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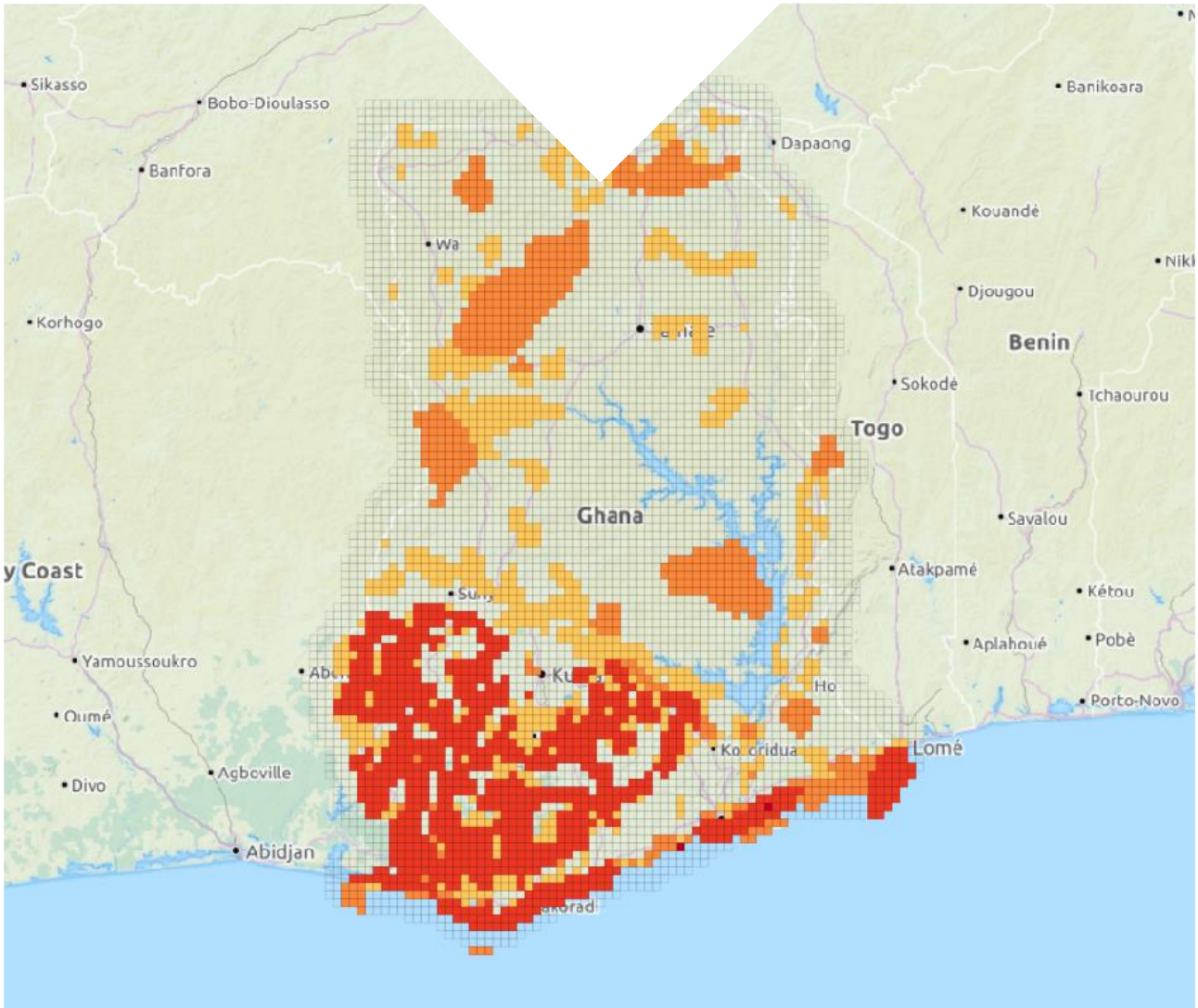
GUIDANCE NOTES

M-1484 | 2019

QGIS User Guide

Oil for Development Programme



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QGIS User guide Oil for development programme, version 1.0

Summary - sammendrag

This QGIS User guide is developed by GIS experts to support use of GIS in decision making processes connected to handling important biodiversity features in oil and gas development in Myanmar.

The manual consists of both theoretical introductions to different topics and practical exercises. It presents fundamental concepts in GIS, emphasising an understanding of techniques in management, analysis and presentation of spatial information. The manual is divided into nine chapters, and the first part reviews an introduction to GIS in general followed by different parts introducing GIS-techniques like cartography and styling, vector and raster analysis and editing.

4 emneord

GIS, QGIS, Cartography, Analysis

4 subject words

GIS, QGIS, Cartography, Analysis

Front page photo

Map produced using QGIS showing sensitive areas in Ghana. The map is based on test data and does not represent actual sensitive areas. Credit: Norwegian Environment Agency, OpenStreetMap

Abstract

Use of geographical information and GIS-tools is an important part of management and decision-making in governmental bodies and in the exercise of authority to solve environmental challenges. Building capacity in GIS is an essential part of the projects and activities in the Oil for Development program (OfD) supported by the Norwegian government and implemented by The Norwegian Environment Agency (NEA). The main focus of our work relates to strenghtening data and capacity for environmental management of the oil and gas sector. This user guide is developed to support training in GIS in the cooperating OfD-countries to support area-based planning and sensitivity mapping.

This user guide provides both theoretical knowledge in GIS and step-by-step exercises in QGIS to strengthen capacity in representing, processing and visualising spatial data. It is developed in the context of Myanmar but can also be utilised in other countries.

The UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) provides support to the Norwegian Environment Agency under the Oil for Development programme, and they are contributing in building capacity both in Myanmar and in other countries on how to manage and use spatial data.

GIS-experts at the contractor, Norkart AS, have been responsible for the main part of this user guide, supported and reviewed by WCMC and NEA. Exercises and data in this user guide are based on spatial data from Myanmar, but it covers general GIS-techniques and practices and should be relevant for use in other countries.

The user guide is developed for QGIS, an open source software free and open for use. Examples are mainly based on QGIS version 3.4 (last long term realease), but some of the exercises are not updated and the illustrations might not correspond to your program. NEA encourage use of open source software in the context of OfD to ensure sustainable use of GIS within restricted budgets.

This is a first version of this manual and we are planning to develop it further with more techniques and topics in the future. Feel free to share, adapt and use this user guide, it is licensed with an open licence.

Content

Attachments:
1. *Appendix*.

1. Introduction to a GIS

Geographic Information Systems (GIS) are all about spatial data. Spatial data are special in the sense that we deal with geometries in addition to regular data like text and numbers. Geometry introduces more complexity than text and numbers, but also more possibilities. There are some pointers that you should be aware of when managing spatial data. Below, we briefly go through some of the most important concepts step-by-step. Be aware that some topics have been simplified. For more details, the reader is referred to GIS and Cartographic textbooks.

1.1 Coordinate systems

A geometry is typically defined in a two-dimensional (2D) space. This means that we have coordinates that are located along a coordinate system. Typically, these coordinates are Latitude/Longitude, X/Y or North/East. It is only when a GIS layer has a correct definition that the coordinates will be placed on their actual location.

GIS aims to create 2D maps from a three-dimensional (3D) world. The world is however not a perfect sphere—but rather like a squeezed ball, called an ellipsoid. The modelling of this 3D shape (ellipsoid) is called a datum. Some common horizontal datums are:

- WGS84: World Geodetic System 1984, used by the Global Positioning System (GPS)
- Euref89: Newer version of WGS84, used specifically for Europe
- Arc1960: Local African datum
- Indian 1954: Local Asian datum for topographic mapping in Myanmar and Thailand (onshore).

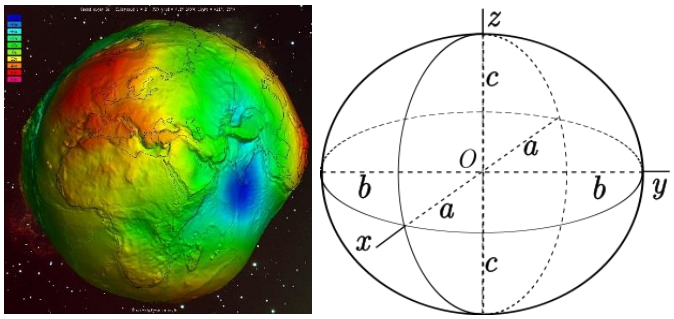


FIGURE Geoide, ellipsoids (source: Wikipedia)

With a model of the 3D world, we can transfer a point on the 3D surface onto a 2D map. This process is called 'projecting', and uses a **projected coordinate system** to translate between 3D and 2D. A projected coordinate system is based on **geographic coordinate system**, but it is defined on a plane (the spheroid projected onto a 2D surface) and uses linear units (feet, meters, etc.). These systems are further explained below.

1.1.1 Geographic coordinate systems (three-dimensional)

The easiest coordinate system we can use is a **geographic coordinate system**, which uses Latitude and Longitude points on a map. These spherical coordinates use angular units (degrees), which are measured from the Earth's center to a point on the Earth's surface. A geographic coordinate system thereby gives a position in three dimensions, as an intersection of the latitude, the longitude and the ellipsoid. For topographic mapping, geographic coordinates should always be used to get the most accurate positions.

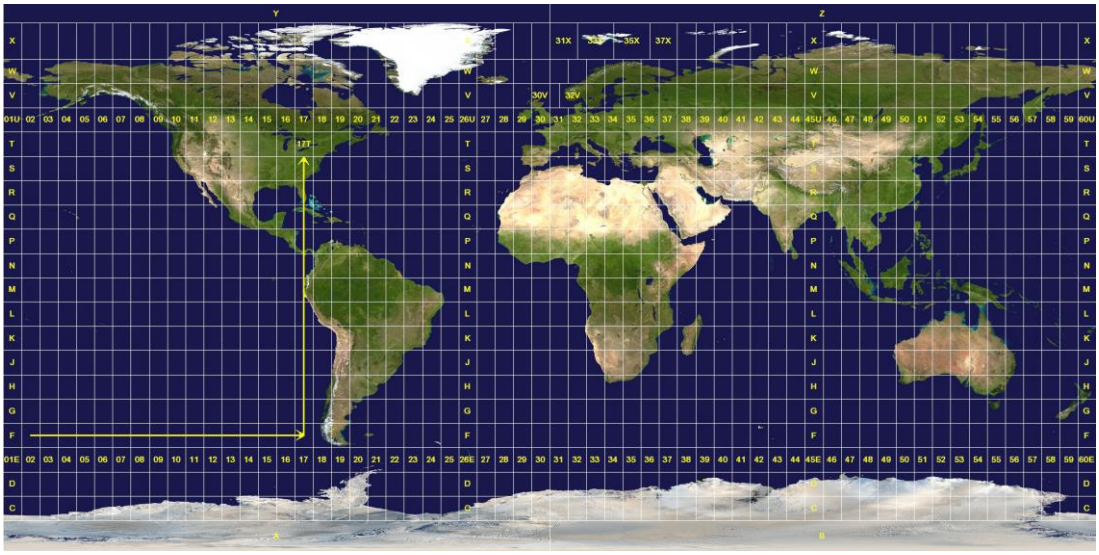
Geographic coordinate systems are usually named after the datum they are based on. The most common system is WGS84 (EPSG:4326) which maps directly to the ellipsoid-model. WGS84 is the datum used by the Global Positioning System (GPS). Since latitude and longitude are angles, these cannot be used directly to measure distances or area. This is because the length between point A (X1,Y1) and point B (X2,Y2) will be in degrees, which does not make sense for measurement purposes.

1.1.2 Projected coordinate systems and UTM zones (two-dimensional)

Different projections have been developed to show the geographic coordinate system on a 2D surface. Even though the geographic coordinates are the most accurate ones, it is more practical to show the world as a flat surface. Coordinates in a 2D plane also makes it possible to do linear measurements on the map, in units such as meters or feet.

The coordinates in a given datum can be presented in many different projections. There are four different factors that matter when making a projection: shape, area similarity, distance similarity and direction. Every **projected coordinate system** is a compromise between these four factors. If one of the factors is considered more than the others, this affects the precision of the other three. There have also been projections developed that try to compromise the four factors. The Universal Transverse Mercator (UTM) is well known and a very good example of this.

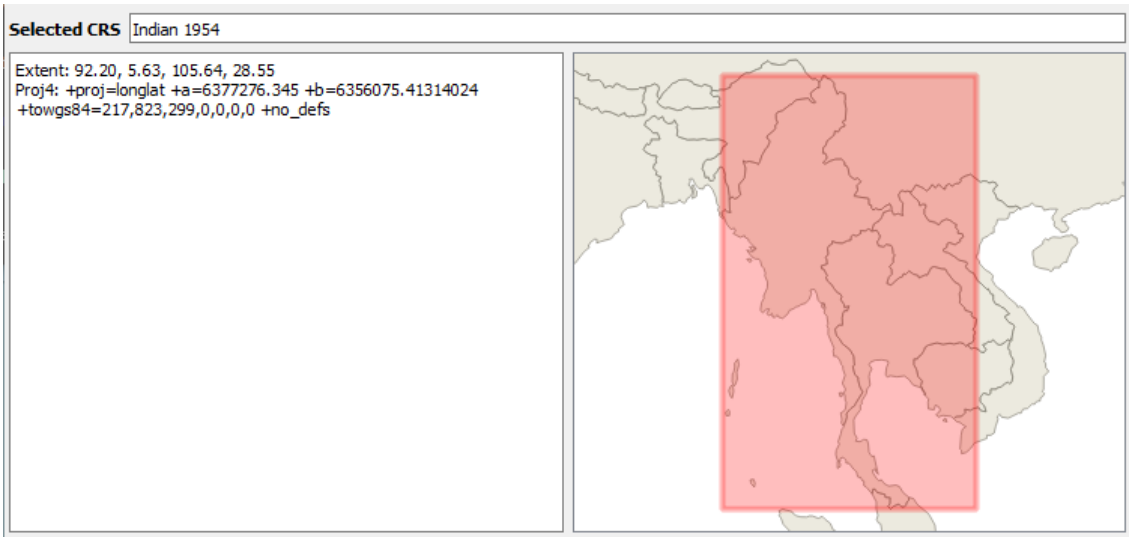
The UTM system is a system of map projections that covers most of the earth's surface. It divides the earth into 60 zones, each of them is six degrees in width.



The UTM grid. (source: Wikipedia)

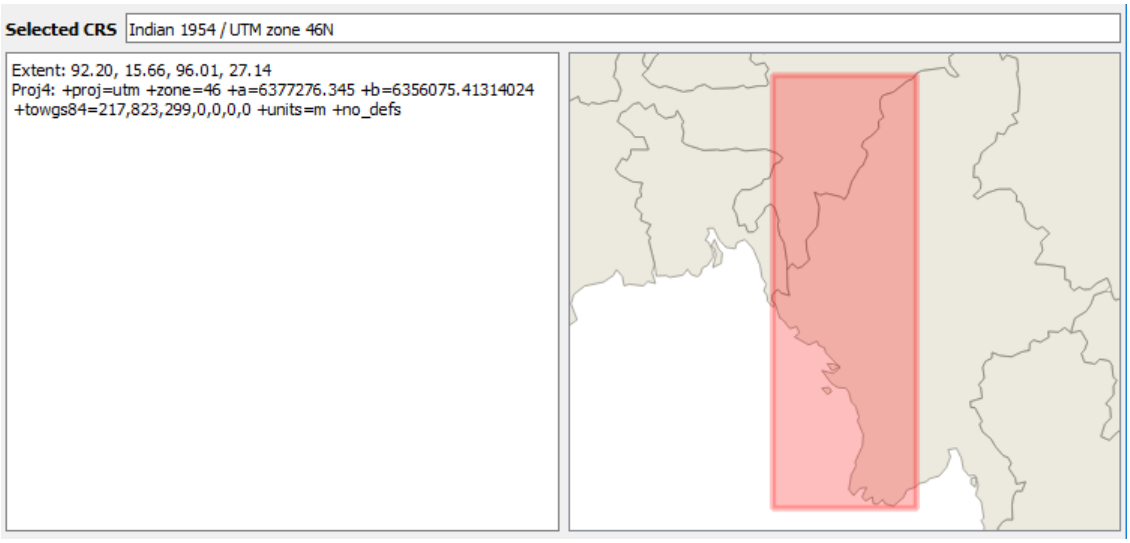
Each country or region often has defined a standardized coordinate system based on the UTM system. This will differ between each country or region. Some countries stretch over more than one UTM zone. For instance, Norway stretches from UTM zone 31 to 36, but not all zones are used on a daily basis. For national data that will be used for the entire country, a national standard of UTM zone 33 has been set for Norway. **For measurements and area calculations, use the projected coordinate system that belongs to your national/regional standard.**

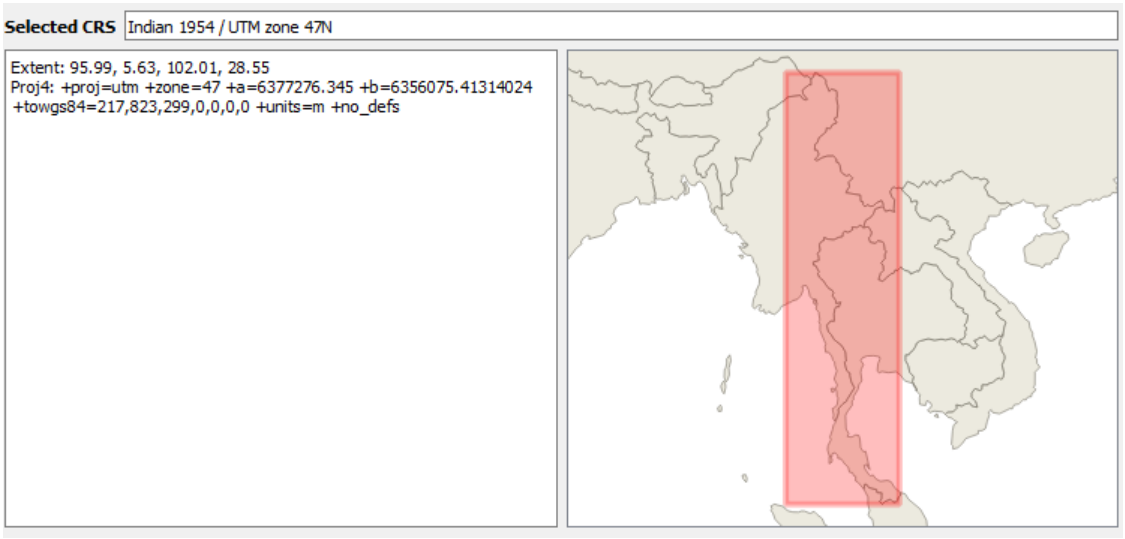
So, what does it really mean to take a choice of using a specific UTM zone? In the case of Myanmar, the local datum is the Indian 1954. The picture below shows the extent of the geographic coordinate system Indian 1954 (EPSG: 4239), which is a geographic 2D coordinate reference system suitable for use for topographic mapping in Myanmar (onshore) and Thailand (onshore).



Onshore, there are two different local projections depending on where in the country you are:

- Indian 1954 / UTM zone 46N – EPSG: 23946 (Myanmar - onshore west of 96°E). Accuracy 21 meters.
- Indian 1954 / UTM zone 47N – EPSG: 23947 (Myanmar - onshore east of 96°E) Accuracy 21 meters.





These two local projections can be useful when working with local data in a specific region of the country. If you are working with spatial data or maps that stretch over larger areas, you should use a projection with a larger area of use. This is also important to consider when you want to georeference a map that covers an entire country. The UTM system would then be a natural choice, since it is adapted to suit larger regions than those of local datums. If you try to use a local projection for this, you may get a bad result. On the other hand, it could be a good choice if you want to georeference a local map, as the extent would occur within the local UTM projection. Different aspects must be considered relative to the trade-offs.

Standard coordinate system of Myanmar

Myanmar belongs to the UTM zones 46 and 47. The standard coordinate system is set to WGS 84/UTM 47N (EPSG: 32647). Most likely this is because most of the onshore area of Myanmar is located within this zone.

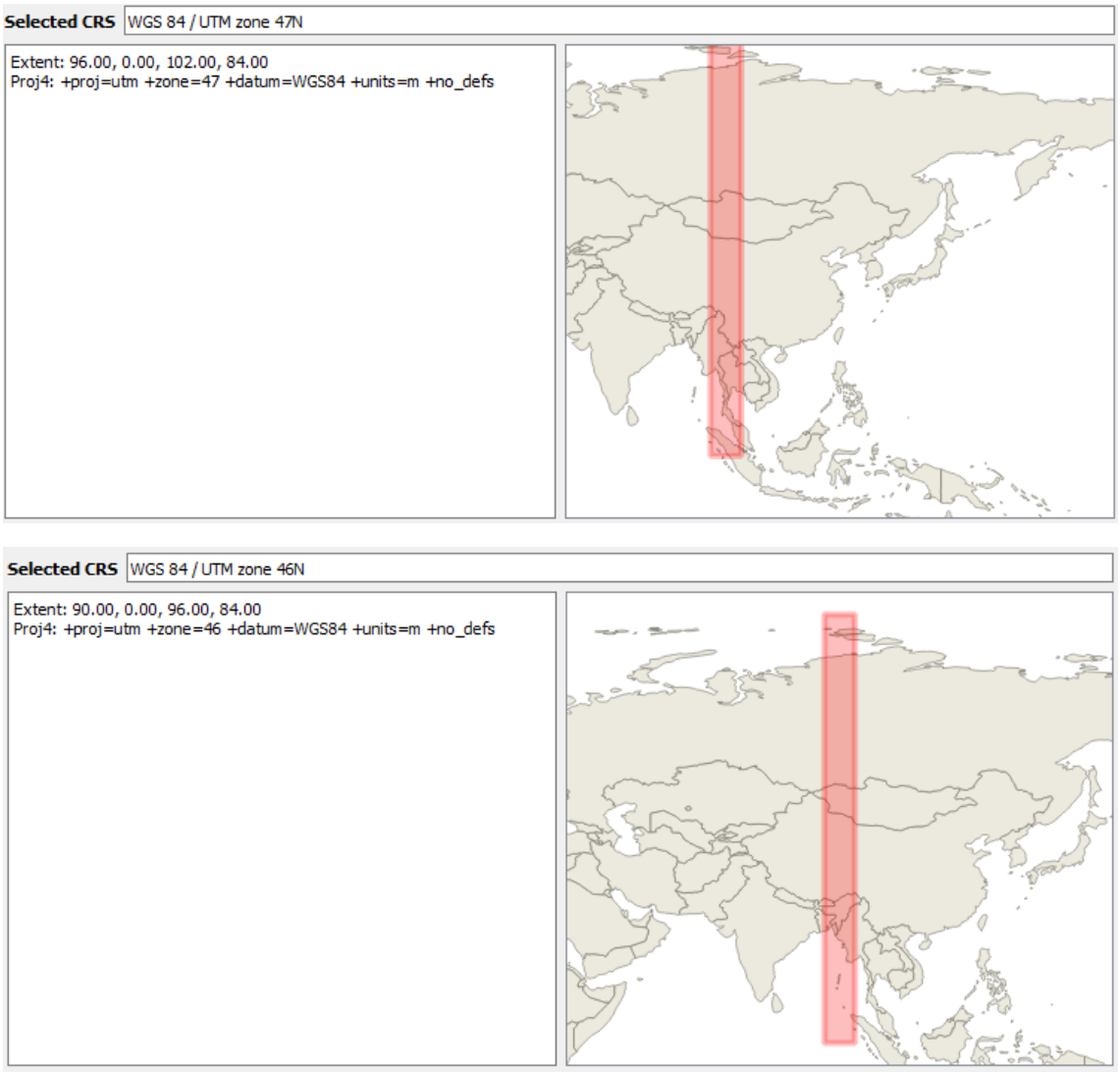


FIGURE. When you choose a coordinate system in QGIS, you will get a small picture in the bottom of the Coordinate Reference System (CRS) window, which shows the extent of the projection.

1.1.3 Our recommendations

So, what does it mean to make a choice about the UTM zones? And when should we use geographic coordinate systems, with latitude and longitude coordinates?

When it comes to coordinate reference systems, there is no one fits all solution. You must adapt the choice of coordinate system to the purpose of use.

When you are digitizing new objects offshore or when you do topographic mapping, geographic coordinates should always be used as they are most accurate. If you later want to use the data for analysis and measurements, make a copy of the layer and save it to a projected coordinate system. To avoid inaccurate measurements offshore, you should always use a 3D geographic coordinate system, such as WGS 84. This is also important when working with data that covers more than one UTM zone. If a projected (flat) surface is used, the locations furthest away from the center of the projection will be inaccurate.

In GIS analyses, measurements are often but not always an important part. If measurement is not part of the analysis, the most important thing is to make sure all of the datasets you are using have the same coordinate system. **It is therefore good practice to use datasets in the same projected coordinate system.** Then, you can be certain that the measurements will be correct.

When making a map, you should choose a coordinate reference system that fits well with both the location in the world and the scale of the map. Projected coordinate systems based on a local datum fit well with large-scale maps, or those that show a small area in greater detail. Examples include guide maps, topographic maps and regional thematic maps.

In contrast, small-scale maps show a larger area with fewer details. Examples include wall maps, atlas maps or small-scale thematic maps.

If you are making a map of your country, you should choose the national standard projected coordinate system or a geographic coordinate system. On a small-scale map, add a geographic grid that shows the geographic coordinates in degrees. On a large-scale map, add a grid that shows the coordinates in linear units (decimal). This helps the user to orientate on the map.

1.2 Raster and vector data

Map data comes primarily in two fundamentally different structures: **raster** and **vector**.

Raster data are “grids” or matrices of cells, which have a defined resolution. Each grid cell has a value. The value can represent very different things, such as height, color, sensor value, observation count and so forth.

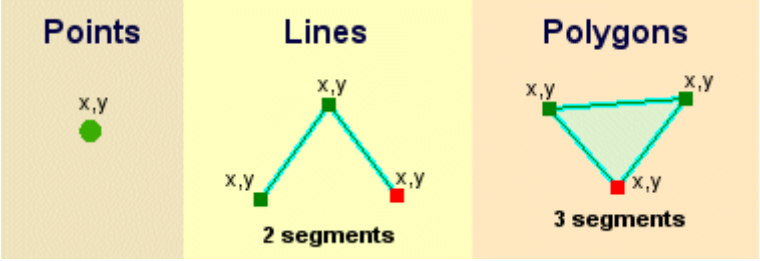
Each grid cell has a predefined resolution, or level of accuracy. This means that if we “zoom in” too close, we lose detail. An immediate example is with satellite imagery, which are raster files (grid cells with color values). Consider the following example with different zoomed in versions of the same image:

Vector data represents the world using points, lines and polygons. It is useful for storing data with discrete boundaries, such as country borders, streets, land use, biodiversity areas and cities. Vector data is also used to represent point observations of species occurrence.

1.3 Geometries

Geometries come in different 2D and 3D forms and shapes. The most commonly used 2D formats include: **Points, Lines,** and **Polygons**.

Often, data files are separated by the geometry type. A point consists of a coordinate pair (i.e. latitude and longitude coordinates). A line consists of several points. A polygon consists of several points and wraps around a surface, which then makes up an area.



1.4 Attributes

A **spatial object** consists of a geometry and a set of attributes. **Attributes** are data or information attached to the spatial object. An attribute has one value, which can consist of text or numbers. For instance, you can have an object type, *bird_reservoir,* where you would store a polygon representing the geographic area. Along with the geometry (polygon) you want to store the *bird_count* and *last_observation_date*. These are the attributes of that object. The *values* of the attributes can be different for each geometry (or polygon).

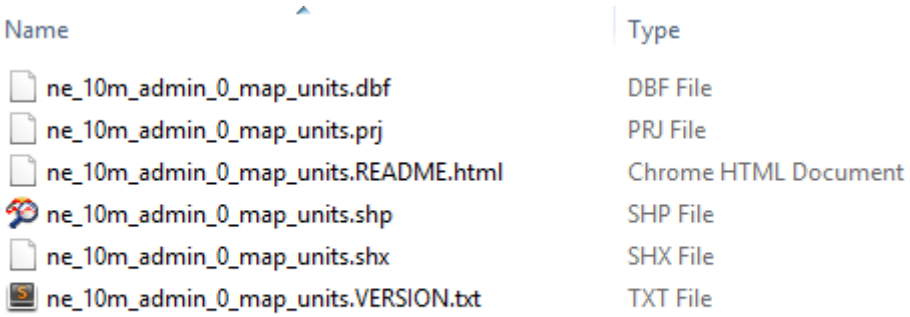
	bird_observation_count	last_observation_date3
0	1233	01.02.2012
1	222231	21.06.2004

1.5 File formats

GIS data are stored in many different ways. Raster files are typically stored as image files like Tag Image File Formats (e.g. .tif, .geotiff) or data files like Digital Elevation Models (DEM). Vector files comes in more varied shapes. Here, we outline some of the most common and useful formats.

1.5.1 ESRI shapefile (.shp)

ESRI shapefiles are one of the most common formats for storing vector GIS data. Shapefiles store non-topological vector data with attribute data. A shapefile consists of several files with the same filename, but different file endings:

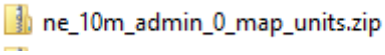


To work, the shapefile must have three mandatory files:

- **.shp** – shape format: the feature geometry itself
- **.shx** – shape index format: a positional index of the feature geometry
- **.dbf** – attribute format

Remember to include these three if you want to share an ESRI shapefile. The other file types are optional. If you also want to include the information of the coordinate system, include the **.prj** file, which is the projection format.

A shapefile can only store one geometry type (i.e. point, line, polygon) at a time, so you will need separate shapefiles for each set of points, lines and polygons. If you are only going to *read* (not change) the contents of the shapefile, you can compress the files into a **.zip** package that can be read directly in the GIS. This is very handy!



1.5.2 File databases

File databases are modern file storage mechanisms. ESRI has one version which is called a **File Geodatabase (.fgdb)**. A file database stores many tables (files) within a single file. Each table can have its own set of geometries and attributes. It is a more efficient mechanism than plain files and is also more practical when managing data.

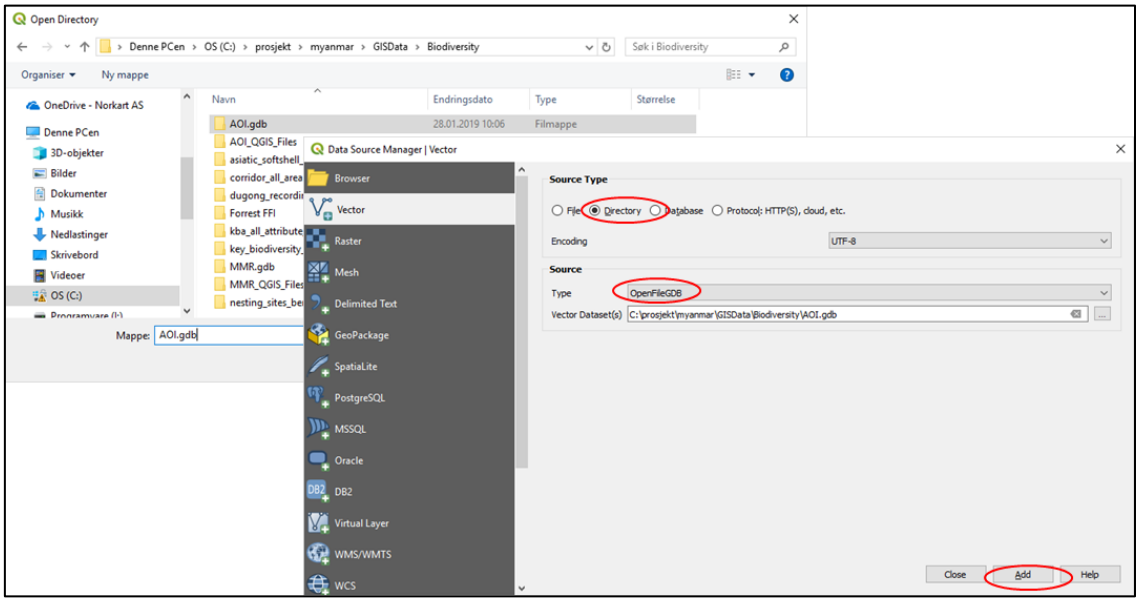
The ESRI file geodatabase is a proprietary format which can be read and to some degree changed. A similar but better format for QGIS is the **SpatiaLite (.sqlite)** file database or the **geopackage (.gpkg)** format.

You should strongly consider using a file database instead of plain files for storing your data!

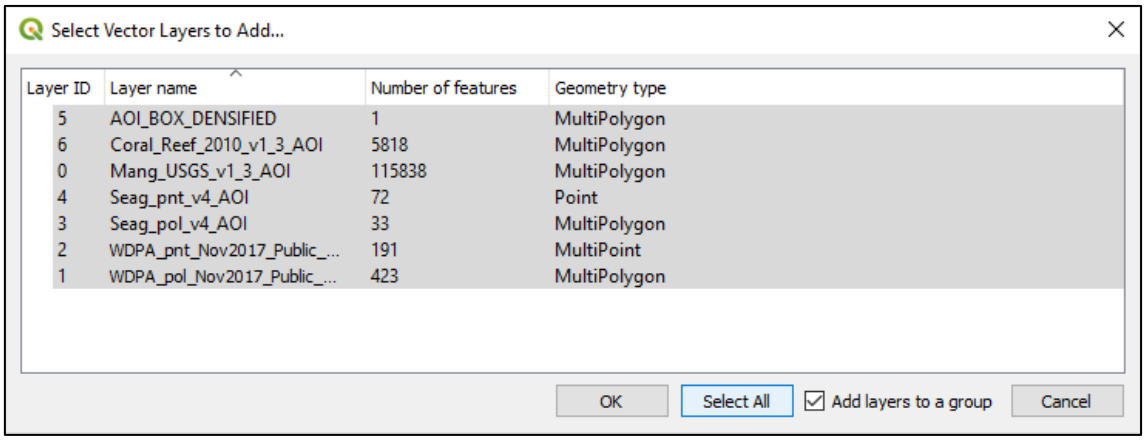
1.5.3 ESRI file geodatabase (.fgdb)

ESRI file geodatabases are ESRI's standard database format. A file geodatabase is a collection of various types of GIS datasets held in a file system folder. This may include both spatial and non-spatial data.

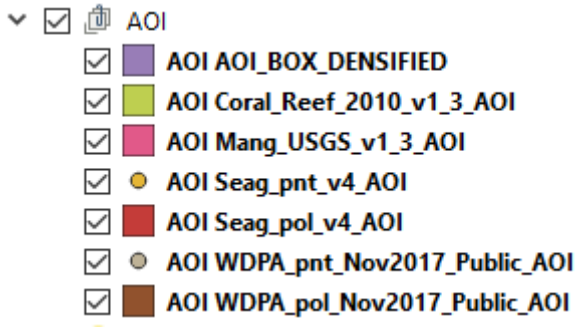
You can easily access ESRI's file geodatabases in QGIS, as read-only utilities. Choose **<Vector>** in the **<Data Source Manager>**, then **<Directory>** as the Source Type and **<OpenFileGDB>** as the Source. Find the folder of the .fgdb file, select it, and press **<Choose folder>**.



When you then select **<Add>**, you will get a new box listing the layers in the database. You may pick layers from the list or **<Select All>**. If you wish to pick a few of them, click them while pushing the **CTRL** button on your keyboard. When you are happy with the selection, press **<OK>**. The layers will be added to your layers bar in QGIS.



If you select **<Add layers to a group>**, the selected layers will be grouped under the name of the ESRI .fgdb. In this case, the group name will be **"AOI"**. In the example below, all of the layers have been selected, and thereby added to the new group.



In QGIS, ESRI .fgdb layers may be used as input layers in analyses or for spatial queries of the dataS, but cannot be changed. The geometries and attributes of the .fgdb objects can also not be changed, and it is not possible to export vector data to an ESRI geodatabase. These actions can only be done using ArcGIS software.

If you need to change the data, export the ESRI geodatabase to a shapefile (.shp) or to a database format such as geopackage (.gpkg) or spatialite (.sqlite) and do the changes there.

1.5.4 Structured text (.xslx or .csv)

Data may also be found in spreadsheets, like Excel spreadsheets (.xslx or .csv) or similar. These files may contain geometry in the form of point coordinates in two columns (e.g. x/y, North/East, or Latitude/Longitude).

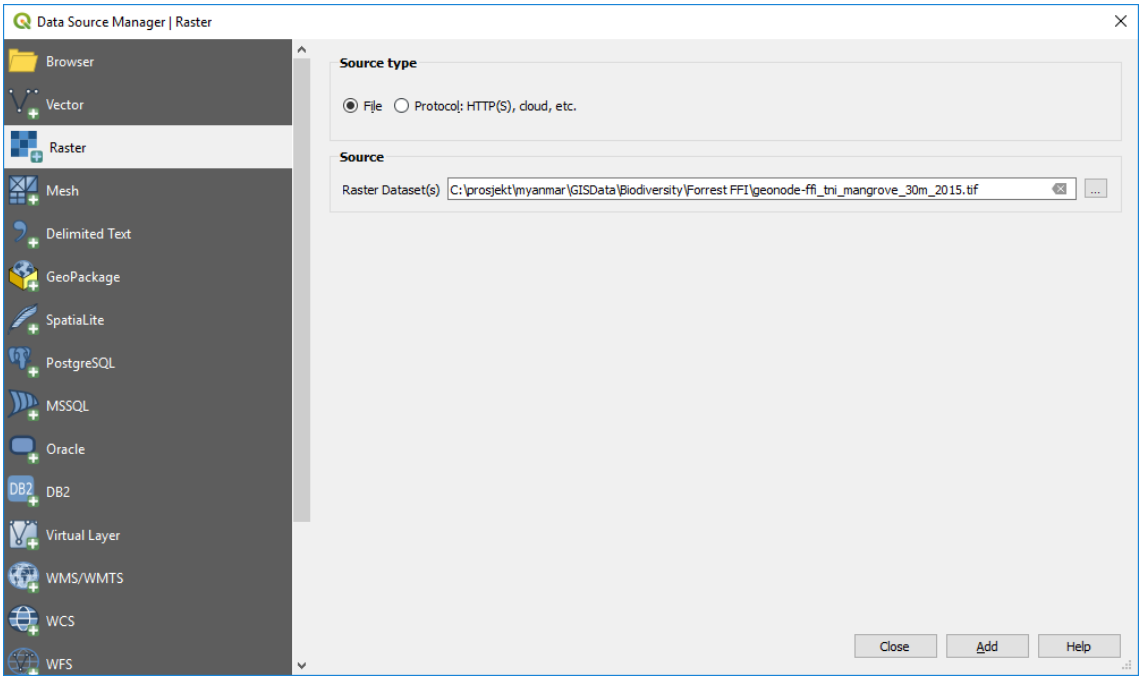
	A	B	C	D
1	id	count	x	y
2	1	312	63.10321	10.12312
3				
4				

These can be imported into GIS, which interprets the columns and generates points for each data entry. Structured text files are often in the form of **.csv** files, which are *comma separated*.

Sometimes, it may be useful to have non-spatial files that you can connect to geometry objects directly in the GIS.

1.5.5 Raster (.tif or .geotiff)

Raster files are stored as image files, such as TIF or a DEM, and can be added from the **<Data Source Manager>**. For instance, of data currently available for Myanmar, there are some **.TIF** files in the 'Biodiversity' group (e.g. "Forest FFI"). Find these files (mark more than one file to add more than one at a time, while holding down the **CTRL** key on your keyboard), and then click **<Add>**.



The TIF files in this example all have defined **symbology**, or the style and colours used to display the data. The symbology has been defined in the QGIS **"Layer Definition Settings"**, and then saved as the default for each of the layers.

If you open a raster file without a defined symbology, it will not be clear at first glance: each cells will have a different value, but these will not be very useful without understanding their meaning. To create a clear display of the raster image, you would need to define a good symbology based on the cell values. The symbology would depend on which kind of raster you are working with: for instance, the symbology used for a terrain model would not suit data classifying forest types.

Note: We will dive deeper into **symbology** in the chapter about *'Cartography and styling'*.

1.5.6 Web Map Services (WMS) and Web Feature Services (WFS)

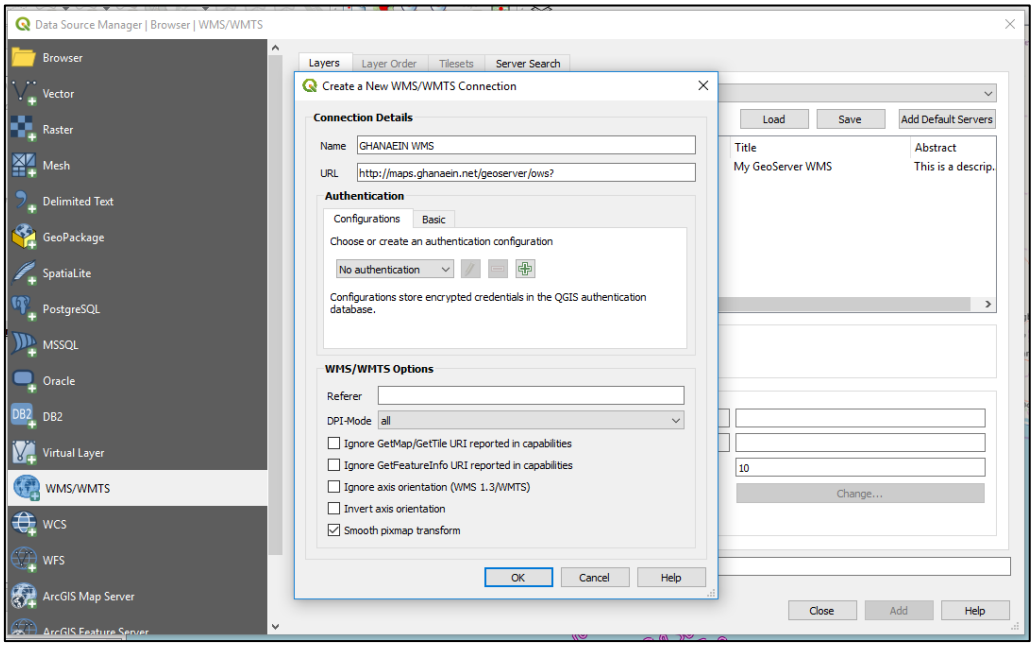
Many file formats are available in QGIS, but we can also load spatial data from online services, accessed via the internet. **<WMS/WMTS>** is a standard service for **Web Map (Tile) Services (WMS)** that provide information about layers, symbology and features. A WMS allows you to display maps and aerial photos in your GIS without having to download the data. The layers are displayed as rasters and, depending on the configuration of the service, can include information about the features or each layer's symbology. Both the data and the aerial photos are stored and maintained by the organization that provides the service.

A **web feature service (WFS)** is a standard service with additional functionality. While the WMS service only gives access to images of the supplier's data, a WFS allows users to select, style and perform other operations with the features of the map layer.

