
OCPP GIS/Remote Sensing Training Workshop:

Identifying priority areas for
protection, conservation and
restoration of mangroves in
Mozambique



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Ocean Country Partnership Programme (OCP) GIS/Remote Sensing Training Workshop:

Identifying priority areas for protection, conservation and restoration of mangroves in Mozambique

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1. Background to Mangroves

1.1. Mangroves

Mangroves are a vital component of tropical and subtropical coastal ecosystems, providing an array of ecological, economic, and social benefits. These unique forested wetlands occupy the intertidal zones between land and sea, where they play an integral role in maintaining coastal biodiversity, stabilizing shorelines, and supporting local livelihoods. Found in over 120 countries globally, mangroves are particularly valuable for their ability to sequester large amounts of carbon, earning them the moniker of "blue carbon ecosystems" (Donato et al., 2011). Despite their significance, mangroves are among the most threatened ecosystems globally, facing degradation and deforestation driven by human activities and environmental pressures (Spalding et al., 2010). This training module focuses on the mangroves of Mozambique, one of the countries with extensive mangrove coverage along the eastern coast of Africa.

1.2. Mangroves in Mozambique

Mozambique is home to approximately 305,000 hectares of mangroves, along its 2,470 km of coastline, making it one of the largest mangrove-rich countries in the western Indian Ocean region (Fatoyinbo et al., 2008; Shapiro 2018). These mangrove forests, which span from the Rovuma River in the north to the Maputo Bay in the south, provide critical ecosystem services to coastal communities. They serve as natural barriers against coastal erosion, offer habitats for diverse marine and terrestrial species, and support fisheries that are vital for food security and income generation (FAO, 2007). Furthermore, mangroves in Mozambique play a significant role in climate change mitigation by storing substantial amounts of carbon in their biomass and soils (Hutchison et al., 2014).

In Mozambique mangroves occur in protected shorelines, deltas and estuaries distributed along the coastline (Barbosa et al 2001). Mozambique coastline can be divided into three main ecological regions.

The **North Zone** is characterised by its coral limestone coastline that runs approximately 800km (from the mouth of Rovuma to the northern limit of the Archipelago of Primeiras and Segundas Islands) and characterized by rocky and clear waters with deep-water bays.

The **Central Zone** (or swampy coast) spans some 900 km of coastline and is characterized by the flow of several rivers, extending from the northern limit of the archipelago of the Primeiras and Segundas Islands, up to the northern limit of the Bazaruto Archipelago, and is marked by more swamp coastlines and wetlands, within this central region harboring extensive areas of mangroves. Further, this zone has a high human population with mangroves supporting many communities that depend upon traditional artisan fishing livelihoods. Salt water in the Zambezi delta protrudes some 80km upstream (Doddema 1997).

The **South Zone** located between the Bazaruto archipelago and Ponta do Ouro is characterized by its sandy coastline, coastal lagoons (e.g. Inharrime and Bilene), swamp systems and ponds.

Mozambique has nine species of mangrove tree, see Table 1 (Barbosa et al 2001). All nine species of mangrove occur in northern Mozambique, with *Heritiera*, *Lumnitzera* and *Xylocarpus* declining in abundance as you go further south, from around Inhambane Province (Barbosa et al 2001). Other plant associates found close to the mangrove areas include *Barringtonia racemosa*, *Hibiscus filiaceus*, *Phoenix reclinata*, and *Thespesia populnea*.

Table 1: List of the mangrove species found in Mozambique and, where available, a brief description of their characteristics and distribution (Barbosa et al 2001).

Mangrove species	Characteristics
<i>Sonneratia alba</i>	Dominant seaward side species. Only recorded from Incomati River northwards. Very common species in northern Mozambique where it thrives together with seagrass species in the coralline intertidal areas.
<i>Avicennia marina</i> (Grey mangrove)	Dominant species. Behind <i>Sonneratia</i> sp. This species also exhibits double zonation, growing as tall trees on the seaward side and as a scub vegetation on the landward side. This species can grow up to 14m tall and have huge root systems.
<i>Bruguiera gymnorrhiza</i> (Oriental Mangrove)	Dominant species. Tend to aggregate with <i>Ceriops</i> and <i>Rhizophora</i> to form communities behind <i>Avicennia</i> .
<i>Ceriops tagal</i>	Dominant species. Tend to aggregate with <i>Bruguiera</i> and <i>Rhizophora</i> to form communities behind <i>Avicennia</i> .
<i>Rhizophora mucronata</i>	Dominant species. Tend to aggregate with <i>Ceriops</i> and <i>Bruguiera</i> to form communities behind <i>Avicennia</i> .
<i>Heritiera littoralis</i>	Decline in abundance in Inhambane Province.
<i>Lumnitzera racemosa</i>	Decline in abundance in Inhambane Province.
<i>Xylocarpus granatum</i>	Found in north Mozambique, close to terrestrial vegetation in areas subject to extreme high tides. Decline in abundance in Inhambane Province.
<i>Pemphis acidula</i>	
<i>Acrostichum aureum</i>	

1.3. Threats to Mozambique's Mangroves

Mangrove ecosystems are increasingly under threat from factors such as urban development, agriculture expansion, aquaculture, and climate change impacts, including sea-level rise and cyclones (Shapiro et al., 2015).

The main threats to mangroves in Mozambique include:

- Harvesting for firewood, charcoal, and material for building etc. that is increasing due to population increase in coastal areas.
- Conversion to salt pans e.g. in Mossuril (northern Mozambique) it is estimated that 50% mangroves have been converted to salt production areas (Barbosa et al 2001).
- Industry including for coastal development and impacts such as pollution (e.g. oil spills).
- Climate change and natural factors such as sedimentation and erosion.

1.4. Mapping Mangroves in Mozambique

Mapping mangroves in Mozambique is an essential step toward their effective conservation and management. Comprehensive mapping efforts allow for the detailed assessment of mangrove extent, health, and species composition, which are critical for understanding the current state of these ecosystems and guiding sustainable management practices. By employing modern technologies such as remote sensing and Geographic Information Systems (GIS), stakeholders can obtain accurate and up-to-date spatial data that informs policymaking, restoration projects, and community-based management initiatives (Fatoyinbo & Simard, 2013).

The importance of mapping mangroves extends beyond ecological considerations. It is a critical tool for enhancing the resilience of coastal communities, as it enables the identification of priority areas for protection and restoration (Dahdouh-Guebas et al., 2005). For instance, mapping can highlight regions most vulnerable to erosion or those that provide crucial breeding grounds for commercially important fish species (Barbier et al., 2011). Additionally, spatial data from mapping efforts can support Mozambique's commitments to international environmental agreements, such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD), by providing robust baselines for reporting and monitoring progress (Giri et al., 2011).

This tutorial will:

- **In Part 1:** Give a brief introduction to using open access mangrove data (available from Global Mangrove Watch) and how to perform basic interrogation of those data with other data such as protected areas, within QGIS.
- **In Part 2:** Provide basic mangrove mapping methodology using a supervised classification approach using Sentinel 2 data to perform vegetation classification.

2. PART 1: Using Open Access Mangrove & Protected Area Data

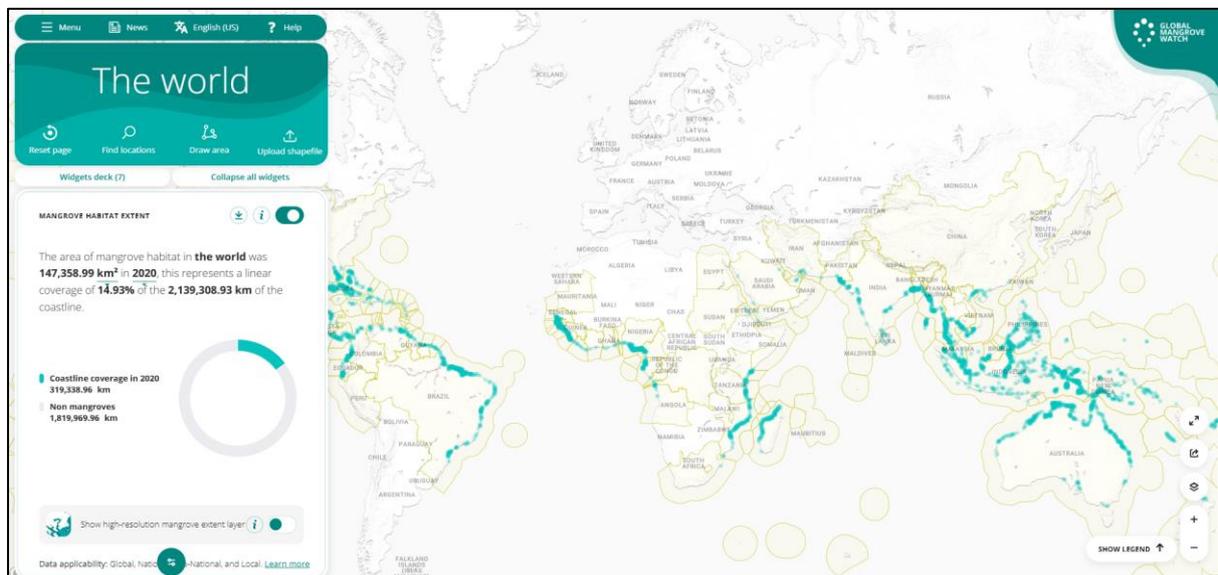
2.1. Global Mangrove Watch

Global Mangrove Watch (<https://www.globalmangrovetwatch.org/>) is a user dashboard where you can view various data associated with mangroves. These data are categorised into several widget decks for the broad categories of: Distribution and Change; Restoration and Conservation; Climate and Policy, Ecosystem Services Contextual Layers and Custom.

Some relevant data available at Global Mangrove Watch, within these categories, include:

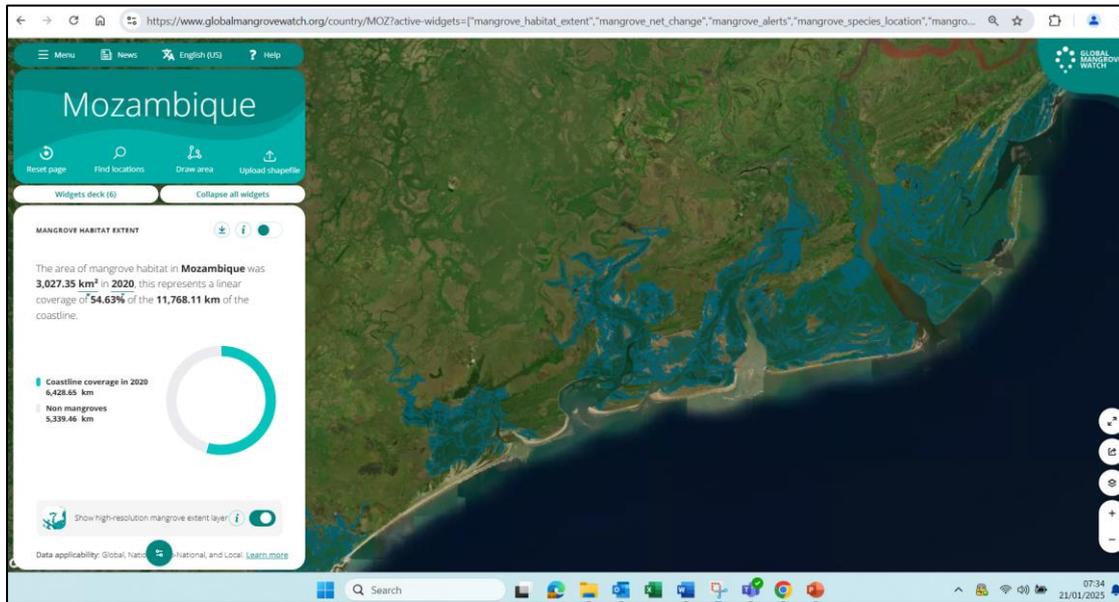
- Extents of mangroves for differing years, the earliest being 1996 and the most recent being 2020,
- Mangrove net change and habitat change,
- Mangrove disturbance alerts,
- Species level distribution maps (although these have limited national/local applications),
- Mangrove biomass, height, emissions mitigations etc.
- Other habitats such as salt marshes, tidal flats and Allen Coral Atlas.

Other data are available in the online portal and is worth the student looking through this in more detail.

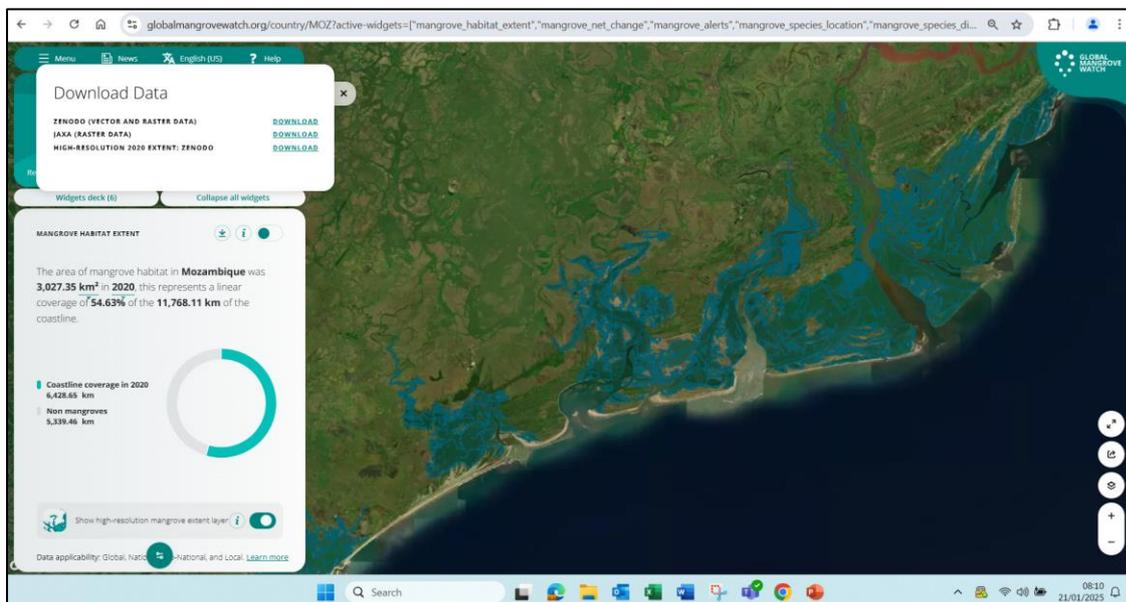


2.2. Accessing data from Global Mangrove Watch

For Mozambique, the GMW data for 2020 estimated 3,027.35km² of mangroves, spanning 11,768.11 km (or 54.63%) of Mozambique's coastline.



- To download the spatial extent data for 2020 for Mozambique click on the “download”  button, and select the bottom option “HIGH-RESOLUTION 2020 EXTENT: ZENODO”



- Then, scroll down the page until you see the box below with three files. Click on the “Download” button for the file “gmw_mng_2020_v4019_vex.zip”.

Files (572.8 MB)		
Name	Size	Download all
gmw_mng_2020_v4019_gtiff.zip <small>md5:a94b1600d891cda0e1ea0f17b312990b</small>	180.1 MB	Preview Download
gmw_mng_2020_v4019_vec.zip <small>md5:11b752bb085c886e1fdf1ed921a2ac29</small>	392.8 MB	Preview Download
gmw_v4019_mng_national_extents.xlsx <small>md5:842dd3ce8377d82fba2e1eef9dab1294</small>	15.5 kB	Download

- Once the data file has downloaded, create a folder in your C:Drive called **“Mangrove Mapping Tutorial”**, then create a subfolder called **“GlobalMangroveWatch”**. Paste the downloaded file called **“gmw_mng_2020_v4019_vec”** into this subfolder and unzip the file.

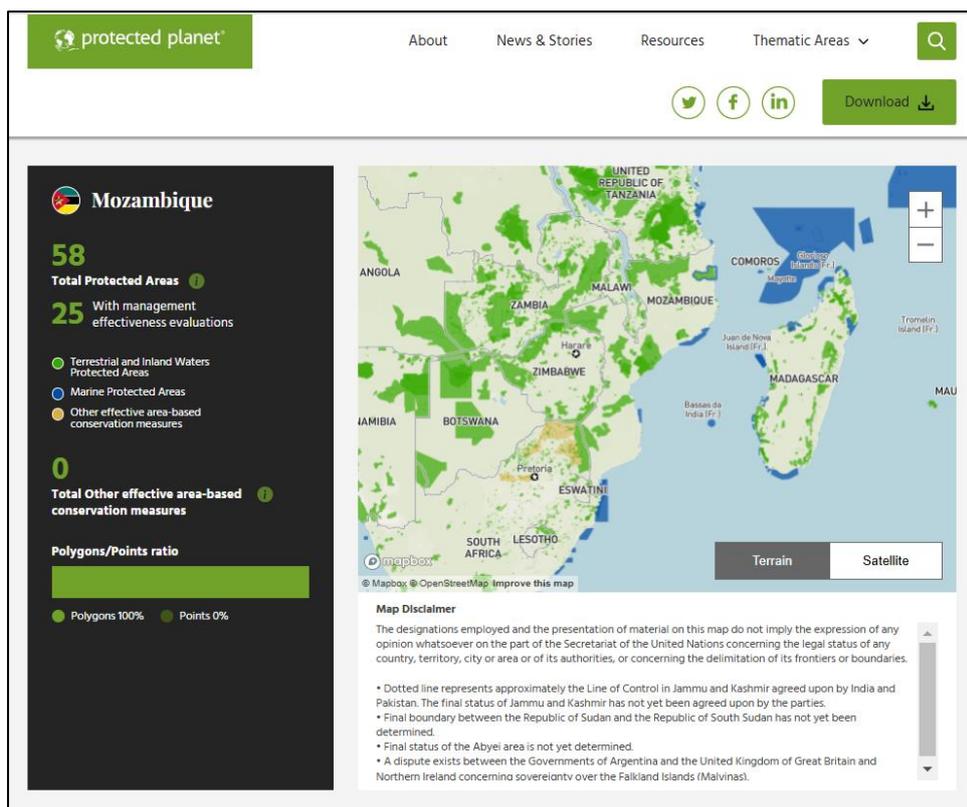
2.3. Open Access Protected Area Data

2.3.1. Protected Planet

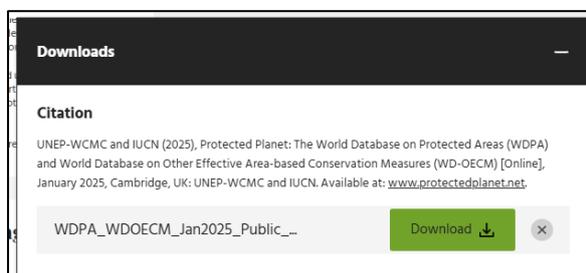
The World Database on Protected Areas (WDPA) is the most comprehensive global database on terrestrial and marine protected areas (<https://www.protectedplanet.net/en>). Data for Protected Areas is publicly available in shapefiles and raster formats.

For Mozambique, you can use the following link to access a country wide summary: <https://www.protectedplanet.net/country/MOZ>. The Protected Planet website currently recognises 58 Total Protected Areas for Mozambique, which includes 231,998km² or 29.49% of land area coverage of Terrestrial and Inland Waters Protected Areas; and 12,213km² of Marine Protected Areas that equates to 2.16% of the total marine and coastal area for Mozambique.

- To download the Protected Area data, go to the green **“Download”** button and select the **“SHP”** dropdown option, which will download a shapefile for protected areas for Mozambique.



- Then click the purple “Continue” button to agree to use the data for Non-Commercial Use, then select again the “Download” button.

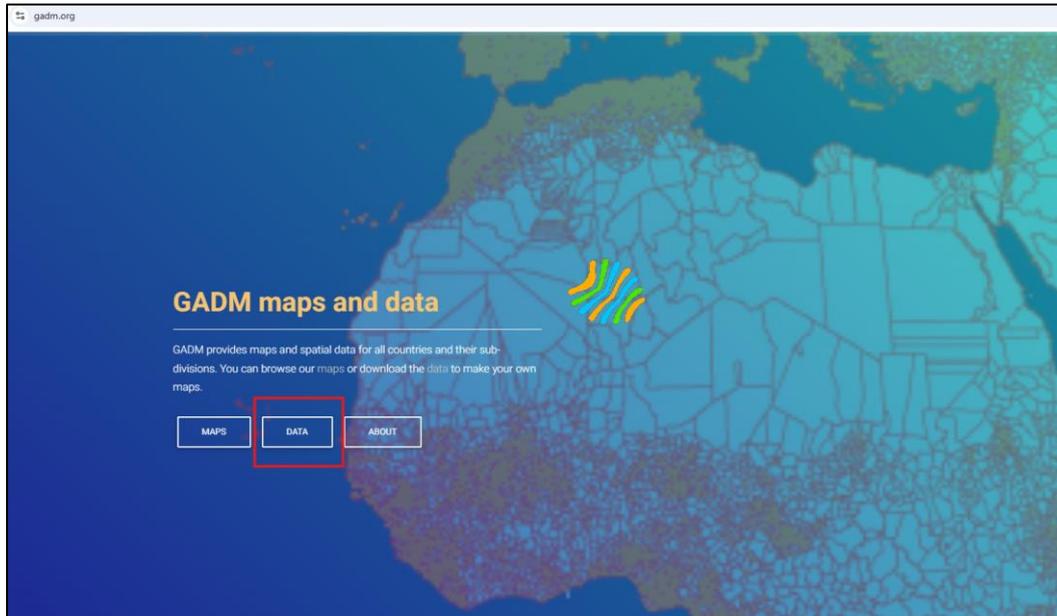


- Once the data has been downloaded, create a folder within the “Mangrove Mapping Tutorial” on your C-Drive called “ProtectedAreas_WDPA”, then copy and unzip the folder.
- Within the unzipped folder, there are three zipped folders that contain protected area data for Mozambique. In the next part of the tutorial, you will bring these files into QGIS and merge them into one file.

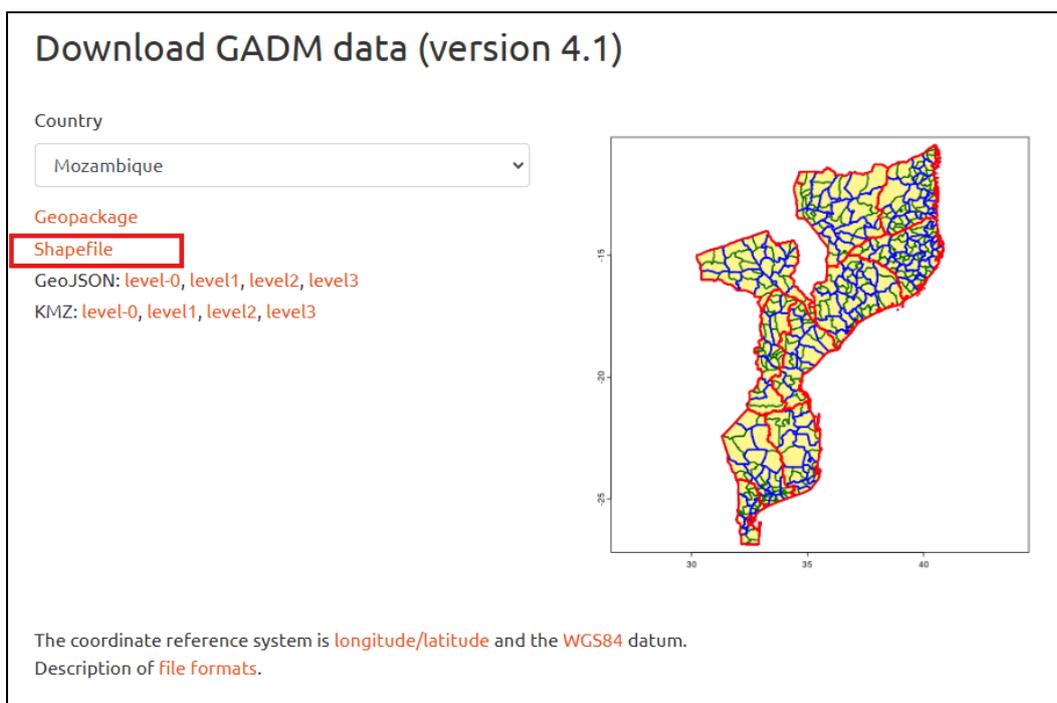
2.4. Open Access Administrative Boundary Data

Next, we will need to download open access data for Mozambique administrative Boundaries.

- There are many options online for acquiring country level shapefiles. In this tutorial, you can go to <https://gadm.org/> and click the “Data” button. Press the “consent” button if it pops up.



- Click on the orange “country” and do not download anything yet. You should see a screen pop up where you can search the data by country. Search for Mozambique. And then click on “Shapefile”.



- After the download is complete, create a folder named “**Administrative_Boundaries**” in your “**Mangrove_Mapping_Tutorial**” folder and copy the zipped file into here and unzip the file.
- These data have differing administrative levels that can be explored. Level “0” is the country boundary.

2.5. Using QGIS to View and Interrogate Open Access Mangrove and Protected Areas Data

In this section, we will download and start to use an open-source GIS (Geographic Information Systems) software to explore the mangrove and protected area datasets you have downloaded, and to process these to then enable you integrate the data for key questions for Mozambique.

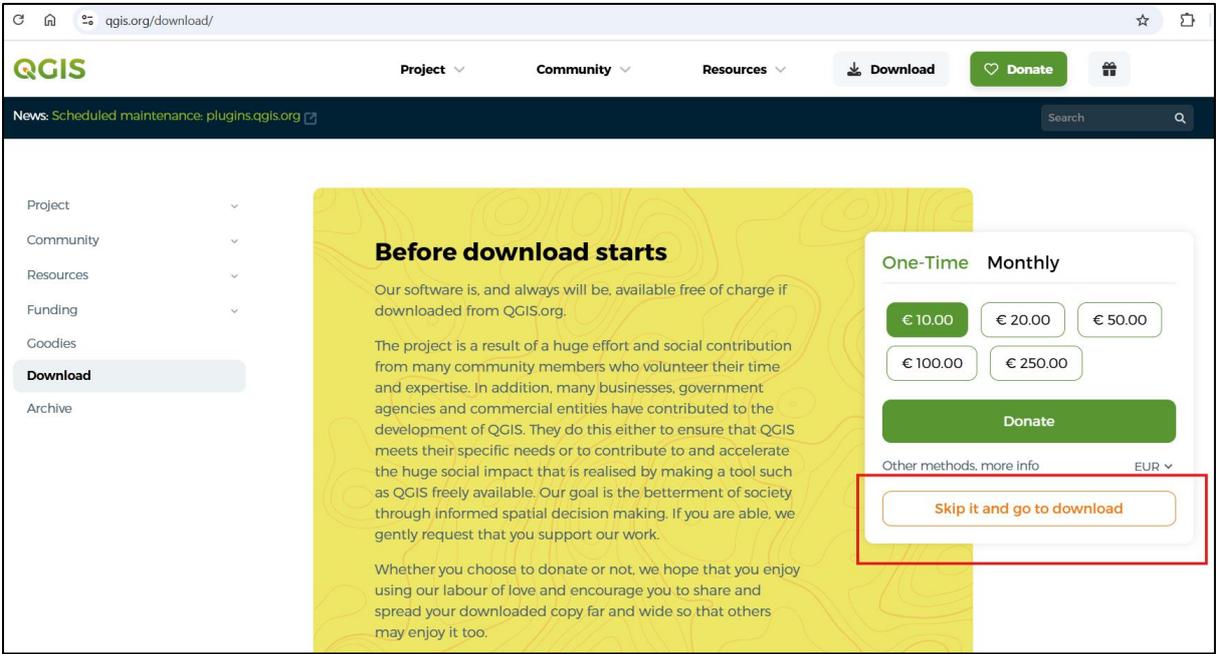
For example, we will look at understanding how to:

1. Identify where and how much mangrove habitat is in Mozambique.
2. Identify which mangroves are protected and quantify the extent of mangroves that are vulnerable to conversion.
3. Create a map using these data.

2.5.1. Download QGIS

In this tutorial, we will be using QGIS. QGIS (Quantum Geographic Information System) is a free, open-source software that allows users to create, edit, visualize, analyse, and publish geospatial information. This software also offers many free online resources and maps available to download, and there are lots of tutorials available for further exploration.

- To download QGIS go to: <https://qgis.org/download/>
- Press the “Skip it and go to download” button



The screenshot shows the QGIS.org website's download page. The main content area features a yellow background with the heading "Before download starts". Below this heading, there is text explaining that the software is free of charge and that the project is supported by community members, businesses, and government agencies. A donation modal is open on the right side of the page, showing options for one-time or monthly contributions in various amounts (€10.00, €20.00, €50.00, €100.00, €250.00). A "Donate" button is visible, along with a "Skip it and go to download" button, which is highlighted with a red box. The website's navigation menu is visible at the top, and a search bar is located in the top right corner.

- Next, the following screen will pop up. Click the “*Long Term Version for Windows*” to download the QGIS version used for this tutorial.

QGIS will then start to download. The file is around 1.2 GB and so the download may take some time, depending on your download speed.

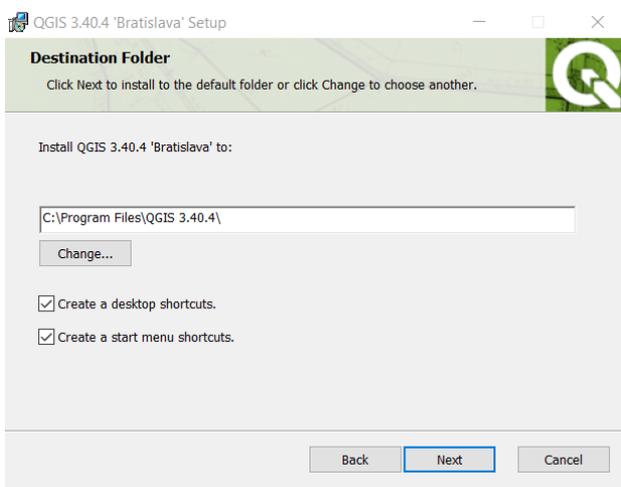
- Once it has downloaded, go to your downloads and double click the “.msi” file.

Name	Date modified	Type	Size
QGIS-OSGeo4W-3.40.4-1.msi	06/03/2025 15:03	Windows Installer ...	1,294,280 ...
gadm41_MOZ_shp.zip	06/03/2025 14:51	WinZip File	4,519 KB
WDPA_WDOECM_Mar2025_Public_MOZ_shp.zip	06/03/2025 14:41	WinZip File	12,617 KB
gmw_mng_2020_v4019_vec.zip	06/03/2025 14:36	WinZip File	383,563 KB

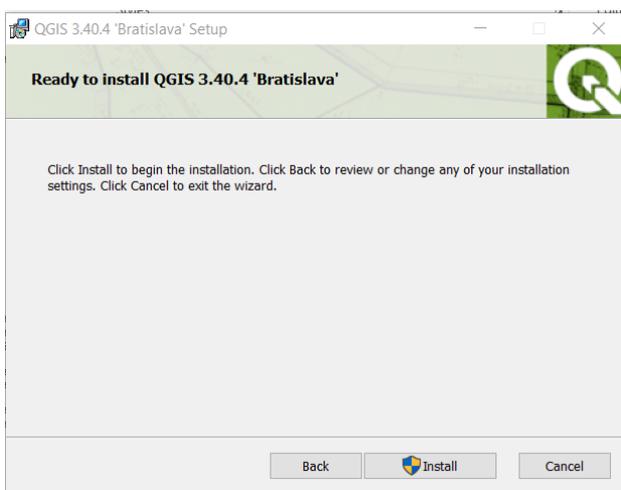
- Then click “*Next*”.



- Accept the terms, and click “Next”.
- Then, accept the default location and click “Next”.

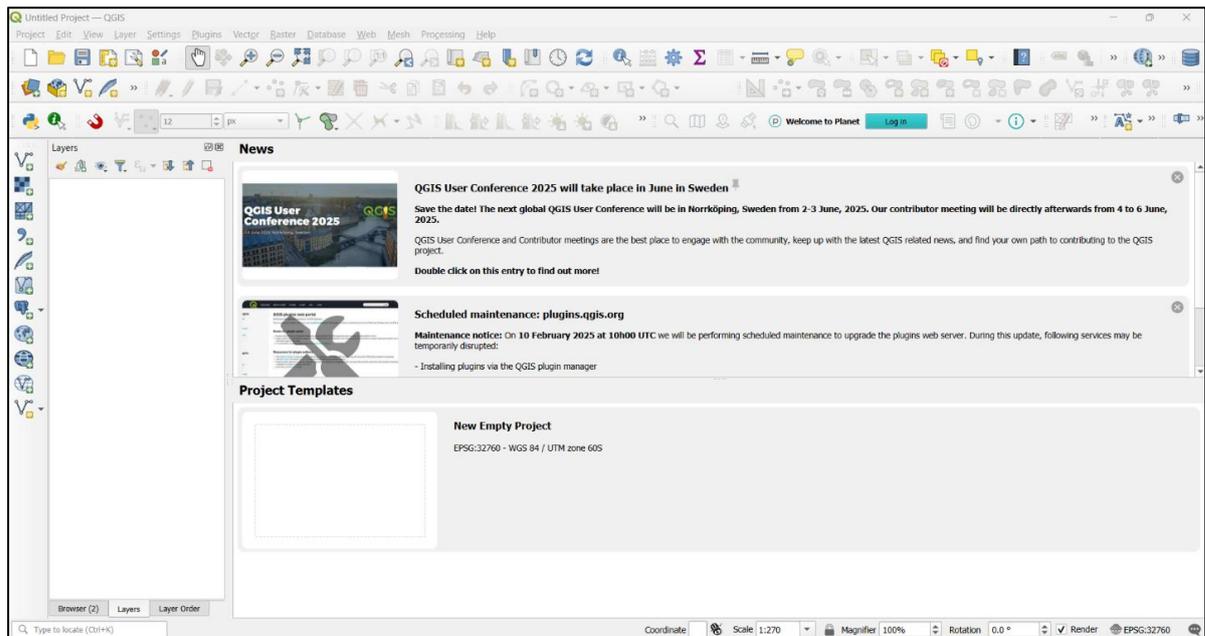


- Then click “Install” then once installed click on “Finish”.



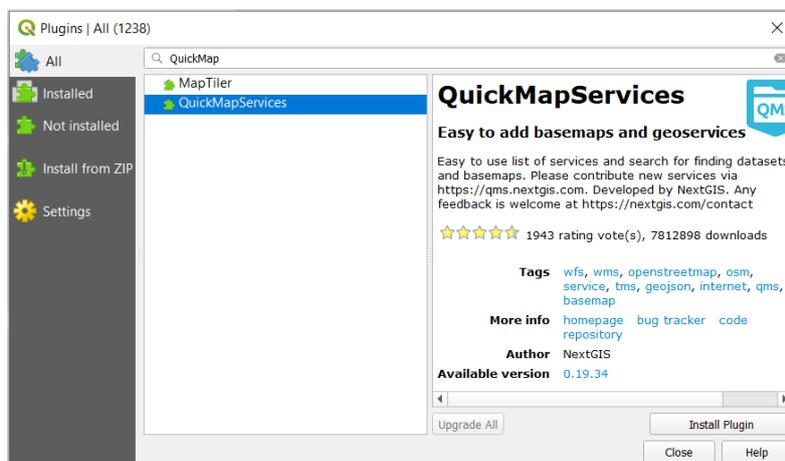
2.5.2. Opening QGIS and Getting a Background Map

- Once you have installed QGIS, navigate to the software in your settings, and double click to open it.
- A screen like below should open. Depending on your set-up you may see different toolbars. Toolbars can be turned on and off by going “View” then “Toolbars”. If in doubt, turn all on.

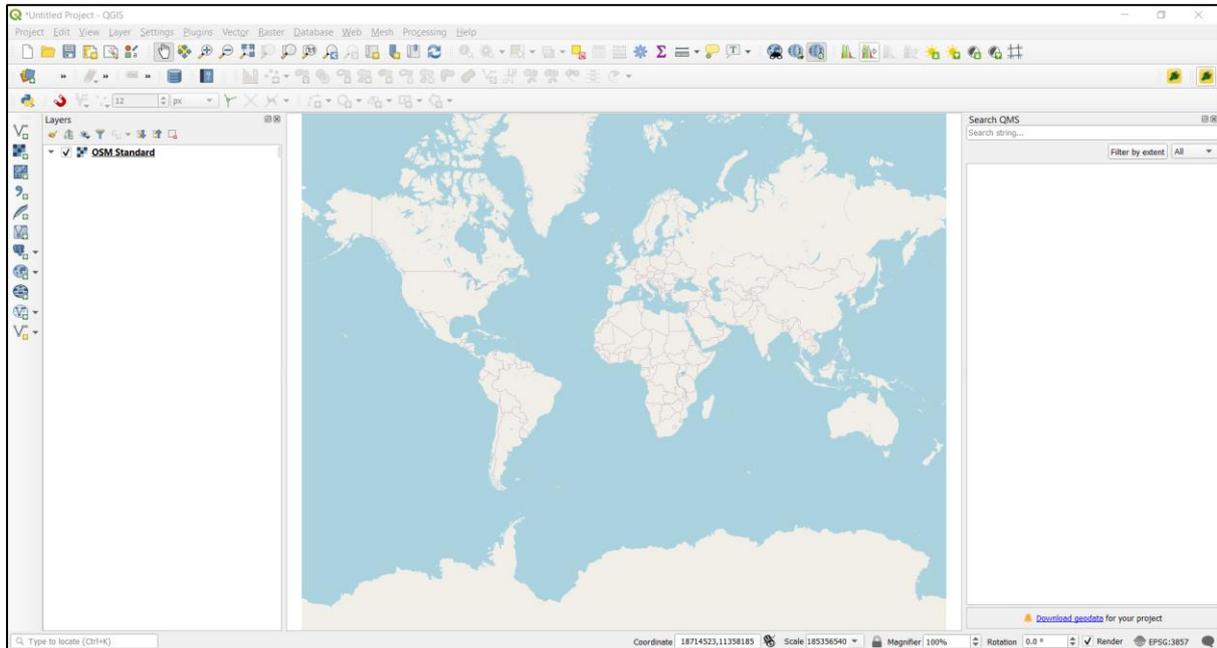


To add a base map we need to now add a plugin.

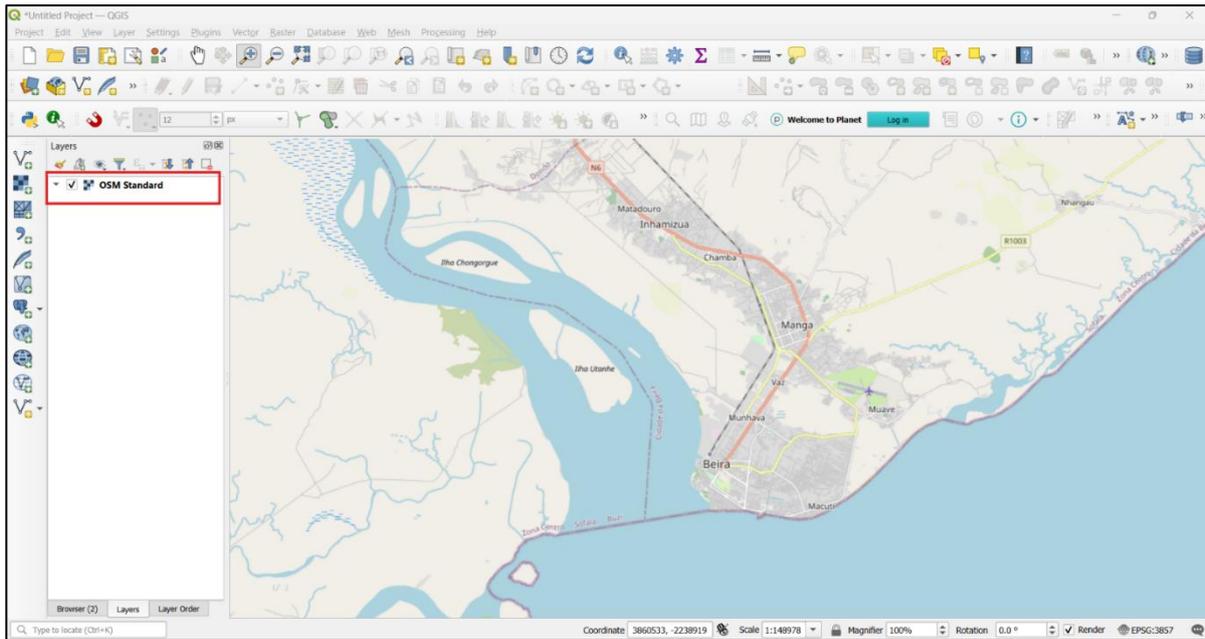
- To do this, go to “*Plugins*” on the main menu, then “*Manage and Install Plugins*”, then in the plugins window, type “*QuickMapServices*” in the search function and select “*QuickMapServices*” click “*Install Plugin*”, then “*Close*” and “*Close*” again.



- The **Quick Map Services** tool should now be visible. Click the “QuickMapServices”  tool, then scroll down to “OSM”, then over to “OMS Standard”. This will bring in a global base map that can provide a background map.

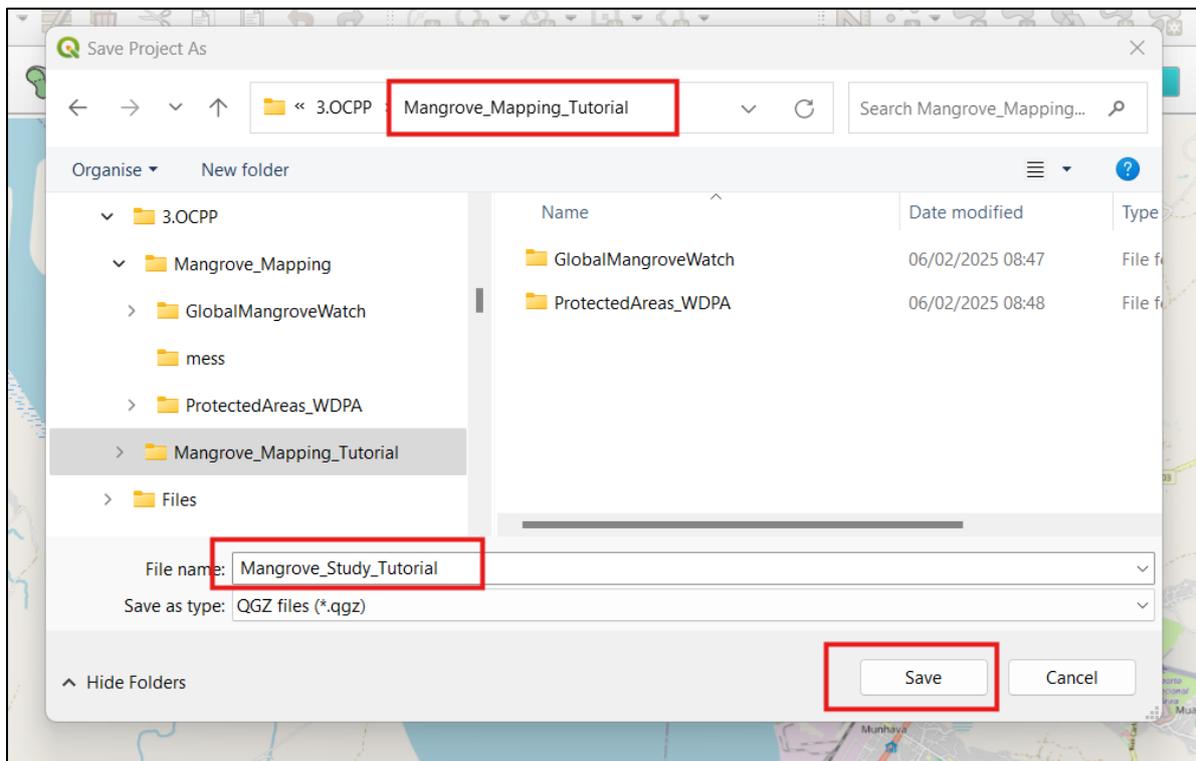


- Click on the “Zoom in” tool  then use this to zoom in to Mozambique and areas of interest where you can then see features such as: roads, areas of land versus sea, settlements, Police stations and other public services and in times where available shapefiles/data is not available or out of date, this base can be used to potentially allow the user to digitise or update spatial data.
- You can also use the “Pan map” tool  to move the zoomed in map around to identify areas of interest.
- To “Zoom out” you can use the tool identified as .
- In general, this is a good basemap to have.
- To toggle the basemap on or off, click or unclick the checked box highlighted in red in the Layers viewer.



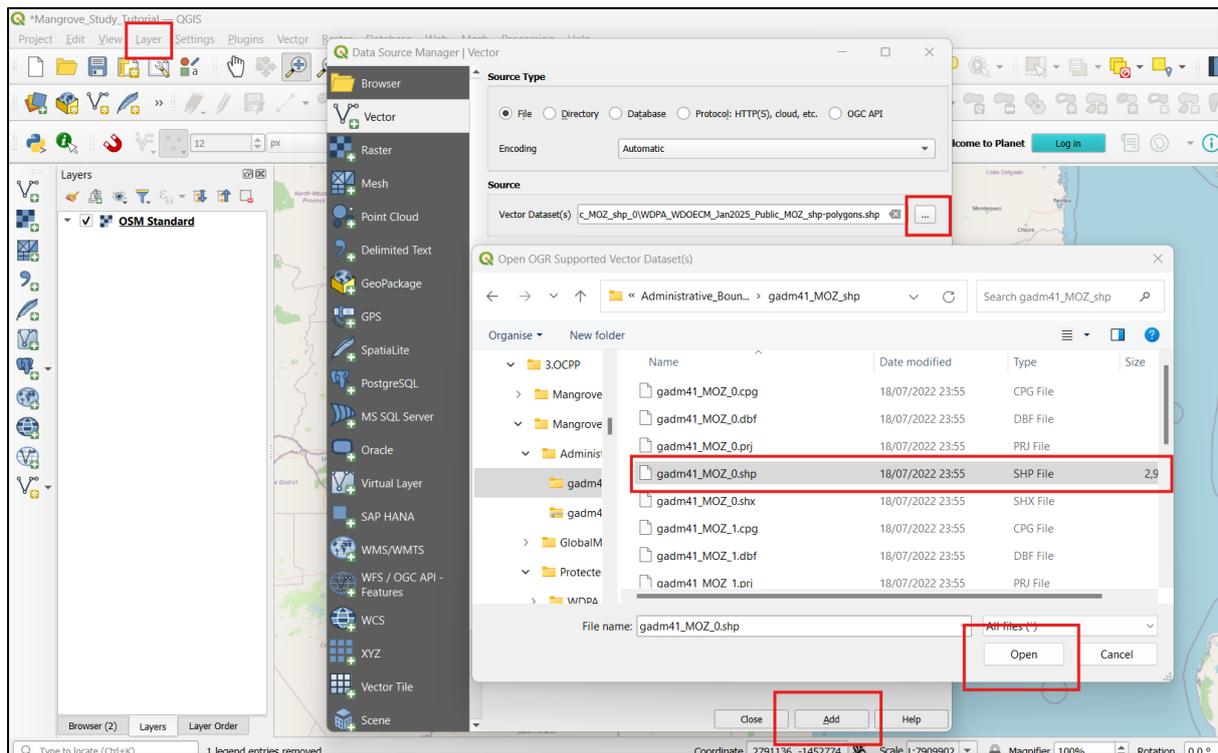
2.5.3. To Save a Project

- Go to “Project” tab, then “Save As” then navigate to the folder you want to save the project, we advise on your C: Drive and in the “Mangrove_Mapping_Tutorial” folder you created in Section 2.2 earlier.
- For this tutorial name this project “Mangrove_Study_Tutorial”.

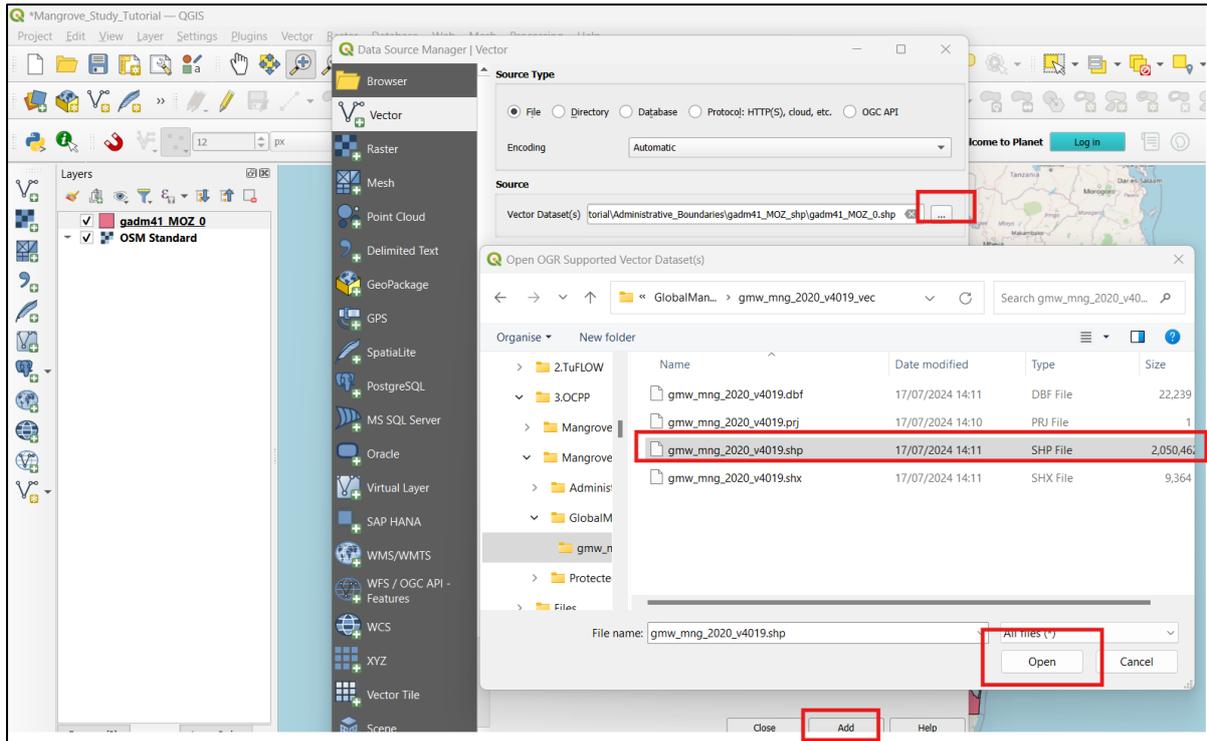


2.5.4. Adding Data into QGIS

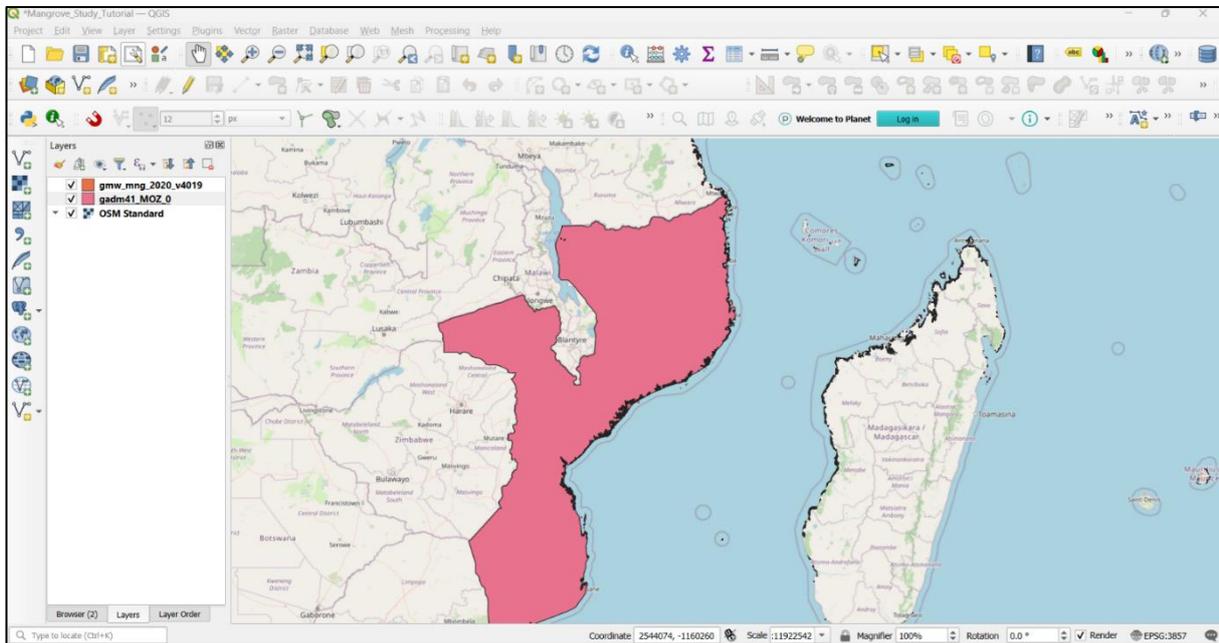
- To bring in downloaded data, go to “*Layer*” at the top, then “*Add Layer*” then “*Add Vector Layer*”. Click the  under “*Source*” and browse to your downloaded datasets.
- First go into the “**Administrative Boundaries**” folder and into the unzipped downloaded data. Select the file “*gadm41_MOZ_0.shp*” by clicking once and then select the “*Open*” button.
- Then in the “*Data Source Manager*” window you can click the “*Add*” button found at the bottom right.



