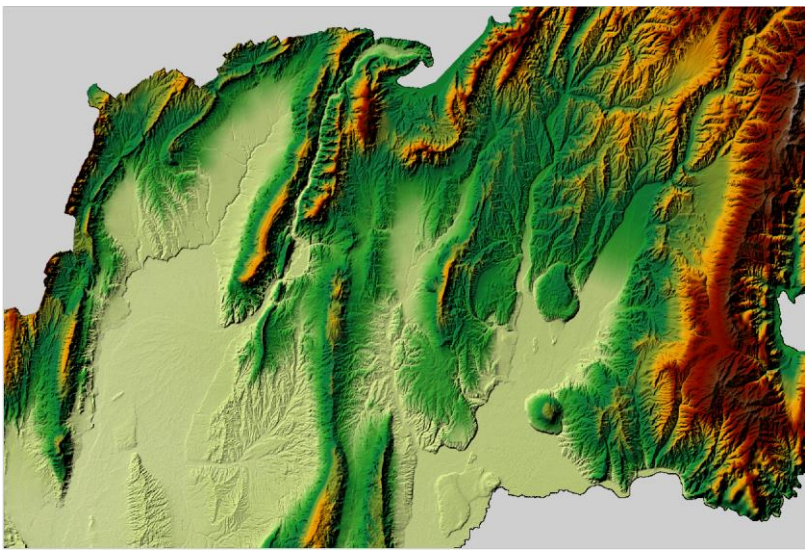
WOCAT

World Overview of Conservation Approaches and Technologies



Tutorial for an

Introduction to QGIS

Title: Tutorial for an Introduction to QGIS

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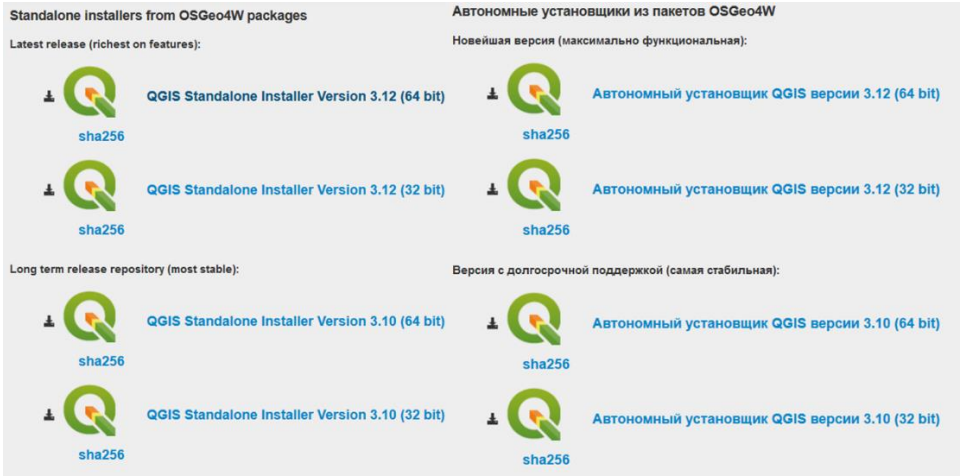
1. BRIEF INTRODUCTION

This guide was developed for a basic training in Geographic Information Systems (GIS), to serve as a quick introduction to QGIS, which is the base software on which other applications and plugins, relevant to Sustainable Land management and Land Degradation Mapping, run, i.e: Trends.Earth (Conservation International) and Watershed Tool (WOCAT). The document aims to convey basic applications offered by this computer tool to produce practical knowledge, solve problems of georeferenced information management and creation of maps. This manual has step-by-step explanations of the practices carried out in the training to serve as a reference material. However, it can also be used by those who want to venture into GIS (self-taught). Please see the QGIS page for further practical and theoretical guidance with sample data and examples:

https://www.qgis.org

2. INSTALLING QGIS

QGIS is an open source and free software that can be downloaded for every operating system. It is distributed in both a Latest Release version, which has the most recent developments and features and a Long-Term Release that is updated once a year, so it remains stable for longer periods. Also, for windows users it is provided in the 32bit and 64bit versions according to your operating system.

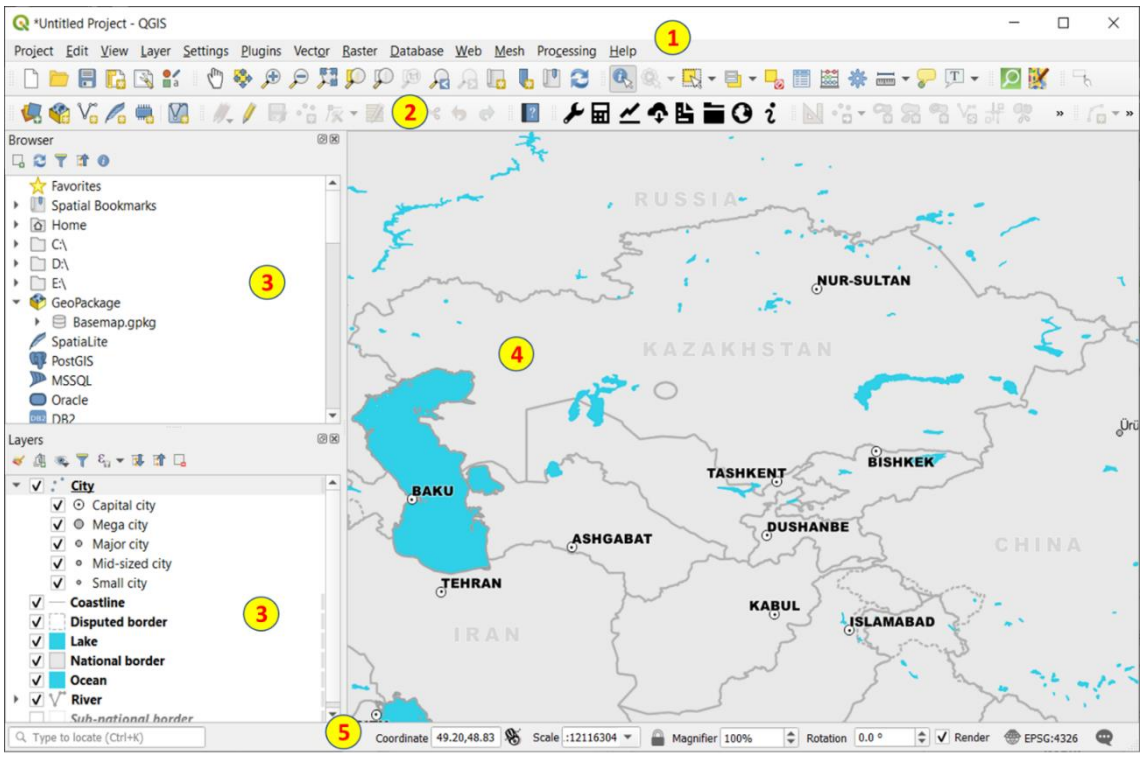


To download the program, visit the web page and select your preferred option. To choose 64-bit or 32-bit version you can check your operating systems first by pressing the **Windows key + Pause** or going to **Control panel → System**.
Once the installer is downloaded, run it and follow the instructions to complete the installation. When completed, a folder will appear on your desktop with all the shortcuts, to start QGIS just double click on **QGIS DESKTOP x.x.x with GRASS x.x.x** .

3. INTERFACE

QGIS can be run from a User Interface (GUI) or command line and integrates tools from other free and open systems like GRASS, GDAL, SAGA and programming languages like Phyton and R. The GUI is has different components that can be re-arranged and personalized. Basically the main QGIS GUI types of components are:

1. Menu Bar
2. Toolbars
3. Panels
4. Map View
5. Status Bar



There are many Panels and Toolbars in QGIS that can be made visible and/or located in different parts of the GUI Windows. Just try a right click on the menu bar (2) to see the available ones.

Also in the Browser or Layer Panels (3) you can make a Right click on a file to access the contextual menu that contains many options.

4. OPENING AND MANAGING VECTOR DATA - EXERCISE 1

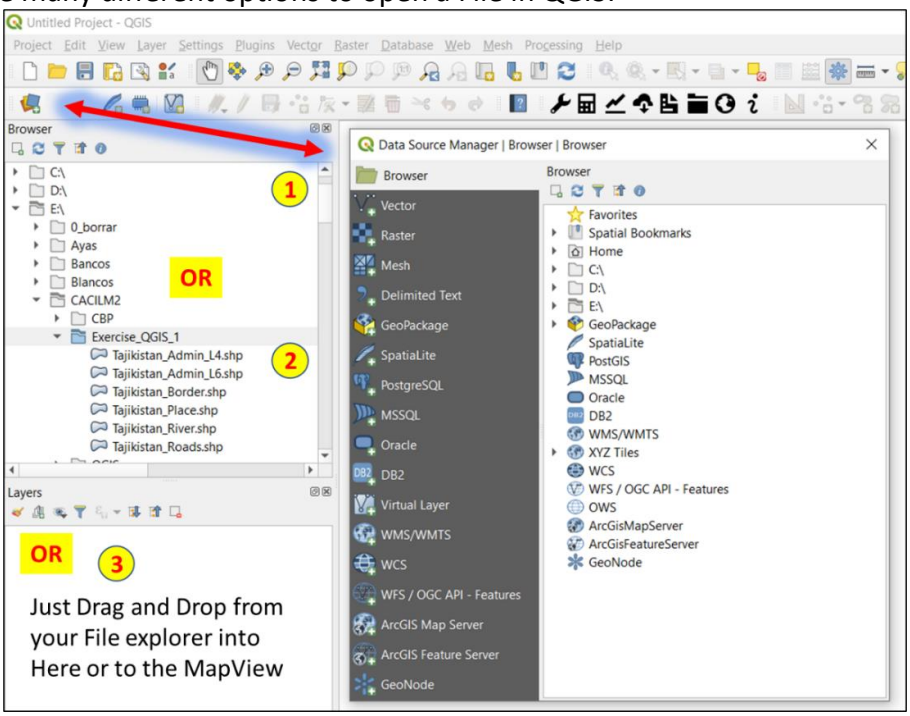
4.1 Downloading and exploring the data

4.1.1 Please first download the Testing Dataset (*QGIS_CACILM2_Exercise1.zip*).

4.1.2 Please extract the data in a folder and explore to see few Shape files (*.shp) that will be used in this demonstration.
Layers are a free open dataset for the whole world produced by OpenStreetMap (OSM) https://www.openstreetmap.org. There are many ways to access and download data from this repository, like external services (https://overpass-turbo.eu/ or https://download.geofabrik.de/) or QGIS plugins like: OSMDownloader or QuickOSM.
The layers provided contain OSM data for:

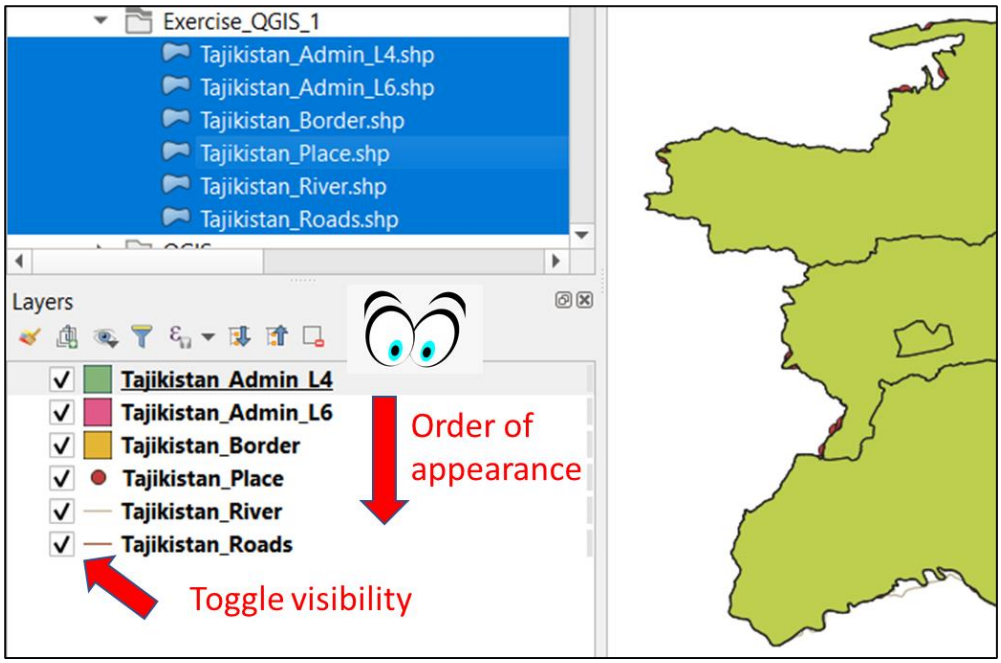
- Tajikistan Border: Country limits
- Tajikistan Admin 4: Second administrative level boundaries (province)
- Tajikistan Admin 6: Third administrative level boundaries (district)
- Tajikistan Roads: Main roads
- Tajikistan River: Main Rivers
- Tajikistan Place: Populated places

There are many different options to open a File in QGIS:



- 1.- Using the Data Source Manager (Ctrl + L) to choose the type of File and specify details.
- 2.- Using QGIS Browser and double clicking on the layer you want to open.
- 3.- My Favorite ☺: Just Drag and Drop from your normal file explorer.

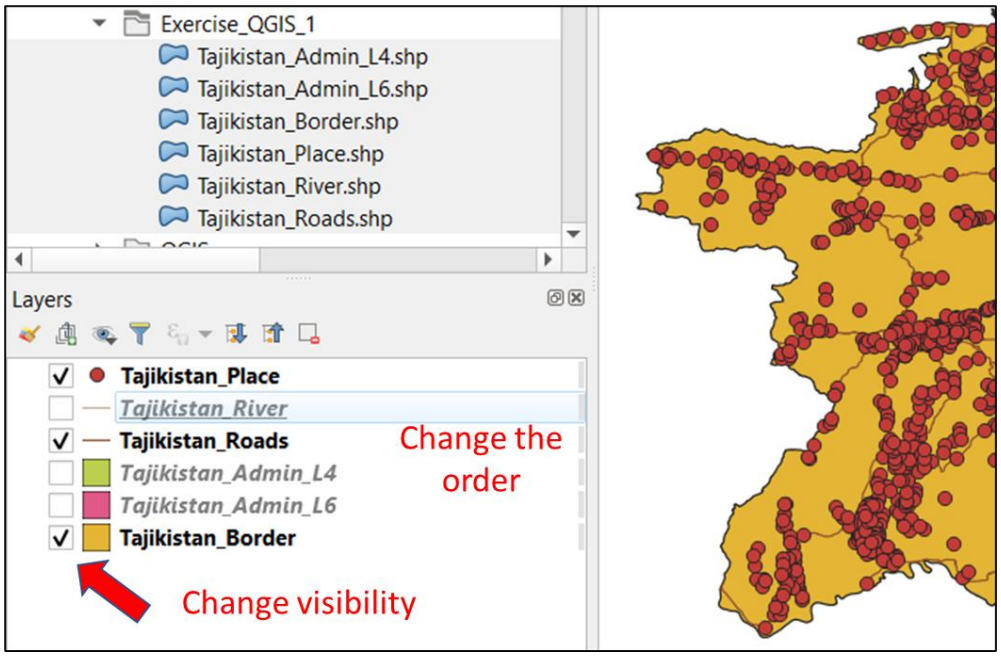
4.1.3 Please, open all the files provided to see their content in the Map View. By using the QGIS Browser you can select all of them and open them all at once:



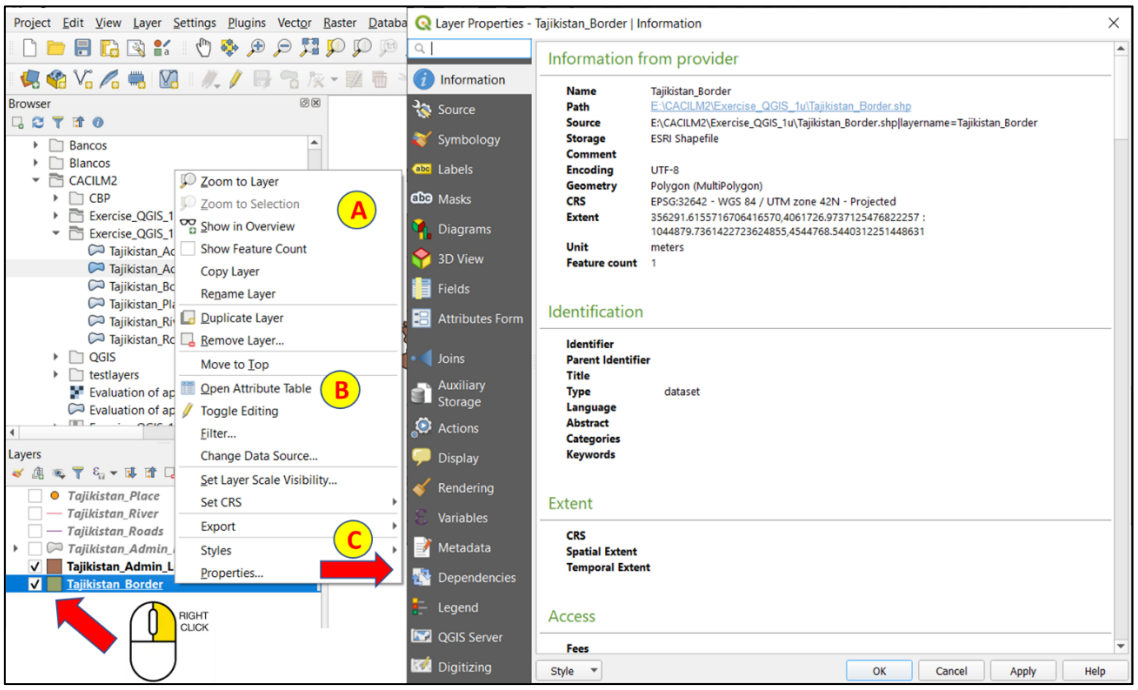
Here you have to consider a few things:

- The color of the layer is assigned randomly
- The order of appearance is from top to botton in the list, so if you have a polygon with solid fill on top it will cover what is below.
- You can just drag and drop items in the list and toggle the visibility in order to organize your view.

4.1.4 Play with the order and visibility to see the layers:

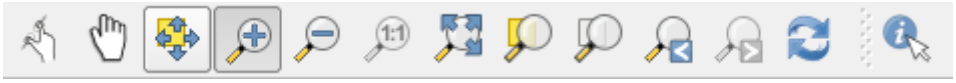


4.1.5 After exploring the structure of the open layers to know what type of vector file we have in each case (point, line, polygon), we should proceed to explore what data we have in the databases and what their representation system is. A lot of information and functions can be obtained trough the **Context Menu,** by Right Clicking the name of the layer**:**



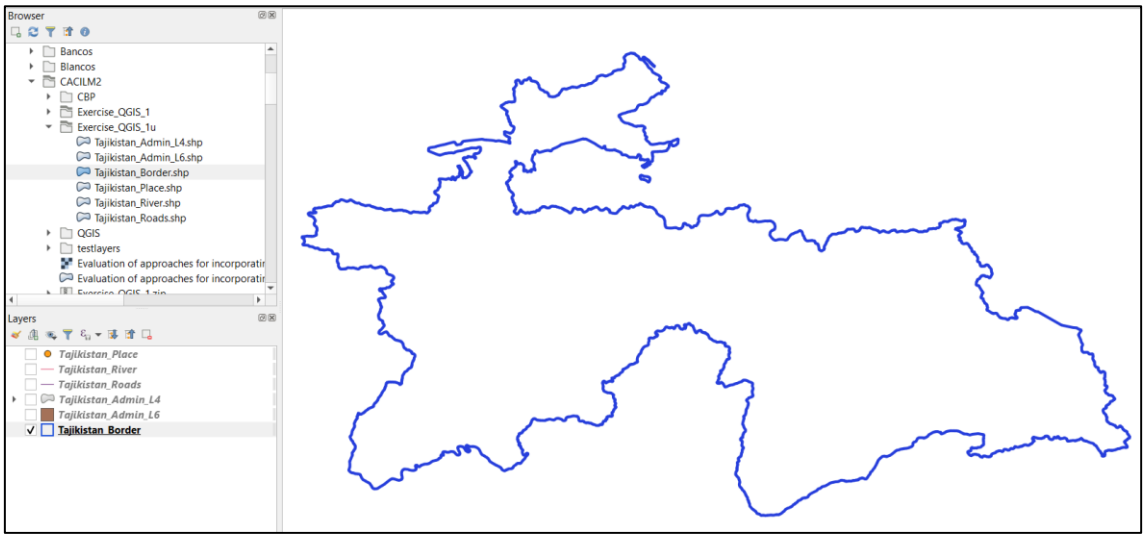
- **A**.- Context Menu: has many basic functions for the specific layer.
- **B**.- Open Attribute Table, will give us access to the database associated with the Layer
- **C**.- Properties: Opens the layer **Properties Menu:** One of the most used functions for Layer management. Here you can (and we will use it a lot):
    - Check the layer **information** and **Sources**
    - Change the **Symbology**
    - Manage **Labels**
    - Etc. etc.

