


# Open solutions for SDG monitoring: Introduction to Quantum GIS

This exercise is based on a series of exercises by Dr. Vince Láng<sup>1</sup>, developed for the course „GIS Applications in Natural Resource Management”.

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## Objectives, materials

**Objective of the exercise:** To give an impression about how QGIS can be used and to make the first steps in using the software in environmental applications related to the Sustainable Development Goals.

**Tasks:** Basic operations in QGIS, including: Display and edit vector and raster maps, link to web services and compose a map for printing.

**Required time:** 3-8 hours, depending on the GIS-QGIS experience of the course participant.

We designed the exercise as a stand-alone teaching material; the execution can be started during the face-to-face part of the Summer School, but can be continued afterwards, if needed.

**Data set:** GIS data about the Lake Uromiyeh Basin, Iran.

The data base is attached in a separate folder IntroQGIS\_data.

File name	Explanation
...\Maps\Islands.shp, .dbf, .prj, .qpj, .shx	Islands in Lake Uromiyeh
...\Maps\lake_20160623.shp, .dbf, .prj, .qpj, .shx	Lake Uromiyeh 23.06.2016
...\Maps\Lakes.shp, .dbf, .prj, .qpj, .shx	Lakes and reservoirs
...\Maps\Pop_larger.shp, .dbf, .prj, .qpj, .shx	Larger populated places
...\Maps\Pop_small.shp, .dbf, .prj, .qpj, .shx	Small populated places
...\Maps\Road_dirt.shp, .dbf, .prj, .qpj, .shx	Dirt roads
...\Maps\Road_highway.shp, .dbf, .prj, .qpj, .shx	Highways
...\Maps\Road_paved.shp, .dbf, .prj, .qpj, .shx	Paved roads
...\Maps\Streams.shp, .dbf, .prj, .qpj, .shx	Rivers and streams
...\Maps\subbasin.shp, .shx, .dbf	Watershed and sub-basins map
...\Landsat\*.*	Landsat 8 image layers of the area

Remarks:



- All maps were digitized from the 1:500,000 topographic maps
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**Conventions in this document:** The following typesetting conventions are used:

⇒ Tasks are shown with this arrow. These are the steps you have to carry out during the exercise.

File names and other computer input is shown with this font.

**Background information about the case study:** Lake Uromiyeh case study at

<http://isepei.org/case-studies/twente-itc/environmental-management-plan-lake-uromiyeh-ecosystem-iran>

## Introduction

In this exercise, we use the Geographic Information Systems (GIS), called QGIS (Quantum GIS). This is a freeware available for Linux, Mac OS, Windows and Android. This makes this program a powerful tool to be used not only in the office but to bring it to the field on a tablet or a smartphone.

Many NGOs and other organizations are moving to open access programs, and many are using QGIS as their main GIS software. QGIS is not only building on its own options and available tools, but it can use great tools of other GIS and related software, like R, SAGA or GRASS, among others, which are tools for statistics of for handling raster data. Additionally, many plugins written by users are available, thanks to being open source. The scripting language is Python, which is an easy to learn coding language, which can be used for building customized workflows or to speed up big data handling.

Loadable and savable data formats include almost every common file types. This includes shape files, different raster formats, AutoCad files etc., which can then be use in other software.

### The Quantum GIS software

⇒ To start from the very basics go to the QGIS website (<http://www.qgis.org/en/site/>).

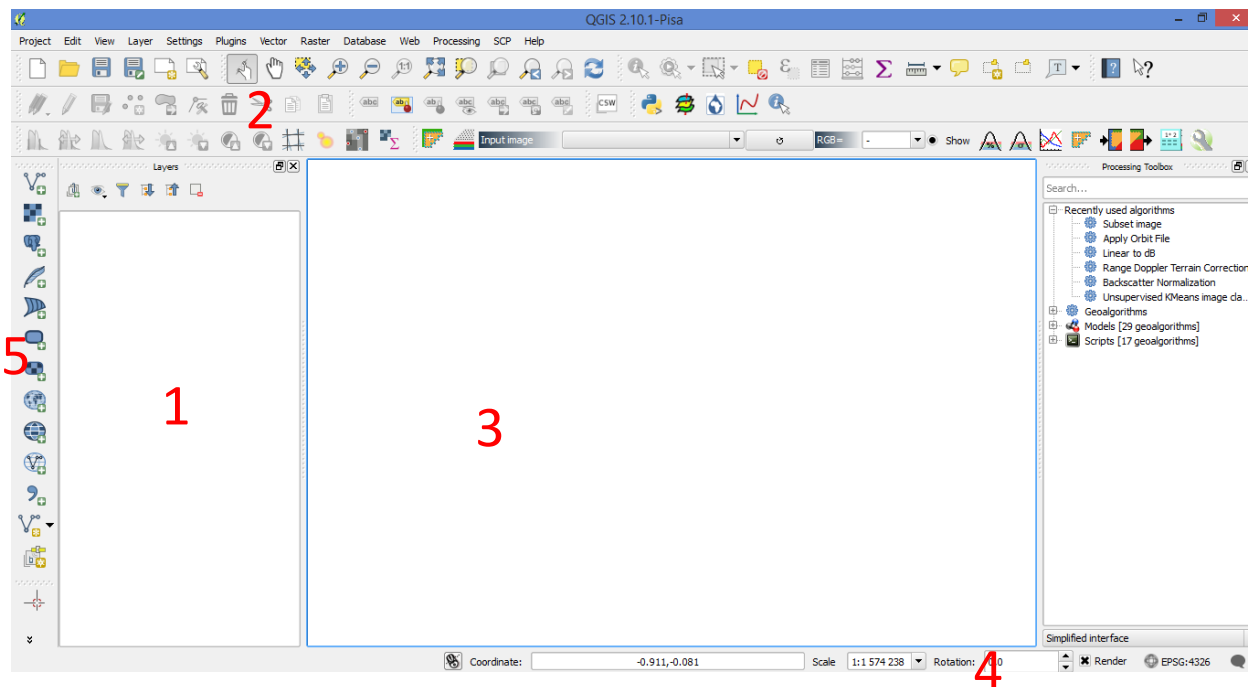
NOTE: QGIS was started as Quantum GIS, but most users used the short form QGIS. They have recently issued an official statement that from 2014 it is officially QGIS.

You will find the download button, where you can find all the available downloadable versions. Besides the program itself many useful and interesting materials are available. Please use this as a source of information if you are stuck with something.

Another good information source is the Geographic Information System Stack Exchange website <http://gis.stackexchange.com/>. Many questions have been raised and answered here so it is also a good source.

## Overview of the QGIS interface

We will explore the QGIS user interface so that you are familiar with the menus, toolbars, map canvas and layers list that form the basic structure of the interface.