Both services use URLs to connect to and request information and features from them. You need to know the URL to get access to the WMS. Here is an example on how we can use services from Geoserver's URL to access a WMS for Ghana: http://maps.ghanaein.net/geoserver/ows?

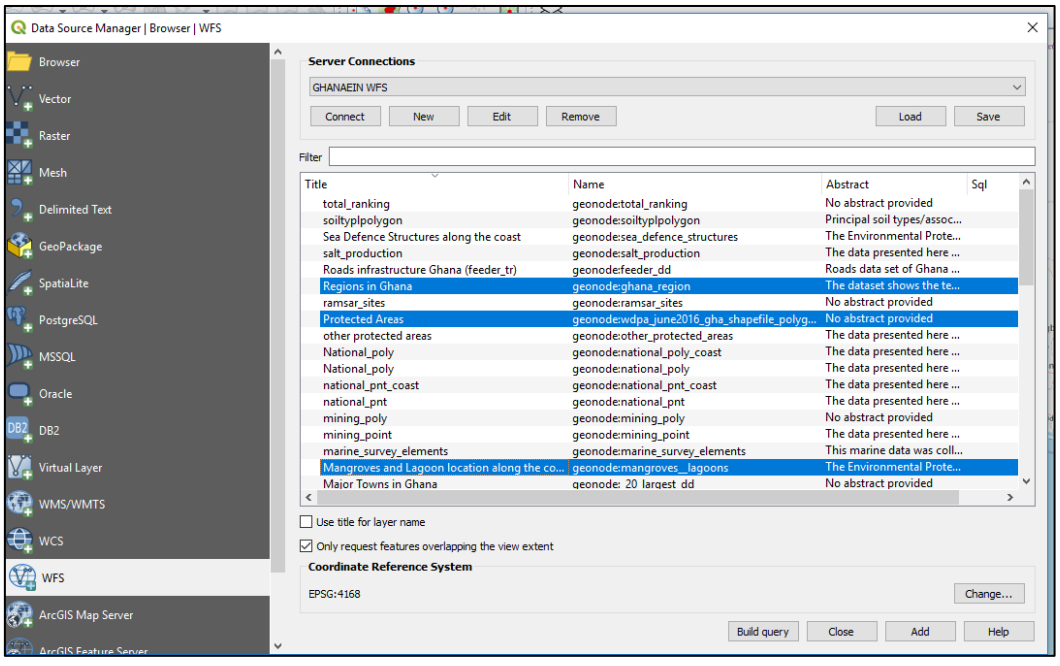
To add a Web Map Service (WMS)

Open the **<Data Source Manager>**, select **<WMS/WMTS>**, and click **<New>**. We will click on **<Layer>**, **<Add Layer>,** and **<Add WMS WMTS Layer>**. A new window will open. In this window, click on **<New>**, give the WMS a name, and write the URL of the service (http://maps.ghanaein.net/geoserver/ows?) into the URL dialog, check the **<smooth pixmap transform>** checkbox, and click **<OK>**. A list of layers will display: choose the layers to load into QGIS canvas and click **<Add>** *(see below)*.



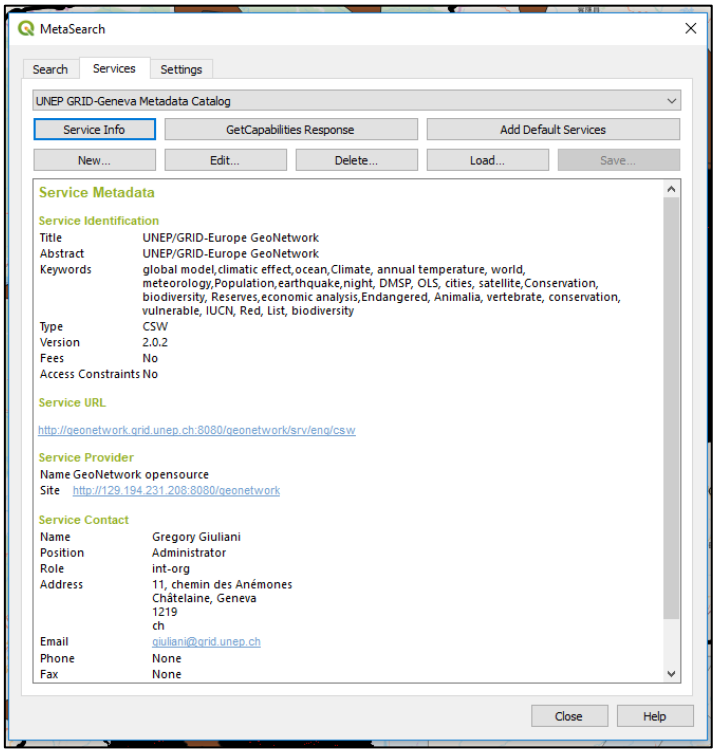
To add a Web Feature Service (WFS)

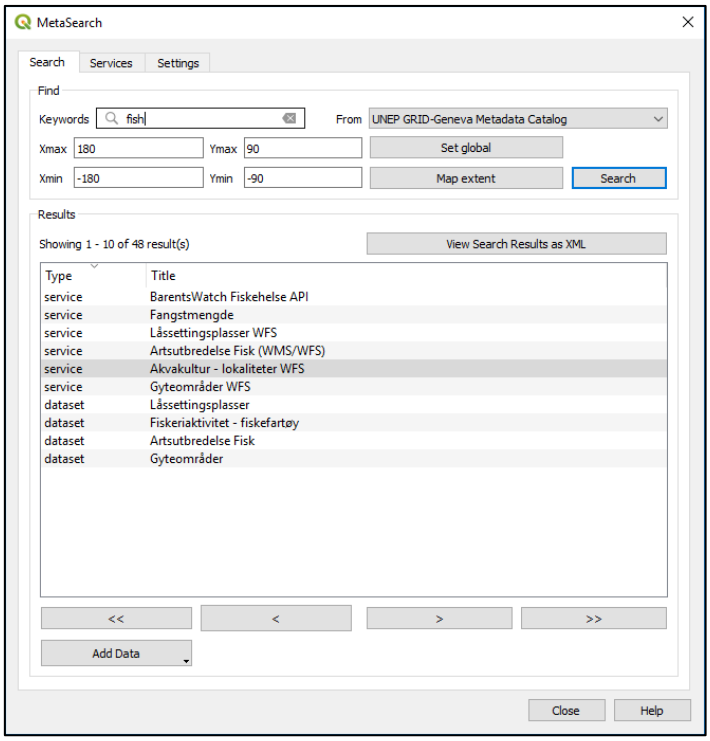
If loading layers from a WFS, open up the **<Data Source Manager>**, select **<WFS>**, and click **<New>**. Choose a name you like, and fill the URL with the Geoserver's URL (http://maps.ghanaein.net/geoserver/ows?). Click **<OK>** and **<Connect>**. A list of layers will display: choose the layers to load into QGIS canvas and click **<Add>** *(see below)*.



MetaSearch

In QGIS there is also a built-in plugin named **Metasearch**. Here, it is possible to search for available WMS and WFS layers. You can access it from the top menu: select **<Web>**, then **<MetaSearch>**. When you open it up for the first time, the first thing you need to do is to choose which Metadata Catalog you wish to use. Choose the one that applies to your part of the world, if there is one. You may get service info from the **<Service Info>** button under **<Services>**. When you have found the correct one, use the **<Search>** banner *(see below)*.





2. QGIS

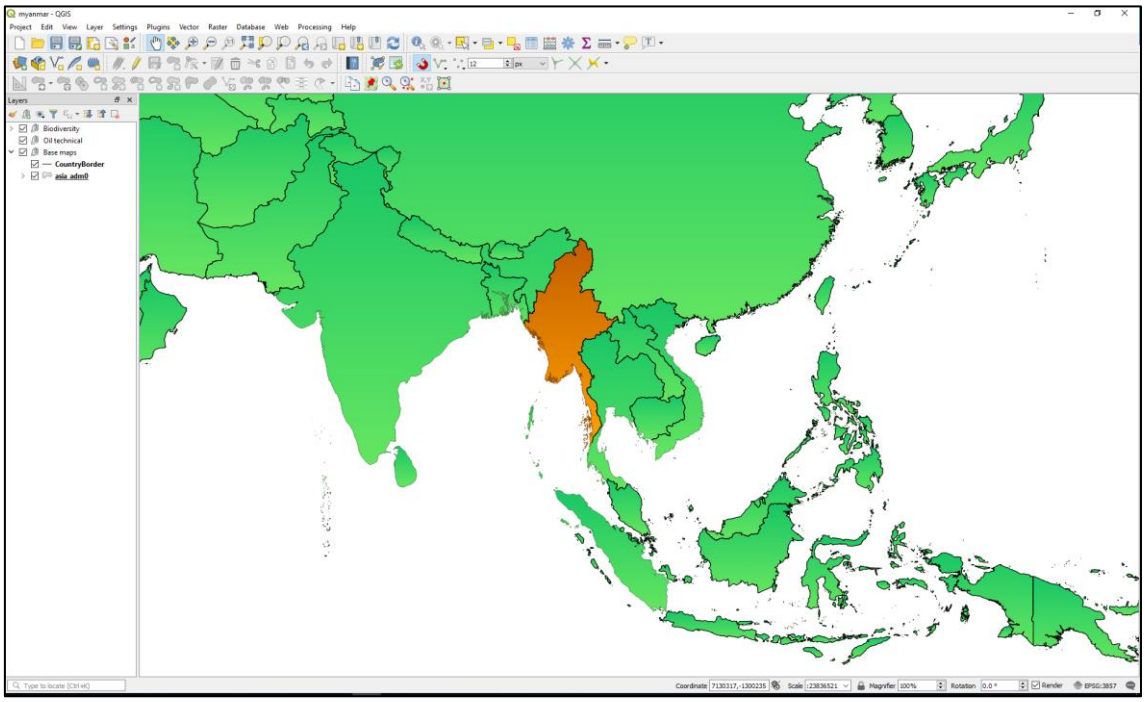
In this chapter, we will dive into QGIS. You will get familiar with the interface and learn how to use the most important functions.

2.1 Installing QGIS

Install QGIS from the QGIS webpage. The easiest way is to use one of the standalone installers listed on the download web page. Depending on your computer's operating system, you will choose the 64-bit or 32-bit version. Choose the **'long-term release'**. QGIS 3.4 has been the long-term release since the end of February 2019.

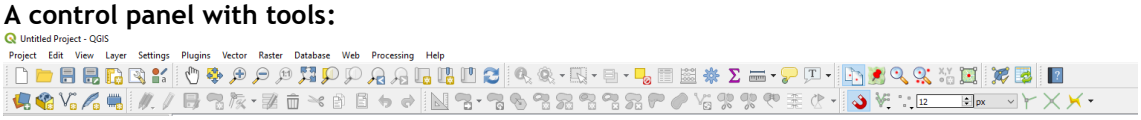
https://qgis.org/en/site/forusers/download.html

2.2 Interface



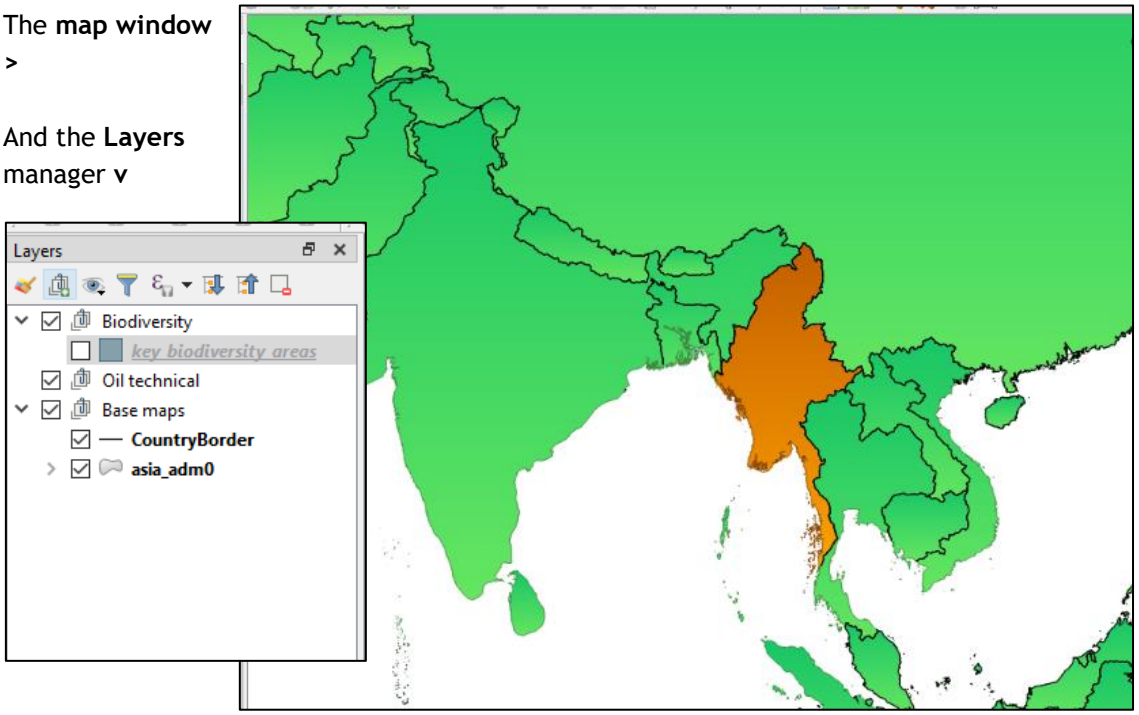
QGIS consists primarily of:

A control panel with tools:

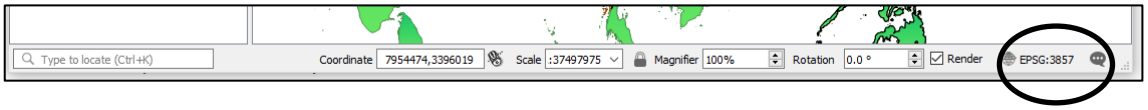


The **map window >**

And the **Layers** manager **v**

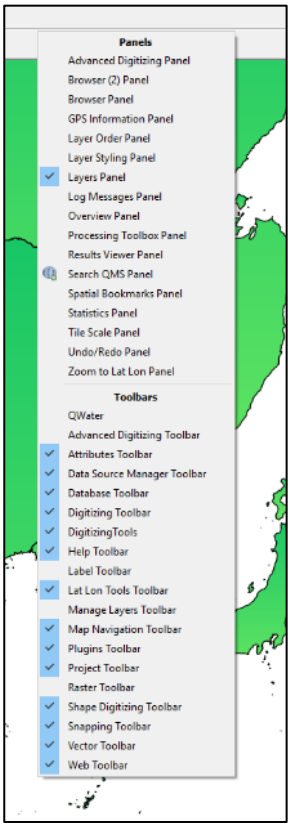


In QGIS, you set the project coordinate system in the bottom right corner of the map window:



This is where you decide what coordinate reference system (EPSG coordinate number) will be presented in the status bar and how the layers are shown or projected. Double click the coordinate numbers to reach the project properties.

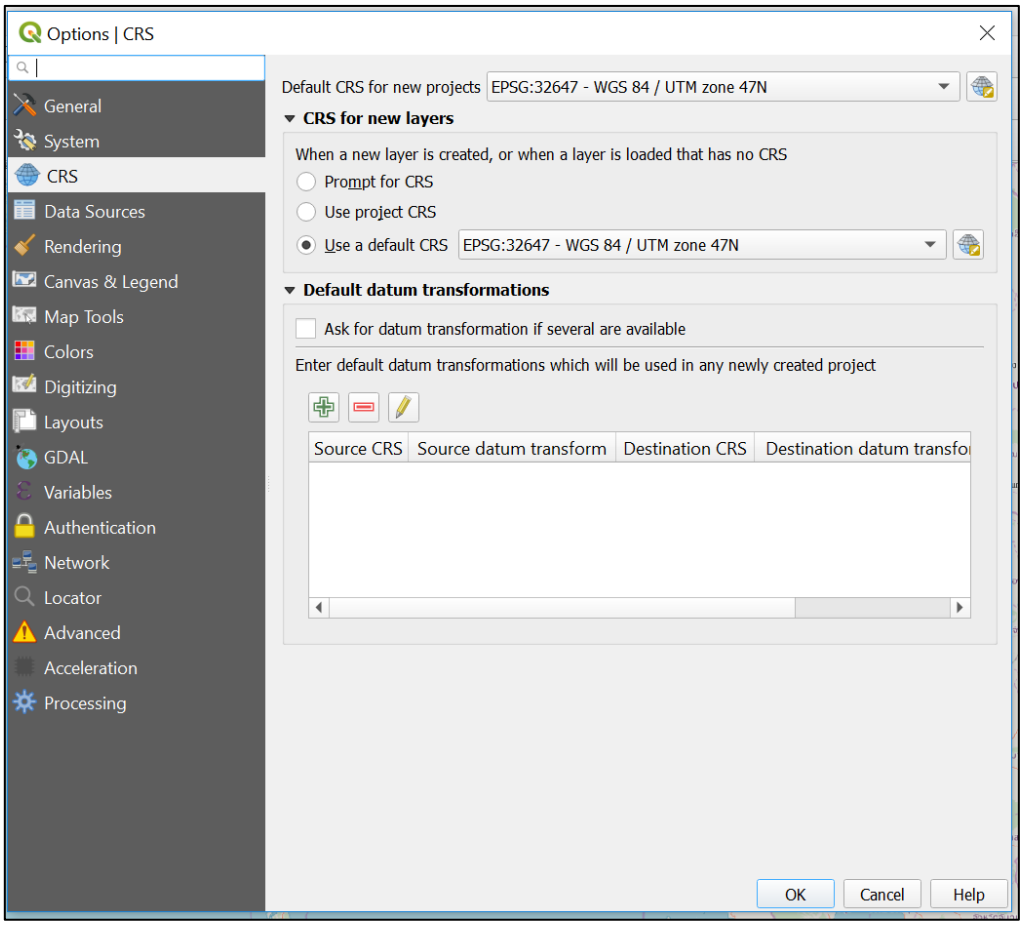
The interface is very customizable, with variations between versions of QGIS. However, the main components are always there. To get an overview of which toolbars and panels are activated, right click in the grey area of the **<Control Panel>**. Activate/deactivate **<Toolbars>** and **<Panels>** by a left click *(see right)*.



2.3 Coordinate systems in QGIS

When you open up QGIS for the first time, there are some settings you need to do.

From the menu bar, go to **<Settings>**, select **<Options>** and then **<CRS>**. You will get this window:



Set the default Coordinate Reference System (CRS) for new projects
Choose the coordinate reference system (CRS) that is standard for your country, or the data you mainly will be working with. The CRS selected will depend on whether you will be working mainly with geographic or projected data.

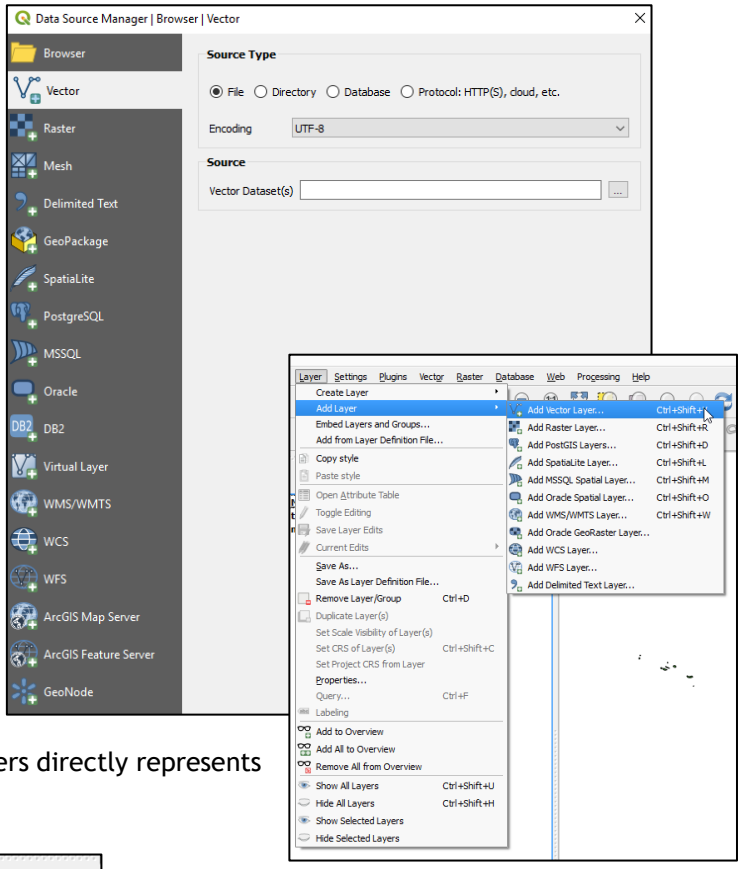
If you will be working mainly with registration of new data, use a geographic coordinate system. For example, you may use the global default CRS: EPSG 4326 - WGS84. This is especially important if you are working offshore, since the UTM zone standards are optimized for mapping onshore.

If you will be working mainly with projected coordinate system you should choose the standard projected coordinate system of your country/region. For Myanmar this would be EPSG 32647 - WGS 84/ UTM zone 47N.

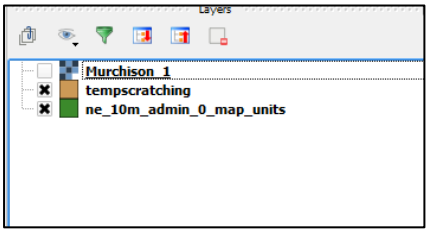
2.4 Add data

Layers can be added to your QGIS project from the <Data Source Manager>, the **<Browser Panel>** or from the **<Menu Layer/Add Layer>**. The **<Data Source Manager>** can be activated from this tool button in the control panel:

…or from the **<Browser Panel>**, or from **<Layer>**, then **<Add Layer>** *(see right)*.



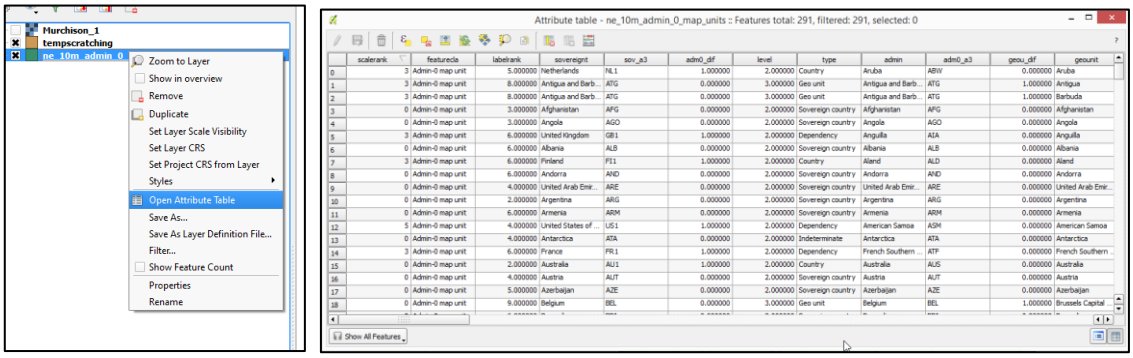
When you add a layer, it is added to the layer manager. The order of the layers directly represents *the drawing order* in the map window.



Layers can be grouped together by selecting them, pressing the **CTRL** key on the keyboard while selecting each layer. Then, right click on the selected layers (while still holding **CTRL**), and select **<Group>**.

You can also rename the layers. Note that this does not change the underlying datasets—only the name in QGIS.

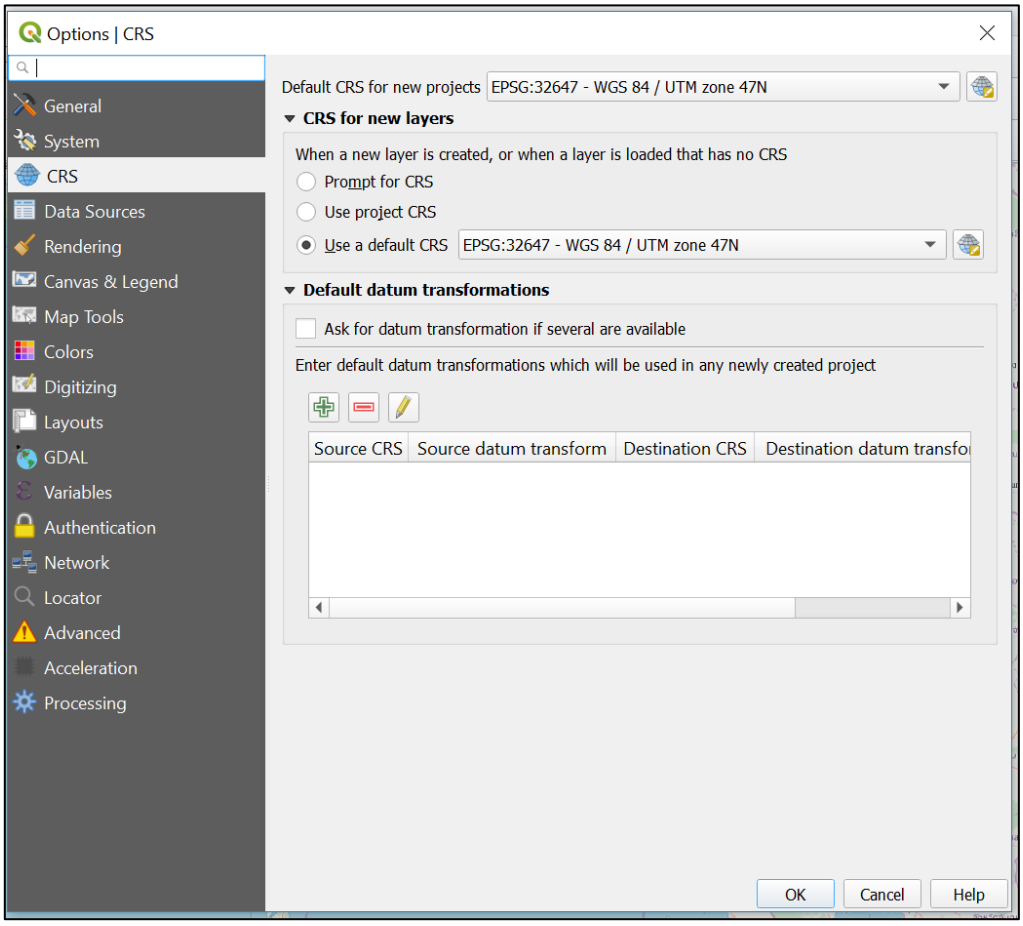
To look at the attribute data you can right click on a layer and select **<Open Attribute Table>**, which brings up a table where all of the data (or 'attributes') are displayed with one line per object.



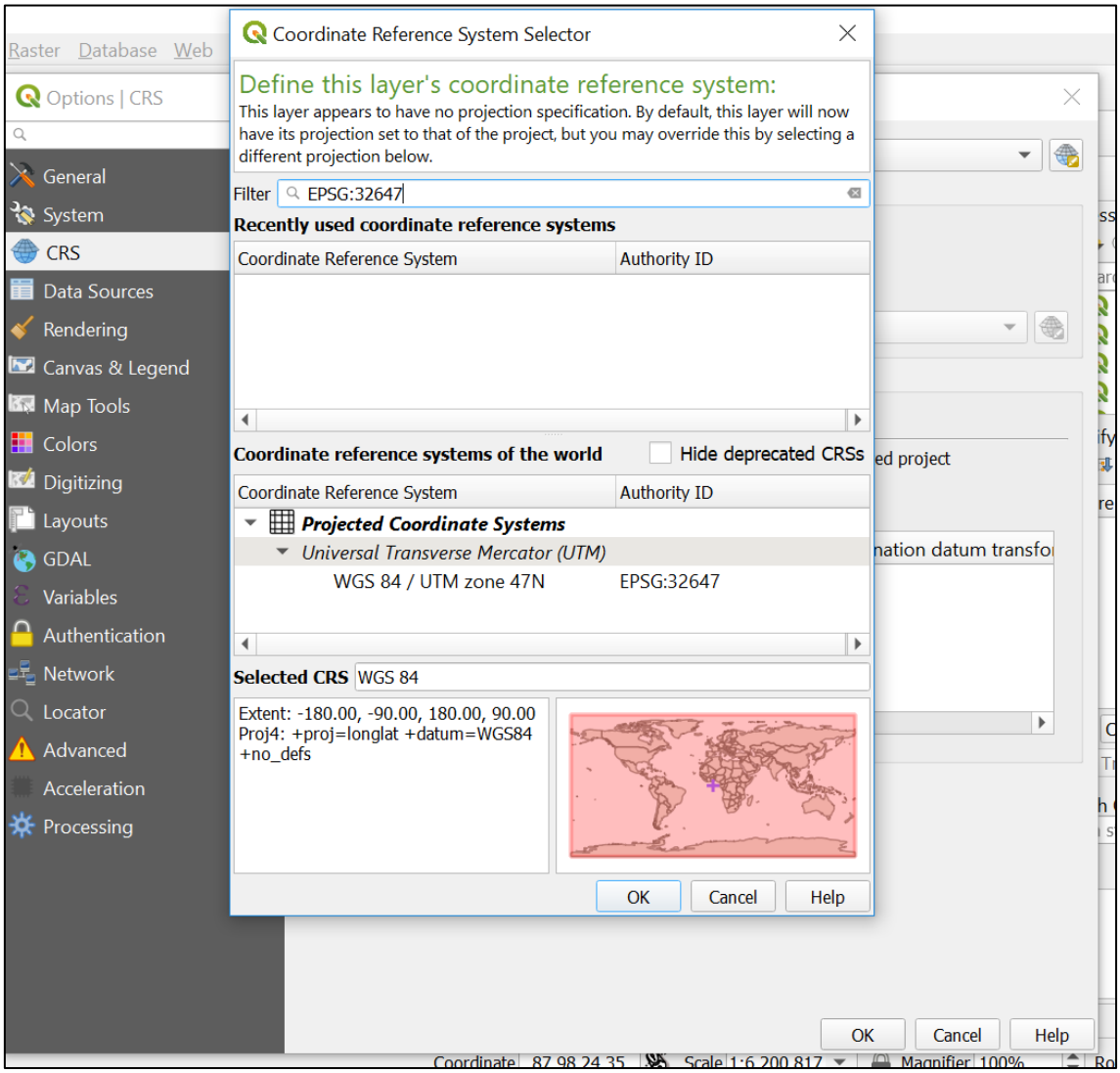
You can actually select and edit the data directly within the attribute table.

2.5 Layer transformations

From the menu bar, go to **<Settings>**, select **<Options>** and then **<CRS>**. You will get this window:



In this window, there is also a setting that applies to new layers: **<CRS for new layers>**. When you use layers that do not have a CRS, you need to define how QGIS responds to them. Here you find three options: **<Prompt for CRS>**, **<Use project CRS>** and **<Use default CRS>**.



In the **<Layer properties>**, which you reach by right clicking the layers, the coordinate system for each layer is defined. This must correspond to the actual coordinate reference system (CRS) of the layer. **Note: Changing the definition of the layer in the layer properties will not change the coordinate system of the layer, and would result in placing the layer in the wrong location.** But, as long as the layer coordinate definition is correct, you can change the project definition system and QGIS will project the layers 'on-the-fly'.

What is 'on-the-fly', and why does it matter?
When you are using GIS, the software will try to translate between different coordinate systems 'on-the-fly' and behind the scenes. 'On-the-fly' means that QGIS is showing a layer in a different coordinate system than it is actually in. **Pay attention to this! This means that you will view the layer in another coordinate system, but it will NOT actually be re-projected.** You must transform the dataset to your desired coordinate system for any analysis. Do not do your analysis on-the-fly.

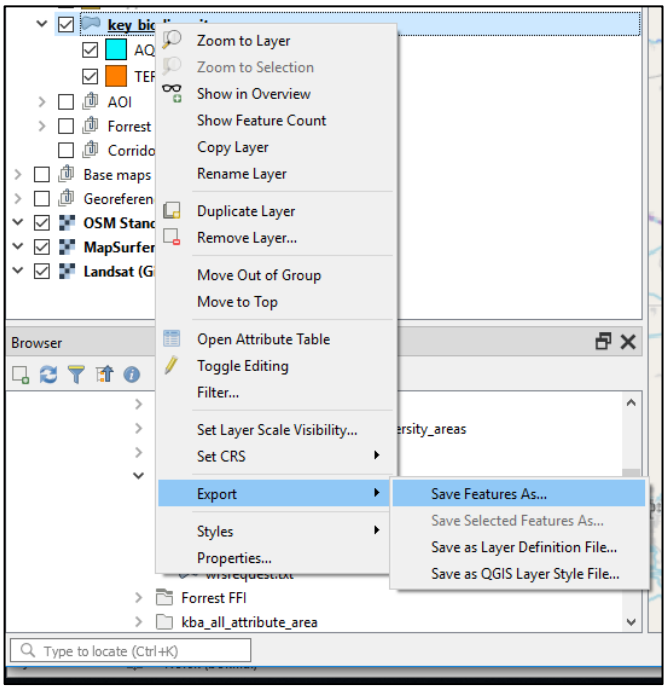
Note: In QGIS, 'on-the-fly' re-projection is automatically enabled (since QGIS 3 was released).

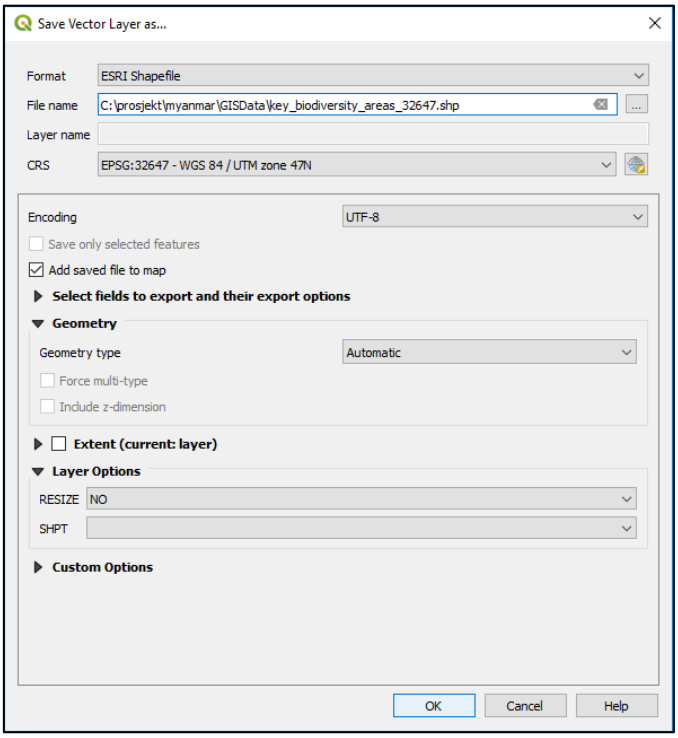
To re-project one of your layers into another coordinate system:

If two datasets are not referenced to the same geographic coordinate system, you may need to perform a geographic transformation. The method converts coordinates between two geographic coordinate systems. The best practice is to always try to have all your data in the same coordinate system—preferably the national/regional standard.

Transformation of a dataset in QGIS is made by exporting the layer and saving it in a new coordinate system.

1. Right click on the layer in the **<Layer Manager>**, select **Export > Save features as**. *(See right)*
2. Choose a format **(e.g. ESRI Shapefile)**, and complete the **<File name>.** In **<CRS>,** select your preferred coordinate system. When you then save the layer, it has been stored in your preferred coordinate system. *(See right)*

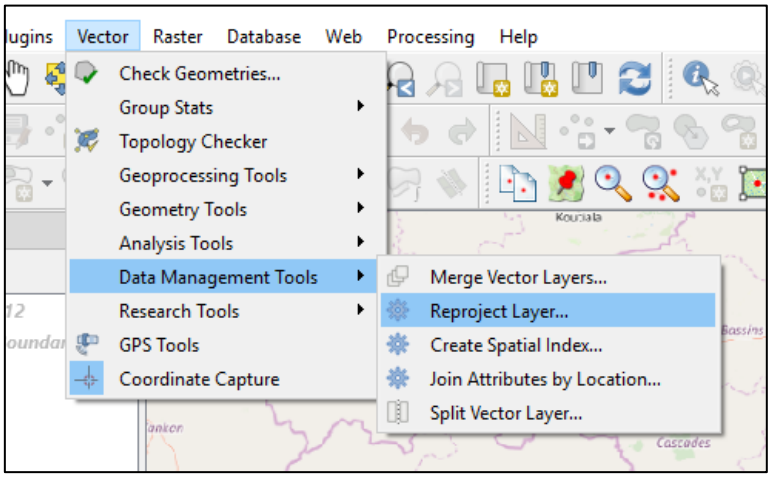




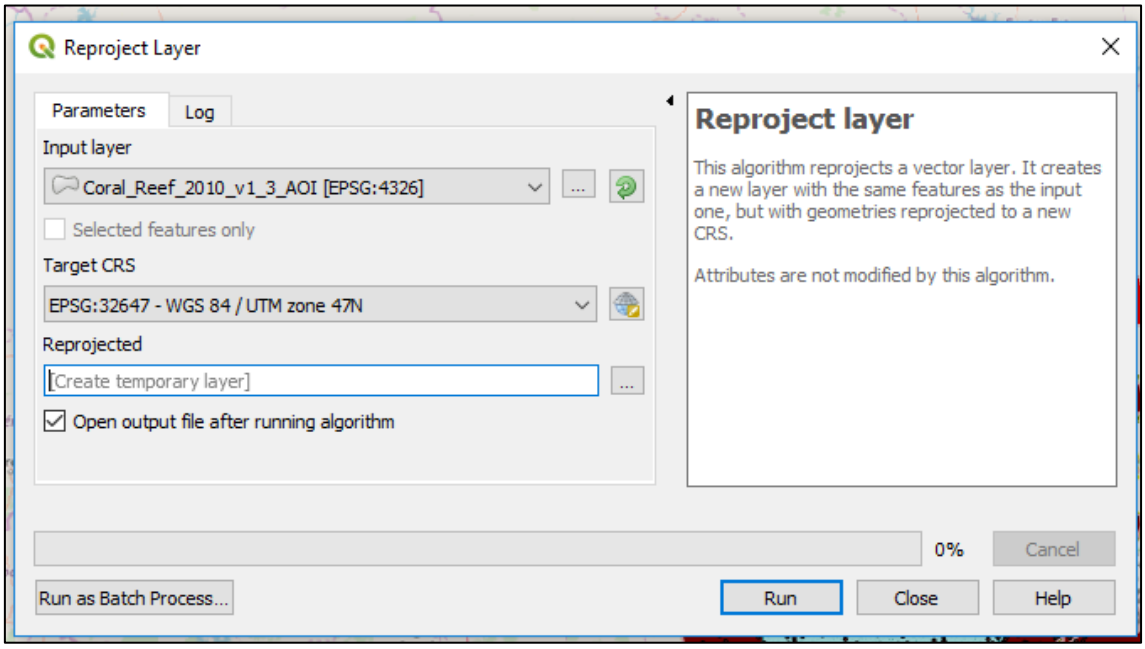
Tip: If you are working with two CRS versions for the same layer, include the CRS code or name in the layer name.

Note: This method may also be used to save only a selection of features from another layer by checking the **<Save only selected features>** box. *See* Section 2.6.1 *for more information.*

Another way to re-project a layer is to use the function **<Reproject>**. Select **Vector > Data Management Tools > Reproject Layer.**



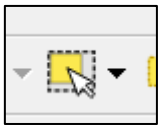
Choose the **<Input Layer>** and the **<Target CRS>**. You may either create a temporary re-projected layer or save the output re-projected layer to a new file. The re-projection algorithm creates a new layer with the same features as the input layer, but re-projected to a new CRS.



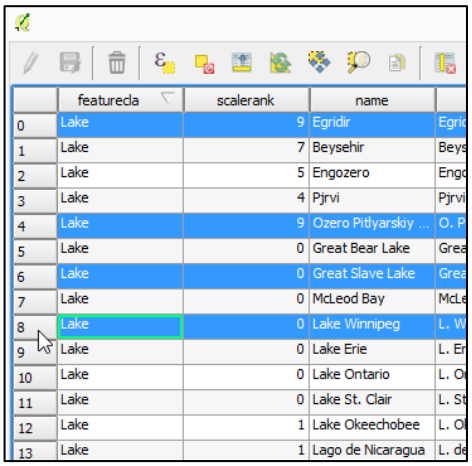
2.6 Selection

You can select objects in a layer using different methods.

The easiest is to use the **<Selection>** tool:



You can also select directly by clicking rows in the attribute table. Select multiple rows by holding down the **CTRL** key on your keyboard, and clicking each row.



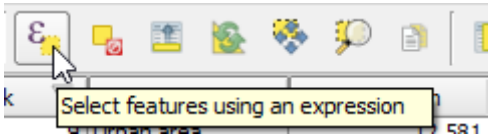
	featurecla	scalerank	name
0	Lake	9	Egridir
1	Lake	7	Beysehir
2	Lake	5	Engozero
3	Lake	4	Pjrvi
4	Lake	9	Ozero Pitlyarskiy ...
5	Lake	0	Great Bear Lake
6	Lake	0	Great Slave Lake
7	Lake	0	McLeod Bay
8	Lake	0	Lake Winnipeg
9	Lake	0	Lake Erie
10	Lake	0	Lake Ontario
11	Lake	0	Lake St. Clair
12	Lake	1	Lake Okeechobee
13	Lake	1	Lago de Nicaragua

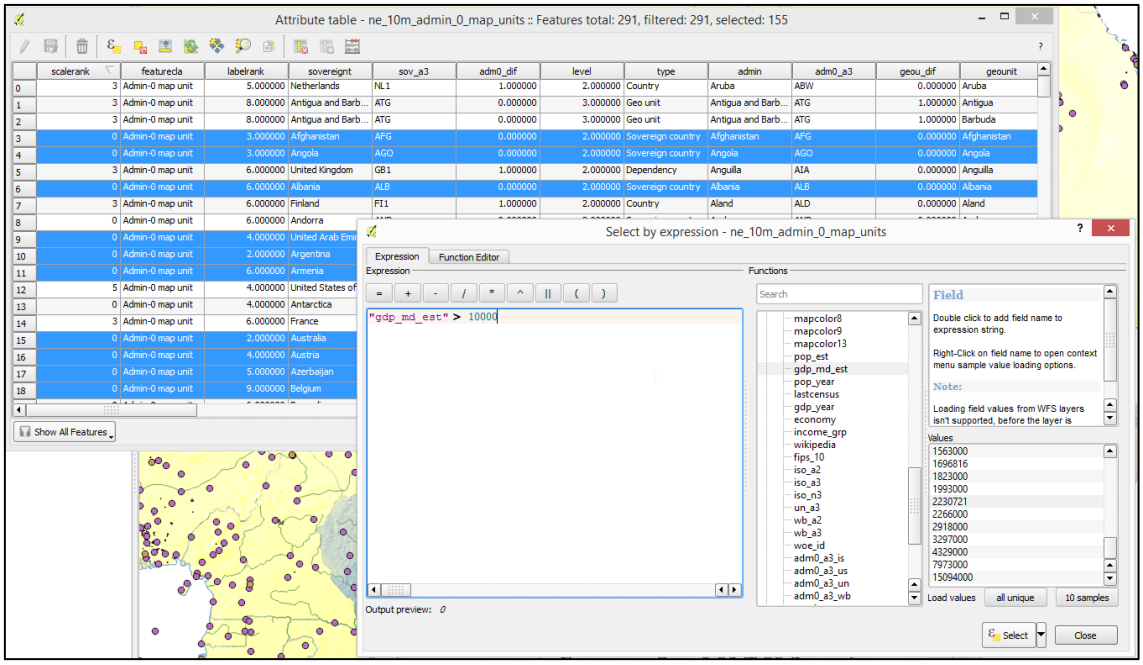
An advanced selection is made by using the **<Select features using an expression>** tool *(see below)*. Here, we can select all objects which fit a criterion we set through an expression. For example, we can select attributes from the layer **"ne_10m_admin_0_map_units"** using the expression:

"gdp_md_est" > 10000

This translates into: "select all objects with "gdp_md_est" greater than 10000".