4.1.6 Please explore the Attribute table of some of the Layers to we what's in there. And try some of this bottons, Specially the last one:



4.2 Changing Polygon Style

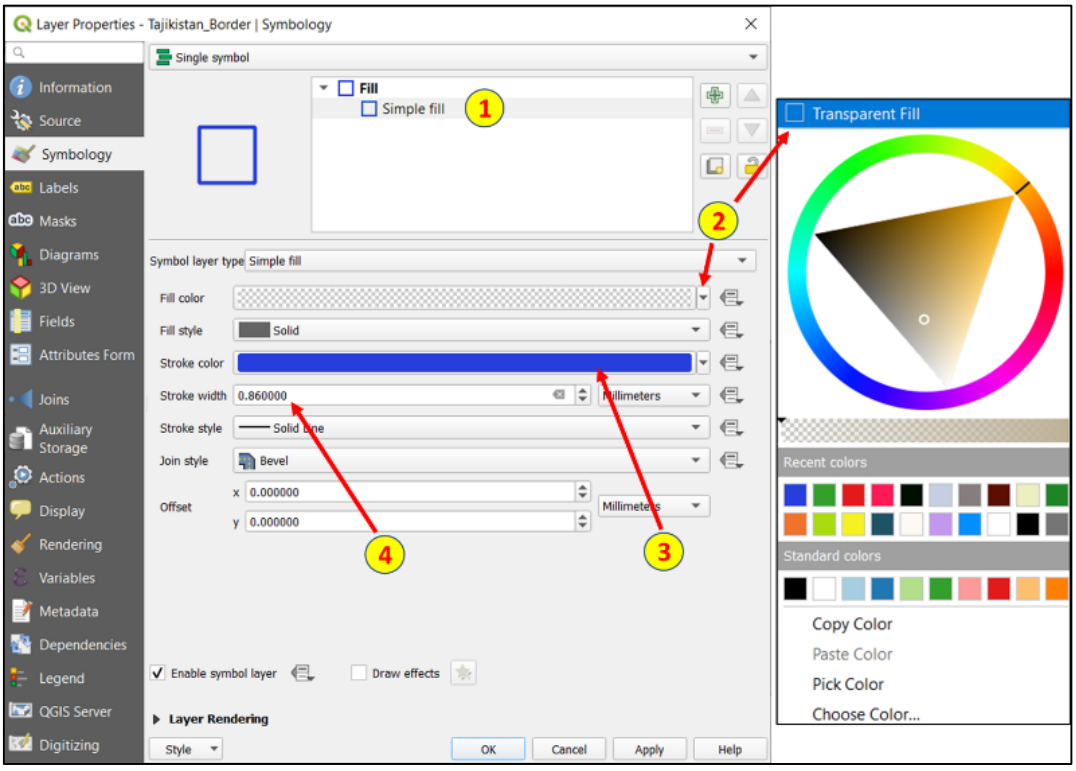
Our objective is to get this view:



STEPS:

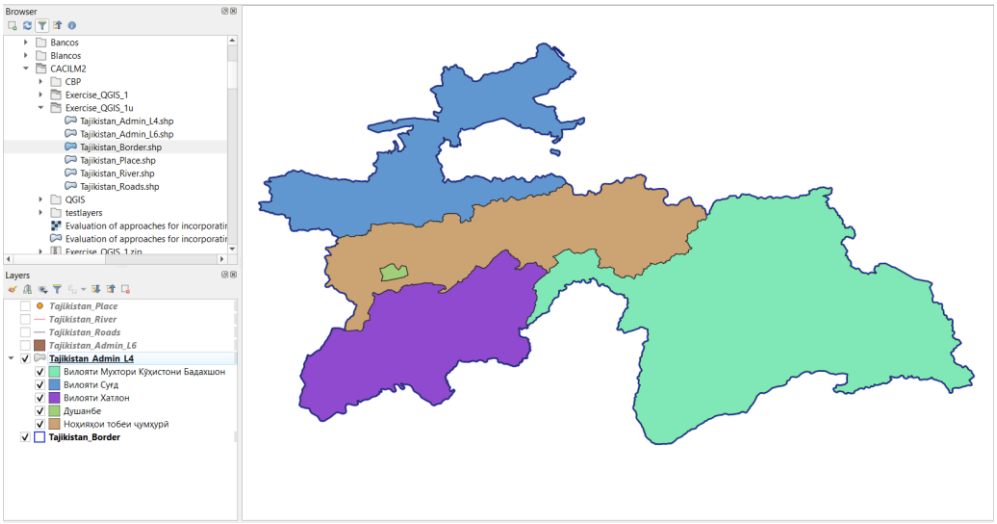
Toggle the visibility off for all Layers except for the **Tajikistan_Border**.

Go to **Layer Properties** -> **Symbology** -> Click on Simple Fill (1), then click the arrow in the Fill color bar (2) and when the Color windows opens, check the Box with Transparent Fill (2). Then choose the color of outline in the Stroke Color bar (3) and set a width for the line 0.86 (4) click **Ok** to see if it works (I Hope so).



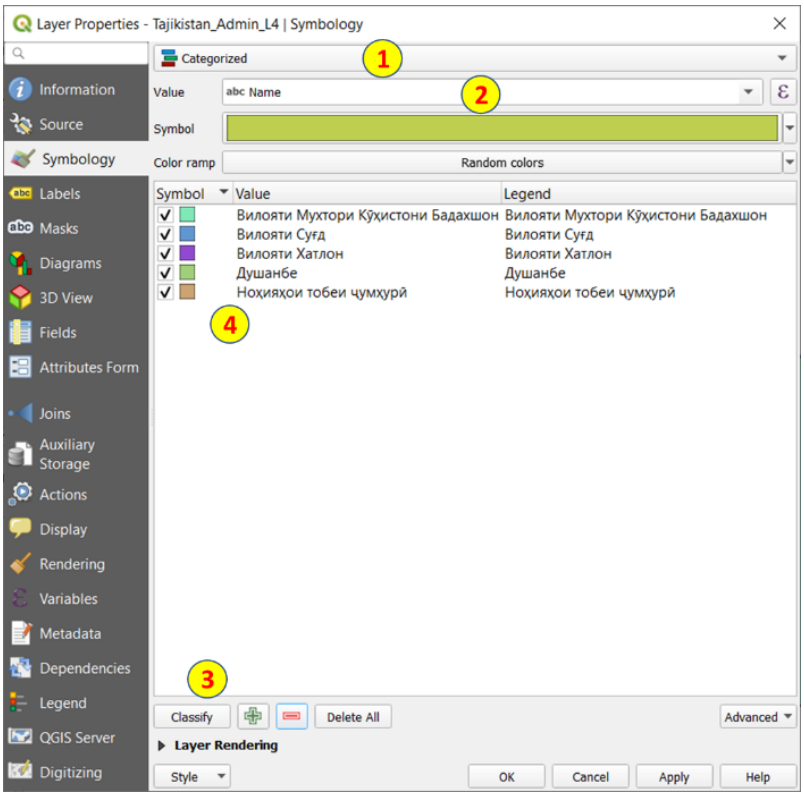
4.3 Styling Polygon by Categories in the data

Now let's paint all the **Tajikistan_Admin_L4** units with a different color:



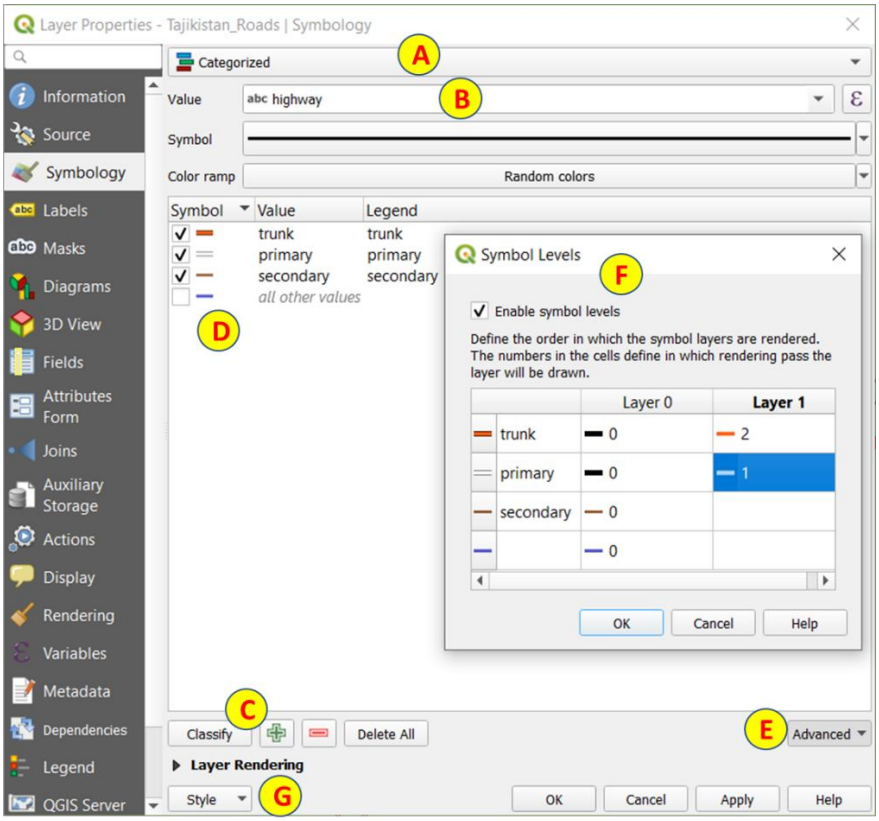
STEPS

Go to **Layer Properties** -> **Symbology** -> Choose **Categorized** (1), Then choose the **Field** from the **Attribute Table** that you want to categorize (2 - "Name") and press **Classify** (3) to get all the possible values for that Field. You can apply different palettes like color ramps for numerical values or Random color for cases like this with nominal categorical values. You can also personalize the colors by clicking on each **Symbol** (4). Press **Ok** when done to see the result.

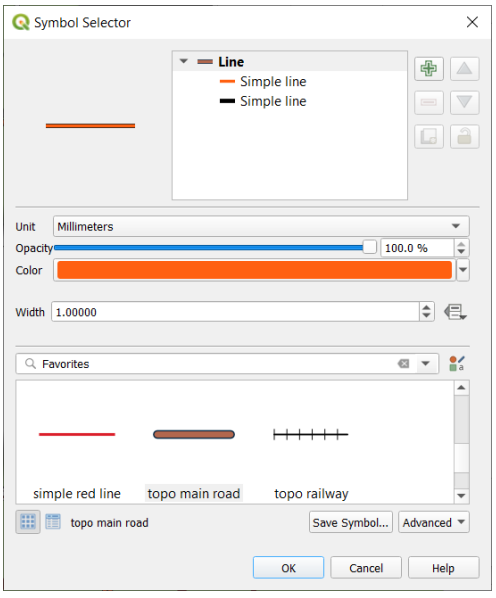


4.4 Styling Lines considering their type and hierarchy

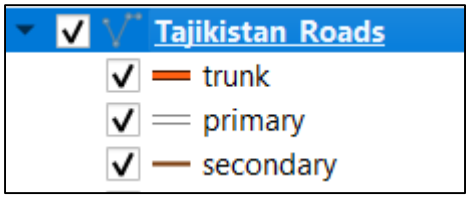
Now it gets a bit trickier, for the **Tajikistan_Roads**, we would like to classify them and assign different type of lines and colors according to hierarchy:



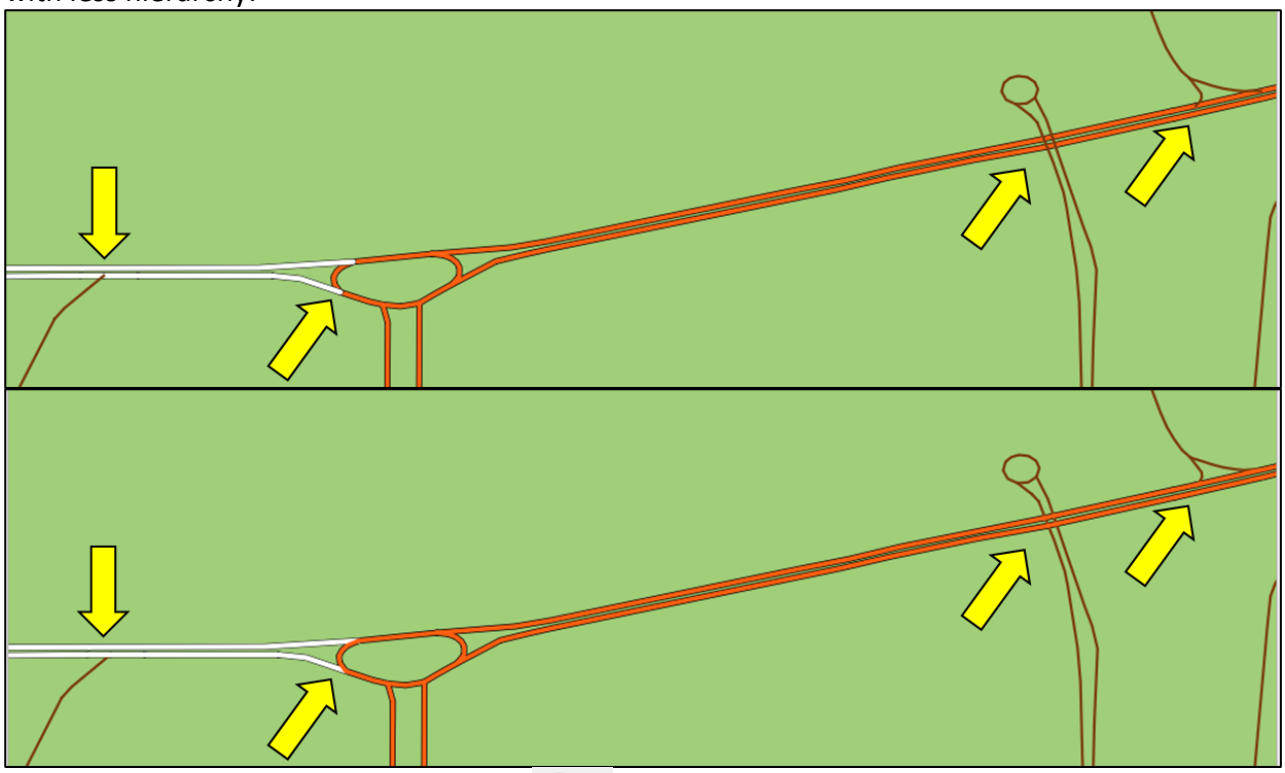
Go to **Layer Properties** -> **Symbology** -> Choose **Categorized** (A), Then choose the **Field** from the **Attribute Table** that you want to categorize (B - "highway") and press **Classify** (C) to get all the possible values for that Field. Now it is time to choose the Symbol for each class (D): Double click on the symbol near "**trunk**" and choose the type of line. You can choose "**topo main road**" from the **Favorites** sections and set **Width** to 1:



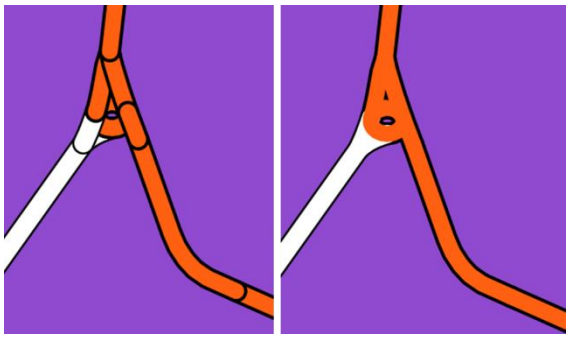
For primary you can choose "**topo road**" also **Width** 1. And for Secondary just change the color of the **Simple Line** to Brown and use a **Width** of 0.5.



You can now press **OK** and see the result. But be aware that some issues arise. For example, "secondary" roads might be on top of "trunk" road. We would like to make sure that a priority order is followed and more important roads appear on top of other with less hierarchy:

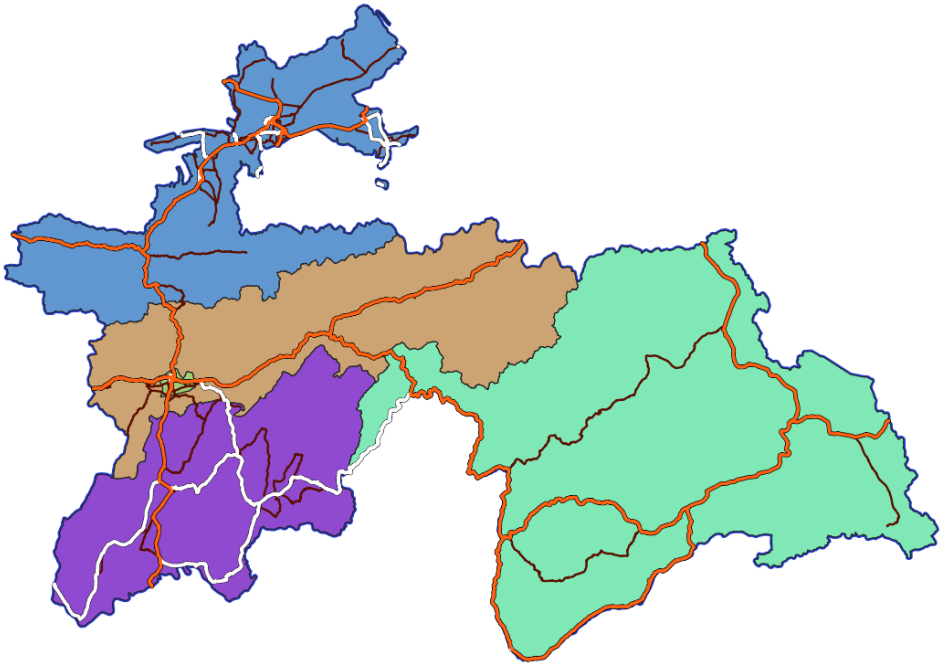


Also, if you use the **Identify feature** tool  you will see that the Roads are made of segments. Normally the joins are not visible if you use a **Simple Line,** like in "secondary" road, but under composed lines (trunk and primary) it produces an effect that we also want to correct:



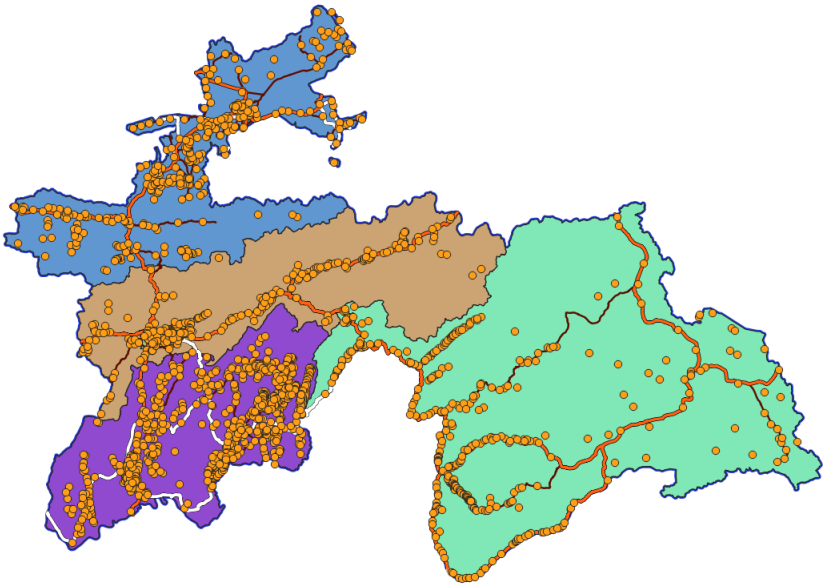
For this please go back to **Layer Properties** -> **Symbology** -> **Advance** (E) -> and choose **Symbol levels…** when the windows Pops-up (F) click on **Enable symbol level**. Please complete the table as shown (F), the logic is to assign a higher number to higher hierarchies. Once you are done press **OK. I**f you want to save a style for later use, you can click on **Style** (G) and choose **Save Style.**

The result should look something like this:



4.5 Points: Style, filter and Labels

Now if we toggle on visibility on the **Tajikistan_Place** Layer, lots of points should appear:



Use the **Identify feature** tool and **Open** the **Attribute table** to explore the data.

According to the **Attribute Table** the total number of points in the layer is:

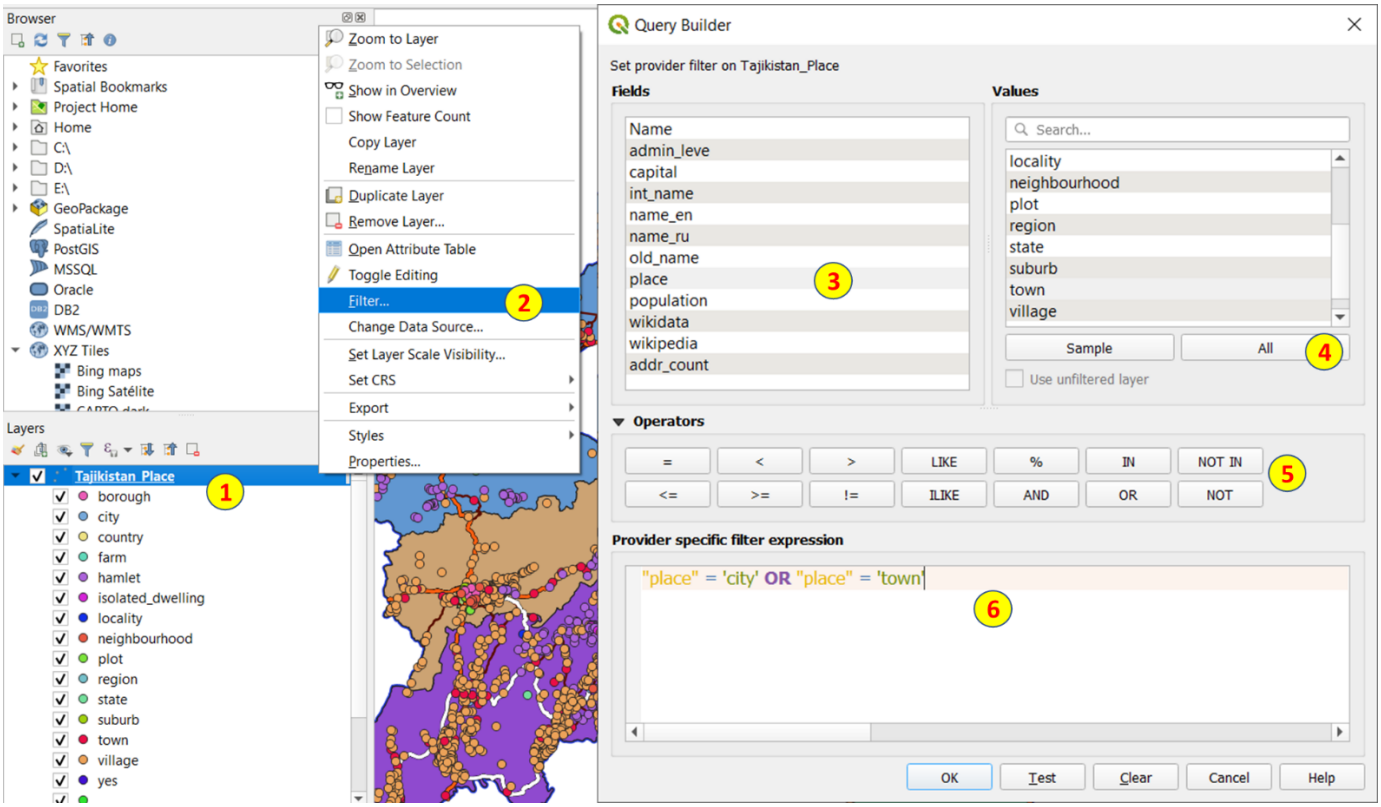
The **field** "**place**" in the database contains lots of different values, indicating the type of settlement. If you want to get a report on all the possibilities, you can run this tool to make a list: **Vector** -> **Analysis Tools** -> **List Unique Values…** and in the **Target Field(s)** Option choose: **"place"**:

Total unique values: 15

Unique values:

- village
- plot
- country
- hamlet
- locality
- region
- isolated_dwelling
- borough
- town
- neighbourhood
- state
- city
- yes
- farm
- suburb

For our map we want to filter this layer in order to have only City and Towns:

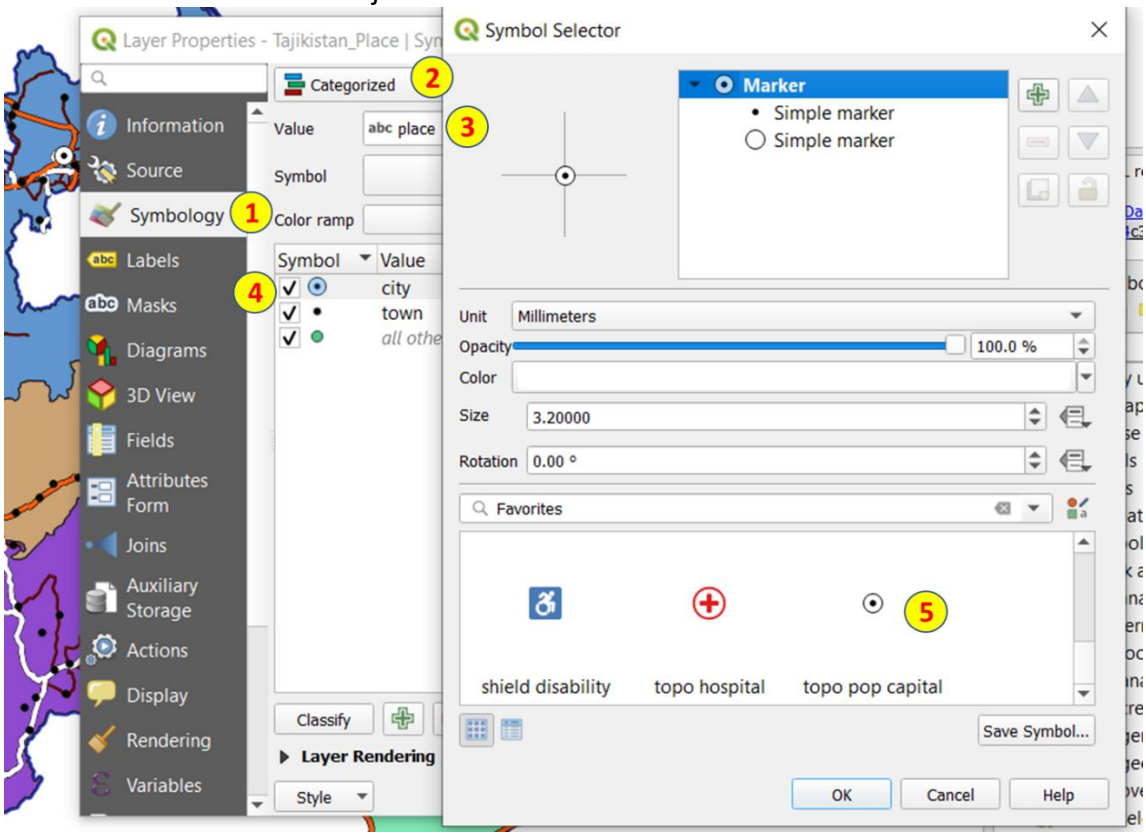


For this please **Right click** on the Layer name (**1**) to get the **Context Menu** and choose **Filter…** (**2**). This should Open the **Query Builder**: Choose the target **field** (**3**) "**place**" and press **All** (**4**) to get the list of all values for this field. You can either write the **Filter**

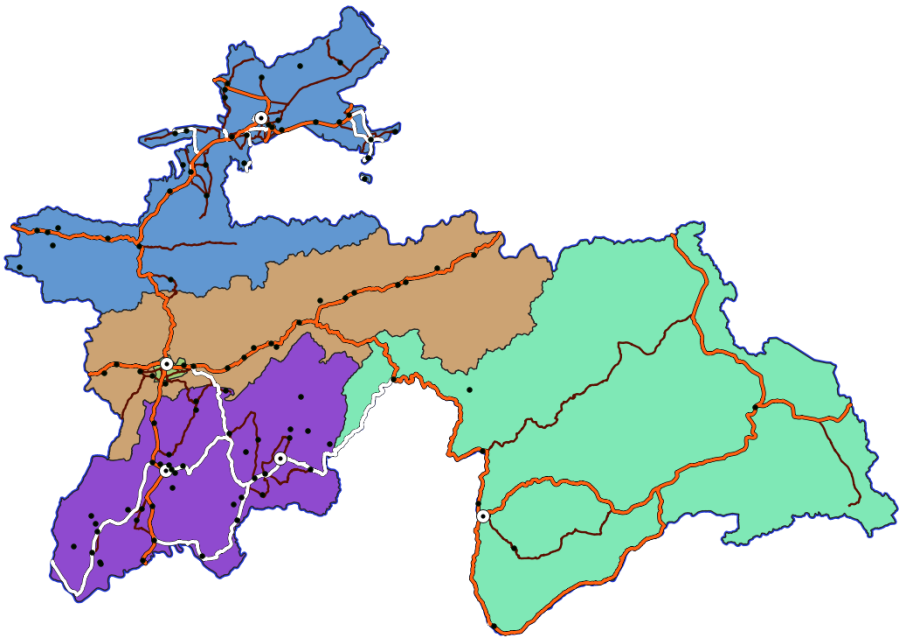
expression below (**6**) or you can just **Double click** on **Fields**, **Values** and **Operators** (**3 , 4 , 5**) and they will automatically be written below (**6**). Press OK when you are done.

If you check now the **Attribute Table** the total number of points in the layer should have changed:

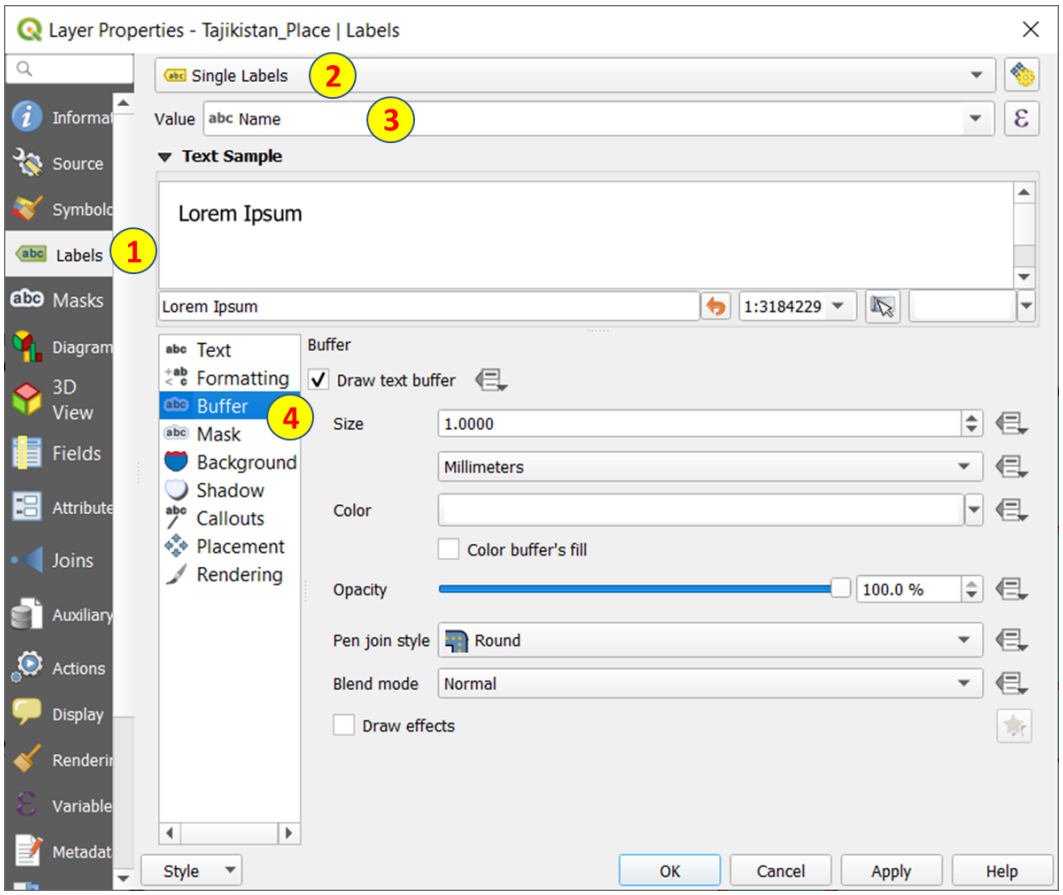
Let's have some styling for these points. You can use the "topo pop capital" (**5**) size 3.2 for the Cities and for Towns just make the dot Black and size 1:



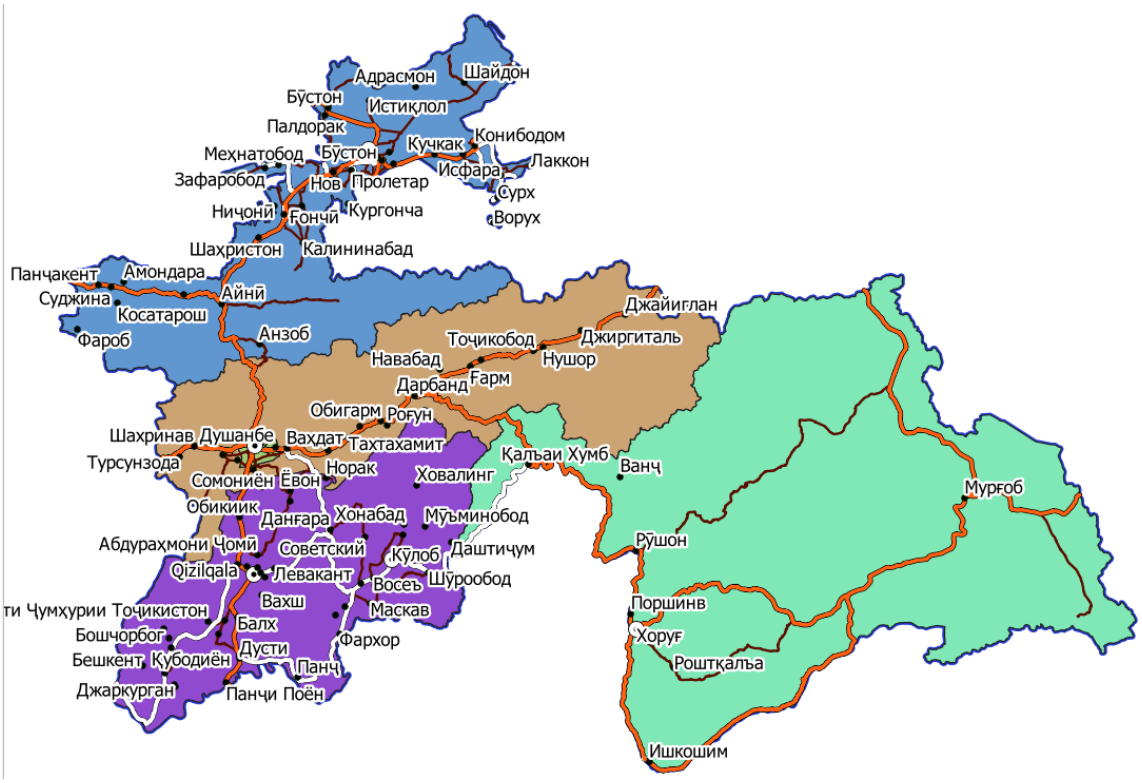
The map should look clearer now:



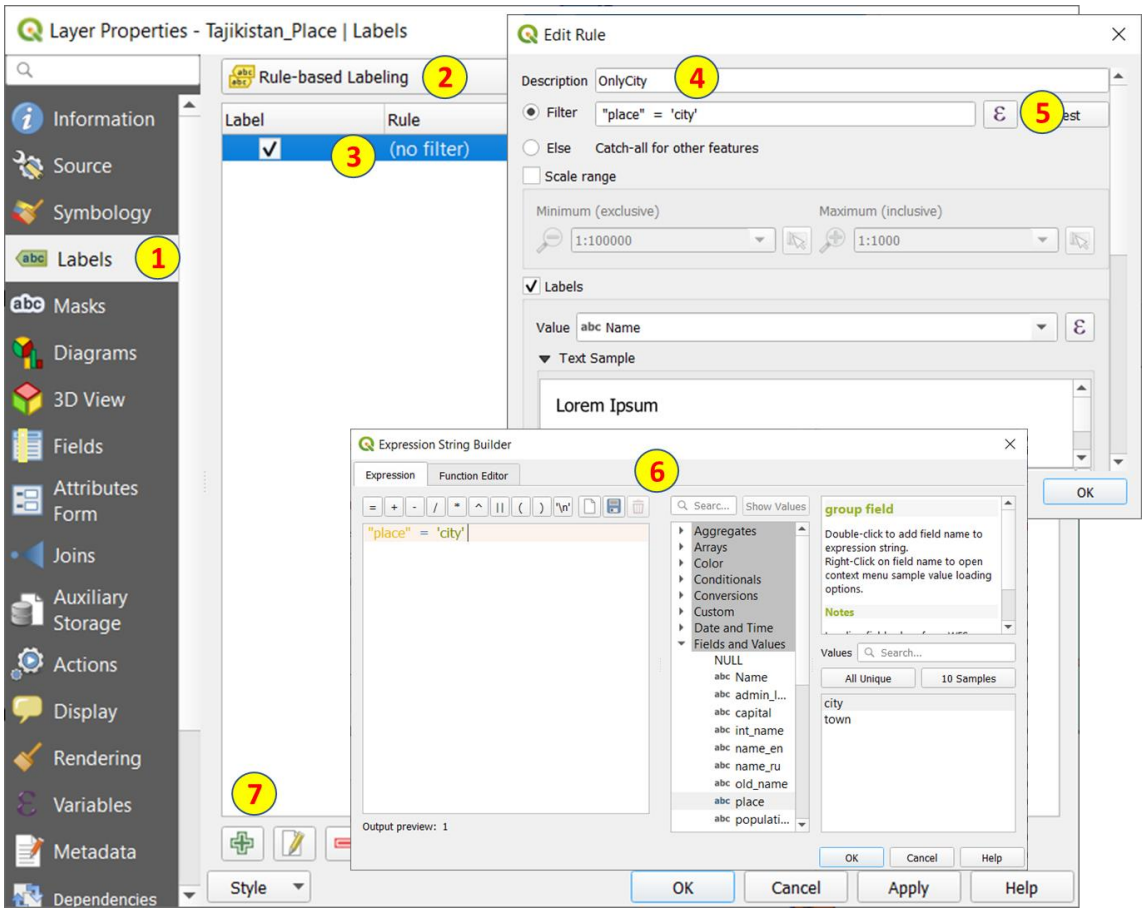
Time to add some Labels for the points:



In **Layer Properties** -> choose **Labels (1)** -> Choose **Single Labels (2)** and the field that contains the text "**Name**" **(3).** There are many options for Labels to control how and where text is added, for now we only add a **Buffer (4)** by checking the option **Draw text Buffer.**



It seems there are too many names in the map ☹. But we can solve that:

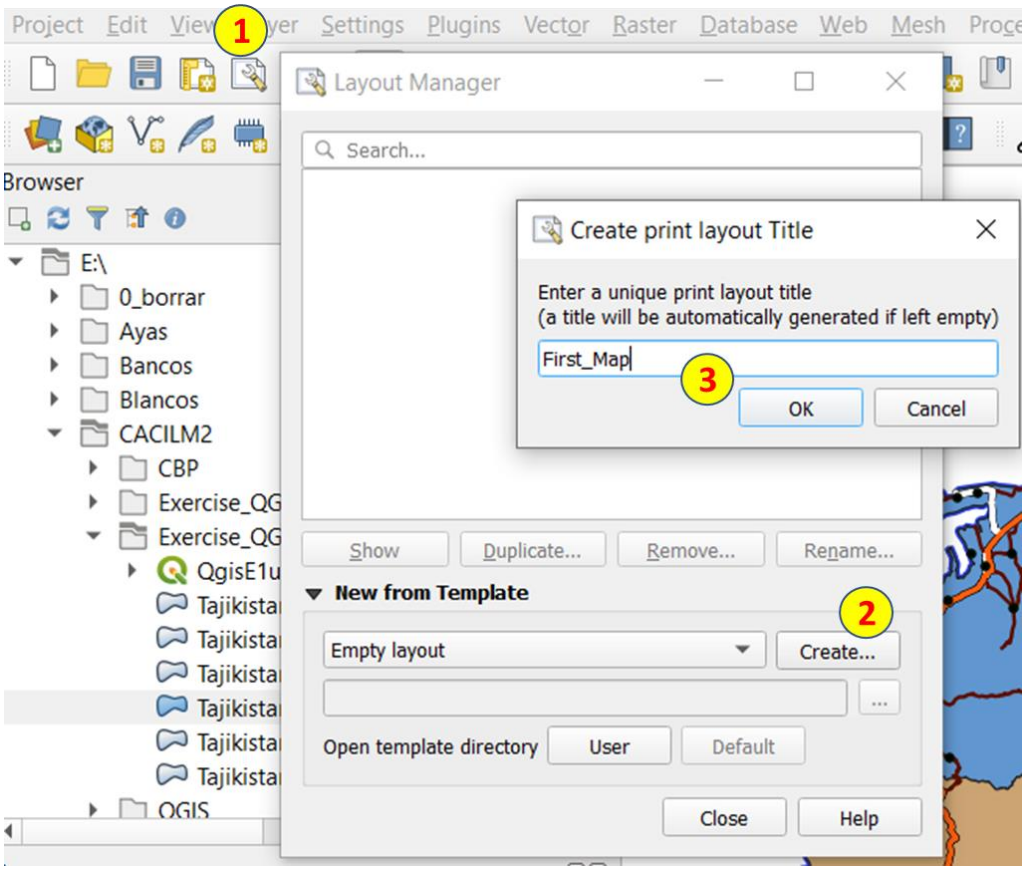


We can choose to Label only certain type of points or use different styles for different hierarchies. In **Layer Properties** -> choose **Labels (1)** -> Choose **Rule-based Labeling (3)** and **Double click** on the first Rule **(3)** to enter **Edit Rule**. Enter a name in **Description (4)** and define the **Filter (5).** You can either write or press the **Ɛ** button to open the **Expression Builder**, this works similarly to the Query Builder we used before (try it!). Then click the **OK** in all windows to get Labels only on the cities. In Rule-based Labeling you can use the **+** button to set new rules for other types of points.

I hope you map looks cleaner and clearer now…. Lets prepare it for printing!!!

4.6 Preparing a Print Layout version of your map

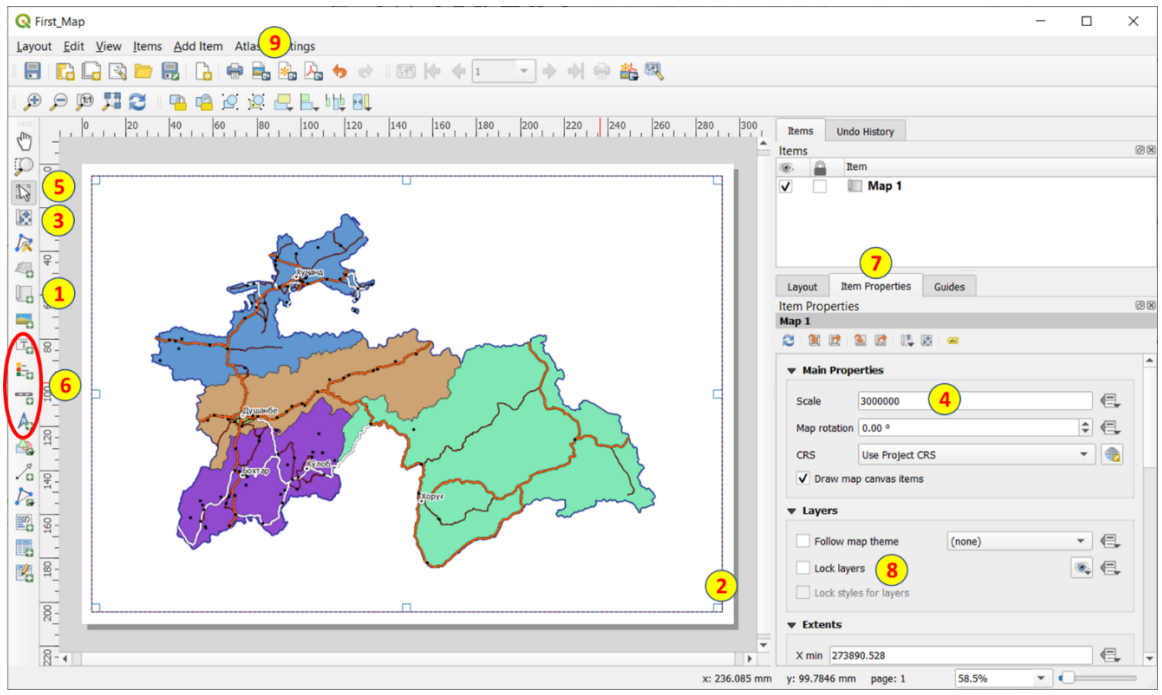
In this section we aim at putting the map into a Page designer and export it from QGIS in one of the many formats or send it to printing. So far, we have been working in the Map Canvas and now we have to lay out items and release our creativity:



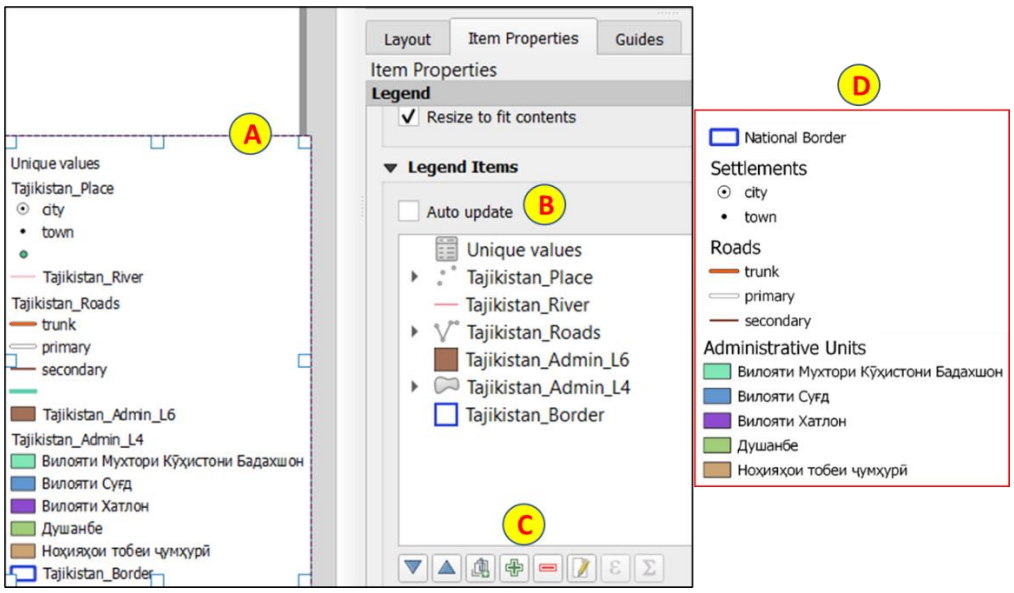
First step is to open the **Layout Manager (1)**, every page for printing that we create will be here to view/edit. Being our first for this project, just create a Empty Layout **(2)**. When the windows pop-ups, just name the name of the print you are creating (**3).**

This will Open the Layout Editor in a separate window… it has so many options that is scary!!! …No worries, you will not suffer alone. 😊

If you place your Mouse on any on the icons you see and wait 1 second a small label will tell you what is the name of that tool.