- The Mozambique country shapefile should now be viewable in the “*Layers*” gallery.
- Next, bring in the “*Global Mangrove Watch*” data using the same method described above.
- Then once the mangrove data is added, hit the “*Close*” button in the “*Data Source Manager*” window to close it so we can view the two datasets.



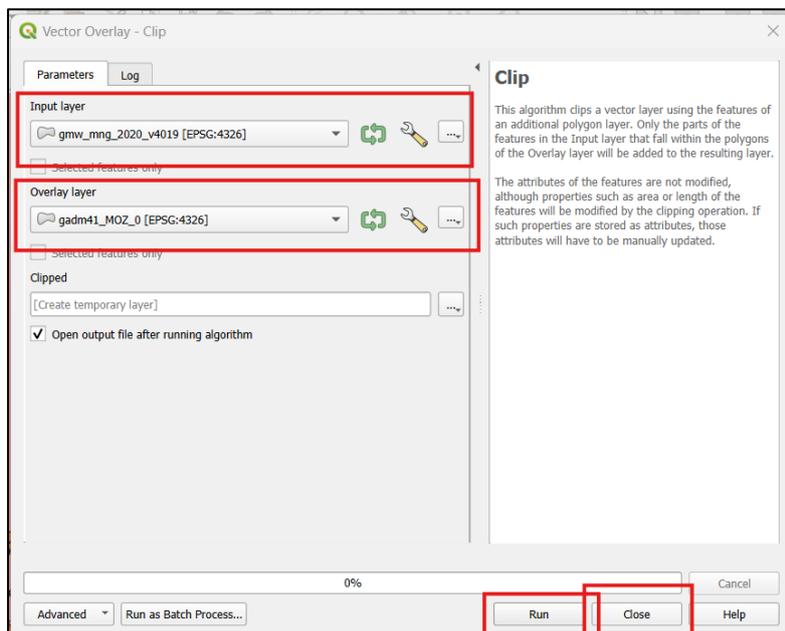
- You can move layers up or down by clicking on one and dragging it up or down.



2.5.5. Clipping Data

The downloaded Global Mangrove Watch data (that you just added) comprises of a shapefile for the entire world. We just need the data for Mozambique.

- To extract mangrove data for Mozambique only, click on “Vector” at the top of the screen, in the dropdown menu select “Geoprocessing Tools”, then “Clip”.
- In the “Vector Overlay – Clip” window under “Input layer” use the dropdown list to select the mangrove file called “gmw_mng_2020_v4019”. Then for the “Overlay layer” select the Mozambique country layer called “gadm41_MOZ_0”. Then click the “Run” button.
- Once the process has run, click “Closed” and a layer called “Clipped” should have been added to the “Layers” gallery. This layer currently is a temporary layer.

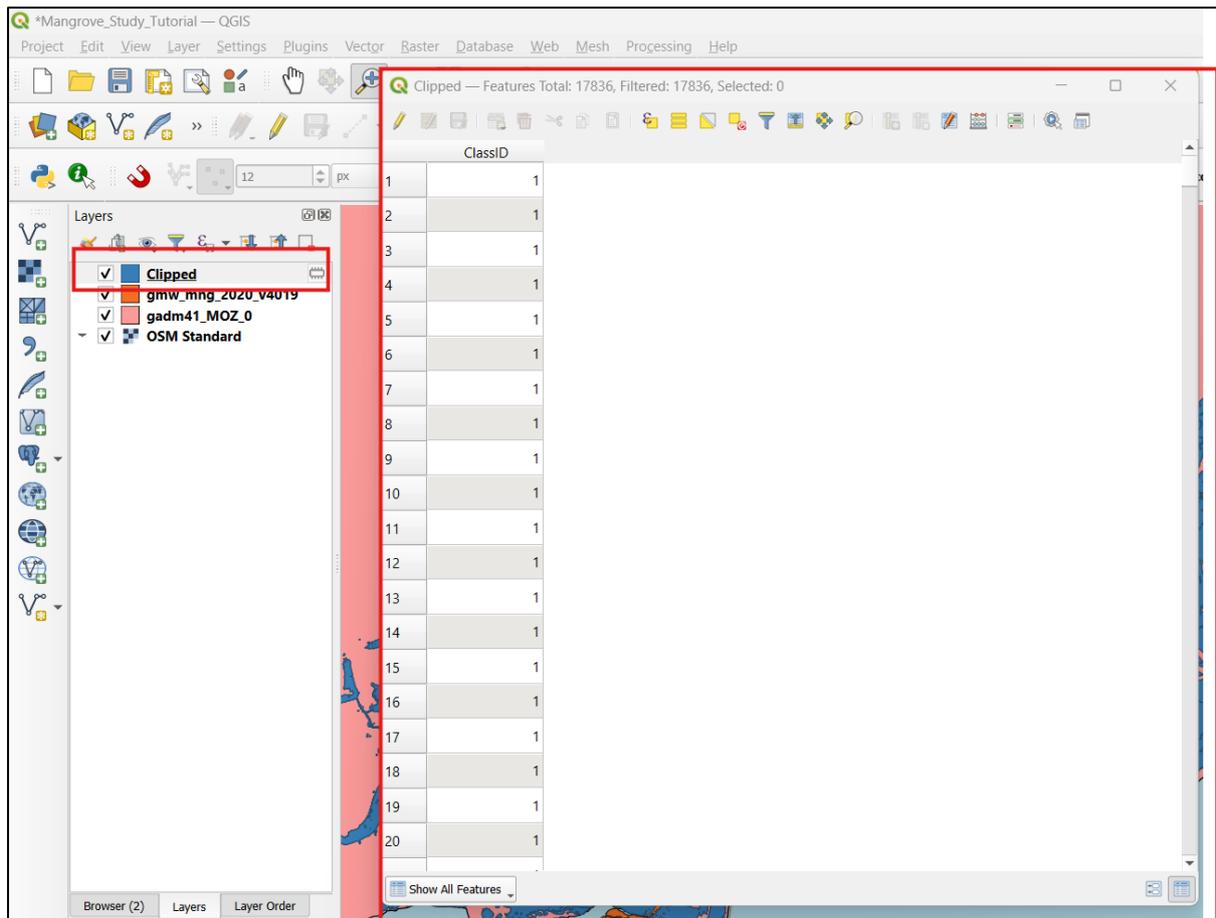


If this process takes too long: Click “Cancel” to cancel the process and use the layer provided in the pre-processed layers found in the folder named “GlobalMangroveWatch” and find the file called “gmw_mng_2020_v4019_clipped.shp”. To add this layer, simply go to “Layer”, “Add Vector”, “Add Vector Layer”, then under “Source” navigate to the file, then “Add” and “Close”.

2.5.6. Dissolving Polygons

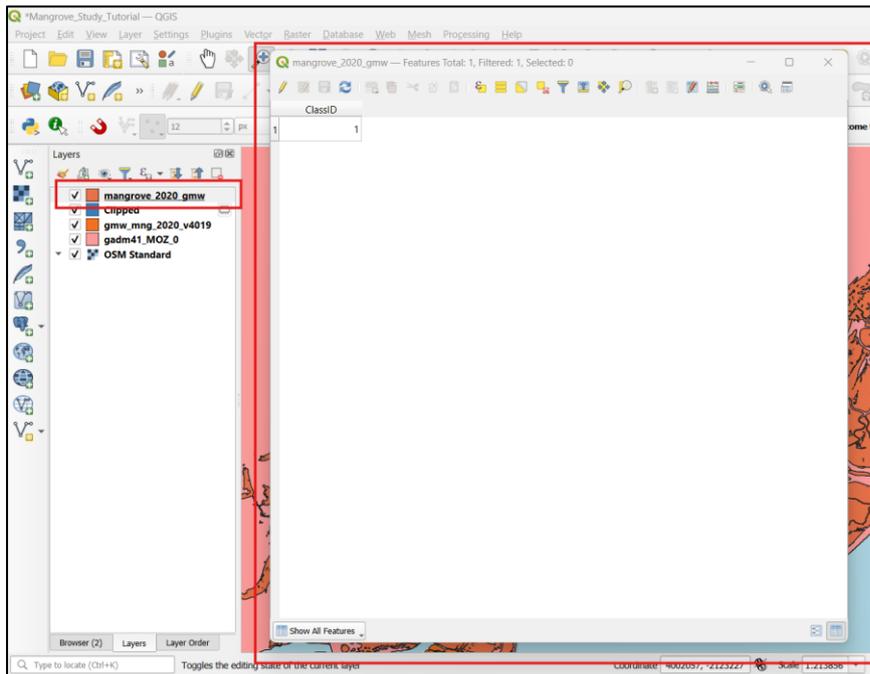
Each shapefile has an associated “*Attribute Table*” that has various associated data, including the number of polygons within the data layer.

- To view the “*Attribute Table*” right-click on the new “*Clipped*” layer and scroll down to the “*Open Attribute Table*”, a table will open in a separate window.
- For the “*Clipped*” layer, you can see that there is one column (“*ClassID*”) and many rows (17,836) that represent individual polygons.



- We now want to dissolve the 17,836 polygons, to one polygon that will assist in things like calculating extents.
- To do this, go to “*Vector*” then “*Geoprocessing Tools*” then “*Dissolve*”. In the “*Vector Geometry*” window ensure that in the “*Input layer*” that the “*Clipped*” layer is selected, and under the “*Dissolved*” section, click  and navigate to the folder named “*GlobalMangroveWatch*” folder and name the file “*mangroves_2020_gmw*” and ensure that the file type is “*SHP files (*.shp)*”. Then, press “*Save*” and “*Run*”.
- Wait for the process to run. It may take a few minutes. Once the process has finished, the dissolved layer should automatically be added to the “*Layers*” gallery.

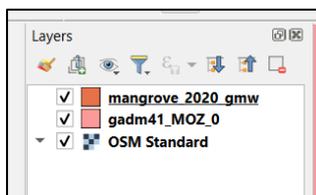
- To check that the dissolved layer has worked, right-click the layer called “*mangrove_2020_gmw*” and view the “*Open Attributes Table*” and you should see one row only that means that the mangroves are dissolved into one polygon (with multiple parts).



2.5.7. Removing Layers

Within GIS it is good practice to keep the “*Layers*” gallery clear of any un-needed layers. We now do not need the “*Clipped*” layer we generated, and nor the layer named “*gmw_mng_2020_v4019*” which is the worldwide Global Mangrove Watch dataset.

- We do not need the global mangrove dataset anymore, and so you can turn off the global mangrove dataset by clicking the box, which will grey out the name of the layer.
- To remove these layers, right-clicking on the layer, then scroll down to the “*Remove layer*” option and click on this. In the “*Remove layers and groups*” window that opens, select “*OK*”.
- You now should be left with the layers shown below.

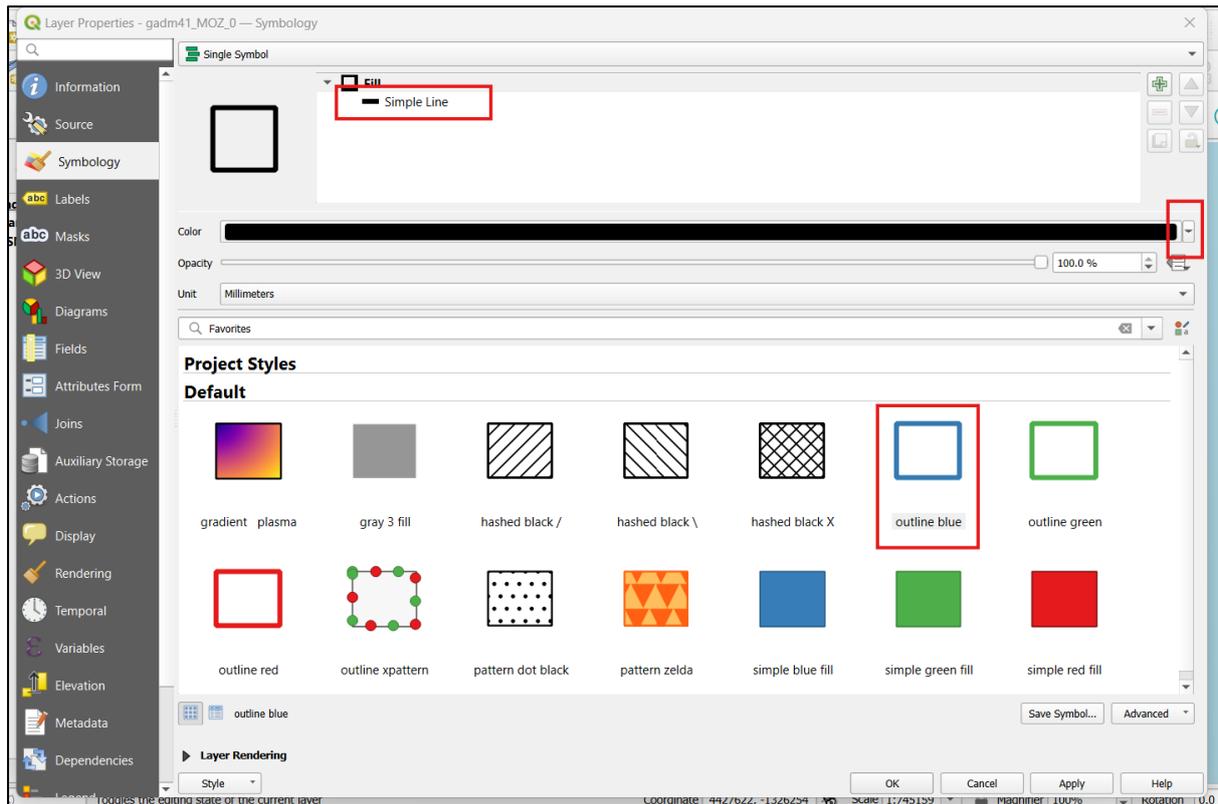


- Click on  to save the project so far.

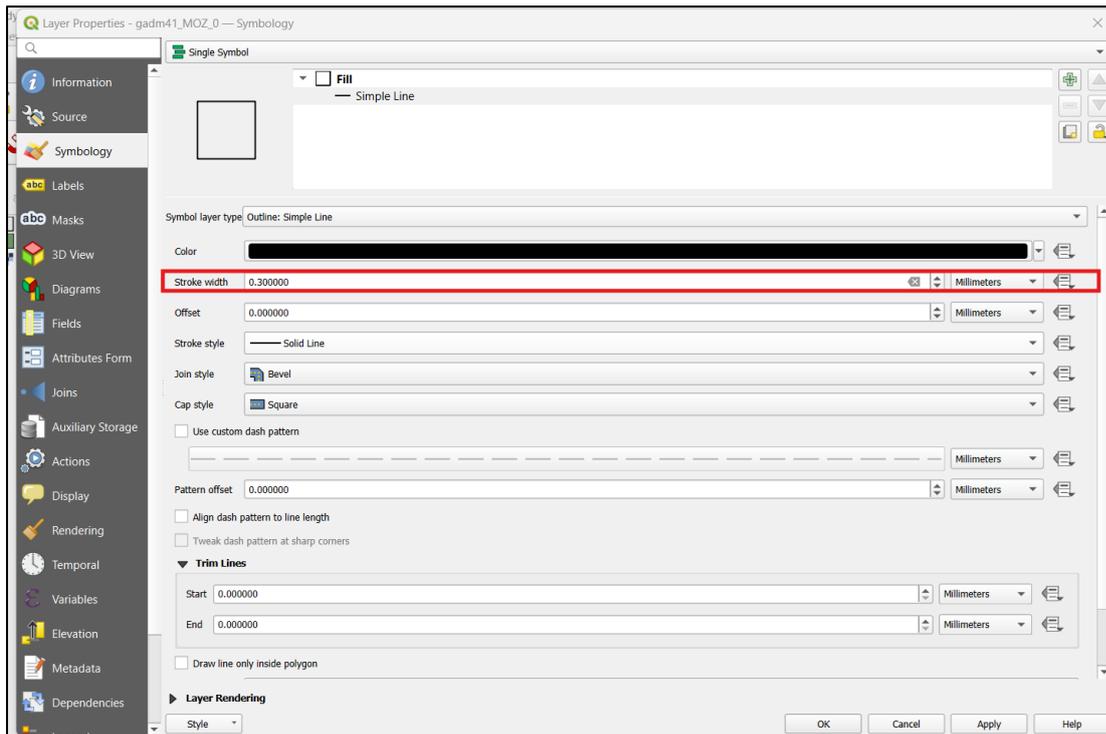
2.5.8. Changing Symbology

We can change the way that layers look so that the data is easier to view.

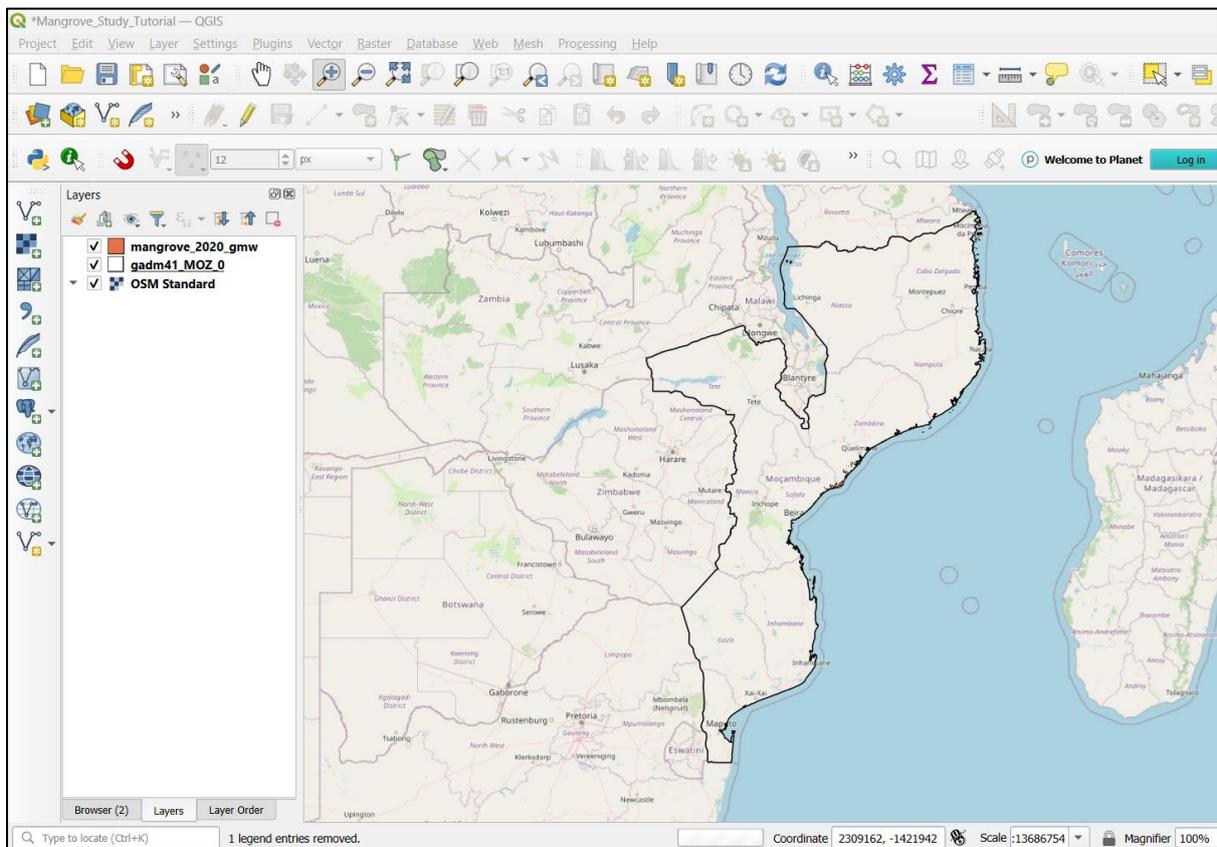
- To do this, right-click on “*gadm41_MOZ_0*”, then go to “*Properties*” at the bottom. Or you can also double click on the coloured box of the layer.
- A “*Layer Properties*” window will open. Click on the “*Symbology*” option on the left to open the symbology window.
- Then select the blue outline option and click the “*Colour*” dropdown option and select black or any colour you would like.



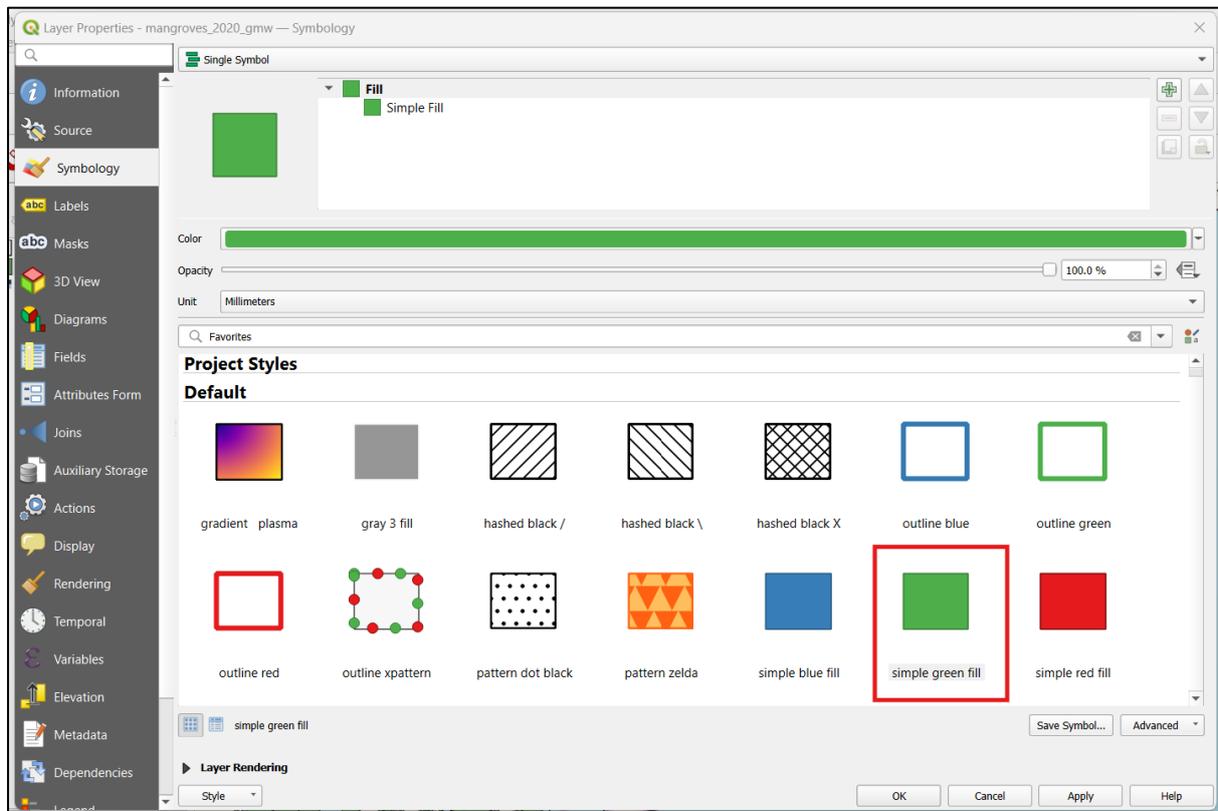
- Then to change the line thickness, click on the “*Simple line*” and another window will open. Then you can amend the “*Stroke width*” by manually editing the value or by clicking on the up and down buttons. Then click “*Apply*” then



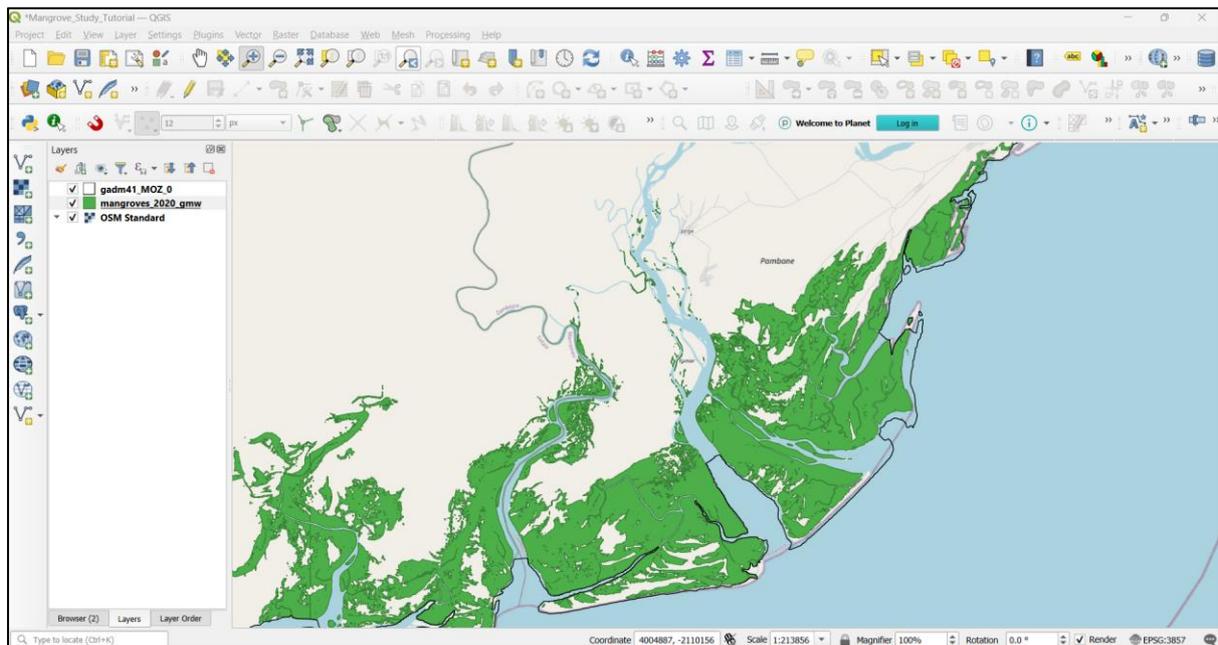
- Then zoom out to view the symbology edit by using , or scrolling out using your mouse.



- Next, click on the mangrove data layer, and zoom into an area to better visualise the data. Select the “Simple green fill” option, then hit the “Apply” then “OK” buttons.



- Drag and drop the mangrove layer to under the Country layer.
- Pan () around to visualise the data more.



2.5.9. Adding Protected Area Data

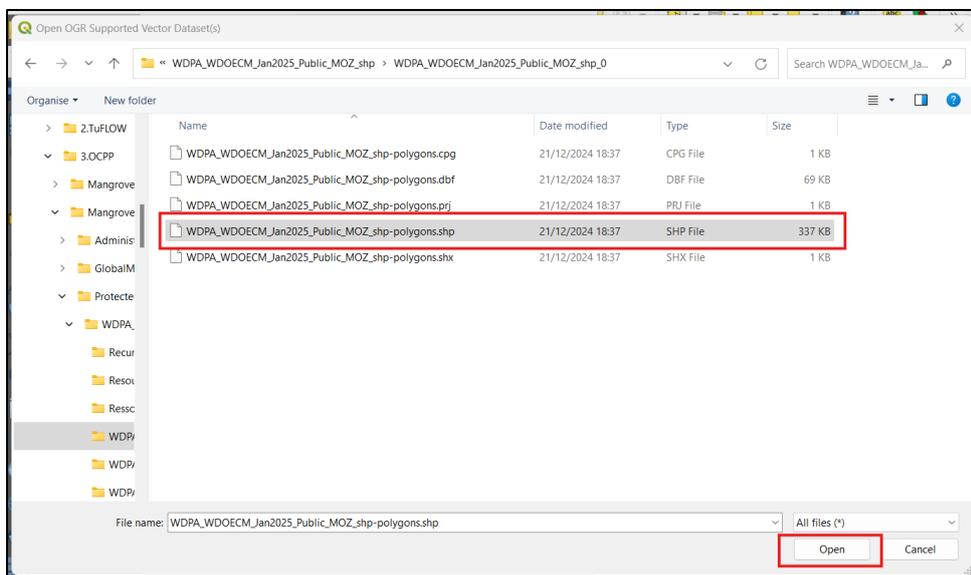
Next, we will add the protected area data we downloaded from **Protected Planet**, open access resource. Ensure all folders are unzipped.

- To do this, go to “*Layer*” then “*Add Layer*” then “*Add Vector Layer*”. Go to  and navigate to the “*ProtectedAreas_WDPA*” folder then go into the “*WDPA_WDOECM_Jan2025_Public_MOZ_shp*” folder.
- We will need to bring in 3 shapefiles for the protected areas in Mozambique. These three files are in the three folders below.



Unfortunately, in each folder the vector layer we need to add to our project each has the same name, which will create an error when we merge these layers in the step below. So, we will need to bring in these data and then export them and modify their name.

- To do this, go into the first folder ending in “*...shp_0*”, click on “*.shp*” and then “*Open*” then “*Add*”, then “*Close*”.



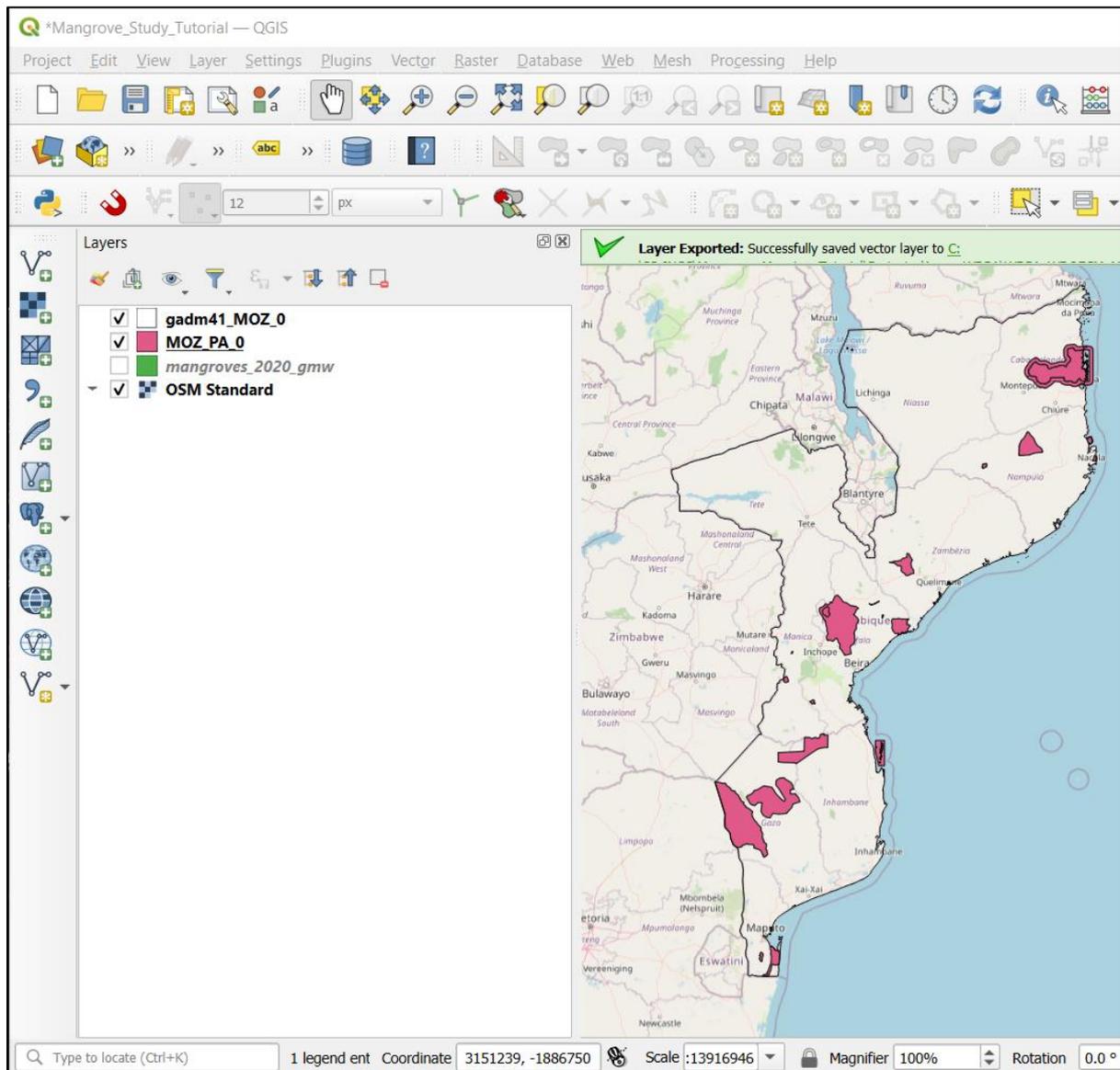
- You will see the file added to the map. Right-click on this layer then go to “*Export*”, then “*Save Features As*”.
- In the “*Save Vector Layer As*” window, ensure the format is “*ESRI Shapefile*”,

Then under “*File name*”, click on  and navigate to the folder “*WDPA_WDOECM_Jan2025_Public_MOZ_shp*” folder and name this first file

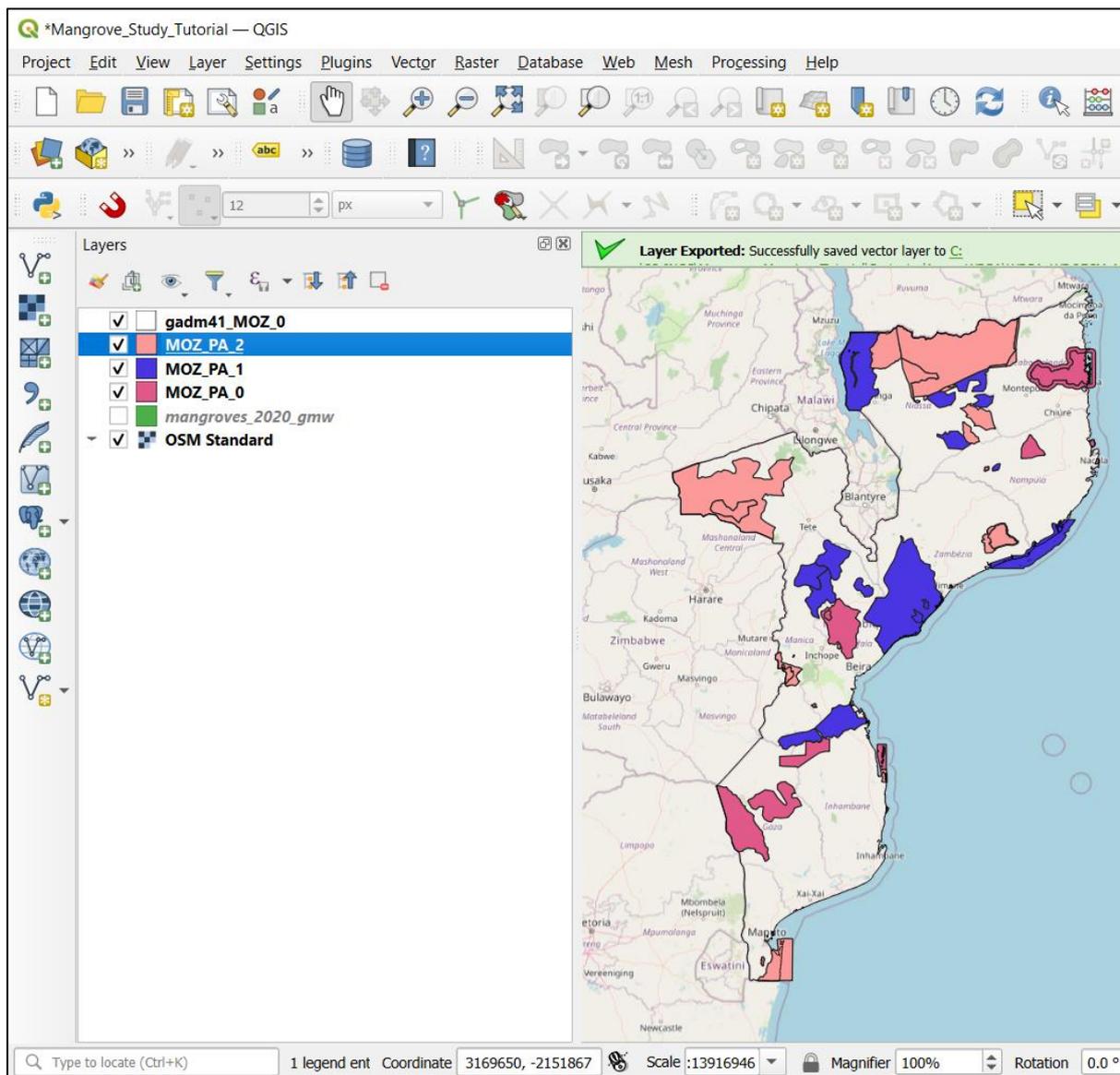
“MOZ_PA_0”, then select “Save” then leave the rest as default and press “OK”.

You should now see the same file but renamed in QGIS.

- Remove the original layer by right-clicking on it and select “*Remove Layer*”, then “OK”.



- Repeat the above for the other two layers, naming the one from the folder ending in “...shp_1”, as “MOZ_PA_1”, and the other from the folder ending in “...shp_2”, as “MOZ_PA_2”,
- Then, you should see the three protected area layers similar to the below (likely with differing default colours).

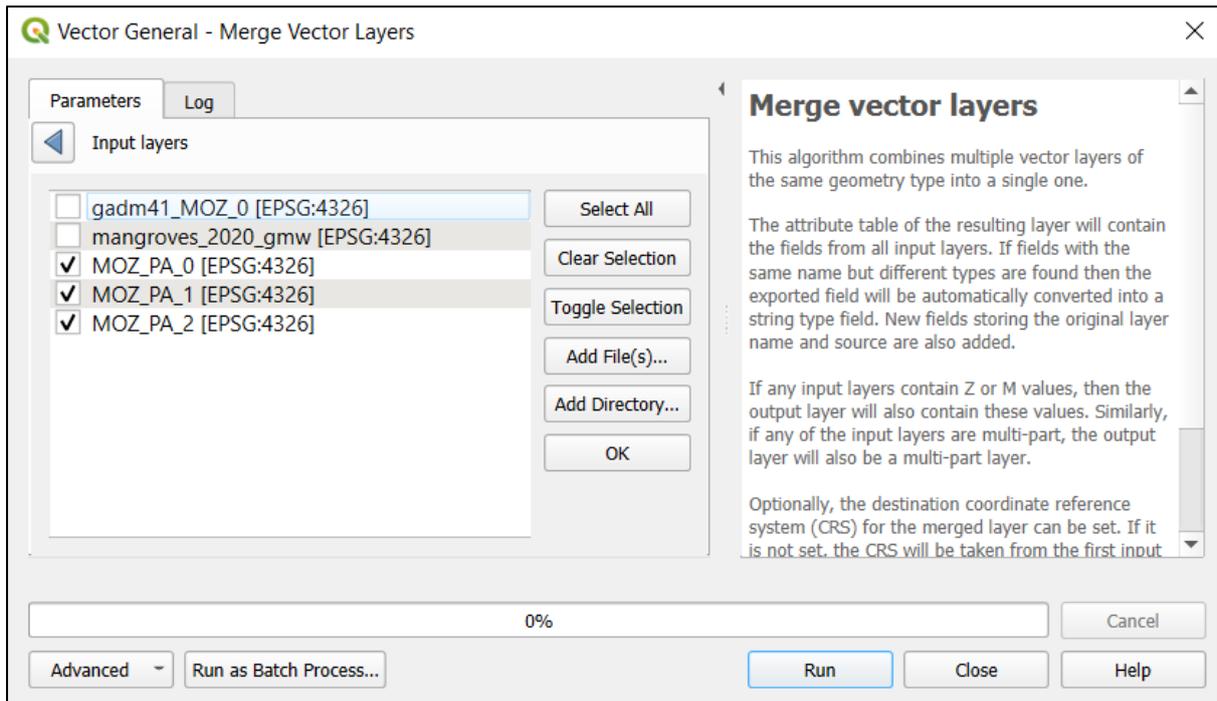


- Click on  to save the project so far.

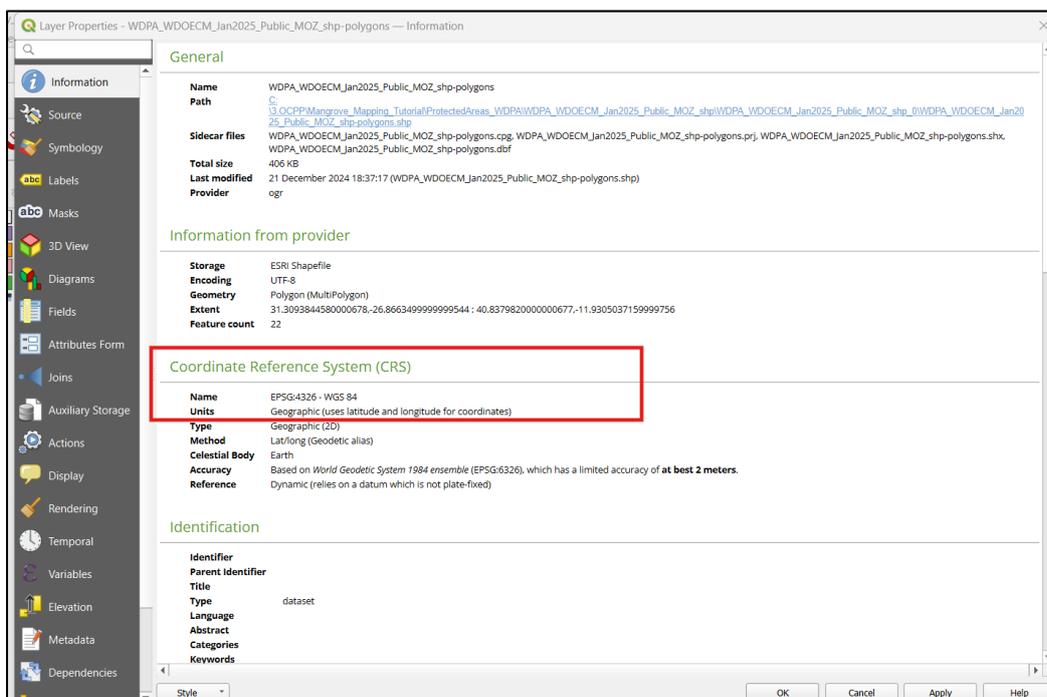
2.5.10. Merging Datasets

For the protected areas layer, we will need to combine or merge these three layers into one.

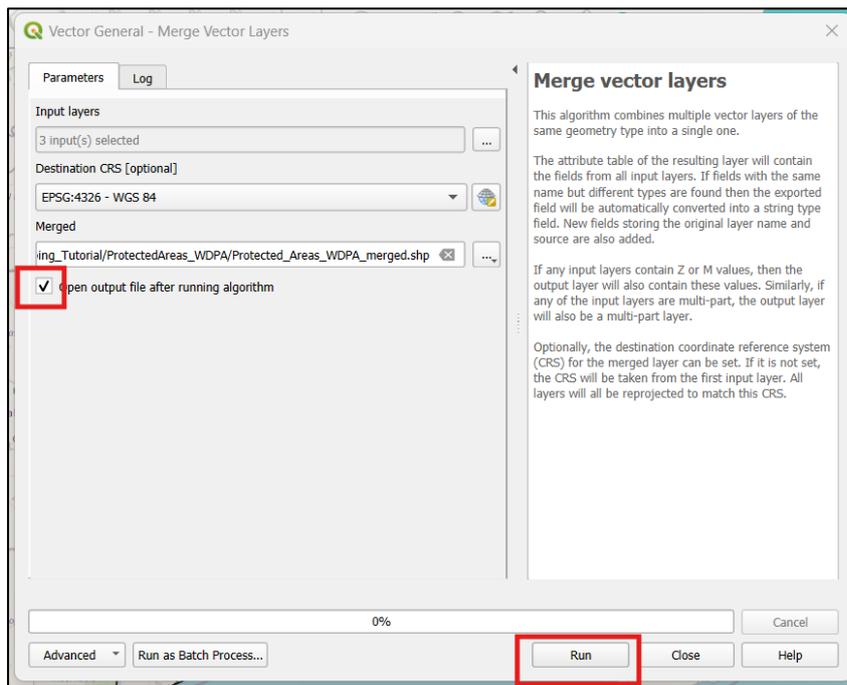
- To do this, go to “*Vector*” at the top of the screen, then “*Data Management Tool*”, then “*Merge Vector Layers*”. A “*Vector General – Merge Vector Layers*” window will open.
- For the “*Input layers*” section, click on  that will then open a layer’s options window you can click on. Click on the three boxed (to tick them) for the 3 protected area layers. Then click “*OK*”.



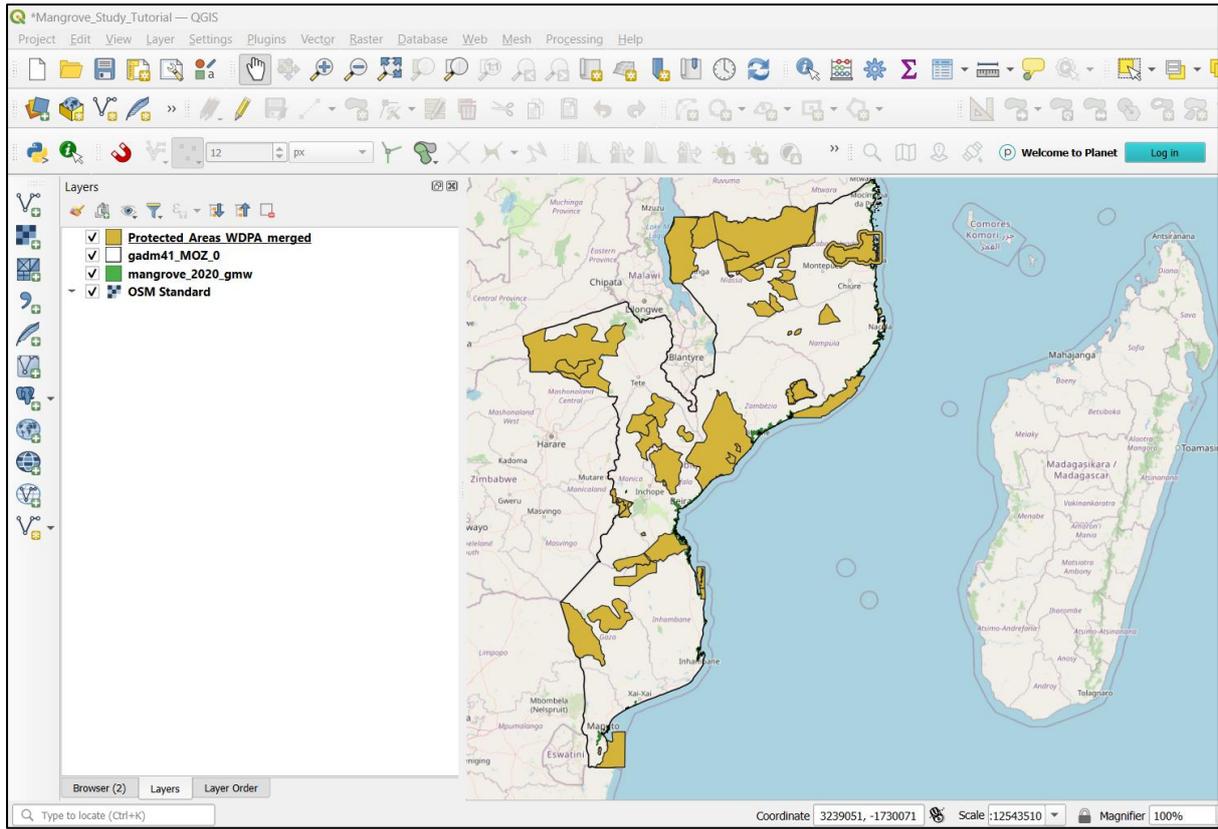
- Then in the “*Destination CRS*” section, you can optionally input the coordinate system that you want to merged layer to be in.
- To understand what coordinate system the protected area layers are in currently, right-click on one of the protected areas in the “*Layers*” gallery, go down to “*Properties*” then on the right-hand side bar ensure “*Information*” is selected.
- You will see that it is in “*EPSG:4326 - WGS 84*”.
- Close this window.