The elements identified in the figure above are:

1. Layers list
2. Toolbars
3. Map canvas
4. Status bar
5. Layers manager

Your interface may differ a bit. It can be changed according to User preferences:

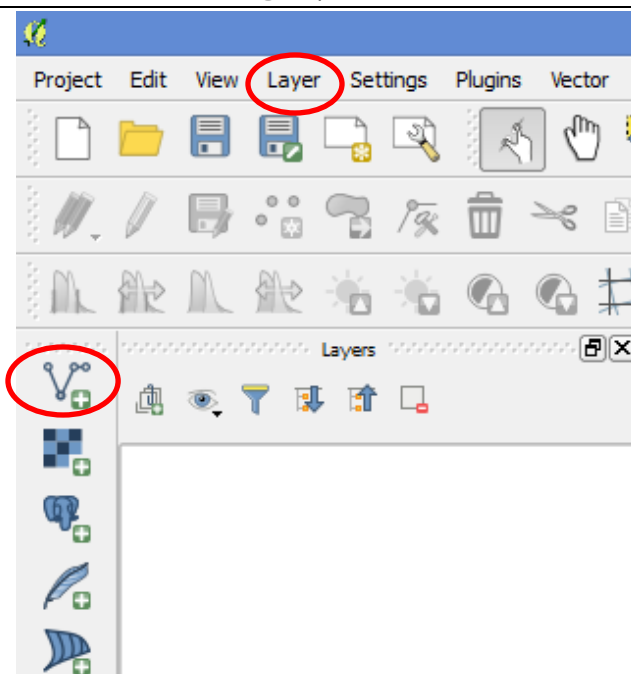
1. Right click somewhere on the menu (Area 2 or 5)
2. A window will pop up with the available menu bars

### 1. Loading and displaying vector data from shapefiles

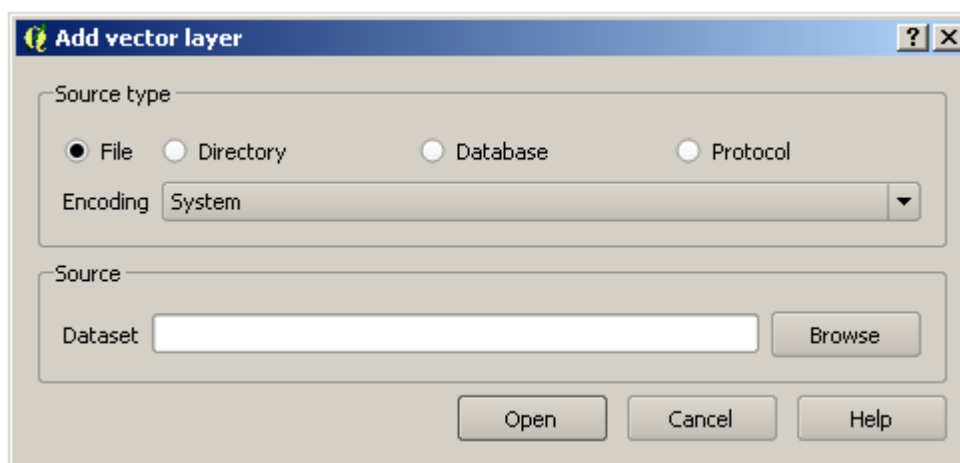
The Shapefile is a specific file format that allows you to store GIS data in an associated group of files. Each layer consists of several files with the same name, but different file types. Shapefiles are easy to send back and forth, and most GIS software can read them.

Refer back to the introductory exercise in the previous section for instructions on how to add vector layers.

⇒ Look for the Add Vector Layer button in Layer menu or Use the Add vector layer on the left side

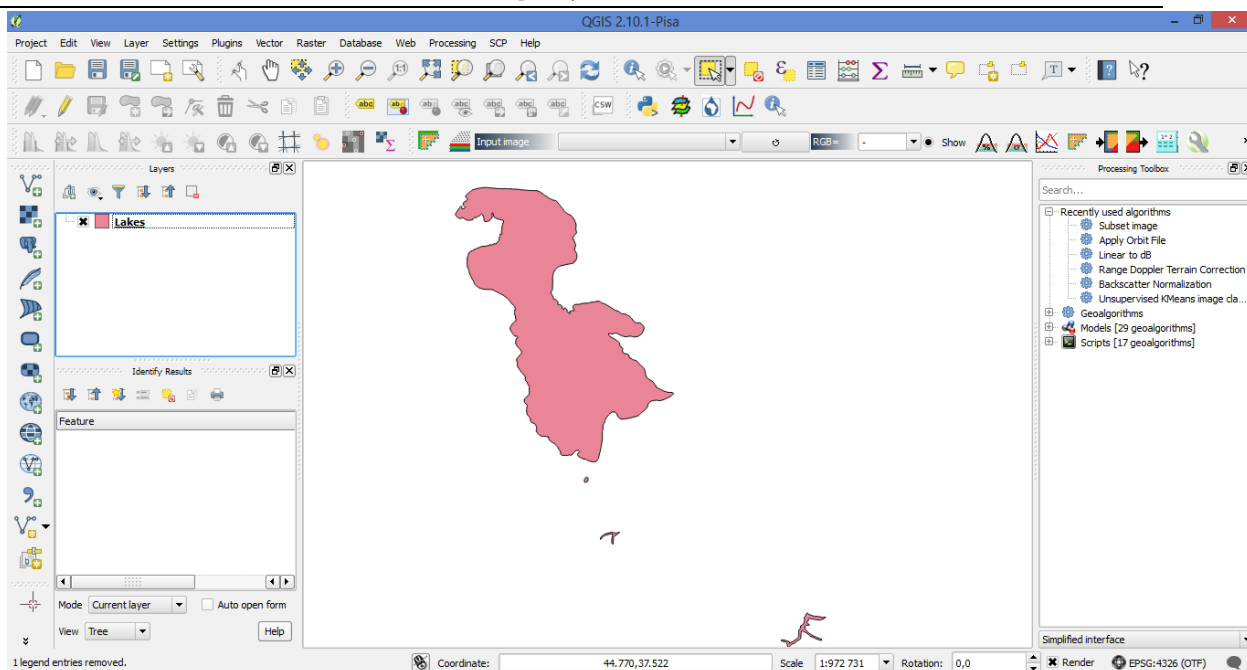


⇒ Click on it to open the following dialog:



⇒ Click on the Browse button and navigate to the file: ...\\Maps\\Lakes.shp

⇒ With this file selected, click Open. You will see the original dialog box, but with the file path filled in. Click Open here as well. The data you specified will now be loaded.



The layer now displayed shows Lake Uromiyeh, along with some smaller reservoirs. To get a feel of the data, try zooming in and out a little:

- ⇒ Use the scroll wheel of your mouse to zoom in and out. Notice that the scale in the status bar is changing.

Let us now load some other layers to our display.

- ⇒ Load the following shapefiles: **Islands.shp**, **Pop\_larger.shp**, **Pop\_small.shp**, **Road\_dirt.shp**, **Road\_highway.shp**, **Road\_paved.shp**, **Streams.shp**

The layers are displayed on top of one another, in the same order you have added them to the display. This means that if you have followed the order above, some roads now run across the dots representing populated areas. Change the order of layers so that we have the **Pop\_small** and **Pop\_larger** layers on top.

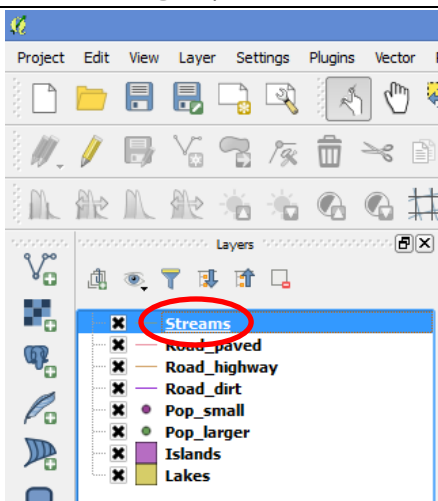
- ⇒ In the Layers list area, move your mouse over the name of the **Pop\_small** layer and by holding down the left mouse button drag it to the top of the list. Repeat the same with the **Pop\_larger** layer.

Using the random palette automatically assigned when loading the layers, your current map is probably not easy to read. It could have colours different than that of the present map. It would be preferable to assign your own choice of colors and symbols.