The first tool we use is **Add Map (1)**, and it will allow us to create an Item **(2)** where the map (whatever is on your canvas) will appear. I made a rectangle almost the size of the page **(2**), but you can choose your how section of the page to put the map.
Next is to move your map and adjust the zoom (scale), use the **Move item content (3)** tool for moving things inside your square, or set a **Scale** manually **(4).** If you want to move or resize the **Item** or select another item (after we add new ones) you need the tool called **Select/Move Item (5).** The other Items we will create and use to make our map are usually the ones in the red circle **(6): Add Label, Add Legend, Add Scale Bar** and **Add North Arrow.** Every **Item** that we create will have an **Item Properties Tab (7).**
Let's see the example of adding the **Legend:**

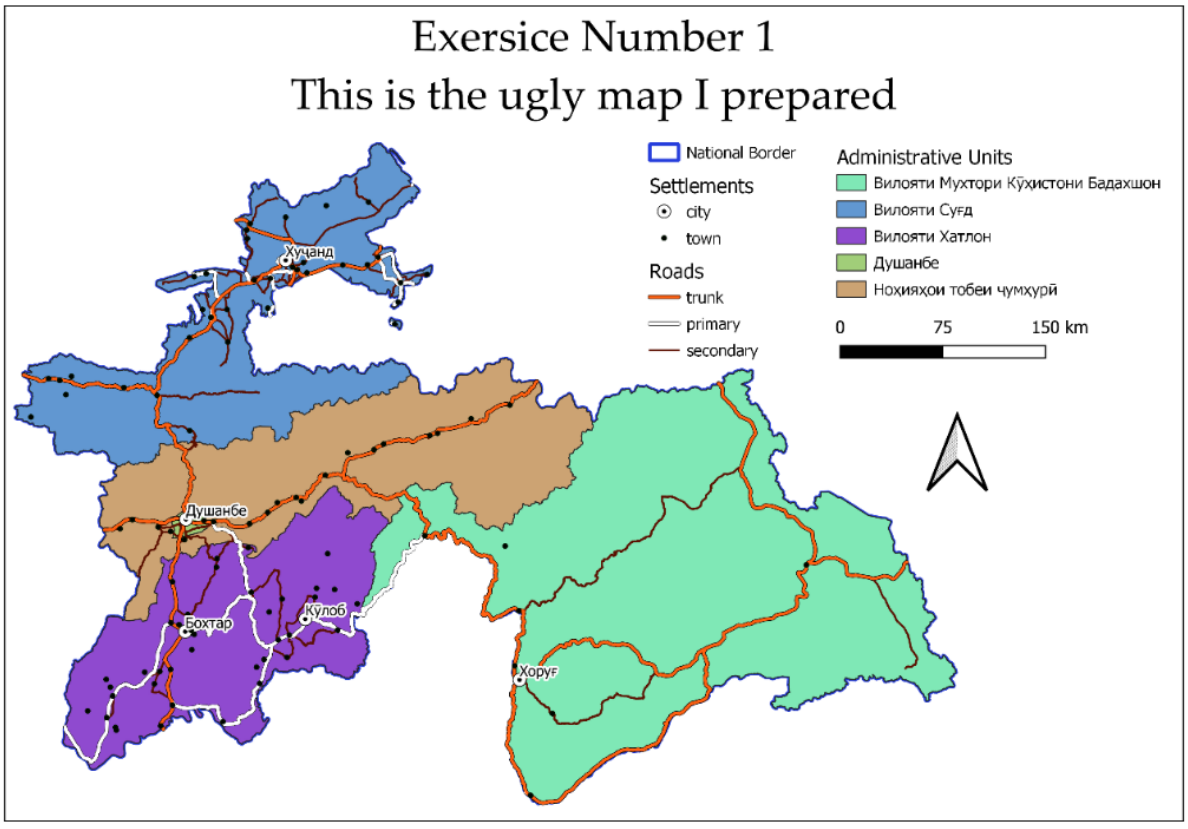


First click on **Add Legend (6)** and choose a place to put the **Item** in the Page. It will appear something like **(A),** where all the legends from all the layers appears. So, this needs editing: for that you need to unclick **Auto update (B)** and using the tools in **(C)** you can change any thing you like and delete all the ones that are not shown in the map. Until you get something like the one in **(D)**.

Please experiment by adding: 1.- North arrow, 2.- A title for the map (Add Label), 3.- scale bar.

Once your map is ready, you can lock the Layers and styles of your Layout by clicking: **Lock layers and Lock Styles for layers** as indicated in **(8).** Finally, you can export it to: PDF, PNG, JPG, TIFF, SVG, etc. using one of the buttons in the top tool bar **(9).**

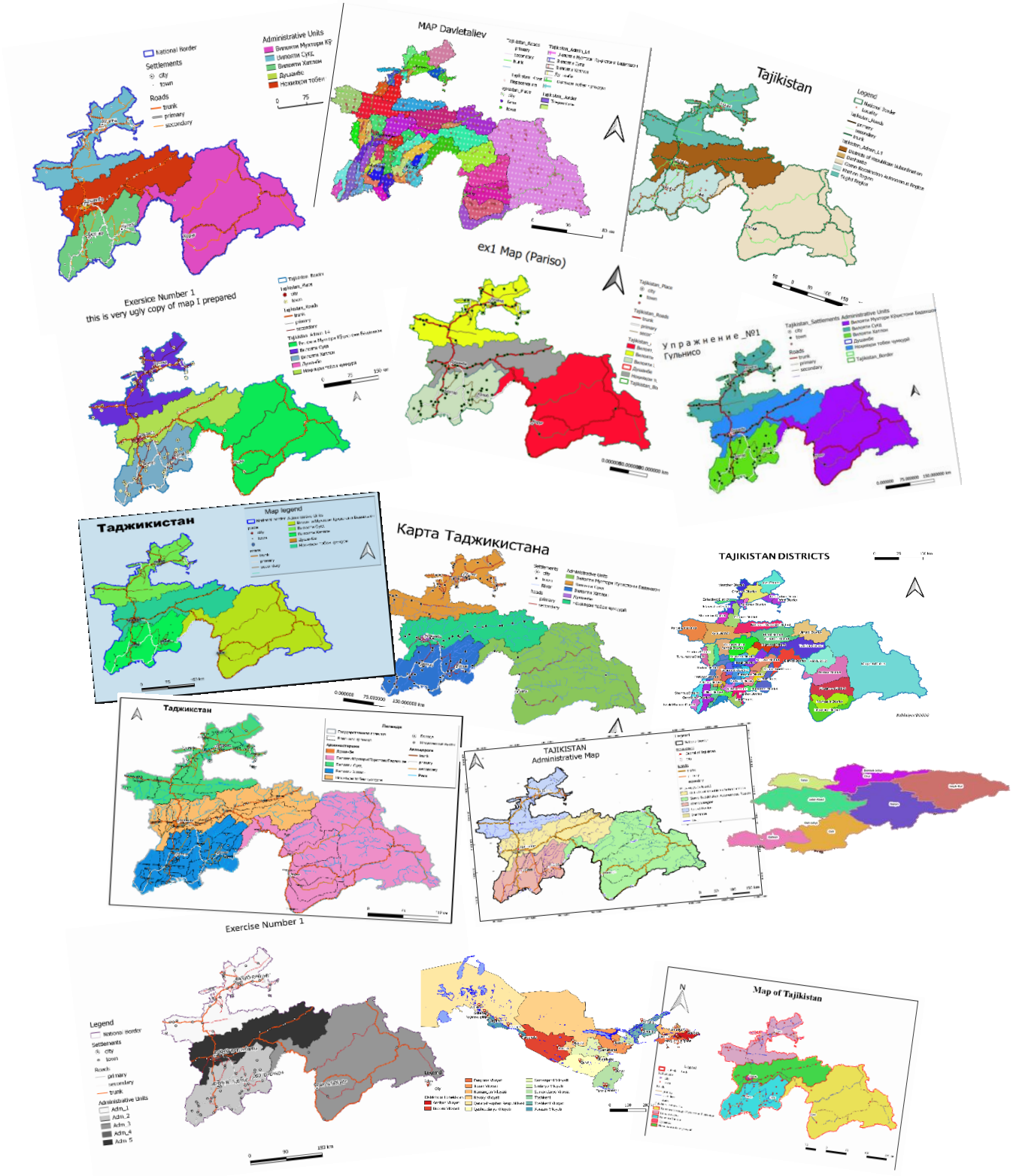
Here is my final map:



4.7 Time to practice

Please now make your own map. You can also make a different zoom, use the river layer or District boundaries. Save your result as .png.

Here are some nice results from participants who took the training.



5. QGIS BASICS 2: WORKING WITH DIGITAL ELEVATION MODELS

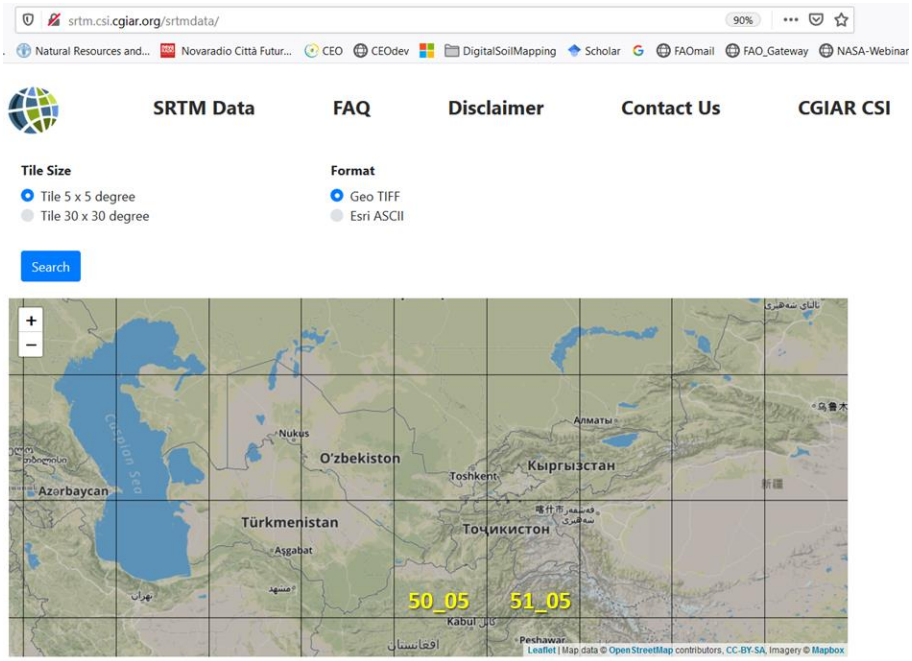
5.1 Introduction: Rater data & Digital Elevation Models