- Back in the “*Vector General – Merge Vector Layers*” window, in the “Destination CRS” section, select the option “EPSG:4326 - WGS 84” from the drop-down menu.
- Next, under the “Merged” section, click on  then select “Save to File” then navigate to the folder named “ProtectedAreas_WDPA” and name the file “**Protected Areas WDPA merged**” and ensure that the file type is selected as “SHP files (*.shp)”. Then select “Save”.
- Then back in the “*Vector General – Merge Vector Layers*” window, ensure that the box for “open output file after running algorithm” is ticked.
- Then, select “Run”.



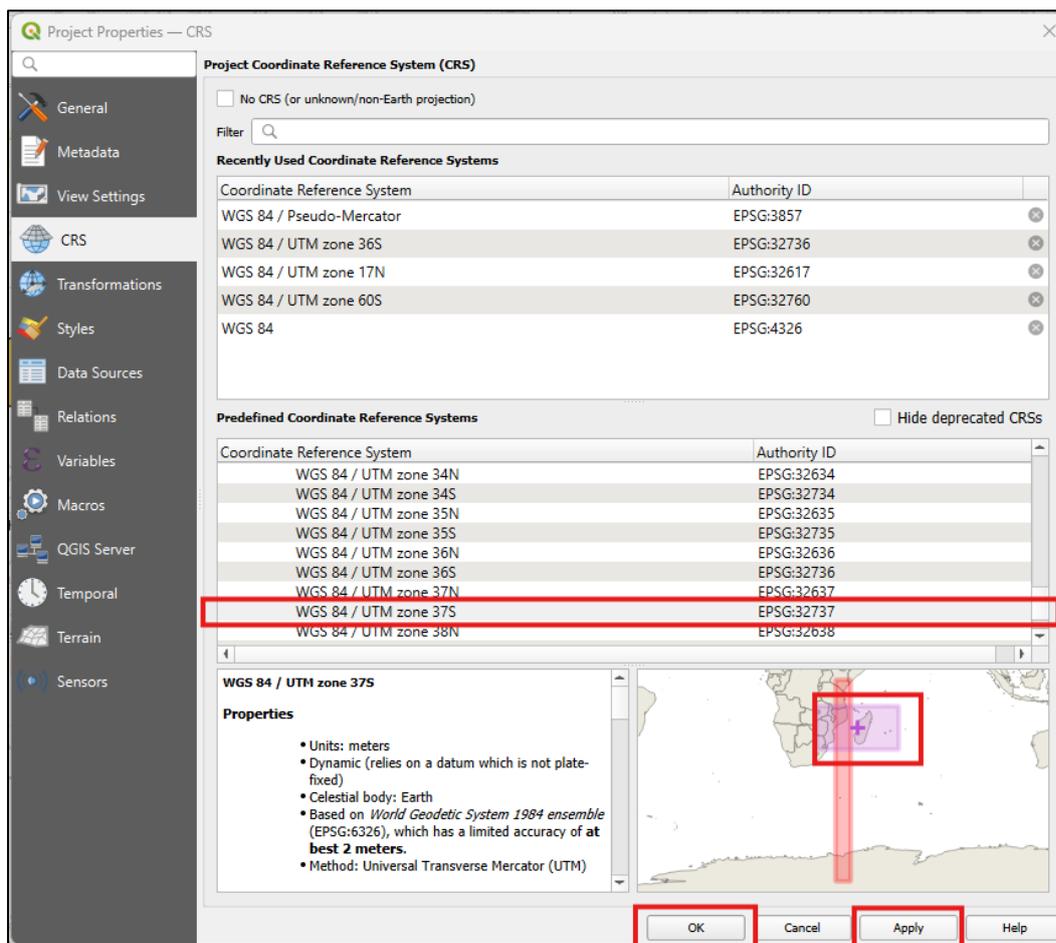
- Once it is “*Completed*” then click “Close”.
- You should now see the newly merged protected areas layer in the “Layer” gallery.
- You can now remove the three layers we used to create this layer, as we no longer need them. To do this, right-click and select “Remove layer” and then select “OK”. Do this for the three files.



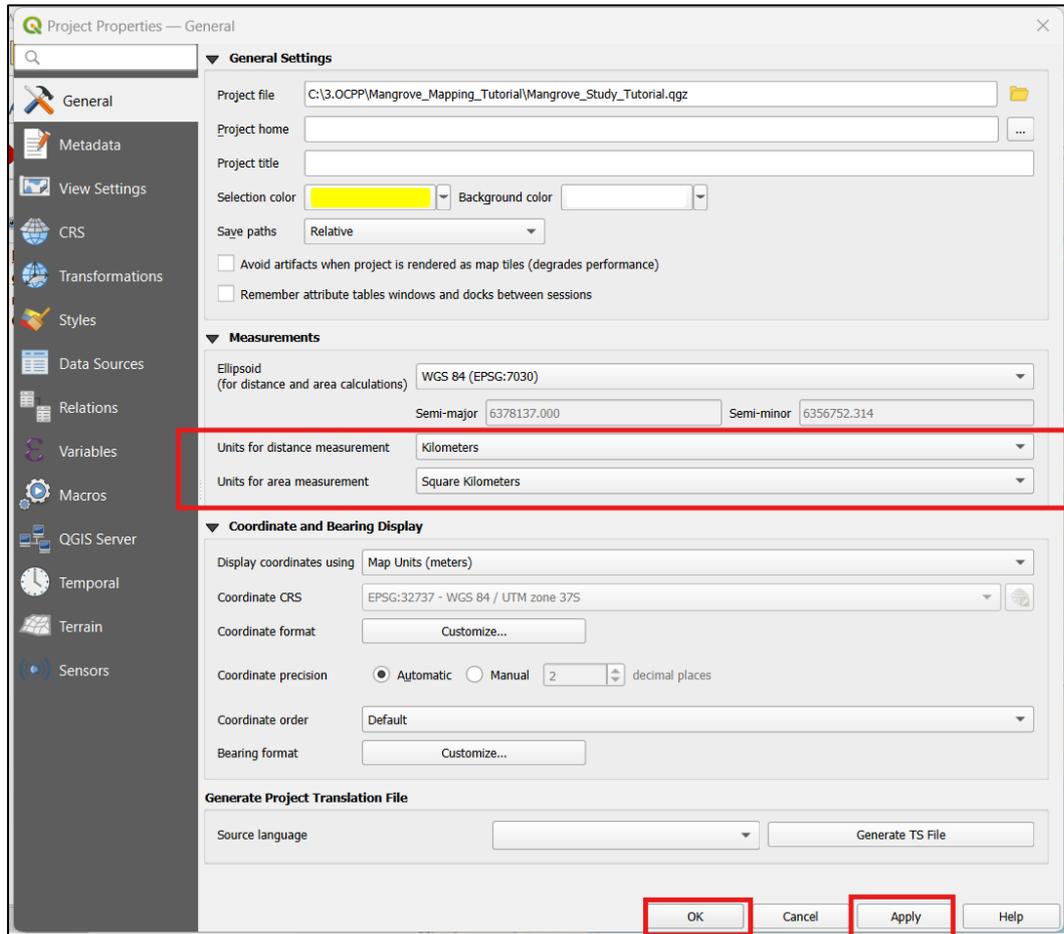
2.5.11. Project Projections

Now that we have amended the files so that we can start to interrogate the data and understand mangrove extents and proportions within protected areas, for example.

- To help us calculate extents, without changing the coordinate system of the individual layers, go to “*Project*” at the top of the screen, and go down to “*Properties*”.
- In the “*Project Properties*” window that pops up, ensure that “*CRS*” is clicked.
- Here you will see information regarding what Project Coordinate Reference System (CRS) the project is in (usually is in in the default projection that your initial layer was in).
- To amend the projection of the project, go to the section named “*Predefined Coordinate Reference Systems*” and select the dropdown for “*Projected*” option.
- Scroll down and select the option “*Universal Transverse Mercator (UTM)*”, then scroll all the way down to “*WGS 84 / UTM zone 37S*”. The projection area can be seen in the map. Mozambique covers both UTM zone 37S (east) and 36S (west). But for now, select zone 37S, then “*Apply*” and “*OK*”.



- Next, “Project”, “Properties” and “General”, use the dropdown menus to change units to “Kilometres” under “Units for distance measurements” and “Square Kilometres” for “Units for area measurement”.
- Then select “Apply” and “OK”.

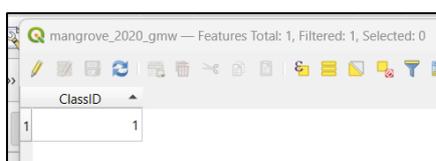


2.5.12. Attribute Tables to Calculate Extents

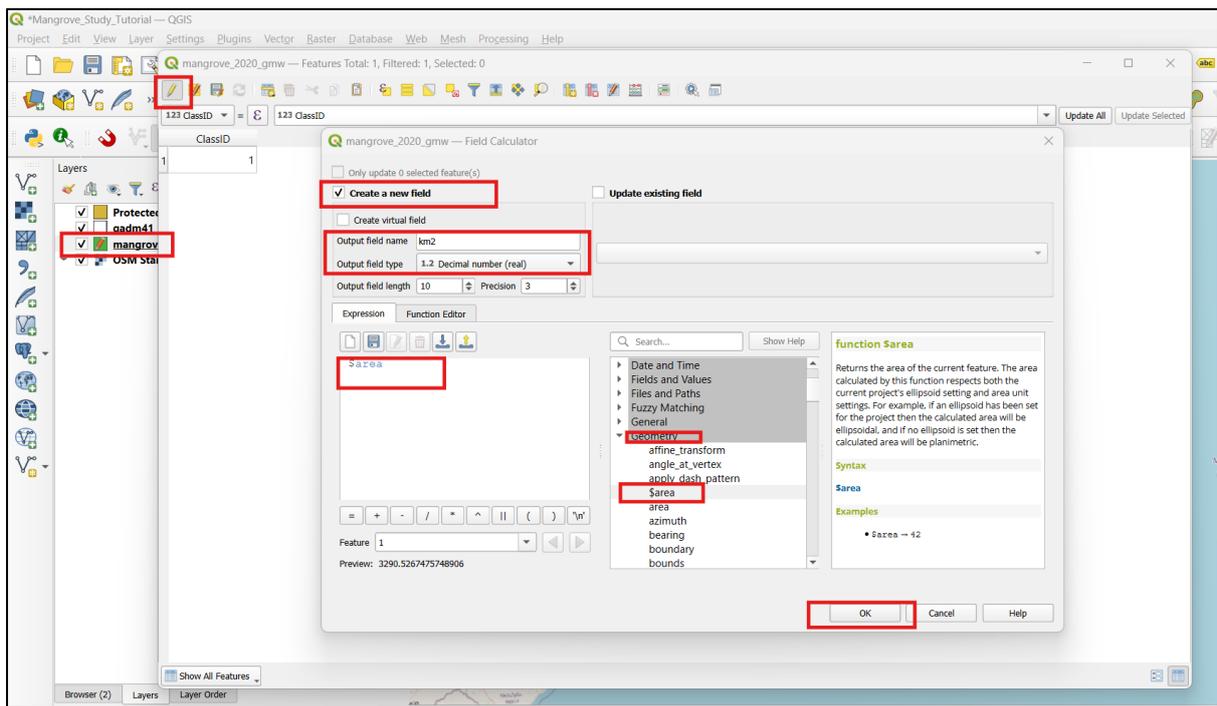
We can now start to calculate the area of polygons/shapefiles we have.

Firstly, we want to know what the total extent of mangroves in Mozambique was for the year 2020 (the year of the data we downloaded from Global Mangrove Watch).

- Right-click on “*mangrove_2020_gmw*” layer and select “Open Attribute Table”.
- You will see one column (or field), called “*ClassID*” and one row that corresponds to our mangrove polygon.



- To start the edit mode for the “Attribute Table” click on . You will then see this symbol in this layer’s box in the gallery.
- Then “Open the field calculator” by clicking on . You will see there is only one polygon of “Feature”.
- We want to create a new field, so ensure this is ticked in the “Field Calculator” window. In this window, in the “Output field name” write “km2”, and in the “Output field type” select “Decimal number (real)”
- Then in the “Expression” section, click on the triangle next to “Geometry”, and find “\$area” and double click then press “OK”.



- Once the process has run, the new column (“km2”) should be visible, along with the calculated extent of the polygon.
- **The result here shows that there is 3,290.5 km² of mangroves in the 2020 Global Mangrove Watch data for Mozambique.**

ClassID	km2
1	3290.527

- You can then click  to toggle off the edit function, then click “Save” when prompted to save your edits to the layer.

Next, we want to calculate the extent of mangroves within Mozambique's protected areas.

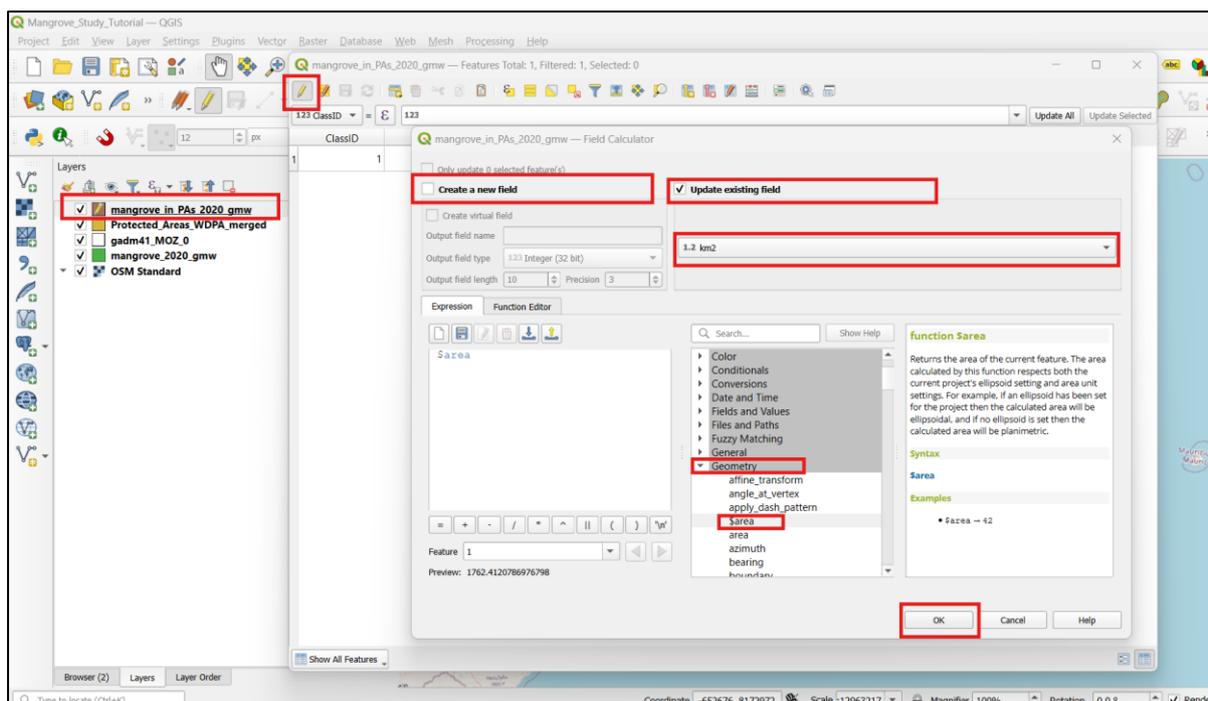
- To do this, click on “Vector”, “Geoprocessing Tools”, then “Clip”. For the “Input layer” chose “mangrove_2020_gmw”, and for the Overlay layer select “Protected_Areas_WDPA_merged”. Then, under the “Clipped” section, click on  and select “Save to File”.
- Navigate to “GlobalMangroveWatch” folder and save file as “mangroves_in_PAs_2020_gmw”, then click “Save”. Then click “Run”. This process may take a little while.

If this process takes too long: Click “Cancel” to cancel the process and use the layer provided in the pre-processed layers found in the folder named “GlobalMangroveWatch” and find the file called “mangroves_in_PAs_2020_gmw.shp”. To add this layer, simply go to “Layer”, “Add Vector”, “Add Vector Layer”, then under “Source” navigate to the file, then “Add” and “Close”.

- Once finished, the new layer should be automatically added to the “Layers” gallery. Right-click the layer and open the “Attribute Table”.

Retained in the “km2” column is the original layers extent (i.e., to total area of mangrove in Mozambique). We need to update this to our new extent to show mangroves within protected areas.

- To do this, click on , then click on “Open Field Calculator”  then unclick the “Create a new field” tick box, and instead click the “Update existing field” box.
- Select “km2” attribute in the drop-down menu.
- In the “Expression” section, find the “Geometry” option and click the arrow for the dropdown menu and double click the “\$area” option. Then press “OK”.



- You should then see the newly calculated area, for mangroves in protected areas. The extent should be around 1,762 km².
- Click on the  to turn off edit mode and select to “Save Edits”. Also click on  to save the project.

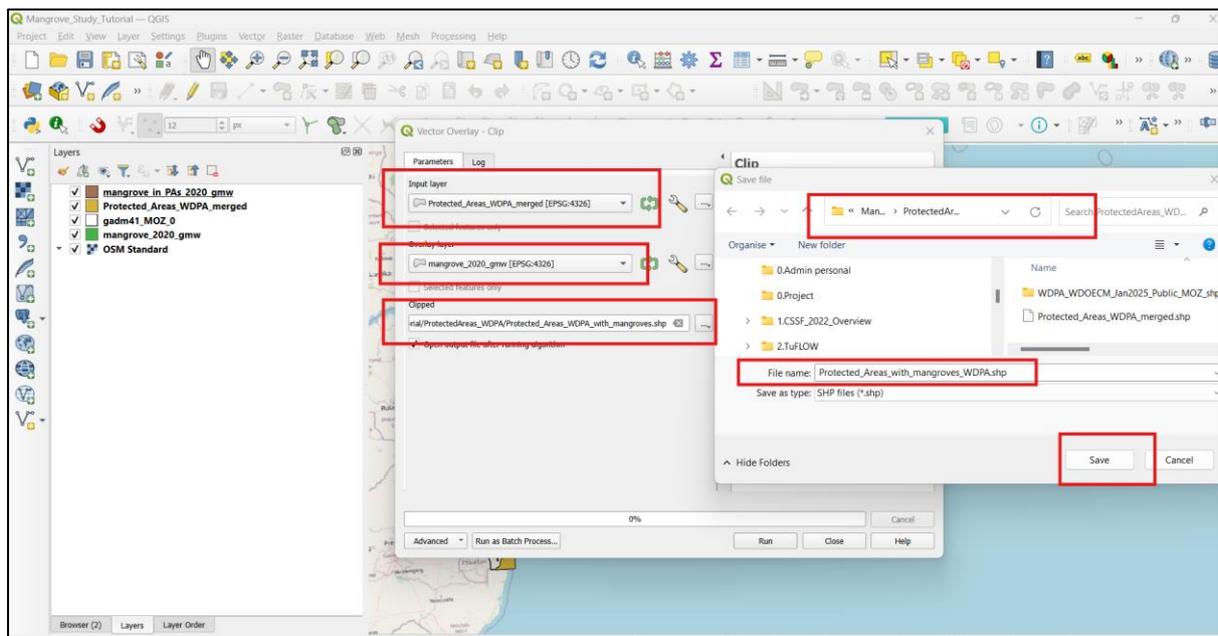
ClassID	km2
1	1762.412

We have calculated the extent of mangroves using the Global Mangrove Watch data for 2020 in Mozambique to be 3,290.5 km². The extent within the protected areas, then totalled 1,762 km².

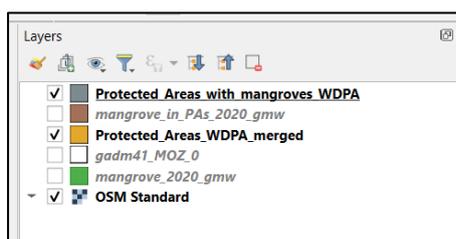
This means that 46.5% of Mozambique’s mangroves (circa. 1,528.5 km²) are not protected, and potentially vulnerable to threats such as conversion.

You can also look at which protected areas have mangroves and calculate the extents within these. Like for many GIS methods, this can be done in several ways. But using the tools already described, we can use the “Clip” tool to identify which protected area has mangroves within it and the extent of those mangroves.

- To do this, go to “Vector”, “Geoprocessing tools”, then “Clip”.
- Then in the pop-up window select,
 - “Protected_Areas_WDPA_merged” layer as the “Input layer”.
 - “mangrove_2020_gmw” as the “Overlay layer”,
 - In the “Clipped” section click on  and select “Save to File” navigate to the “ProtectedAreas_WDPA” folder, and name the new file “Protected_Areas_with_mangroves_WDPA.shp”. Then, “Save”, and “Run”.



- Once the process has run (this may take a few minutes) the newly created file should be visible in the “Layer” gallery. Drag this layer to the top, if it’s not there already.
- Click off other layers that you do not need right now.



- Open the attribute table, by right-clicking on the new layer, and select “*Open Attribute Table*”.
- This table now shows the number of protected areas that intersected with the mangrove layer. The number of rows or features, that corresponds with the number of protected areas that have mangroves can be found at the top of the table or to the left.
- There are many attributes or columns in this table, and you can use the scroller to the bottom to explore the rest of the data that it contains.

	WDMAID	WDMAID_PID	PA_DEF	NAME	ORIG_NAME	DESIG	DESIG_ENG	DESIG_TYPE	IUCN_CAT	INT_CRIT
1	4649.00000000...	4649	1	Marromeu	Marromeu	Reserva Nacional	National Reserve	National	IV	Not Applicable
2	4652.00000000...	4652	1	Maputo	Maputo	Reserva Especial	Special Reserve	National	II	Not Applicable
3	7941.00000000...	7941	1	Baixo Pinda	Baixo Pinda	Reserva Florestal	Forest Reserve	National	IV	Not Applicable
4	7942.00000000...	7942	1	Matibane	Matibane	Reserva Florestal	Forest Reserve	National	IV	Not Applicable
5	9035.00000000...	9035_B	1	Quirimbas	Quirimbas	Zona Tampao	Buffer Zone	National	V	Not Applicable
6	9035.00000000...	9035_A	1	Quirimbas	Quirimbas	Parque Nacional	National Park	National	V	Not Applicable
7	555698168.000...	555698168	1	Ponta do Ouro	Ponta do Ouro	Reserva Nacional	National Reserve	National	IV	Not Applicable
8	555698170.000...	555698170	1	Pomene	Pomene	Reserva Nacional	National Reserve	National	IV	Not Applicable
9	555698172.000...	555698172	1	Cabo de São Se...	Cabo de São Se...	Santuário	Sanctuary	National	IV	Not Applicable
10	555705347.000...	555705347	1	Maputo	Maputo	Area de conser...	Environmental ...	National	V	Not Applicable
11	303676.000000...	303676	1	Nº10	Nº10	Coutada	Hunting Reserve	National	VI	Not Applicable
12	342679.000000...	342679	1	Nº5	Nº5	Coutada	Hunting Reserve	National	VI	Not Applicable
13	342680.999999...	342681	1	Primeiras & Se...	Primeiras & Se...	Area de Protec...	Environmental ...	National	V	Not Applicable
14	902679.000000...	902679	1	Zambezi Delta	Zambezi Delta	Ramsar Site, W...	Ramsar Site, W...	International	Not Reported	(i)(ii)(iii)(v)(vi)(vii)
15	555697575.000...	555697575	1	Luabo	Luabo	Coutada	Hunting Reserve	National	VI	Not Applicable
16	555697579.000...	555697579	1	Micaune	Micaune	Coutada	Hunting Reserve	National	VI	Not Applicable

We now want to insert a column in the table to calculate the extent of mangroves within each of the 16 protected areas.

- Like what we did before, in the attribute table click on  to allow for edit mode. Then “*Open the field calculator*” by clicking on .
- We will create a new field, so ensure this is ticked. Then in “*Output field name*” write “*km2*”, and in the “*Output field type*” select “*Decimal number (real)*”
- In the “*Expression*” section, click on the triangle next to “*Geometry*”, and find “*\$area*” and double click then press “*OK*”.

The field calculator will close, and if you scroll over to the right-hand side of the attribute table you should see your new field with the extent of mangroves for each protected area. You can click on the header of the field to show the data in ascending or descending order.

path	km2
:/3.OCPP/Man...	0.19
:/3.OCPP/Man...	0.249
:/3.OCPP/Man...	2.030
:/3.OCPP/Man...	2.093

As you will see, there are many columns, and it can be difficult to read the name of the protected area along with its extent of mangroves.

- To help us view these data, click on “Organise Columns” or .
- An “Organise Table columns” window will open, and you can click off the columns you do not want to see. The columns will still be there, and you can turn them back on. But for now, turn most off apart from the “NAME”, “DESIG”, and “km2”. Then select “OK”.
- Then toggle off the edit function by clicking on , and save edits when prompted. And click  also to save updates to the project.

WDPAID	WDPA_PID	PA_DEF	NAME	ORIG_NAME	DESIG	DESIG_ENG	DESIG_TYPE	IUCN_CAT	INT_CRIT	
1	555697579.000...	555697579	1	Micaune	Micaune	Coutada	Hunting Reserve	National	VI	Not Applicable
2	7942.00000000...	7942	1	Matibane	Matibane	Reserva Florestal	Forest Reserve	National	IV	Not Applicable
3	7941.00000000...	7941	1	Baixo Pinda	Baixo Pinda	Reserva Florestal	Forest Reserve	National	IV	Not Applicable
4	...	...	1	Pomene	Pomene	Reserva Nacional	National Reserve	National	IV	Not Applicable
5	...	...	1	Ponta do Ouro	Ponta do Ouro	Reserva Nacional	National Reserve	National	IV	Not Applicable
6	...	...	1	Quirimbas	Quirimbas	Zona Tampao	Buffer Zone	National	V	Not Applicable
7	...	...	1	Cabo de São Se...	Cabo de São Se...	Santuário	Sanctuary	National	IV	Not Applicable
8	...	...	1	Luabo	Luabo	Coutada	Hunting Reserve	National	VI	Not Applicable
9	...	...	1	Maputo	Maputo	Reserva Especial	Special Reserve	National	II	Not Applicable
10	...	...	1	Maputo	Maputo	Area de conser...	Environmental ...	National	V	Not Applicable
11	...	...	1	Nº5	Nº5	Coutada	Hunting Reserve	National	VI	Not Applicable
12	...	...	1	Marromeu	Marromeu	Reserva Nacional	National Reserve	National	IV	Not Applicable
13	...	...	1	Quirimbas	Quirimbas	Parque Nacional	National Park	National	V	Not Applicable
14	...	...	1	Primeiras & Se...	Primeiras & Se...	Area de Protecç...	Environmental ...	National	V	Not Applicable
15	342680.999999...	342681	1	Zambezi Delta	Zambezi Delta	Ramsar Site, W...	Ramsar Site, W...	International	Not Reported	(i)(ii)(iii)(v)(vi)(v
16	902679.000000...	902679	1							

The Attribute Table should now show just three columns, showing the name of the protected area, its designation type and the extent (in km2) of mangroves found within that protected area, according to the Global Mangrove Watch 2020 data.

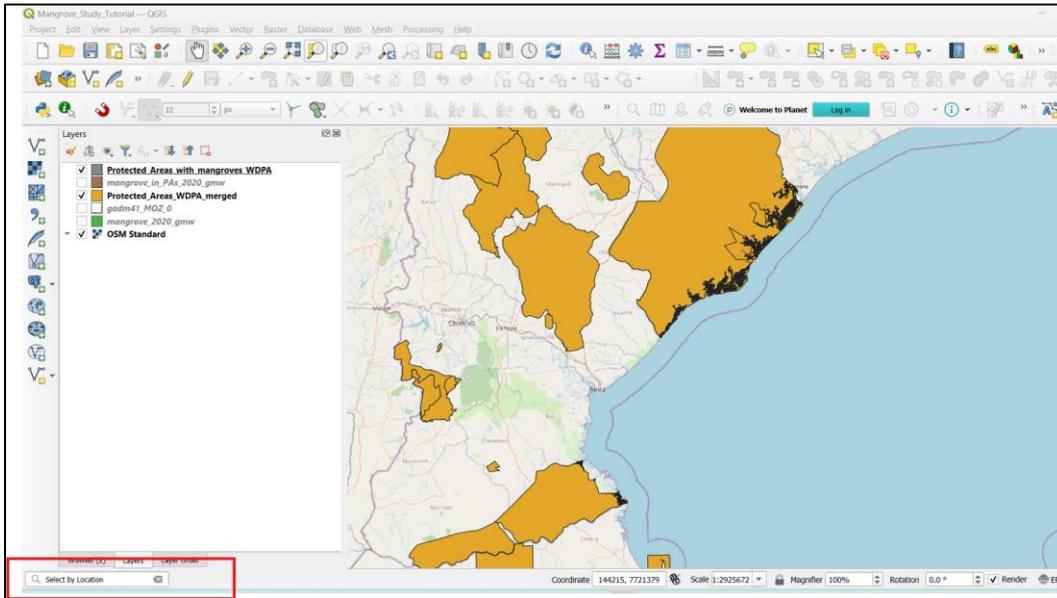
If you cannot see all the text in the table, hover the cursor between two columns at the header, and like excel, you can click and move the width of the column to the size you want.

	NAME	DESIG	km2
1	Micaune	Coutada	0.19
2	Matibane	Reserva Florestal	0.249
3	Baixo Pinda	Reserva Florestal	2.030
4	Pomene	Reserva Nacional	2.093
5	Ponta do Ouro	Reserva Nacional	2.739
6	Quirimbas	Zona Tampao	9.048
7	Cabo de São Sebastião	Santuário	9.101
8	Luabo	Coutada	21.207
9	Maputo	Reserva Especial	30.370
10	Maputo	Area de conservacao ambiental	41.961
11	Nº5	Coutada	66.422
12	Marrromeu	Reserva Nacional	114.447
13	Nº10	Coutada	115.512
14	Quirimbas	Parque Nacional	139.442
15	Primeiras & Segundas	Area de Proteccao Ambiental	587.049
16	Zambezi Delta	Ramsar Site, Wetland of International Importance	901.895

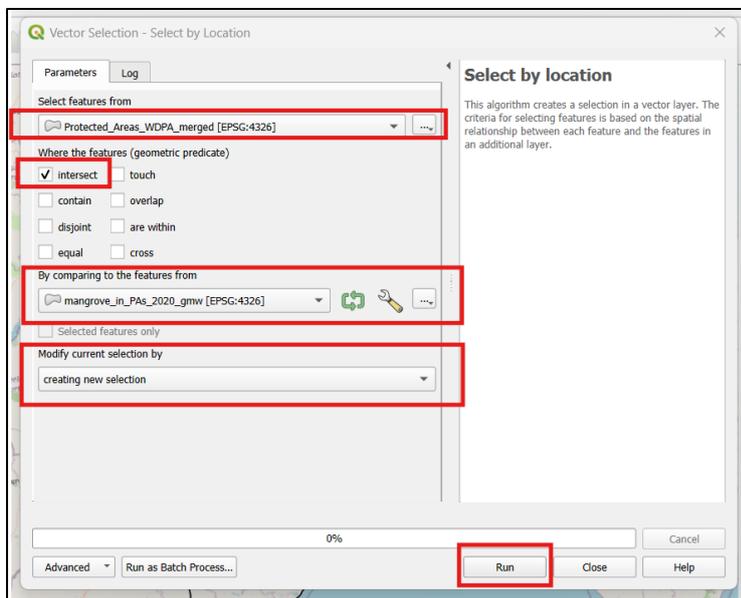
Here we can now start to see information about which protected areas are key for mangrove conservation, which can help with targeting resources and monitoring efforts to ensure that these critical ecosystems are managed accordingly. For example, we can see that some mangroves are in National Parks versus Hunting Reserves, which may have differing levels of protection, for example.

To better visualise, which protected areas have mangroves, we can also perform another function that will help us map this out.

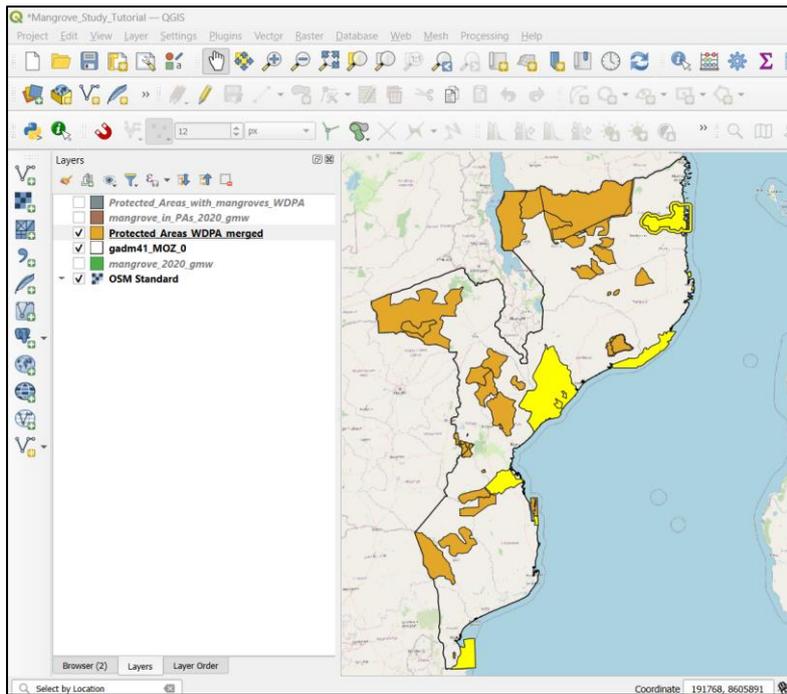
- To do this we will use a “*Select by Location*” function, which you can find by typing this in the search bar at the bottom-left of the screen. And double click the option that pops up.



- In the “Vector Selection - Select by Location” window, under “Select features from”, select “Protected_Areas_WDPA_merged” layer. Tick the “intersect” option.
- Under “By comparing to the features from”, select “mangrove_in_PAs_2020_gmw” layer.
- Then under “Modify current selection by” ensure that “creating new selection” is selected, then click “Run”. Click “close” once done.



- In the map, you should now see selected protected areas highlighted in yellow, these are the 16 protected areas that contain mangroves.



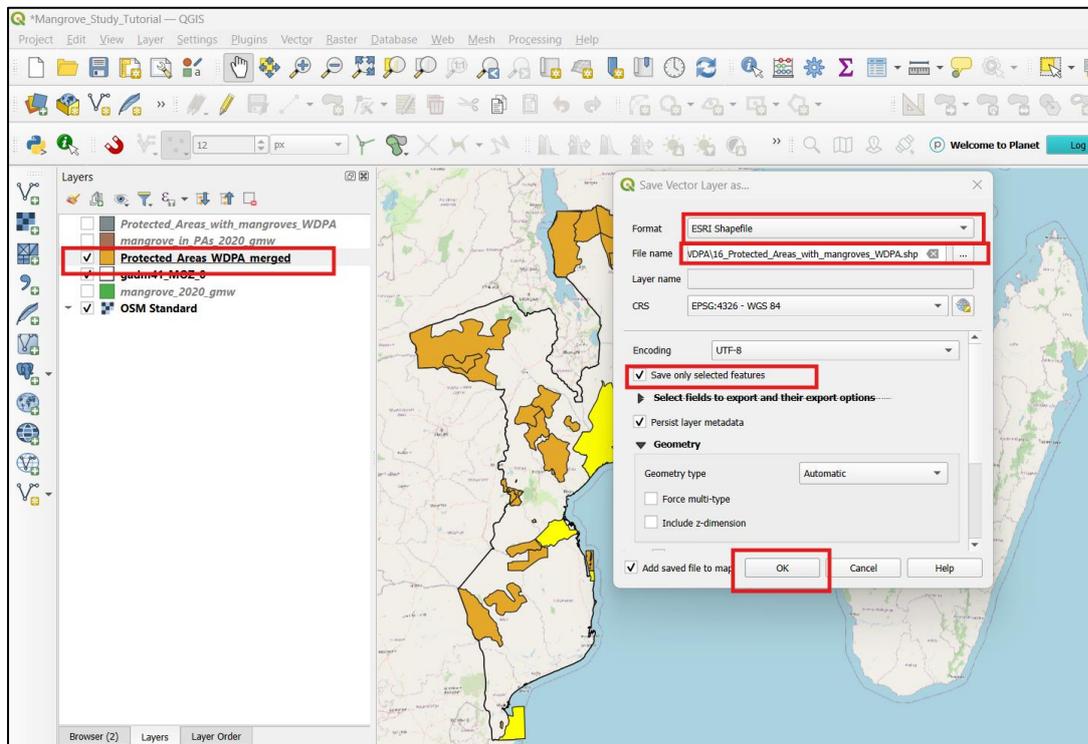
If you open the Attribute table of the file “*Protected_Areas_WDPA_merged*” by right-clicking on the layer, you will see the 16 highlighted features as blue.

WDPAID	WDPA_PID	PA_DEF	NAME	ORIG_NAME	DESIG	DESIG_ENG	DESIG_TYPE	IUCN_CAT	INT_CRIT
1	799.000000000...	799	Banhine	Banhine	Parque Nacional	National Park	National	II	Not Applicab
2	800.000000000...	800	Zinave	Zinave	Parque Nacional	National Park	National	I	Not Applicab
3	801.000000000...	801_A	Gorongosa	Gorongosa	Parque Nacional	National Park	National	II	Not Applicab
4	801.000000000...	801_C	Serra da Goron...	Serra da Goron...	Parque Nacional	National Park	National	II	Not Applicab
5	801.000000000...	801_B	Gorongosa	Gorongosa	Zona Tampao	Buffer Zone	National	VI	Not Applicab
6	802.000000000...	802	Bazaruto	Bazaruto	Parque Nacional	National Park	National	II	Not Applicab
7	4649.000000000...	4649	Marroneu	Marroneu	Reserva Nacional	National Reserve	National	IV	Not Applicab
8	4652.000000000...	4652	Maputo	Maputo	Reserva Especial	Special Reserve	National	II	Not Applicab
9	7938.000000000...	7938	Mecuburi	Mecuburi	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
10	7939.000000000...	7939	Ribáuê	Ribáuê	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
11	7941.000000000...	7941	Baixo Pinda	Baixo Pinda	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
12	7942.000000000...	7942	Matibane	Matibane	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
13	7943.000000000...	7943	Derre	Derre	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
14	7944.000000000...	7944	Inhamitanga	Inhamitanga	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
15	7945.000000000...	7945	Nhapacu?	Nhapacu?	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
16	7947.000000000...	7947	Régulo Zomba	Régulo Zomba	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
17	7948.000000000...	7948	Maronga	Maronga	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
18	7949.000000000...	7949	Mucheve	Mucheve	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
19	7951.000000000...	7951	Licuat	Licuat	Reserva Florestal	Forest Reserve	National	IV	Not Applicab
20	9035.000000000...	9035_B	Quirimbas	Quirimbas	Zona Tampao	Buffer Zone	National	V	Not Applicab

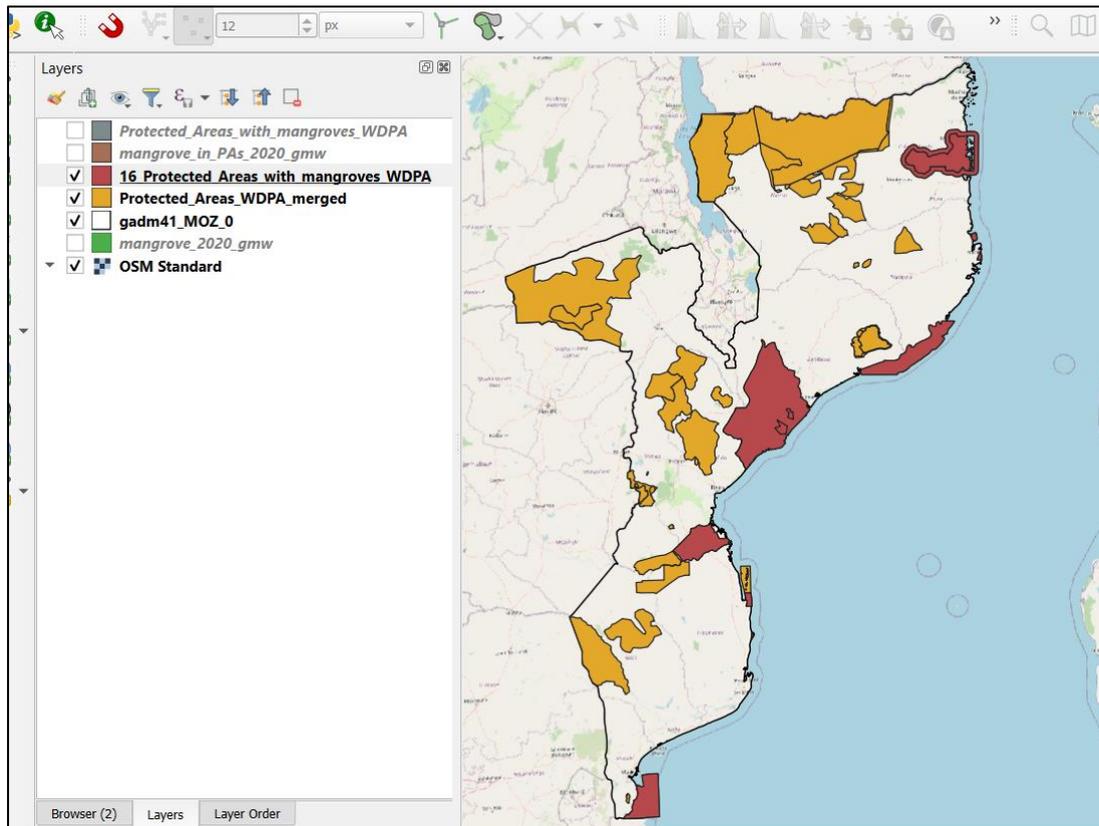
We now want to save the 16 selected protected areas into a new layer, to help us to create a map.

- To do this, right-click on the layer “*Protected_Areas_WDPA_merged*”, scroll down and select “*Export*” and then select “*Save Selected Features As*”. In the window that opens, select “*ESRI Shapefile*”, navigate to your “*ProtectedAreas_WDPA*” folder and save the file as

“16_Protected_Areas_with_mangroves_WDPA”. Ensure the “Save only selected features” option is ticked and keep the remaining default settings and select “OK”.



- Once the process is completed you should see the new layer being added to the “Layer” gallery. Press  to save the project.



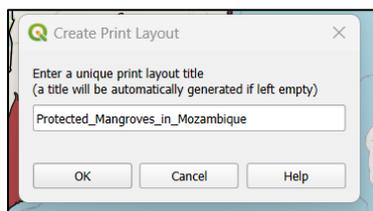
2.6. Creating a Map in QGIS

In addition, being able to use QGIS to analyse spatial data, we can also create maps for reports and presentations, for example.

We now want to create a map of Mozambique showing those protected areas that have mangroves, versus those that do not, and mangrove extents outside of the protected area network.

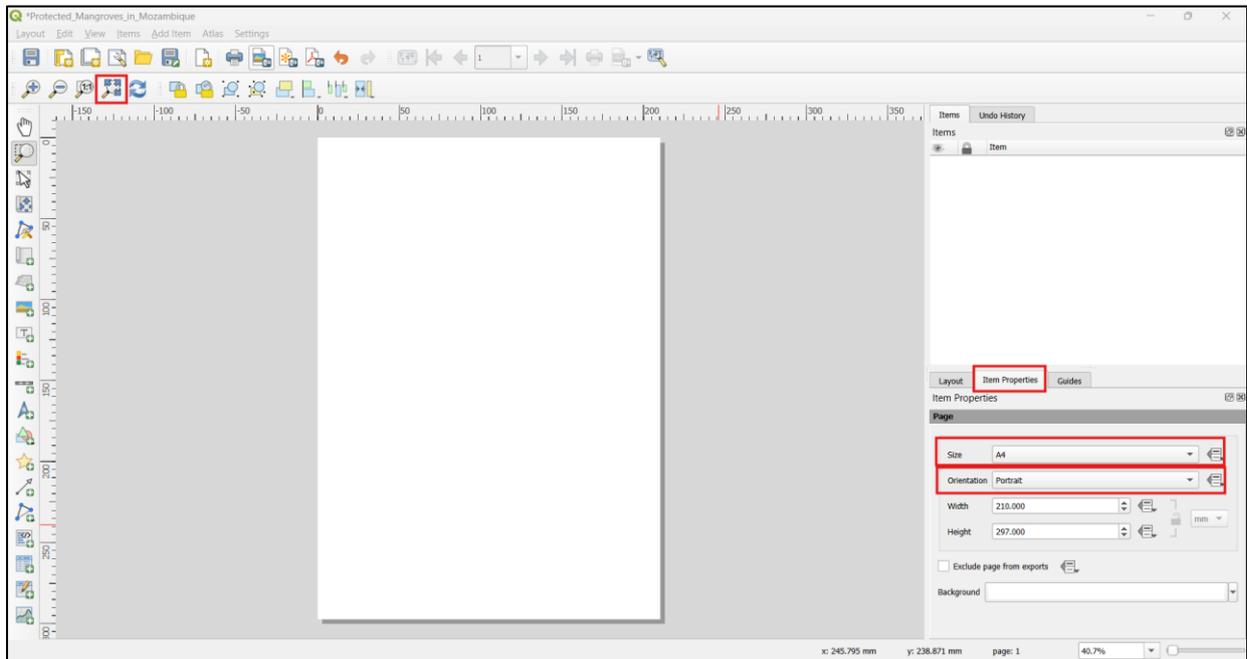
2.6.1. Create a Print Layout

- To create a map, go to “*Project*”, “*New Print Layout*” and then in the pop-up window, enter a layout title. Name it “*Protected_Mangroves_in_Mozambique*” and click “*OK*”.



- A new window should pop up, which is your new print layout called “*Protected_Mangroves_in_Mozambique*”.

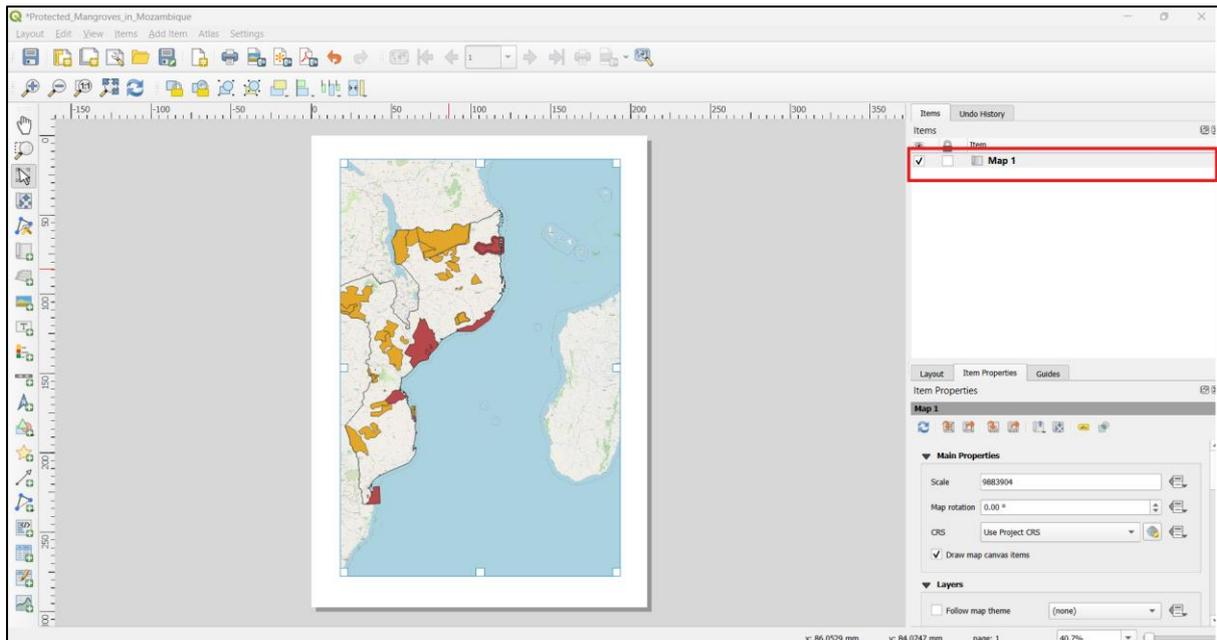
- To check the page size is OK, right-click on the layout and select “*Page Properties*” then to the right, under “*Item Properties*” select “*A4*” for size and “*Portrait*” for “*Orientation*”.
- Then press the “*Zoom full*”  button to allow for the layout to fit the page.



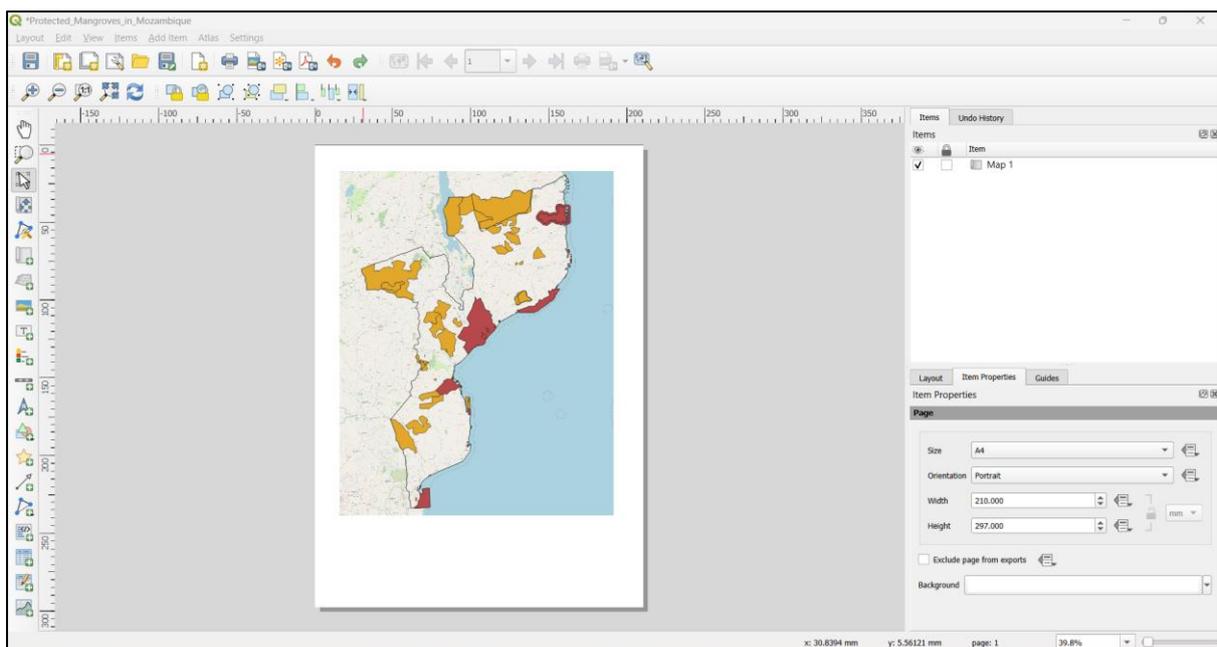
This is a canvas, and you need to pull in the project you wish to map.