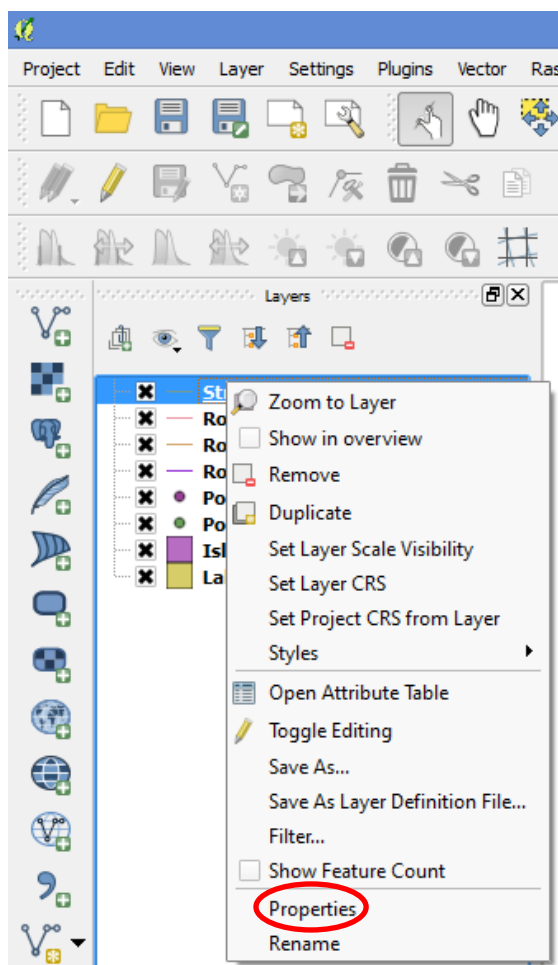
## Changing colors

To change a layer's symbology, open its Layer Properties. Let's begin by changing the color of the **Streams** layer.

- ⇒ Right-click on the **Streams** in the Layers list.



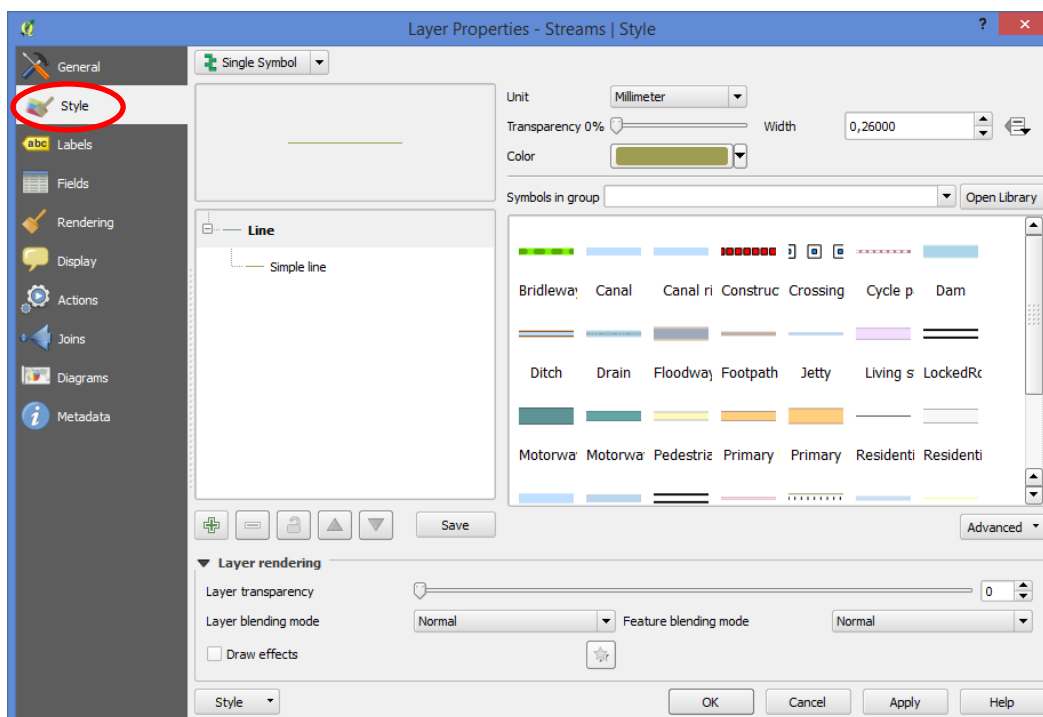
⇒ Select the menu item Properties in the menu that appears.



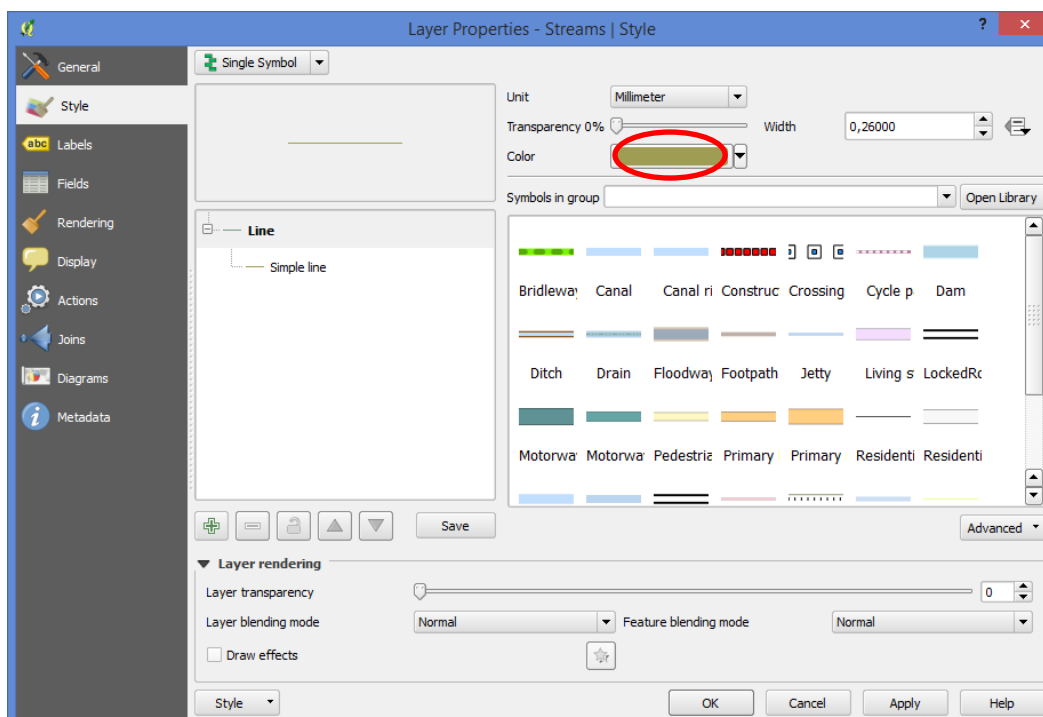
⇒ Note: By default, you can also access a layer's properties by double-clicking on the layer in the Layers list.

⇒ In the Properties window:

⇒ Select the Style tab at the extreme left

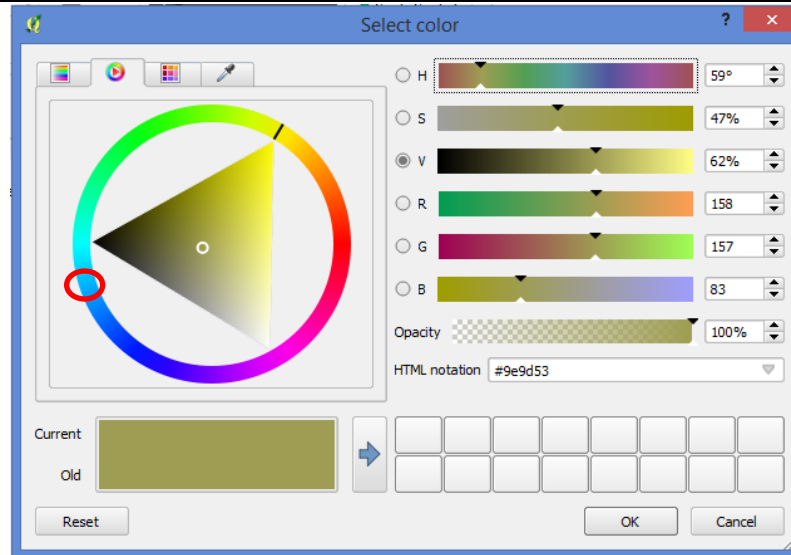


⇒ Click on the displayed color right from the Color sign.