Notice that the rows in the attribute table as well as the objects in the map window are immediately highlighted with the matching rows.





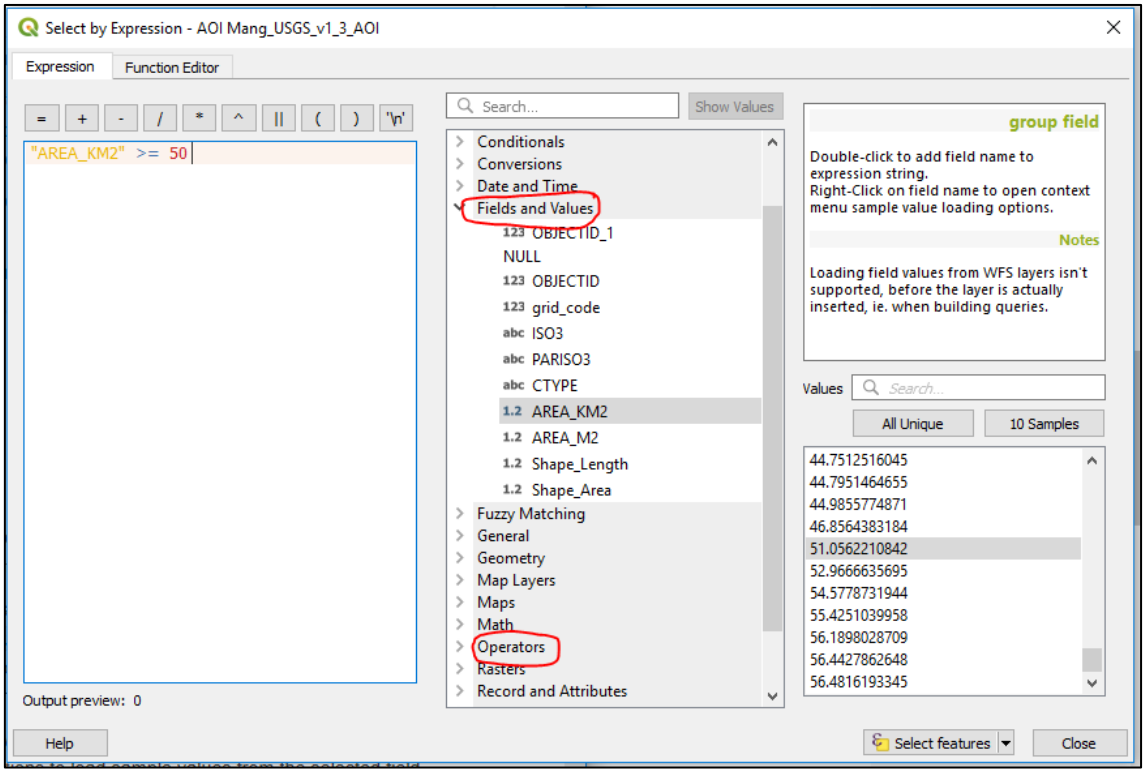
There are many functions available in the **<Select by expression>** window, which may be overwhelming for a beginner. To start, **<Fields and Values>** and **<Operators>** are good functions to become familiar with. By clicking each, you will you receive some information about it in the right window.

Fields and Values contains a list of fields from the layer. You may either write your expression directly in the expression field, or you may use the function and alternatives, to select fields.

Selecting by one attribute

You want to select the mangrove areas with an area larger or equal to a certain value.

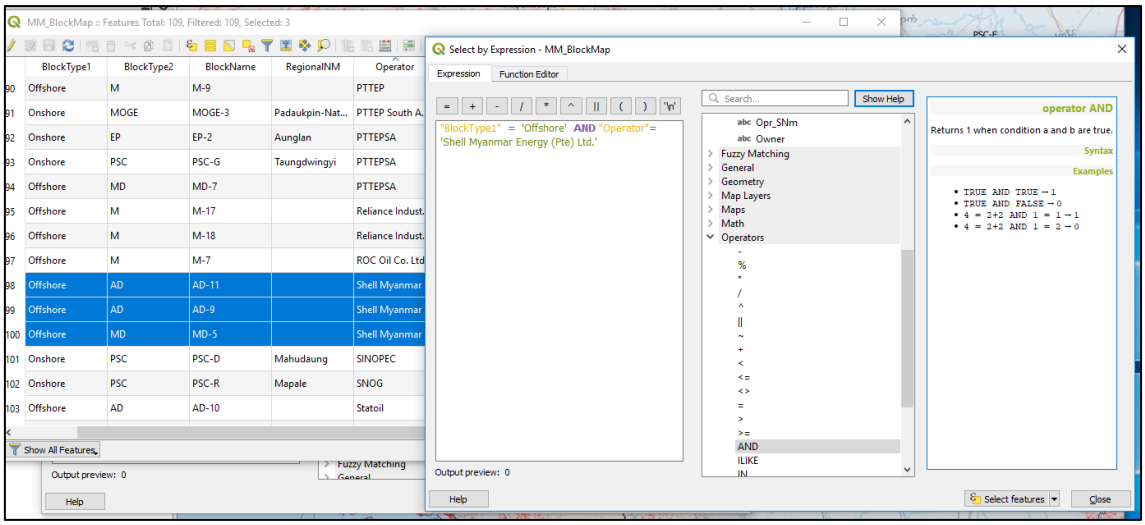
1. Select the attribute **"AREA_KM2"**.
2. Open up the **<Fields and Values>** to get the list of attributes.
3. Double-click the attribute you want (i.e. **AREA_KM2**) to add it to the expression.
4. Open up **<Operators>** to get the full list of options (i.e. some operators are available on the top of the expression window, but not all of them!).
5. Double-click **>=**. The operator is added to the expression window.
6. Return to **<Fields and Values>**, select **AREA_KM2**, and find the **<Values>** field.
7. When selecting a value, you may either search for a specific value, list all unique values, or get 10 samples. If you have a large dataset, it may take some time to list all unique. Double-click the value under **<Values>**, or write in a value in the **<Expression>** field.
8. Click **<Select features>**, close the window and go back to the attribute table.
9. To show only the selected features, left-click in the bottom corner, and then choose **<Show selected features>**. You have selected the features with an area larger than or equal to 50.



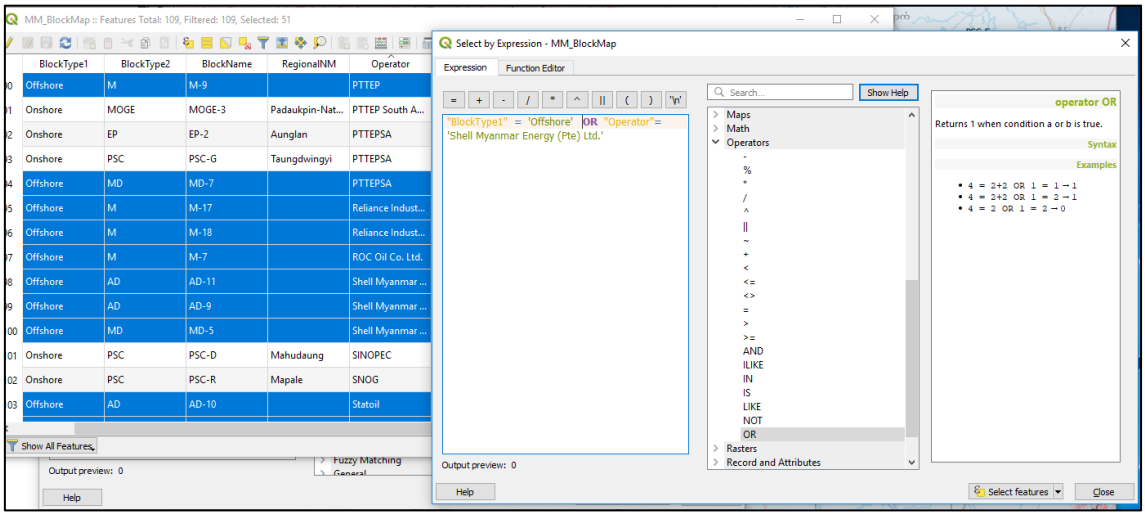
Selecting by more than one attribute

Another example is selection based on values for two different attributes. Let's say we want to select all the Block types that are "Offshore," which are operated by "Shell Myanmar" *(see image below)*.

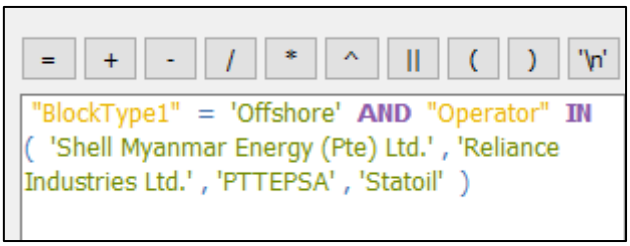
1. We make one expression for each of the attributes, to select the preferred values. For the first attribute (condition a): add **"BlockType1"** to the **<Expression>** field, and make it **= 'Offshore.'** *(Note: Single quotations for the second part!)*
2. For the second attribute (condition b): add **"Operator"** and make it **= 'Shell Myanmar Energy (Pte) Ltd.'**
3. Then, add **AND** between the two expressions to select both of them. This will return those blocks where both condition 'a' and 'b' are true.



4. If we change the operator to **OR**, we select all features which have either condition 'a' OR condition 'b' *(see below)*.



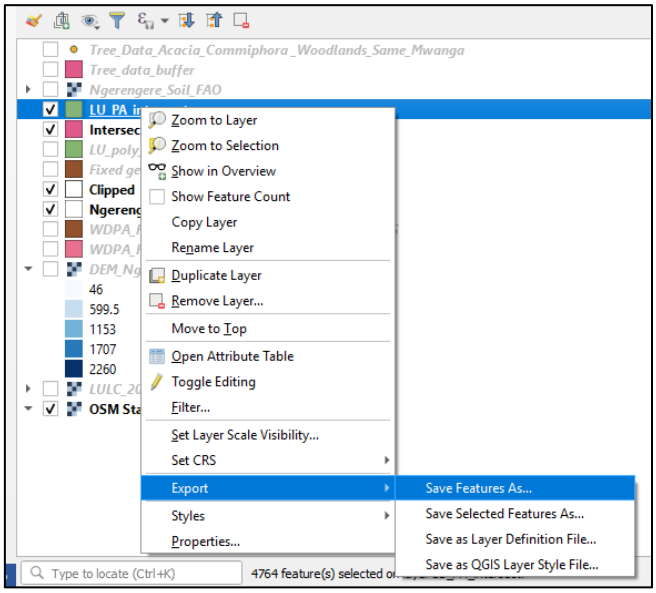
5. You can also use the operator **IN** to list values (i.e. **“Operator” IN (‘Shell Myanmar Energy (Pte) Ltd.’, ‘Reliance Industries Ltd.’, . . .)**, which may also be combined with an **AND** syntax and another value.



2.6.1 Save selection

In the previous chapter, we looked at how you can select the features (objects) you are interested in by clicking or by using expressions. When you have made your selection, you can *extract the selected features* into a new datafile and layer. If you want to manage this data, you can then import the new layer into your file database.

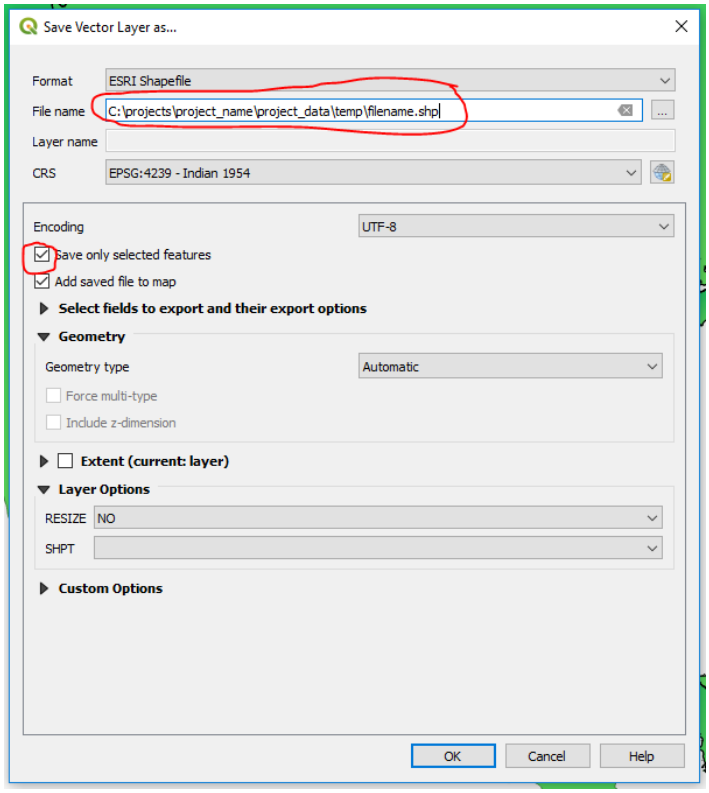
1. Right click the layer you selected from in the layer manager and click **Export > Save Features As**:



2. Choose the path to save the *temporary selection file* to. According to the work routines ‘best practices’ described in the appendix, the path for the temporary files would be like this:

/projects/projectname/project_data/temp/”filename”.shp

We choose to save the temporary file as an ESRI shapefile for convenience. **Note:** You need to check the checkbox **“Save only selected features”**. This is the key to export our selected features *(see next page)*.



You have now saved the selected data in an ESRI shapefile which is also automatically added to the layer manager.

2.7 Excel handling

2.7.1 From Excel to QGIS

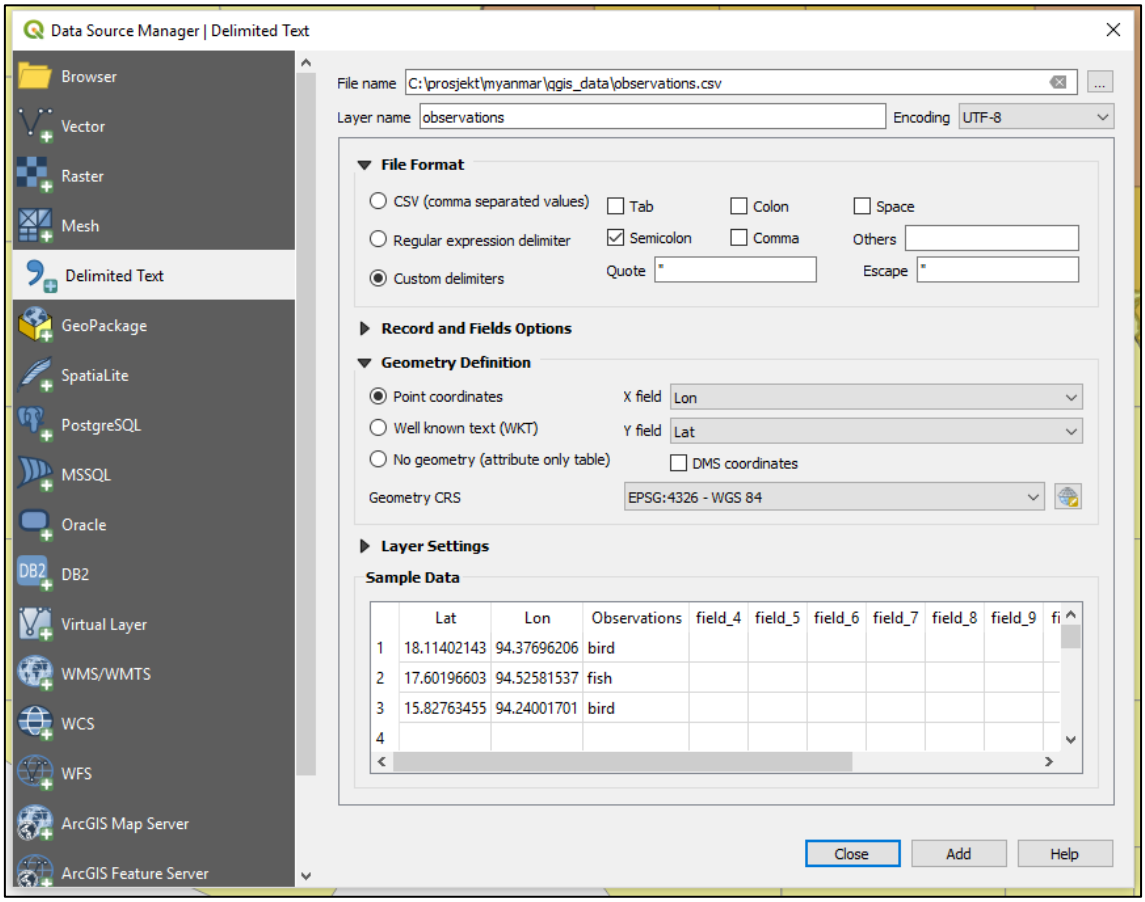
Often, GIS data are delivered in a table or an Excel spreadsheet. If the data has a list of latitude/longitude coordinates, you can import it into QGIS.

1. First, examine your tabular data source. The file must have columns for the X and Y coordinates.
2. To import the data to QGIS, save it as a text file: use the **"Save as"** function in Excel, and save as a **Tab Delimited File** or **Comma Separated Values (CSV)** file.
3. Open it up in a text editor such as Notepad to look at the contents.

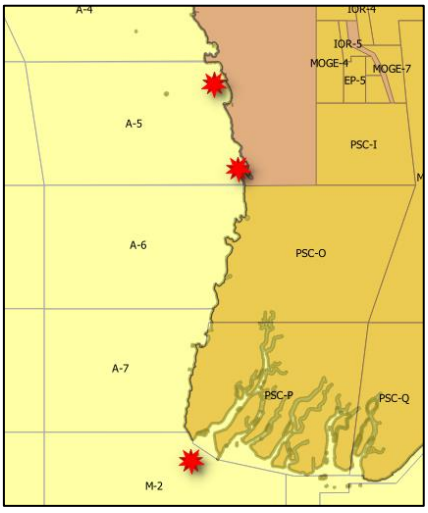
	A	B	C	D	E
1	Lat	Lon	Observations		
2	18.11402143	94.37696206	bird		
3	17.60196603	94.52581537	fish		
4	15.82763455	94.24001701	bird		
5					
6					

4. In QGIS, open up the **<Data Source Manager>** window and select **<Delimited text>**.

5. Specify the path to the text file in **<File name>**. Check for the correct **<File Format>**. For 'custom delimiters', you must also choose how data are separated in the text file. If you are unsure, you can try different options. When you have chosen the correct one, the data will look like a table in the **<Sample data>** preview.
6. Choose **<Point coordinates>** under **<Geometry Definition>**, and provide in the fields for the X ("Lon") and Y ("Lat") coordinates.
7. Choose coordinate system (in **<Geometry CRS>**) and then **<Add>** the layer.

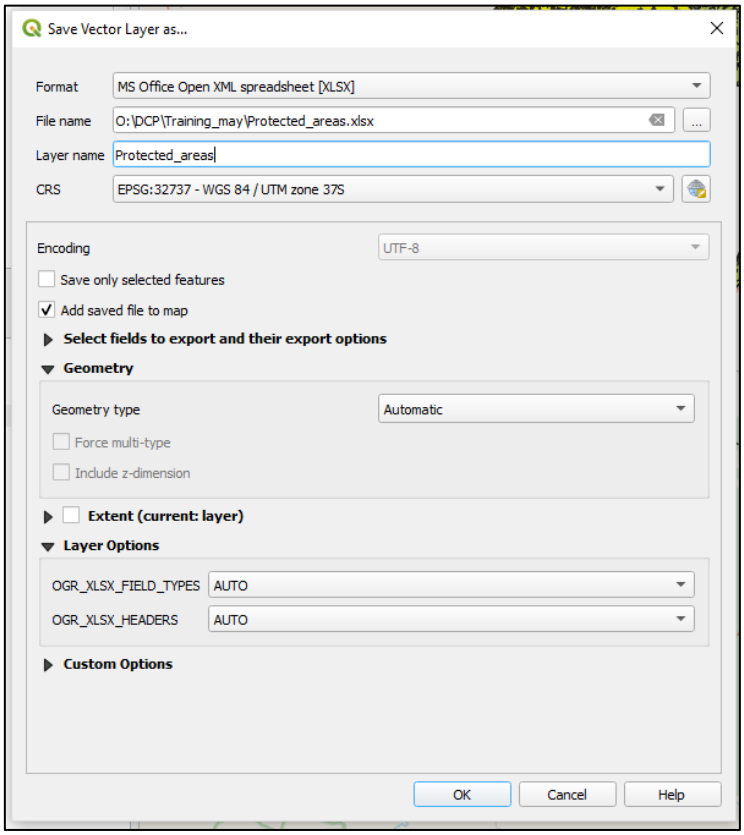


The delimited text layer will be added to the layer manager, and is displayed as points in the map window.

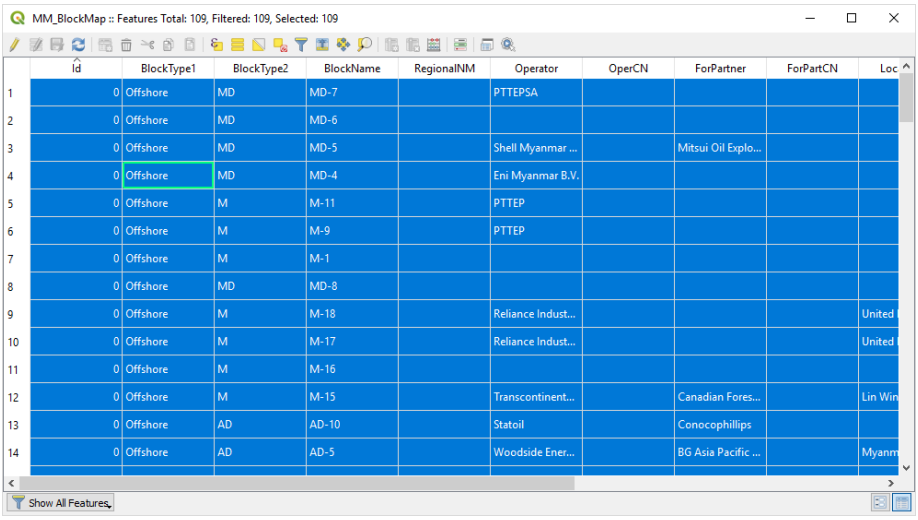


2.7.2 From QGIS to Excel

To get data from an attribute table of a QGIS layer to Excel is quite easy. The main way to do this is by right clicking on the layer with the attribute table you want to export and click **Export > Save Features As**. Select the format as **MS Office Open XML spreadsheet [XLSX].** Choose where you want to save it and give it a **<File name>**, then click **<OK>.**

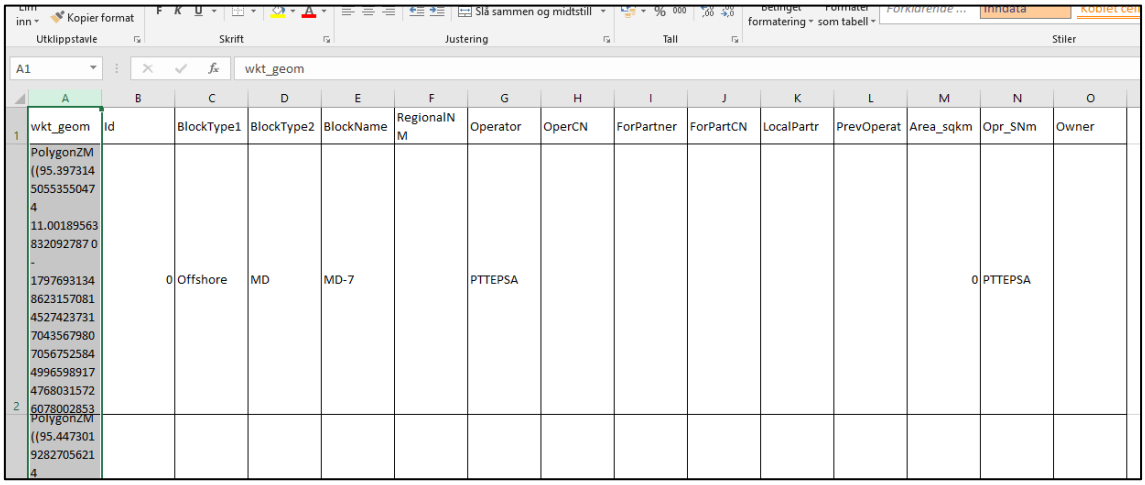


Alternatively, go into the attribute table of your preferred layer. Mark all rows by clicking the upper left corner. The marked rows turn blue. Press **CTRL + C**. All the cells are copied to the clipboard.



	Id	BlockType1	BlockType2	BlockName	RegionalNM	Operator	OperCN	ForPartner	ForPartCN	Loc
1	0	Offshore	MD	MD-7		PTTEPSA				
2	0	Offshore	MD	MD-6						
3	0	Offshore	MD	MD-5		Shell Myanmar ...		Mitsui Oil Explo...		
4	0	Offshore	MD	MD-4		Eni Myanmar B.V.				
5	0	Offshore	M	M-11		PTTEP				
6	0	Offshore	M	M-9		PTTEP				
7	0	Offshore	M	M-1						
8	0	Offshore	MD	MD-8						
9	0	Offshore	M	M-18		Reliance Indust...				United
10	0	Offshore	M	M-17		Reliance Indust...				United
11	0	Offshore	M	M-16						
12	0	Offshore	M	M-15		Transcontinent...		Canadian Fores...		Lin Win
13	0	Offshore	AD	AD-10		Statoil		Conocophillips		
14	0	Offshore	AD	AD-5		Woodside Ener...		BG Asia Pacific ...		Myanm

Open up Excel and press **CTRL + V**. The chosen rows are pasted into Excel. As you can see, there is a column that describes the geometry. Delete this column to get a more readable table.



	wkt_geom	Id	BlockType1	BlockType2	BlockName	RegionalNM	Operator	OperCN	ForPartner	ForPartCN	LocalPartr	PrevOperat	Area_sqkm	Opr_SNm	Owner
1															
2	PolygonZM ((95.397314 5055355047 4 11.00189563 8320927787 0 - 1797693134 8623157081 4527423731 7043567980 7056752584 4996598917 4768031572 6078002853	0	Offshore	MD	MD-7		PTTEPSA						0	PTTEPSA	
	PolygonZM ((95.447301 9282705621 4														

2.8 Joins

Joins transfer attributes from one layer to another based on their spatial relationship *(2.8.1 Spatial joins)* or a common attribute *(2.8.2. Vector joins)*, joining the two tables together. The **input layer** and **join layer** do not need to have the same geometry type to be able to join (e.g. a vector layer may be joined with a non-spatial layer, such as a table).

2.8.1 Spatial joins

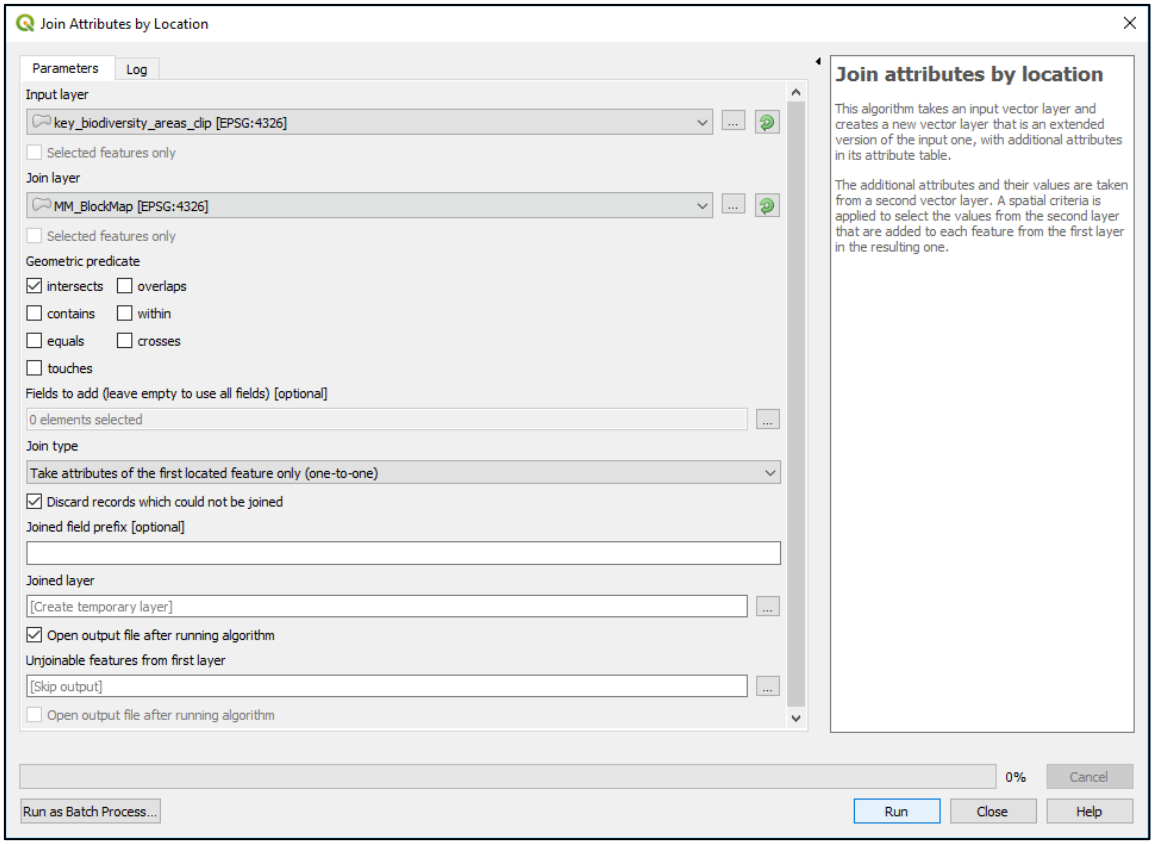
To do a spatial join in QGIS, use the top menu **<Vector/Data Management Tools>** and open the function called **<Join Attributes by Location>**. Fill in the:

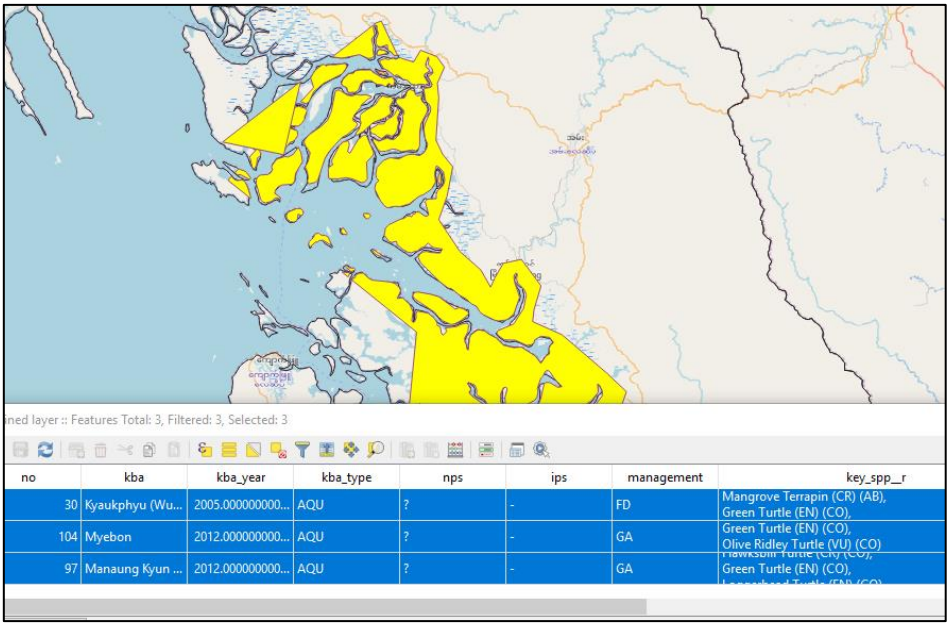
- **<Input layer>**, or the layer you want to add data to;
- **<Join layer>**, or the data being added; and
- **<Geometric predicate>**, or the spatial criteria (for example the intersection between the two layers) that is applied to select the values from the join layer *(see image below)*.

Choose the join type that matches your preferred result in the joined layer.

- One-to-one (takes attributes of the first located feature only);
- One-to-many (creates a separate feature for each located feature).

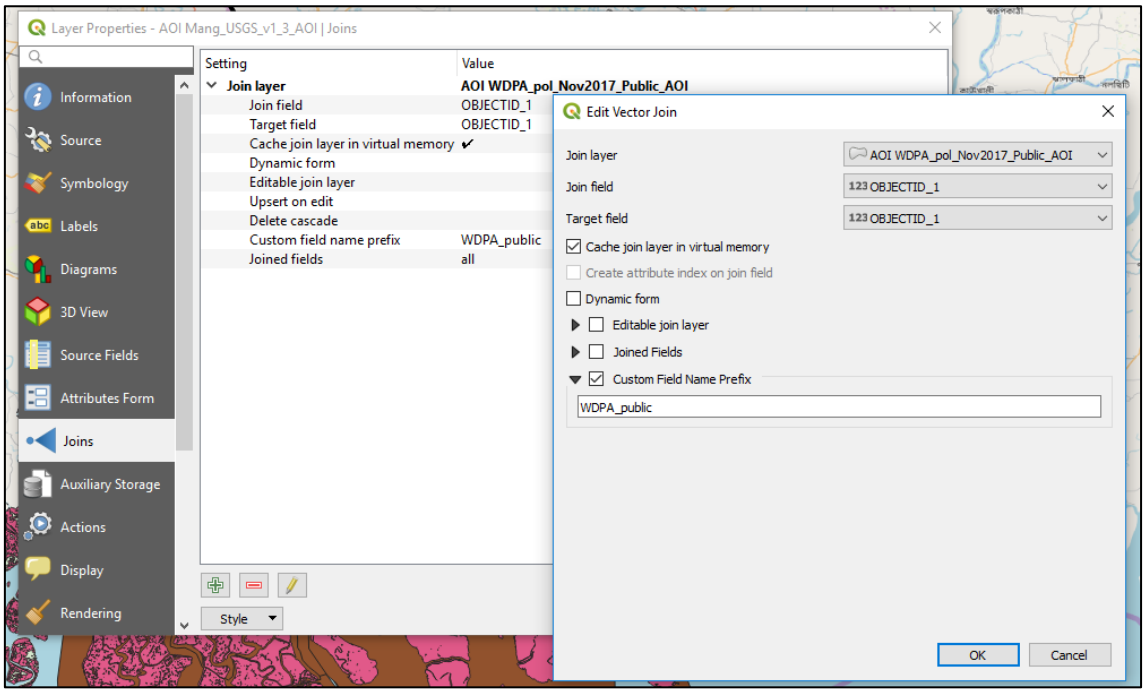
The resulting joined layer will be a new vector layer that is an extended version of the input layer. The new layer has additional attributes in its attribute table, based on the spatial criteria. If you do not want the records that did not match with your output layer, check the box for **"Discard records which could not be joined"**.





2.8.2 Vector joins

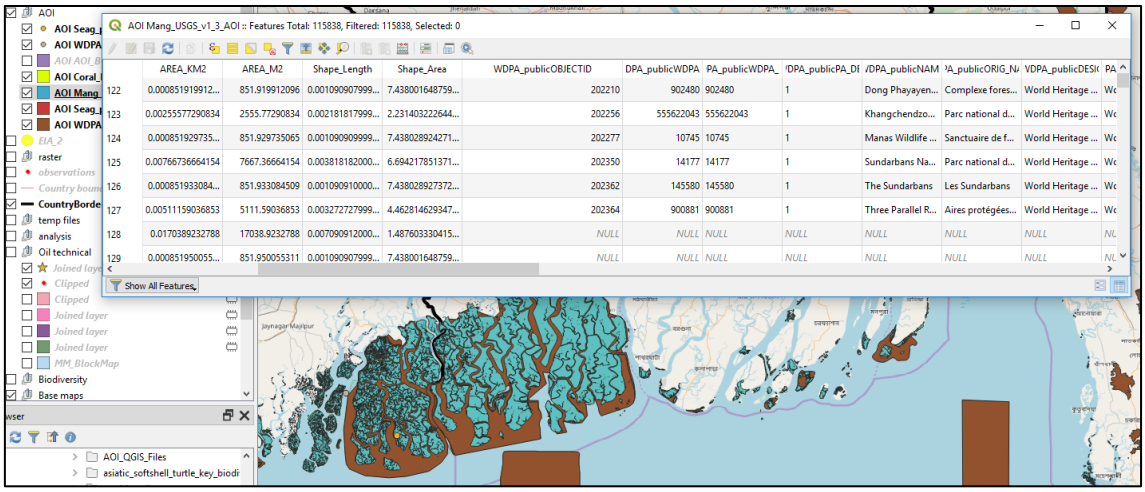
Vectors may also be joined in the joins section of the layer properties. This is a way to associate data in one table with data in another. It may be used either between two vector layers or between a vector layer and a non-spatial dataset, such as a table. This is excellent if you have a table or spreadsheet you want to link with your existing spatial data.



You can access it from the **<Layer properties>** in the tab **<Joins>**. Open it up for the layer you want as your input layer for the join. Select the join layer. Then select the field with unique id for both the join field and the target field, this is how the two datasets will be matched. All information from the join layer and the target layers will be displayed in the attribute table of

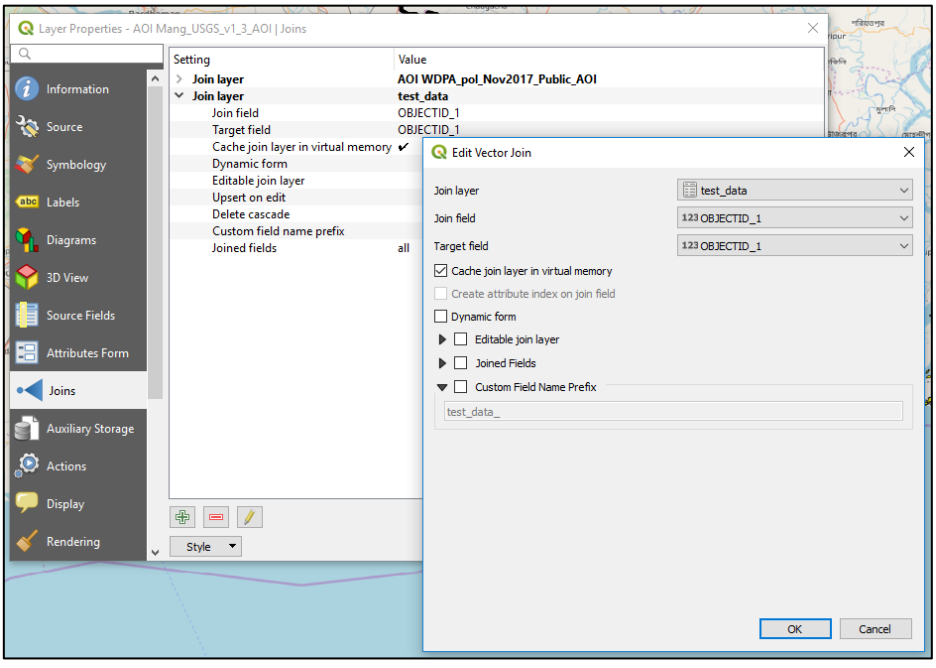
the target layer as joined information. If you only want specific fields added from the join layer, select them in “Joined Fields”. If you want to be able to edit join features from the target attribute table, you have to select “editable join layer”.

Click **<OK>**. The join result will show in the Joins window. The selected fields will now appear when you open up the attribute table of the input layer.



If you get no data (NULL) values in these fields, it means there was no overlap between the features. For instance, the turquoise vector layer *(shown above)* was chosen as **<Input layer>** and the brown vector layer was chosen as the **<Join layer>**. For turquoise features that do not overlap the brown features, the values of the join fields will be NULL. For the features that do have a spatial overlap, the values are shown in the joined fields.

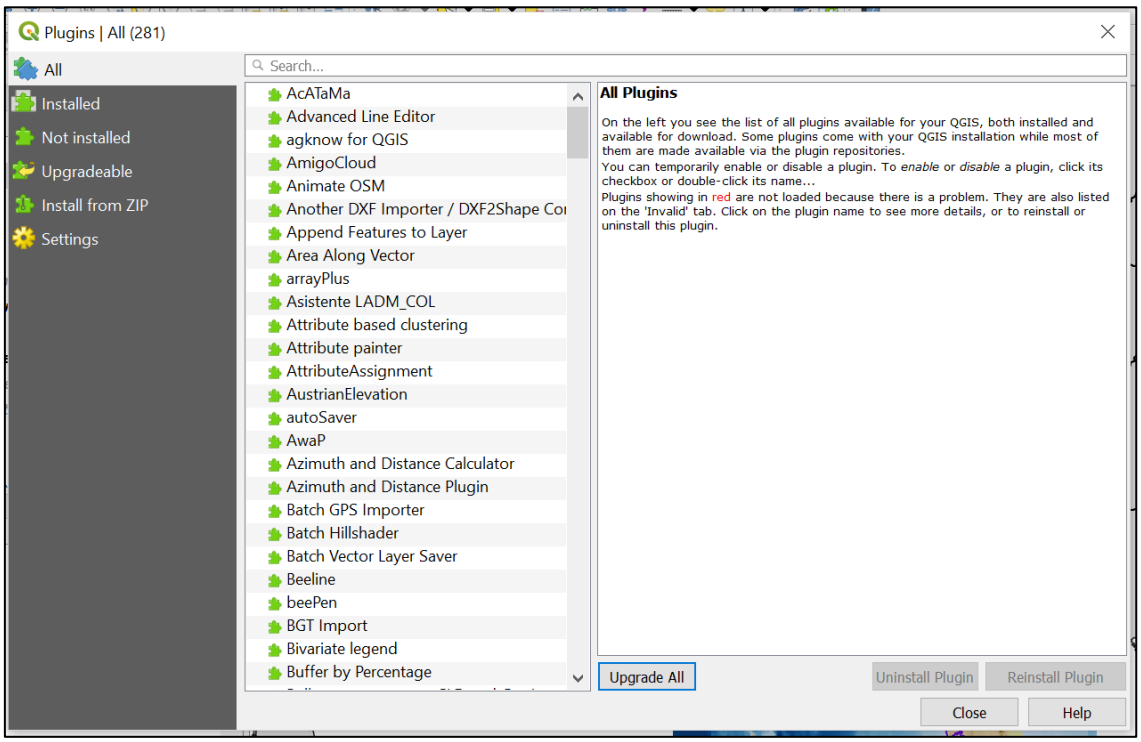
It is also possible to join a vector layer with a non-spatial layer. Select join field and target fields with unique ID’s. The data from the text file, is added based on the selected join fields.