2.6.2. Pulling in a Project

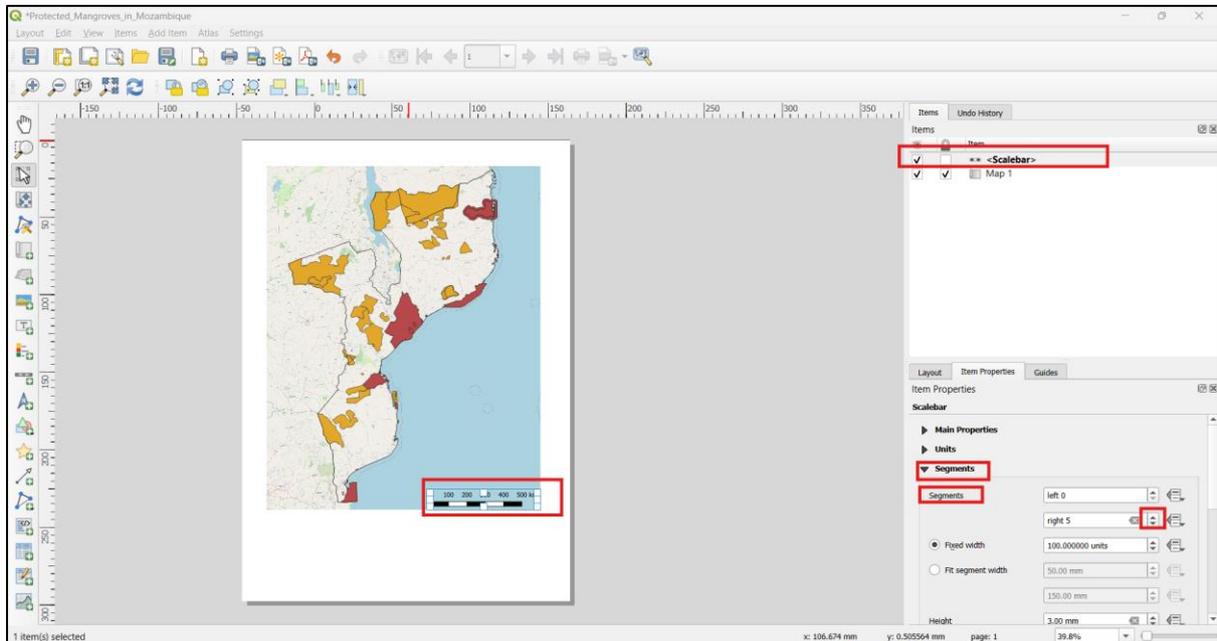
- Next, click on “*Add Item*” at the top of the screen, and then “*Add Map*”.
- Then with the cross cursor, click and drag and drop where you want to position the map in the layout then the map will render, and you will see data for Mozambique that you have been working with.



- Next, determine the extent of the map layout. You can do this by ensuring the map area is selected, then click hover the cursor at the edges and move these in and out, according to what you want.
- Select “*Move Item Content*” or  on the left side panel.
- Then, using the “Ctrl” key on your keyboard, you can use the scroll wheel on your mouse to zoom in or out of the map, and reposition it using the mouse also so that it best fits your layout.
- When you are happy with it unclick .

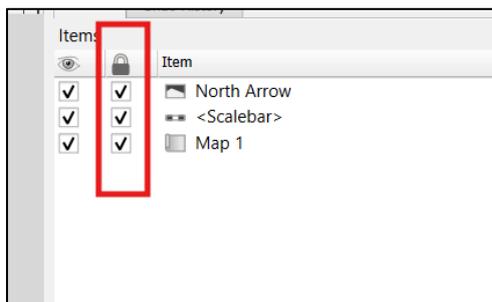


- To add a scale bar, go to “Add Item”, “Add scalebar” and use the cursor to drag and drop where you want it. To edit the scalebar, click on the scalebar in the top-right “Items” right-click and go to “Item Properties” then in the bottom-right, under “Segments” increase the value to say, “right 5”, which will increase the scale bar to 500km. Then, using the cursor click on the scalebar and reposition to fit on the bottom right of the map.



- Next, go to “Add Item”, select “Add North Arrow”, and using the cursor drag and drop where you wish to place it. Reposition, if needed.

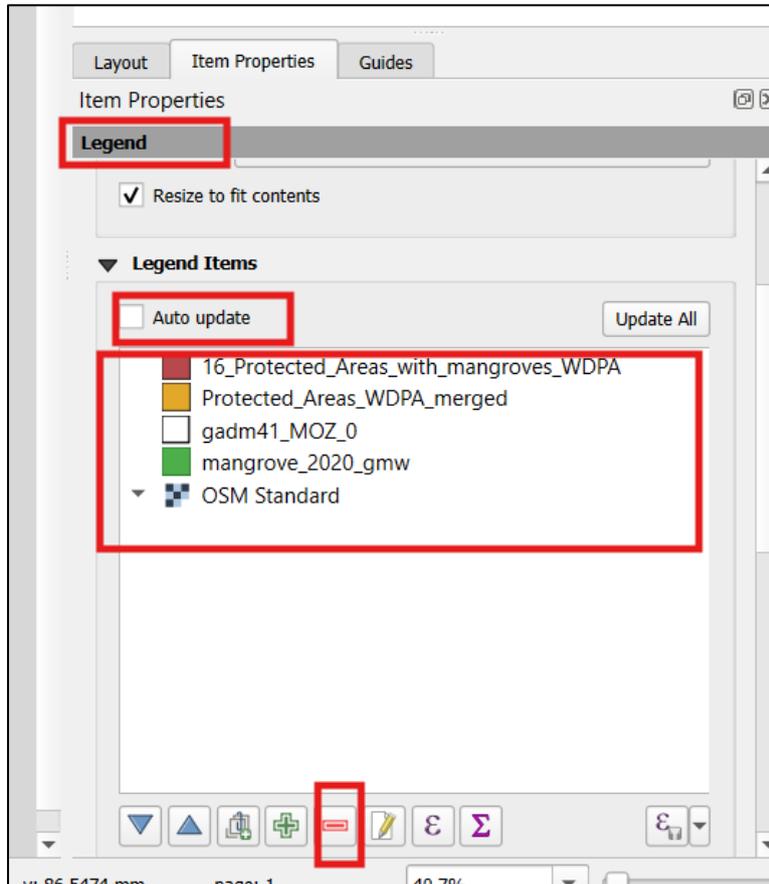
- To lock the edits, click on the respective box in the “Items” list, as per below. To edit, unclick them.



- Then from “Add Item”, click “Add Legend” and drag and drop the cursor to where you want the legend to go. To edit the legend, right-click on the newly added “Legend” row under “Items” and click “Item Properties”, then in the bottom-right corner options, insert “Legend” for the “Title”, then scroll down to “Legend Items” section, and unclick the “Auto update” box then for those

layers we do not want in the legend, click on them and then click the “*Remove Selected Items from Legend*” button, seen as a red minus sign .

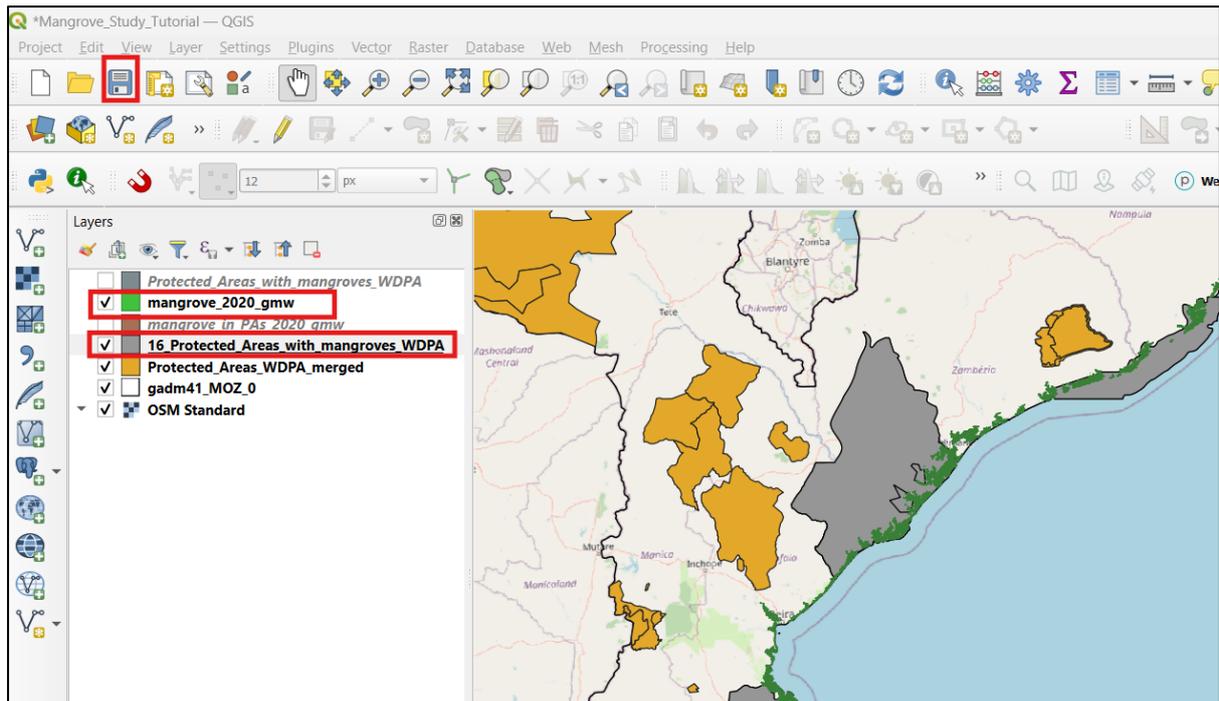
- Press the save button .



The map document we are currently working in is linked to our “***Mangrove_Study_Tutorial***” project.

We want to show the distribution of mangroves, but it is not shown on our current map. Also, we would like to have the protected areas that have mangroves in a light grey.

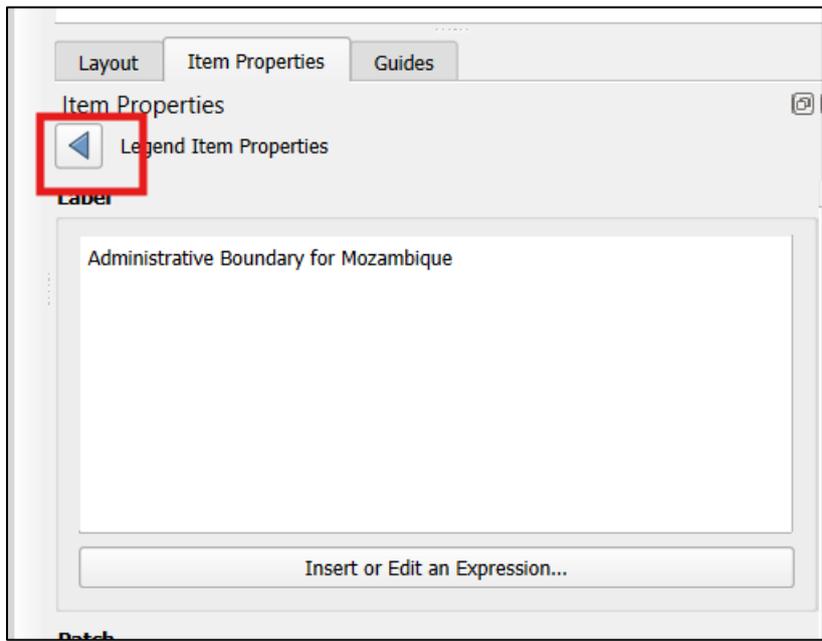
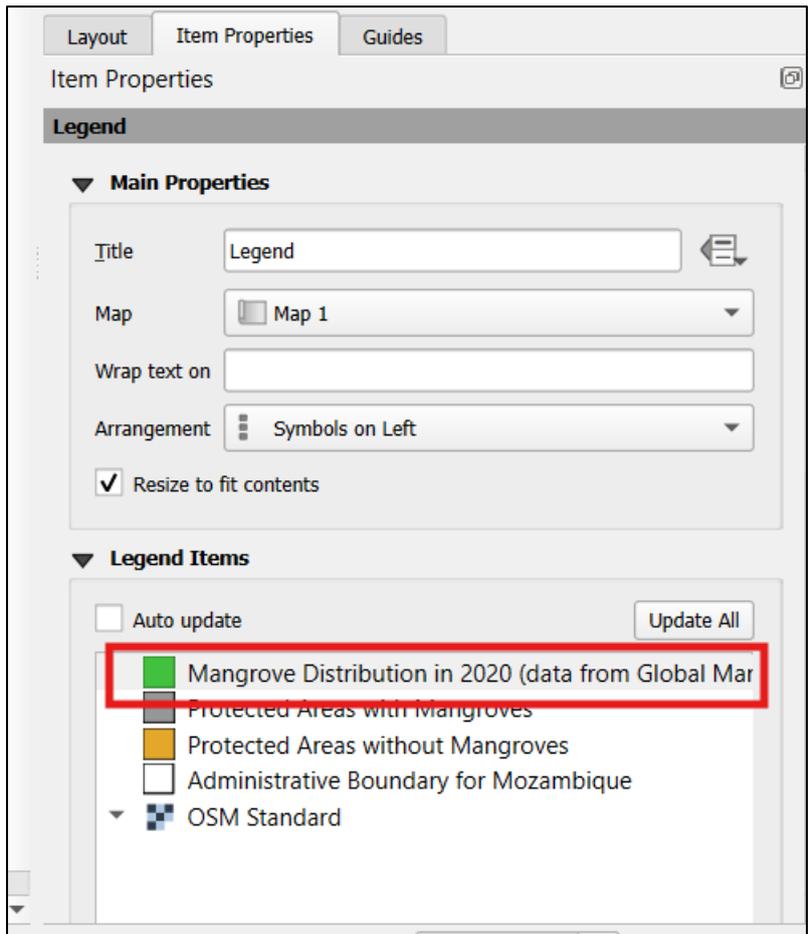
- To do this, go back into “***Mangrove_Study_Tutorial***” project. Click on the layer called “*mangrove_2020_gmw*” and move this to the top of the active layers.
- Then for the layer called “*16_Protected_Areas_with_mangroves_WDPA*” double click on the red colour box so that the symbology options open and change to grey.
- Then press  to save the project.



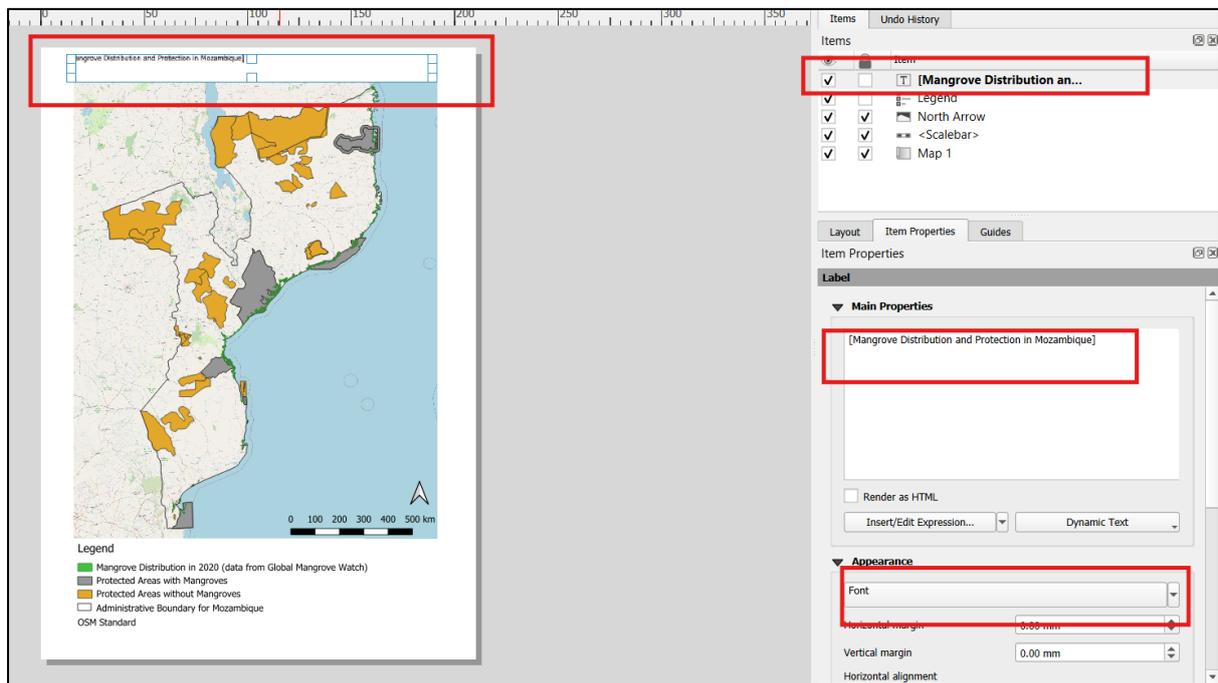
Next, go back into the map project and the amended changes you just made, should be reflected in your map and its legend.

Next, you can now rename the layers so that they are more informative for the reader.

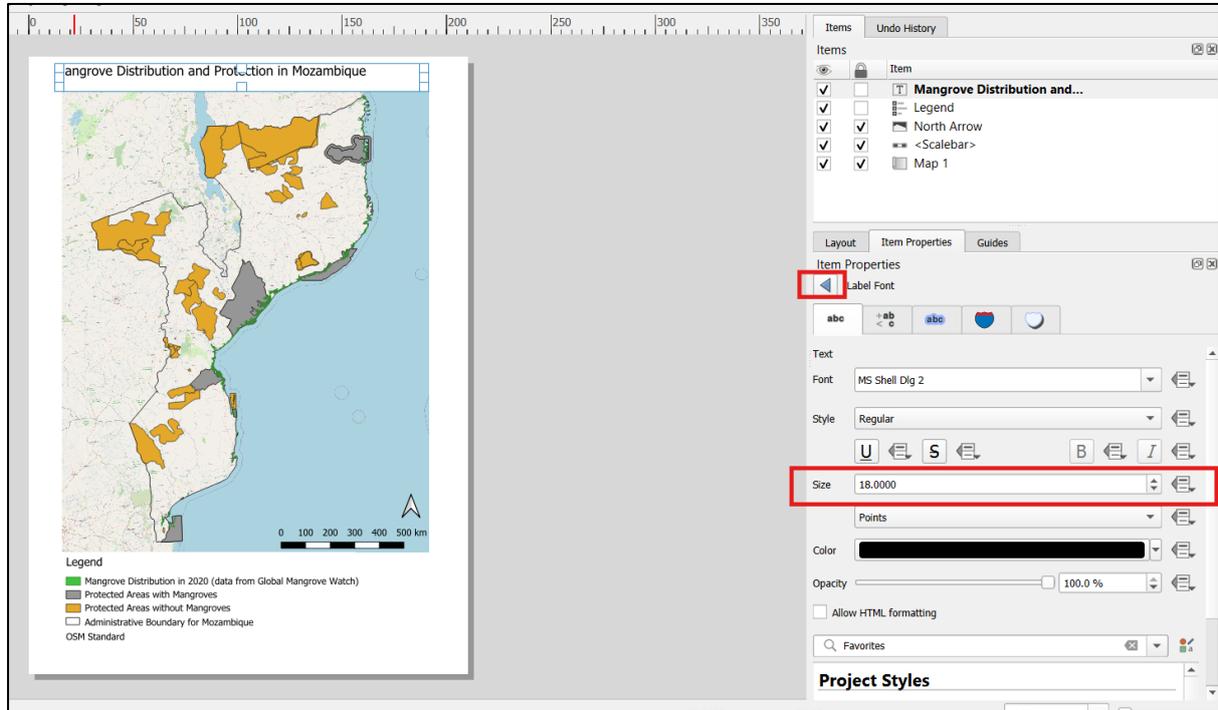
To do this, double click on the layer you want to edit, then the text will open in a box that is editable. Once you have edited the text, click the back arrow and continue to edit the remaining layers.



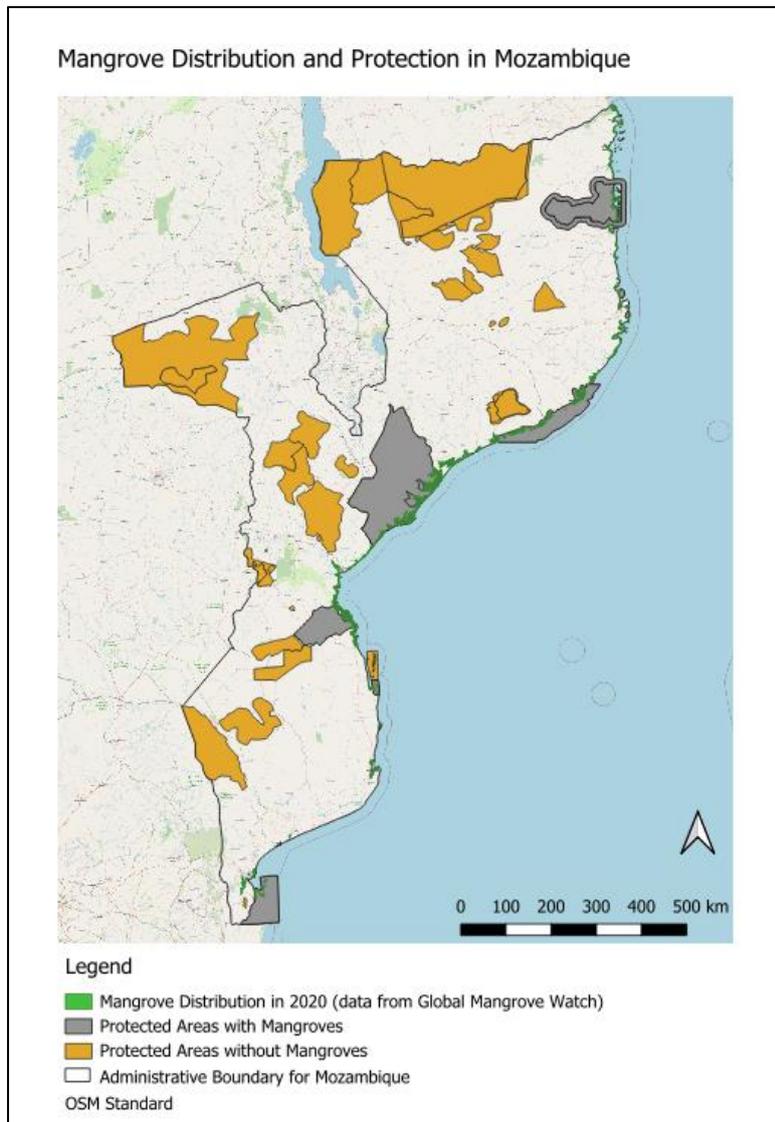
- Now, add a title. To do this, go to “Add Item”, “Add Dynamic Text”, then “Project Title”. Use the cursory to select location and drag and drop.



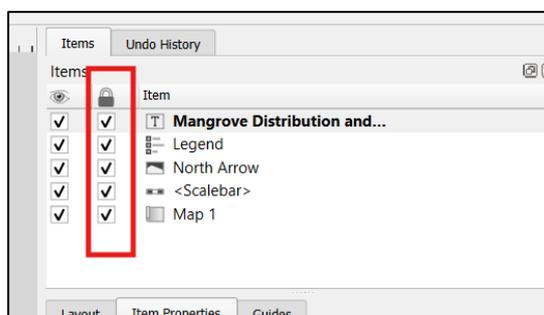
- Click on the “Font” option, and under Size increase to 18pts. Then use the back arrow to return.



- If you wish, you can now adjust any or all the “Items” positions, by unclicking the lock, and then clicking on the items you wish to move.



- Once you are happy with your map, ensure that all “Items” are now locked, by clicking on any unchecked box.

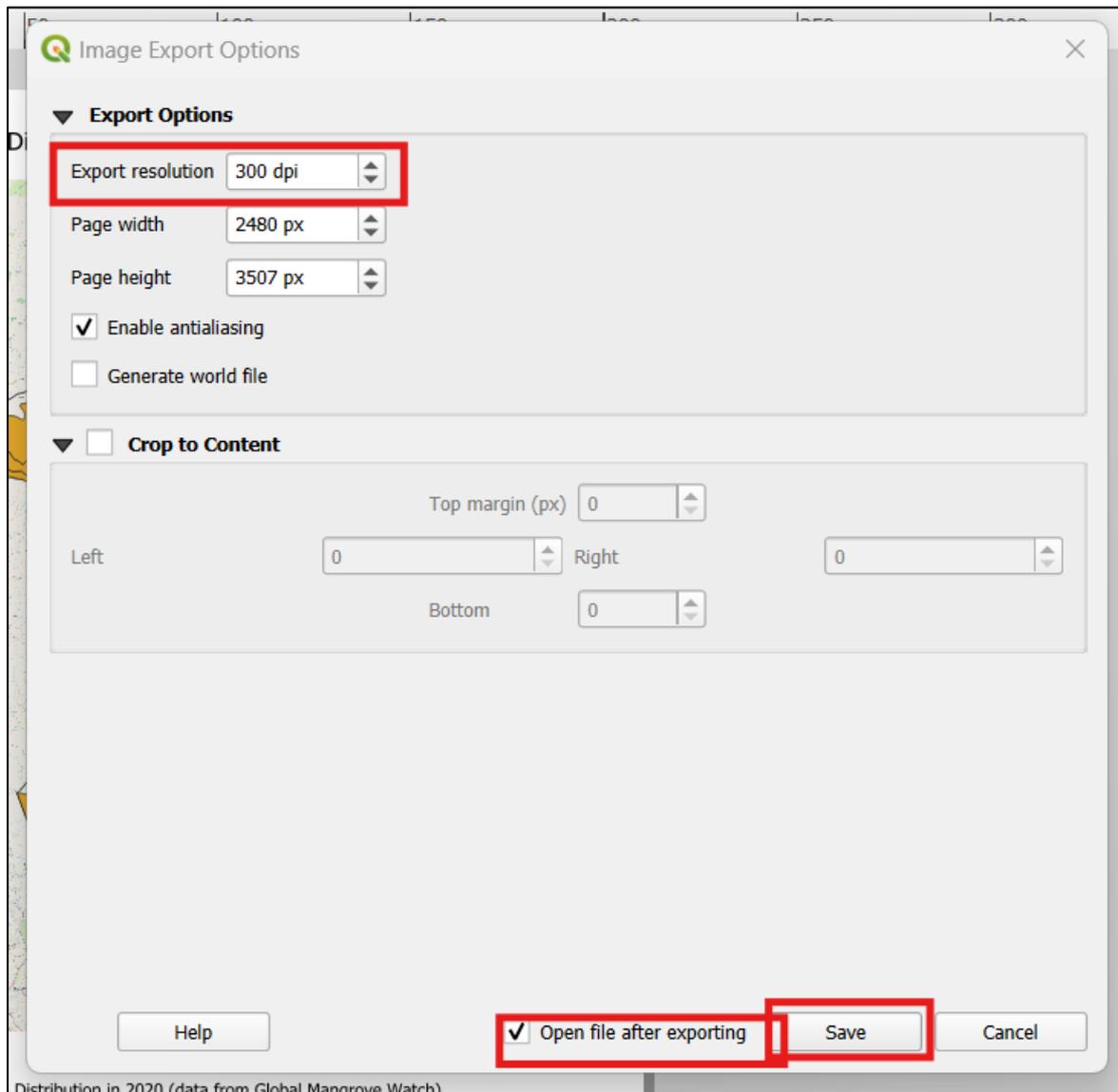


- Press the save button  to save your edits.

2.6.3. Exporting a Map

Lastly, you can export your map to print, using in a report or presentation for example.

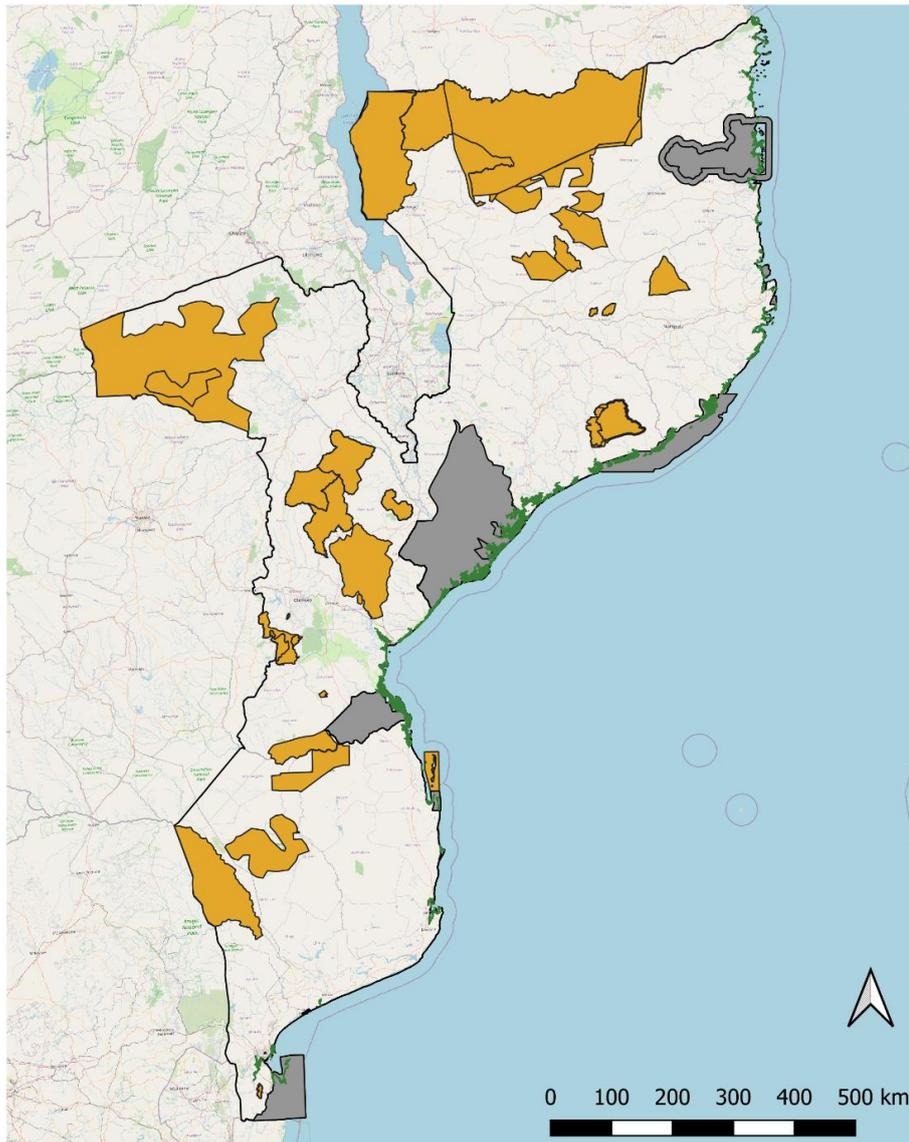
- To do this, go to “*Layout*”, “*Export as Image*”, click “*Close*” for a notice informing you of parameter limits, then navigate to the folder named “*Mangrove Mapping Tutorial*” and name the map “*Protected Mangroves in Mozambique*” and select the file type you wish to save the map as (e.g. .png or .tiff) then click “*Save*”.
- Amend the “*dpi*” if needed and check the “*Open file after exporting*” then click “*Save*”.



You should now have an exported map that you can open in whatever software you use.

- Once you have finished with your map you can save  and close this QGIS project

Mangrove Distribution and Protection in Mozambique



Legend

-  Mangrove Distribution in 2020 (data from Global Mangrove Watch)
 -  Protected Areas with Mangroves
 -  Protected Areas without Mangroves
 -  Administrative Boundary for Mozambique
- OSM Standard

3. PART 2a: Using QGIS to Map Mangroves from Satellite Imagery

3.1. Accessing Satellite Imagery

3.1.1. Copernicus Data Space Ecosystem

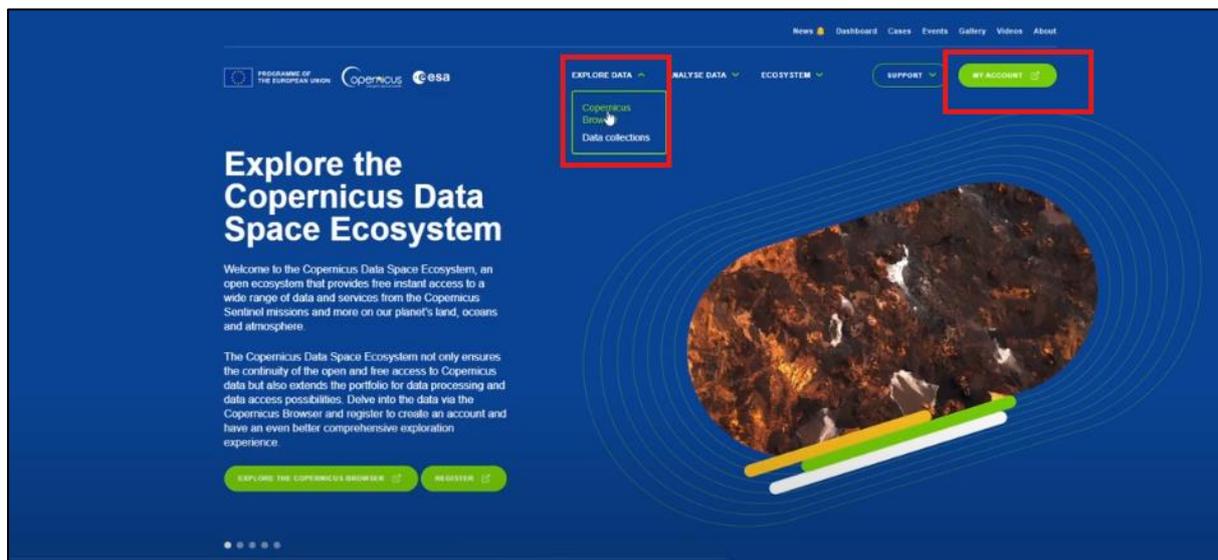
The Copernicus Data Space Ecosystem (<https://dataspace.copernicus.eu/>) is an open ecosystem that provides instant access to freely available data and services from the Copernicus Sentinel missions. For this tutorial we will be using Sentinel 2 projects for Mozambique.

The Copernicus Sentinel 2 mission consists of two polar-orbiting satellites that have a wide swath (image) width (290 km), a high revisit time (5 days at the equator), and 13 various spectral bands (four bands at 10m, six bands at 20m, three bands at 60m) that can be used for an array of services and applications to help monitor changes on Earth. You can explore the data more in the website.

3.1.2. Register or Login to Copernicus Data Space Ecosystem

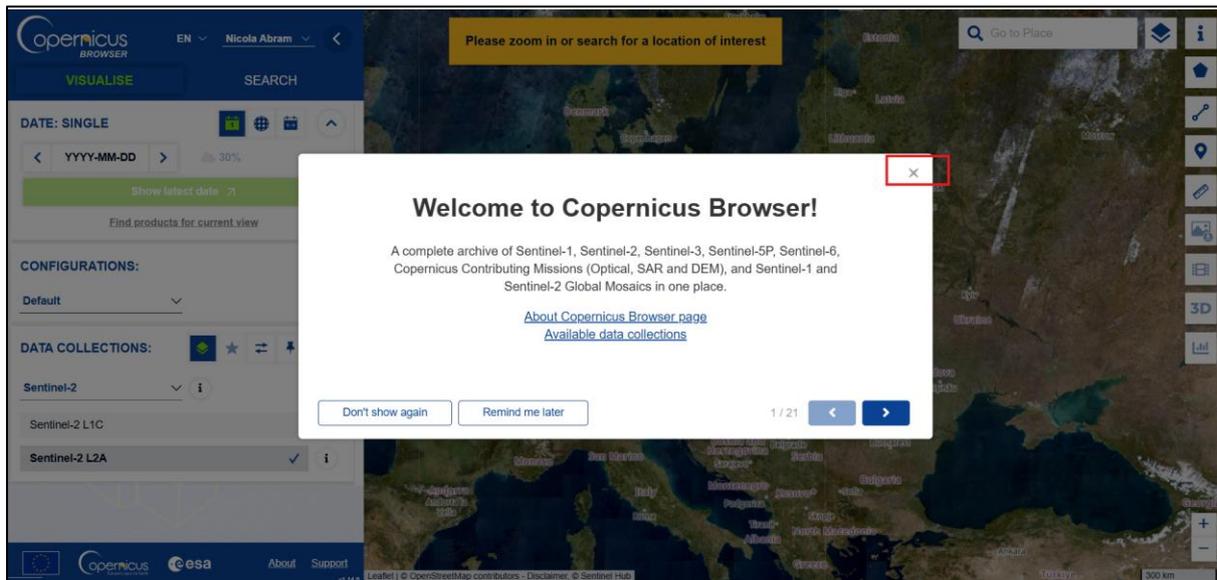
To access data, you will need to register or login to the Copernicus Data Space Ecosystem website.

- If you do not already have an account, you will need to register and fill out your personal details. Otherwise just login.

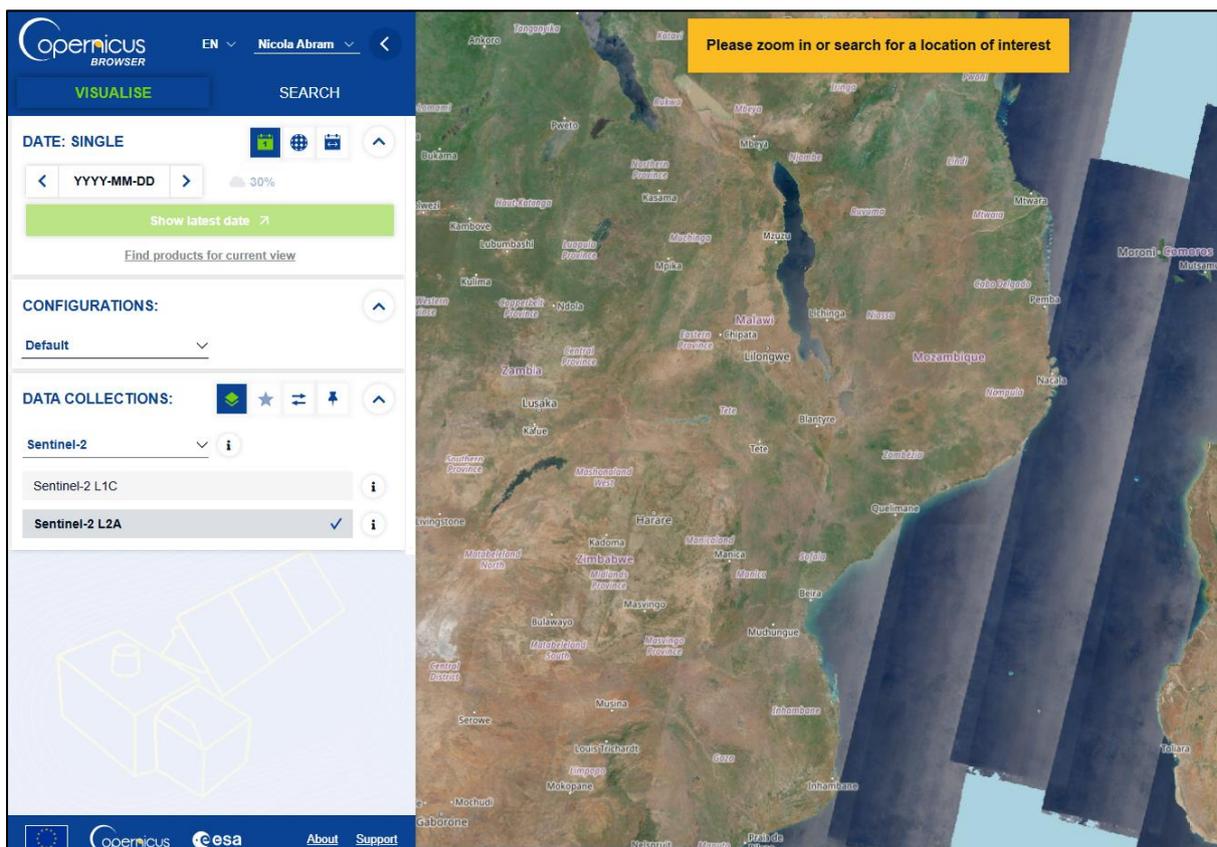


3.1.3. Exploring the Image Collection for your AOI

- Then go to the “*Explore Data*” tab and in the drop-down options select “*Copernicus Browser*”.
- The “*Copernicus Browser*” should open, click on the cross to close the welcome window.



- Using the mouse with the hand icon, move the window and scroll in to see Mozambique.
- You will likely see diagonal strips, which show the paths that the satellite take when capturing satellite image data.



Mozambique has a large land mass and requires many images to be taken at any given time. For mapping mangroves along its 2,470 km of coastline, for a full mapping campaign many images would need to be acquired and processed. For this

tutorial, however, we shall be zooming in to undertake mangrove mapping for a small region or Area of Interest (“AOI”).

For this tutorial, we will focus on an area of mangrove west of the town of Moma and contained with Pebane District, and within and around the “*Primeiras & Segundas Environmental Protection Area*”.

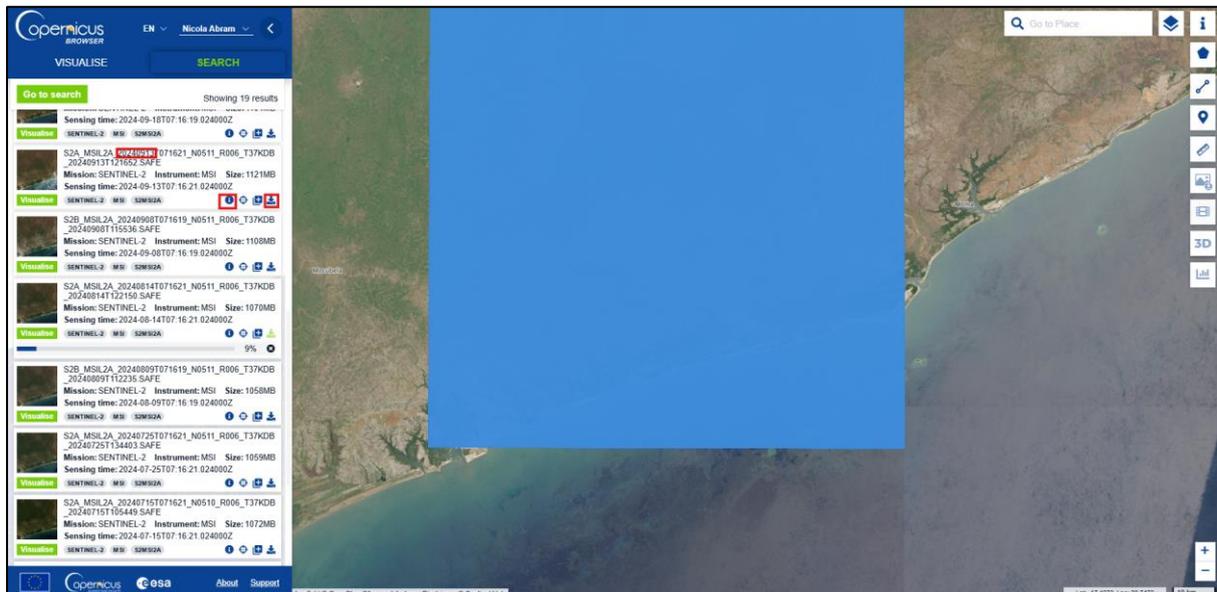
- At the top right of the browser, click on  “Create and Area of Interest”, then select the rectangle from the options that pop up.
- Then with the “Bulls eye” cursor click on the general area you want to select and then click again, somewhere over the other side of the rectangle you want to create, then a blue box should appear.
- You can edit the size of this, if you wish, by using the hand icon cursor to drag and drop the sides of the rectangle.
- Then go to the “Search” Tab on the left browser.
- Select “Sentinel 2” then “L2A” in the drop down, then scroll the “Cloud density %” to 5%.



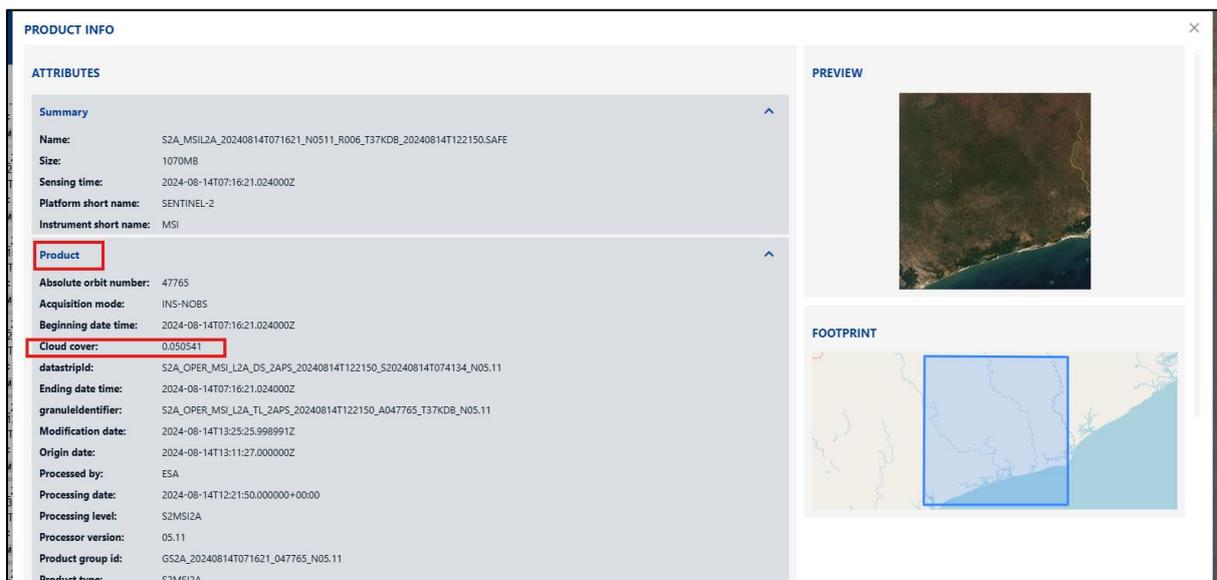
The L2A data has already been atmospherically corrected using the Sen2Cor correction and therefore can be used straight away for analysis without the need of any other pre-processing applications.

As mangroves have a year-round growing season dates of image capture is somewhat flexible. In other cases, however, where you have deciduous foliage, considering when vegetation may lose their leaves is important, when selecting the time of year of when the images were taken.

- In this tutorial, under the “*TIME RANGE*” options, select the timeframe that you want the catalogue to show you. For example, we selected from the 1st of June 2024 to the 19th of February 2025. Then select “*SEARCH*”.
- This may take a few moments.
- Then you should see a range of image options down the right-hand panel. These are the selection of satellite images that your search has found.



- You will be able to see certain information on the images, such as the date of image capture.
- For more information you can also click on the information  button that will open a attributes window, where you can look for more detailed information. Under “*Product*” you can also see the % of cloud cover.



3.1.4. Downloading Satellite Image Data

- Have a browse through and select an image that you like and that has the least cloud cover and download your selected image by clicking on the “Download” button.
- You can then see the download progress running. This may take a little while, depending on your internet speed.



- The zipped folder that you will download contains the image bands and additional information and are large, around 1GB in size.
- Once the zipped folder has downloaded, navigate to your “**Mangrove Mapping Tutorial**” folder on your “C-Drive” and create a new folder named “*Remote Sensing*”.
- Then copy, past and unzip the downloaded Sentinel 2 folder so that the data is ready to bring into QGIS when needed.

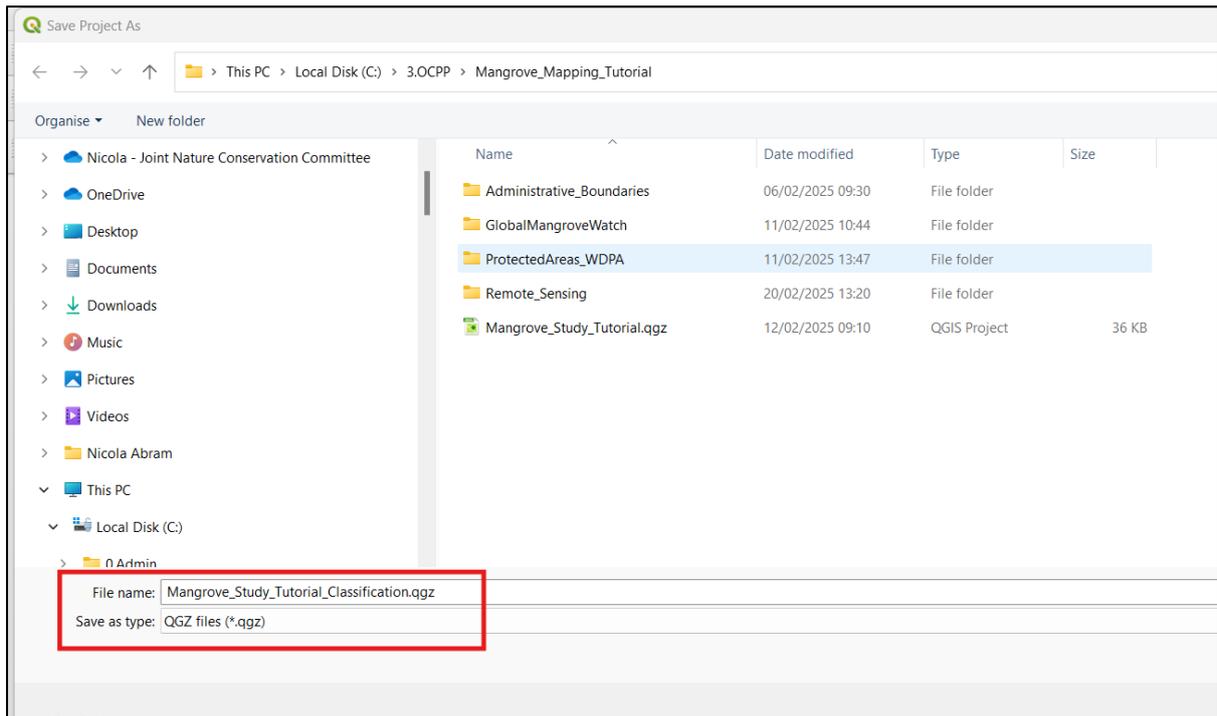
3.2. Performing Supervised Image Classification in QGIS

Remote sensing techniques allow us to extract information from images to analyse landscapes and how they change over time. One of the main remote sensing techniques is supervised image classification. With supervised classification, a user identifies areas of the image that represent land cover classes of interest. These areas are marked and used to train a computer algorithm to identify those same land cover classes throughout the image extent.