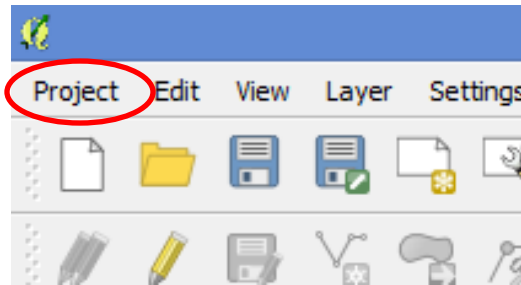
⇒ The Select color menu will appear and you can choose the desired one. Since the layer is about streams let's choose something blue.



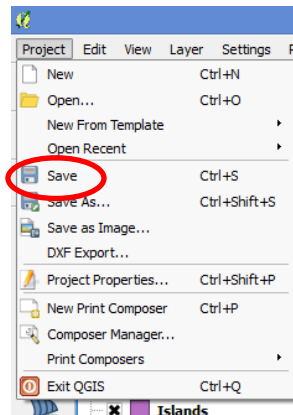


Now would probably be a good time to save your progress. QGIS can save all the layers that you have opened in a project file, so you can come back to them as they were and continue from there.

⇒ Click on the Project menu.



⇒ From the menu, select “Save”, and browse for your working directory. Select a name for your project (suggestion: Uromiyeh).



Next time you need to load the project, you can load just double click the project file from your file manager to start QGIS where you left off, or you can load a project from the “Project” menu from QGIS.

### Defining a Coordinate Reference System

Sometimes, when you access data from different sources, they can use different coordinate systems. Upon opening these layers QGIS is generally able to transform them to the view, so you see no error messages or problems. However, if for some reason your data is missing spatial reference, you will have to define it.

⇒ Load the `subbasin.shp` layer.

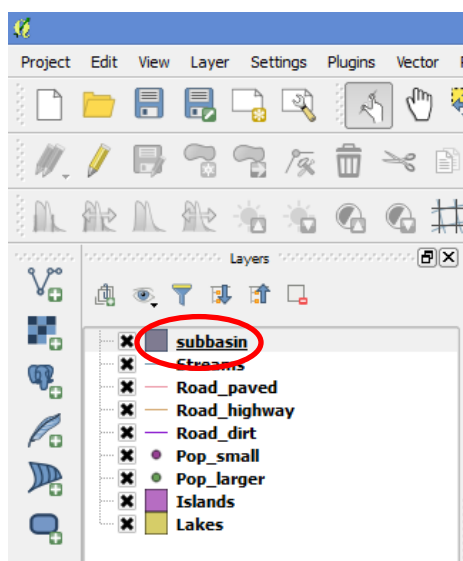
Notice the yellow alert message in the top of the display area.



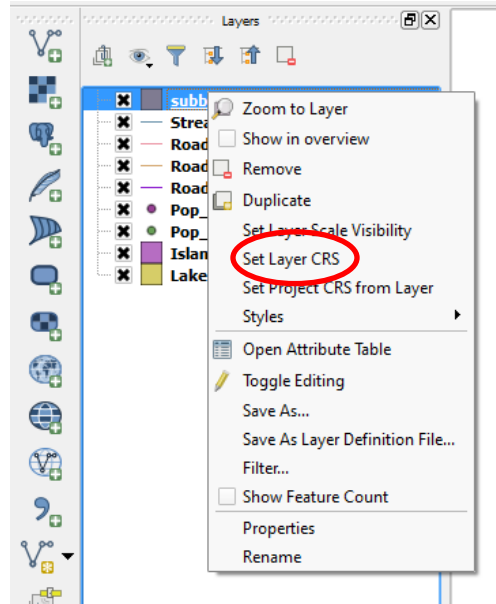
Note: under some settings the Coordinate Reference System Selector window may pop up automatically.

If you look at the files, you can see that the subbasin layer is missing a .prj file. Without any information, QGIS is trying to use a default projection system (WGS84), but it is unable to add the layer to the current view. Let's sort this out.

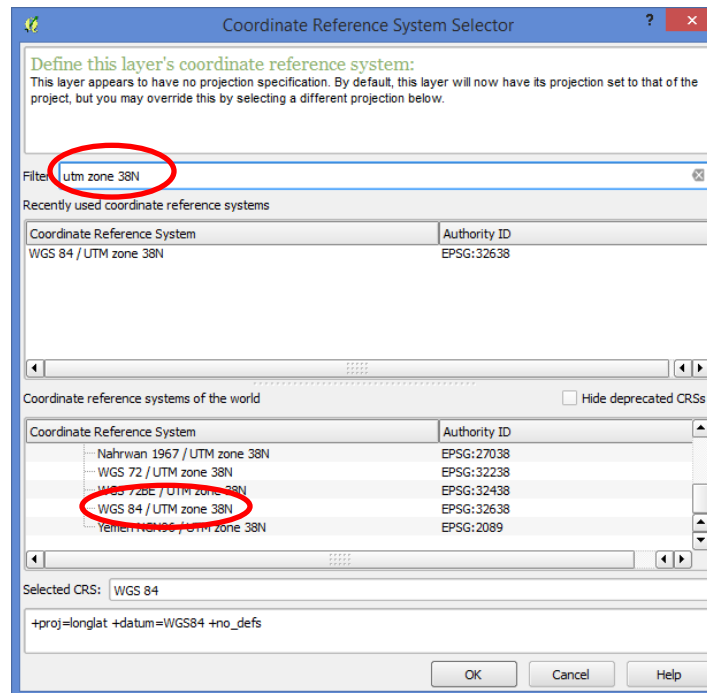
⇒ Right click on the subbasin layer.



⇒ Left click Set Layer CRS.



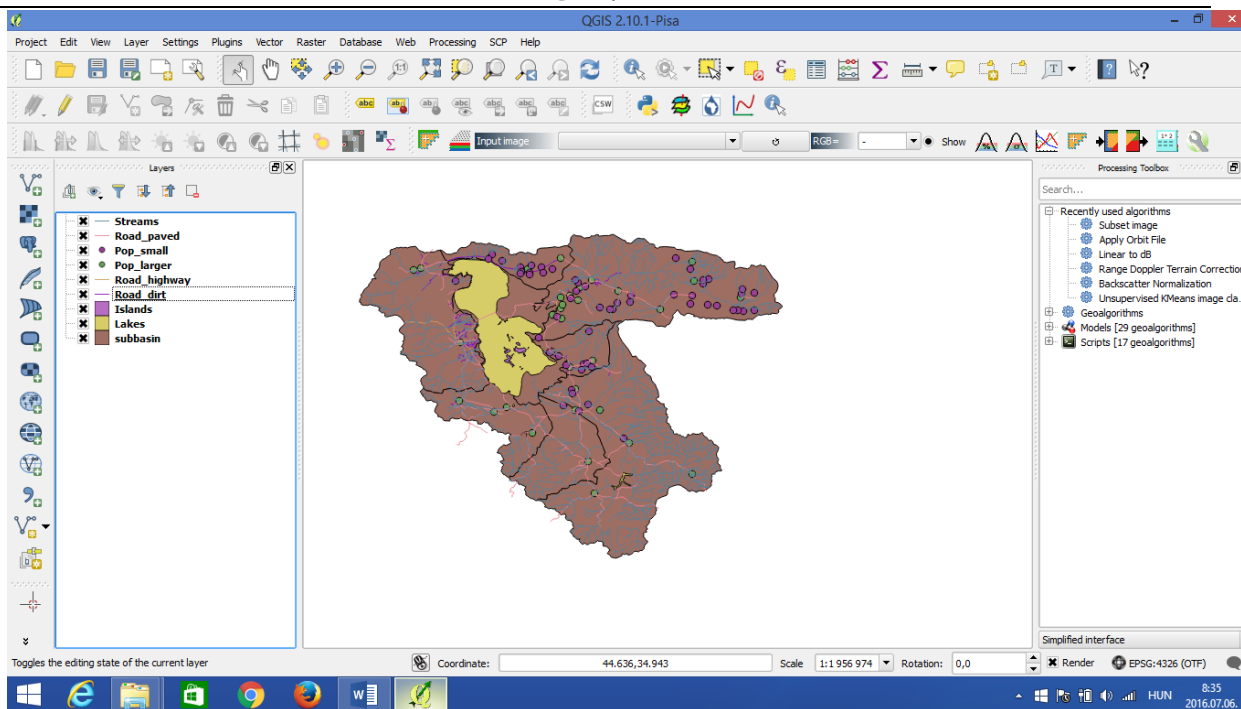
⇒ In the Coordinate Reference System Selector window, left-click to the box next to Filter, and type “UTM zone 38N”. From the filtered list, select “WGS84 / UTM zone 38N”.



