NDVI^2)))

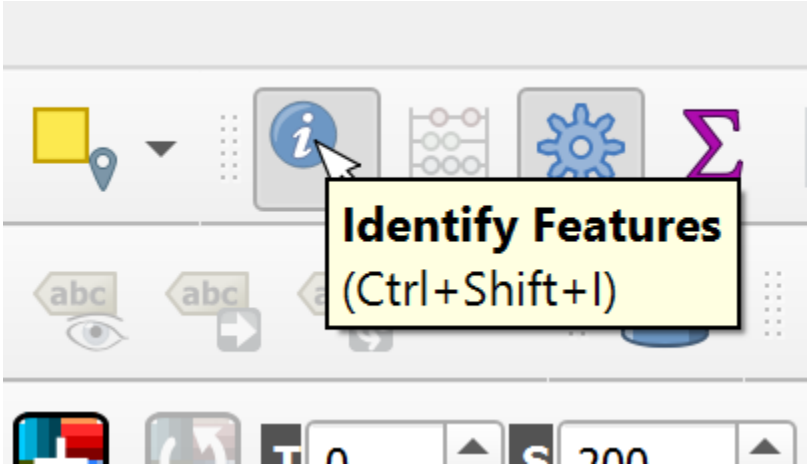
- **AGB** = Above-Ground Biomass (kg/m²)
- **NDVI** = Normalized Difference Vegetation Index (from Sentinel-2 or other satellite data)
- **19.15, 123.42, 56.42** are coefficients from the biomass estimation model for the specific melaleuca forest.
- Please note that this equation changes depending on the area. Allometric equations for specific areas require a literature review for field analysis.

- In QGIS > raster calculator > enter equation and use the NDVI data > save file to location > OK
  - 

## Step 2: Visualizing the data

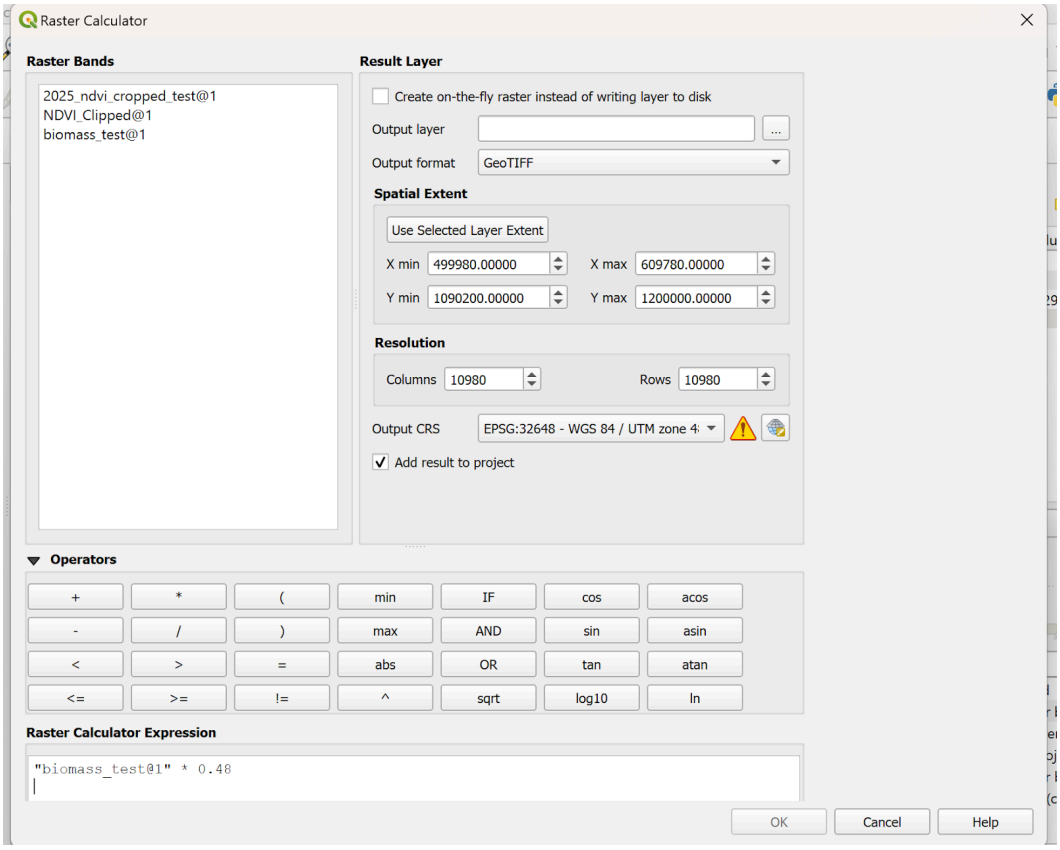
- Once complete, you can change the color to your choice, which should look similar.
  - 

- The ‘Identify Features’ allows the user to click on an area to see the specific values like biomass.