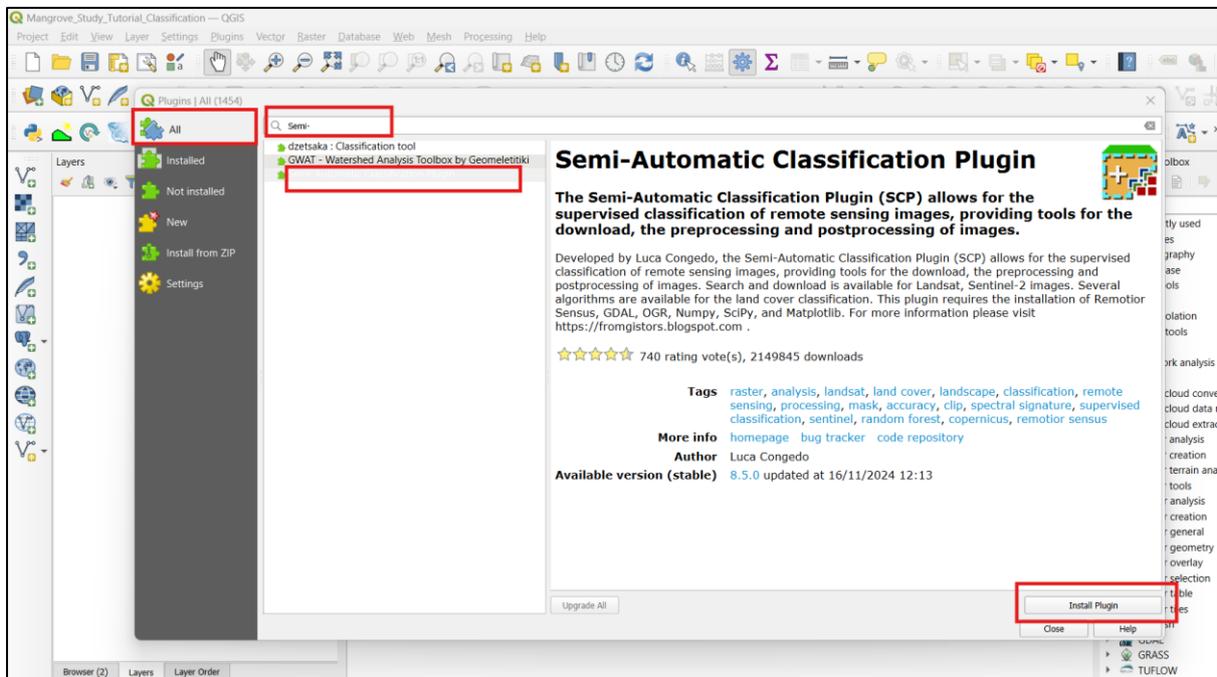
You can perform a Supervised image classification, in an array of remote sensing and GIS software’s. In this part of the tutorial, we will perform a supervised image classification on the Sentinel 2 data we just downloaded, using QGIS and a semi-automatic classification plugin called “**Semi-automatic Classification Plugin**” (SCP).

3.2.1. Installing the Semi-automatic Classification Plugin in QGIS

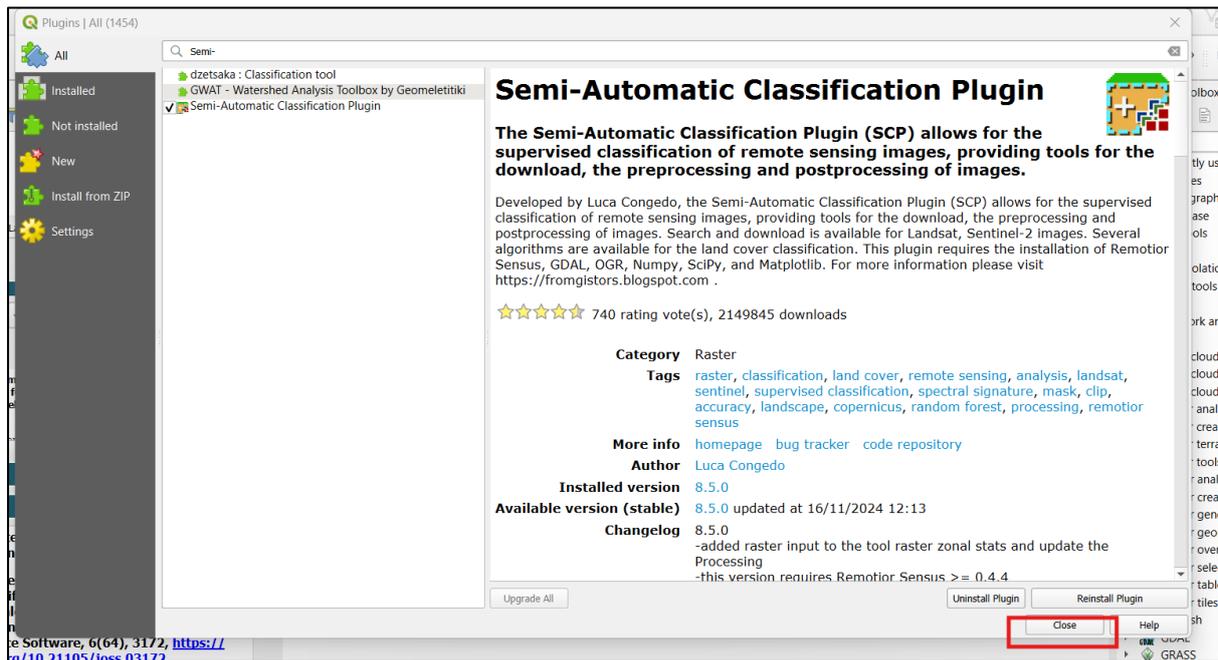
- Open the QGIS software you downloaded earlier in Part 1 of this tutorial.
- Click on “Project” and then go down to “Save As” to save this project. Then navigate to “**Mangrove Mapping Tutorial**” folder and save this project here as “*Mangrove_Study_Tutorial_Classification*”.



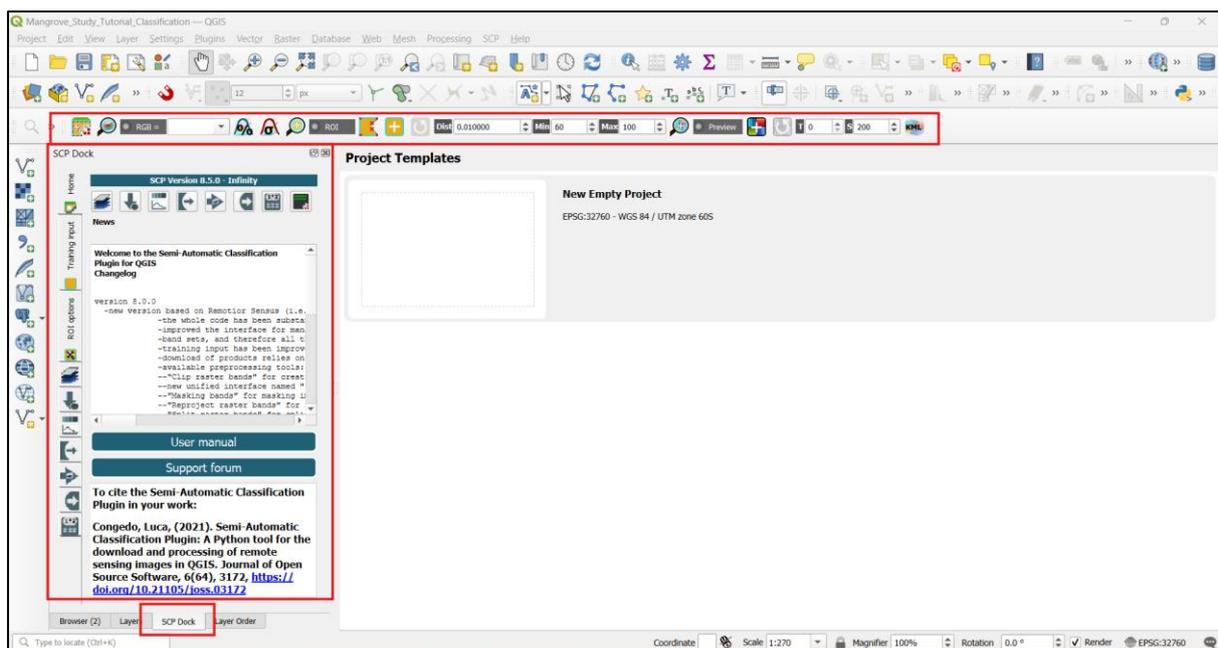
- Next, go to “*Plugins*” then “*Management and Install Plugins*”. In the window that opens, go to “*All*”, then in the search function, start to write “*Semi-automatic Classification Plugin*”, and the plugin should appear.
- Click on it (it may turn white) and then click on the “*Install Plugin*” button.



- This operation should be fairly quick and once done you should see amended text in the window. Click “Close” to now close this plugin window.



- Now, in the bottom-left of the QGIS screen you should see the “SCP Dock” and you can click at the top and drag and drop it so that it replaces where the “Layers” gallery is, and at the bottom of the “SCP Dock” move the tab so that it is after the Layers and Browser tabs.
- You should also be able to see a new toolbar. You can click on the two faint dotted vertical lines to then drag and drop where you want the toolbar to go.



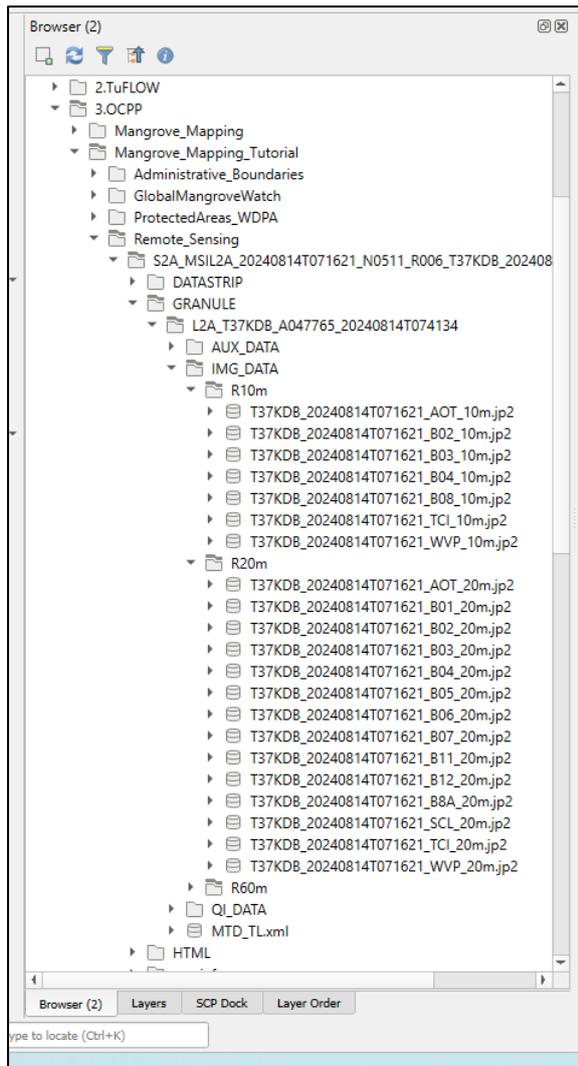
Note, if you do not see these, go to “View”, “Panels” and find “SCP Dock” and click on. And then “View”, “Toolbars” and ensure the check mark is on.

Note: If the download is taking too long, then you can use the same image we have used in this tutorial, which is provided (for both the 20m layers, and the 10m TCI layer – mentioned below).

3.2.2. Sentinel 2 Satellite Image Data

Next, we want to just look at the files we just downloaded for Sentinel 2 data to familiarise ourselves with these.

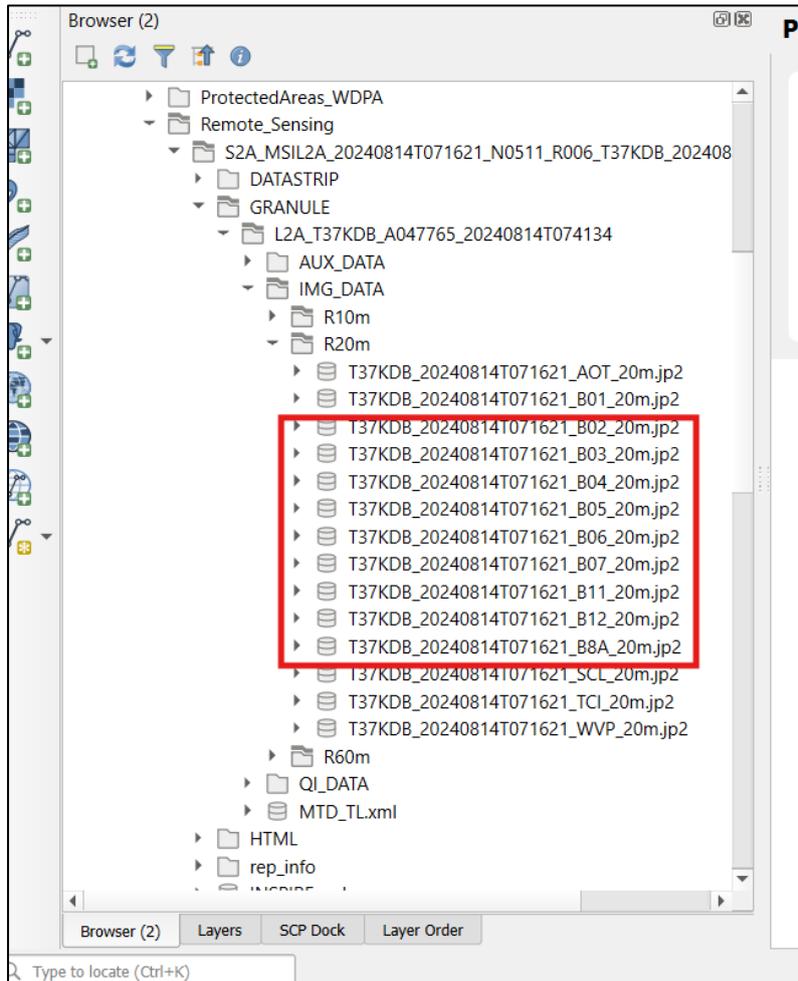
- Click on the “*Browser*” tab in the bottom-left and open the drop-down options and navigate to your “***Mangrove_Mapping_Tutorial***” folder, then “*Remote_Sensing*” then open the folder you downloaded from Copernicus Data Space Ecosystem. The name will resemble something like ours, “S2A_MSIL2A_20240814T071621_N0511_R006_T37KDB_20240814T122150.SAFE” then go to “*Granule*”, then “*IMG_DATA*”.
- In here you will notice folders with data at varying resolutions i.e., “R10m”, “R20m” and “R60m”.



These layers/bands correspond with differing data, seen in the Table below.

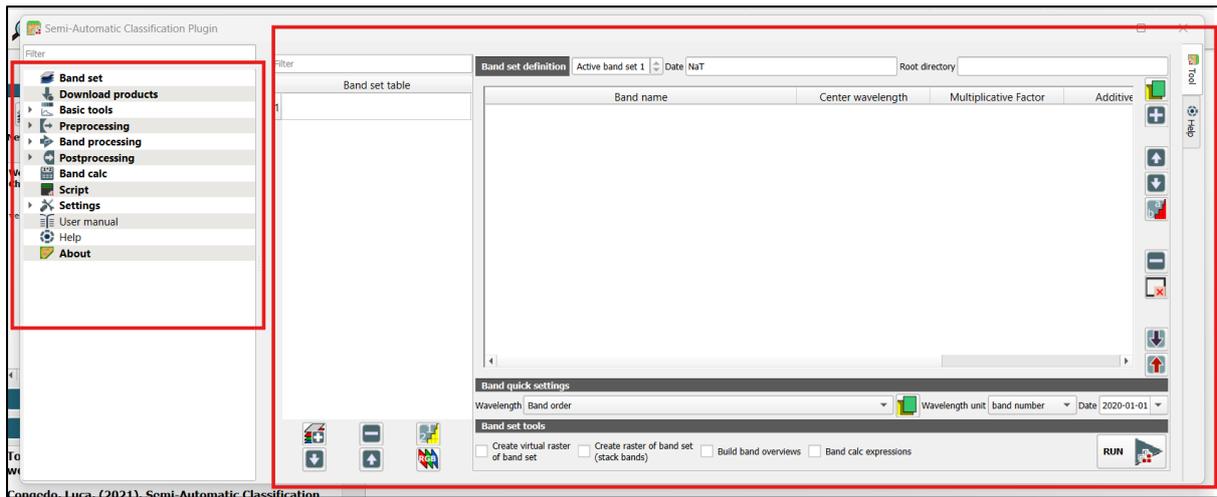
Sentinel-2 Bands	Central Wavelength (µm)	Resolution (m)
Band 1 - Coastal aerosol	0.443	60
Band 2 - Blue	0.490	10
Band 3 - Green	0.560	10
Band 4 - Red	0.665	10
Band 5 - Vegetation Red Edge	0.705	20
Band 6 - Vegetation Red Edge	0.740	20
Band 7 - Vegetation Red Edge	0.783	20
Band 8 - NIR	0.842	10
Band 8A - 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

For this tutorial, we will be using bands 2, 3, 4, 5, 6, 7, 8A, 11 and 12 – all at the 20m resolution.



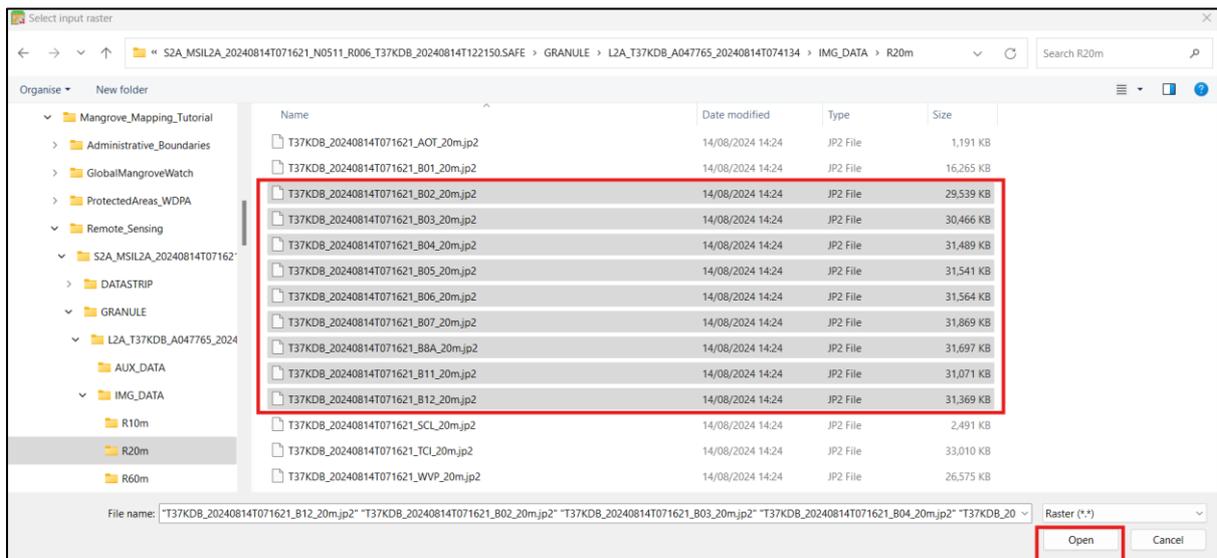
Now go to the “SCP” menu and click on the “*Band set*” tool.

The Semi-automatic classification plugin window will open. On the left, you can see the available tools that we can access from the menu there. And on the right is the interface for the band set definition.

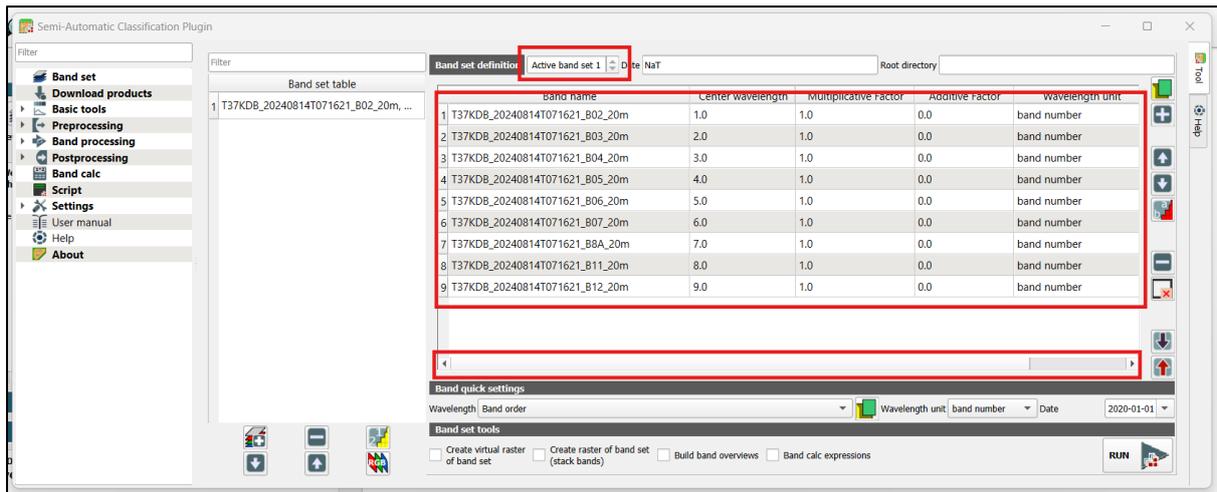


Next, we will pull in our Sentinel 2 bands.

- To do this, go to the “Open a file”  icon and the “Select input raster” window will open. Navigate to the folder with the Sentinel 2 20m resolution data, and select bands 2, 3, 4, 5, 6, 7, 8A, 11 and 12. To select multiple bands hold down the “Ctrl” key on your keypad whilst selecting the Sentinel 2 bands.

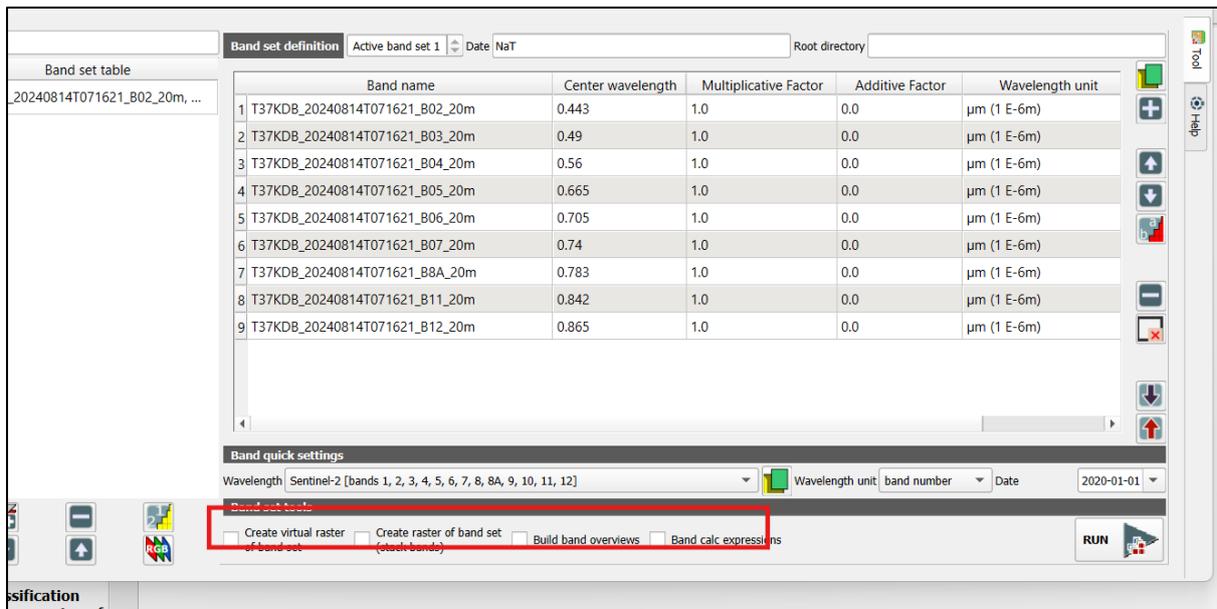


You should now see the bands in the “Band set” interface. These are now defined as “Band set 1”. You can use the scroller to see the various columns associated with the bands, including (in column 2) the “Center wavelength”, which is just currently showing the number of the band.



If you wish to add in the “Center wavelength” you can click on the dropdown menu for “Wavelength” and select “Sentinel 2” option.

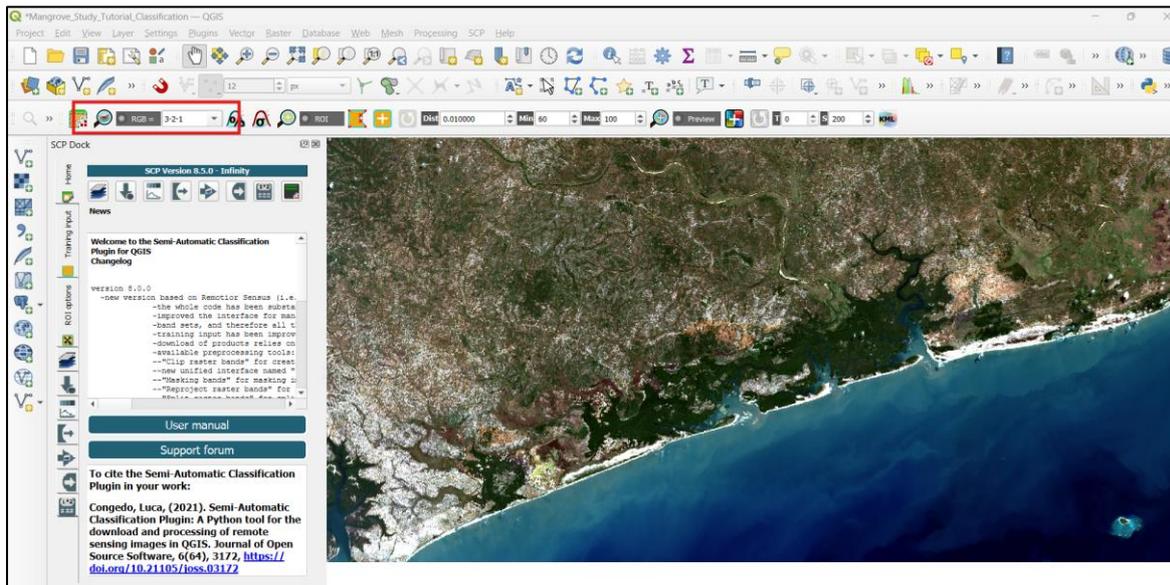
- Close the “Band set” window.



3.2.3. Viewing a Virtual Band Set

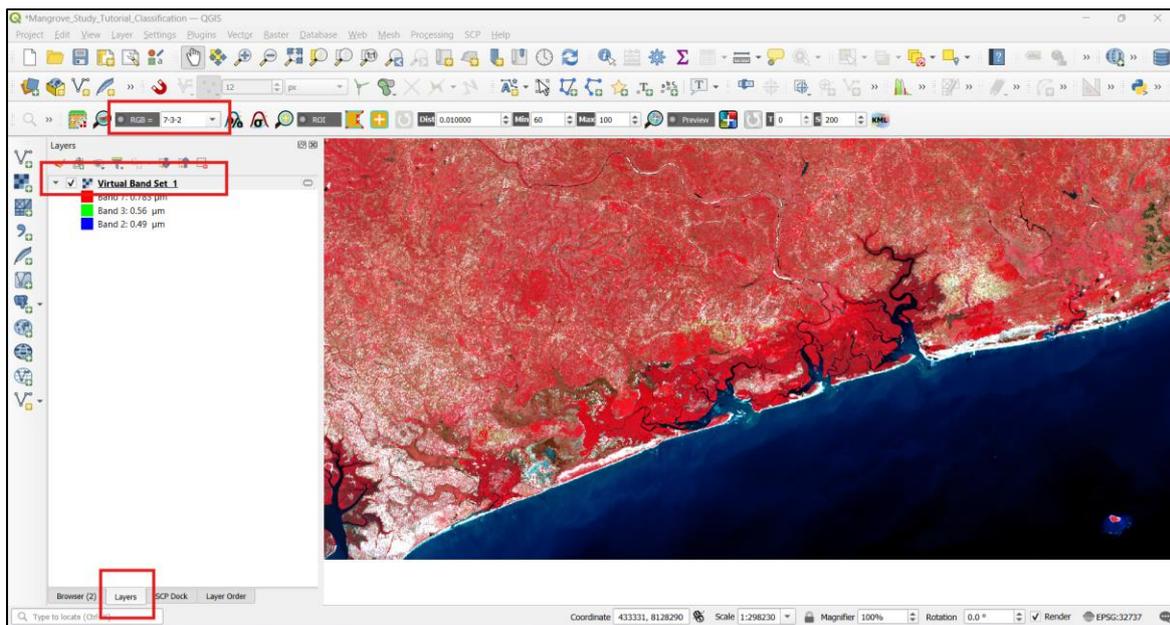
Next, we want to be able to visualise our Sentinel 2 data so that we can then use these data to select our training data.

- To do this, in the “RGB” dropdown select the option “3-2-1”, this will show you are True Colour Composite.
- You can zoom in closer to where mangroves are to take a better look.



- Alternatively, you can also select the option “7-3-2” which will give you a False Colour Composite.

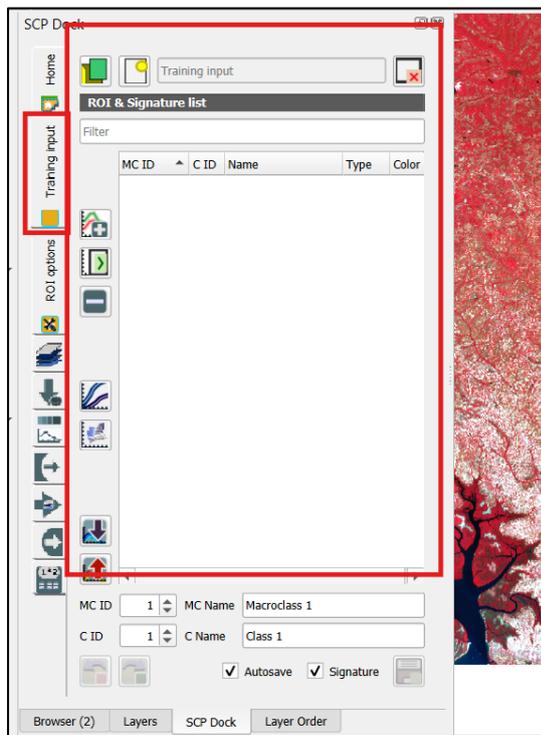
If you go to “Layers” in QGIS you will then see that the “Virtual Band Set 1” has been added.



3.2.4. Defining Regions Of Interest (ROIs)

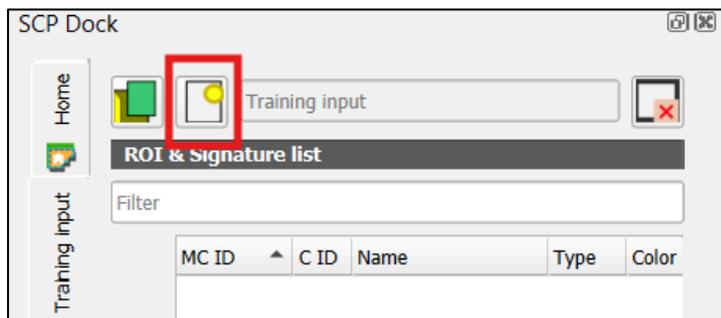
Next, we need to manually define some “*Regions Of Interest*” (ROIs) that will be used as our “*Training data*”, which will then inform the algorithm to determine our land cover classes. This is the basis of a “*Supervised classification*” approach.

- In the “*SCP Dock*” tab, select “*Training Input*”, which allows you to define the ROIs (that then inform the spectral signatures of these).

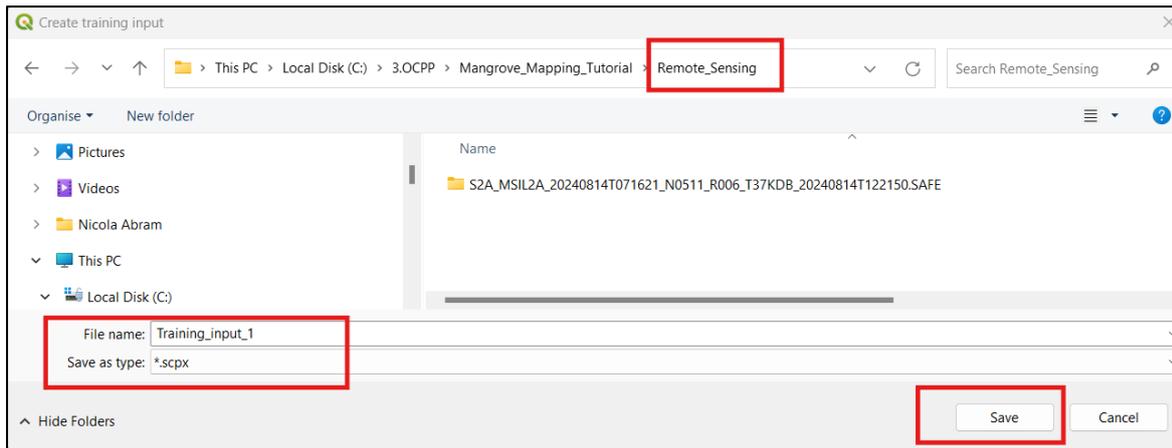


We want to create a new training input file.

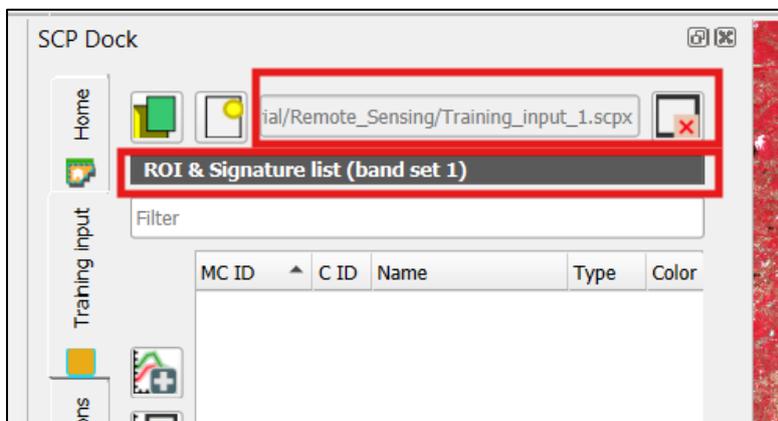
- To do this, click on “*Create a new training input*”  button.



- In the “*Create training input*” window, navigate to the folder called “*Remote_Sensing*” and name the file that you are saving as “*Training_input_1*” and ensure the file type is “**.scpx*” then click on the “*Save*” button.



You will now see the path to the training input file, you just created, in the “SCP Dock”, along with the band set it is relating to.



Click on the “Save Project”  to save your work.

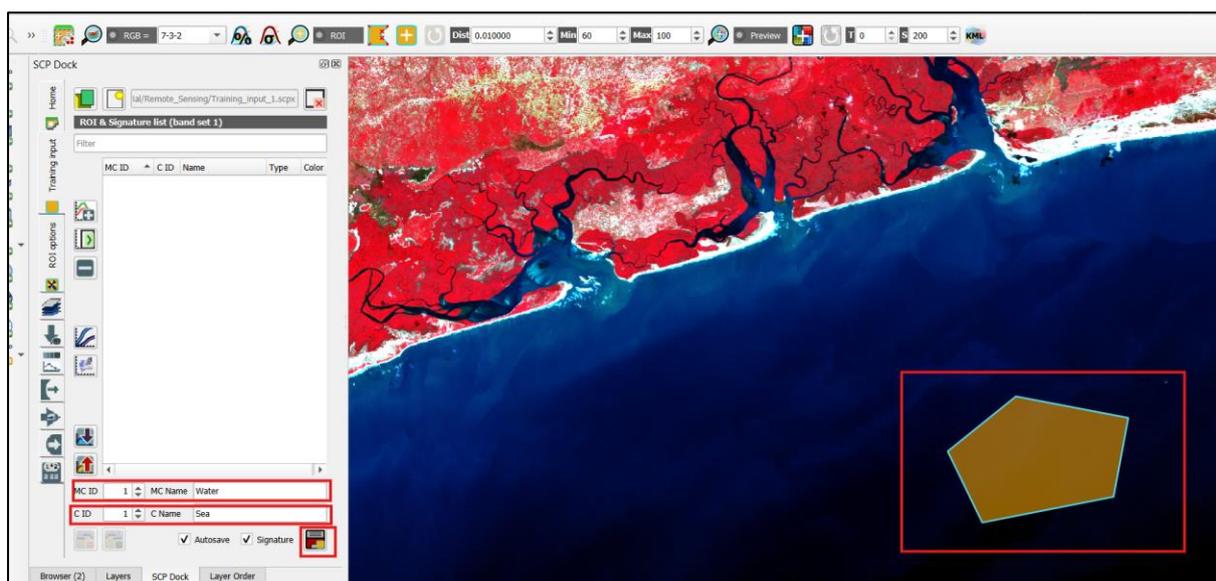
Next, we will create training data for the land cover classes we want to identify. Our “*Macroclass*” names and ID numbers are shown in the table below. We will also create sub-classes or “*Classes*” to allow for a more detailed classification.

Macroclass ID	Macroclass name	Class ID	Class Name
1	Water	1	Sea
		2	River
		3	Coastal lagoons
2	Vegetation	4	Mangroves
		5	Forest
		6	Wetlands
		7	Cultivated
3	Other	8	Sand/rocks/bare earth

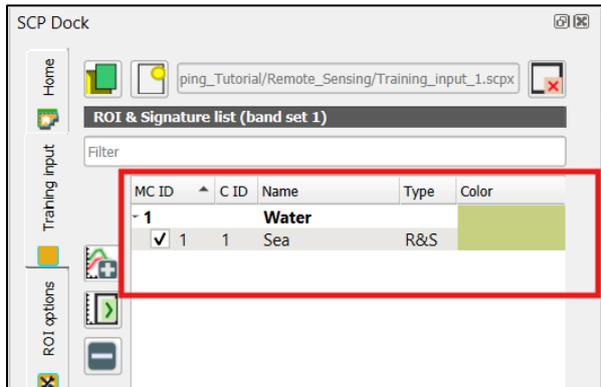
To better visualise areas for your training data, you can use Google Earth, Google Maps or high-resolution imagery, for example.

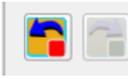
Let’s first select some areas of **Sea**.

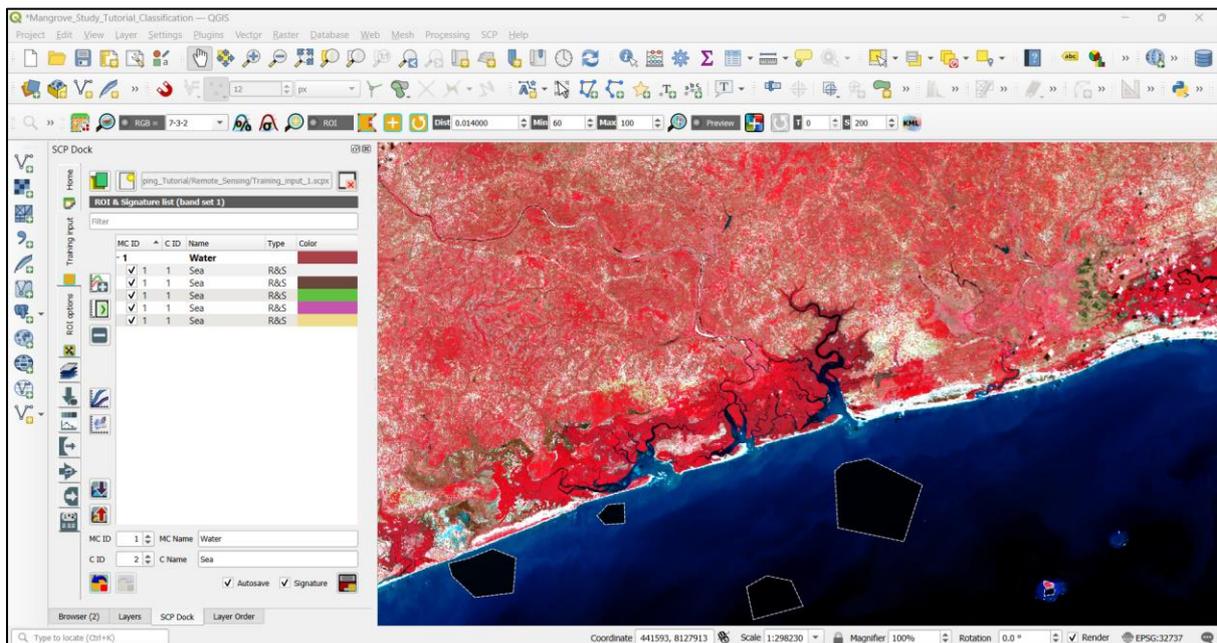
- Navigate to an area of the sea and zoom in. Click the “*Create a ROI polygon*”  button, then in the map with a left-mouse click select your ROI, right-click to finish the polygon. Here you can see that we have created a temporary training polygon. We now need to save it.
- First, ensure that in the MC ID box, that this is “1” as that is the “*Macroclass ID*” for our land cover class water. Then, in the “*MC Name*” write in “*Water*”.
- Then in the “*C Name*” (or class name) write “*Sea*” as this is one of our sub-class categories for water. Then click “*Save temporary ROI to training input*”  button.



- After clicking on the  button, you should now see that the ROI is now saved in the “ROI & Signature list (band set 1)”.



- Continue to add in ROIs for the sea, selecting different areas to capture shallower areas (inshore) and deeper areas (offshore).
- Note, that you can use these buttons  to undo a “ROI” save or add back in one you just removed.
- Your selections and ROIs may look something like below.



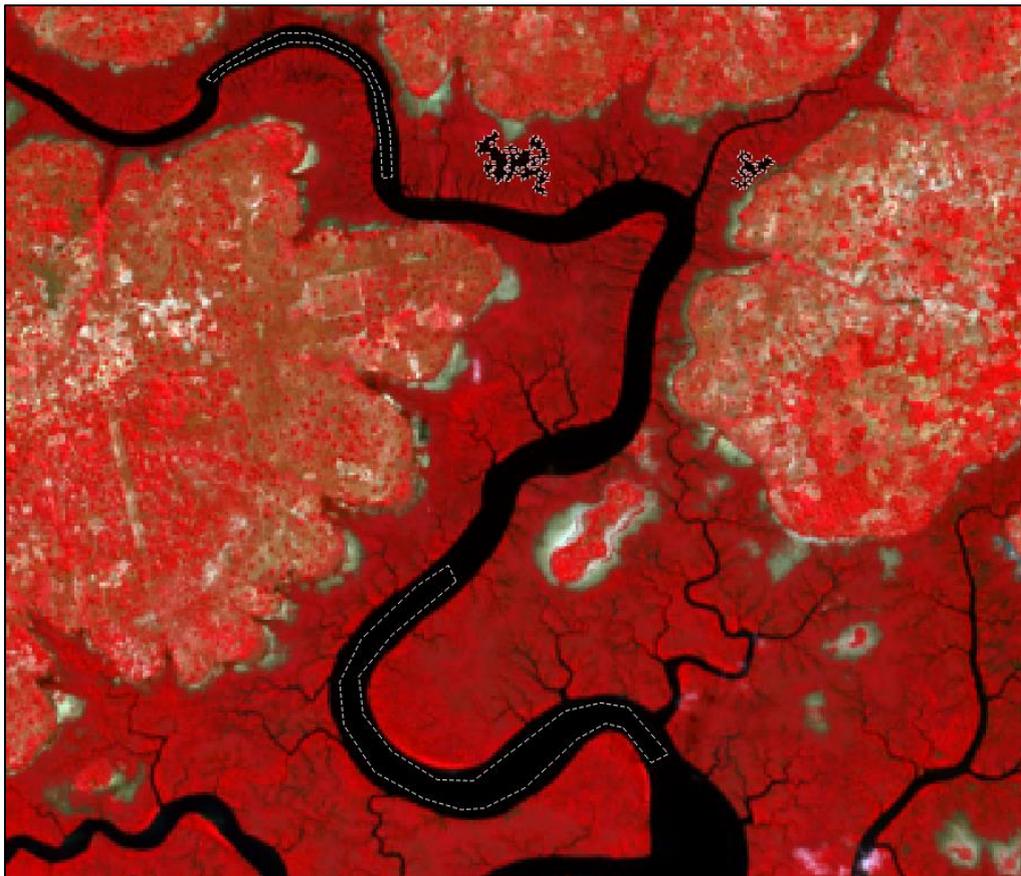
Next, we will select training areas for **rivers**.

- Zoom into a river and click on  then digitise part of the river, ensuring that you do not include riverbanks. Keep the “MC ID” as “1”, and “MC Name” as “Water”.
- Then for the “C ID” insert “2”, and for the “C Name” insert “River” and press .



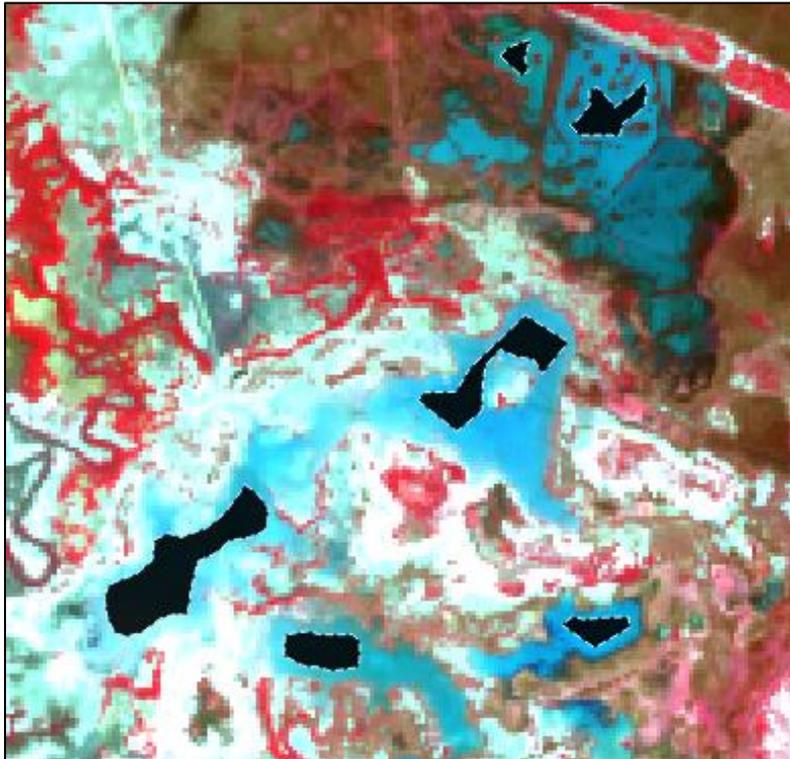
- Continue to add in ROIs for rivers, selecting different areas to capture variation. Note that some rivers may be seasonal and have very little water in them in the dry season and may show more soil than water.

Your selected river ROIs may look something like below (see black and white dotted areas).

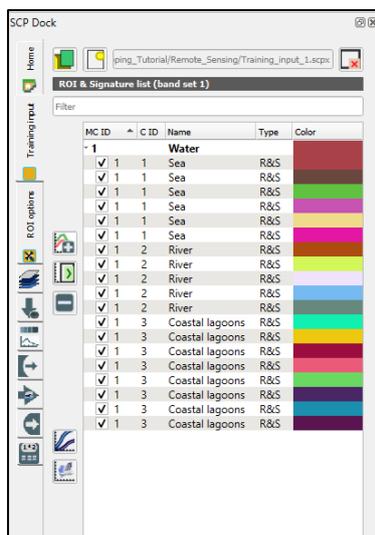


Now, let's add in some training data for **Coastal lagoons**.

- Zoom in and try and find some coastal lagoons and select some training areas.
- Coastal lagoons will be listed as "1" under "MC ID", and as "3" under "C ID" and name it as "Coastal lagoons".
- Like rivers, if you have a satellite image captured in the dry season then these coastal lagoons maybe dried up. Only include areas with water. Examples of lagoons can be seen below, along with our training area allocations in black.



Your ROIs/training data now may look something like below.



Next, we are going to add training data for **mangroves**.

Here we are going to use a different tool to add training data polygons, so that you become familiar with the options you have.

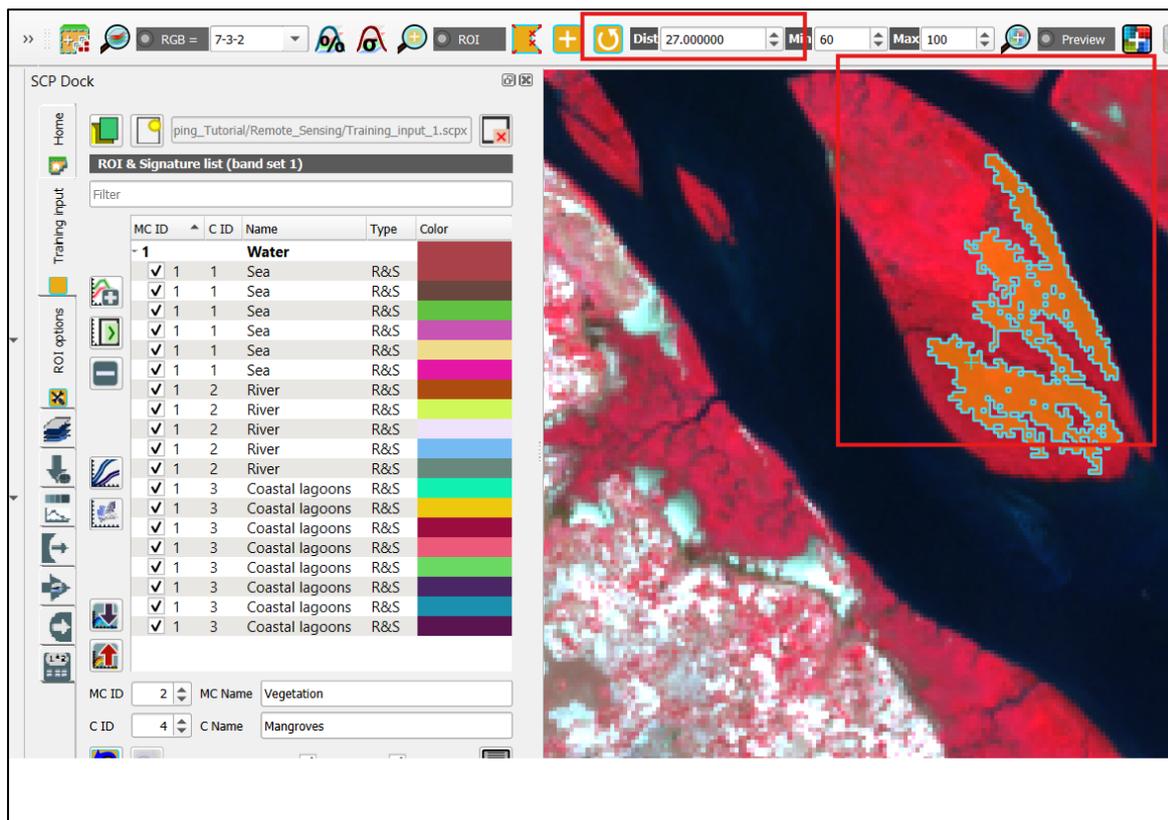
This time we will use the “*Activate ROI pointer*”  tool that is next to the tool you have been using. When you click on the image, this tool automatically aggregates nearby pixels that have the same values to form a polygon.