2.9 QGIS Plugins

Plugins in QGIS add useful additional features which enhance the software. Many contributors share tools that can simplify our work. They are written by QGIS developers and other independent users who want to extend the core functionality of the software. The plugins are made available in QGIS for all users.

An easy way to browse and install plugins is to use the **<Plugin Manager>** tool. You can reach it from the menu: **Plugins > Manage and install plugins**.

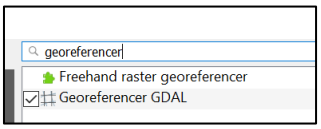


In the **<All>** tab, search for plugins in the search field at the top of the **Plugins** window. If there is a specific function you need, you can search for it. Often someone has created a plugin for the function you are looking for.

Here is a list of some useful plugins that you may install or activate (for core plugins):

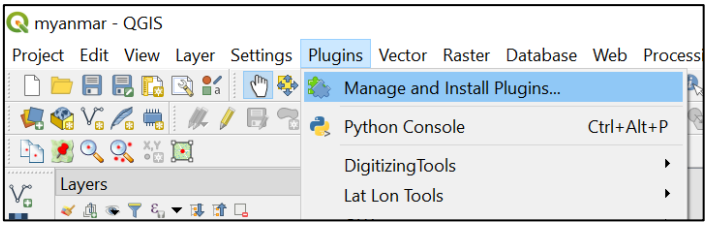
- QuickMapServices (Collection of easy to hold basemaps)
- Map Library (a map library which makes it easy to add much used maps)
- Group Stats (Stats and anlysis for vector layers data)
- Coordinate capture (activate it)
- Lat Lon Tools (Tools to capture and zoom to coordinates)
- Grass 7 (activate it)
- GPS Tools (activate it)
- Georeferencer (activate it)
- Geometry checker (activate it)
- Digitizing Tools (Subsumes different tools useful during digitizing sessions)
- OpenLayers Plugin (Google Maps, Bing Maps, OpenStreetMap layers and more)

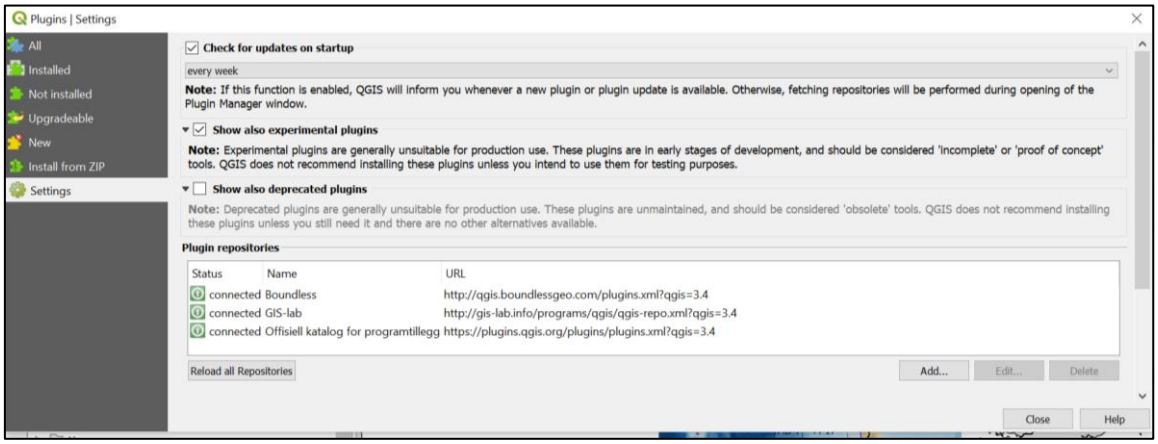
There are core plugins and there are external plugins. Core plugins are already part of the standard QGIS installation. To use them, you just need to enable them in the plugin manager tool. One of the core plugins is the **Georeferencer GDAL**, which will be described further down.



Plugins are located into repositories. The default repository is the official one and is added to QGIS by default. This is the standard repository that you will be searching in when you enter the Plugin Manager tool. There are also some contributors that maintain their own repositories, and if you wish you may add them as well. They are available in the QGIS Plugins Repository and need to be installed by the users before using them. Two important ones are Boundless Plugin repository (http://qgis.boundlessgeo.com/plugins.xml) and GIS-Lab repository (http://gis-lab.info/programs/qgis/qgis-repo.xml).

Click on **Plugins > Manage and Install Plugins > Settings to add/change/remove repositories.**

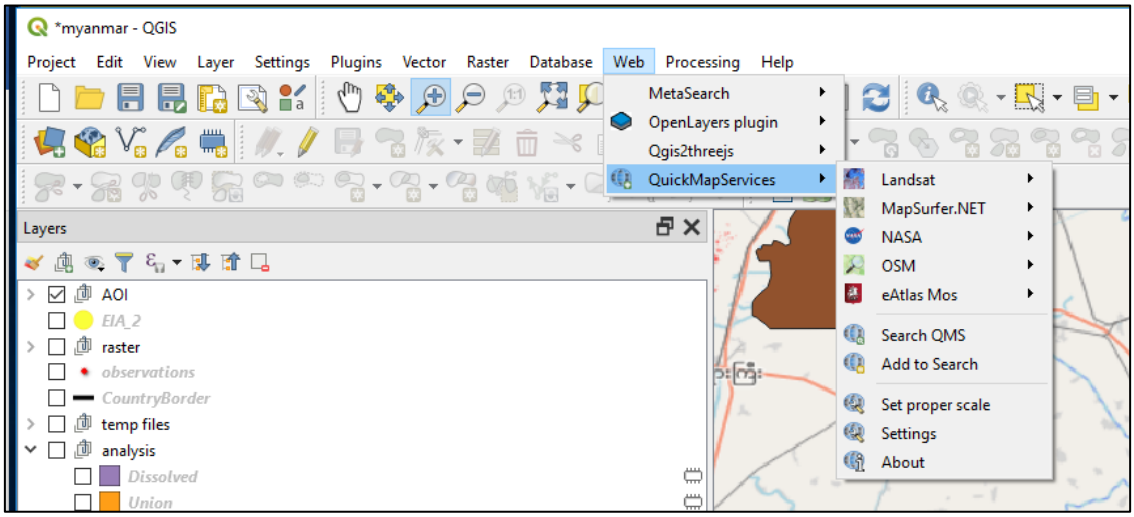




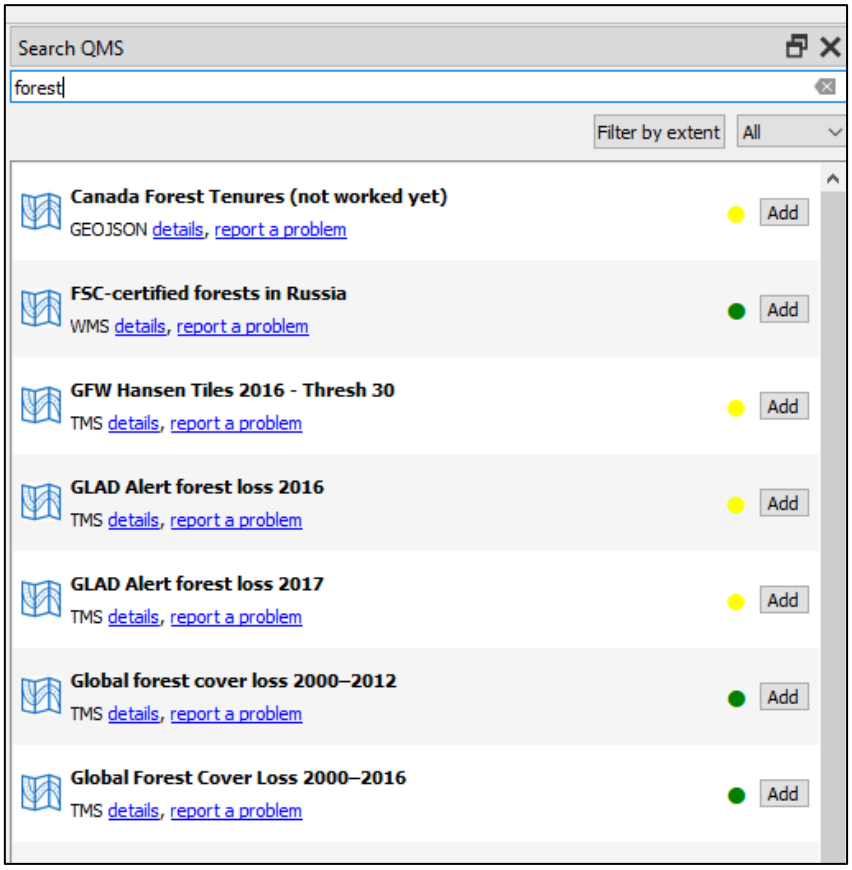
Useful plugins

QuickMapServices

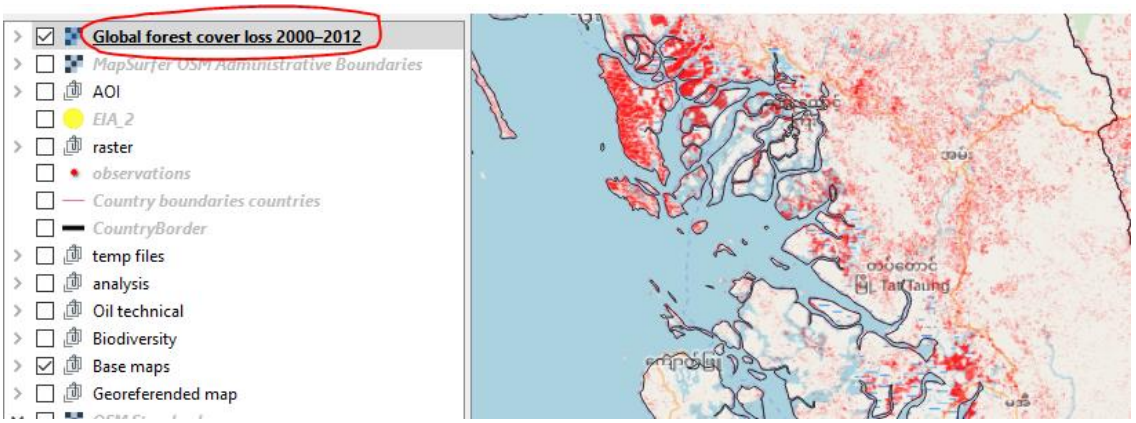
QuickMapServices is a very useful plugin in QGIS. It includes a collection of easy to add basemaps. Add it to QGIS from the Plugins repository: **Plugins > Manage and Install Plugins.** Search for it in the search field, and then choose “Install Plugin”. It will be available to you from the **Web > QuickMapServices** menu.



Add the Open Street Map standard map: **OSM** standard. This is a very useful web service basemap. You may also search for available service maps from **"Search QMS"**. When you click it, you will get a window where you can search for available Web Map Services:

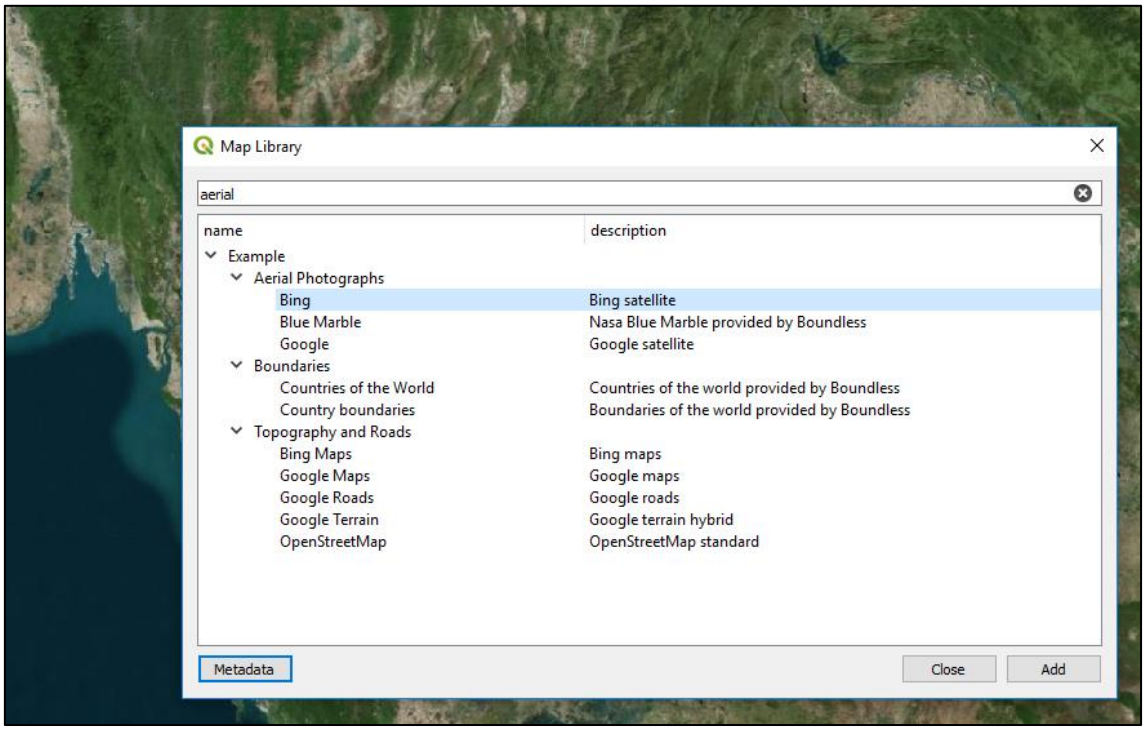


In this example we have searched for services with the tag "forest". The services marked with green are valid for use. You may filter out the valid layers in the "Filter by extent". If you find a service of interest, click add to get it into the QGIS project. In the example below, we have added the service "Global forest cover loss 2000-2012".



Map library

Map library is another useful plugin, which makes it easy to add useful maps to your project. Add it from the Plugins repository. You will then get access to it from the Web-menu bar. Open it up and search for available maps.



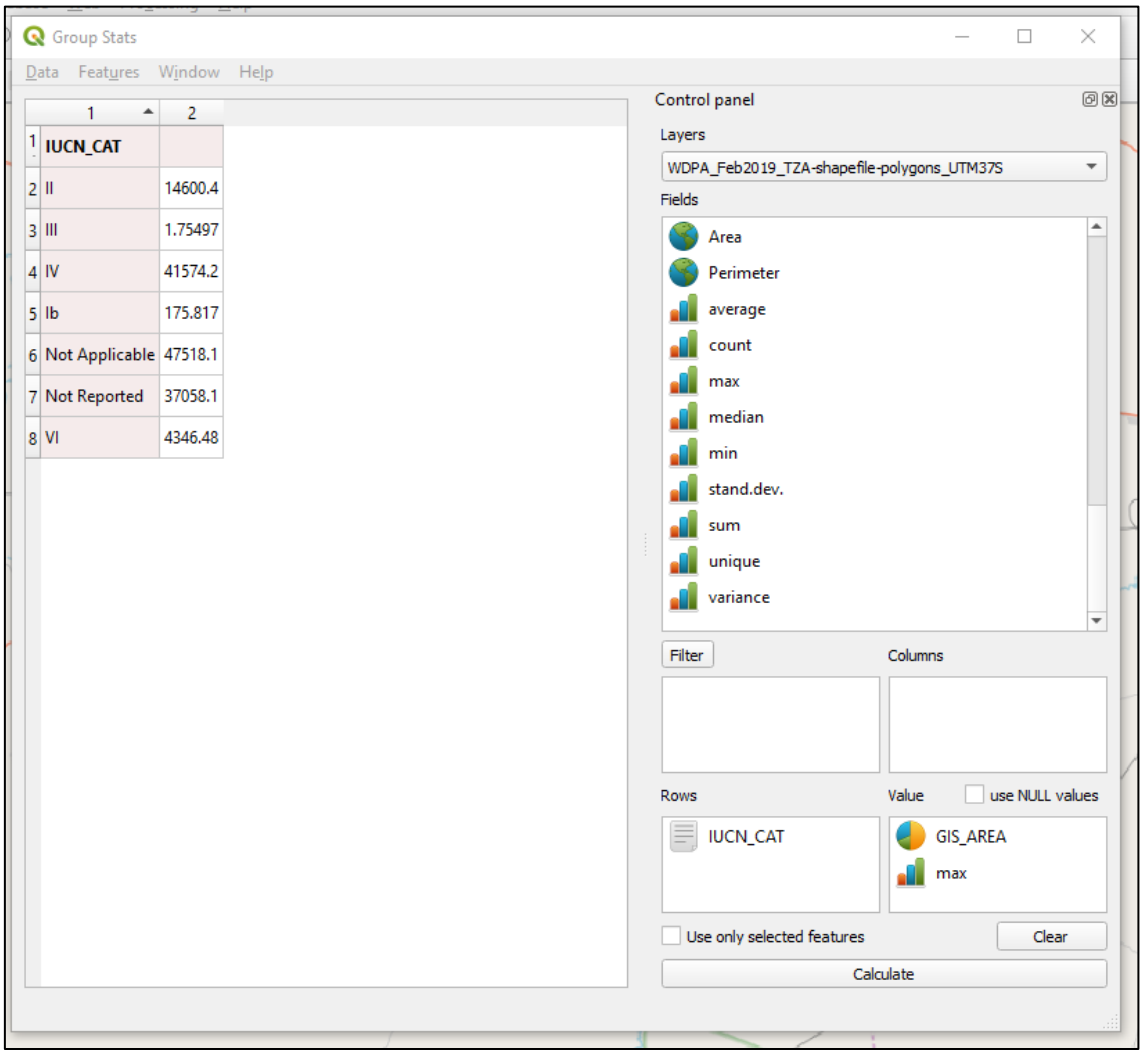
Group stats

Simple statistics can be calculated from vector layers using the standard QGIS tools from the **Vector > Analysis Tools > Basic statistics or Vector > Analysis Tools > List Unique Values** menus. However, these are not sophisticated enough for summarizing the results of overlay analyses.

The **Group Stats** plugin is useful for creating summary statistics about a dataset based on groups of features. It is similar to a pivot table in Excel.

1. Click on **Plugins > Manage and install plugins.**
2. In the All section, search for Group Stats and install the plugin.

3. One installed, Group Stats can be accessed from the **Vector > Group Stats** menu.
4. Drag a summary field into Rows.
5. Drag a function into Value.
6. Drag the value to summarise into Value.
7. Click Calculate to calculate the summary statistics.

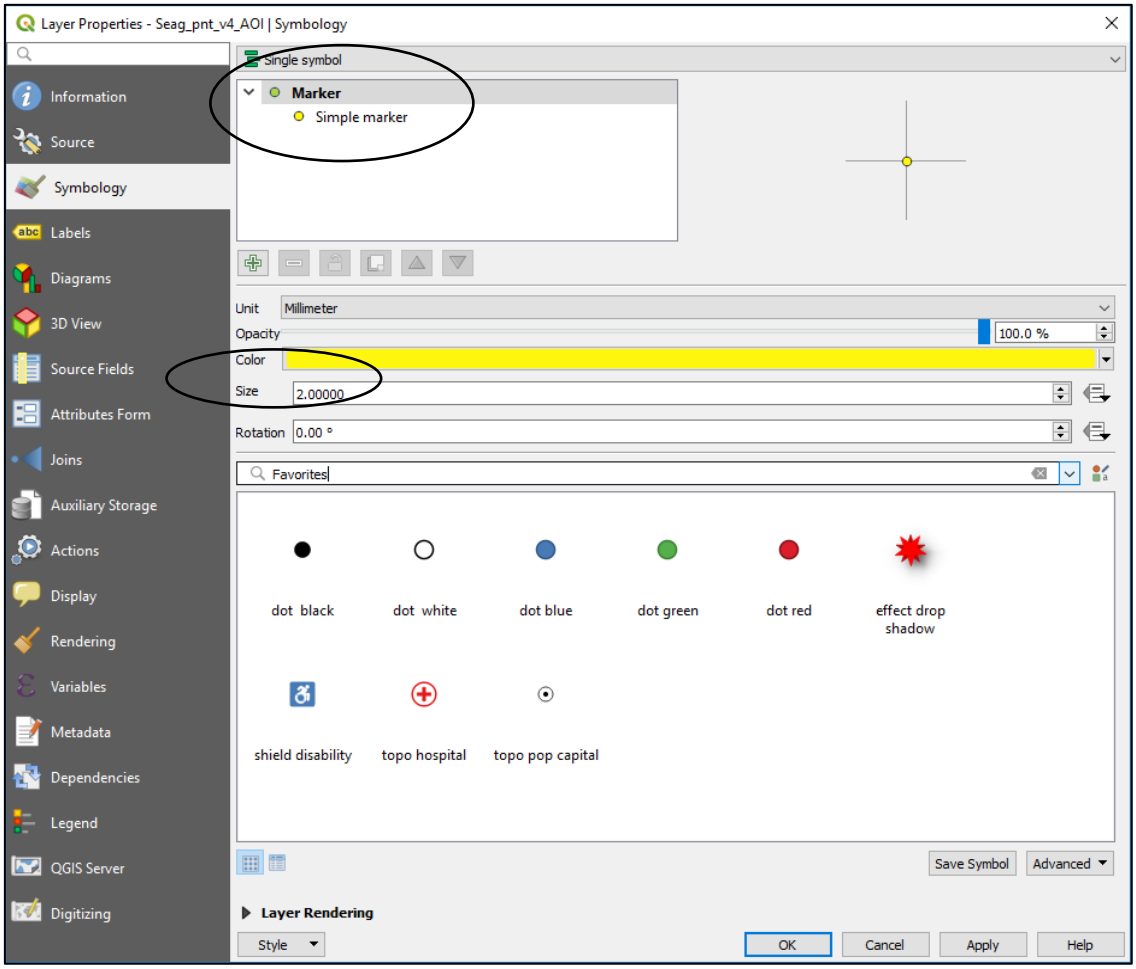


3. Cartography and styling

The cartographic functionality in QGIS is excellent and compares very well to features in ESRI ArcMap. QGIS offers advanced functionality to style your map just as you like it. In this chapter we will rapidly go through some of the most useful functionalities. We will use a combination of point, line and polygon layers. Make note that there are some small differences between the styling capabilities of each data type, but the functionality is similar for all.

3.1 Single symbol style

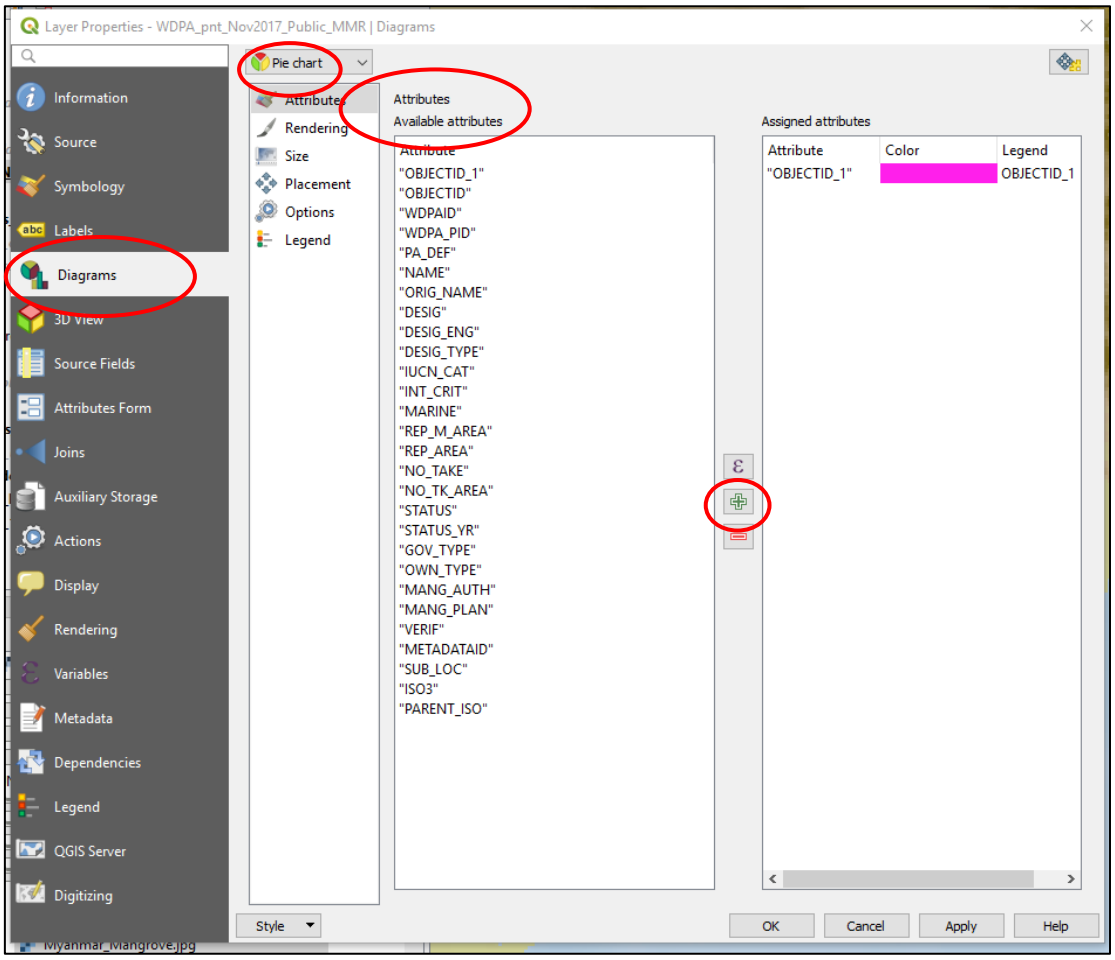
Right click the layer you want to style: select **Layer properties > Symbology** in the left selection.



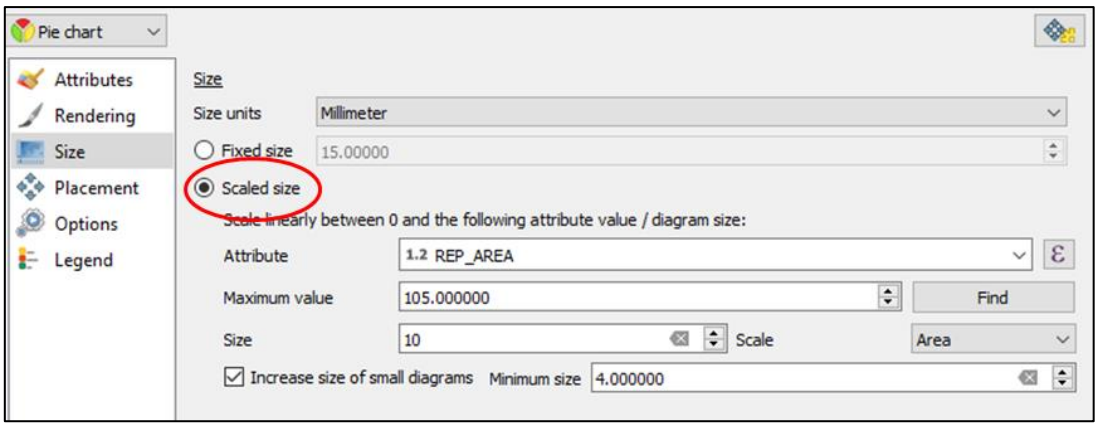
In this interface you can choose to symbolize all features with a single symbol. The marker is as a default a “Simple marker”. You may change the size and color along with other variables.

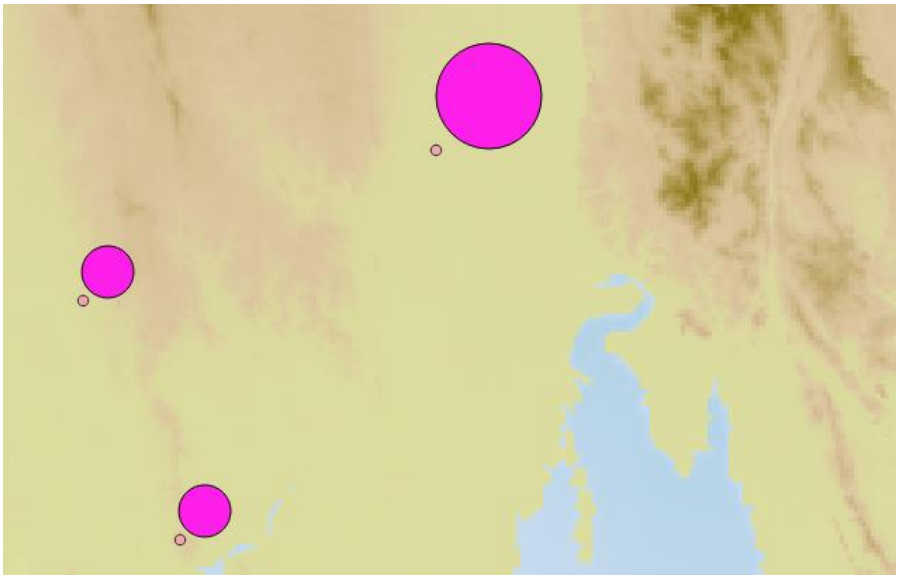
3.1.1 Changing the size according to the value of an attribute

You can scale the symbol (for points primarily) according to the value of an attribute. Choose “diagrams” – “pie chart”. In the attributes field, you select an attribute that best represents the objects you wish to scale. Mark it and use the plus symbol.



Then go to the size menu and select the scaled size. Select the attribute field that you want to control the scaling. Pay attention to what you are scaling: you can choose between area and diameter. Notice that you can also choose an “expression” which can be very useful for normalizing your data. Set maximum value to the max scale area. Then change the size and the minimum size for the scaled symbols. Hit “apply” and take a look at the resulting map.

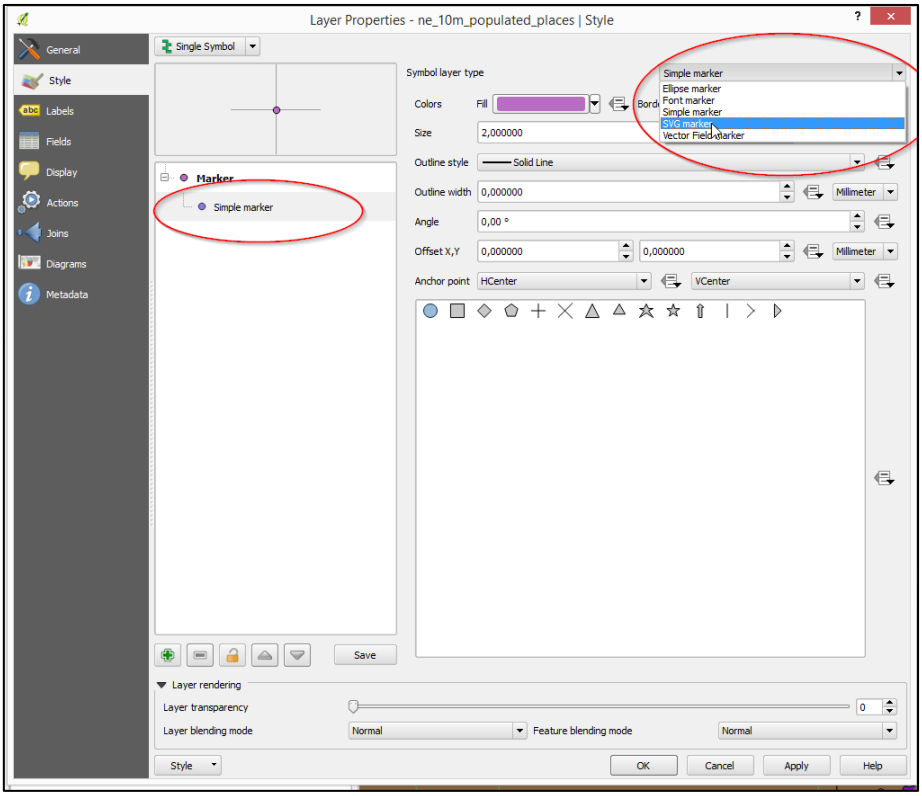




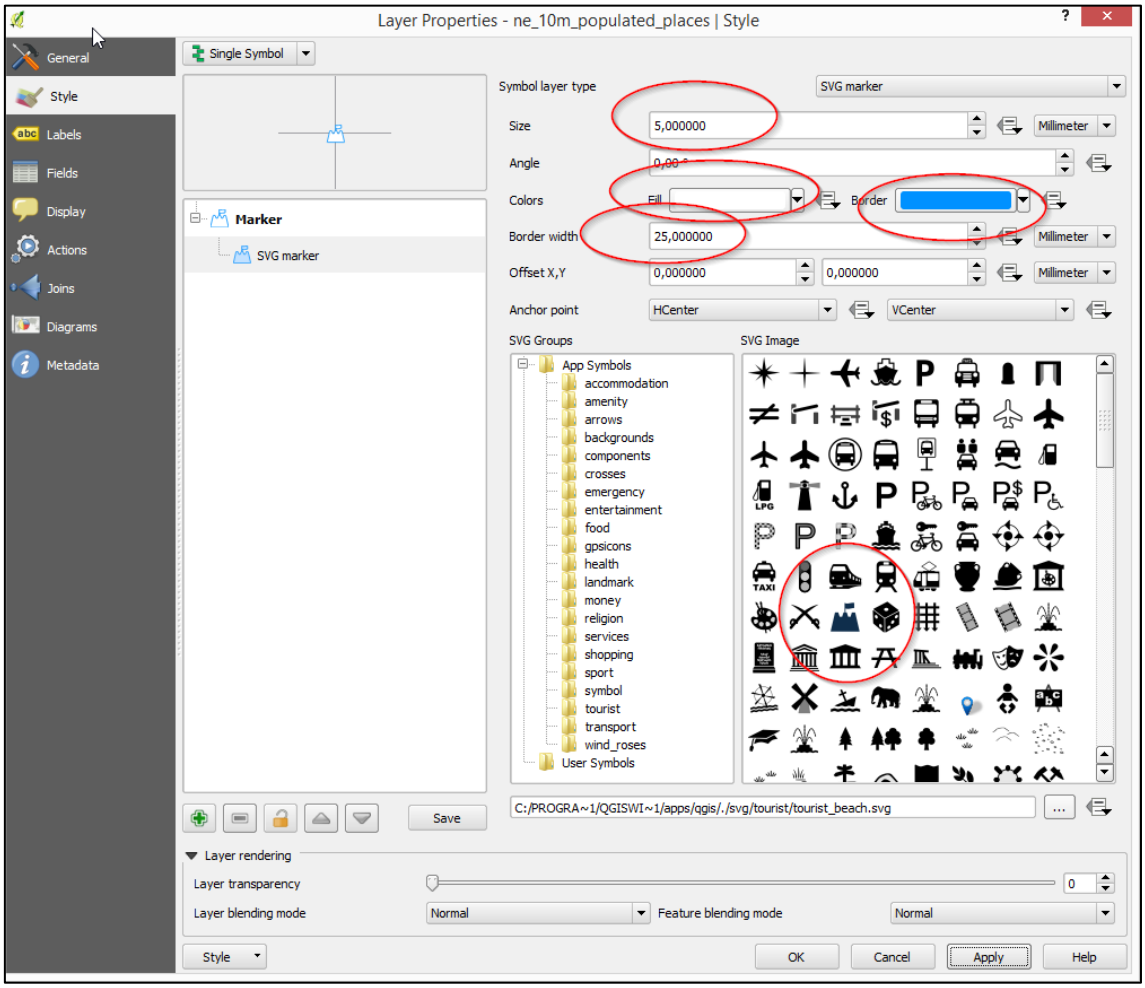
3.1.2 Changing the symbol and style of vector symbols

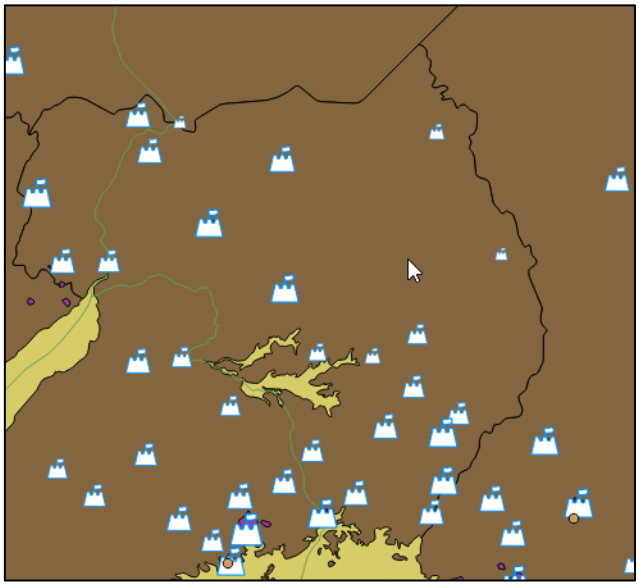
Note: The screenshots in this section use an older version of QGIS; these will look slightly different in newer versions.

You can select more graphic symbols by changing the marker from a “simple marker” to a “SVG marker”. QGIS comes pre-defined with an array of different markers you can choose from. Each of these are scalable and customizable in terms of size, color, border color and rotation. Select the “simple marker” and choose “SVG marker” in the dropdown list.



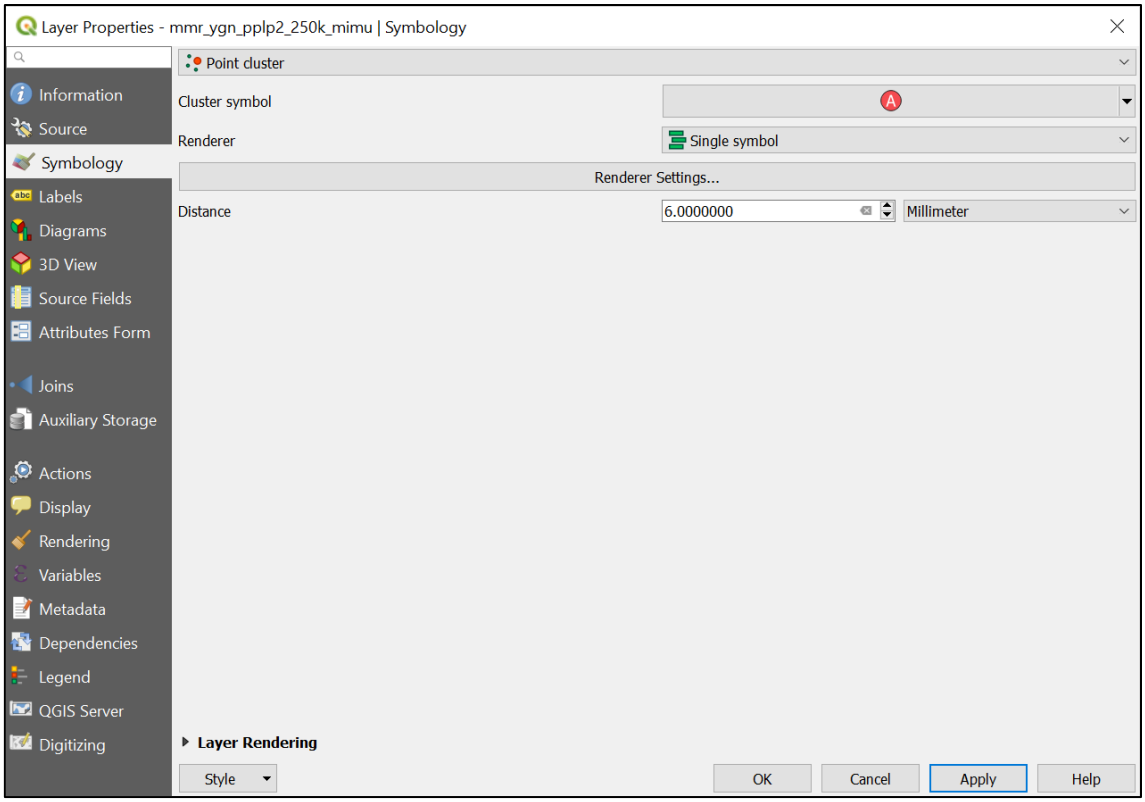
Select an icon of choice—set the size, fill color, border color and border width. Choosing contrasting border and fill colors gives a better readability than similar colors, or single colors, and makes the icon “pop out” regardless of background or overlaps. Notice that the symbols are scaled according to the scaling set earlier.

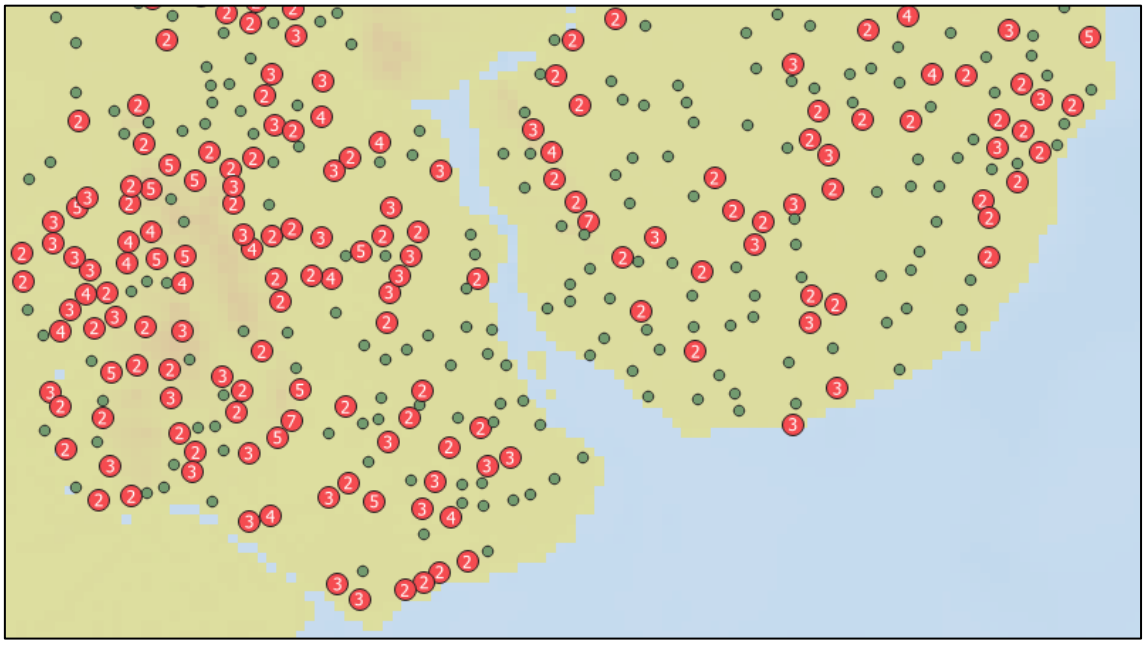




3.1.3 Point clusters

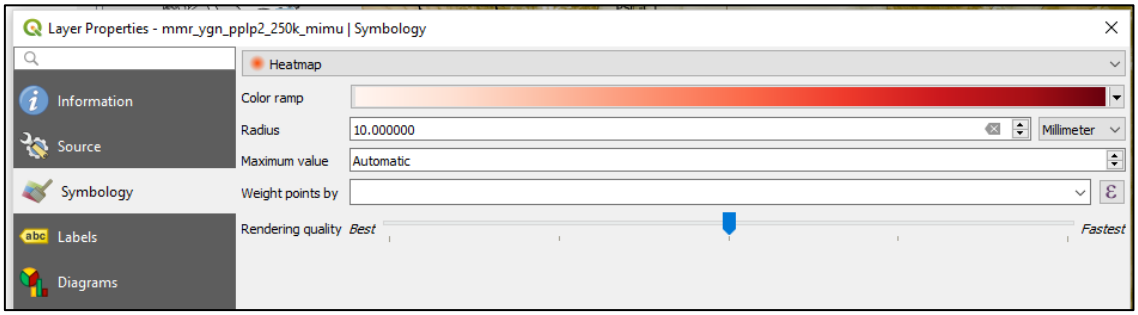
Point clusters can be useful for point representation, to make a map with many points more readable. It is mainly used in web maps/interactive maps. Decide yourself the distance for the points to cluster and the cluster symbol. The number in the cluster symbol tells about how many points the point is representing. When you zoom in the number will change and eventually all of them will be represented as single points.