⇒ Click “OK”.

Move the subbasin layer to the background so you can see the other layers.

Your display should resemble something like this:



Now would probably be a good time to save your progress.

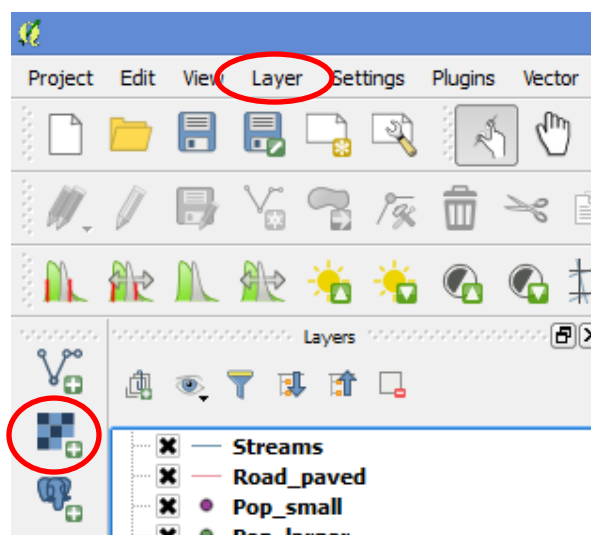
## 2. Adding a raster layer

Raster layers are different from vector layers. They are defined with cells. On 1 layer cells are normally the same size. Each cell has value(s) assigned to them and these values can be viewed, analyzed etc.

Let's add a raster layer to our map.

Now we will just add 1 raster layer (a coarse resolution satellite image) to our map to make it „nicer“.

- ⇒ From the Layer menu click on Add Raster Layer (or on the left menu bar). Load the file LC81690342016175LGN00\_B2.tif



If your view of the layer is obstructed by other layers, you can set the layer order as learned before, or you can switch on and off layers by (un)checking the little boxes next to them in the Layers list.

- ⇒ Arrange the layers so that you have a clear view of the raster layer.

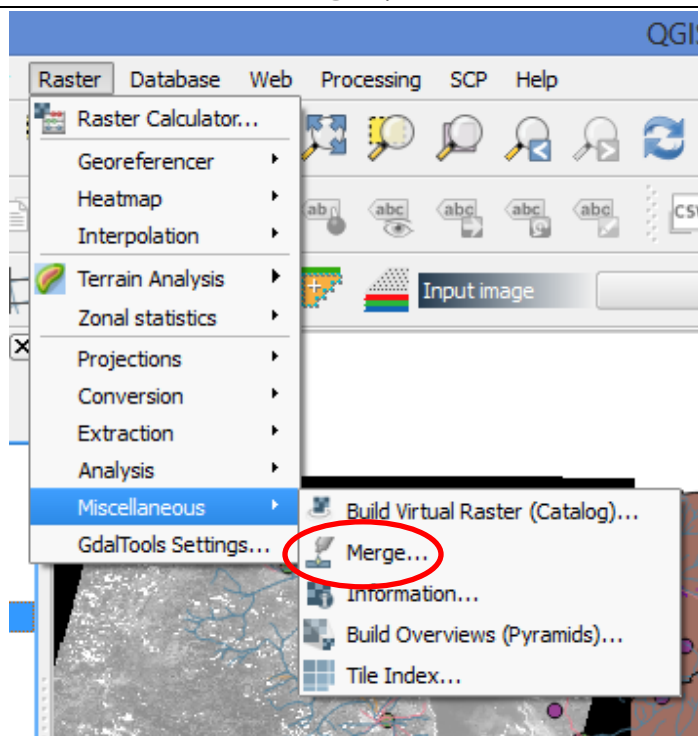
The layer we have just loaded has the data of Band 2 for a Landsat 8 satellite image. Band 2 refers to the spectral range for the color blue.

### Merging image layers (optional)

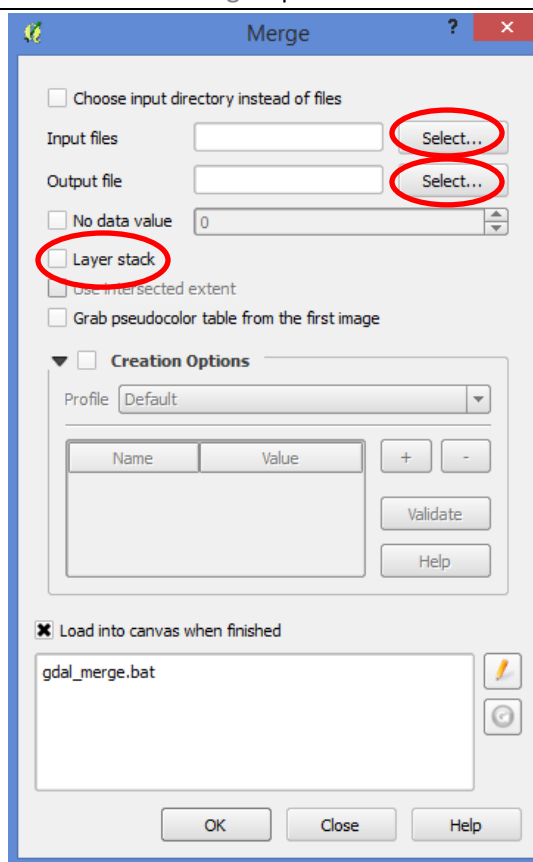
Most satellite images data is distributed as separate layers for each spectral band. This means that we can display them individually (see Exercise 2). However, while for certain purposes (such as processing and handling data) such arrangement is beneficial, but we generally prefer to look at images in color, or false color. This helps with the visual interpretation of the images, even if some of the bands are actually not in the visible range (false color). In order to have all bands in one file, we will have to merge the different raster layers together.

Note: this part of the exercise is optional, since the processing can take a significant amount of time depending on the computer.

- ⇒ From the menu select Raster -> Miscellaneous -> Merge



- ⇒ In the Merge window, browse for input files. You will have to select all 11 layers for the Landsat image from LC81690342016175LGN00\_B1.tif to LC81690342016175LGN00\_B11.tif.
- ⇒ In the Merge window, browse for the output directory and name your output file "Landsat\_2016". The format will be GeoTiff.
- ⇒ Select "Layer stack"



⇒ Click OK to run the merging process. It may take a long time. Once it is done you will see two windows popping up, one for finishing the process, and one for the progress (you should see it through the merge, but your computer may not be able to display it. Click OK for both.

⇒ Click “Close” to get rid of the Merge window.