- Select this tool, and once selected, with the crosshair cursor, zoom in and click on an area of mangrove. After a few seconds, you will see a polygon display.



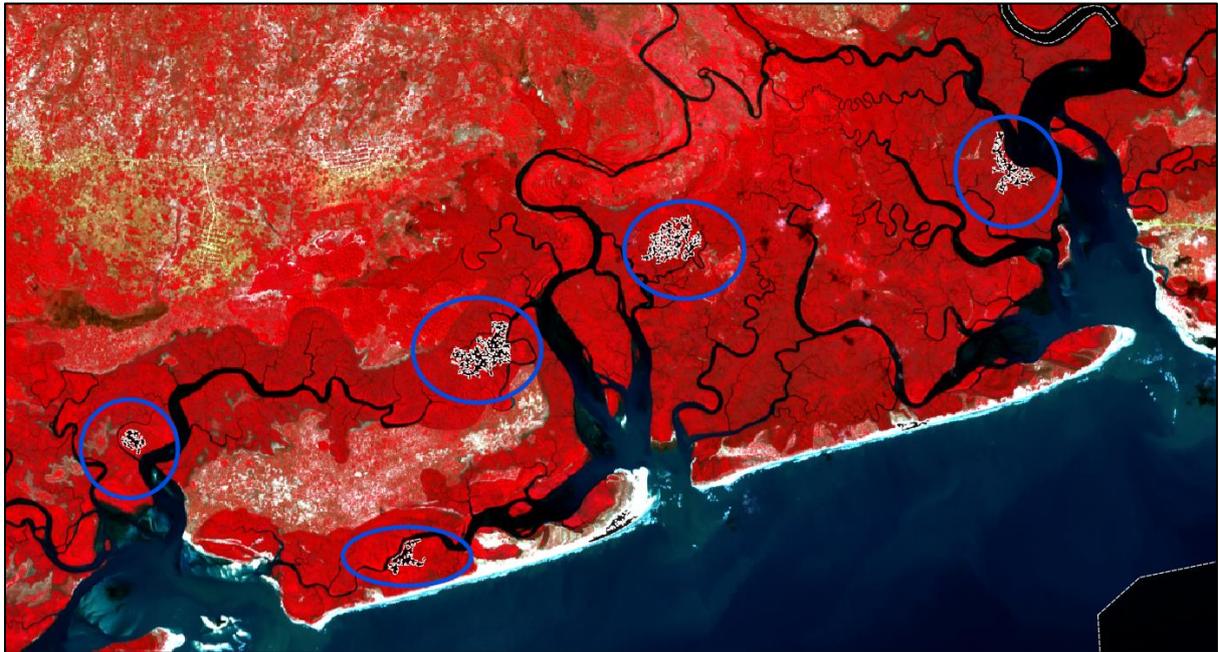
- The area selected, may be small. To increase the size, insert a larger value in the “*Dist*” bar (e.g. 27.00) and click on the “Redo ROI at the same point” .
- You should now see a larger polygon (see below image). Ensure that it covers the pixels for the class you want.



- Then save the ROI under “MC ID” as “2”, and under “MC name” as “Vegetation”. Then for the “C ID” insert “4” and as the “C Name” enter “Mangroves”. Then click .
- Continue to select mangrove training data either by using the “Create a ROI polygon”  button (the manual option) or “Activate ROI pointer”  tool (the more automated option).

Note, if you use the “Activate ROI pointer”  tool you will need to keep amending the “Dist” value so that you don’t over select the pixels. Try and keep them contained to the land cover type you are selecting for.

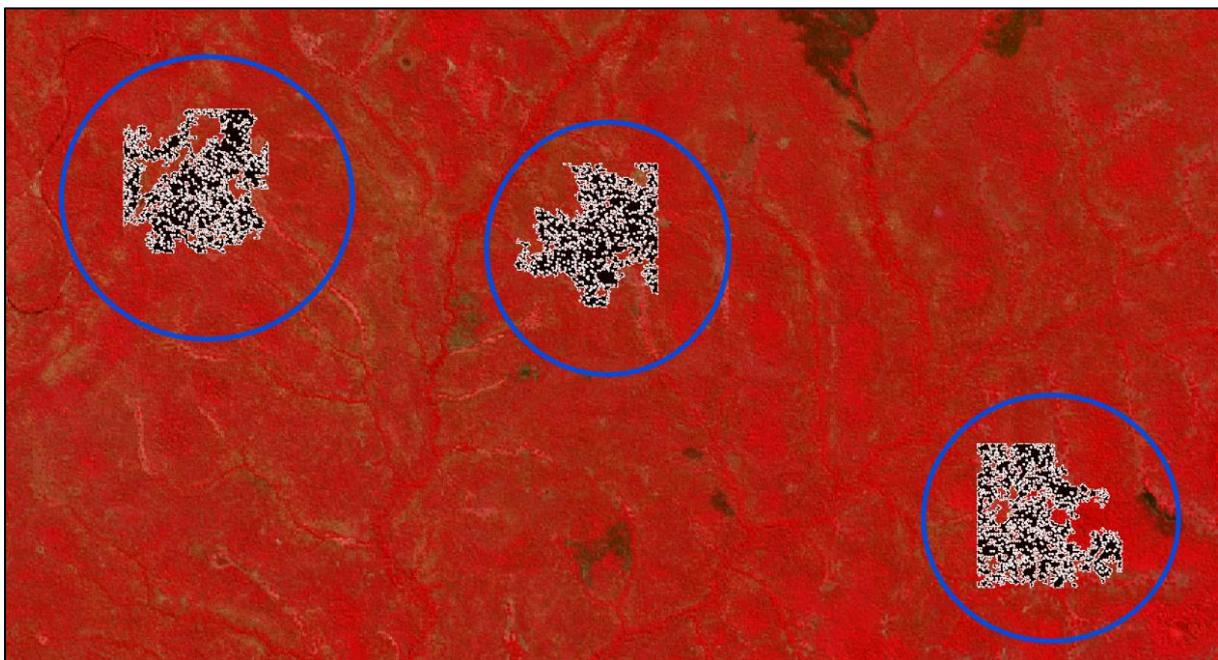
To help you identify areas of mangroves for your ROIs, we show some of our ROIs below (ROIs are seen as black polygons) that are circled in blue, for ease of viewing.



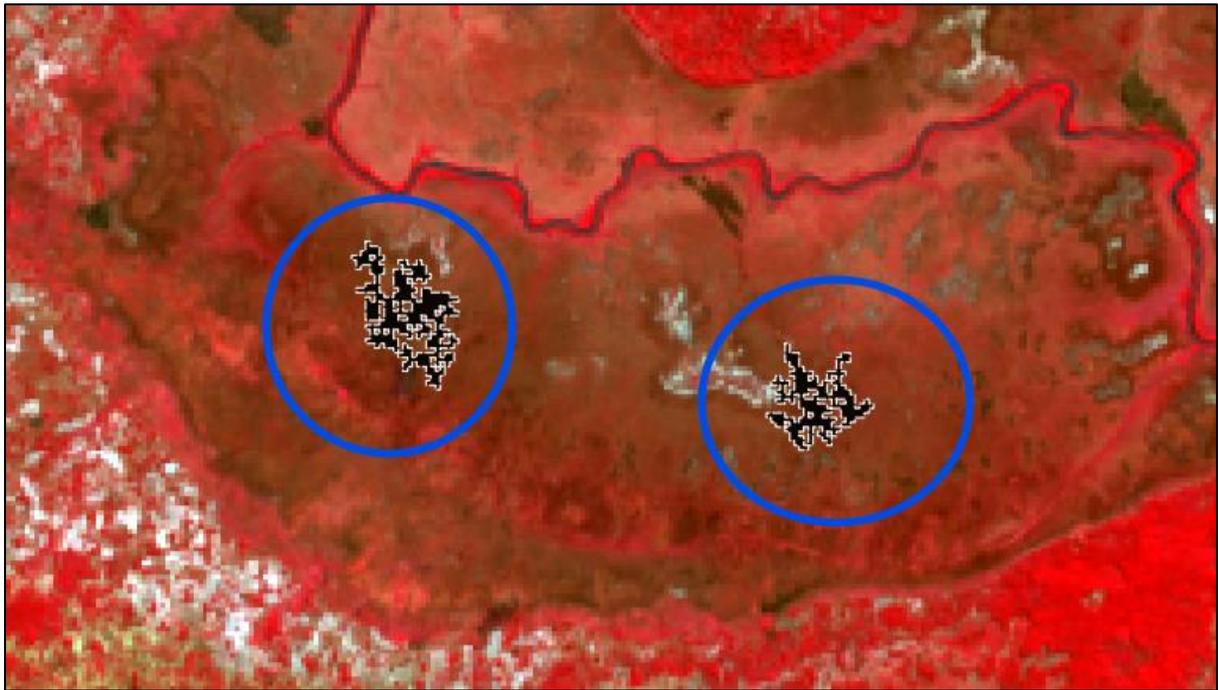
Using the methods, outlined above, continue to add in your land cover classes for Forest, Wetlands, Cultivated, and sand/rocks/bare earth. To help you, we show some of our ROIs below.

Following the Macroclass names and IDs, and Class names and IDs presented in the table above. Select a minimum of 5 training data for each Class type.

Examples of ROIs selected for **Forests**, many of which were in Gile National Park.



Examples of ROIs selected for **Wetlands**.



Examples of ROIs selected for **Cultivated areas**.



Examples of ROIs selected of **Sand/rocks/bare earth**.



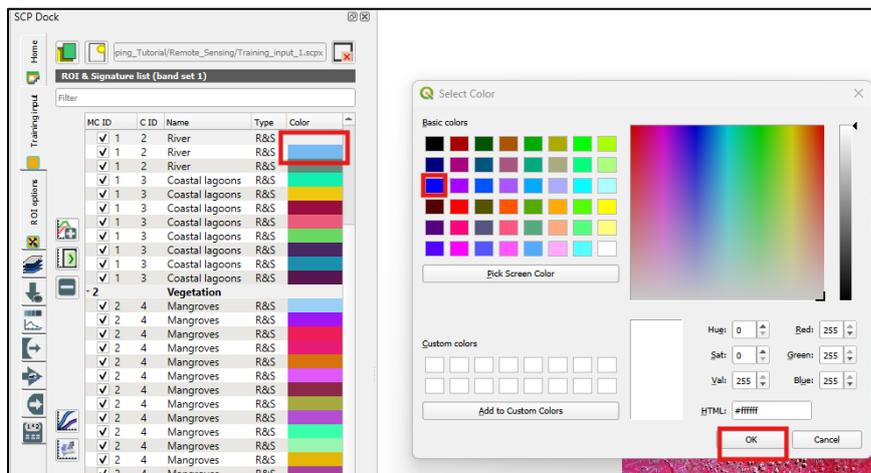
- Click on the “Save Project”  to save your work.

3.2.5. Colour Pallet for the Classification

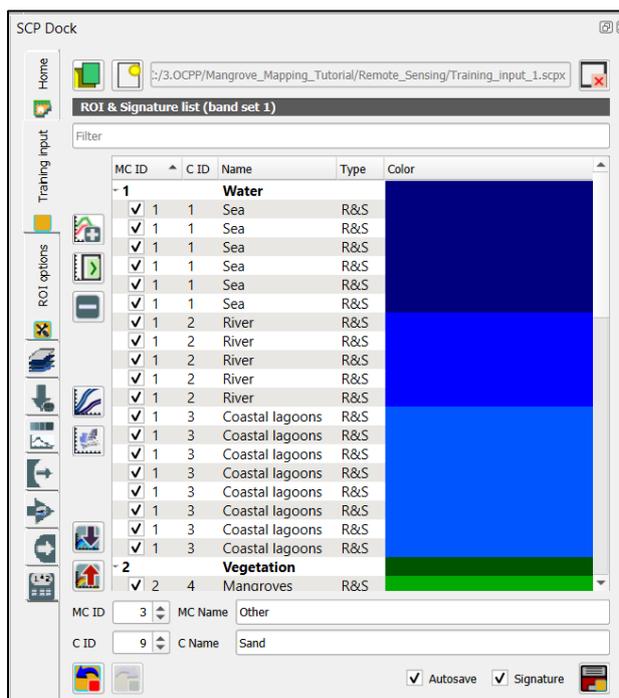
You will have noticed that when you have created a training data polygon (ROI) for each Macroclass and class, a colour has been automatically assigned. We now want to amend these so that each class has the same colour, and that the Macroclasses show the colour we want.

Note, the colour chart prescribed here will inform the colours used in the classification result, once run.

- To do this, simply click on the colour on the “ROI” you want to change, then in the “Select Colour” window select the colour you wish you have, then “OK”.



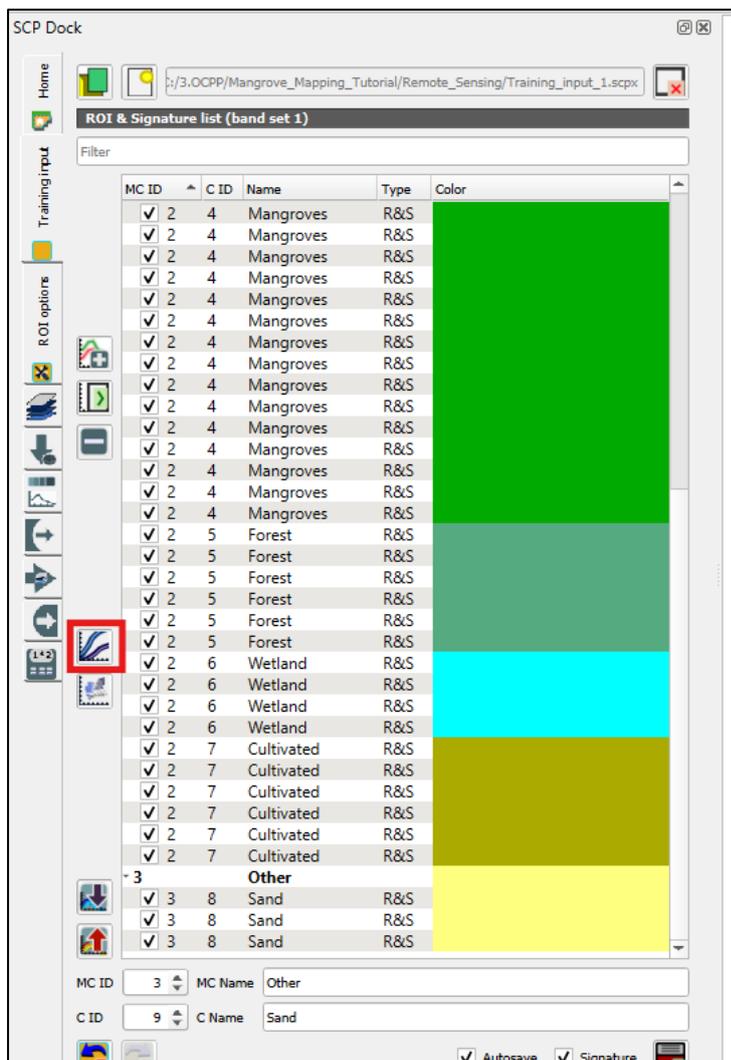
After changing colours, it should look similar to the example shown below, depending on the colours you selected.



3.2.6. Viewing Spectral Signatures of Classes

We can display the spectral signatures of our ROIs, to get some understanding of the wavelength values for the differing classes.

- To do this, click on the Macroclasses you want to look at. You can select them all by clicking once on then, to highlight them in blue. Then click on the “Add highlighted signatures to spectral signature plot”  button.



Next, you should see the “SCP:Spectral Signature Plot” window. Open this to fit your full screen. The top part of the window contains a table of the ROI classes you have chosen to show and to the left there are tick boxes to allow you to “turn-off” those you do not want to include in the plot below.

The plot below, shows information on the wavelengths of your ROIs.

If the plot is too complicated, then you can unselect classes you do not want to show. Below, for example, shows the classes within the “*Macroclass*” of “*Vegetation*”. You can see that the colour palette we have chosen in the section above is used in this plot.

We can see, different spectral signature patterns for the different classes, which will help classify the remotely sensed images when we come to run the classification.

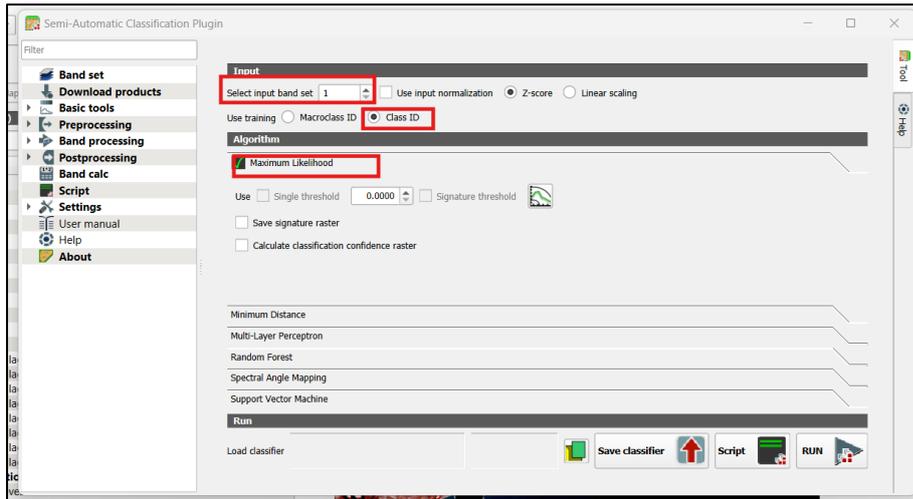


- Once you have finished looking at the “*SCP:Spectral Signature Plot*” you can close the window.

3.2.7. Create a Classification Preview

Next, we can create a classification preview on a section of our satellite image.

- To do this, go to “*SCP*” menu, “*Band processing*” then “*Classification*”. The “*Semi-Automatic Classification Plugin*” window will open.
- In this window under “*Input*”, we need to “*Select the input band set*” that we created earlier. As we have only created one so far, “*Band set 1*” should be there as default. Ensure this is selected.
- Then, we have two options. We can either select the “*Macroclass ID*” training data to use, which will give us a simple map of the classes: “*Water*”, “*Vegetation*” and “*Other*”. Or we can select “*Class ID*” and that will give us a preview of the 8 classes we have defined. For now, click on the “*Class ID*” option.
- Next, you will see under “*Algorithm*” there are several options, such as Maximum likelihood, Minimum distance and Random Forest. In this tutorial, we will use the “*Maximum likelihood*” algorithm. You can now close this window.

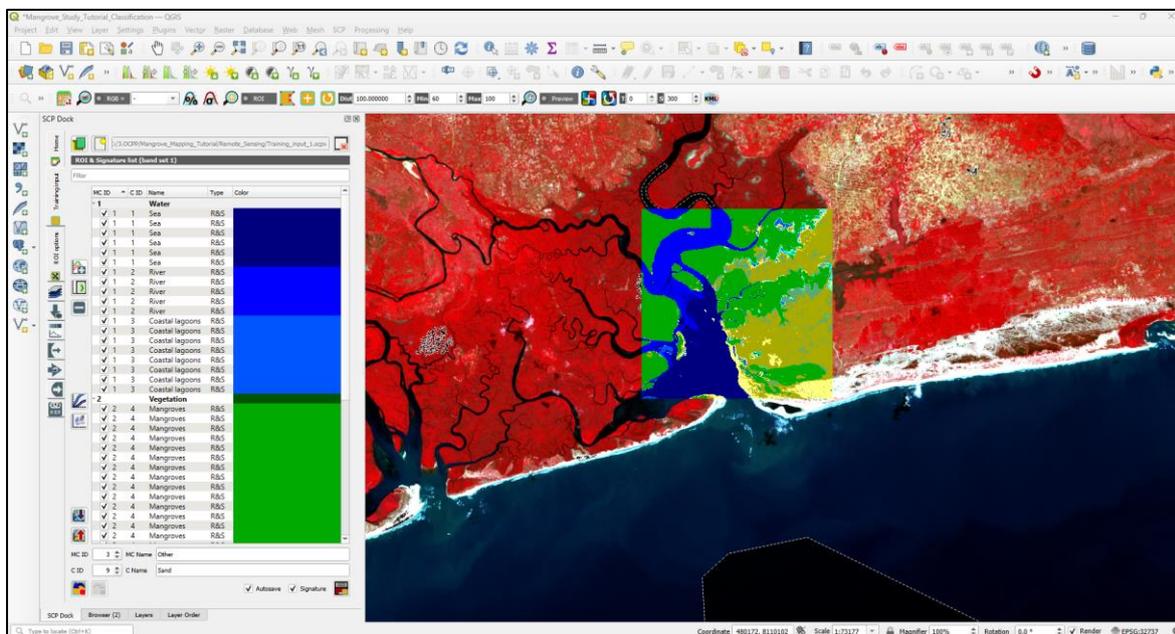


- For the classification preview, we can set the preview size using the parameter “S” on the toolbar, which is expressed in the number of pixels.

Enter 300, then click on the “Active classification preview pointer” , then with the crosshair cursor click on an area you wish to preview.



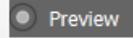
- Time for this process may vary, depending on the number of pixels you enter. We entered 300 in this example, and so this should be relatively fast.



If you wish to preview another location, keeping the preview crosshair toggle on, click on the area you wish to view and click . You should then be able to view

the preview for this new area. Further you can increase or decrease the pixel value also to change the size of the preview if you wish.

By previewing areas, you can then decide if you need to add any additional training polygons, or whether what you have is sufficient.

- To remove the preview, click on the “*Preview*”  button and click on the “*Pan map*”  button.
- Click on the “*Save Project*”  to save your work.

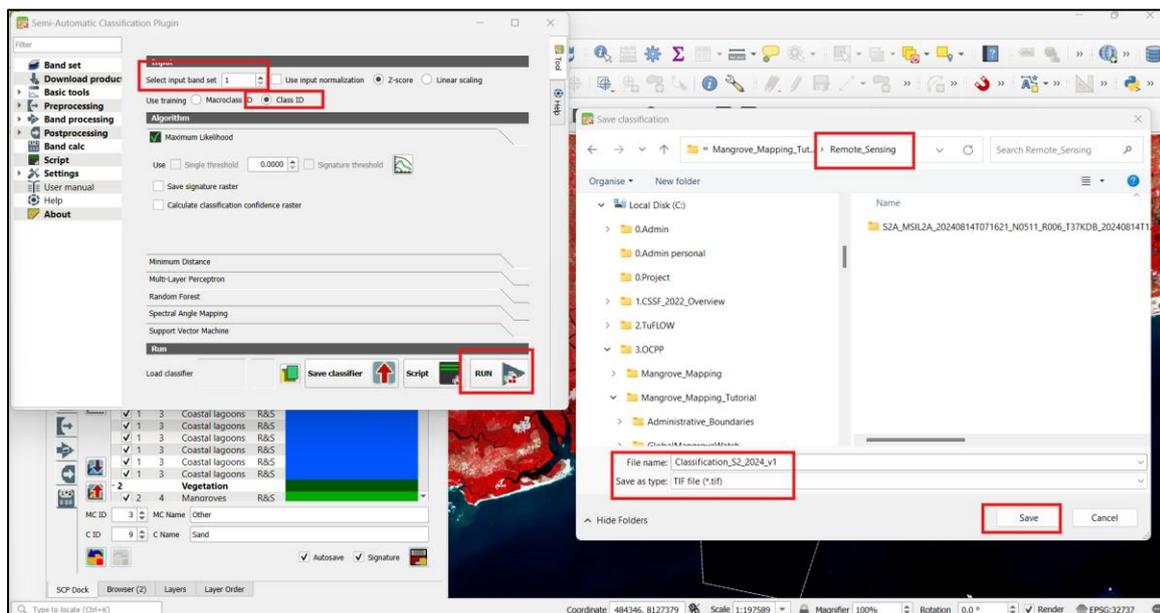
3.2.8. Create a Classification Output

Next, we will run the classification algorithm for the entire image to create out land cover class layer.

- To do this, again open the “*Semi-Automatic Classification Plugin*” window by clicking on “*SCP*” in the menu, “*Band processing*” then “*Classification*”.
- Ensure that for the “*Select the input band set*” that “*1*” is still entered here, and that “*Class ID*” is selected for the “*use training*” option.



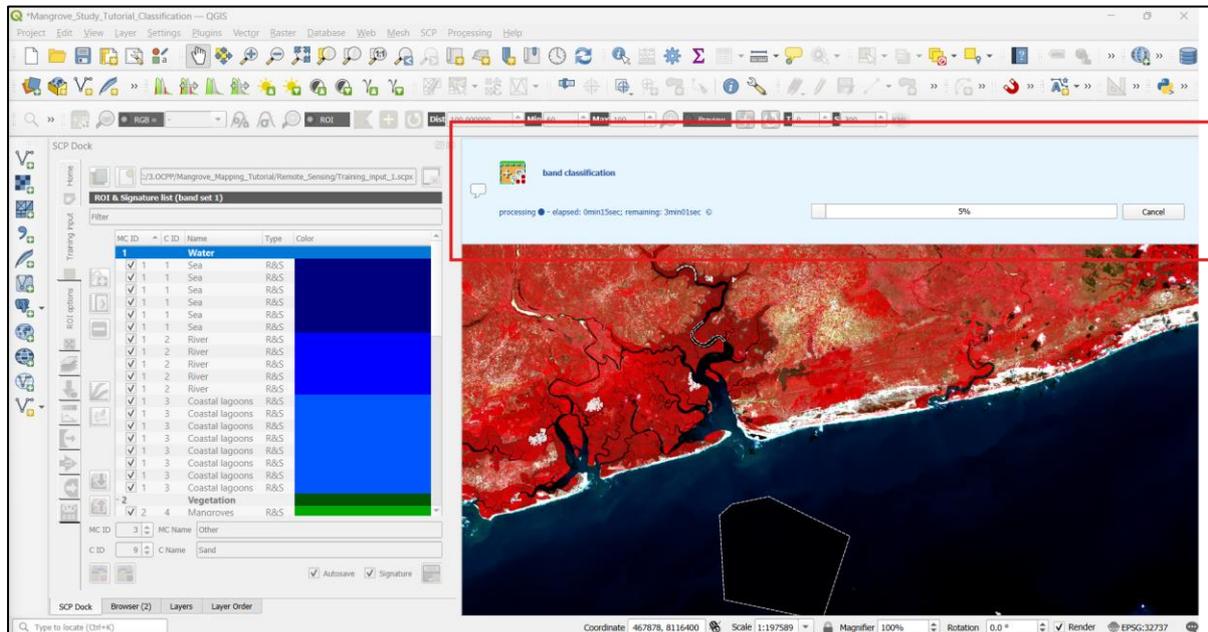
- Then click “*Run*” and a “*Save classification*” window will open. Navigate to the “*Remote Sensing*” folder on your “*C-Drive*” and name the classification as “***Classification_S2_2024_v1***” and ensure that the file type it will save as is “.tif”. Click the “*Save*” button.



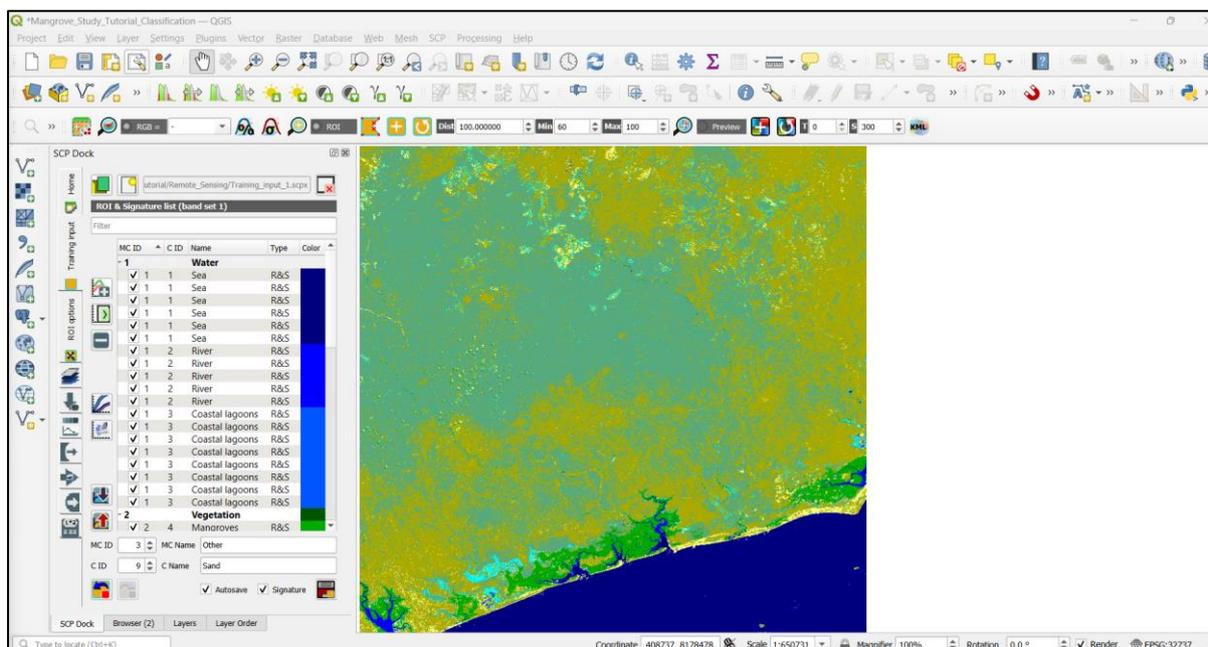
You will then see the “*Band classification*” start to run and this will give you an estimated run time, along with its percentage of run completion. The run time will

depend on various factors such as the number of ROIs you have, the size of the image, and of course your computer specification.

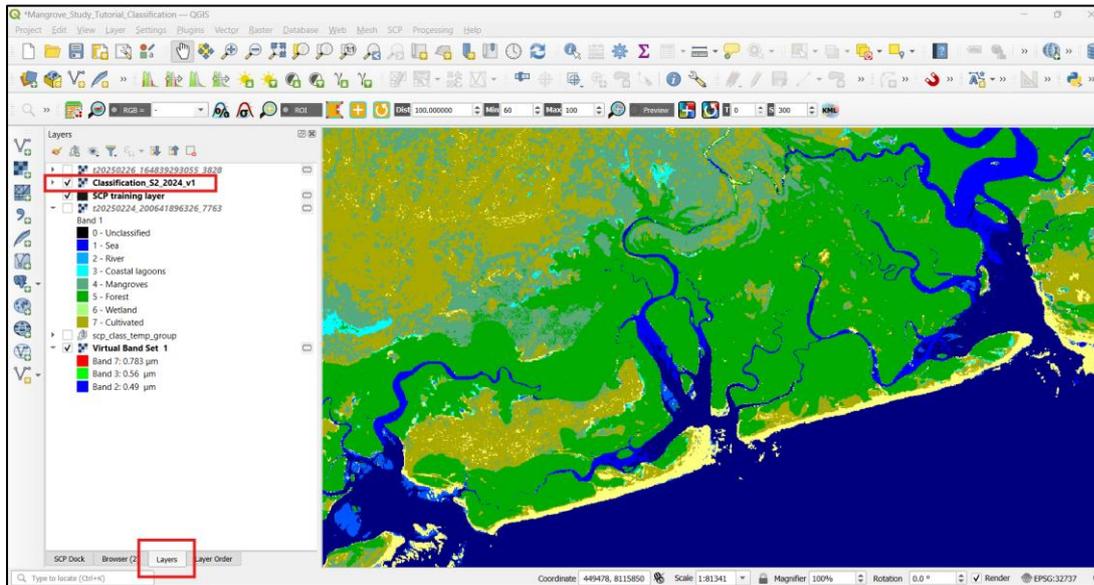
For this tutorial, run time should be several minutes.



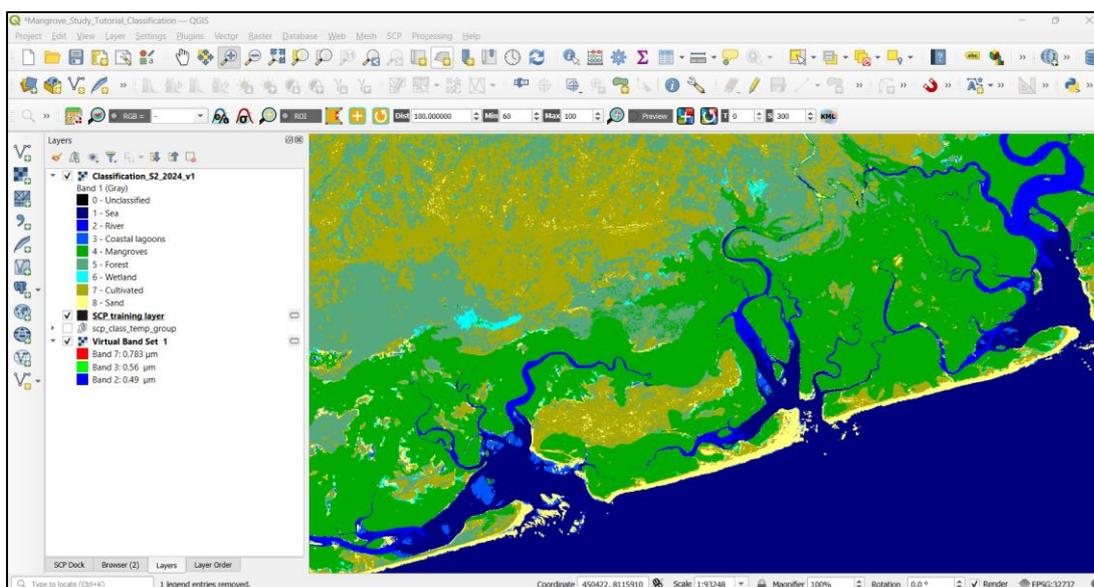
Once the classification has completed, the newly created layer (a ".tif" layer) should be visible in QGIS.



- Next, click on the “Layers” tab. You should now see your classification layer (“Classification_S2_2024_v1”) that has been automatically added.



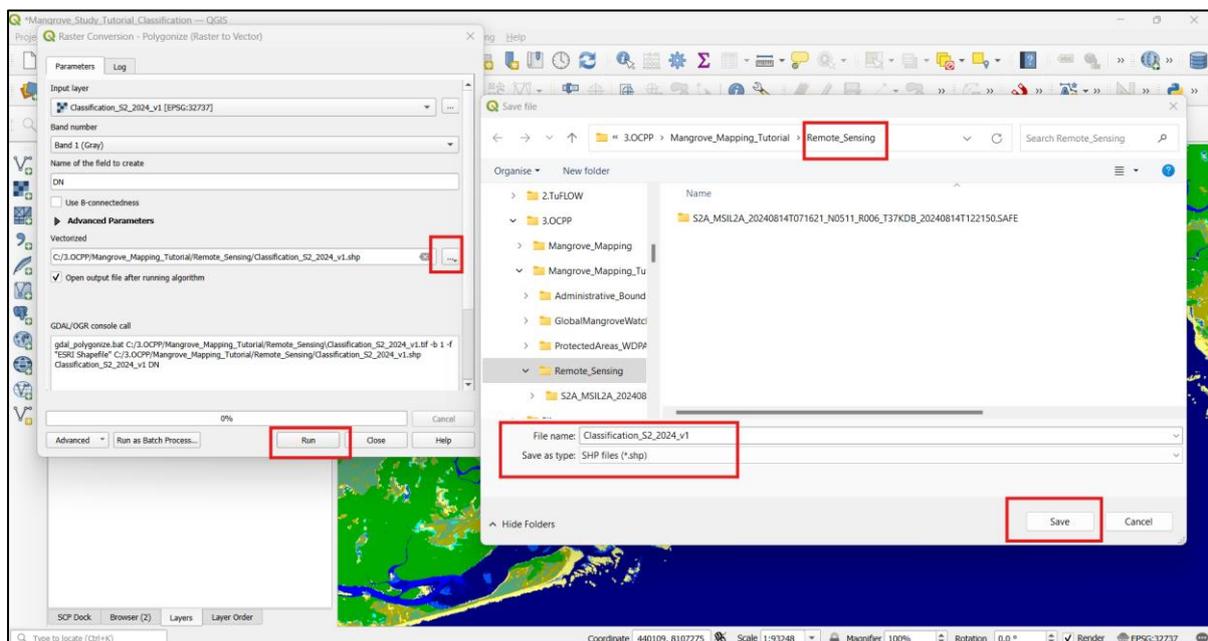
- You should also see two greyed out layers. These are temporary layers that we no longer need and can be removed. To remove these, right click on them and go down to “Remove layer”, then “OK”.
- Ensure the “Classification_S2_2024_v1” layer is at the top (by dragging and dropping it) and click on the left triangle to view the classes in your classification layer.
- Now you can zoom in to areas, and toggle on and off the classification layer to visually inspect the predicted class with the Sentinel 2 satellite image. Click on the “Save Project”  to save your work.



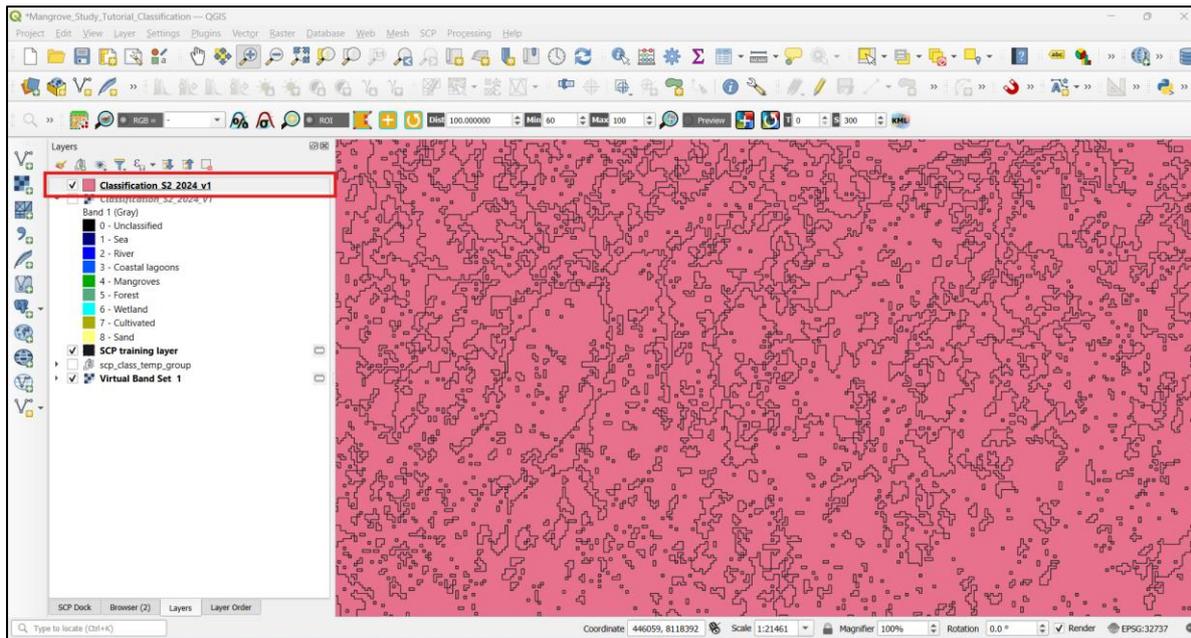
3.2.9. Convert Raster to Vector

Next, we want to convert our supervised classification layer, which is currently in a “*Raster*” layer to a vector format, in this case the vector will be polygons. Vector data are typically easier to work with and enable us to manipulate and interrogate the data easier.

- To convert the raster to vector format, go to “*Raster*” on the menu bar, “*Conversion*”, then “*Polygonize (raster to vector)*”. Under the “*Vectorized*” section, click on  , then “*Save to file*”. Navigate to the “*Remote_Sensing*” folder on your “*C-Drive*”, then name the file “*Classification_S2_2024_v1*” and ensure the file type is “.shp”. In this way, we can name the file the same as the raster layer which is a “.tif” file. Then click “*Close*”.



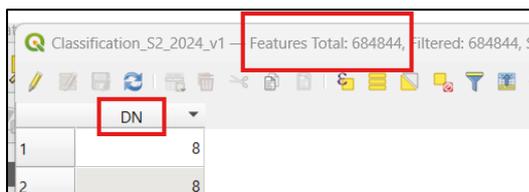
After the process is complete you will see a uniform-coloured vector layer. This layer will be larger than the raster and computationally may be slow to load into your viewing panel. It may help, to zoom in a little to quicken the viewing process.



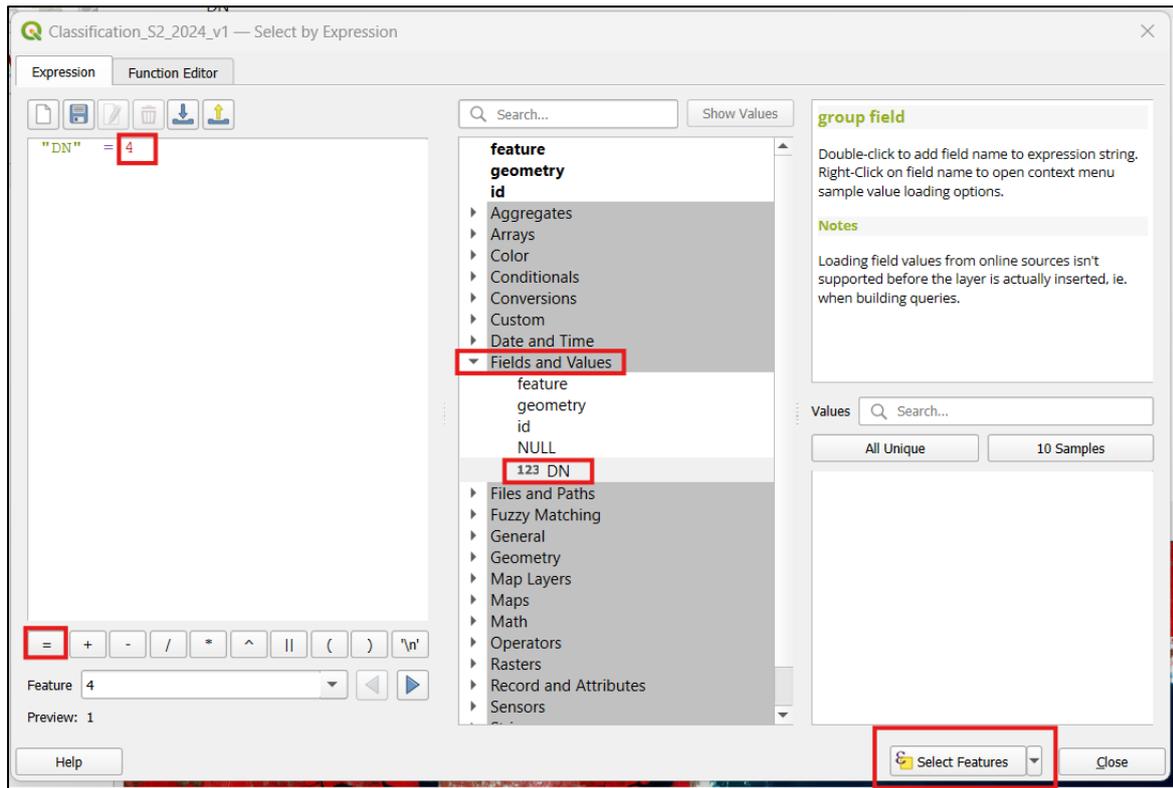
3.2.10. Selecting and Extracting Feature Classes

Now, we have our classification in a vector (polygon) format, we can see that this file is very large and computationally heavy. As we are just focusing on mangroves within this tutorial, we want to extract only those polygons that are classified as mangroves. Then we will merge these polygons into one.

- To do this, right-click on the layer “*Classification_S2_2024_v1*” and select “*Open Attribute Table*”.
- The “DN” column corresponds to our 8 land cover classes, and you can see at the top there are 684,844 features or polygons in this dataset.

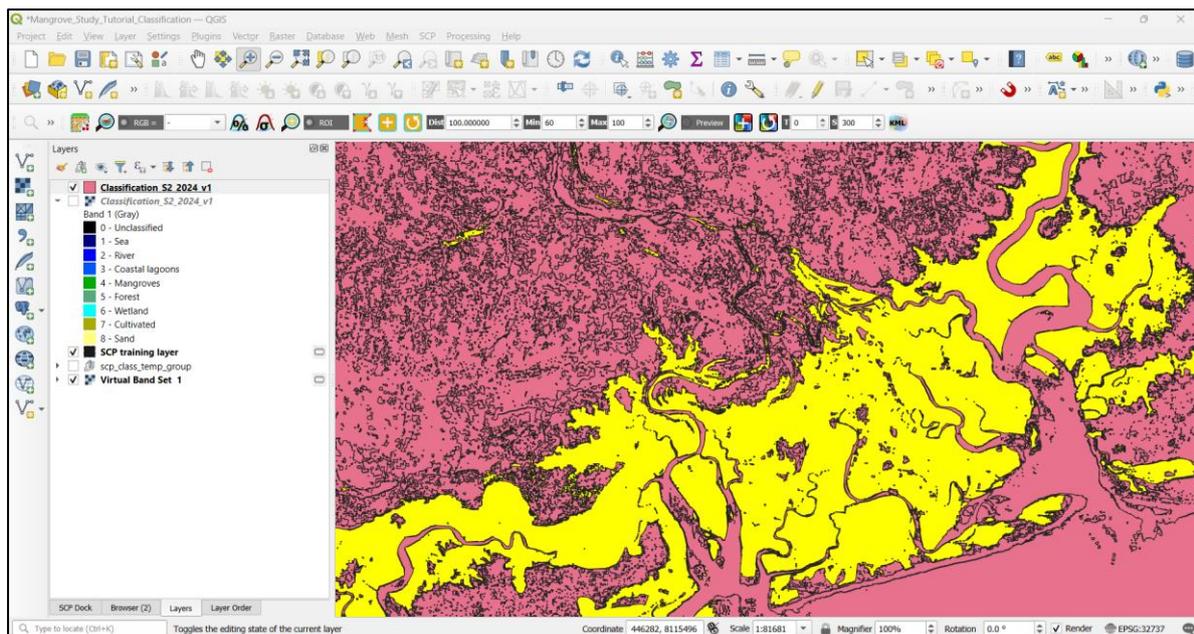


- To select mangrove polygons, go to “*Select features using an expression*” . In the “*Select by expression*” window, click on the drop-down arrow for “*Fields and Values*”, double click on “*123 DN*”, then double click on the equals button and manually add “*4*” to the expression, and click on the “*Select Features*” button. Wait until this process has finished then close both the window and the attribute table.



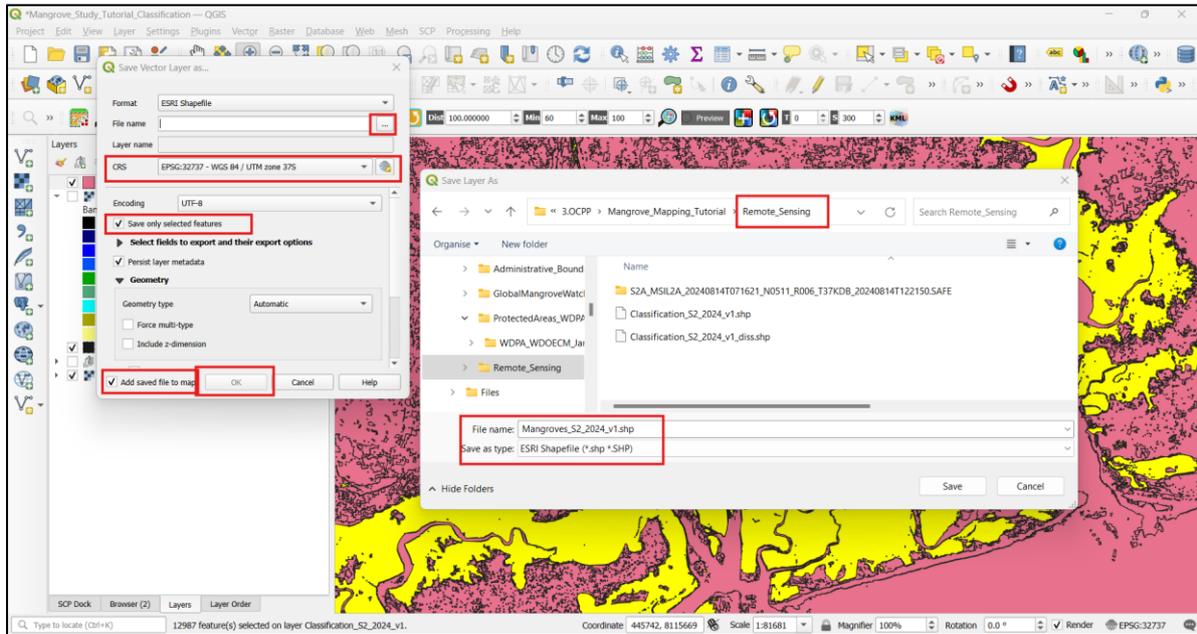
In your attribute table you should now be able to see the selected features. In our dataset there are 12,987 features selected for the mangrove feature class "4". Note, that in your dataset the number of features will differ. If you scroll down the table, you will also see that the classes with the value of 4 are highlighted in blue.

You should then be able to see the selected features that represent mangroves highlighted in yellow. Note, that because these data are large QGIS can be slow in viewing these.