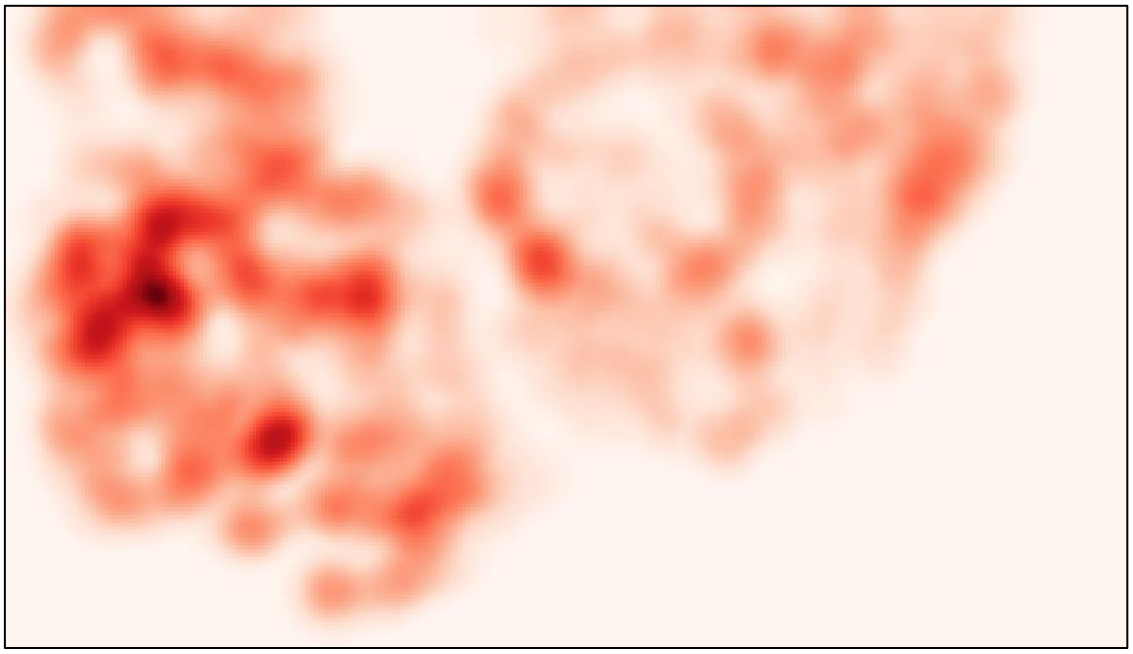




3.1.4 Heat maps

Another way of representing points are the use of heat maps. The darkest color in the map is representing the highest density of points in the map. You can choose the color ramp and the radius for the heat map. It is also possible to weight points by an attribute.



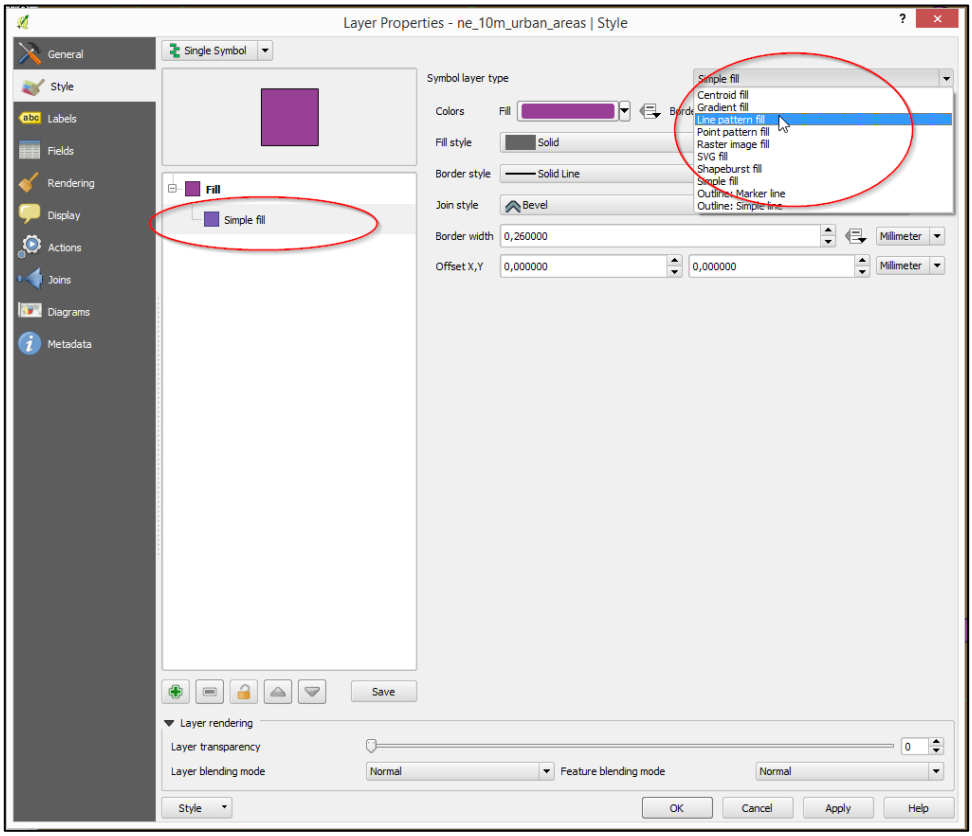


3.1.5 Texture polygons

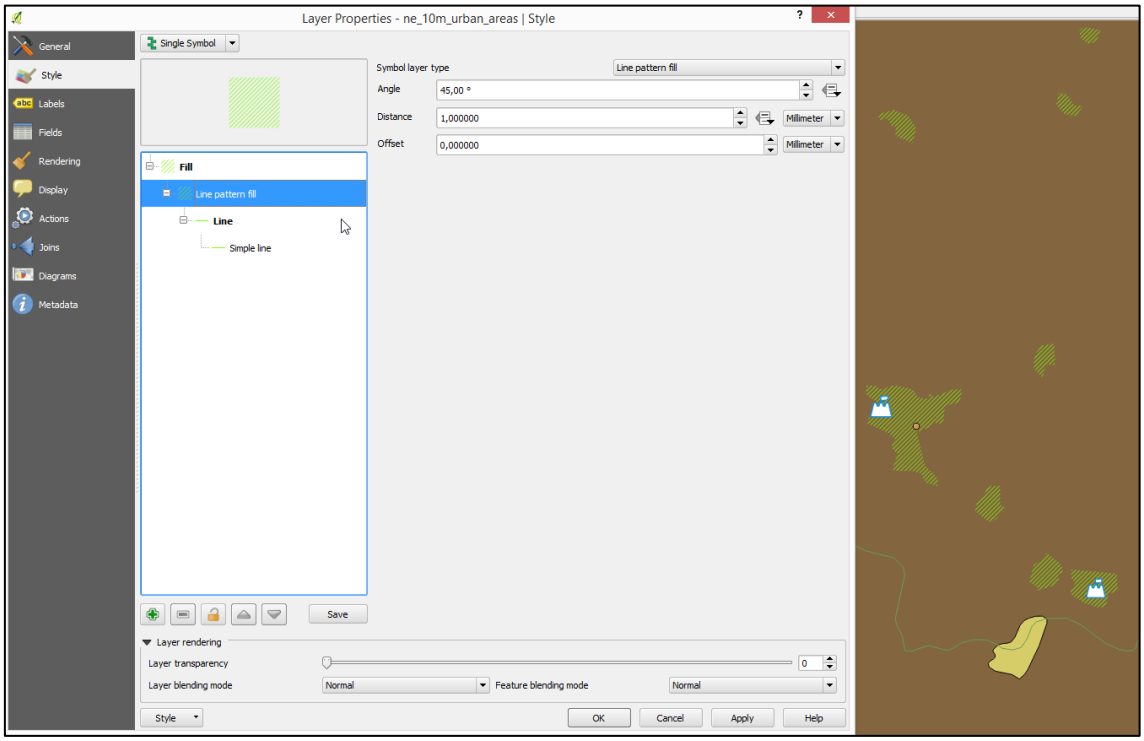
Note: The screenshots in this section use an older version of QGIS; these will look slightly different in newer versions.

Using patterns on areas to represent a value is a powerful cartographic tool. The benefit of clearly standing out, while at the same time allowing the background to shine through is often a much-desired effect in thematic map making.

Open the **<Layer Properties>** and **<Style>** (or symbology) of the layer you like to visualize. It should be a polygon layer. Select the “Simple fill” and change it to a “Line pattern fill” using the dropdown as illustrated in the figure below.



Now you can control the pattern **Angle**, **Distance** (density) and **Offset**. Often a dense pattern is desired on smaller areas, while a bright color helps to make the pattern clearer. You can also change the type of line that forms the pattern. Try with different angles, like 0°, 45° or 90°. See that you can have overlapping areas and still retain readability by using a pattern with different color, angle and distance!

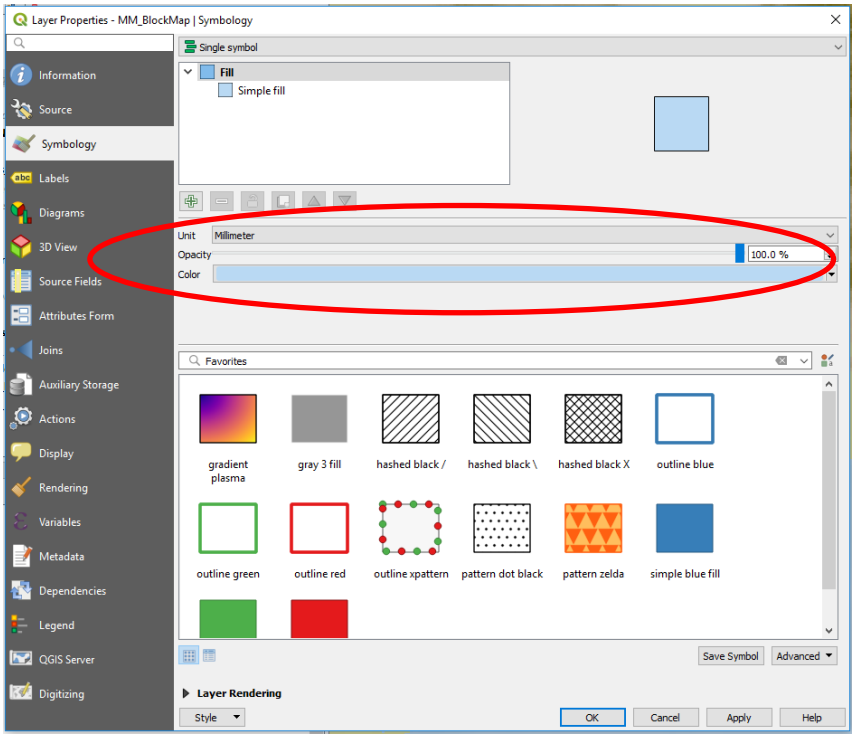


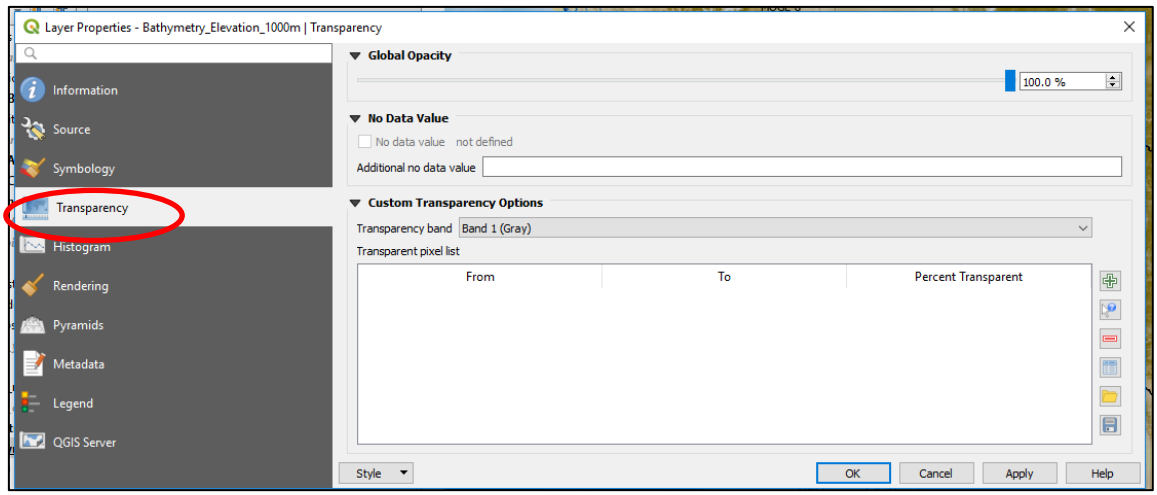
3.2 Classification and styling: standards

Setting clear classification standards can help to make maps clearer to those who are viewing them. For instance, classification standards may define a set colour (RGB) and symbol for cities, roads, administrative boundaries, protected areas, or other frequently used features.

3.3 Transparency

Layers can be transparent, which allows you to see through the layer. This can be very useful when digitizing and also for visualization. Setting the transparency of the whole layer can be done using the **Symbology > Opacity** field (or **Style > Opacity**, in some versions) for vectors, or **<Transparency>** tab for raster layers.





3.4 Blending modes

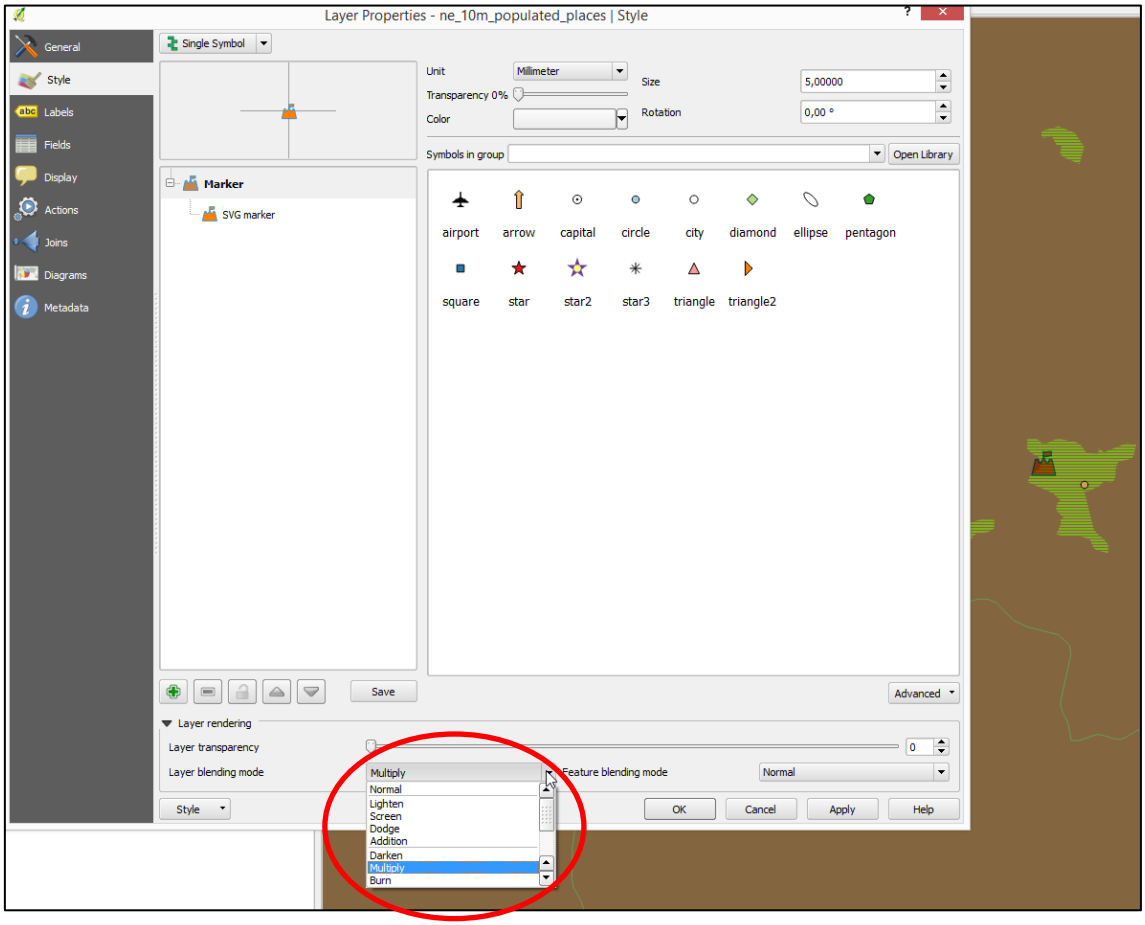
Note: The screenshots in this section use an older version of QGIS; these will look slightly different in newer versions.

Blending is a graphical rendering technique. It is fairly advanced, and we will illustrate one useful mode. Experiment and read more on the subject in graphical text books and resources. It is a very useful technique to "magically" merge different overlapping layers into each other—without using transparency! Often, blending modes is what takes a map from okay to excellent.

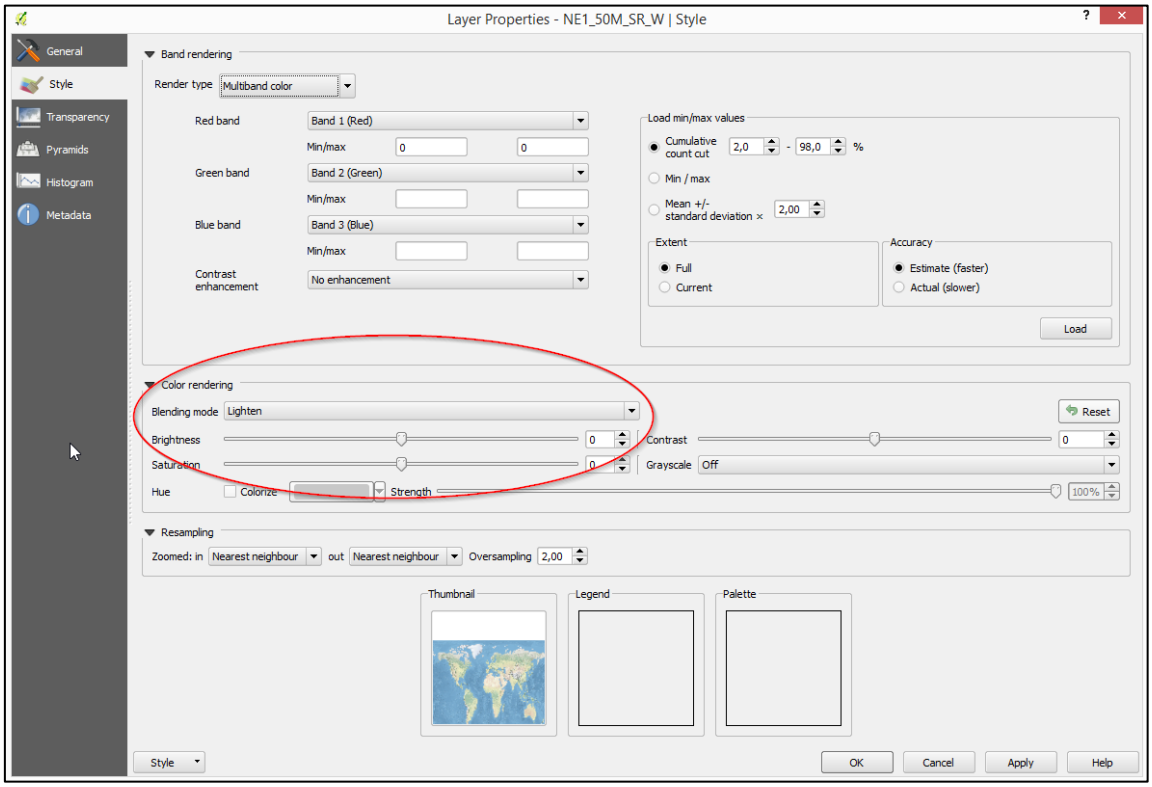
Layer and feature blending are found in the **<Symbology>** (or **<Style>**) properties of a vector layer: choosing **"Multiply"** is often a good start. Notice how the icons now blend into the background *(see below)*.

With blending 

Without blending: 


Layer Properties - ne_10m_populated_places | Style
General
Style
Labels
Fields
Display
Actions
Joins
Diagrams
Metadata
Single Symbol
Unit
Millimeter
Size
5,00000
Transparency 0%
Color
Rotation
0,00 °
Symbols in group
Open Library
Marker
SVG marker
airport
arrow
capital
circle
city
diamond
ellipse
pentagon
square
star
star2
star3
triangle
triangle2
Save
Advanced
Layer rendering
Layer transparency
0
Layer blending mode
Multiply
Normal
Lighten
Screen
Dodge
Addition
Darken
Multiply
Burn
Feature blending mode
Normal
Style
OK
Cancel
Apply
Help

For a raster layer, the **<Blending mode>** is found under **<Symbology> (<Style>),** but the interface is a bit different:



3.5 Color schemes: varying color according to attributes

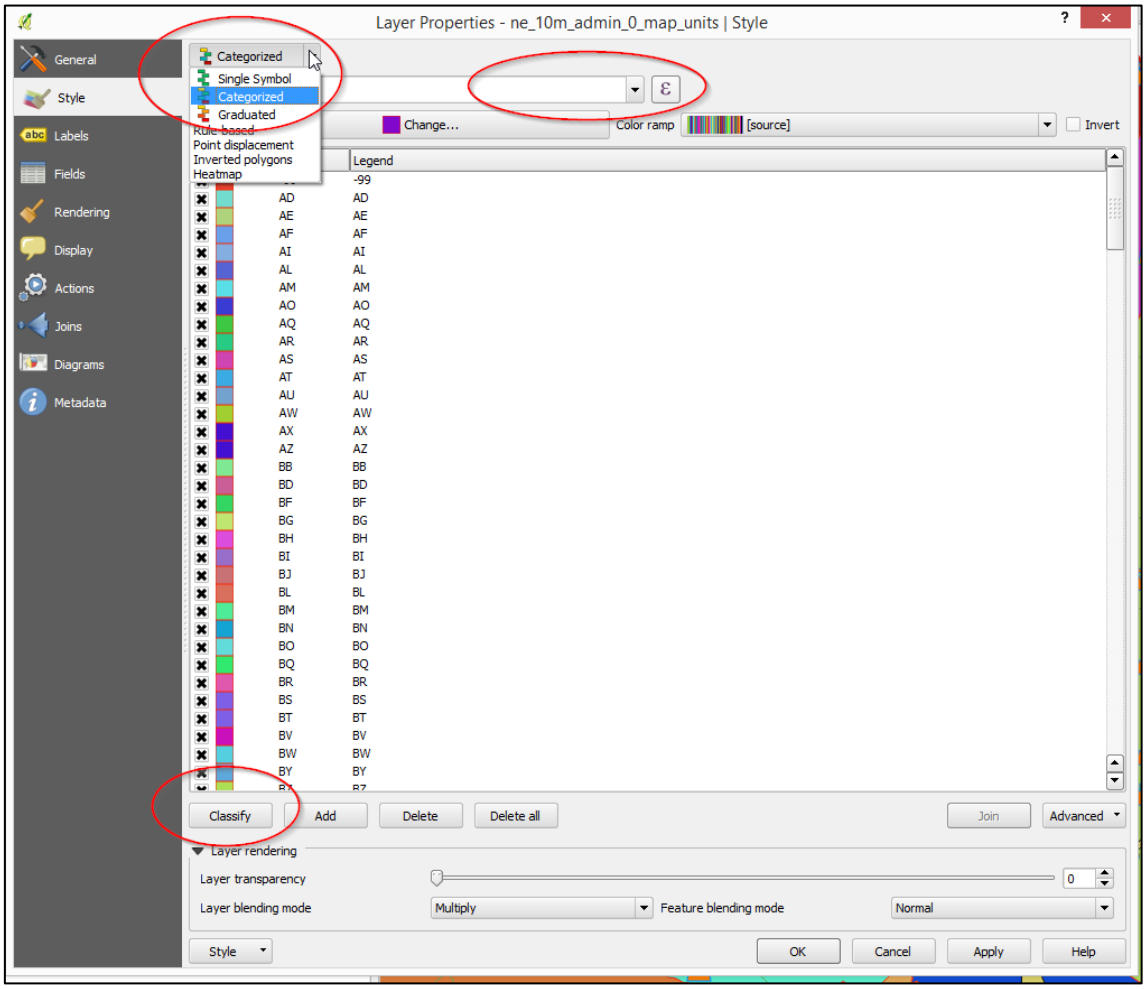
Note: The screenshots in this section use an older version of QGIS; these will look slightly different in newer versions.

When making a thematic map, you would often like to use symbology that differs according to an attribute value of the object. This can easily be achieved using two different methods of colorizing the objects: **Categorized scheme (also known as qualitative)** or **Graduated scheme (also known as quantitative).**

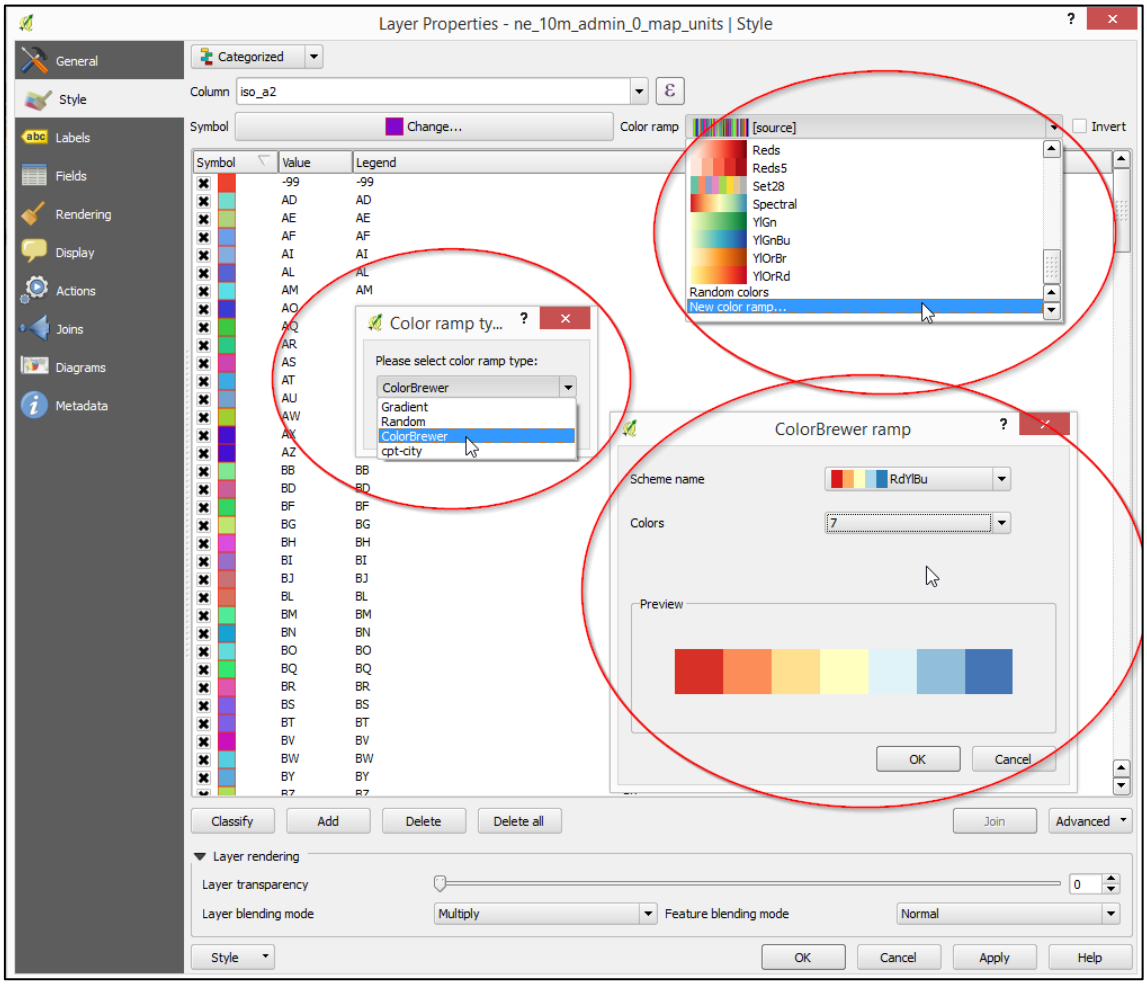
Categorized color scheme

A categorized color scheme is used when you want to map unique values that do not compare directly, i.e. one value is not greater or lesser than another value.

A perfect example is countries that we want to color differently. We start by choosing the **<Categorized>** scheme in the dropdown list *(see image below)*. This gives us the option of choosing *which attribute* or expression should be used to categorize the data. For our country map we use **"iso_a2"** as the category. Select the **<Color ramp>** that you want to use and click **<Classify>** to automatically create rules for all values within the category we choose. Click **<Apply>** to apply the symbology to the map.



You can manually edit the rules and their labels by double clicking them. Try to play around with different color ramps. It is especially useful to add a new color ramp and use **"ColorBrewer"** or **"cpt-city"**— both offer expert-chosen and scientifically-funded color ramps that you can use directly *(see image below)*.

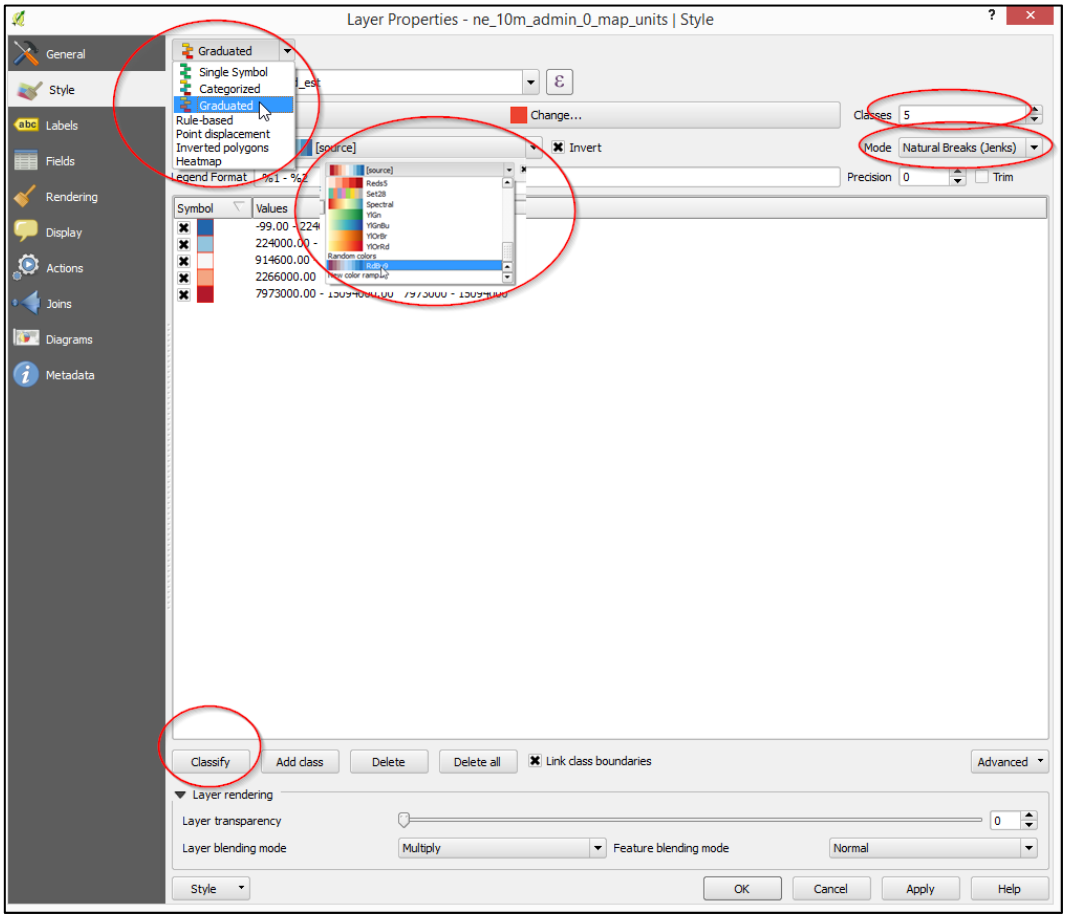


Graduated color scheme

When visualizing values that can be compared—e.g. count data, temperatures—you would use a *graduated* scheme. Graduated schemes are made to visualize ranges of values, typically split into classes so that you can visualize thousands of values within 5 to 9 color classes.

1. Start by selecting the **<Graduated>** style.
2. Select the attribute or expression you want to symbolize.
3. Choose the number of **<Classes>** you want to have, and the **<Mode>** of which these classes are divided.
4. Click **<Classify>** to generate the classes based on the actual values in the attribute you chose.

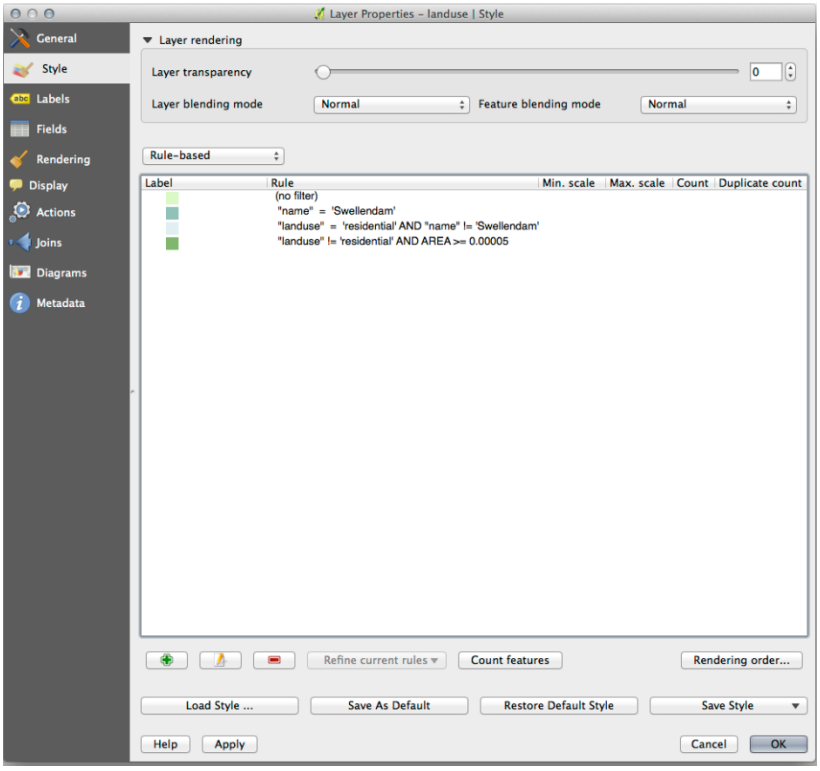
Note: Pay attention to the fact that you should try only to use variables which have a relation to the area that they symbolize. Ideally, the value should be normalized to the area. This is often not the case, and sometimes you can skip this if you are sure you are getting the message of the map clearly across to the reader. You can manually adjust the class breaks by double clicking on the values and the legend entry.



3.5.1 Rule-based styling

Rule-based classification or styling is useful for styling layers on the basis of more than one attribute.

1. Open **<Layer Properties>**, and switch to the **<Style>** tab.
2. Switch the classification style to **<Rule-based>.**
3. Click the **<Add rule>** button.
4. In the new dialog, click the ellipsis button **<...>** and add a rule in the **<Expression string builder>** window.



For further information, visit:
https://docs.qgis.org/2.8/en/docs/training_manual/vector_classification/classification.html.

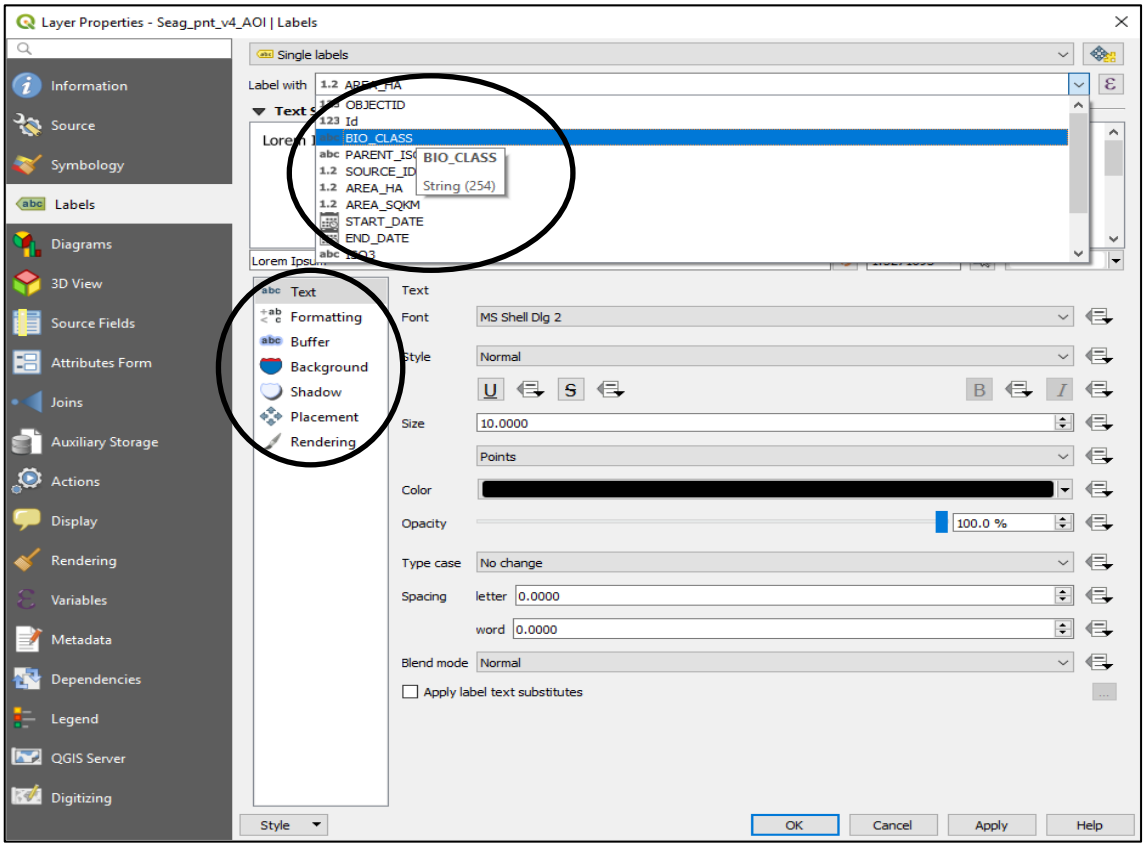
3.6 Labelling

Note: The screenshots in this section use an older version of QGIS; these will look slightly different in newer versions.

Labelling is fairly easy in QGIS and can be combined with other symbology. A practical way of adjusting the position of labels is by making a dedicated point layer with an attribute "labeltext" and generate the points yourself.

Labelling objects in an existing layer

1. Go to **<Layer Properties>** and select **<Labels>**.
2. Select which attribute the label text should come from (in the example below, this is **BIO_CLASS**). Click **<Apply>** and the labels are drawn.
3. Below you find an array of customization options. There is not a one-fits-all solution—but good practice is to use a "sans serif" text type (under **<Text>**), avoid overlapping and use **<Buffer>** with contrasting colors for clearer text. Text size can also be changed dynamically from an attribute value or expression.