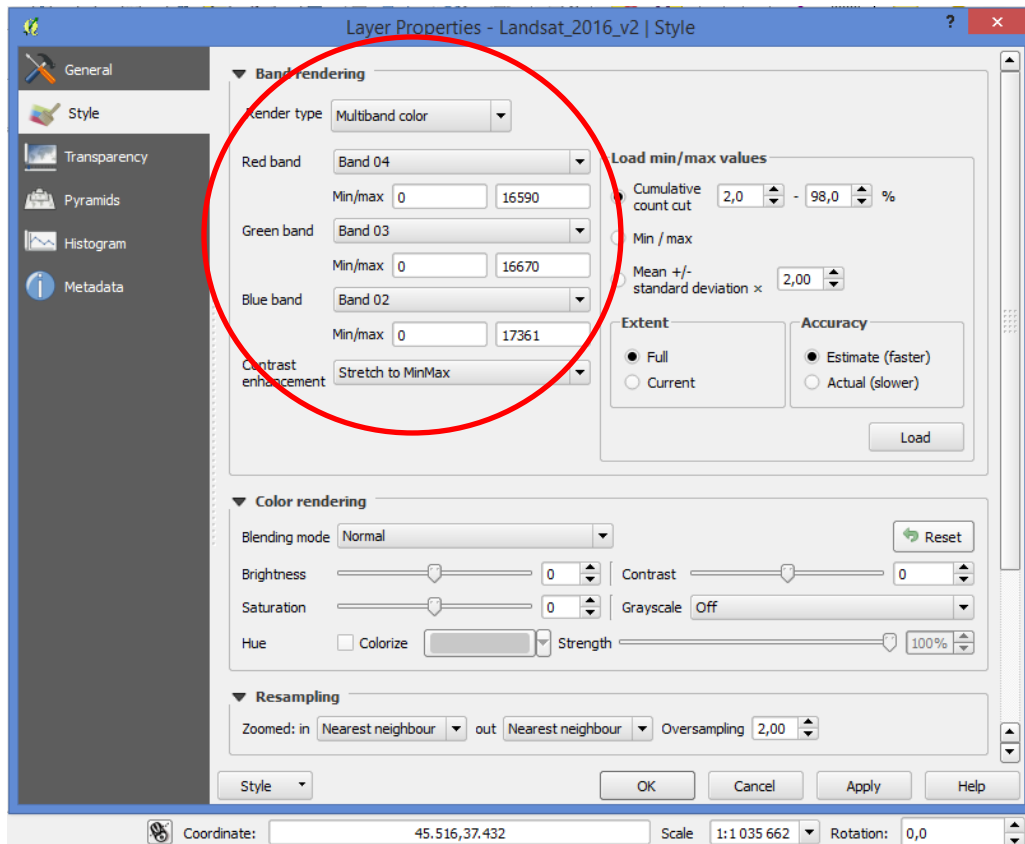
Now you should have a new layer called “Landsat\_2016” and it should

### Selecting different bands for display

For the purpose of this exercise, let’s present a true color image of Lake Uromiyeh based on a Landsat 8 satellite image. For Landsat 8, Band 2 is for the Blue, Band 3 is for the Green and Band 4 is for the Red color range.

⇒ Load the prepared Landsat image (Landsat\_2016.tif or use the pre-merged Landsat\_2016\_v2.tif)

- ⇒ Open the Properties window for the layer
- ⇒ For Render type, choose “Multiband color”. Select the three bands: Red = 4, Green = 3, Blue = 2. Click OK.



The resulting image should look like this:



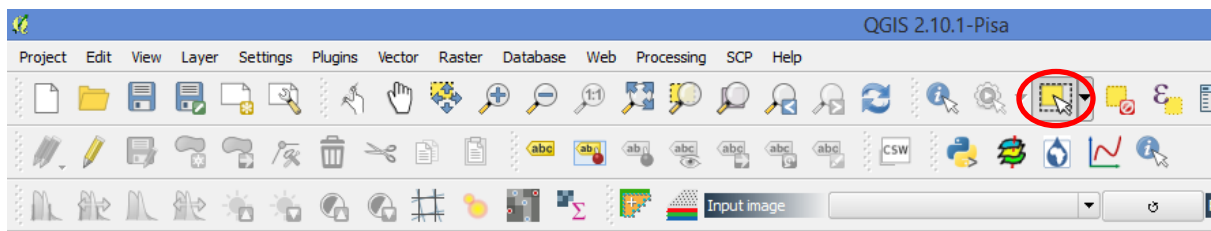


## 4. Case study: changes in lake area

As displayed in the case study, Lake Uromiyeh's area is changing. Let's assess the change to see how much of the lake has dried out.

We already have the Lakes layer that includes Lake Uromiyeh along with some smaller reservoirs. We will now create a new layer that only contains the lake itself. Also, we will change the Coordinate reference system, so that we can calculate lake area in square kilometers.

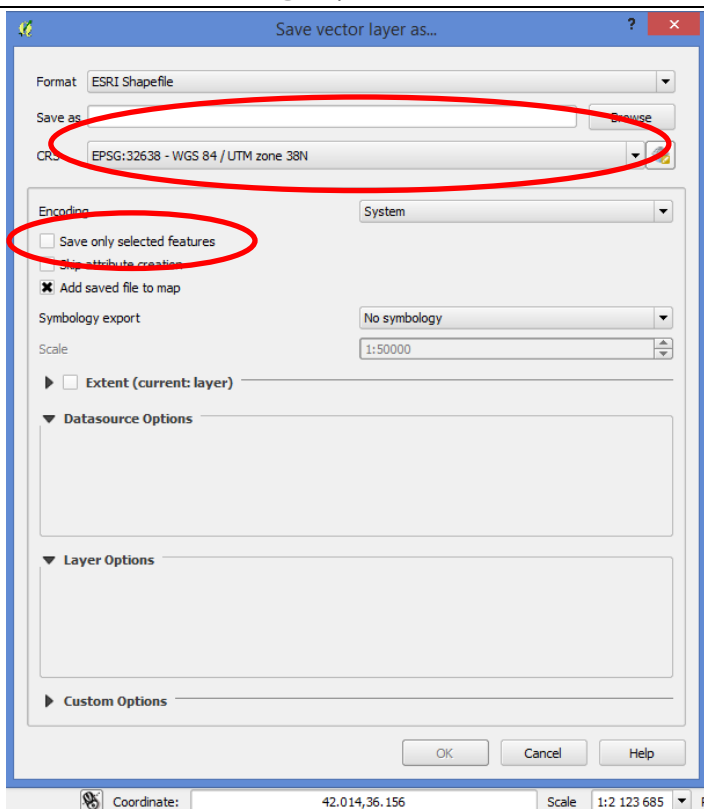
- ⇒ In the Layers list, select the Lakes layer
- ⇒ From the toolbars click on "Select Features by area or single click"



- ⇒ Click within the area of Lake Uromiyeh. It should now be displayed as bright yellow.



- ⇒ In the Layers list, right-click on the Lakes layer and select "Save as"



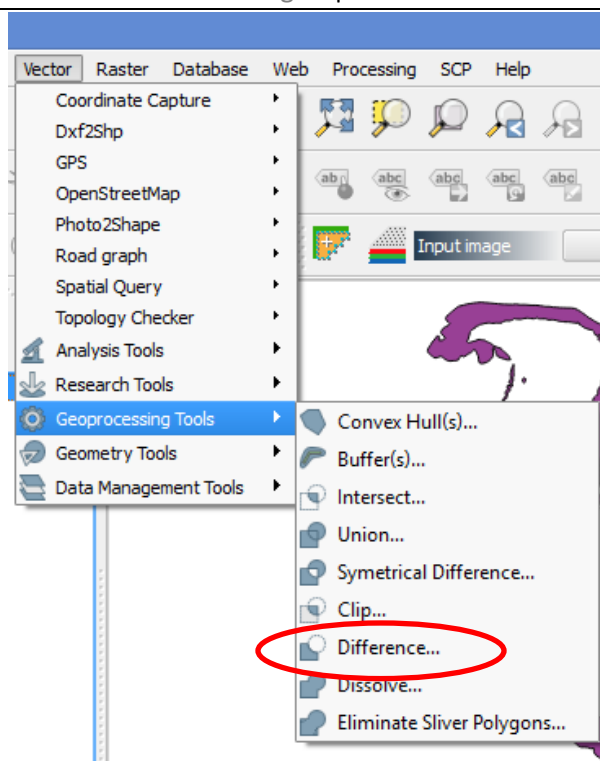
⇒ In the Save vector layer as window, choose a name (“Lake\_old” for example) and folder for the new file. Also, in the CRS section, select WGS 84/UTM zone 38N (see above). Don’t forget to tick the Save only selected features box.