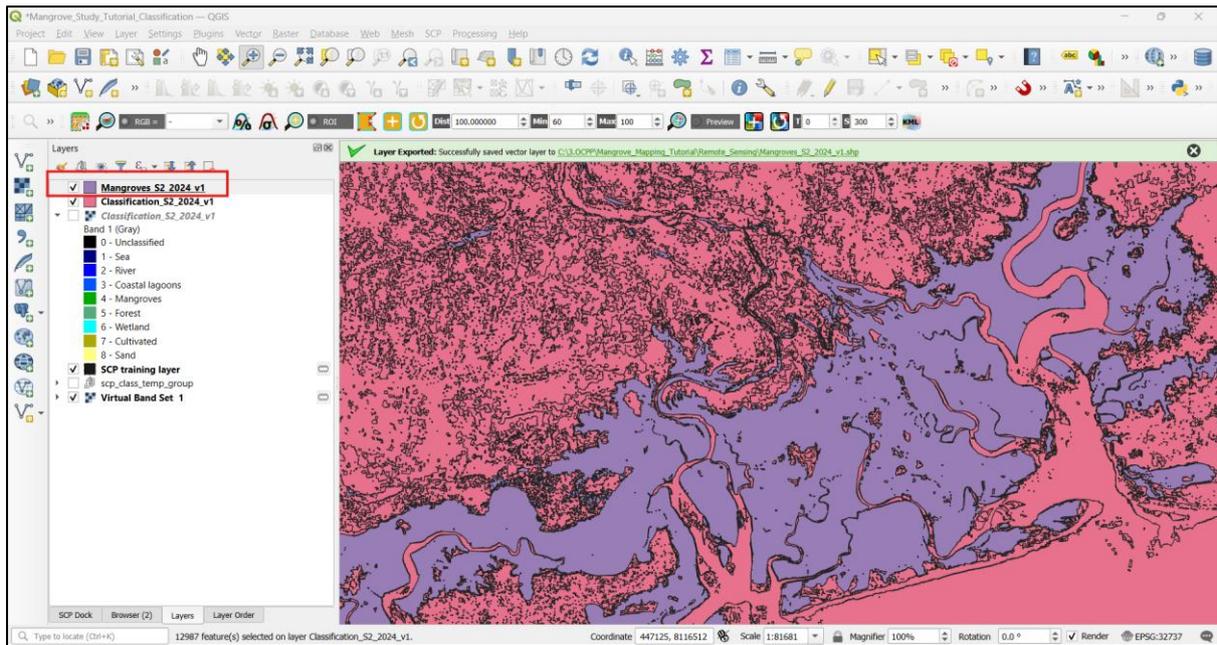


- As we only want the mangrove polygons, right click on the layer “Classification_S2_2024_v1”, go down to “Export”, then “Save Selected Features As”.

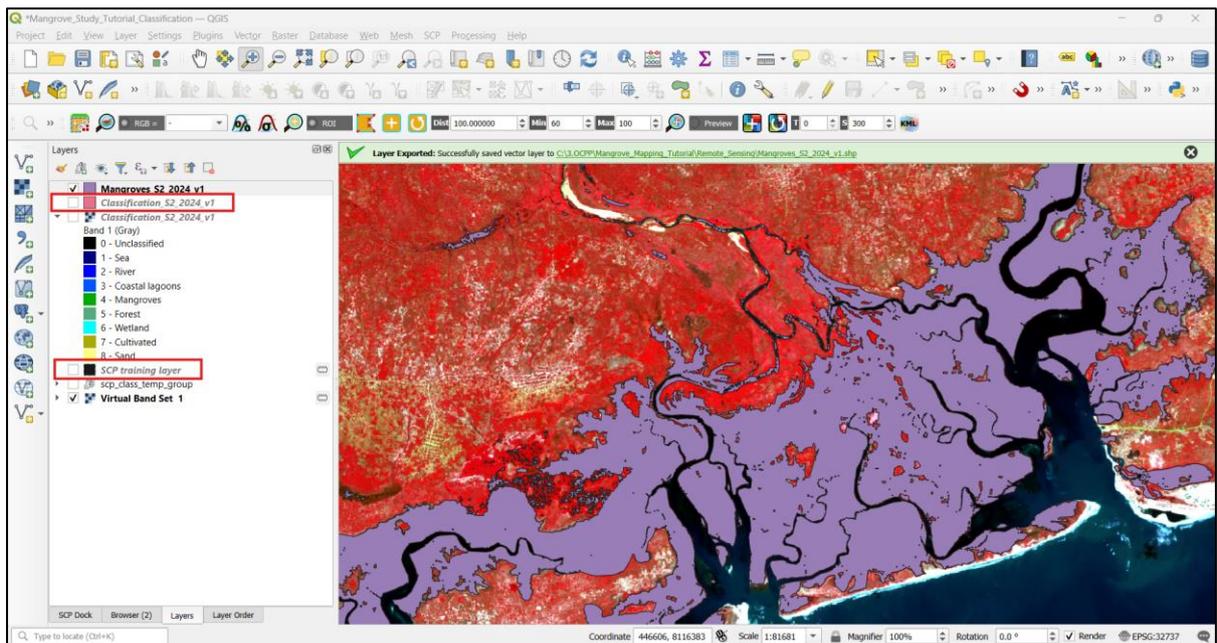
- In the “Save Vector Layer as” window, click on the “Browse” button, then in the “Save Layer As” window, navigate to your “Remote_Sensing” folder on your C-Drive. In that folder, name the file as “Mangroves_S2_2024_v1”, and ensure it is saved as a ESRI shapefile “.shp” file.
- Then back in the “Save Vector Layer as” window, keep the same coordinate system, ensure “Save only selected features” is clicked, and press “OK”.



You should then that the newly created mangrove layer is added to the “Layers” gallery, as per example below.



- You can now click the “*Classification_S2_2024_v1*” layer off and the “*SCP training layer*”, if that is still on.

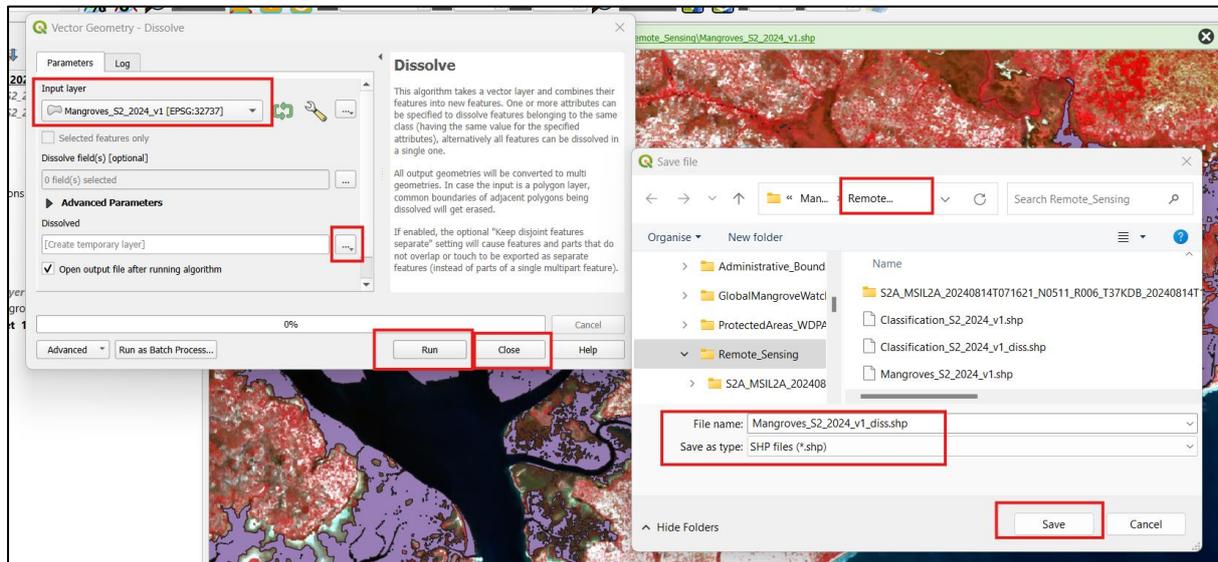


3.2.11. Dissolve Multi part Vector to Single part

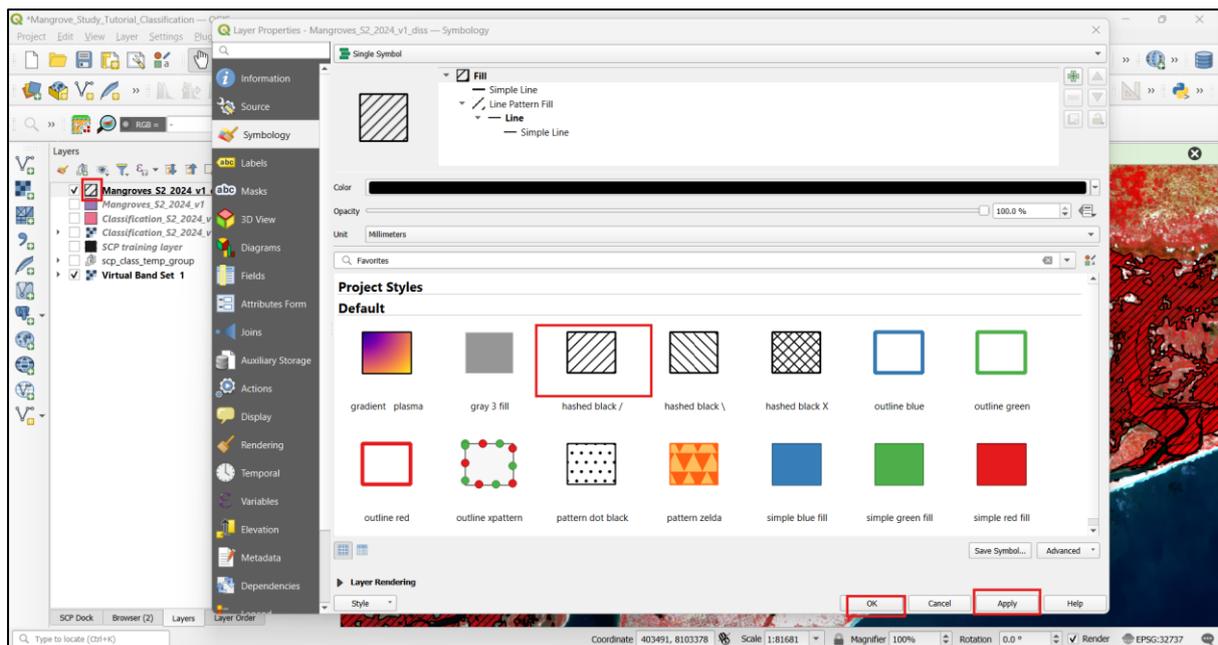
Our mangrove layer still has thousands of discrete polygons. To reduce the number of polygons to just one, we can use a dissolve function.

- To do this, go to “*Vector*” on the main menu, “*Geoprocessing Tools*”, then “*Dissolve*”. The “*Vector Geometry – Dissolve*” tool window will open.

- Under the “Advanced Parameters” then “Dissolved” section, click the navigate  button, then select “Save to file” option.
- Navigate to the “Remote_sensing” folder on the C-Drive, then save the file as “Mangroves_S2_2024_v1_diss”, ensuring the file type is “.shp”, then click “Save”. Then click “Run”, then once the process is complete, click “Close”.

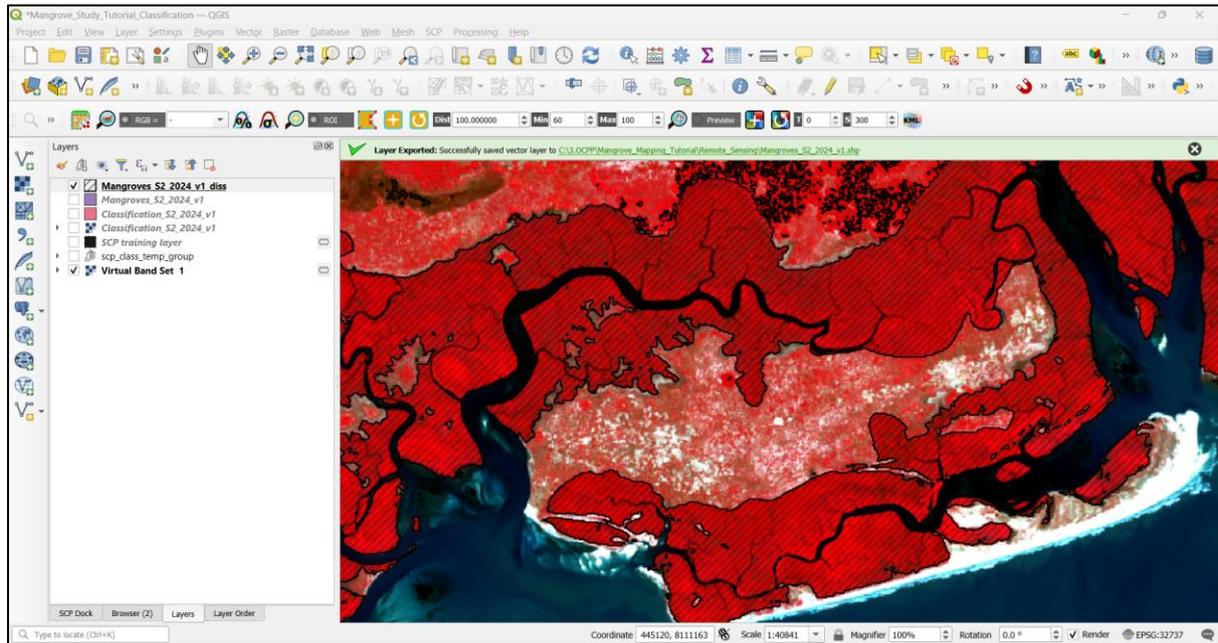


- Now, you can deselect the previous mangrove layer in the “Layers” gallery so that we only see the newly dissolved version.
- Double click on the new layer’s symbology box in the “Layers” gallery and the “Layer Properties Symbology” will open. Select one of the “hashed back” symbology styles, amend the line thickness and colour if you wish, then click “Apply” then “OK”.



- Click on the “Save Project”  to save your work.

You now will be able to compare your predicted mangrove now with the Sentinel 2 data, and at least at this stage visually assess the degree of accuracy and error of your classified layer.



4. PART 2b: Comparing and Mapping Mangrove Data

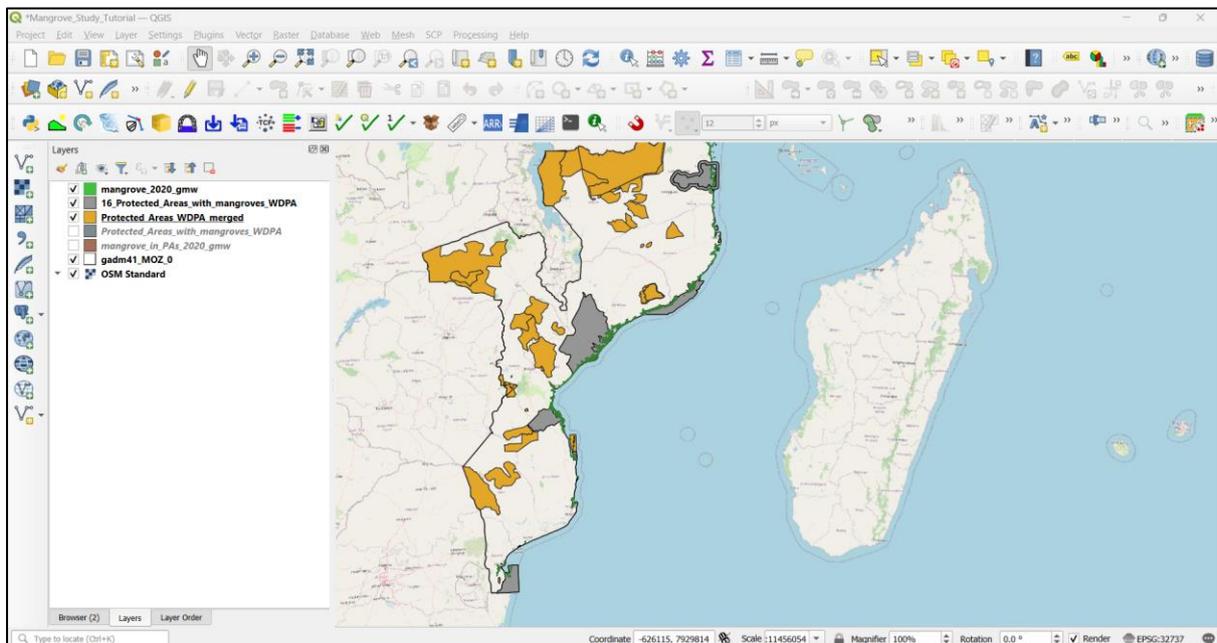
So far in this mangrove mapping tutorial, you have downloaded and used opensource mangrove data (from the Global mangrove Watch global dataset) for Mozambique, and you now have undergone a Supervised Classification to determine where mangroves are located within part of the Pebane District. Now, we want to compare these two datasets, edit our mangrove dataset and create a map.

4.1. Opening Existing QGIS Project

First, navigate to the folder on your C-Drive named “*Mangrove_Mapping_Tutorial*”, then inside this folder double click on the QGIS file named “*Mangrove_Study_Tutorial.qgz*”, which was our QGIS mapping workspace we created and worked in for Part 1, of this tutorial.

Name	Date modified	Type
Administrative_Boundaries	06/02/2025 09:30	File folder
GlobalMangroveWatch	11/02/2025 10:44	File folder
ProtectedAreas_WDPA	11/02/2025 13:47	File folder
Remote_Sensing	27/02/2025 10:42	File folder
Mangrove_Study_Tutorial.qgz	12/02/2025 09:10	QGIS Project
Mangrove_Study_Tutorial_Classification.qgz	26/02/2025 21:38	QGIS Project
Protected_Mangroves_in_Mozambique.png	11/02/2025 20:06	PNG File

The map document should open and look similar to below, if not toggle the layers on or off so that your viewing pane looks similar.

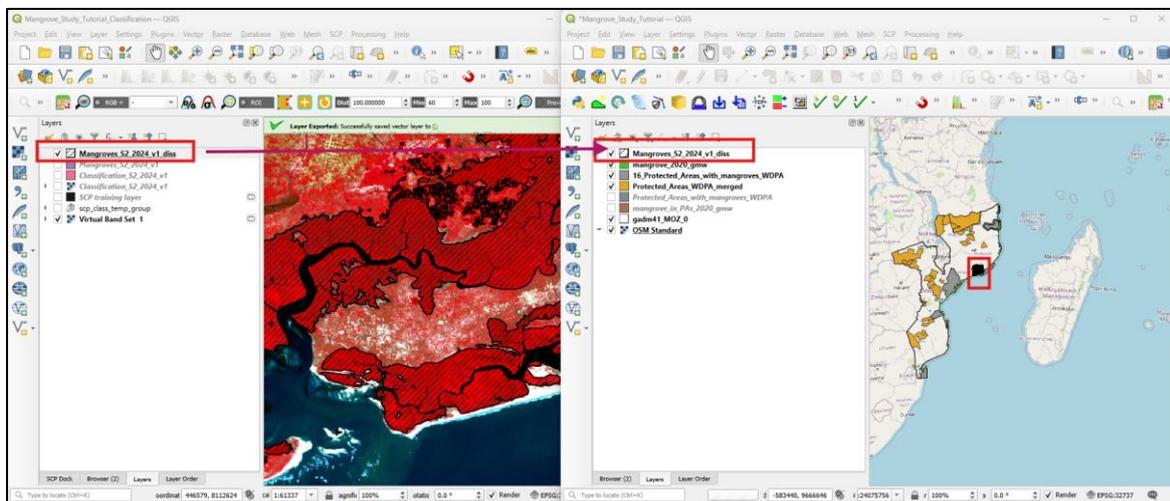


4.2. Pulling in Our New Data

Let's now bring in our new mangrove data. You can either add in data by going to, *Layer* on the menu bar, *Add layer* then *Add vector layer*. Then in the *Data Source Manager – Vector* window, under *Source* navigate to your *Remote Sensing* folder, and click on the *Mangroves_S2_2024_v1_diss.shp* and select *Open* then *Add*.

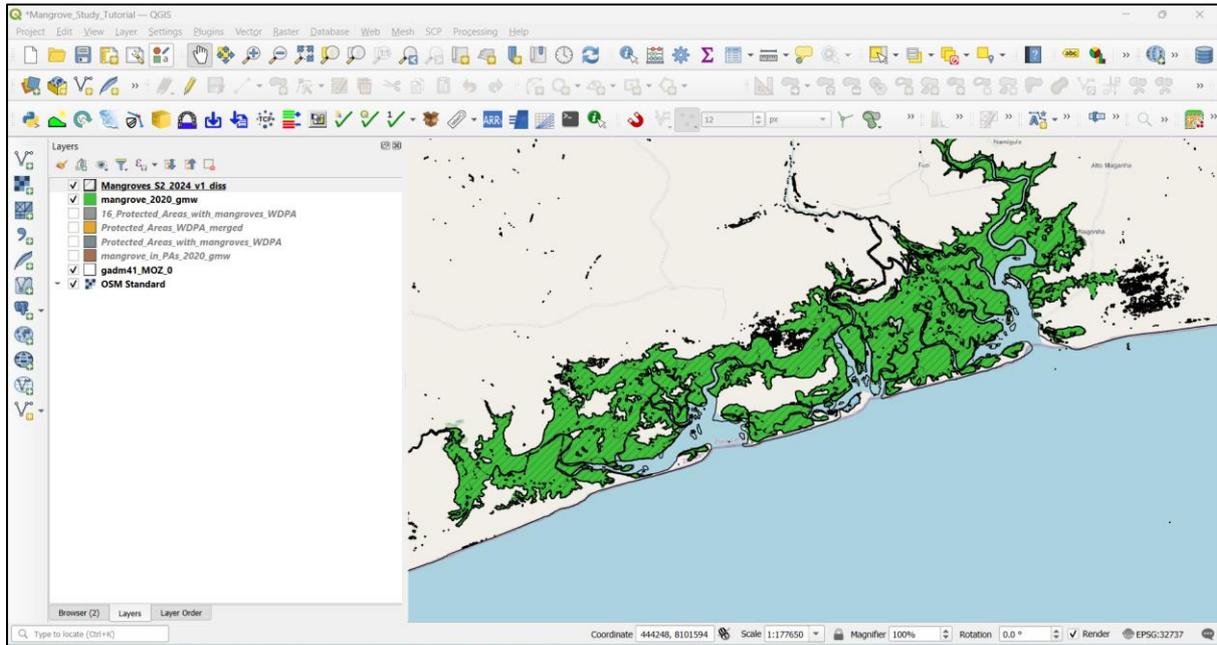
Or you can use a *drag-and-drop* method that is easier, and it keep the symbology of the mangrove layer that we just amended. This method is possibly only if you have the 2 QGIS Projects open simultaneously.

- To do this, left click on the *Mangroves_S2_2024_v1_diss.shp* from your classification project (Part 2) and *drag and drop* this layer into the *Layers* gallery of the projects you created in Part 1 of this tutorial.
- You should now see your mangrove classification in the viewer pane.



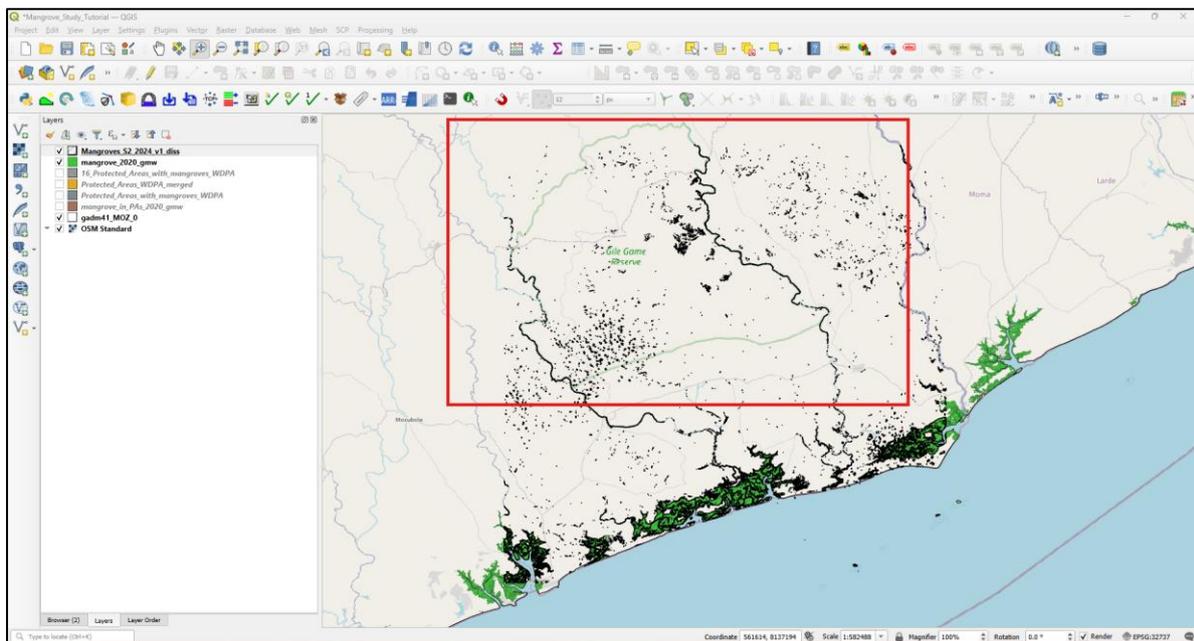
Using the *Zoom in*  tool, zoom into the area with your mangrove data.

When you compare our mangrove dataset with that of the *2020 Global Mangrove Watch* data, we can see that our data overlaps very well within mangrove areas. This can be seen in the image below, where the *Global Mangrove Watch* data is in *green*, and ours is in the *black hashed back* symbology.



However, if you *zoom out* you will notice that our classification has overclassified, in areas along and in small, dispersed patches all too far inland to be mangroves.

It is normal for land cover classification to not be 100% accurate and there are methods to calculate the classification accuracy. For this introductory tutorial, however, we are just using a simple visual assessment approach.



- Click on the “*Save Project*”  to save your work.

4.3. Refining our Mangrove Data

Manual editing of land cover classes, such as our mangrove layer, can be done in several ways. As mangrove as a land cover class is relatively easy to identify gross errors, we shall employ a simple method here by creating a new AOI shapefile to which we will use to “Clip” our Mangrove data too.

4.3.1. Creating a New AOI Shapefile

- To do this, go to “Layer” on the main menu, “Create Layer”, then “New shapefile layer”.
- In the “New Shapefile Layer” name the file “**AOI_mangrove_cleanup.shp**”, in the “Geometry type” dropdown menu select “Polygon”, and retain the same coordinate system. Under “New Field” insert the field name “**aoi**”, select the “Type” as a “Text” and insert the number of characters for the text string e.g. 10. Then click the “Add to Fields List”. You should then see your “New Field” added to the “Fields List” below. Press “OK”.

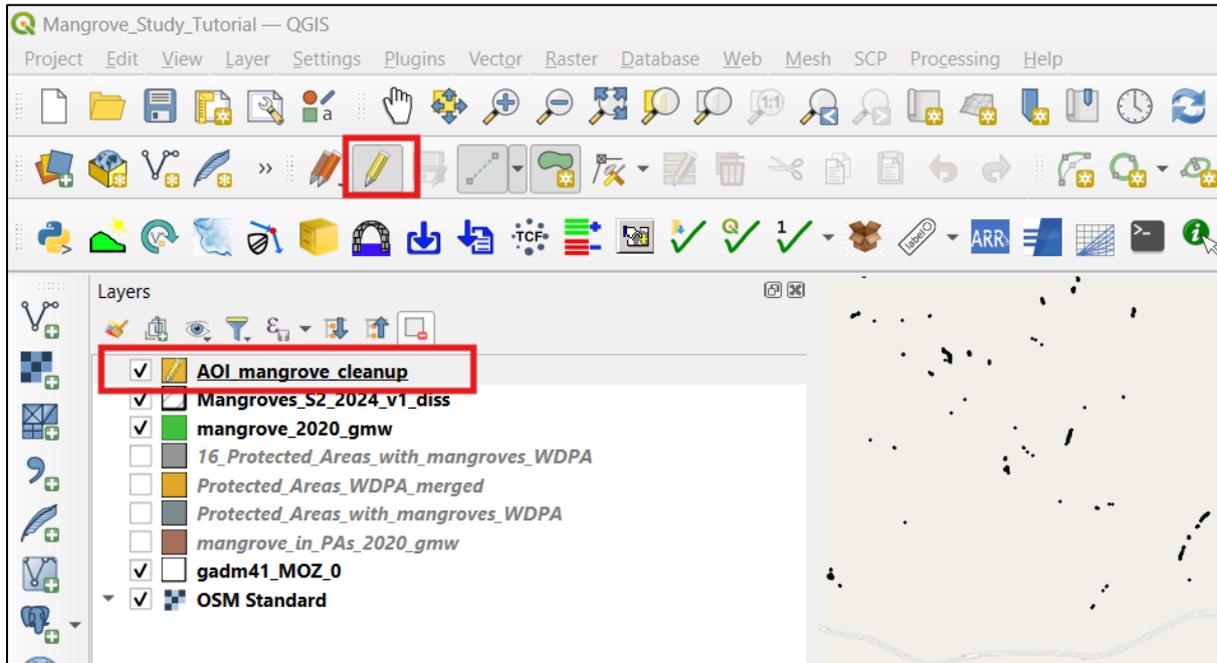
The screenshot shows the 'New Shapefile Layer' dialog box with the following configuration:

- File name:** AOI_mangrove_cleanup.shp
- File encoding:** UTF-8
- Geometry type:** Polygon
- Additional dimensions:** None (selected), Z (+ M values), M values
- Coordinate System:** EPSG:32737 - WGS 84 / UTM zone 37S
- New Field:**
 - Name: aoi
 - Type: abc Text (string)
 - Length: 10
 - Precision: (empty)
- Fields List:**

Name	Type	Length	Precision
id	Integer	10	
aoi	String	10	

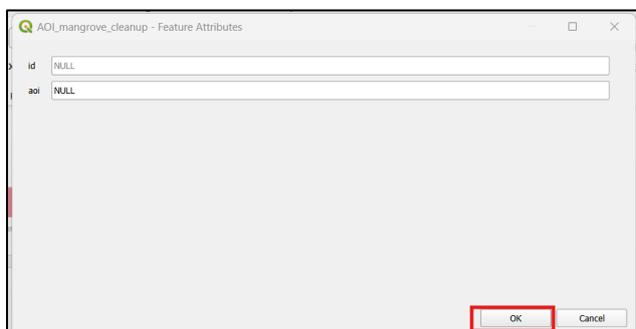
4.3.2. Editing a Shapefile

- To edit the shapefile, click on the “*AOI_mangrove_cleanup*” layer. Then click on the “*Toggle Editing*”  button on the editing toolbar. You should then see the that the “*Toggle Editing*” symbol is expressed in the “*AOI_mangrove_cleanup*” layer.



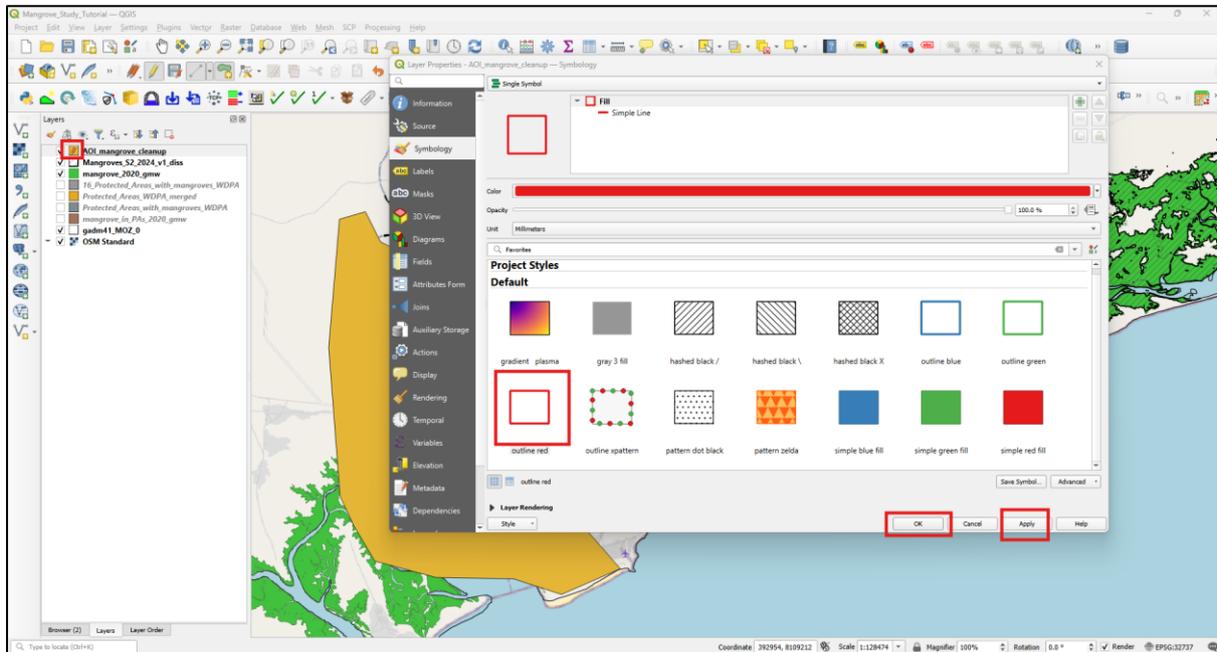
You are now in editing mode.

- To add a polygon to the editable layer, click on the “*Add Polygon Feature*”  you will then see the change to your cursor. You can now click on the areas you want to create a polygon by left clicking on the mouse, and to finish the polygon, right click.
- When a “*Feature Attributes*” window opens, keep the default values and select “OK”.

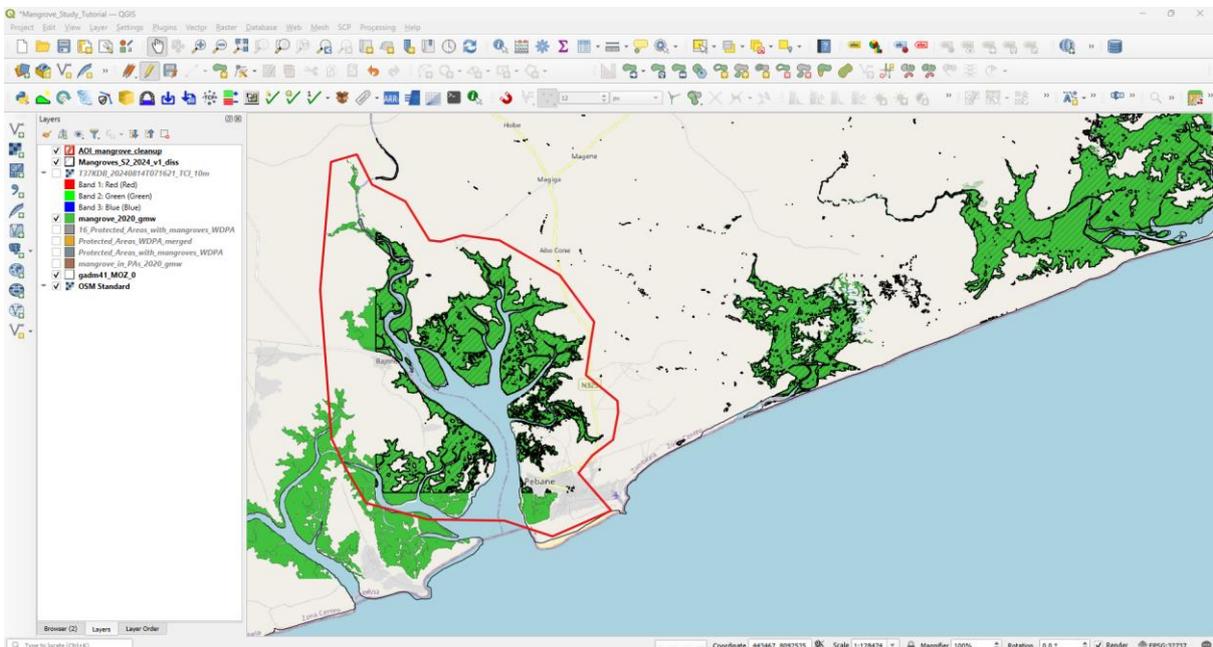


- Your newly created polygon should have now been added.
- For the purpose of this “*AOI_mangrove_cleanup*” layer, we want to create polygons that cover the general areas that we are certain have mangroves.

- When creating the polygon, the draft will be transparent to facilitate the digitising. Once you right click to finish the polygon, it will default to the layer's symbology.
- If you want to change the symbology at this point, double click the layers colour, and select the symbology you want, then “Apply” and “OK”. We selected the red outline style.

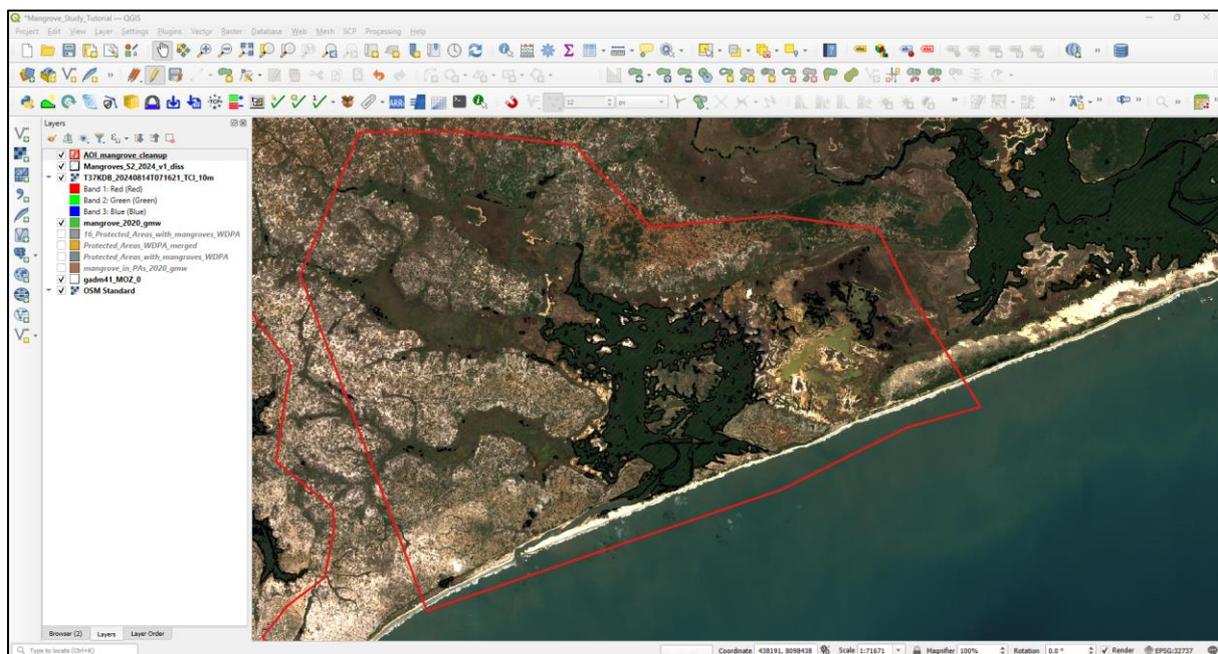


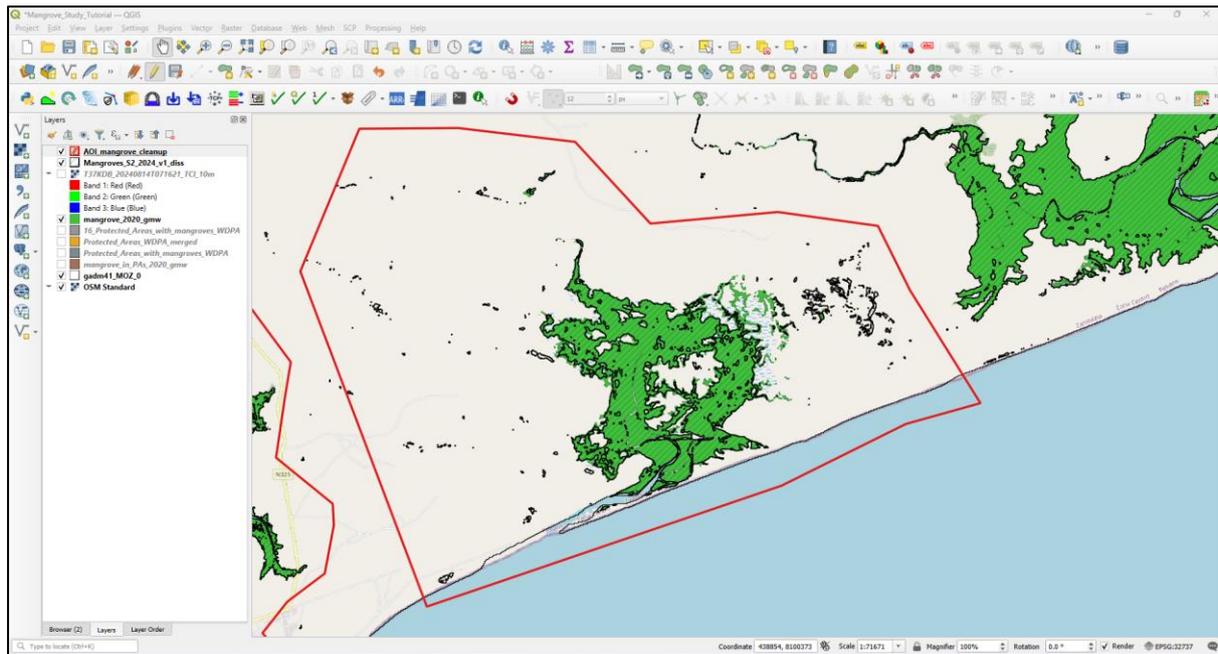
You should now be able to view the area within your newly created polygon.



If, at this point you are struggling to clearly know which areas of predicted mangroves are indeed mangroves you can pull in a “*True Colour Composite*” or “*TCI*” in the Sentinel 2 data we downloaded earlier.

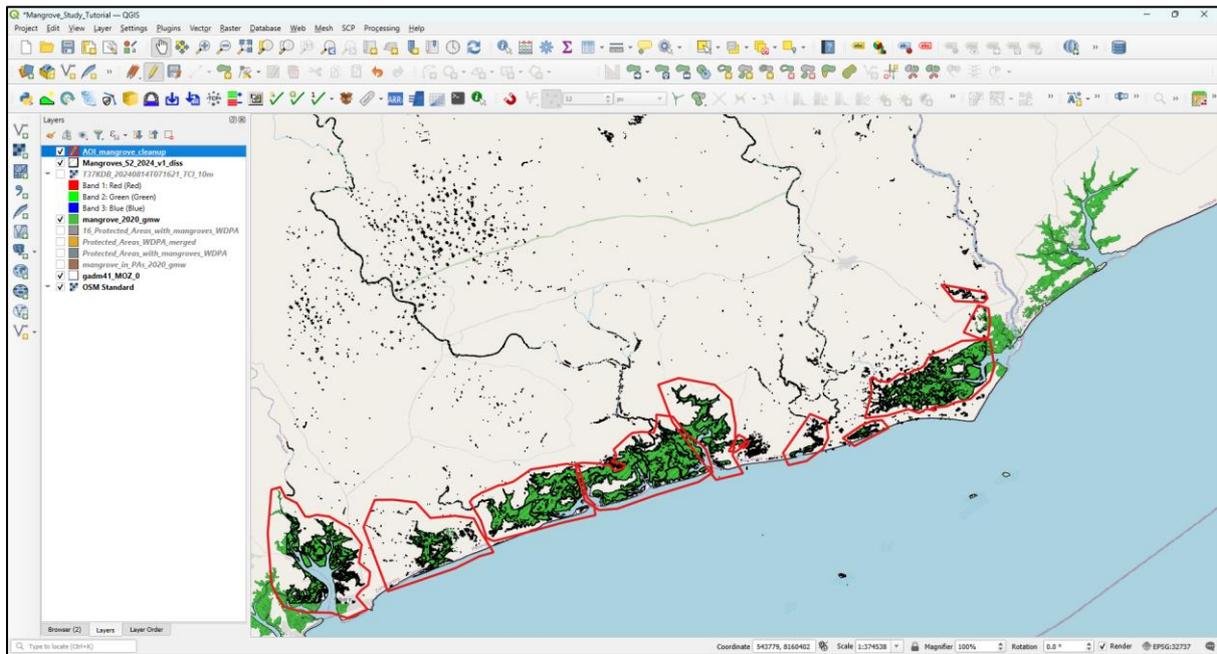
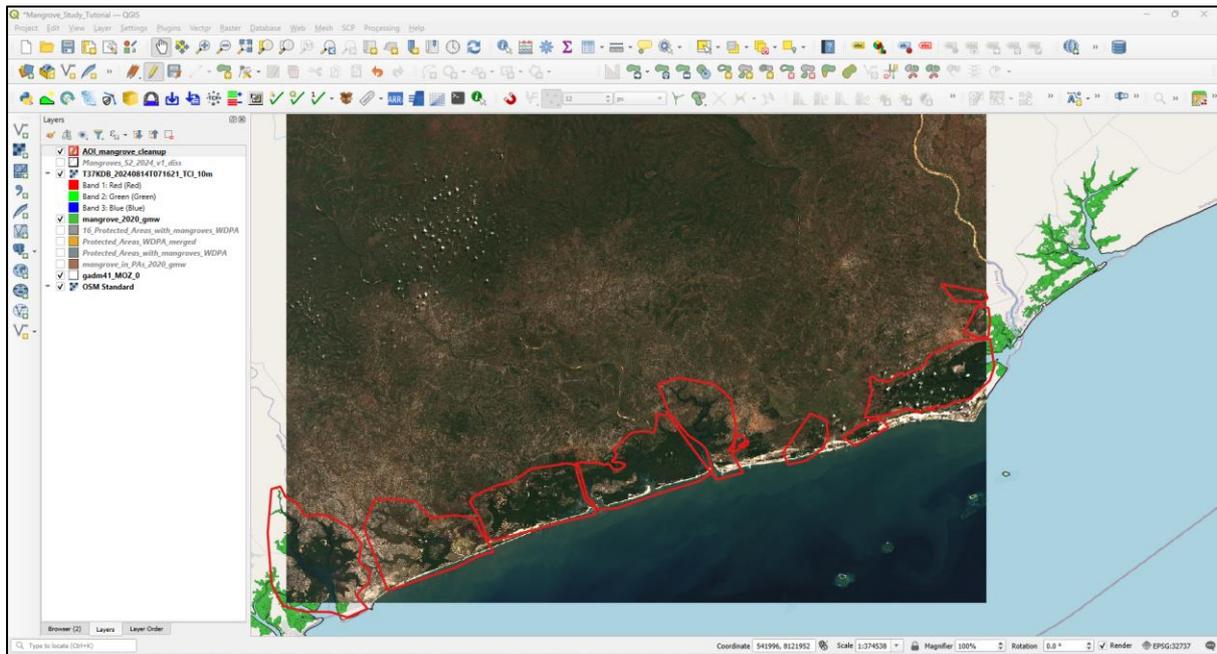
- To add this layer, go to “*Layer*”, “*Add Layer*”, “*Add Raster Layer*” then under “*Source*” click on  and navigate to the Sentinel 2 folder. Ours was named “*S2A_MSIL2A_20240814T071621_N0511_R006_T37KDB_20240814T122150.SAFE*”, then go into the “*Granule*” folder, then into the next folder, then into the folder named “*IMG_DATA*”, then go into the folder “*R10m*”, and select the layer that has a file name ending with “*..._TCI_10m.jpg*”. Click on it and select “*Open*”.
- This layer should then be added to your “*Layers*” gallery. Drag this raster down to below the layer you are editing and your dissolve mangrove layer, so that you can better see them.
- You can toggle on and off this TCI raster layer as you go, adding additional polygons.



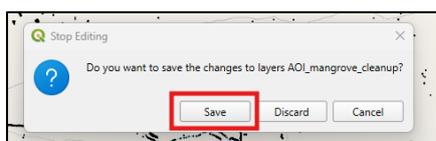


- Continue to add polygons that cover your mangrove data, ensuring that the “Add Polygon Feature”  is again selected if you select another cursor tool such as the Pan  tool for moving around your area of interest, or “Zoom In” or “Zoom Out”  tools.
- Also, the “Undo” and “Redo”  tools, are helpful if you want to remove or replace your polygons.
- Polygons for this layer can overlap, as we will simply be using them to extract out areas of mangroves that we want to retain.

Once you have finished, your polygons, should look something like the below images.



- As we have finished creating the polygons, click on the “Toggle Editing”  tool to turn it off, and when prompted to save the edits/changes you made, click “Save”.

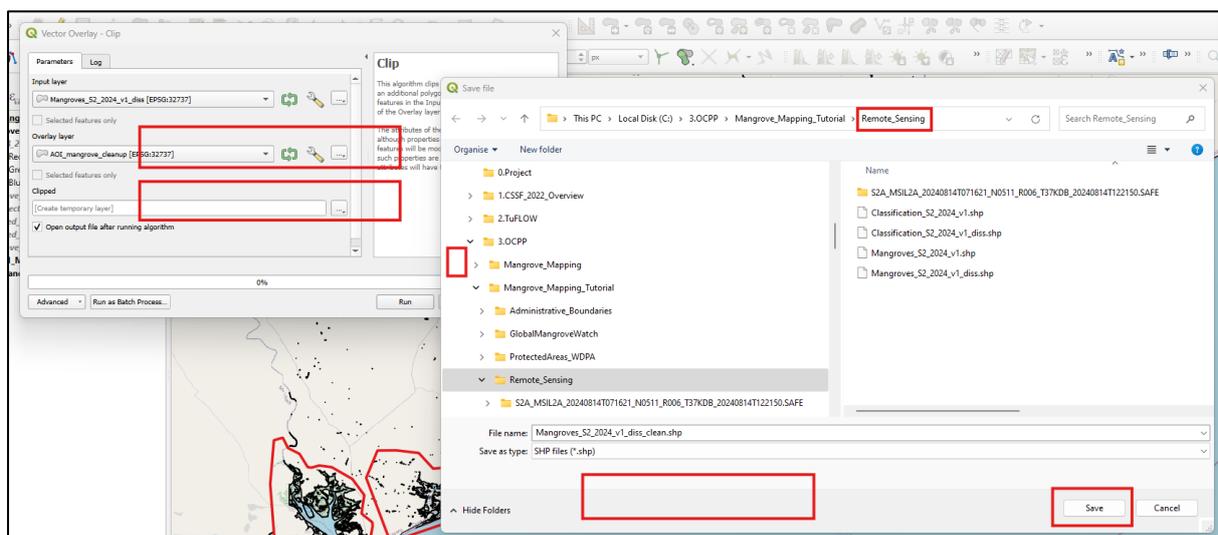


- Click on the “Save Project”  to save your work.

4.3.3. Clipping Our Mangrove Data

Now, we want to simply clip our mangrove data to the shapefile we just created so that we can get a clean and more accurate mangrove layer.