Creating layer definition files

Layer Definition Files (.QLR) save all characteristics of a layer, such as its source, projections, spatial filters, styles and labels, so it can be reopened with these characteristics. Once a layer is setup with the characteristic you would like, right click on the layer and **<Save as Layer**

Definition File>. Layers can be added with their corresponding .QLR via **Layer > Add from Layer Definition File.**

4. Creating new layers

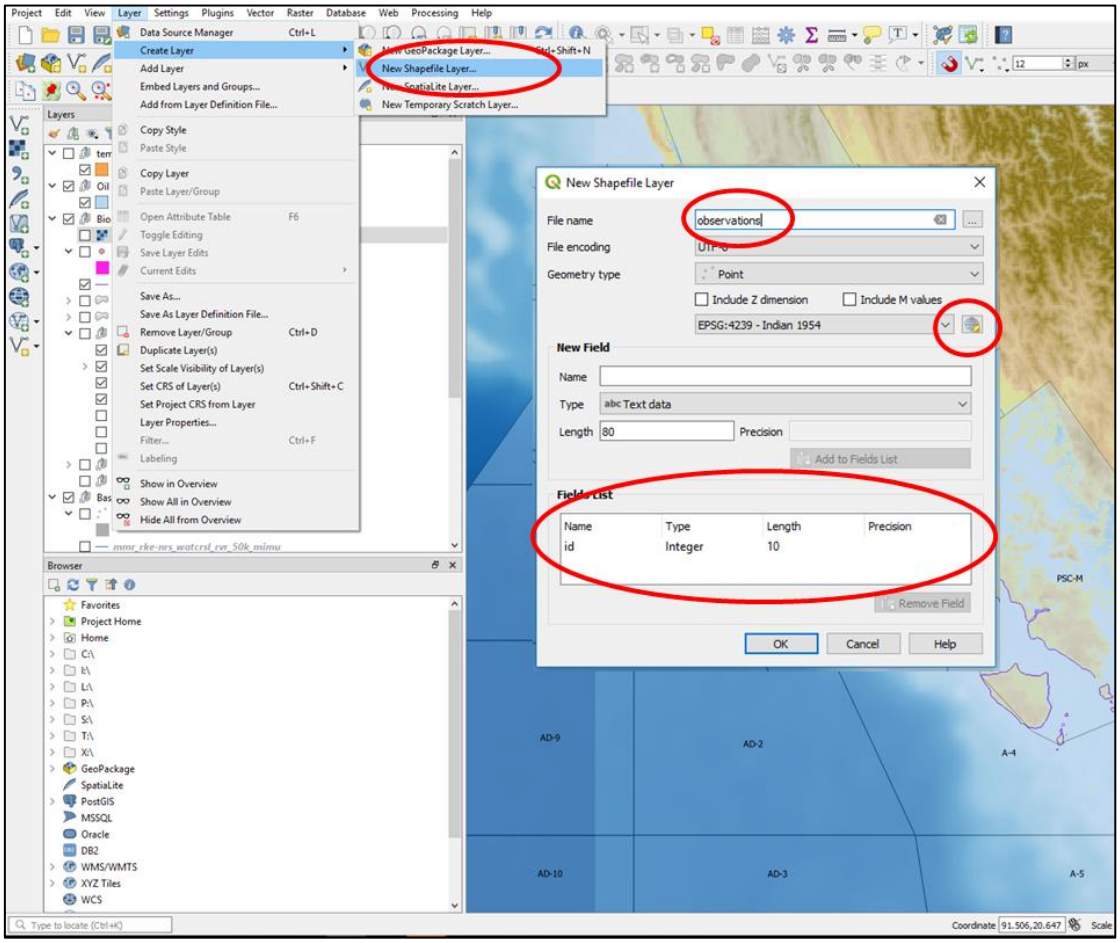
QGIS allows you to create new Shapefile layers, new SpatiaLite layers, new GPX layers and new Temporary Scratch layers. This can be useful when you are about to do some field work and wants to record your observations in a separate file before updating an existing dataset, for instance.

4.1 Creating a new shapefile layer

To create a shapefile layer:

1. Select **<Layer>** from the menu, and go to **Create layer > New Shapefile Layer**.
2. Specify:
    - The layer **<File name>**.
    - The **<Geometry type>. It is important to select the geometry type that you want to work with (either point, line or polygon) as it will only allow you to add this geometry type to the layer**
    - The coordinate system.
3. Add attributes that you want to store along the objects (geometries), under **<Fields List>**.

When you have created the new layer, it is automatically added to the layer manager. You are now ready to edit the layer and add features to it.



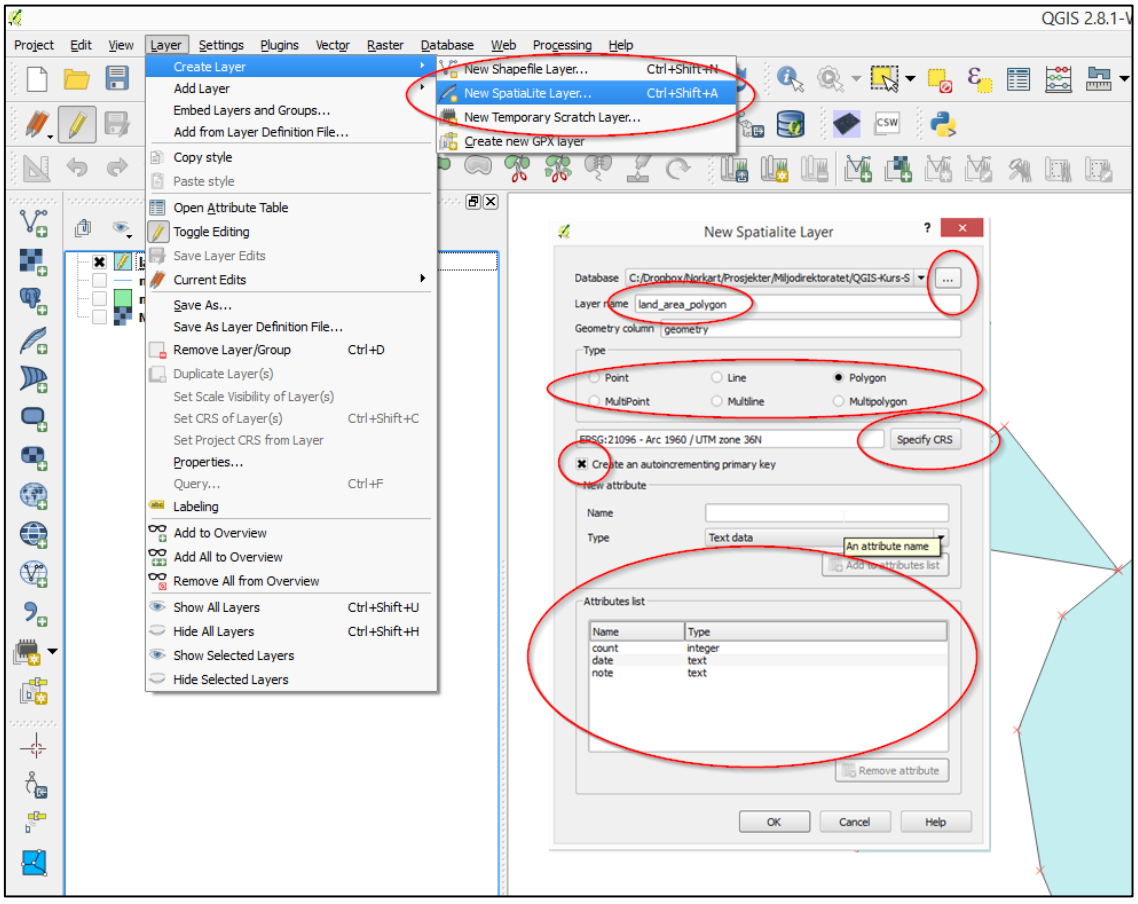
4.2 Creating a new file database and layers

Note: The screenshots in this section use an older version of QGIS; these will look slightly different in newer versions.

To create a new file databases and layers:

1. Select **<Layer>** from the menu, and got to **Create layer > New SpatiaLite Layer**.
2. Specify:
    - The **<Layer name>**.
    - The geometry **<Type>.**
    - The coordinate reference system, through **<Specify CRS>**.
3. Add attributes that you want to store along the objects (geometries), under **<Attributes List>**.

When you have created the new layer it is automatically added to the layer manager. You are now ready to edit the layer and add features to it.



4.3 Creating new temporary scratch layers

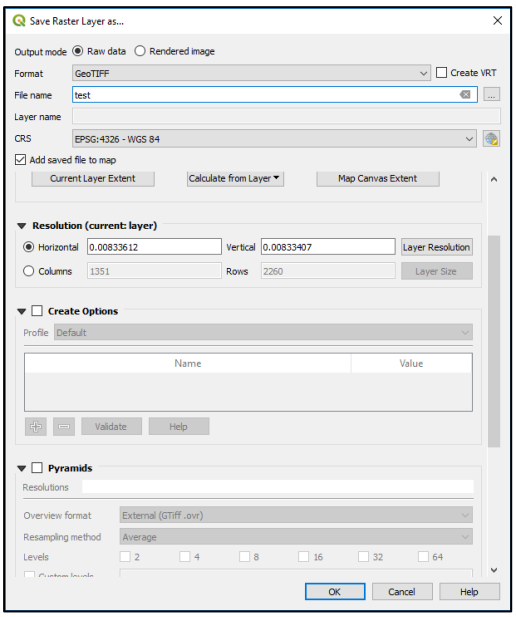
Temporary scratch layers are temporary layers, which are not saved on the disk. They will be discarded when QGIS is closed. When you need to store features temporarily, or as intermediate layers during geoprocessing operations, they can be useful.

Creating a temporary scratch layer:

1. Select **Layer > Create layer > New temporary scratch layer**. You can also reach it by clicking this button: 
2. Specify:
   a. The layer name.
   b. The geometry type.
   c. The coordinate reference system.
3. Select **<OK>** to create the temporary layer. *Note:* By default, it does not have any attributes. It is possible to add attributes to the layer from the attribute table.

4.4 Creating new layers from an existing layer

Vector and raster layers can be saved in a different format or reprojected to a different coordinate system either by using the **Layer > Save As** menu or by right-clicking on the layer in the **<Layers Panel>**.

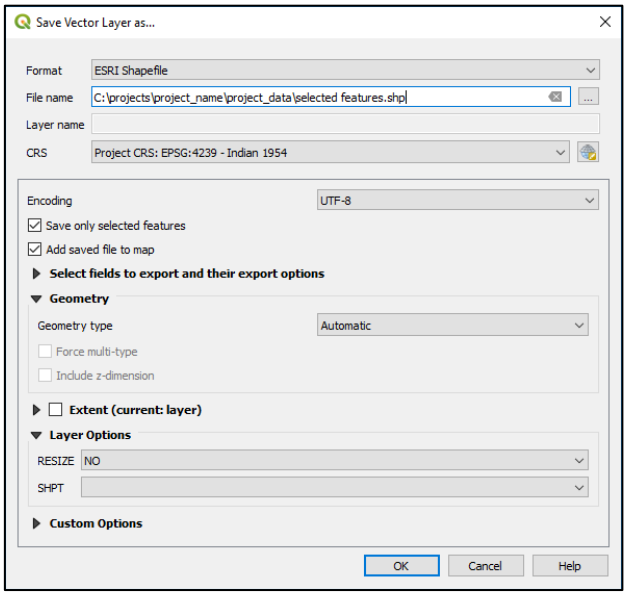


Raster layers:

Select **Export > Save as.**

Vector layers:

Select **Export > Save Features As** or **Export > Save Selected Features As** if you want to save only selected features. Make sure to check it before saving the layer.



5. Editing data

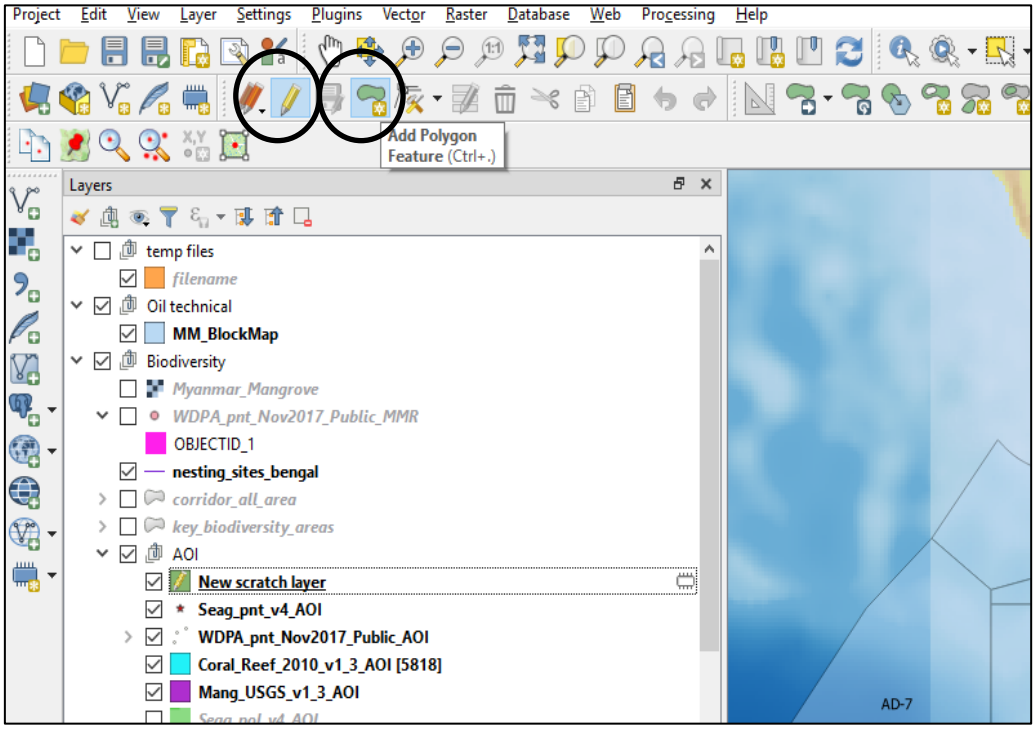
Editing the data of a layer is fairly easy in QGIS. It is in particularly well supported when using a SpatiaLite file database. Select the layer you want to make changes to in the layer manager. In the editor toolbar click the "toggle editing" button. This makes the layer ready for editing.

5.1 Add new feature

To add a new feature, either go to the Edit dropdown list or select **<Add feature>** on the digitizing toolbar. Depending on the geometry type of the layer you are adding a feature to, it will either be:

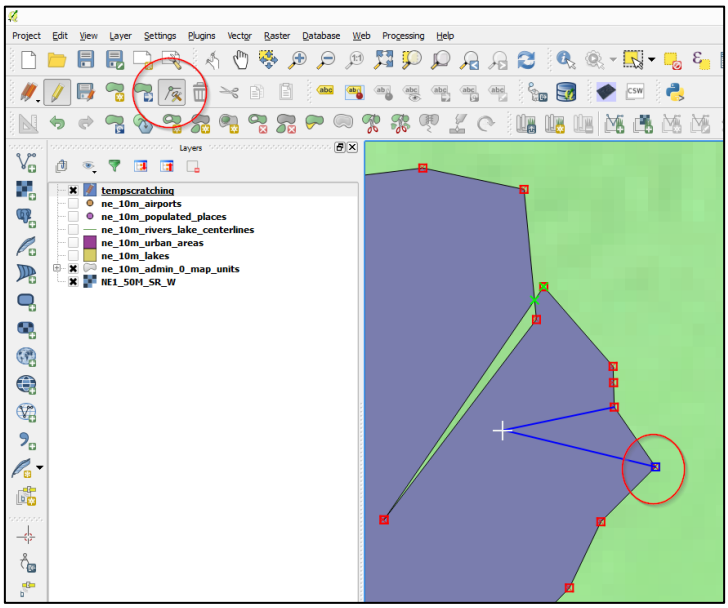
- Add Polygon Feature 
- Add Point Feature 
- Add Line Feature 

Now you can draw directly in the map window and digitize the object. When you are finished, click the right mouse button. If the layer has attributes, you will be prompted to input the values of these. Click **<OK>** and the feature is added to the layer. When you are finished with the editing, click the **<Save>** button and the **<Toggle editing>** button. The changes are now saved permanently to the data file.



5.2 Node tool

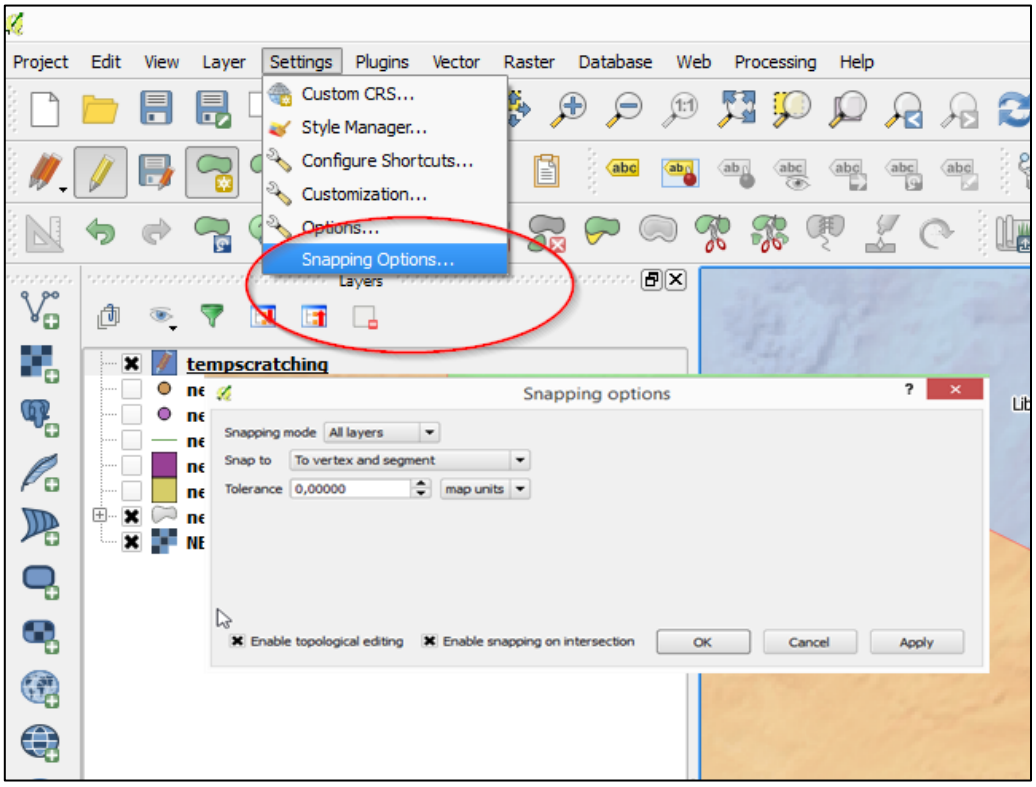
If you want to change existing objects you should use the **<Node>** tool. This enables you to change (move, add, delete) each node of the object. Activate the tool by clicking the **<Node>** tool button (*see below*) and click the red nodes that appear on the objects. Double clicking on the line adds a new node. Single click selects the node—you can then delete the node by hitting **<Delete>** on your keyboard.



5.3 Snapping

Note: The screenshots in this section use an older version of QGIS; these will look slightly different in newer versions.

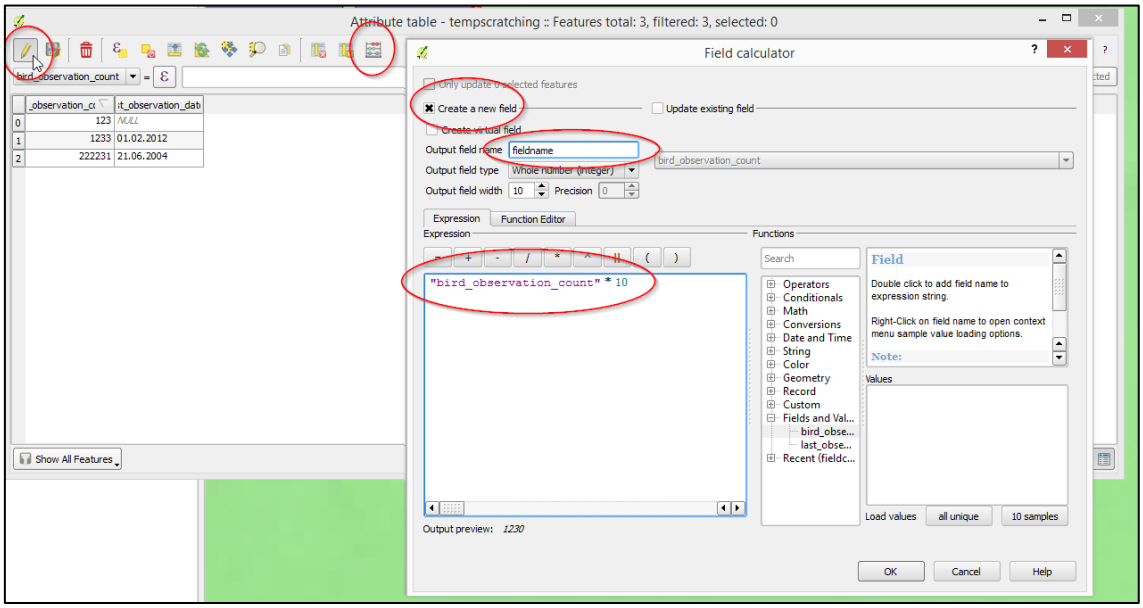
You can enable “snapping” when editing to allow you to easily “snap” onto existing vector data. This is very useful for boundaries and similar where you want the objects to have shared borders with zero distance between them. Enable snapping in the “snapping options” under settings.



5.4 Field calculator

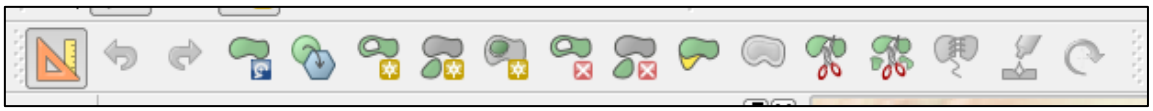
If your primary interest is in editing the attribute values, you should use the **<Attribute table>**. The attribute table allows you to edit values directly. Click **<Toggle edit>** and double-click on the values you want to edit.

Another powerful tool is the **<Field calculator>**. This tool allows you to generate a new field on all objects with a value that is calculated based on an expression. The expression can consist of mathematical expressions, plain numbers and text, one or more of the objects attributes (fields) or a combination of either.



5.5 Advanced editing

Enable the **<Advanced editing>** button (*see below*) to get access to more advanced tools for editing features. This tool can be used to create geometries based on exact coordinates and angles, and to do advanced geometry functions, such as adding a ring, merging features or rotation. The tools like **<Rotate>**, **<Simplify>**, **<Add rings>**, etc. are fairly self-explanatory.

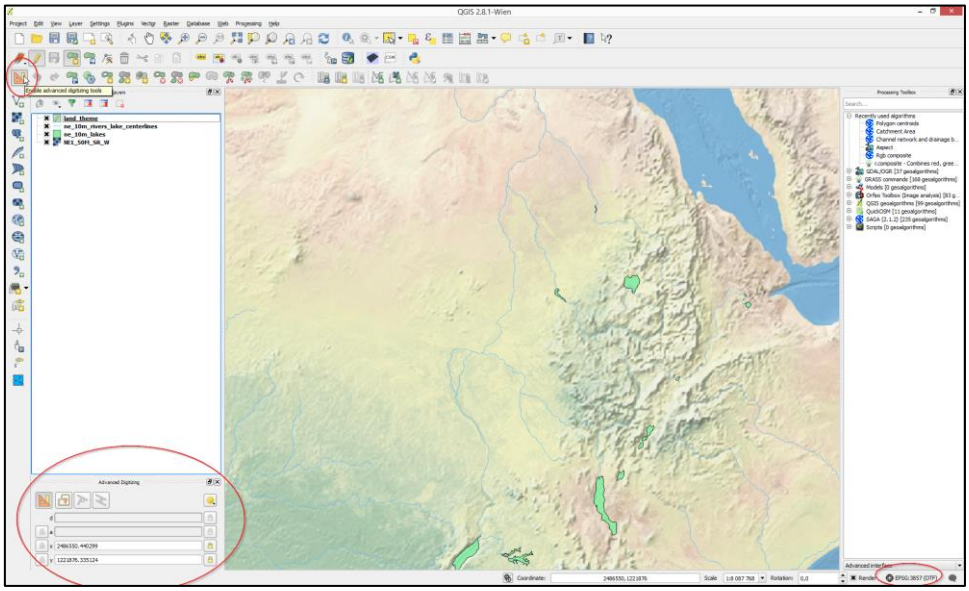


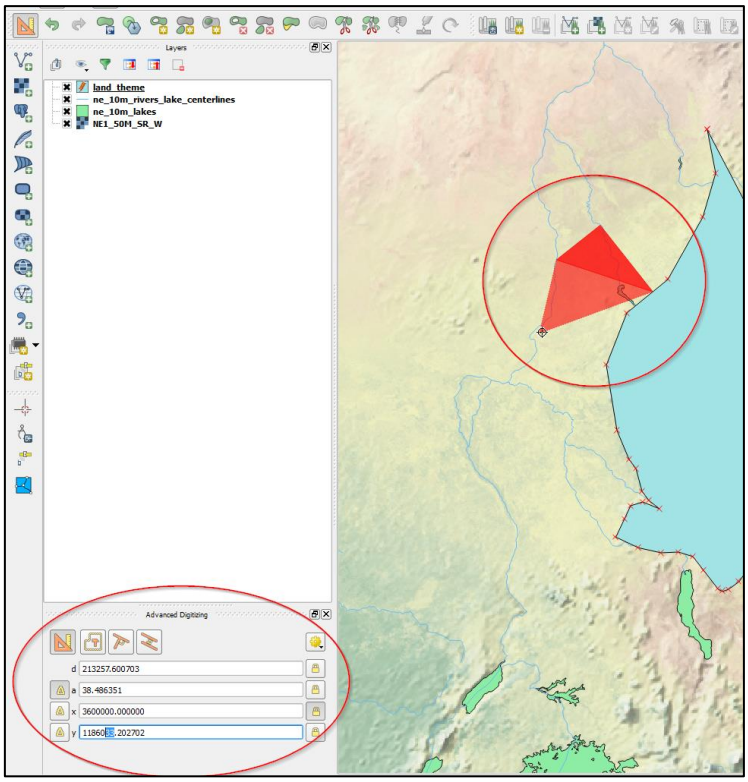
If you need accurate digitization where you require CAD-like control of the angles – you would use the **<Advanced digitizing>** tool. These tools add guidelines and snaps to angles, parallels and similar. You can also control the coordinates, angle and parallels with the hotkeys listed below.

> ***Note:*** You *must* have your project in a *projected coordinate system* for this to work.

Shortcuts are accessible if the MapCanvas or the CadInputWidget have focus :

- *A* : angle
- *D* : distance
- *X* : x coordinate
- *Y* : y coordinate
- Combine those with "shift" to toggle absolute/relative mode
- Combine those with "alt" or "ctrl" to toggle locked mode.
- *C* : construction mode
- *P* : parralel / perpendicular to a segment
- *ESC* : unlock all locked parameters

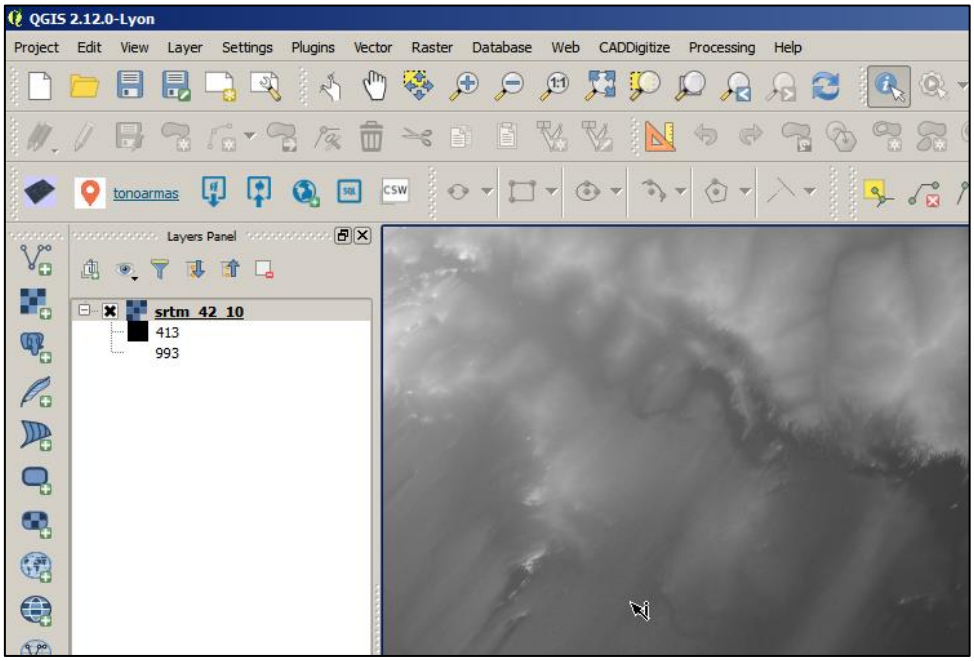




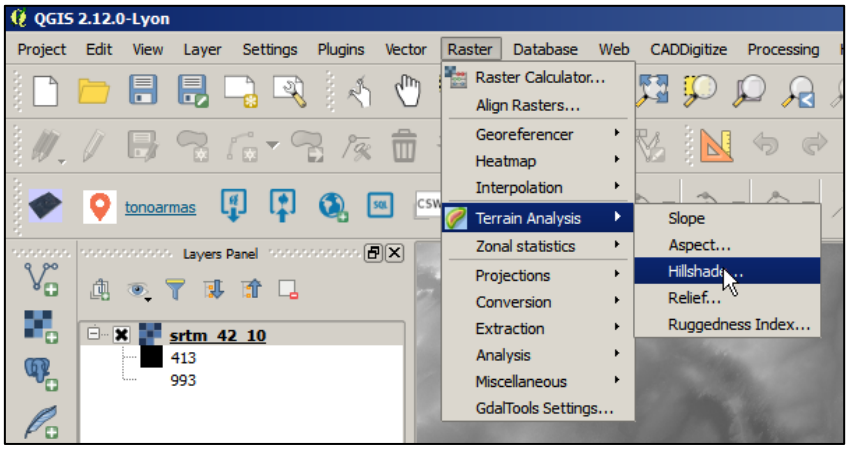
5.6 Building a hillshade

Note: The screenshots in this section use an older version of QGIS; these will look slightly different in newer versions.

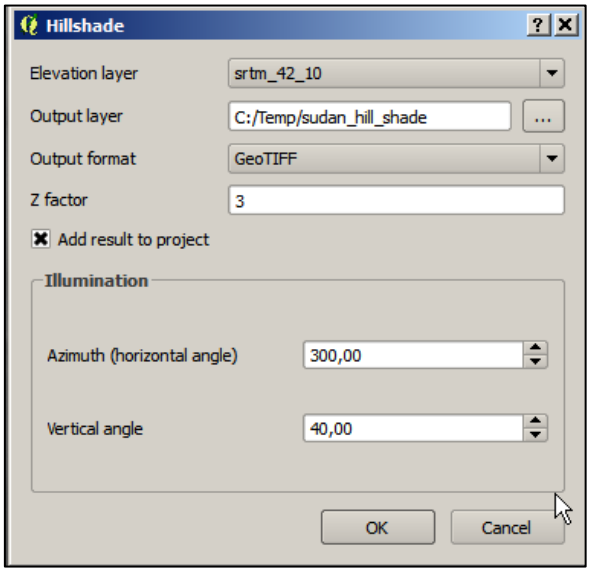
Usually, maps have a background layer to show 3D effects. This can be achieved in QGIS using a digital elevation model (DEM). This DEM keeps altitude values on pixels.



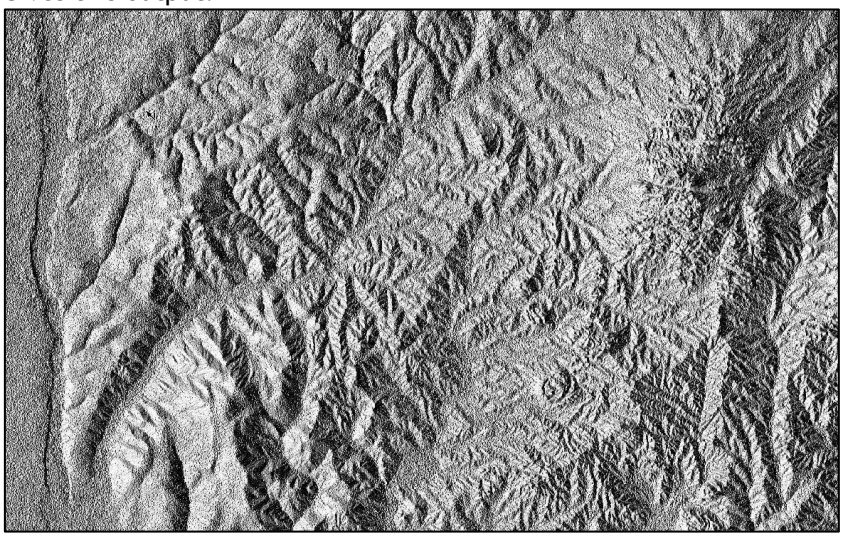
In QGIS, **Raster** > **Analysis > Hillshade** is the solution for creating amazing hillshades.



The settings are quite simple, only defining the input raster, output raster, position of the sun in azimuth degrees, the multiplying factor for elevations (used to exaggerate the altitudes) and the vertical inclination of the sun:



Gives this output:

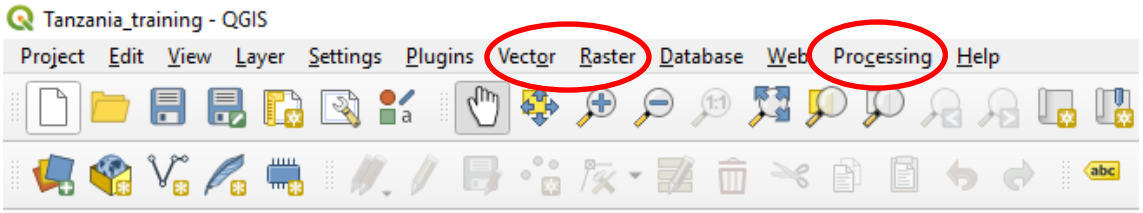


6. Vector analysis for problem solving

One of the greatest strengths of GIS is spatial analysis. When it comes to making good and evaluated decisions, it is important to know the relationship and interactions between different features. GIS analysis combines attribute information and spatial information from geographic objects to find spatial patterns, find interactions between spatial data and to solve problems. There are a lot of different analyses to choose between. In this chapter, we will dive into a few of them.

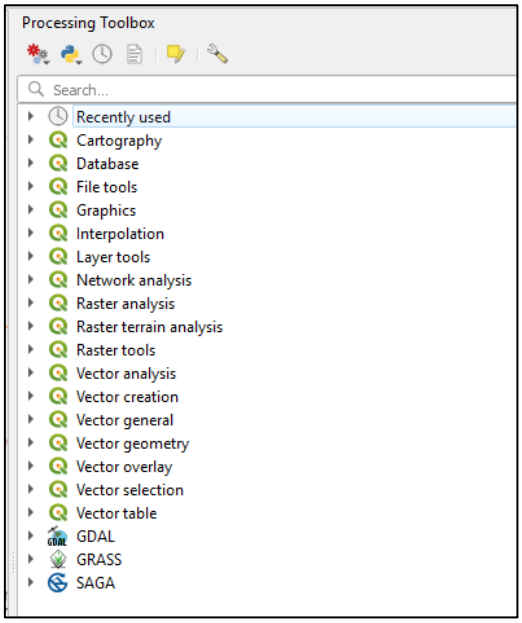
6.1 Processing Toolbox

QGIS has a large variety of tools for spatial analysis. Many of the commonly used tools can be accessed from the main toolbar at the top of the window, through the **Vector** and **Raster** tabs.



However, there are many other tools that are not available from here. To access these other tools, use the Processing Toolbox which is accessible through the **Processing** tab.

You can search for a tool in the Processing Toolbox in the search tab or use the dropdown menus.



6.2 Buffer analysis

A buffer analysis is often used to check whether an object affects its environment. A buffer consists of a calculated zone within a given distance from an object. You can do buffer analysis to points, lines and polygons.

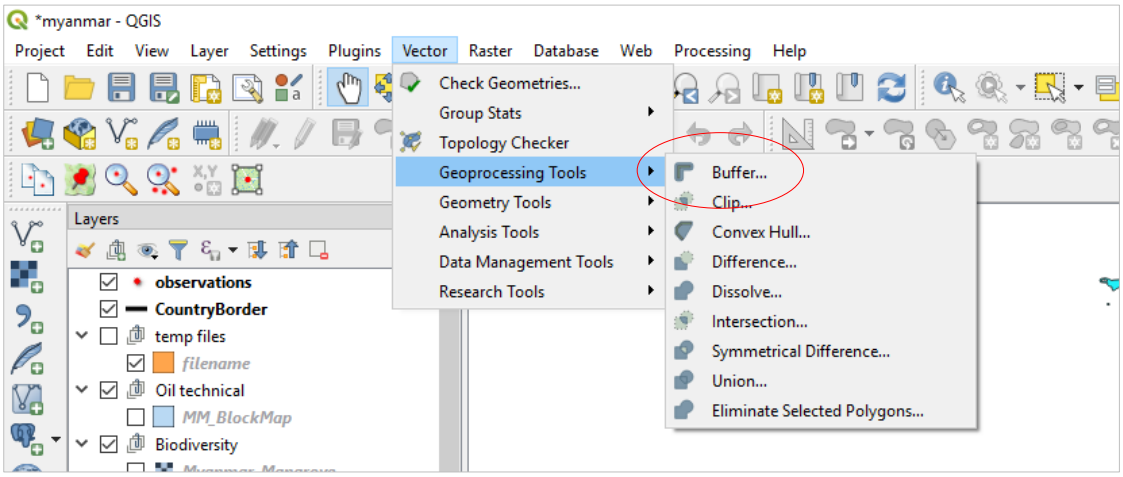
Example 1: You want no construction development to occur closer than 1,000 meters from a mangrove forest.

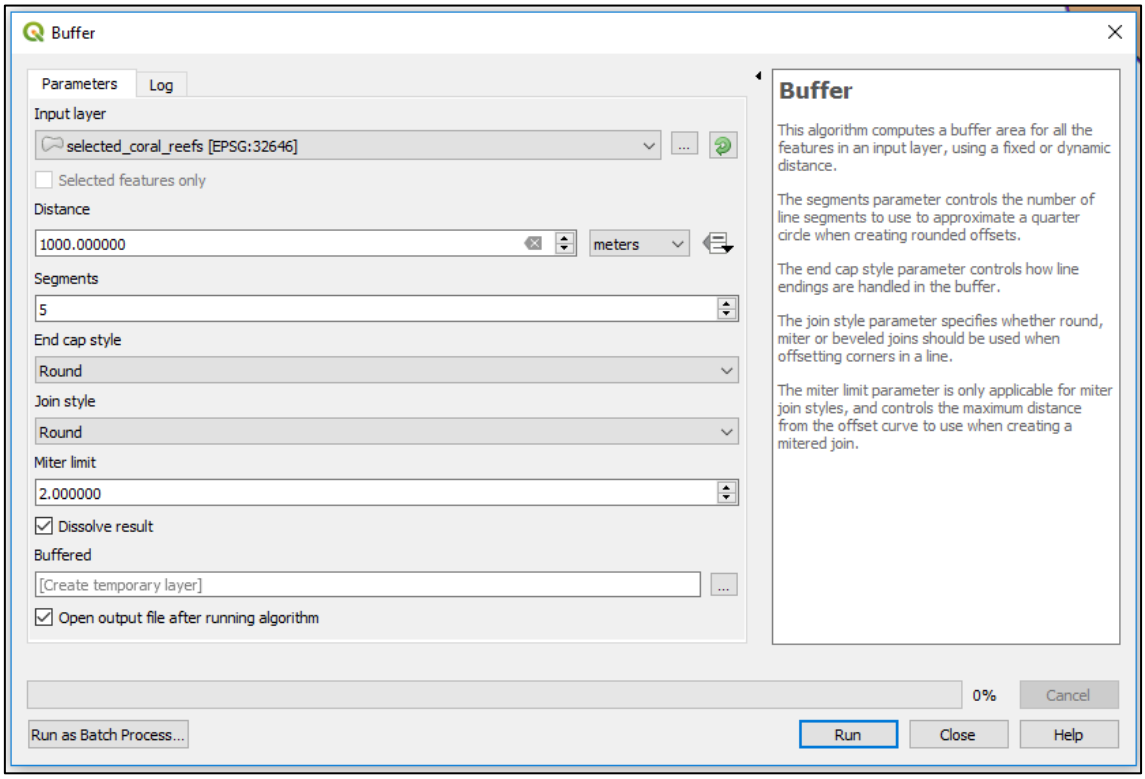
Example 2: You know that seagrass locations are important areas for fish spawning. Pollution must never occur closer than 2,000 meters of these locations.

Note: *Buffering measures distances in meters, kilometres, feet, miles or yards. To get a correct result, the layer you want to buffer should first be saved in a projected coordinate system.*

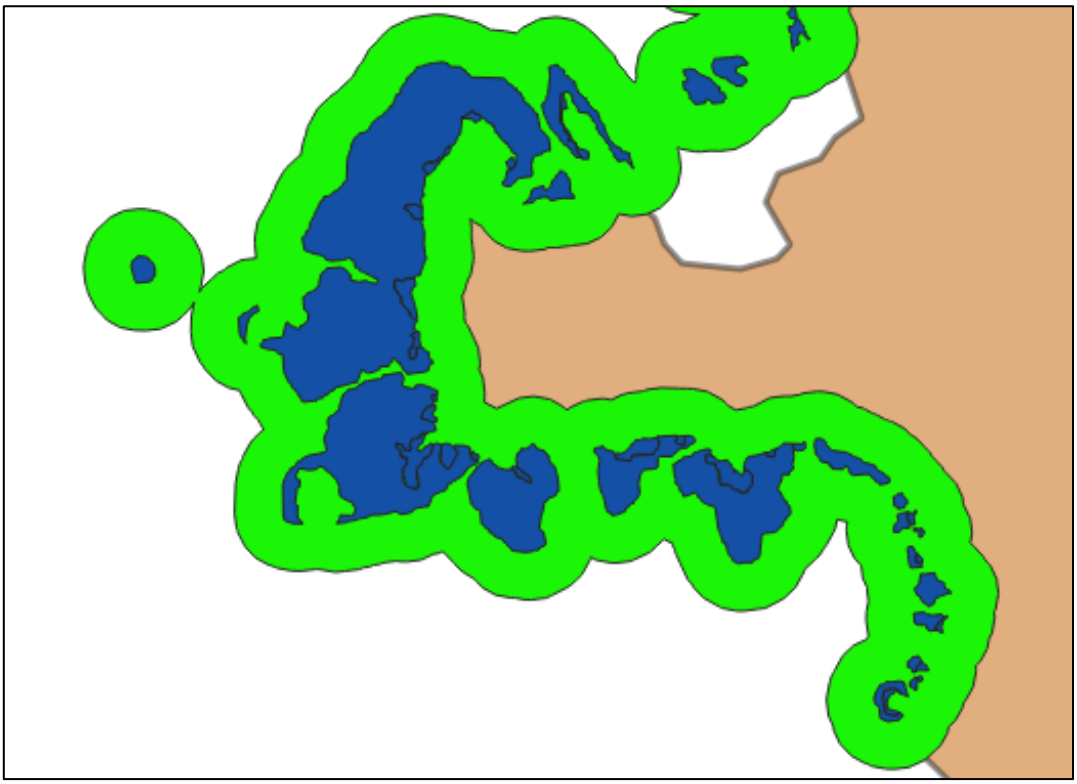
6.2.1 Buffer in QGIS

Choose the layer you want to buffer. It is also possible to buffer only a selection of the chosen layer. If so, first select the objects you want to buffer. Remember to mark the layer you want to select from before selecting. From the menu bar, select: **Vector > Geoprocessing Tools** > **Buffer**.





Choose correct layer. If you have selected features, make sure you check the box for **"Selected features only"**. Choose the **<Distance>** and unit for the measurement. In this case, the buffer distance will be 1,000 meters. Select **<Run>** to create the buffer.



Result: The dark blue layer represents the coral reefs, while the green is the buffer zone surrounding the coral reefs. The result of such a buffer analysis can be used in decision making, to avoid impact closer than a given distance.