We now have a map of the lake with meters as map units. Let’s load a recent extent of the map.

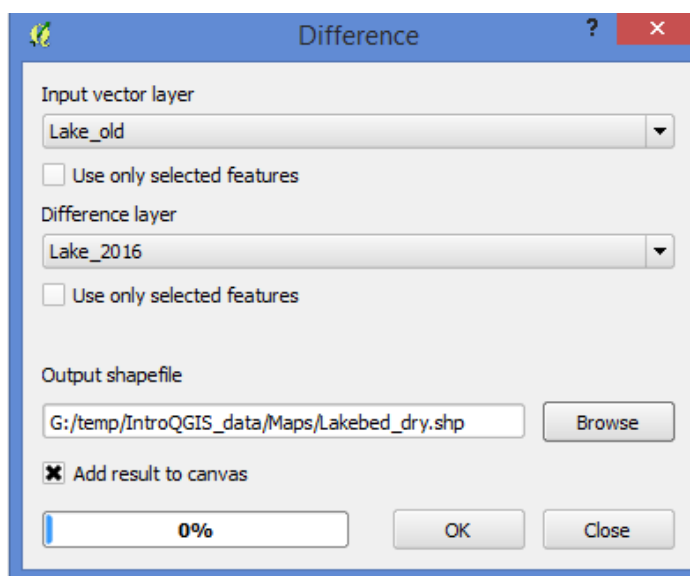
⇒ Load the vector layer from `Lake_2016.shp`

Now you should have both layers. After arranging the layers it should be clear that the 2016 extent is much smaller than the older one. Now we will create a new layer showing only the difference (i.e. the area that is now dry).

⇒ Select Vector -> Geoprocessing tools -> Difference



- ⇒ In the Difference window, select Lake\_old as input layer, while Lake\_2016 as your difference layer. Select the location and name (Lakebed\_dry) of the output file.

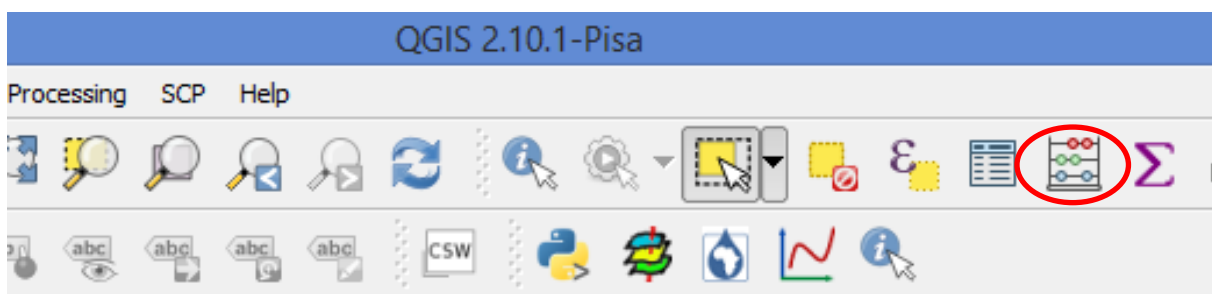


The output layer will now contain the area that has dried out from the old lakebed.



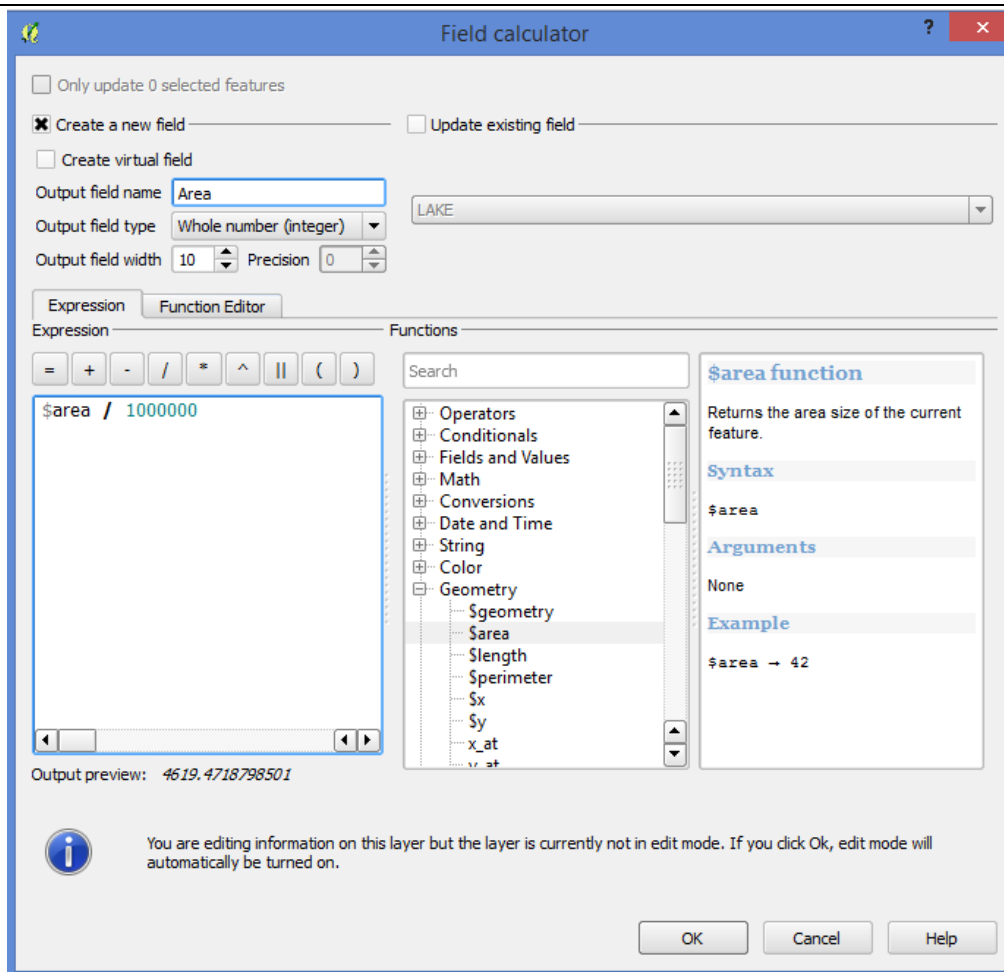
Now we need to calculate the actual area of the polygons. First, let's do it for the old lakebed.

⇒ Select the Lake\_old layer. Now open the Field Calculator as shown below:



⇒ In the Field calculator window, name our new field "Area". From the Functions list, select Geometry -> \$area by double clicking it.

⇒ Since it is a large lake, and the map units are in meters, we should expect large numbers, so let's convert to square kilometers by adding "/1000000" to the expression on the left.



⇒ Alternatively, you could just type the whole thing: “\$area / 1000000”

⇒ Now click OK.

Note: the actions above will toggle editing. This can be undone by clicking the “Toggle editing” button.

Now we should have a new column in the layer’s attribute table.

⇒ Right click on the layer, select Open Attribute Table.

This opens up the attribute table, where you can see that the area of the lake was 4619 km<sup>2</sup>.

LAKE	Area
0 Uromiyeh	4619

⇒ Repeat the same process for the 2016 area.

If you have done everything correctly, your result should be 2452 km<sup>2</sup>.

Based on this you can calculate that the Lake has lost  $(4619-2452=)$  2167 km<sup>2</sup> or  $(2452/4619*100=)$  53 % of its area.