- To do this, go to “Vector” on the main menu, “Geoprocessing Tools”, then “Clip”.
- In the “Vector Overlay – Clip” window, ensure that the “Input layer” is “Mangrove_S2_2024_v1_diss”, and that the “Overlay layer” is the “AOI_mangrove_cleanup” layer. Under “Clipped” click on the navigate button and in your “Remote_Sensing” folder save this file as “Mangroves_S2_2024_v1_diss_clean” and ensure it is saved as a shapefile “.shp”. Then click “Run”.



- You can now remove the “AOI_mangrove_cleanup”, and the “Mangroves_S2_2024_v1_diss” layers by right clicking and selecting “Remove layer” then, “OK”. Do this for both layers.
- Move the TCI image down, by dragging this.
- Then change the colour of the new/clean mangrove layer by double clicking on it, and under the “Symbology” tab, select a colour of your choice, then press “Apply” and “OK”.
- Click on the “Save Project”  to save your work.

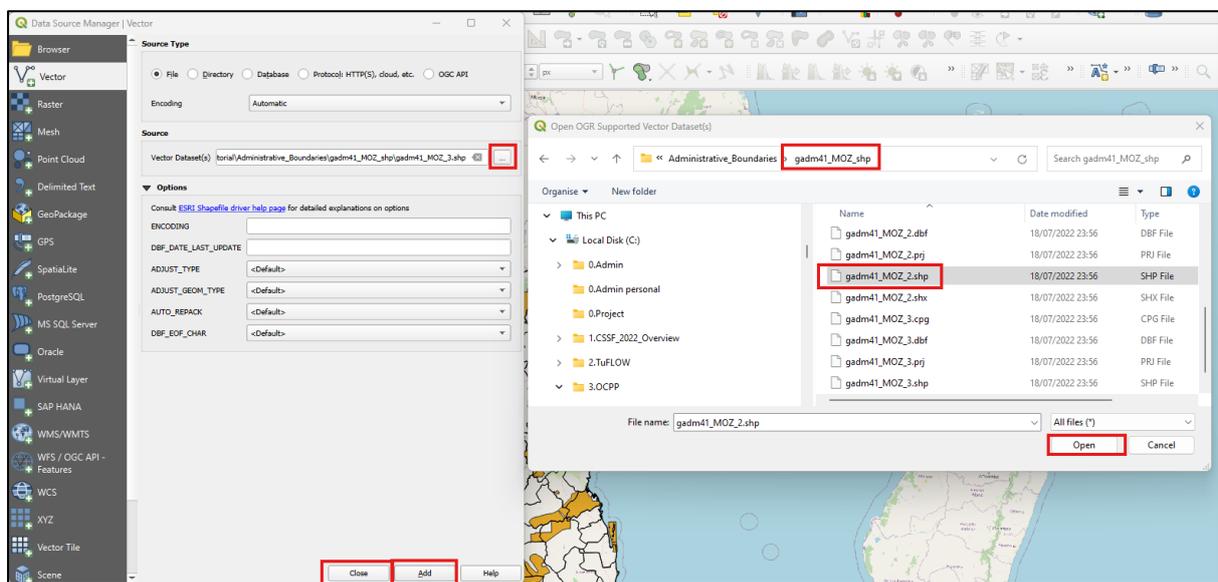
4.4. Creating a Map of Pebane Districts Mangroves

4.4.1. Preparing the Layers for Mapping

We now want to create a map showing our mangrove for Pebane District, within the context of Mozambique.

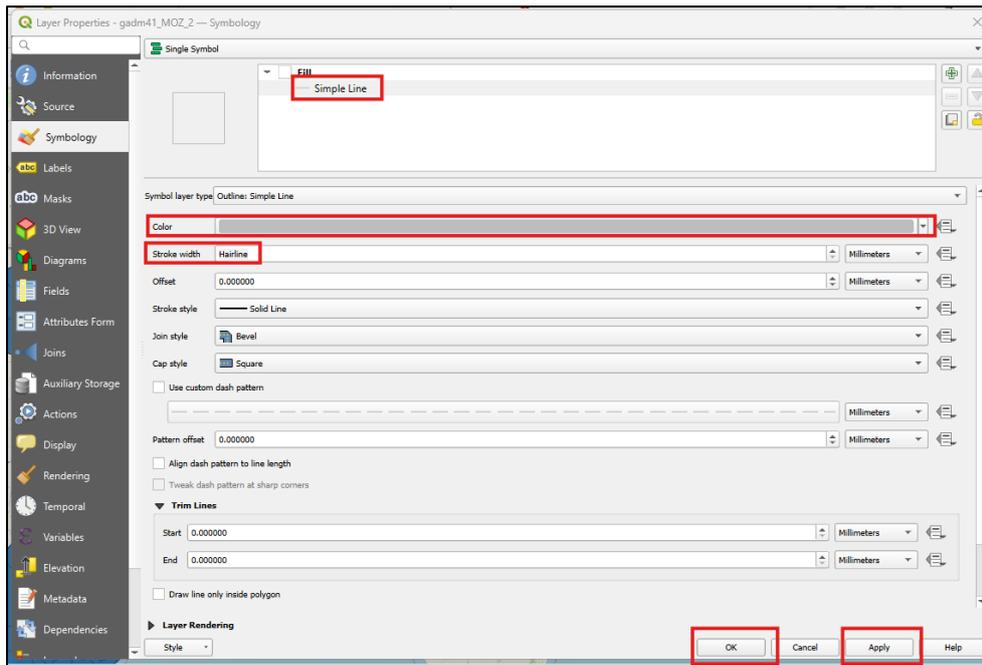
To do this first we need to add District level data.

- Go to “*Layer*” on the main menu, “*Add Layer*”, then “*Add Vector Layer*”. Under the “*Source*” section, click on  and navigate to the “*Administrative_Boundaries*”, then “*gadm41_Moz_shp*” folder that we downloaded in Part 1. Go into this folder and select the file “*gadm41_MOZ_2.shp*”, then press “*Open*”, then “*Add*”, then “*Close*”.

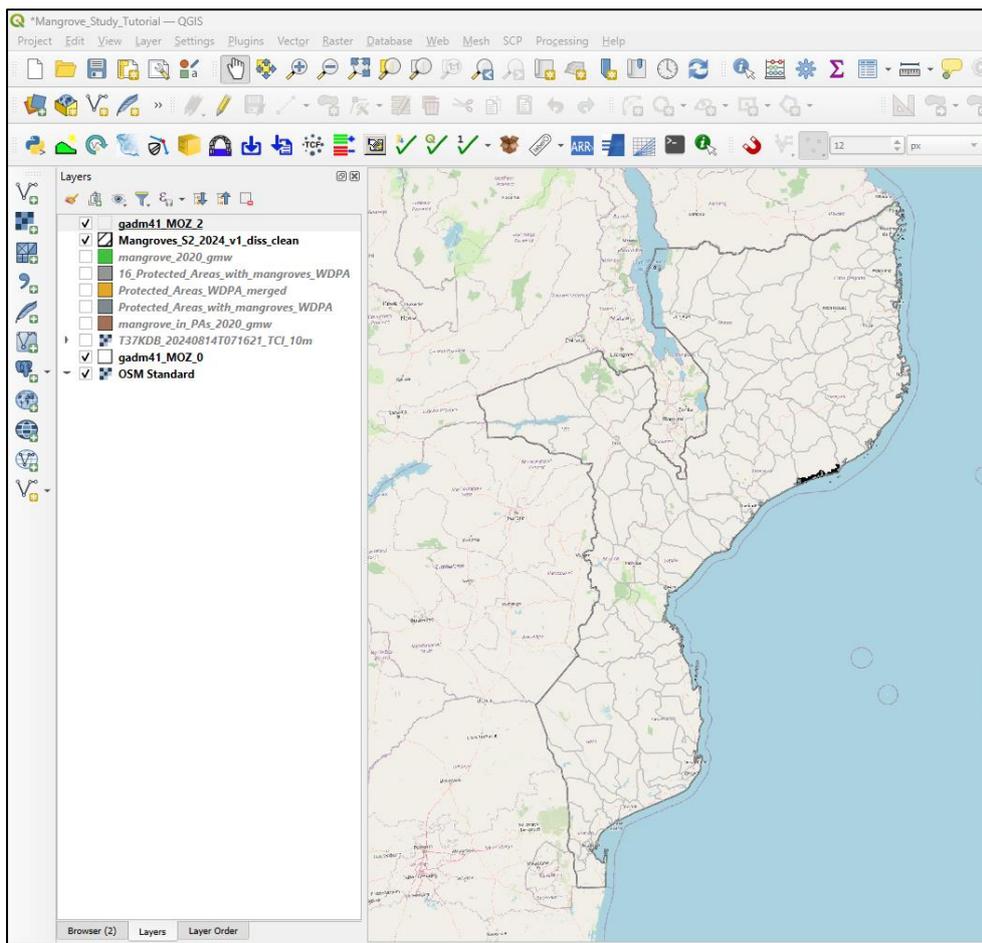


The district layer that you have just added, should now be visible in the QGIS viewer pane. We now want to amend the symbology of this layer.

- Double click on the “*gadm41_MOZ_2.shp*” layer, and under the “*Symbology*” tab, click on one of the “*outline*” options (any colour for now). Then, click on the “*Simple line*” option at the top, then select a mid-grey colour, and for “*Stroke width*” use the up and down options to select “*Hairline*”, then press “*Apply*” then “*OK*”.

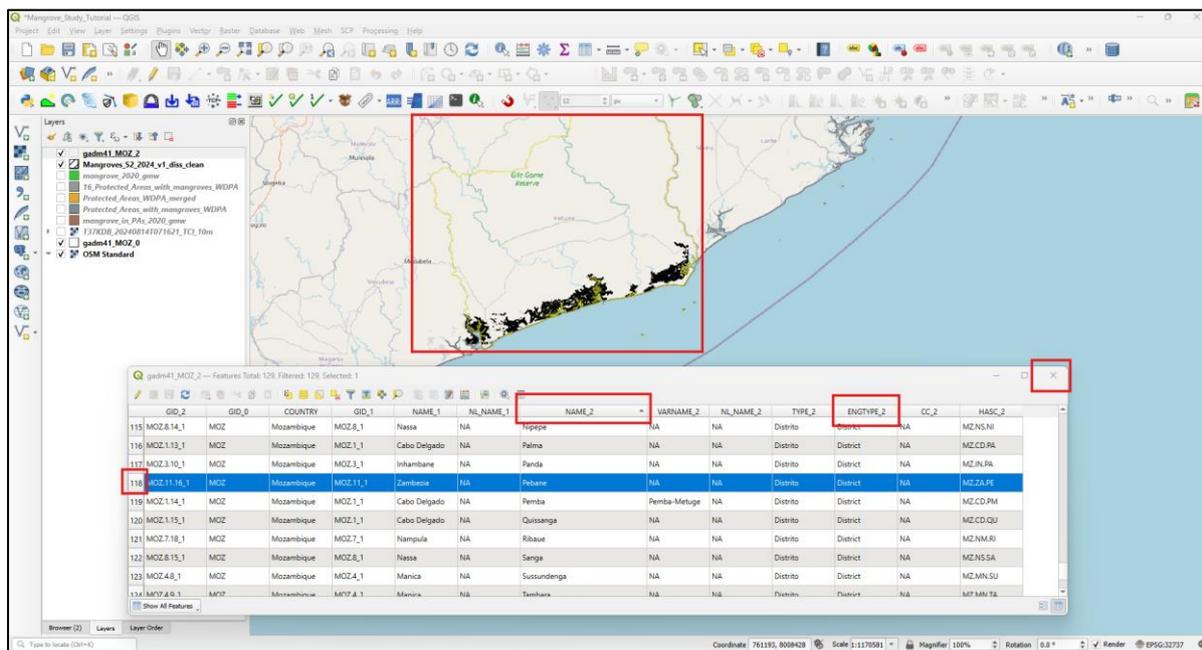


You should now see the symbology changes in the layer.



Next, we want to find the polygon for Pebane District, within the district layer (“*gadm41_MOZ_2.shp*”) we just added, and extract this to its own shapefile.

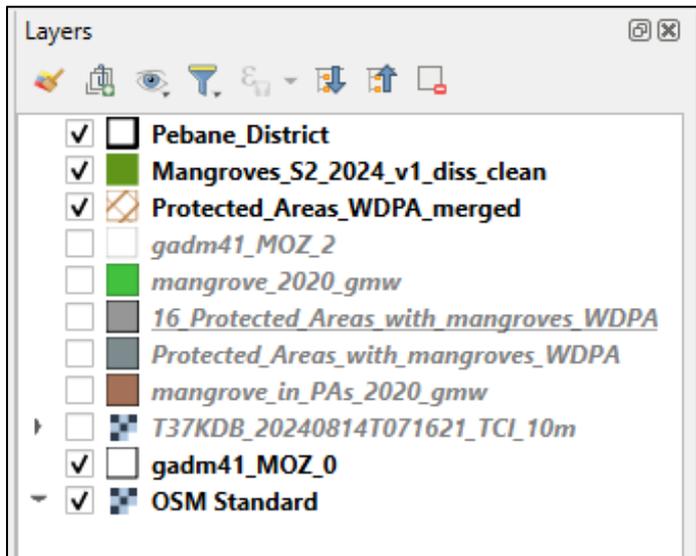
- To do this, right click on the “*gadm41_MOZ_2.shp*” and select “*Open Attribute Table*”. In this table you will see that the polygons are showing district level information, and that the district names are listed in column “*NAME_2*”.
- Scroll down and find the district named “*Pebane*” and then click on the far left of this row that shows the feature number. This should then highlight the row in blue. In the map, the outline for Pebane District should be highlighted in yellow, this shows that this feature has been selected.
- Close the table.



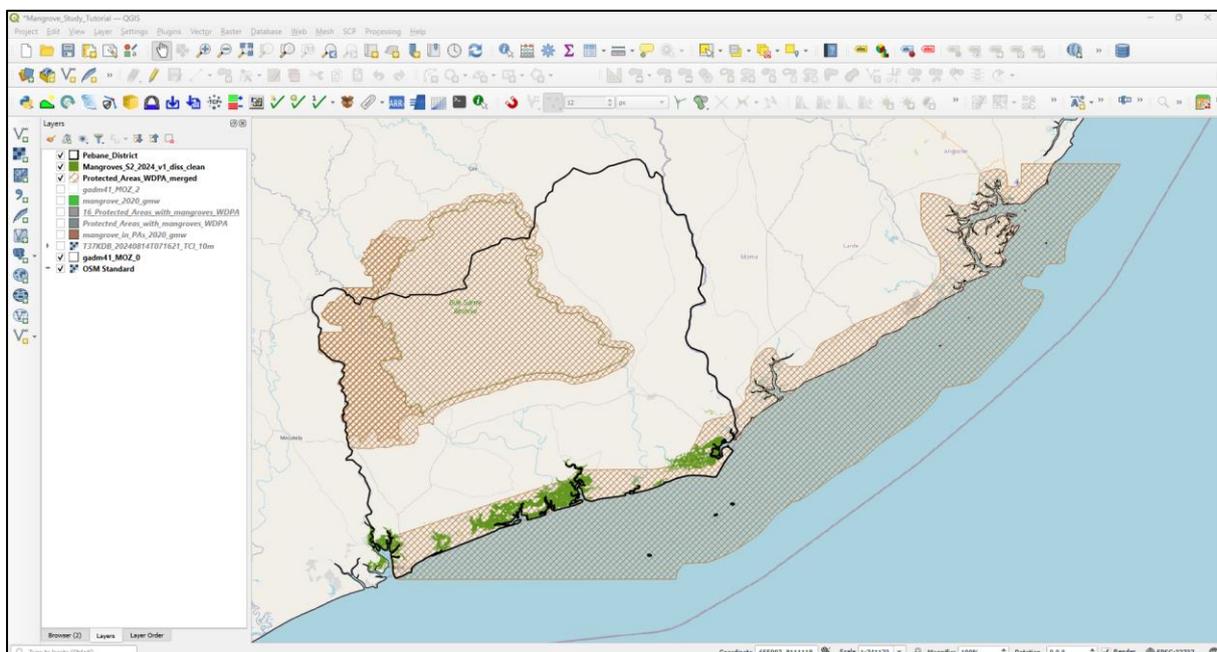
- To create a separate shapefile for this district, right click on the layer, go to “*Export*”, then “*Save Selected Feature As*”. Then in the “*Save Vector Layer As*” window, ensure the format is “*ESRI Shapefile*”, for the “*File name*” navigate to your “*Administration_Boundaries*” folder, and inside that folder save the file as “*Pebane_District*”. Press “*Save*” and “*OK*”.
- If the polygon for “*Pebane District*” in the “*gadm41_MOZ_2*” is still selected (i.e. you see it highlighted in yellow) then click on the “*Deselect Features from All Layers*”  tool on the main menu.

Next, we want to prepare the file order and amend the symbology for the layers we want to use in a map.

We have now changed symbology's of layers several times, so try and have a go at amending the symbology's yourself, to try and anchor into your memory how to do these processes. We provide below, our suggested colour and styles for the map that we will do in the next steps.

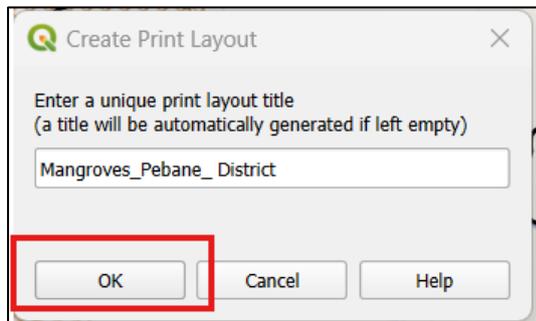


The suggested symbology colour and styles can be seen in the image below. If you prefer to have different colours/styles, then please select your preferences.

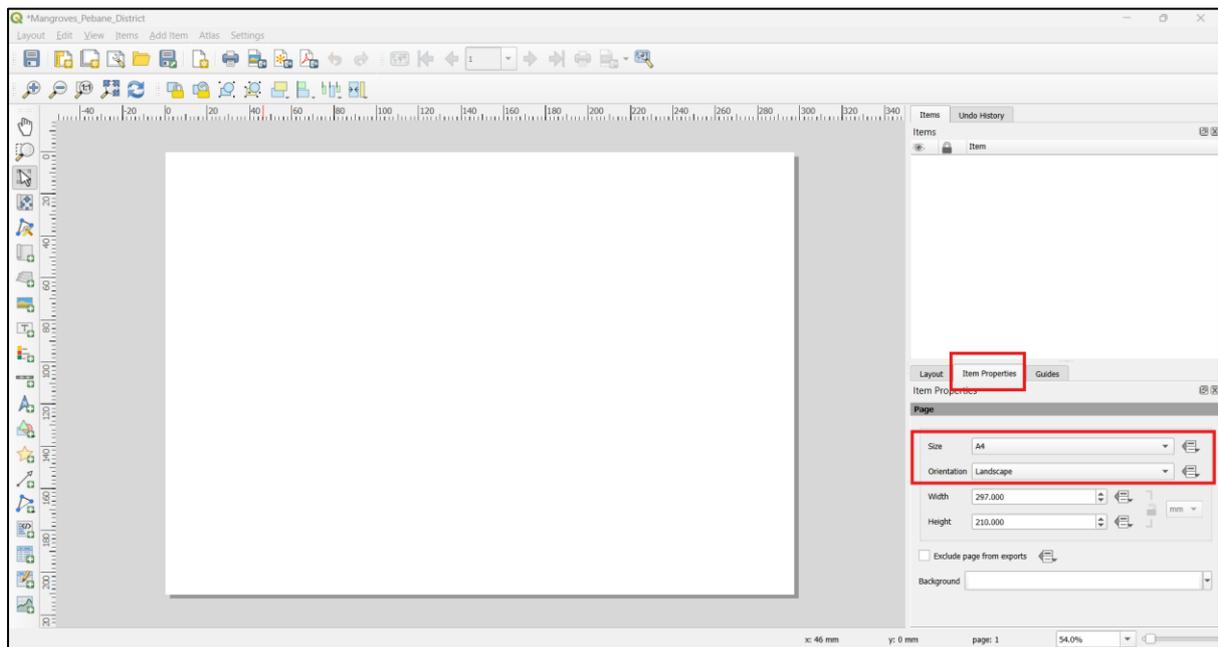


4.4.2. Creating a Print Layout

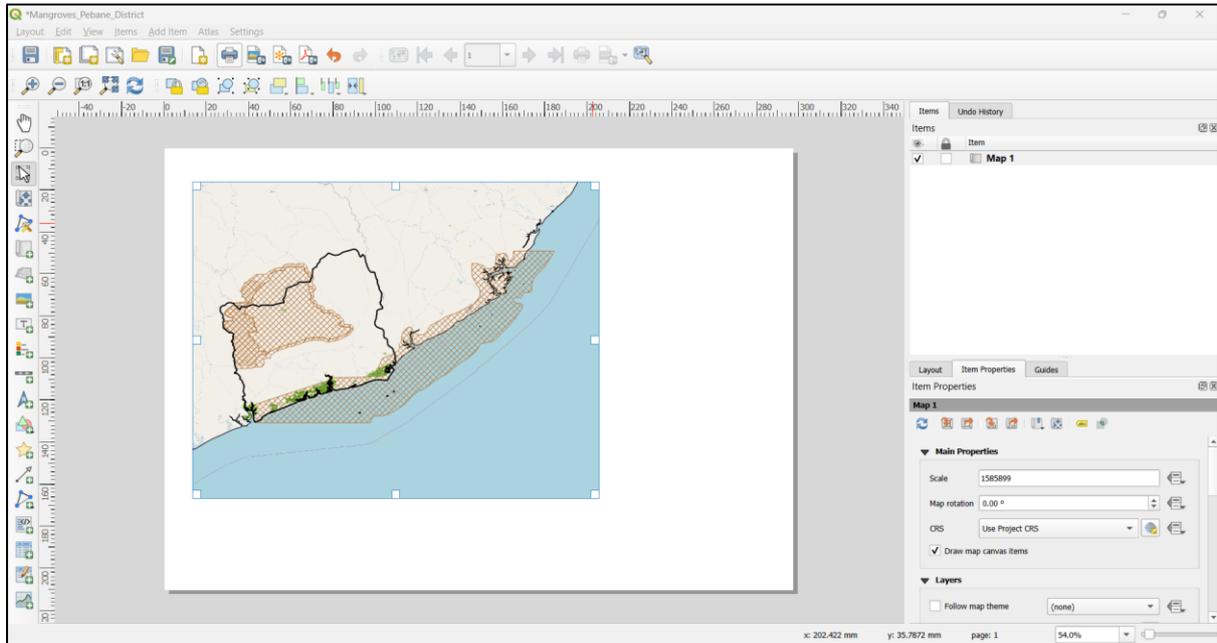
- To create a map, go to “*Project*”, “*New Print Layout*” and then in the pop-up window, enter a layout title. Name it “*Mangroves_Pebane_District*” and click “*OK*”.



- The “Print Layout” window named “*Mangroves_Pebane_District*” will open.
- To check the page size and layout is OK, right-click on the layout and select “*Page Properties*” then to the right, under “*Item Properties*” ensure “*A4*” for size, and “*landscape*” for “*Orientation*” are selected.
- Then press the “*Zoom full*”  button to allow for the layout to fit the page, if it does not already.

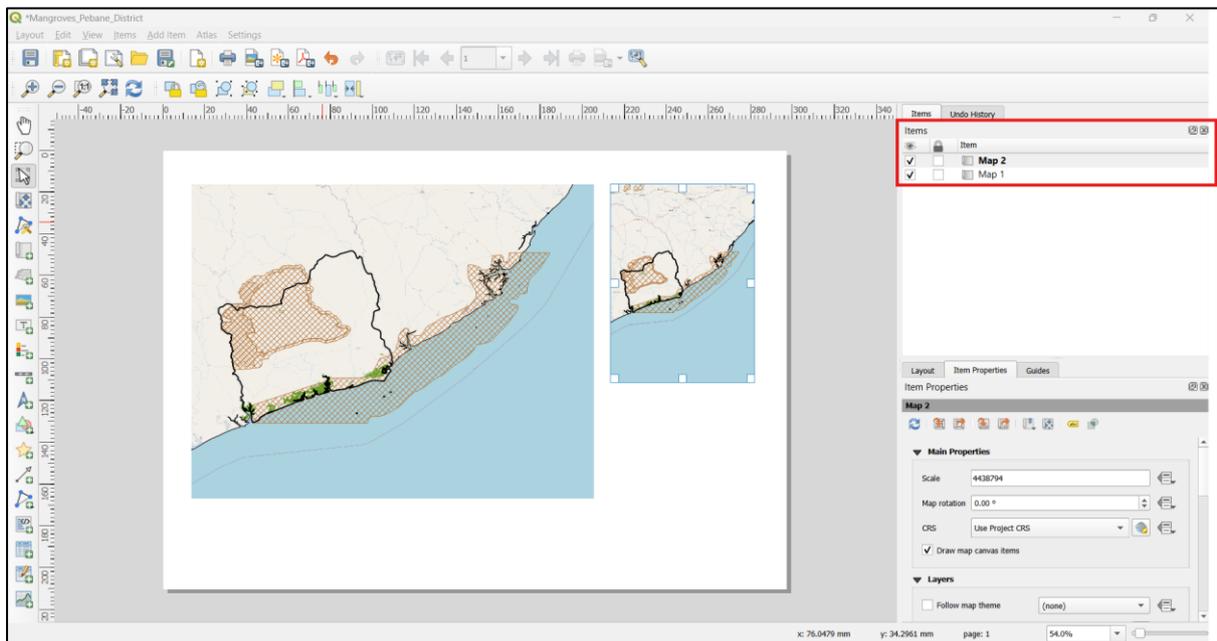


- Next, click on “*Add Item*” at the top of the screen, and then “*Add Map*”.
- With the cross cursor, click and drag and drop where you want to position the first map in the layout, then the map will render.



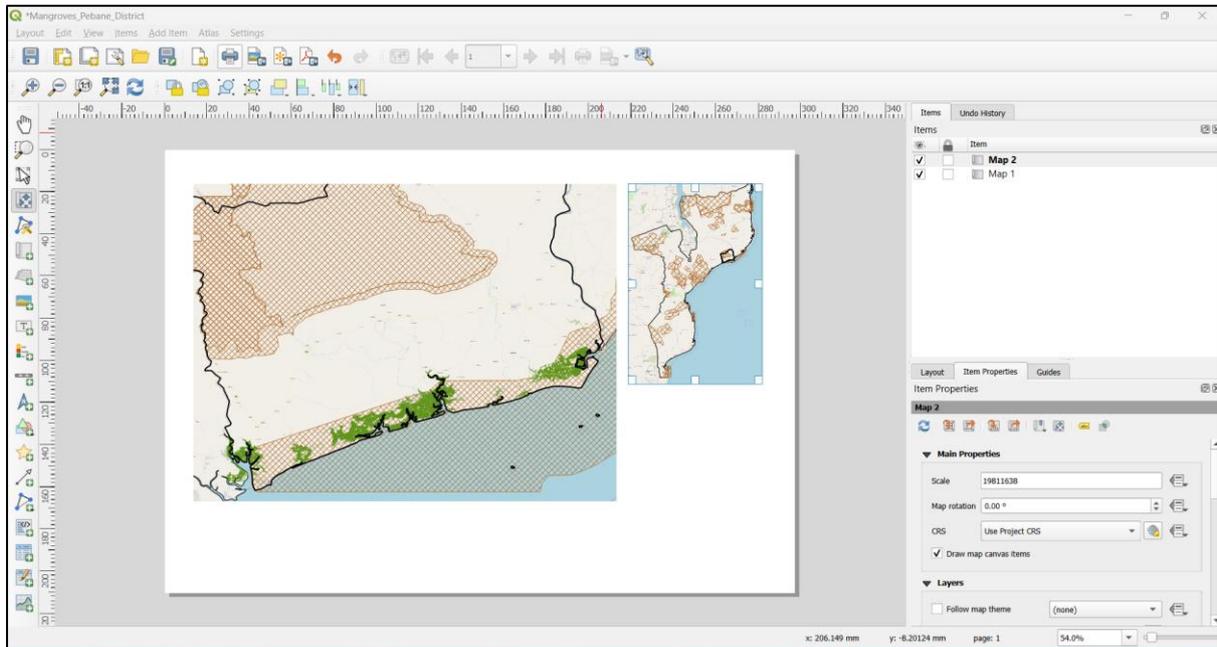
We are going to add in a second map that will help orientate where Pebane District is located.

- To create a second map in the same Print Layout, again click on “Add Item”, and then “Add Map”, and then drag and drop the second map to the right of the first, as seen below. You can see that the two maps are treated separately in the “Item” list.



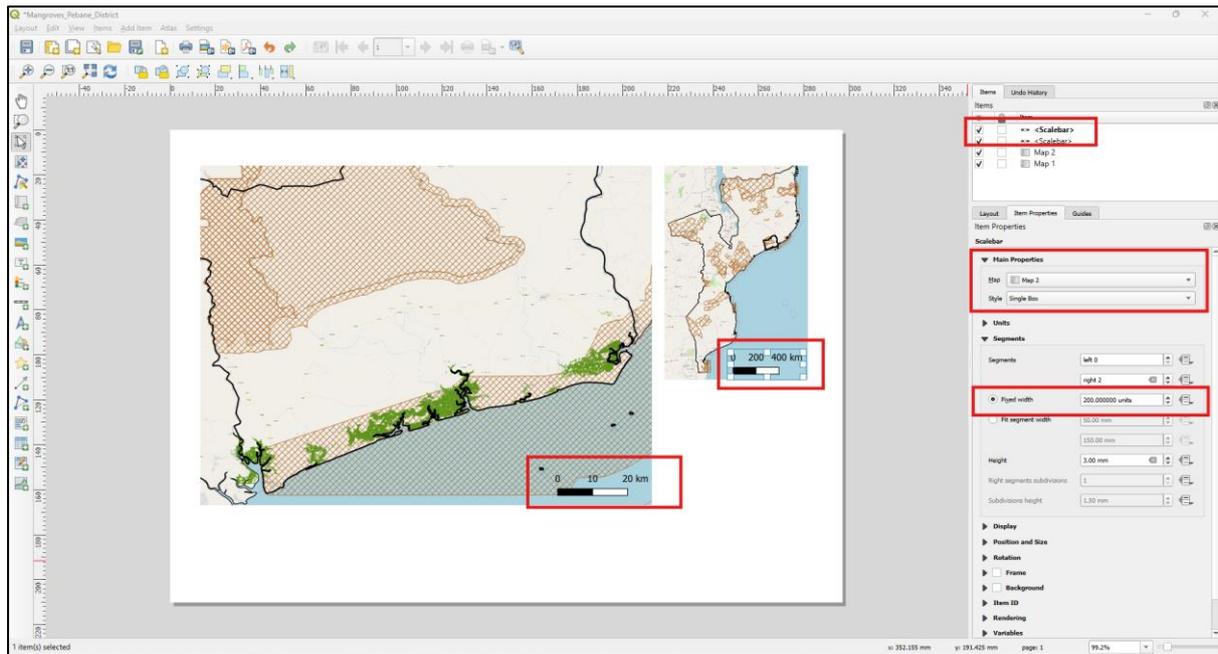
- If you need to at this point, amend the extents of the two-map layout. You can do this by ensuring the map area is selected, then hover the cursor at the edges and move these in and out, according to what you want.

- Next, select “*Map 1*”, then select “*Move Item Content*”  on the left side panel. This allows you to zoom in or out by holding down the “*Ctrl*” key on your keyboard and using the scroll wheel on your mouse. Zoom in and position the map so that you are happy with it. Then select “*Map 2*” and do the same. When you are happy with it unclick . These can be tweaked also later.



Next, we want to add two scale bars, one for the first map we added (“*Map 1*”), and the second map (“*Map 2*”).

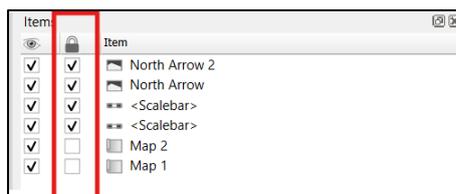
- To do this, go to “*Add Item*”, “*Add scalebar*” then drag and drop where you initially want it in “*Map 1*”. Then repeat for “*Map 2*”. Ensure you insert the scale bars in their respective maps.
- To edit the scalebars, select the scalebar you want to edit. Then you can amend the style in the “*Item Properties*” dropdown sections seen in the bottom-right of the pane.
- If the scalebar doesn’t fit well, you may need to edit the unit size under the “*Segments*” and “*Fixed with*” section.
- Move the scale bars to the bottom-right of their respective maps by simply clicking on them and moving.



Next, we want to add in north arrows.

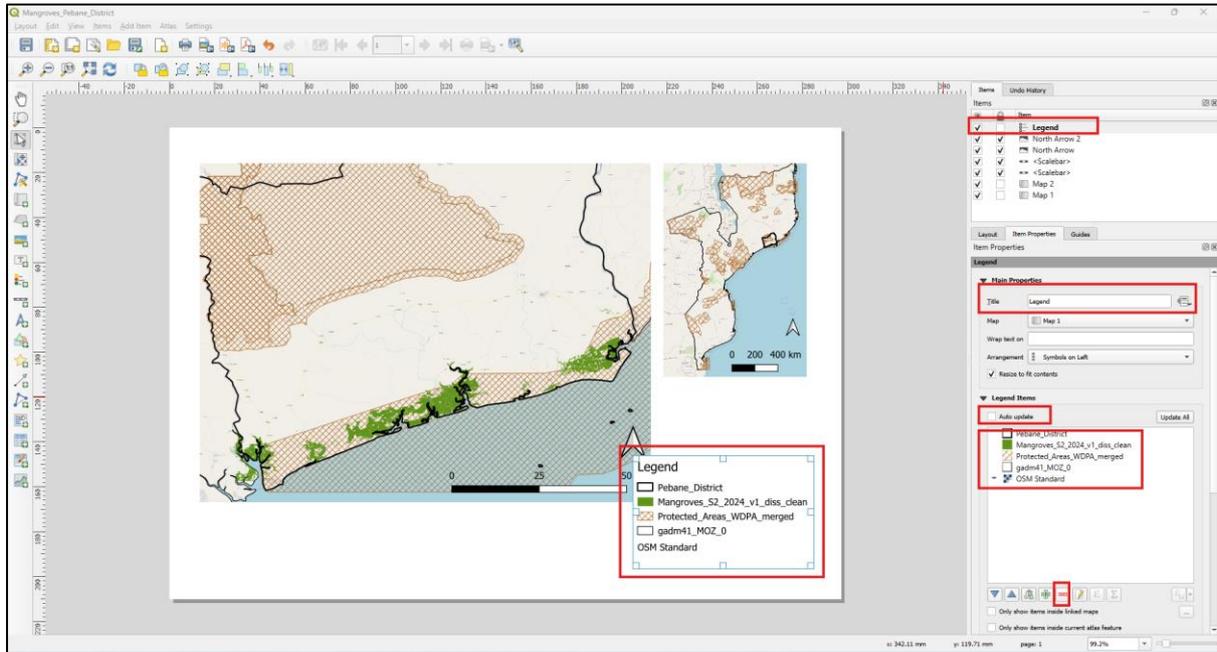
- To do this, go to “Add Item”, select “Add North Arrow”. Using the cursor drag and drop where you wish to place the north arrow. The location can be amended by simply clicking on it and moving it to where you prefer.
- Below, we used the default style, but you can explore style options by looking at those in the “Item Properties” sections.
- Add a second north arrow (as per above), for the second map.

At this point, if you wish to lock any of your edits so far for any of the items, you can click on the “Lock” function in the “Items” list, as per below. To edit, simply “unlick” them.



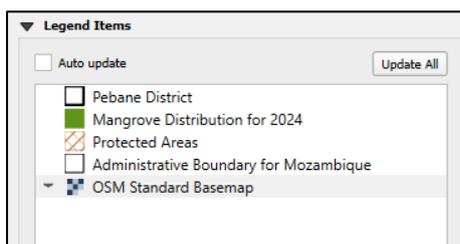
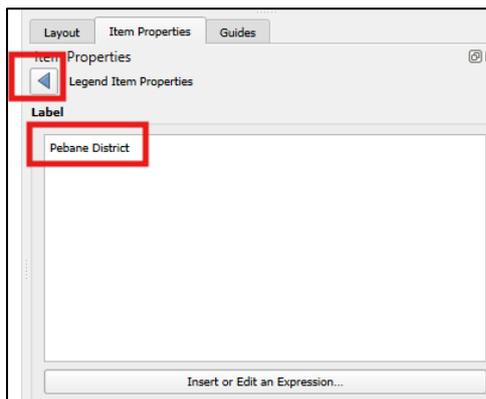
Now, we would like to add one legend that will serve both maps.

- From “Add Item”, click “Add Legend” and drag and drop the cursor to where you want the legend to go.
- The Legend needs several edits. To edit the legend, click on it to enable the “Item Properties” sections.
- First, insert “Legend” for the “Title”, then scroll down to “Legend Items” section. Unlick the “Auto update” box and for those layers we do not want in the legend, click on them and then click the “Remove Selected Items from Legend” button, seen as a red minus sign .



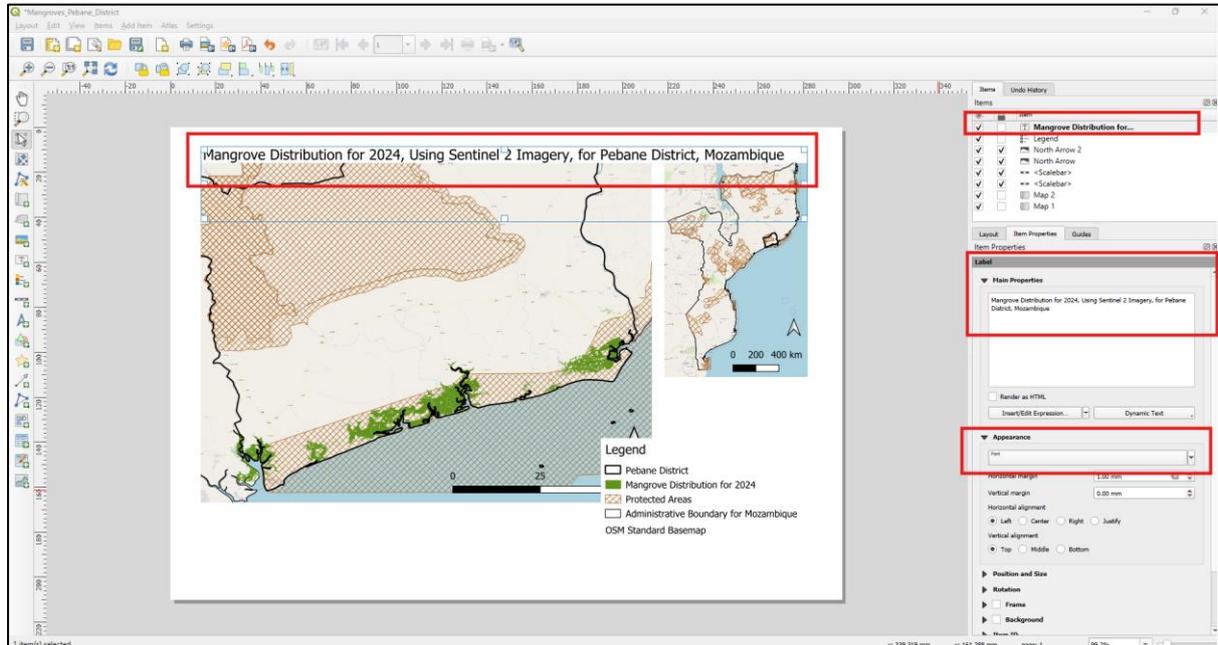
Now, we wish to rename our layers so that they are more intuitive/informative for the reader.

- To do this, ensure that the legend is still selected, and under the “*Legend Items*” section, double click on the layer you want to edit. This takes you to the “*Label*” box, where you can edit your layer names.
- Once you have edited the text, click the back arrow and continue to edit the remaining layers.
- We have suggested text for the layers below.

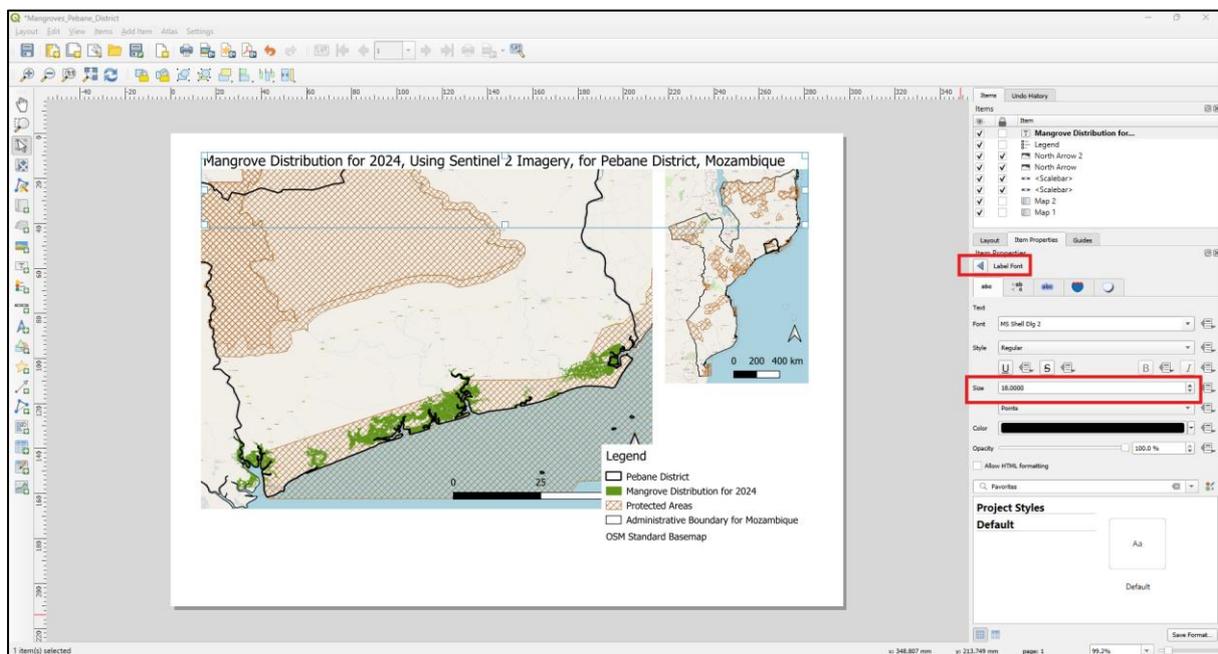


We now would like to add a title for our map.

- To do this, go to “Add Item”, “Add Dynamic Text”, then “Project Title”. Use the cursory to select location and drag and drop.
- Then in the “Label” under “Item Properties” insert your title.



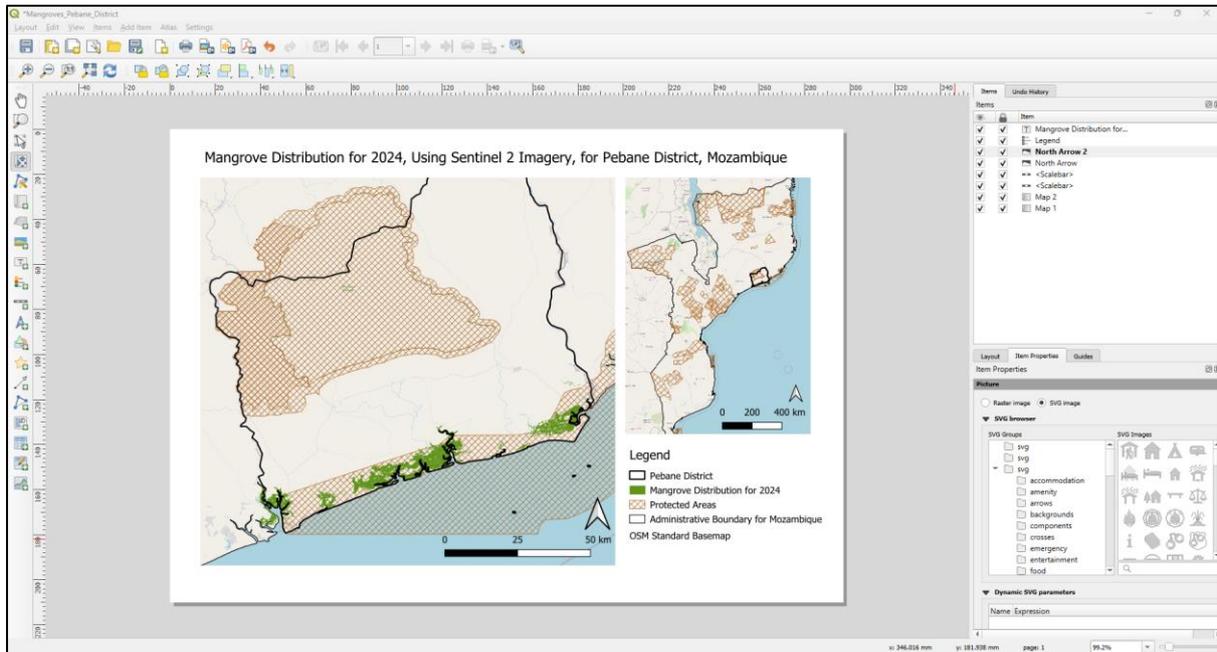
- To amend the font size, click on the “Font” option, and under “Size” increase to 18pts. Then use the back arrow to return.



You may now need to adjust any or all the “*Items*” positions. If you have locked any, then you will need to unlock these before attempting to edit them or their location.

See below our example of the repositioned items.

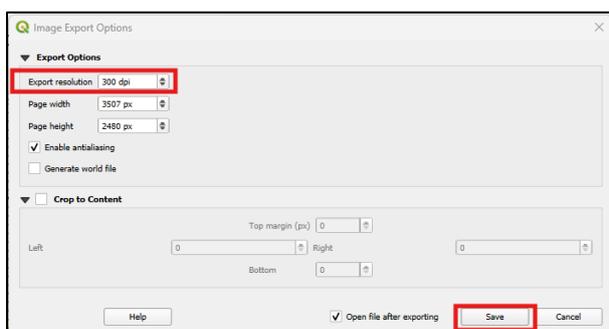
- Once you are happy with your map, ensure that all “*Items*” are now locked, by clicking on any unchecked box. Press the save button  to save your edits.



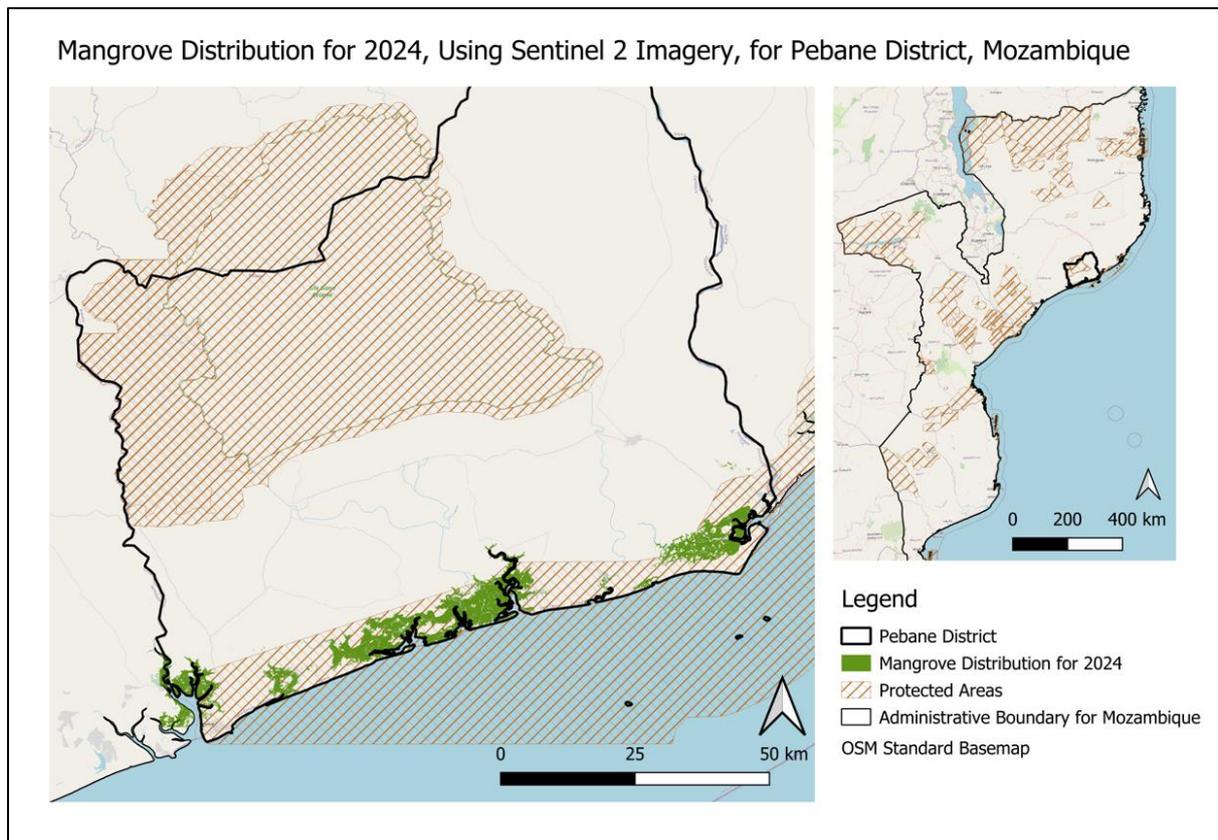
4.4.3. Exporting a Map

Lastly, let’s now export your map so that you can print it, use it in a report or presentation, for example.

- To do this, go to “*Layout*”, “*Export as Image*”, click “*Close*” for a notice informing you of parameter limits, then navigate to the folder named “***Mangrove Mapping Tutorial***” and name the map “***Mangrove_2024_Distribution_Pebane_District***” and select the file type you wish to save the map as (e.g. .png or .tiff) then click “*Save*”.
- Amend the “*dpi*” if needed and check the “*Open file after exporting*” then click “*Save*”.



You should now have an exported map that you can open in whatever software you use.



- Once you have finished with your map you can save  and close this QGIS project

Well done on completing the tutorial!

5. References

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Ocean Country Partnership Programme

The Ocean Country Partnership Programme (OCPP) is a bilateral technical assistance and capacity building programme that provides tailored support to countries to manage the marine environment more sustainably, including by strengthening marine science expertise, developing science-based policy and management tools and creating educational resources for coastal communities. The OCPP delivers work under three thematic areas: biodiversity, marine pollution, and sustainable seafood. Funding is provided through the overarching Blue Planet Fund (BPF) by the UK Department for the Environment, Food and Rural Affairs (Defra).

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