6.3 Overlay analysis

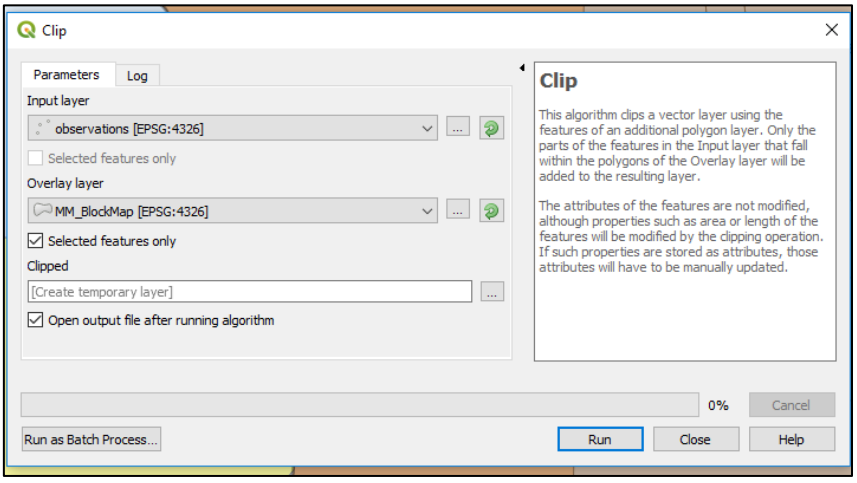
Overlay analysis is a method that combines different themes to create new themes. Combining polygon layers is probably the most common overlay analysis of vector data, where the attributes of both layers are combined into one new layer. From the combinations of these attributes, new attributes can be calculated or classified. The most common overlay analyses are **Clip**, **Union** and **Intersect**.

6.3.1 Clip

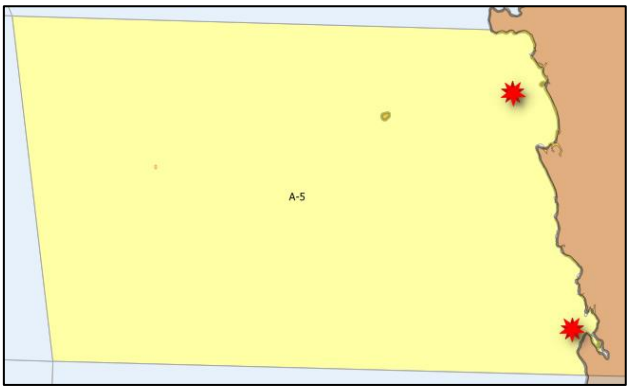
<Clip> is an analysis that clips a vector layer using the features of another polygon layer. To do a clip analysis you need two layers. The input layer is the layer you want to clip. The overlay layer is the layer you use to do the clip.

Example: You want a clip of all the observations (or other theme of interest) that are located inside one of the blocks in the 'MM_BlockMap' dataset. First you need to select the specific block in the blockmap layer. You can either save the selection as a layer for the analyses, or choose **"Selected features only"** when you are doing the clip analysis. This will be your clip layer (overlay layer).

1. Make sure both the input and overlay layers are in the same coordinate system.
2. Select the specific block of interest in the 'MM_BlockMap' layer.
3. Select the clip function from the menu **Vector > Geoprocessing tools > Clip**.
4. Choose the observations layer as your **<Input layer>** and the blockmap layer as the **<Overlay layer>**.
5. Choose **"Selected features only"** to clip features only found within the specific block.
6. Select **<Run>** to clip all of the observations found within the specified block, creating a temporary layer.
7. If you are satisfied with the result, save the clip as a new layer.



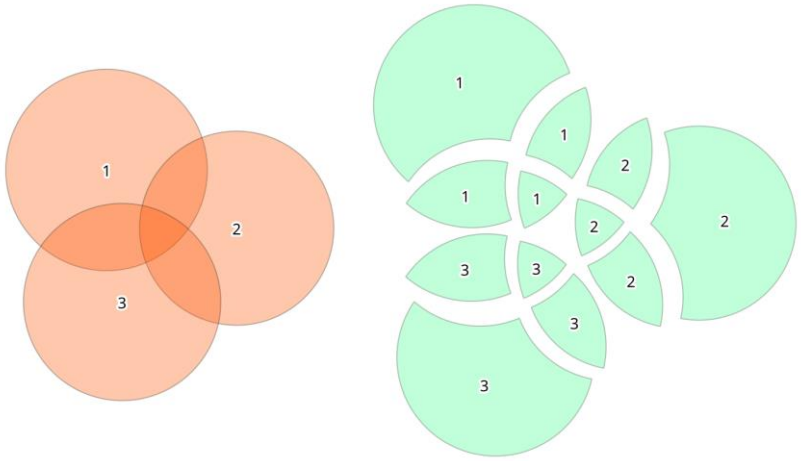
The two red points are clipped from the observation layer by the selected block.



6.3.2 Union

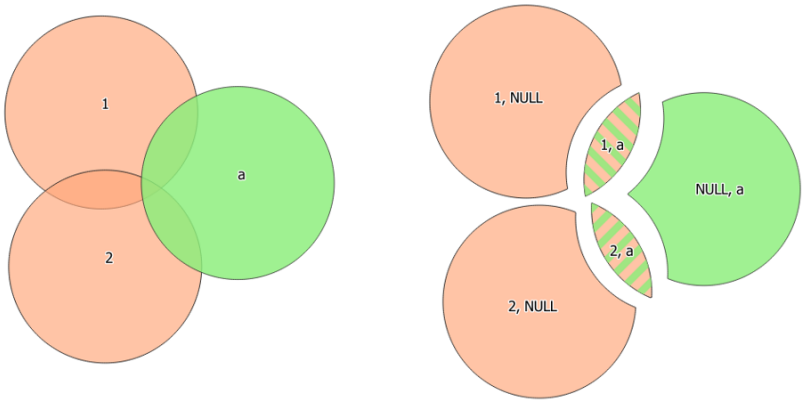
The **<Union>** tool combines two layers into one, containing the attributes from both layers.

This analysis can be used to check overlaps between features within an input layer. When it is used in this way separate features are created for overlapping and non-overlapping parts.



Union for one layer (Source QGIS user documentation).

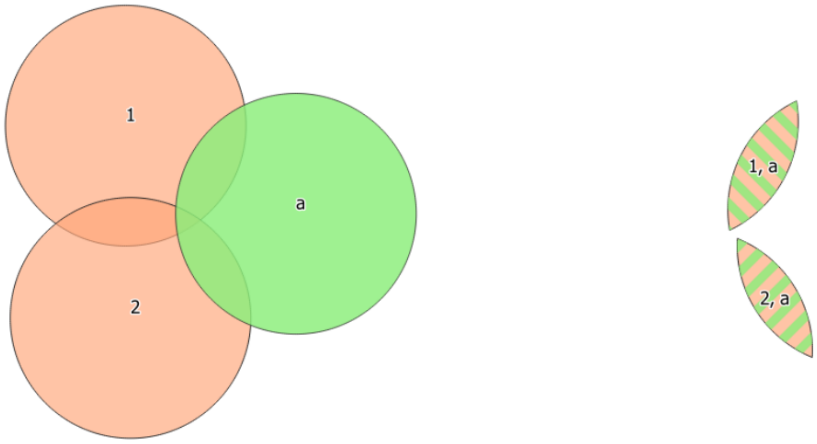
The analysis can also be used to union an input layer with an overlay layer. In this case, each layer is split at its' overlap with features from the other layer. The output from the analysis will be a layer which contains non-overlapping features from each of the layers and features for the parts that overlaps. The attribute table of the resulting union layer will contain attribute values from both of the original layers. Non-overlapping features gets attributes from its' original layer and overlapping features from both layers.



Union between an input layer and an overlay layer (Source: QGIS user documentation).

6.3.3 Intersect

<Intersect> is an overlay analysis which computes which features or portions of features overlap in the input layers. The output intersection layer will have the geographic extension of the overlapping area, and its features will contain the attributes from both the input and the output layers. Intersection can be made between simple features: points, line or polygon.

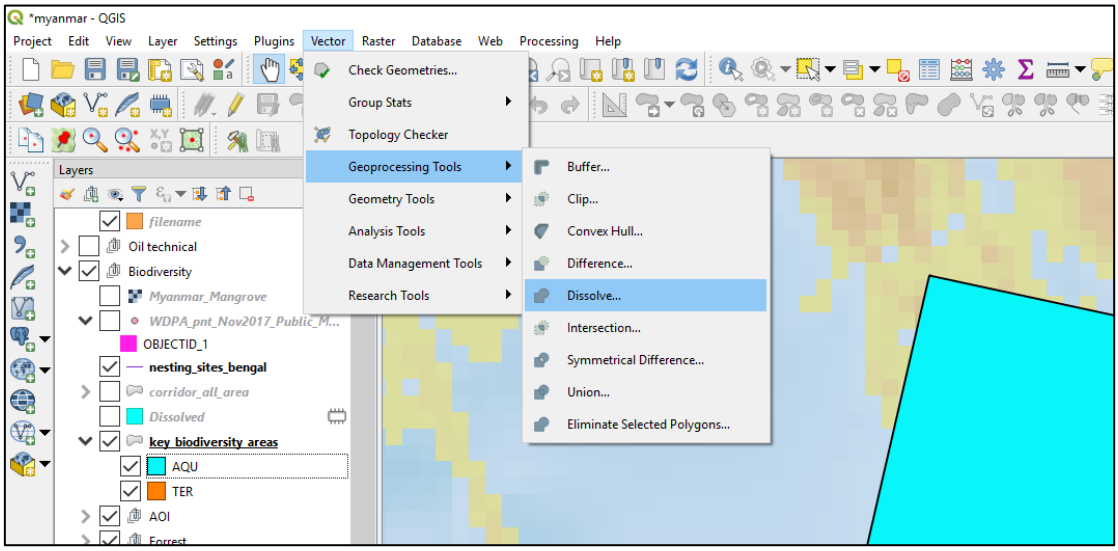


Intersect between an input layer and an overlay layer (Source: QGIS user documentation).

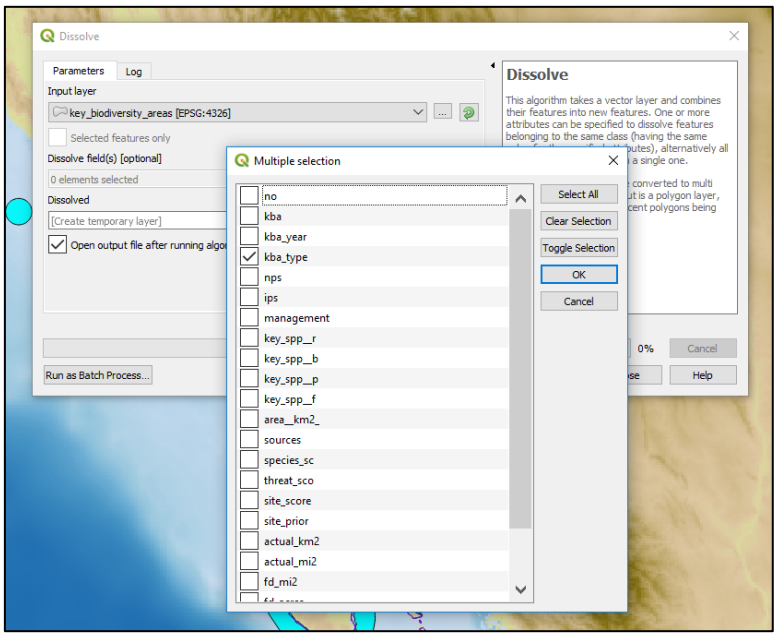
6.4 Dissolve

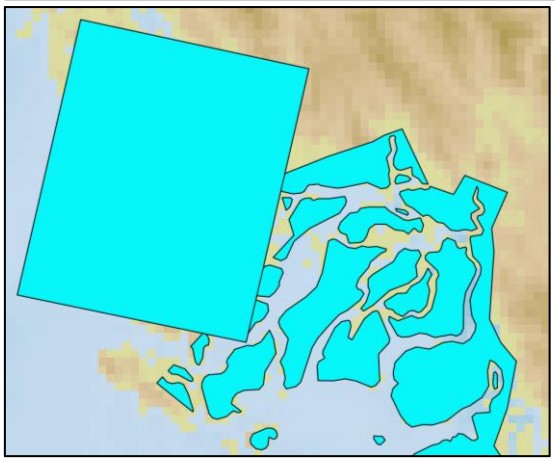
Dissolve is an algorithm which aggregates features in a vector layer by a common attribute. It may be used to dissolve boundaries.

Example: You have a layer showing key biodiversity areas, which is divided into many features. You wish to have a layer that shows this information without the borders. You decide to dissolve the borders based on the attribute **"kba_type"**. Make sure the layer you wish to dissolve is enabled. Then choose **Vector > Geoprocessing > Dissolve** *(see below)*.



Choose input layer and then which attribute/attributes you wish to use as the **<Dissolve fields>**. In this case we wish to dissolve the borders based on the attribute **"kba_type"**. Select this attribute, click **<OK>**, and select **<Run>**.





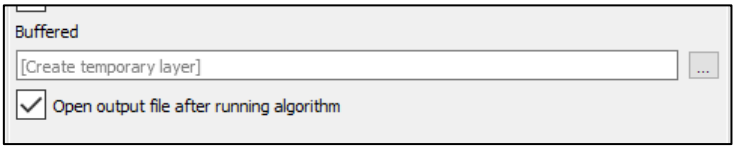
Input layer

Output layer

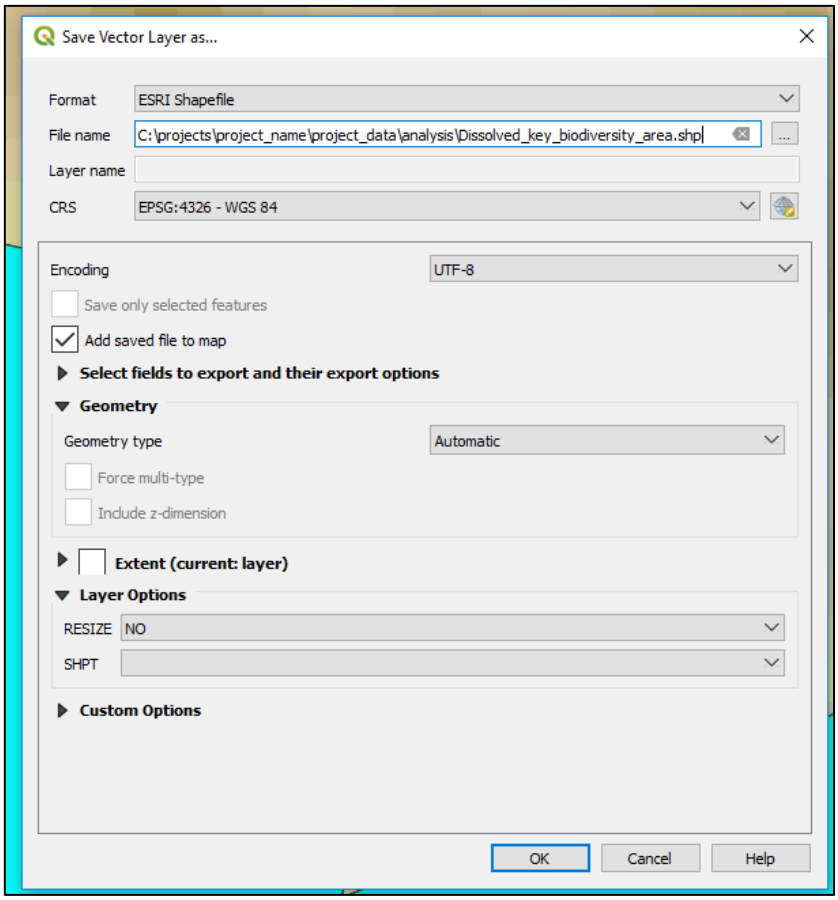
Output geometries are converted to multi geometries. If the input layer is a polygon layer the boundaries of polygons are erased. If an attribute is chosen for the dissolve, the boarders are erased with basis in this attribute.

6.5 Creating new layers from the result

When you are doing different analyses in QGIS, the output layer you get is temporarily stored if a location to save the file is not identified before running the analysis. You may choose to save the layer immediately, but sometimes you will need to run an analysis many times before you are satisfied with the result. In this case, it is convenient to have the results as temporary files that are deleted when the project is closed.



When you are satisfied with the result of your analysis you may export the temporary layer to a permanent file. Right-click on the layer and select **Export > Save features as**. You will then come to the **"Save Vector Layer as…"** window. Choose the path, filename, and coordinate system. If you want to add your layer to the map, choose **"Add saved file to map".** Select **<OK>** to create a layer from the result of your analysis.



7. Raster Analysis

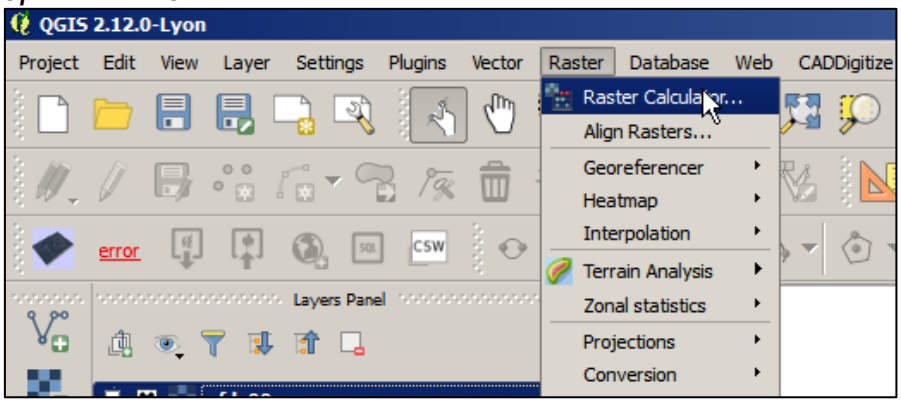
Rasters represent the world using grid cells, where each cell has a distinct value. Each raster layer represents one attribute, while the level of detail depends on the cell size. By combining raster layers, we can create new layers with new cell values. This is the most common way of using raster analysis.

7.1 Raster Calculator

We will use two raster files to generate a new raster file that shows the change in values between these two rasters. The two rasters contain population data from the African continent, one for 1990 and the other one for 2000. Each pixel has population data assigned. Clicking on each pixel using the **<Identify>** tool will show its value.

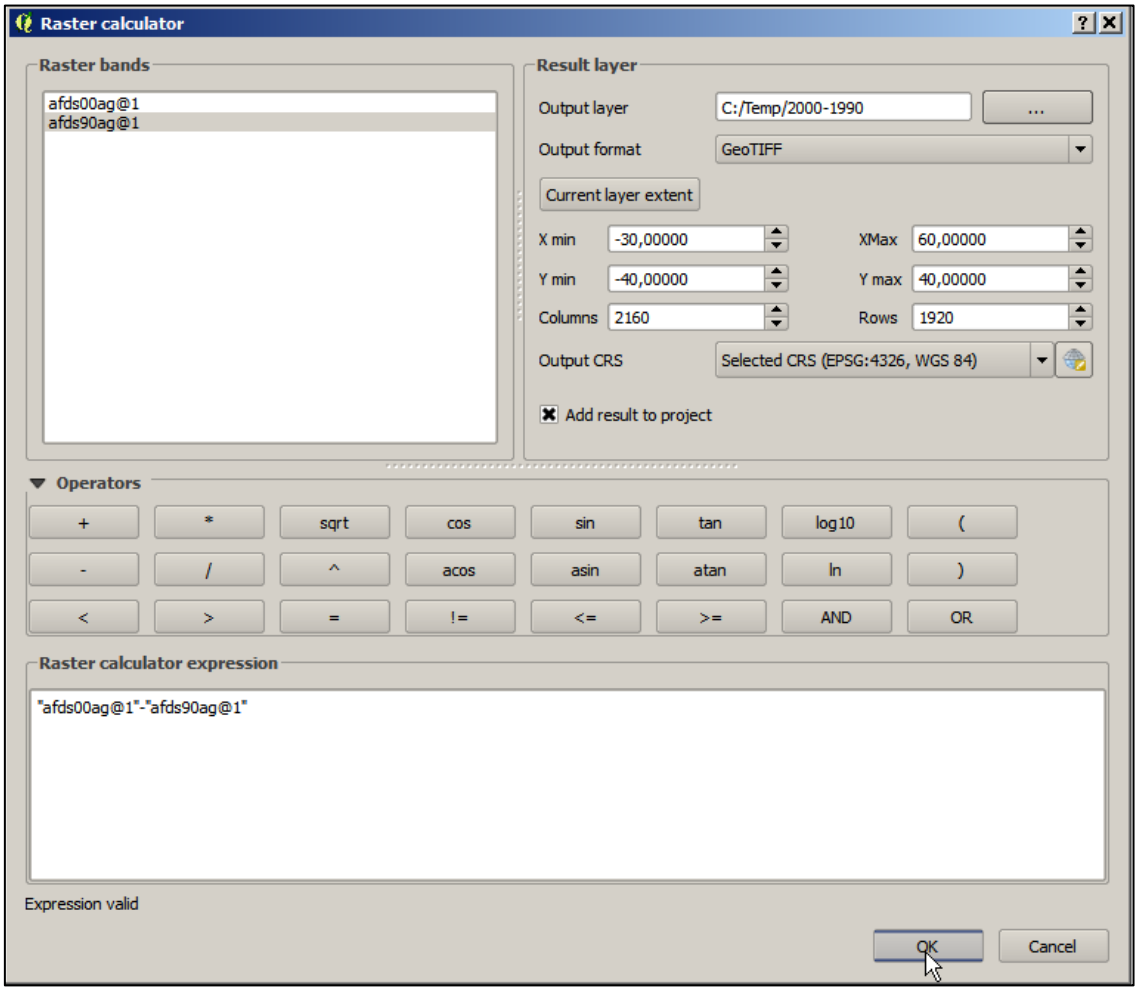
We first need to style these rasters, using the same process as that used for the vector files. We will style the only band on those rasters as **"singleband pseudocolor"**, **"continuous distribution"**. The aim of the analysis is to find the changes in population in Africa. So we need to find the difference in population between these rasters.

Open Raster Calculator

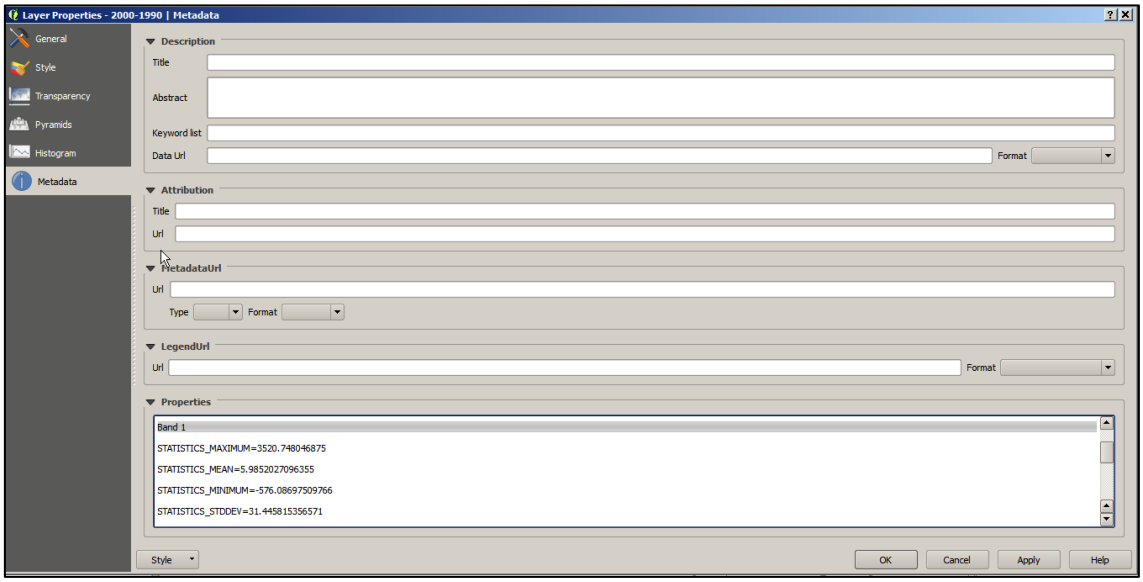


Like we did using **<Field Calculator>** for vectors, rasters can also build new pixels from operations. To find the difference in population, you need to subtract the 1990 raster from the 2000 raster. This will subtract the overlapping grid cells from each other. The new raster will hold the difference between 1990 and 2000 for each grid cell.

Double click on the raster for the year 2000 to add it to the expression. Then click the minus symbol in the operators section and then double click on the 1990 raster. Press **<OK>**.



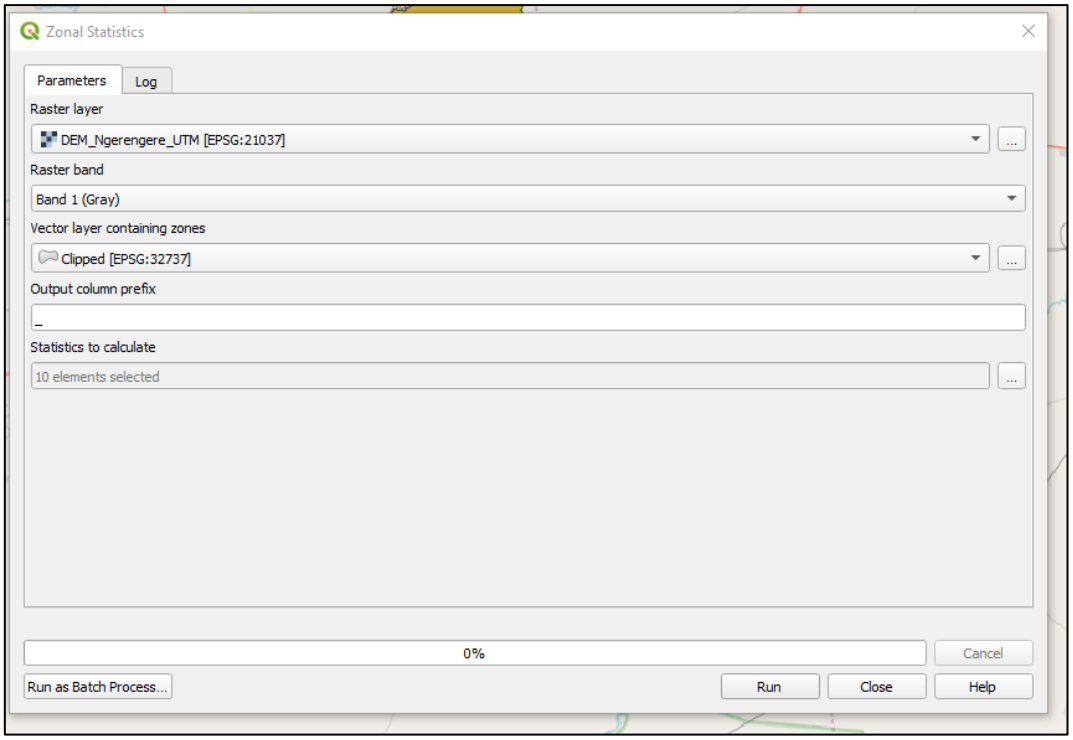
Using the correct styling with the resulting raster layer can be very meaningful. So let's change it to **"singleband pseudocolor"** and colour interpolation **"discrete"**. Four intervals would be used from the maximum to minimum value to represent *neutral change*, *population increased*, and *population decreased*. These values are available on **Layer Properties > Metadata**.



7.2 Zonal Statistics

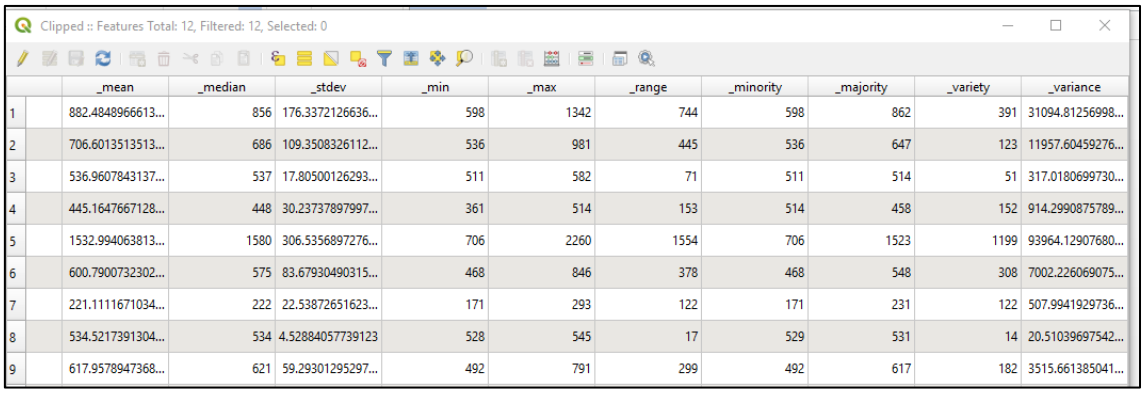
The **<Zonal statistics>** algorithm produces statistics based on raster attributes per zone (or location) within a vector layer. For example, you can generate statistics of altitude (from the raster layer) within each protected area (from a polygon layer).

1. Search for and double-click on the **<Zonal Statistics>** tool in the processing **<Toolbox>**.
2. Choose a raster layer for which to generate statistics (i.e. “DEM_Ngerengere_UTM” in the example below).
3. Choose a polygon layer to use as the zones to generate statistics (i.e. “Clipped”).
4. Select the **“Statistics to calculate”**.
5. Select **<Run>**.



6. Right-click on the vector layer you selected and open the attribute table.

The tool has added additional fields (_min, _max, _sum, _count, _mean, _std, etc.) containing statistical summaries relating to the raster layer within each polygon.



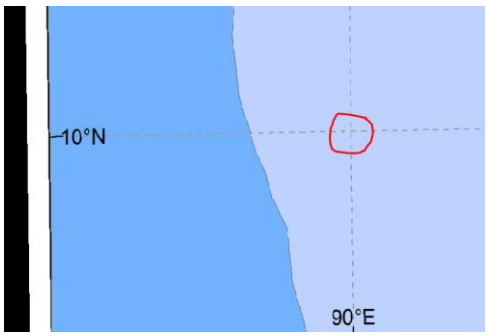
	_mean	_median	_stdev	_min	_max	_range	_minority	_majority	_variety	_variance
1	882.4848966613...	856	176.3372126636...	598	1342	744	598	862	391	31094.81256998...
2	706.6013513513...	686	109.3508326112...	536	981	445	536	647	123	11957.60459276...
3	536.9607843137...	537	17.80500126293...	511	582	71	511	514	51	317.0180699730...
4	445.1647667128...	448	30.23737897997...	361	514	153	514	458	152	914.2990875789...
5	1532.994063813...	1580	306.5356897276...	706	2260	1554	706	1523	1199	93964.12907680...
6	600.7900732302...	575	83.67930490315...	468	846	378	468	548	308	7002.226069075...
7	221.1111671034...	222	22.53872651623...	171	293	122	171	231	122	507.9941929736...
8	534.5217391304...	534	4.52884057739123	528	545	17	529	531	14	20.51039697542...
9	617.9578947368...	621	59.29301295297...	492	791	299	492	617	182	3515.661385041...

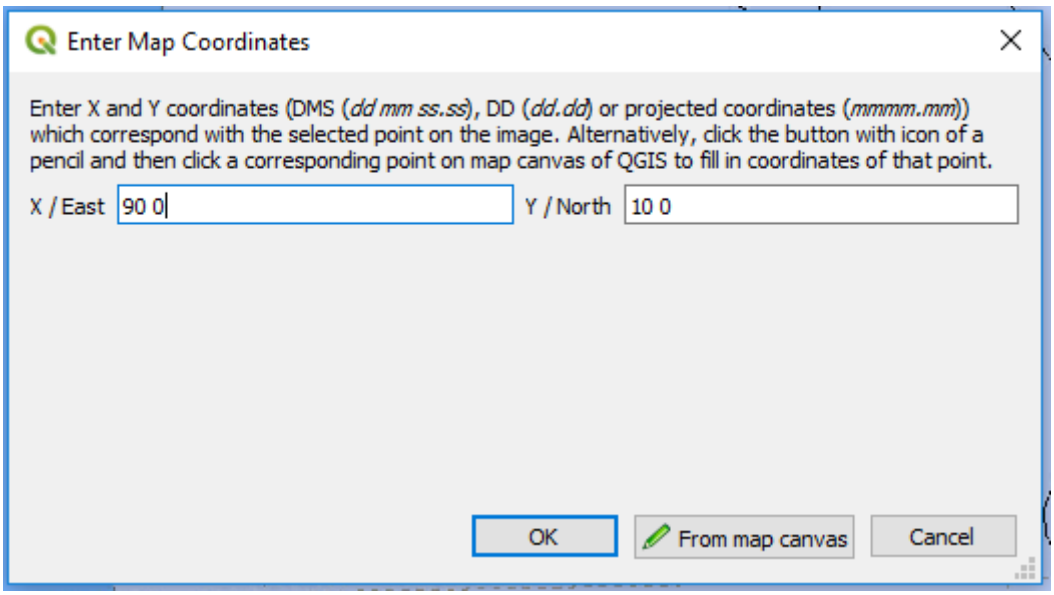
8. GeoReferencing

Many maps and images are scanned or similarly digitized and do not have a digital reference to a geographic coordinate system. This means QGIS does not know where in the world they are, and what extent they are covering. Georeferencing is the method by which we provide known points that "map" the scanned paper map to the digital map. The "paper map" can also be an aerial photo or similar format that lacks a georeference. To achieve this, we use the <GeoReferencer> tool in QGIS. ArcGIS users will be familiar with the concept and user interface.

There are many different transformation types. Each has different properties. For most cases, you can safely use the **<Polynomial 1>** when georeferencing. This algorithm requires 3 or more **<Ground Control Points> (GCPs)** to link unique features on the paper map with the same unique features on the digital map. You should aim to have at least 5 to 8 GCPs spread across the map to ensure the best alignment, as each GCP will "pull" the map into place.

There are two ways to georeference a map: either by entering the map coordinates, or from points in the map canvas. If you have a good and easily readable grid in your map, the use of map coordinates is the best method. If this is the case, use the coordinate system which the map is based on. For this method you will need 4 points, preferably the map's corner coordinates. If they are difficult to read, use coordinates from the grid crossings.

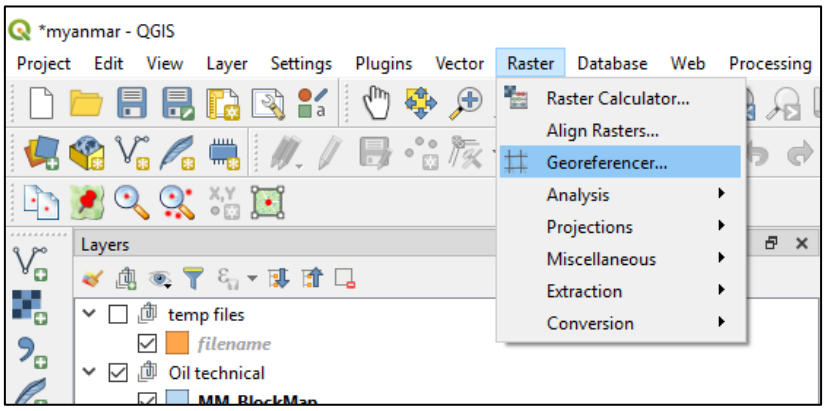




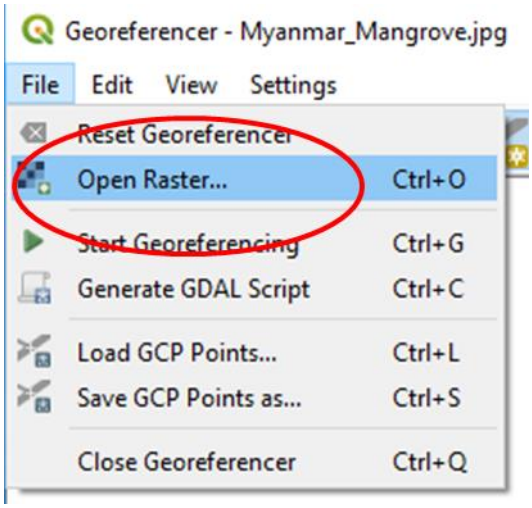
If the grid is not detailed enough to read the corner coordinates or grid crossings, or if we would like to georeference an image without a grid, we use a method where we define GCPs on both the raster and in the map canvas. When we are georeferencing a map by defining GCPs in the map canvas, we should refer it to recognizable locations. This could be locations where country borders meet or locations where a river crosses a street, and so on. The important thing is that the GCPs are easy to locate both in the map you want to georeference and in the map canvas.

Although some areas of the world do not have a lot of data available, there is often enough OpenStreetMap data to use for this purpose. In those cases, we use the **<OpenLayers>** plugin to view OpenStreetMap and use it as a reference for the tif. In Myanmar, a layer of the Country borders is available as a shapefile. We also have layers for railways, roads and waterways from OpenStreetMap that may be used to find good GCPs.

Open the Georeferencer plugin in QGIS:
If you are unable to find it here, you must first enable it in the Plugins manager, as described in the Section 2.9 (QGIS Plugins).



Load the .tif image:

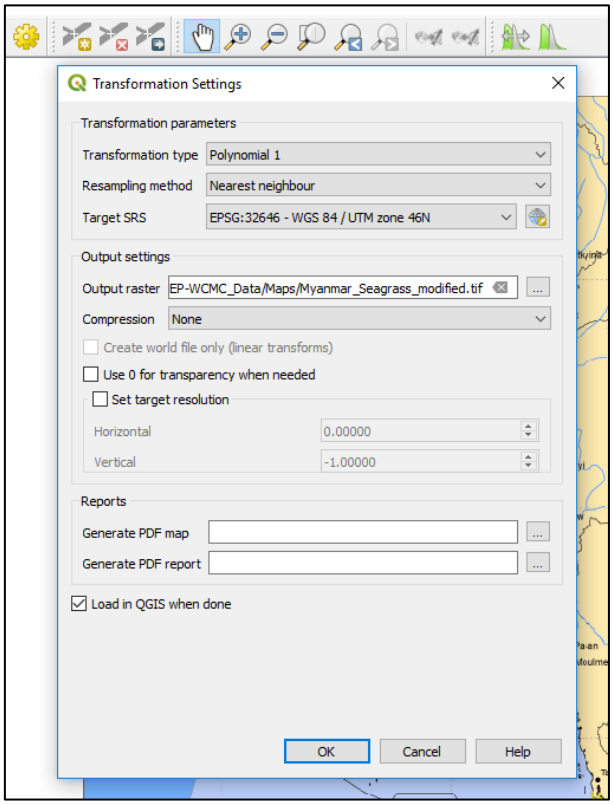


You will be asked to fill in the information related to the coordinate system that is going to be assigned to the raster. Choose the coordinate reference system that fits best to the map's regional zone. The raster maps of Myanmar are stored in .jpg files, and contain a grid with

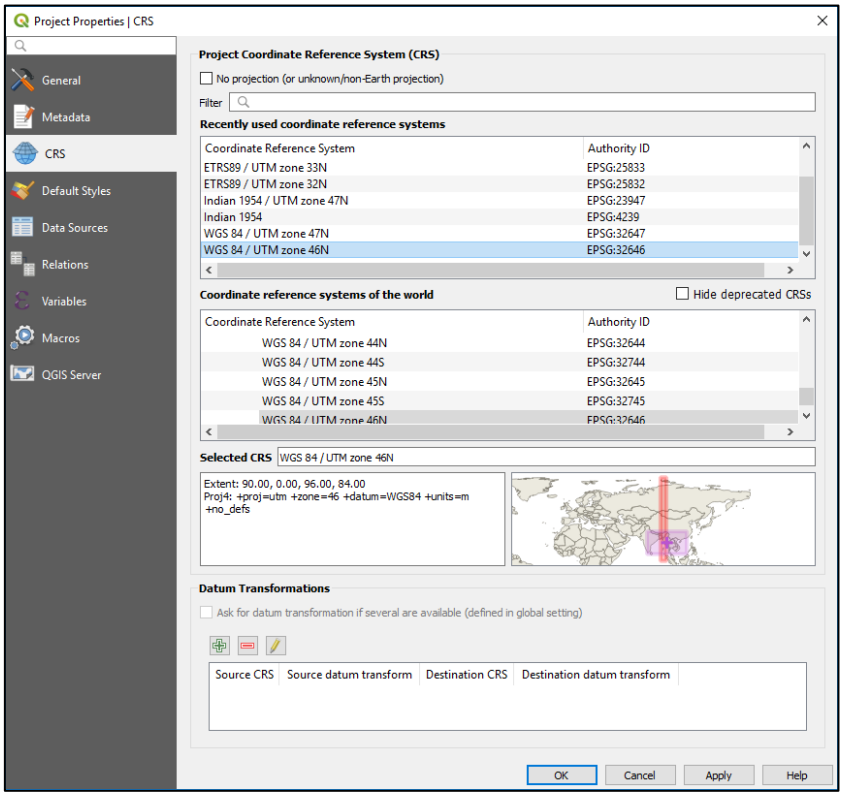
geographic coordinates (WGS 84), measured in degrees. The EPSG is 4326. If you are working with projected maps, for example for maps in larger scales you would need to use a projected coordinate system instead.

Note: In the case of Myanmar there are two different UTM zones onshore: one west of 96 degrees (WGS 84/UTM 46N) and one east of 96 degrees (WGS 84/UTM 47N). The country standard projection is WGS 84 / UTM 47N.

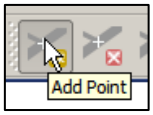
Once we have opened the **<Transformation Parameters (Settings)>**, select **"Polynomial 1"** (minimum 6 GCPs required), **"Nearest neighbour"** and run the transformation:



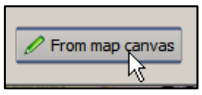
Before you start georeferencing using the "from map canvas" method, make sure the project CRS is the same as the one of the raster map. If the map and the project CRS are different, you may get a bad result.