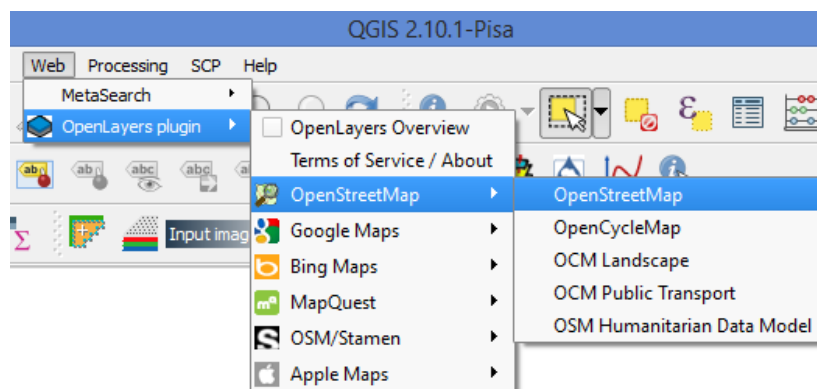
## 5. Creating a print-ready map

In this exercise, we will create a very simple print ready map that shows the difference in surface extent for the lake.

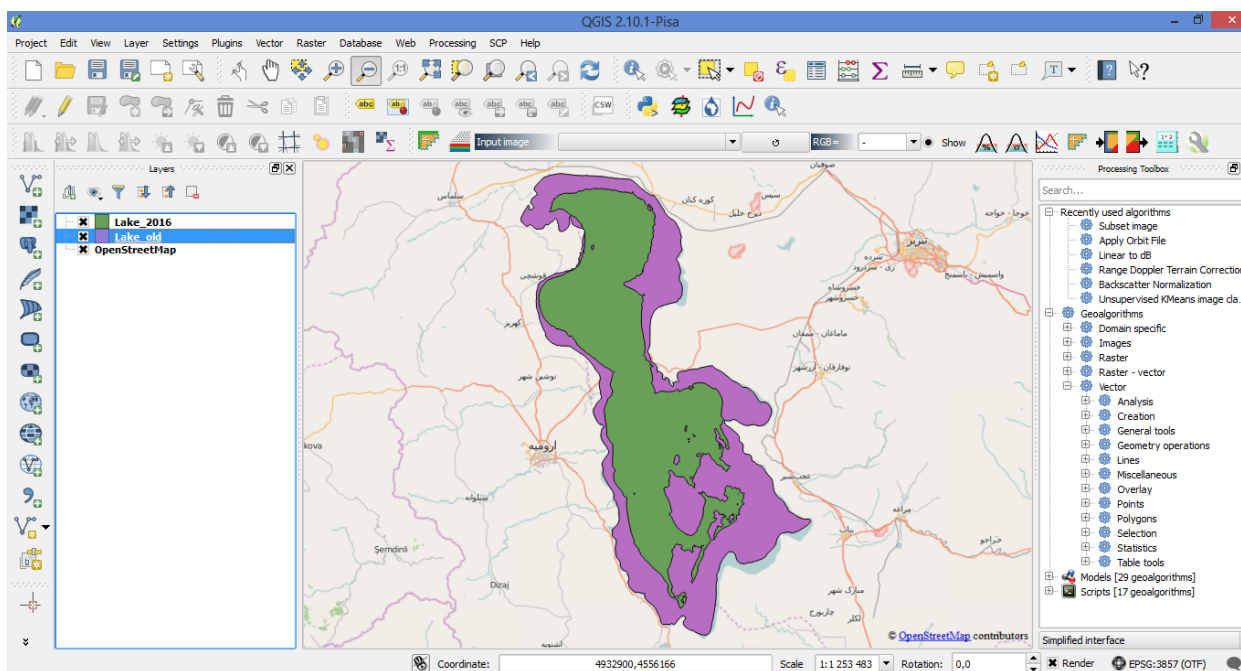
- ⇒ Remove all layers from the map, except Lake\_old and Lake\_2016. You can remove a layer by right-clicking on it and selecting "Remove". Arrange the remaining two layers so that we can see the outline of both (2016 should be on top).

Let us now add some background.

- ⇒ From the main menu bar select Web -> OpenLayers plugin -> OpenStreetMap -> OpenStreetMap

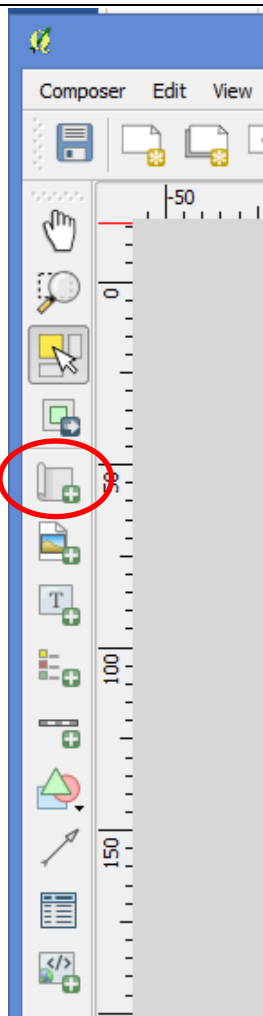


Now you can see your layers displayed on top of the OpenStreetMap layer.



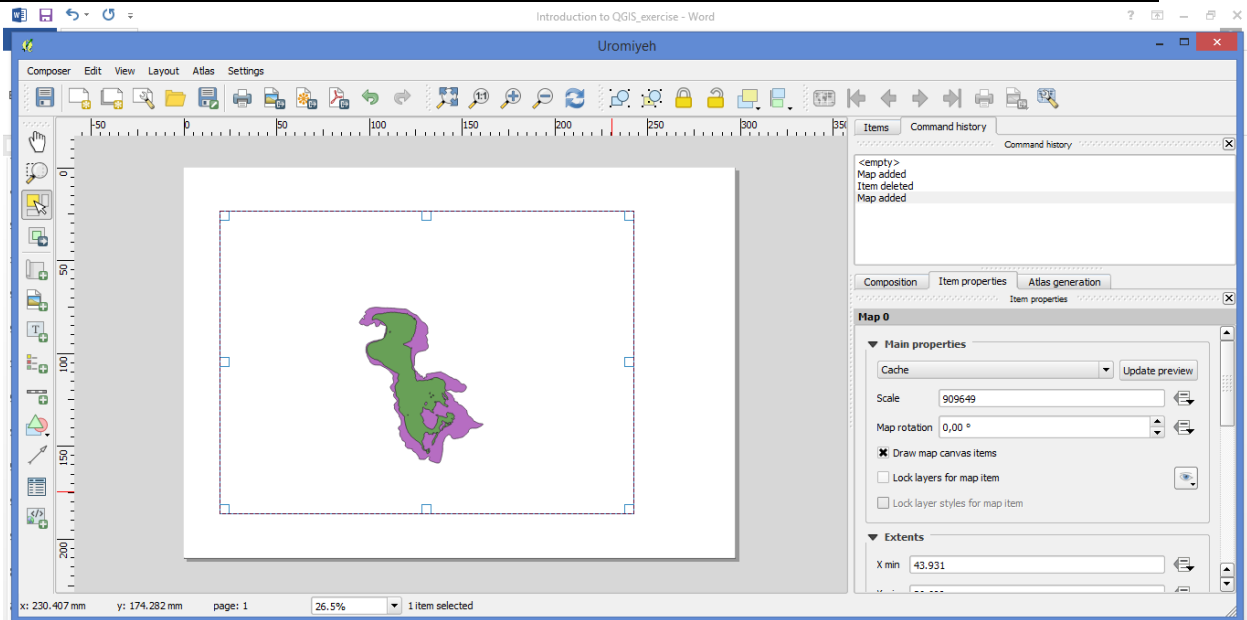






⇒ Create a map area on you blank page by clicking and dragging while holding down your left mouse button.

You now should see the same layers in your composer as in the display area of QGIS.



⇒ Explore your options within the Composer. Use your creativity to create your own custom map from the data you have. Your map should have at least all of the following:

- a map
- a scale bar
- a legend
- a title.

⇒ Once you are done and your map is perfect, you can either print it, or export it as an image or a pdf.