# Above-ground Carbon Stock

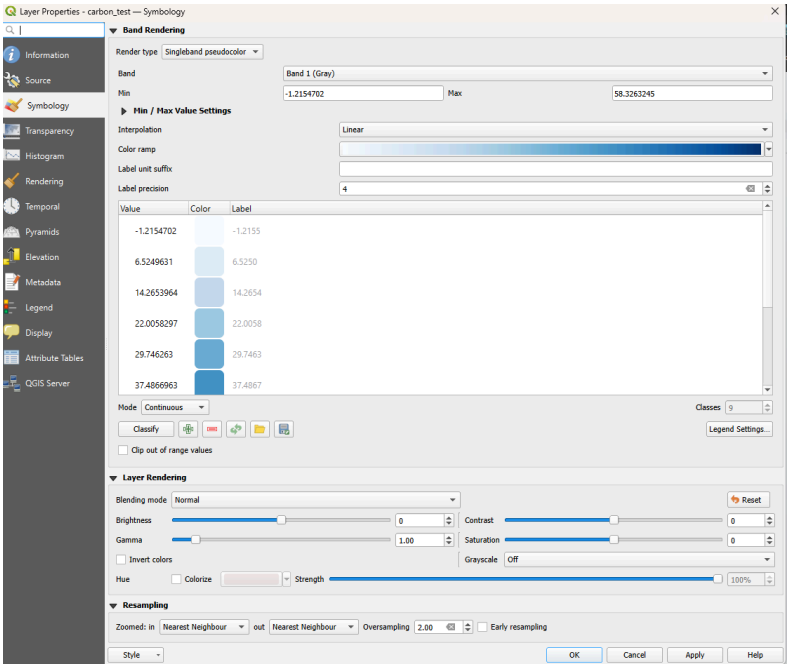
## Step 1: Create above-ground carbon stock

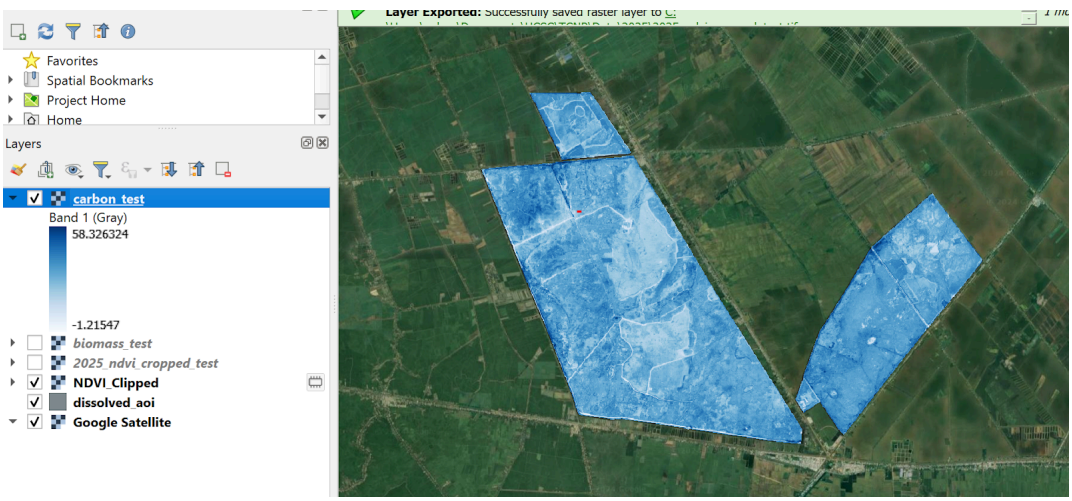
- Open ‘Raster Calculator’
- Apply specific equations for carbon stock. In this example, it is: Carbon Stock=AGB×0.48
    - However, depending on the habitat, the equation varies
    - 

- Save the file > ‘OK’

## Step 2: Visualize the Data

- Change the color to your liking in the Symbology section

- 

- 


## Step 2: Statistics

- In the Processing Toolbox > Raster layer statistics
- Select a specific band > Run
  - The result will give you:
    - Minimum, maximum, range, sum, mean, and standard deviation.

# Other: Vegetation and Boundaries Classification

Manually labeling each vegetation class can be time-consuming and labor-intensive. However, using supervised classification can help speed up the process by automatically categorizing vegetation types based on spectral data. This method allows you to define training samples for each class, and the algorithm will classify the entire image accordingly, making it more efficient for large-scale mapping.

Here is the link to follow the instructions and videos for performing supervised classification.
https://semiautomaticclassificationmanual.readthedocs.io/en/latest/interface.html