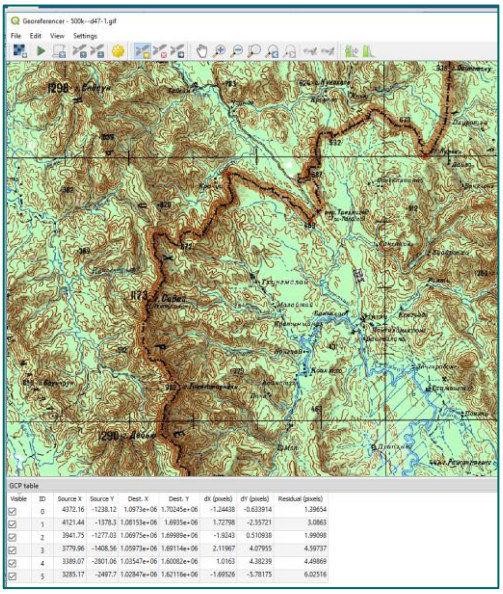
On the .tif file, there are 5 red points that will be used to match the chosen layer/layers in QGIS. Now, select the **"Add Point"** tool:

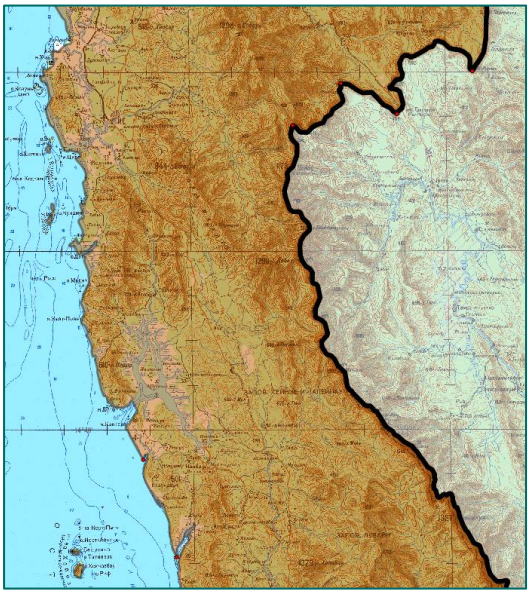


Click into the first point and choose from map canvas.

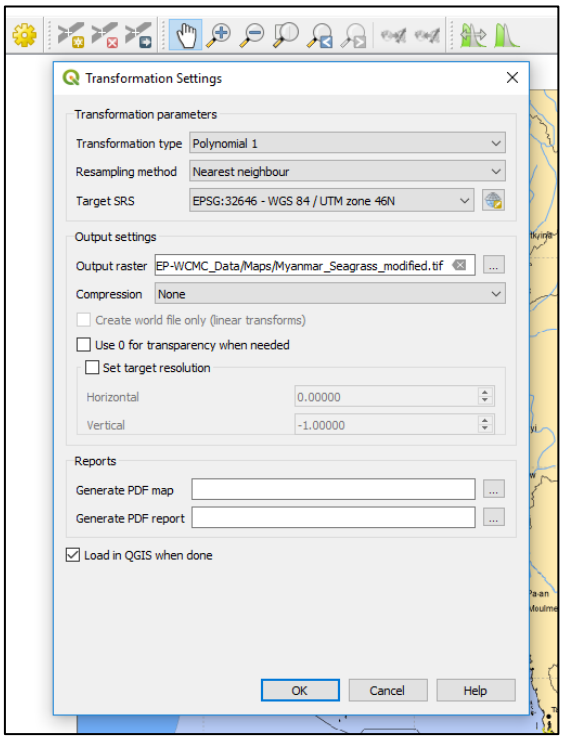


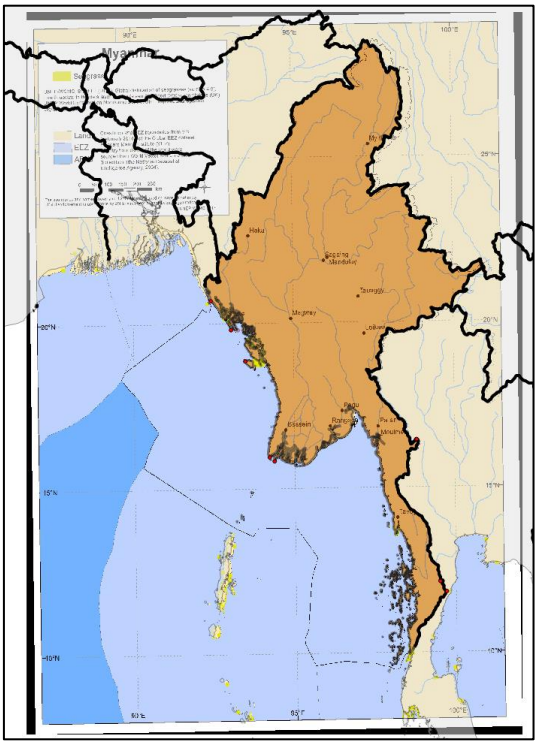
Search for the same point in the map canvas and click on it. This process will fill the coordinates fields needed for the next transformation. If something goes wrong choosing a point, we could move it or even delete it.





Once we have opened the **<Transformation Parameters (Settings)>**, select **"Polynomial 1"** (minimum 6 GCPs required), **"Nearest neighbour"** and run the transformation:





Do not worry if you do not get the map totally correct on your first try. It can sometimes be a bit tricky to get a satisfying georeferenced result, especially if you are dealing with maps/images that stretch over more than one UTM zone. You can add and remove points until the result is satisfying.

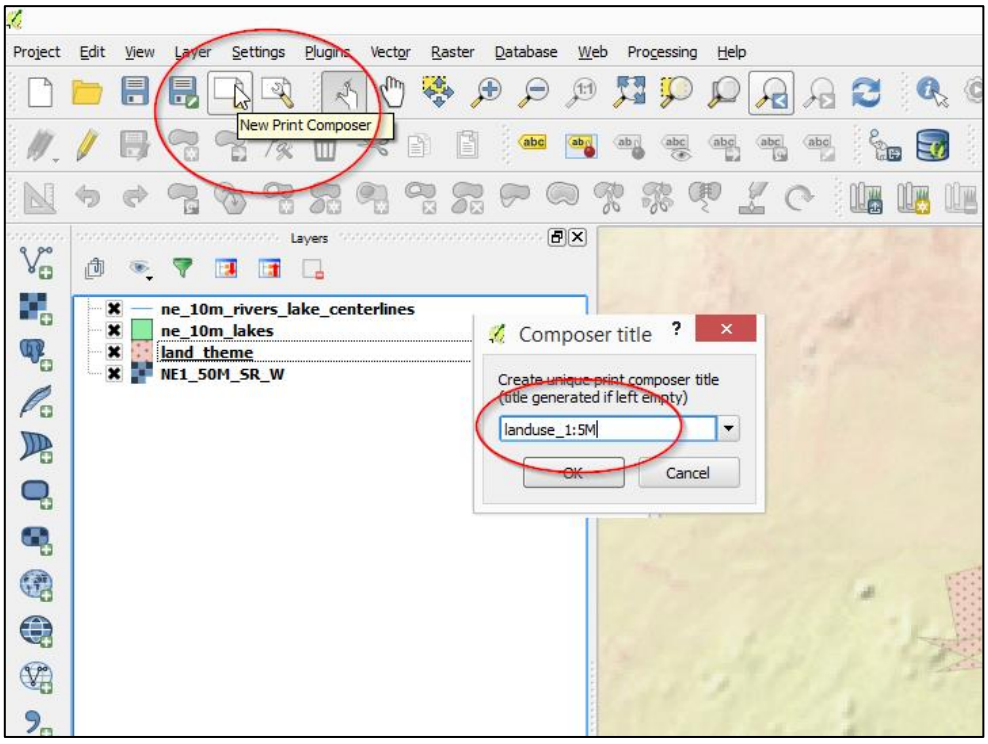
If you are georeferencing a map showing an entire country, you should use the available grid and georeference by entering the map's coordinates.

9. Preparing for a report: printing and export

Preparing maps for reports and printing is achieved in the <Print Composer> (or <Print Layout> in later versions). You can have several "composers" or layouts within a single QGIS project. You can also use the composers in other projects. This is very useful when you want to use the same style with different map content.

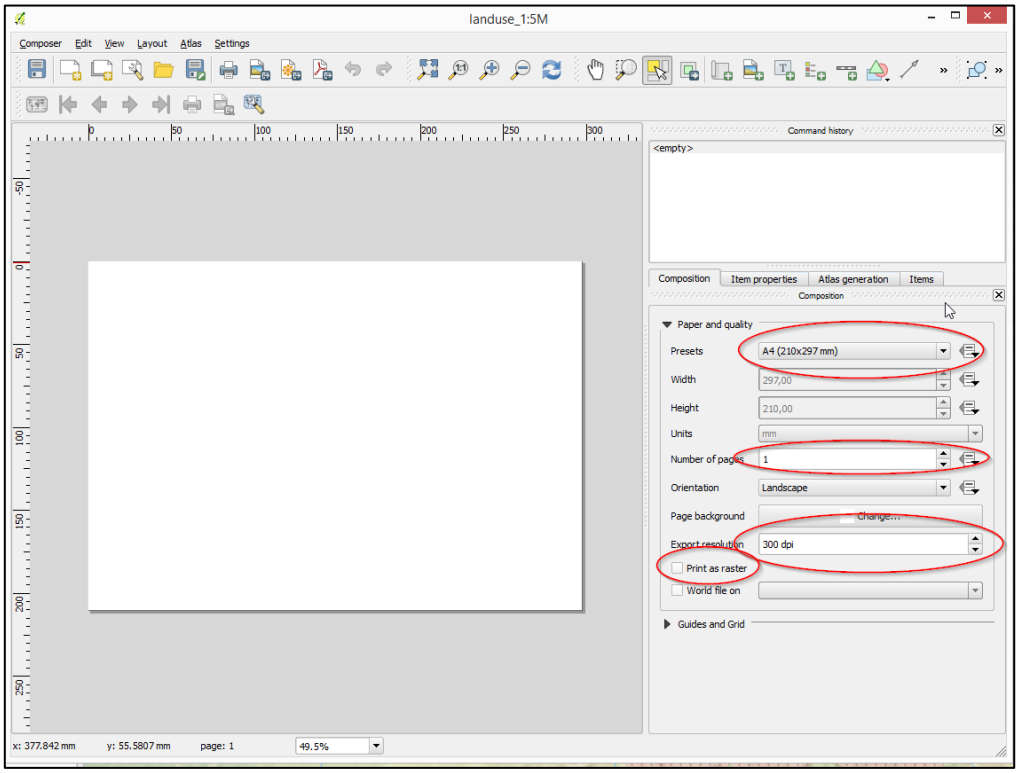
Note: The screenshots in this section use an older version of QGIS; these will look slightly different in newer versions.

You can also make "composer *templates*" of which you can base new composers on. Open a new print composer by clicking **<New Print Composer>** and add a descriptive name to the composer you are creating.



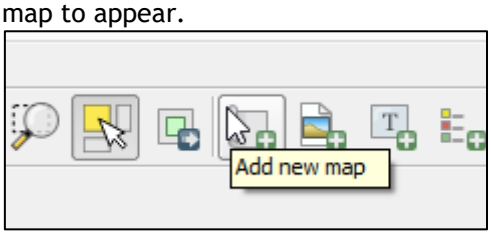
9.1.1 Composition

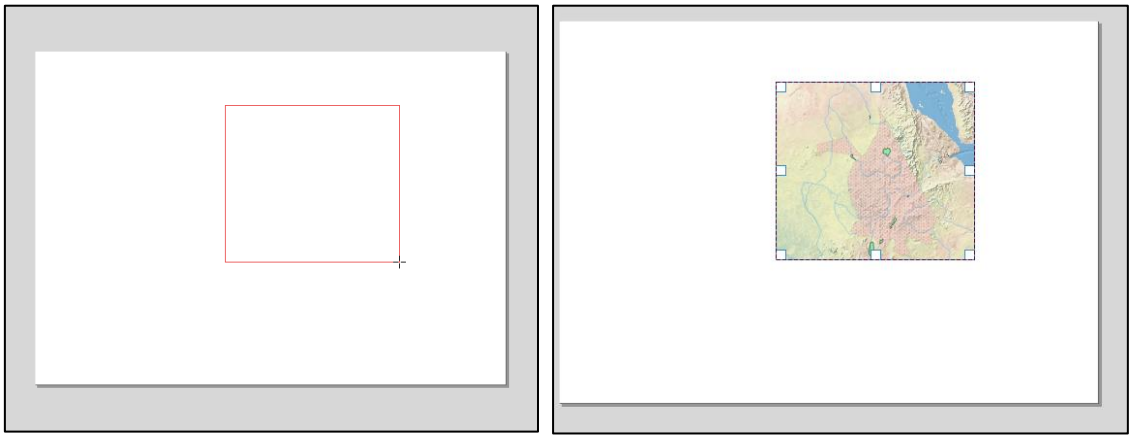
The first step is to choose the paper size and similar general attributes. These values are set in the **"Composition"** tab. Notice the **"Print as raster"** checkbox which we can experiment with later.



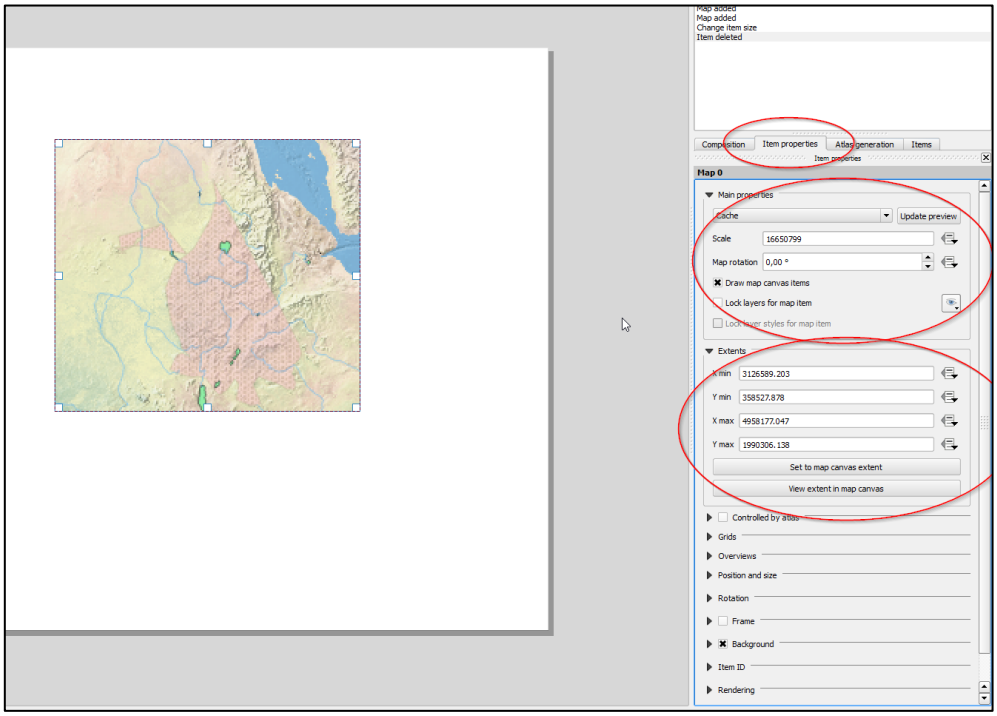
9.1.2 Map item

A print composer consists of multiple items. One item is the “map item”. You can have several map items in one composition, and each can be controlled individually. Add a map item by clicking **“Add new map”** and drag and drop the extent on the page where you would like the map to appear.

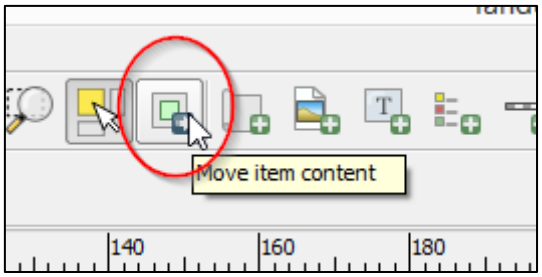




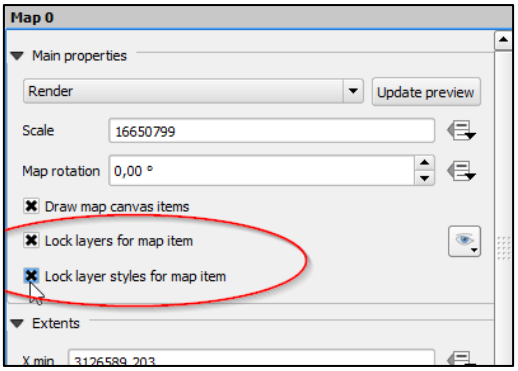
In the **“Item properties”** tab you find all the details and controls on the *selected item*—in this case, the map item. We can control a lot of properties: perhaps most useful is the scale, rotation and extent. When you change anything, click **“Update preview”** to update the map.



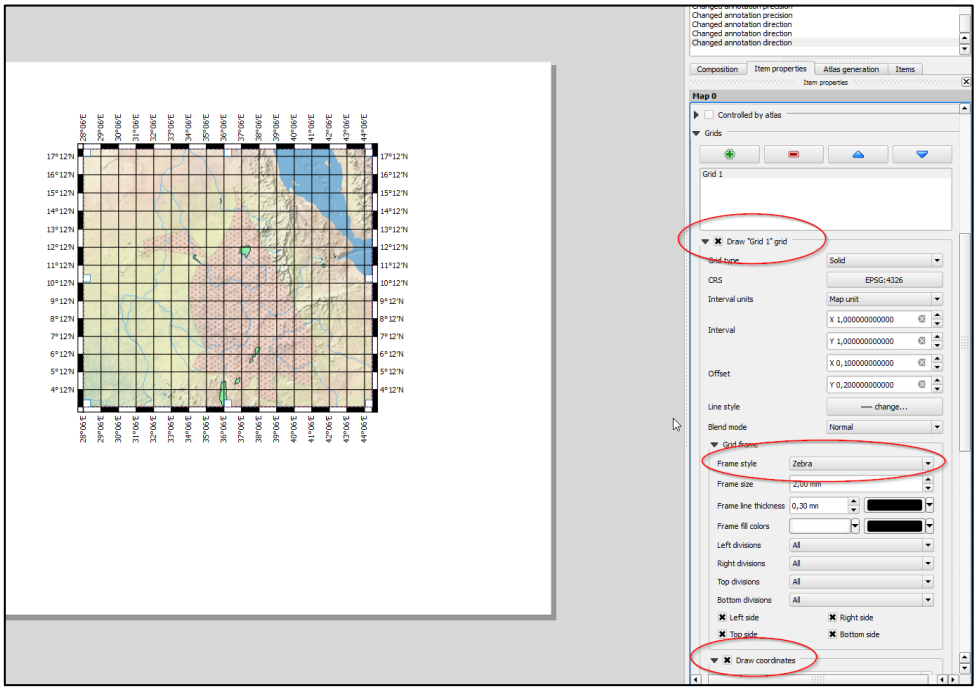
In addition to controlling the extent by typing in the coordinates and scale number, you can also interactively navigate the content of the map item. You do this with the tool **"Move item content"** and drag-pan and scroll inside the map item to move the actual map content.



When you are satisfied with the style and content of a map item – it can be useful to *lock* the map item for further changes. This can also be set to preserve the actual style of the map. You control this by the "locking" checkboxes:

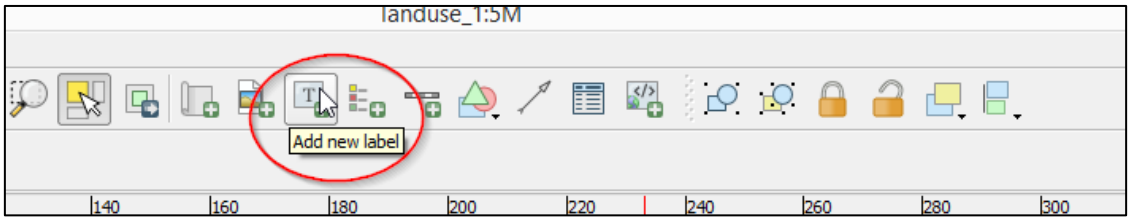


As mentioned, there is a vast number of possibilities in styling the map item, including adding grids, zebra-lines and coordinates on the border. Try out the different options in the map item properties:

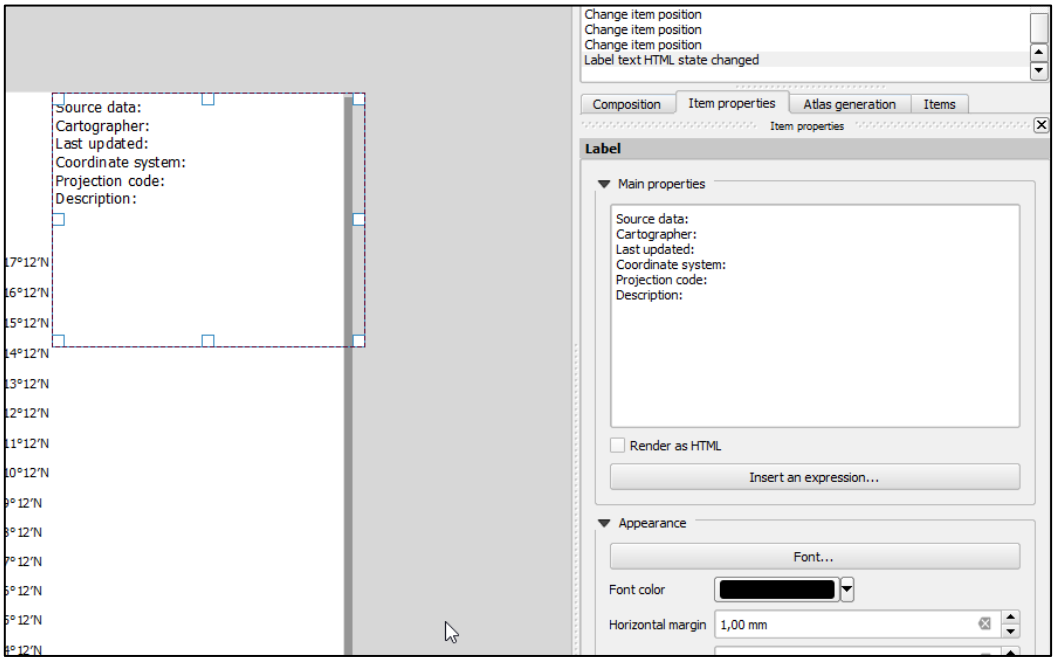


9.1.3 Text items

Text items are very useful for adding static text to the map. Adding metadata like projection, update date, data sources, name of the map maker and so forth is essential for a professional map. This can be added by using a “text item” in the composer. You add this by using the tool **“Add new label”**. For more control of the style you can also try the “add html frame” which requires some code for formatting.

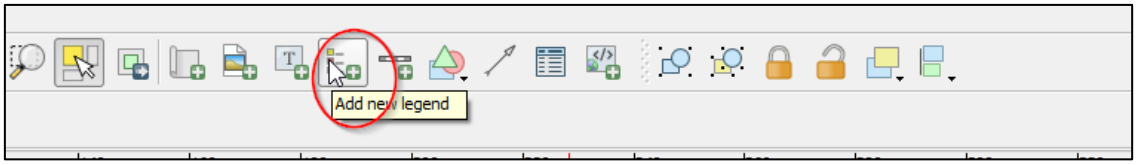


The content in a text item is controlled in the sidebar. You can add many text items in the same composer, and even add them on top of the map to “write” directly on the map.

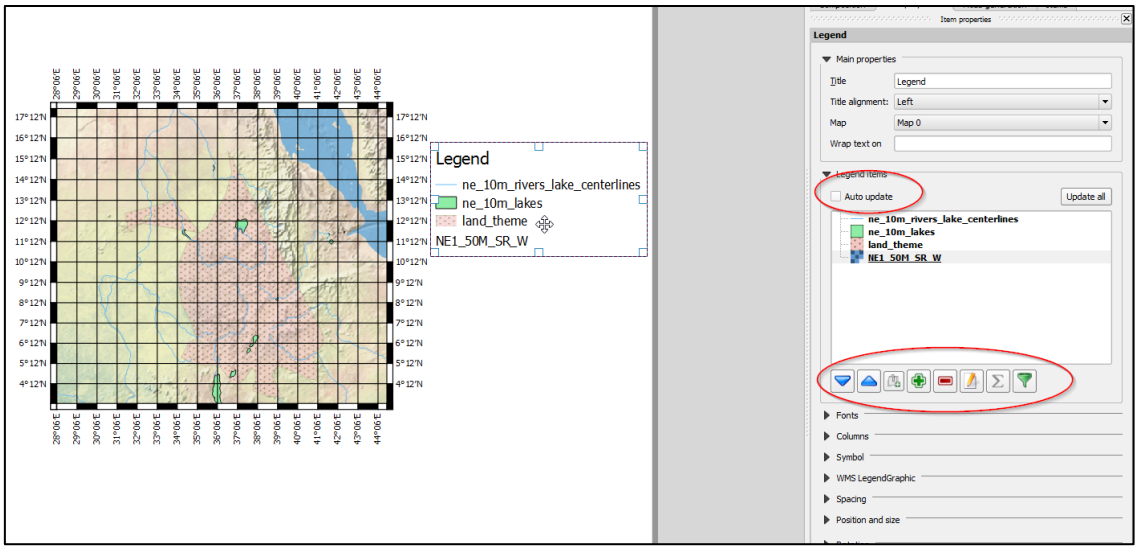


9.1.4 Legend

Legends are essential to convey the symbology of the map to the map reader. Legends can be automatically created in the composer by using the “Add new legend” tool.



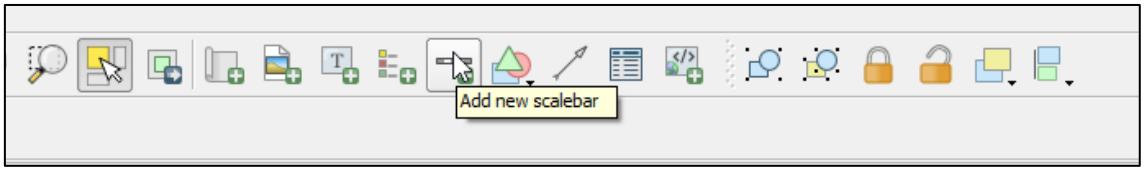
You control the content in the sidebar. You can choose to **“Auto update”** the legend, or manually control the legend items. The text and symbols are fetched from the layer manager in QGIS and controlled by the style manager which is presented in earlier chapters.

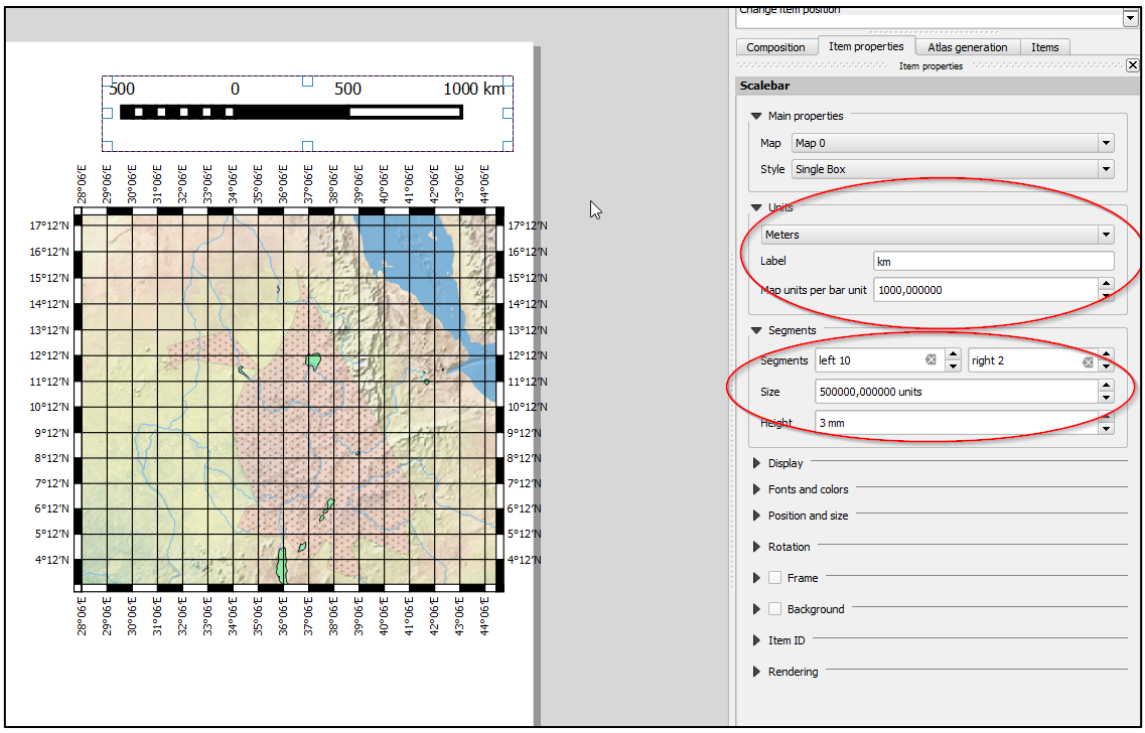


Pay attention to the relationship between symbol size and legend icon size, which can cause troubles for large symbols. A practical tip is to avoid using the symbol size, but scale symbols in the map using the **“Scale area”** or **“Scale diameter”**.

9.1.5 Scale bar

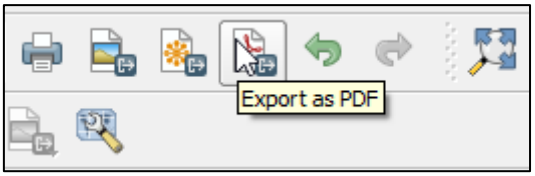
Adding a scale bar is a fairly straight forward task. You add it with the tool **"Add new scalebar,"** and control the appearance in the sidebar. Pay attention to the relationship between the **"Map units per bar unit"** and the **"Segments"** control.





9.1.6 Exporting the map

Exporting a map is done via the "export tools". Mostly, you will want to export a PDF (**"Export as PDF"**) or a PNG. Notice that the dots-per-inch (DPI) and "print raster" affects the performance and results tremendously. You should also be aware that for large files QGIS will "hang" while the image is processed. Do not worry about this: QGIS is working, but is locking the interface for interaction. Be patient and it will finish after a while for large files. Save the results in the "Results" folder of your project folder structure.

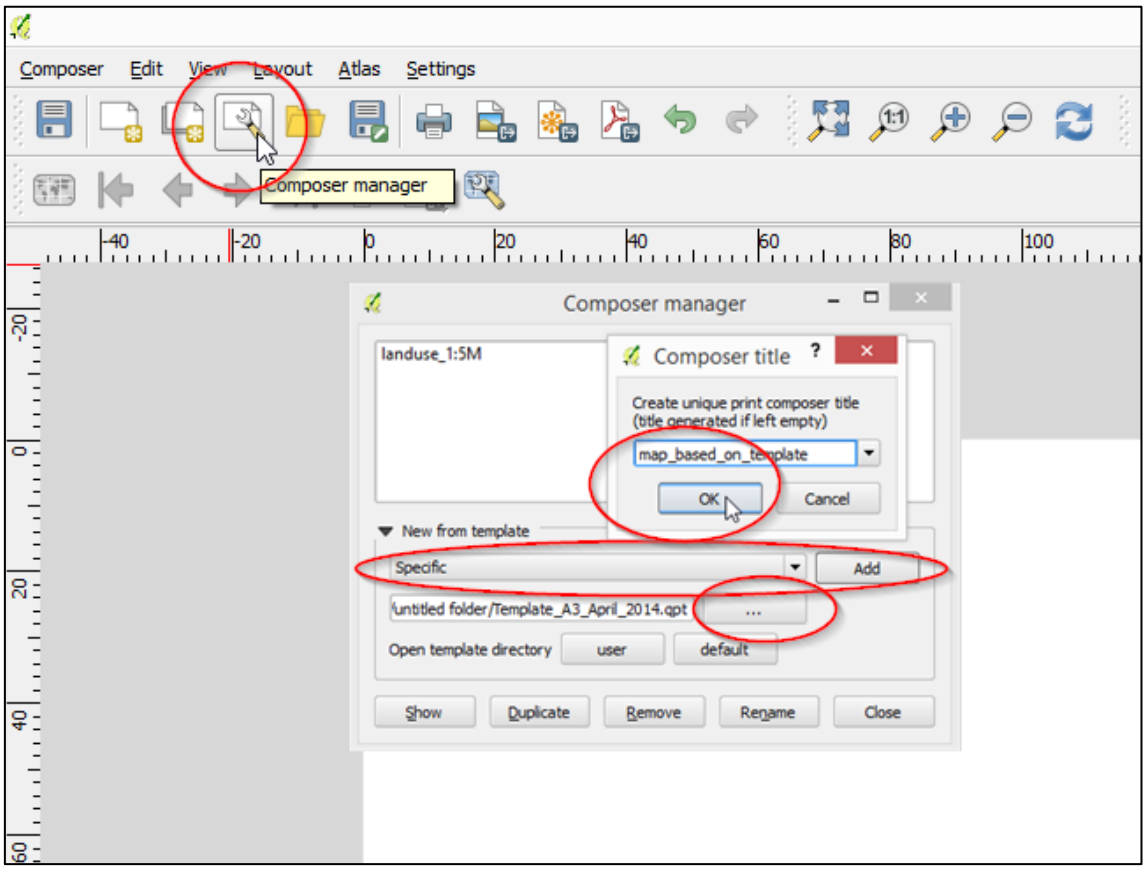


9.1.7 Templates

Using a map template

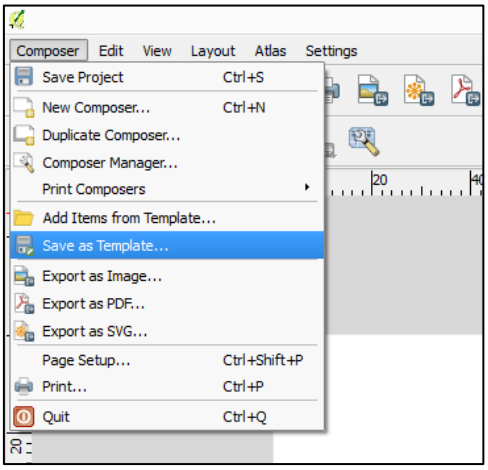
> Note: A set of Myanmar basemap templates, including administrative boundaries, are available in the Network Attached Storage system.

When you want to make a new map composer based on a template, select the **Composer manager > New from template > "Specific"**, and choose the map template "qpt" file. Click **<Add>** and type in the name of the new map composer you are making. In the course material folder, you will find several templates which you are free to use directly or be inspired by.

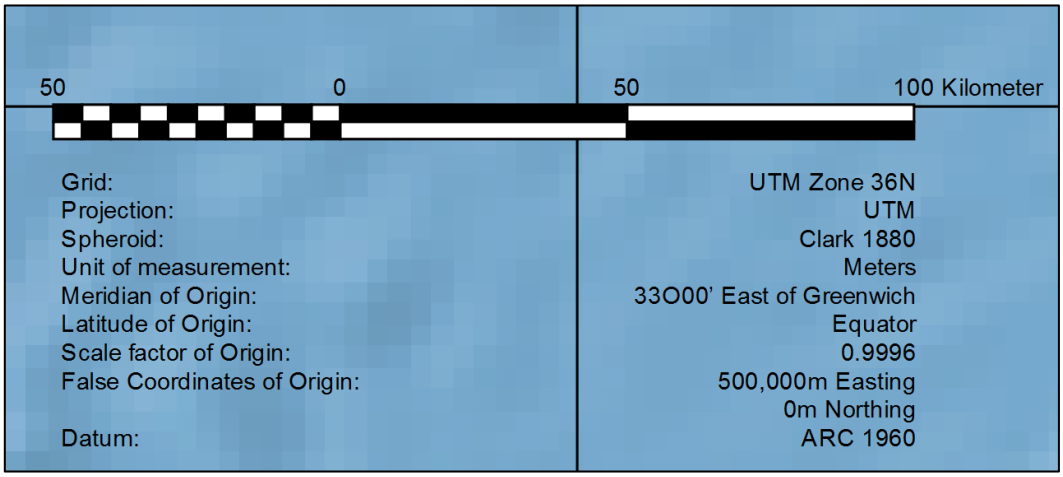


Creating a map template

When you have designed a composition that you like, you should make a template of it that you can reuse and build upon. To make a composer template you choose the "save as template" option. This saves a ".qpt" file on the specified location. You should ensure that the resulting template file is copied to a centralized file share which allows you to efficiently share and manage the templates across the organization.



Make sure you include enough metadata in your map template. At a minimum, you should include the following information, noting that more information is almost always better than missing information:

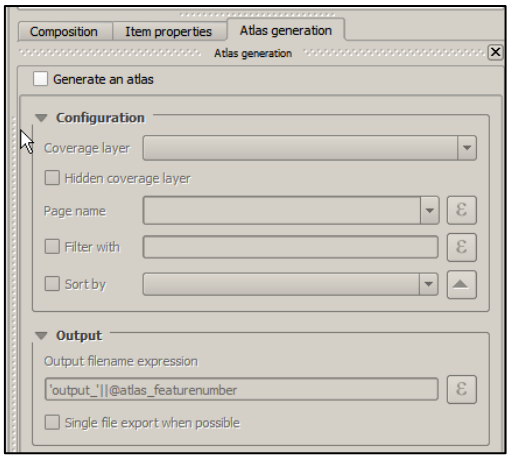


When you have finished your map template, you should incorporate routines in your organization to manage the map templates. Use the same routines as you would when sharing and managing your centralized databases: the benefits to the quality of reports and map products are tremendous.

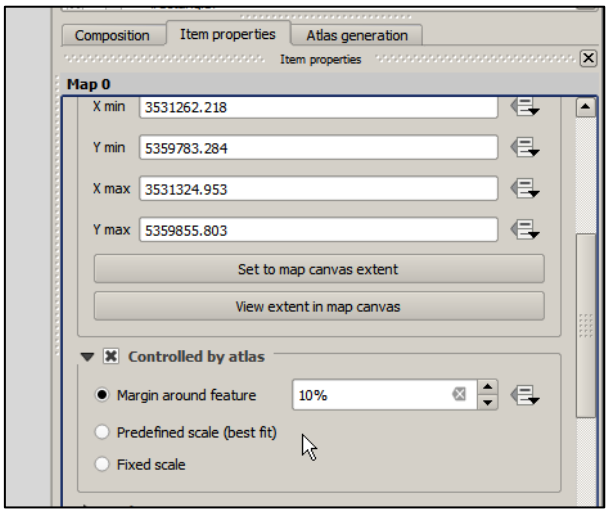
9.2 Creating an atlas from print composer

Printing an atlas in QGIS involves printing several pages with maps in the same composer format.

1. On the right side of the composer, there are three tabs: one of them is **<Atlas generation>**.
2. Check **"Generate Atlas"** and some option will become active on this tab.



3. The **<Coverage layer>** is the layer that will define those printed areas on each page of the atlas, such as a grid that covers the whole atlas. As you choose the coverage layer, select the map and check **"Controlled by atlas"** in its **<Item properties>** tab *(see below)*.



4. Back in the **<Atlas generation>** tab, a set of choices define the way we will name each file and page names (via **"Output filename expression"**).
5. Below **<Controlled by Atlas>,** three options control how information is displayed: (1) keeping a margin around each feature; (2) predefined scale in each page; or (3) fixed scale, which will keep the same map scale through all pages.

10. Appendix

10.1 Work routines – best practice

Data management and good work routines are essential in professional GIS work. Below, we review some good routines which should be followed.

Basemap data, **thematic map data** and **project-specific map data** are three categories of data. It is very important to understand the difference between them, which we discuss further below.

10.1.1 Basemap data, thematic data, and project map data

Basemap data are those managed by **other agencies**: these are not changed, but used to make maps. Typically this can be country borders, administrative regions or similar. You should always make sure that you have requested the **latest updated version** of the data **from the data owners.** Ideally you should be able to get the data from a centralized source—such as a file share—where you can copy the data onto your local computer. Maintain metadata on the data, including the source, the date last updated, and any use constraints or licences.

Thematic map data are those that you or your agency is responsible for changing and keeping up-to-date. **You are the data owner:** you manage the datasets, but other organizations use them as well. It is very important that your agency (as data owners) manage these data in a centralized location. In addition, you should have good routines when changing the data. If you need to change/update the data, one approach would be:

1. Go to the centralized location where data are stored, and identify the dataset of interest.
2. Add a line to a "sign out" text file (if this does not exist, make a new textfile). Write your name, address/phone/email, purpose, date, and time of the change.
3. Copy the data to your local computer and update the data.
4. Go back to the centralized location where the files are shared.
5. Copy the old file into a folder named "archive."
6. Add a line to the "sign in" text file. Write your name, address/phone/email, changes made, date, and time the updated data were copied back into the folder.
7. In the "sign out" text file, add a comment before your line with the text: "FINISHED".
8. Copy the updated data file back into the folder.

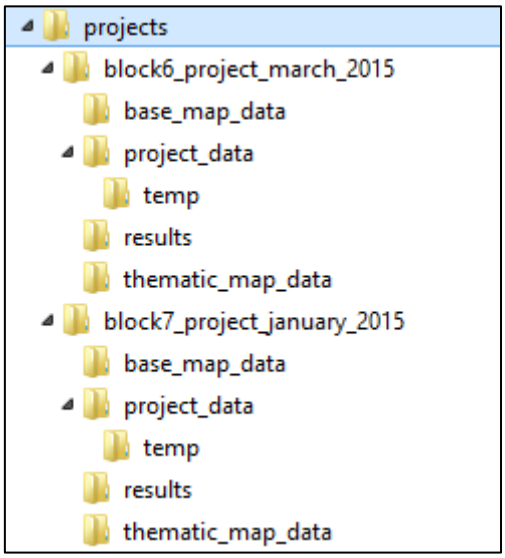
This routine ensures that you have updated data in a centralized location with minimal effort. If such a work routine is not followed, you will soon have many different versions with changes in many different files, which will cause problems. These data should also be accompanied by metadata, outlining the source(s), the method of creation, the date last updated, and any use constraints or licences.

Project map data are data which are specific to the project you are doing. This means that no one relies on this data. You should keep this data on your local computer and may have less

strict routines on managing this data. However, you should regularly make backups on file shares or USB sticks, and be prepared for any requests that may come for those data (including the accompanying metadata).

10.1.2 Local file organization

With professional GIS work, it is important to maintain good folder structure to control many files and many folders. We suggest the following folder structure for a project (illustrated with two projects):



Keep your data in the designated folders. Use the “temp” folder for temporary trials and errors and scratch-data. Place all of your metadata documentation, notes, reports, map products in the “results” folder.

10.1.3 Documentation and note-taking

It is very good practice to start a project with a blank text file where you can write quick notes documenting what you are doing in the project. You can use this to make your report, and it gives you a good basis for teaching others to do this work. Some note-taking ideas:

- Take brief notes of every step you do;
- Use screenshots for documentation and note taking:
    - Use **<PrintScreen**> or Windows’ **<Snipping Tool>** to take screenshots.
    - Copy and paste code and snippets of data.

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The Norwegian Environment Agency is working for a clean and diverse environment. Our primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature, and prevent pollution.

We are a government agency under the Ministry of Climate and Environment and have 700 employees at our two offices in Trondheim and Oslo and at the Norwegian Nature Inspectorate's more than sixty local offices.

We implement and give advice on the development of climate and environmental policy. We are professionally independent. This means that we act independently in the individual cases that we decide and when we communicate knowledge and information or give advice.

Our principal functions include collating and communicating environmental information, exercising regulatory authority, supervising and guiding regional and local government level, giving professional and technical advice, and participating in international environmental activities.