There are many sources and resolutions of Digital Elevation Models (DEM), and you will have to choose depending on the use you want to make with these datasets. Among the free options are:

- **SRTM** mission (NASA's Shuttle Radar Topography Mission), which covered the whole world and many DEMs have been produced with resolutions ranging from 30m to 1km.
- **ALOS PALSAR produced global DEM at 30m and 12.5m resolution and contains images of different years.**
- **ASTER Global also produced many different versions of a classic 30m DEM.**

Most of these products are made by or with support of NASA and JAXA and can be found in this repositories:
ASF Vertex:
https://search.asf.alaska.edu/#/
NASA
https://search.earthdata.nasa.gov/search
USGS
https://earthexplorer.usgs.gov/

One of the more classic interpretations of SRTM is the SRTM 90m Digital Elevation Database v4.1 produced by CGIAR-CSI. More information about this product can be found in their webpage (http://srtm.csi.cgiar.org/) and we will use this one for our exercise. Downloads can be made from the page at either 5° or 30° Tiles.
We already provide in the course´s shared folder two of these tiles downloaded for our Study area: srtm_50_05.tif and srtm_51_05.tif

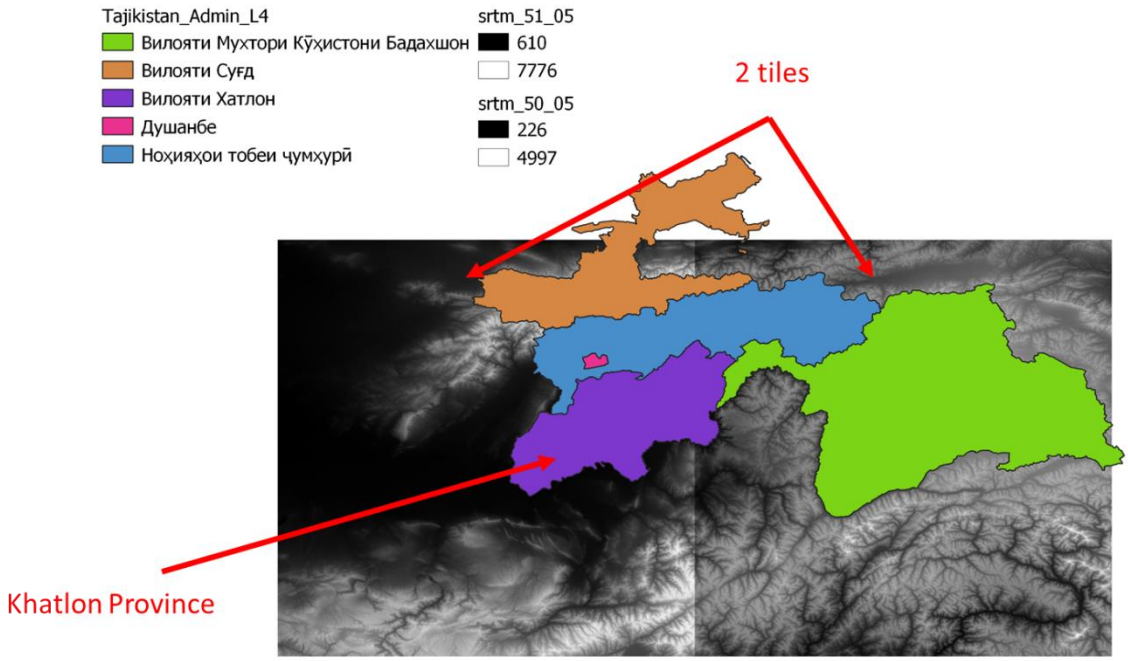


5.2 Opening and viewing the data set

First of all, please download and unzip the Exercise_QGIS_2.zip file in your working folder.

Raster or Satellite images come in different resolutions in different tile or scene sizes and in different reference systems. So, it is very important to learn how to use a tool to stich neighboring images, change their projections and clip them to the study area. Now we have our DEM from CGIAR and we will do exactly that.

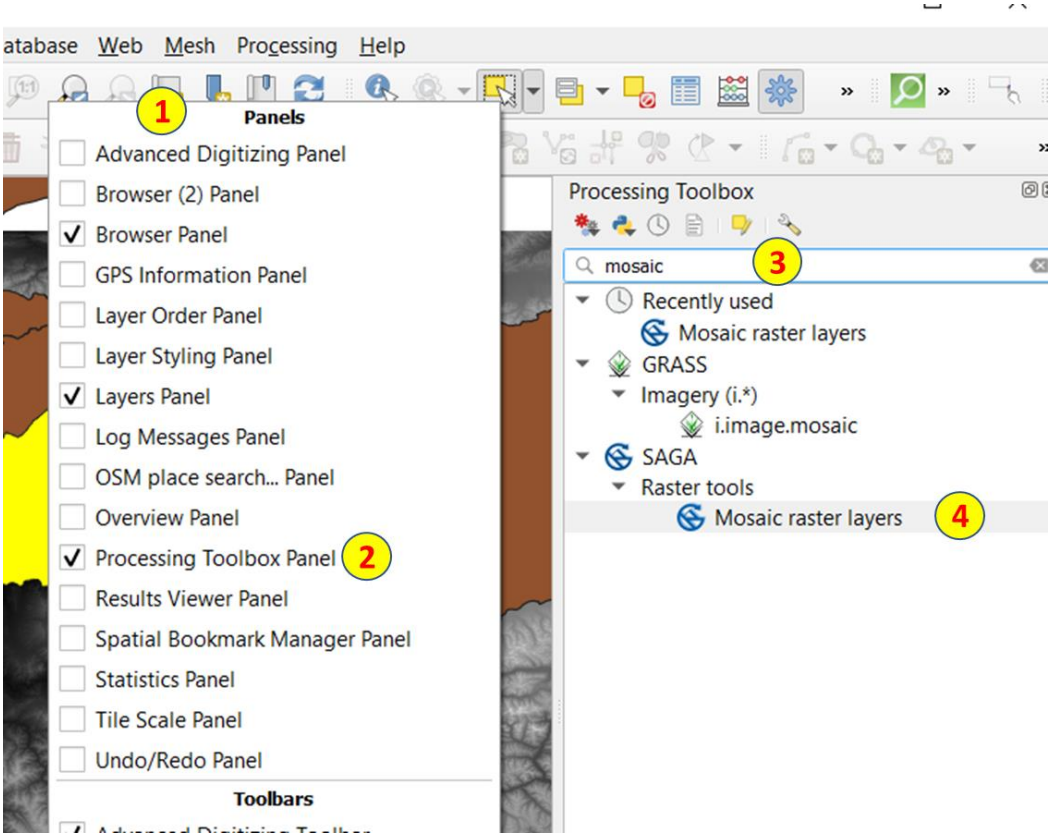
Please **Open** in a new QGIS project the file **Tajikistan_Admin_L4.** Then **Open** the **2 SRTM files**. We are going to work in the **Khatlon Province** in Tajikistan:



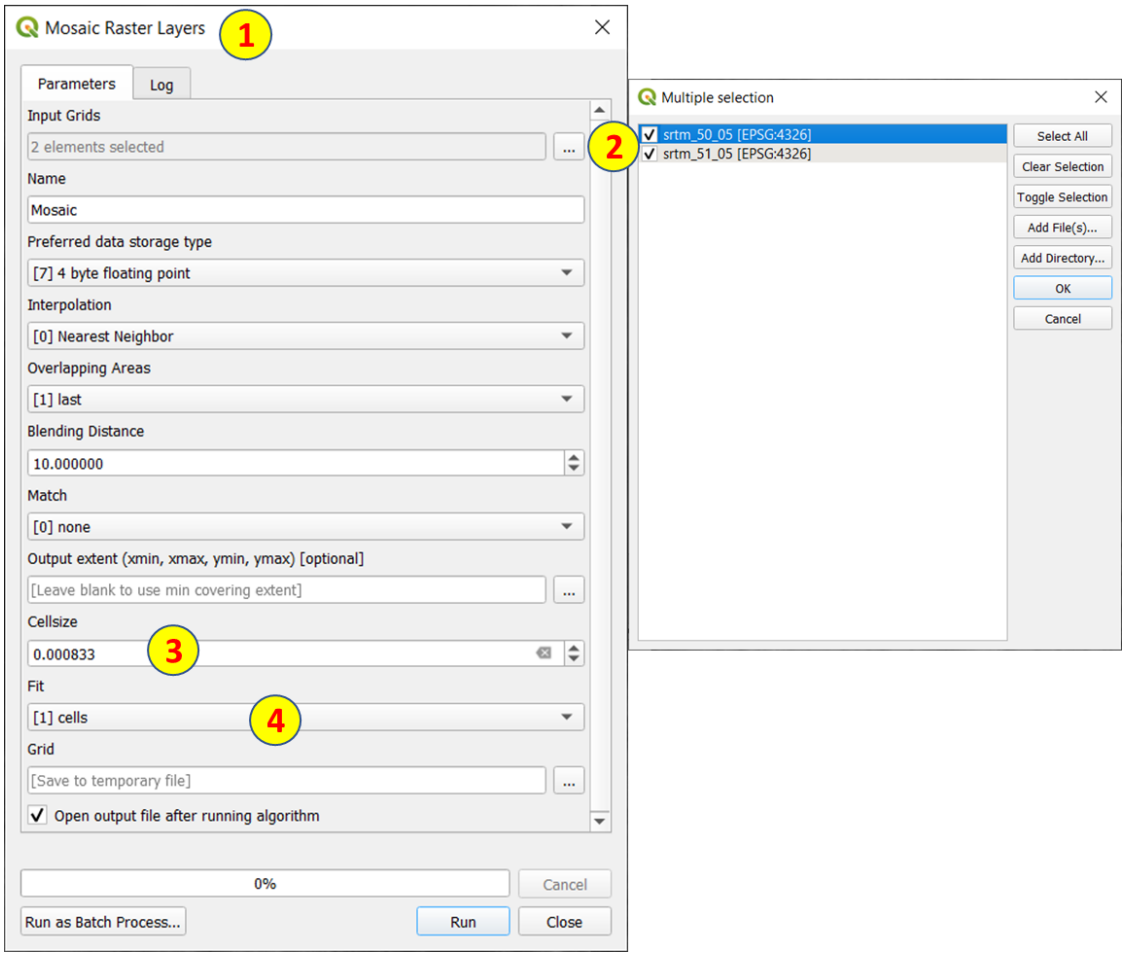
As you can see these are separate images so we will need to find a tool to merge them in order to cover the province with one image.

5.3 Mosaic raster layers

To find the necessary tools, you first need to find the toolbox. You can **Right Click** in any place on the toolbar (1) and when the panel option appears choose **Processing Toolbox Panel (2)**. This will open your **Toolbox** in a new **Panel** where you can simply Browse or use the search bar to search for tools **(3)**.



The first tool we will use is one to stich the images together into a single mosaic. There are few tools that do this in QGIS, we will try the one that comes from SAGA GIS. Please search in the search bar **(3)** the word "**mosaic**" and find the "**Mosaic raster layers**" tool indicated in **(4)** and **Double Click** to open it.



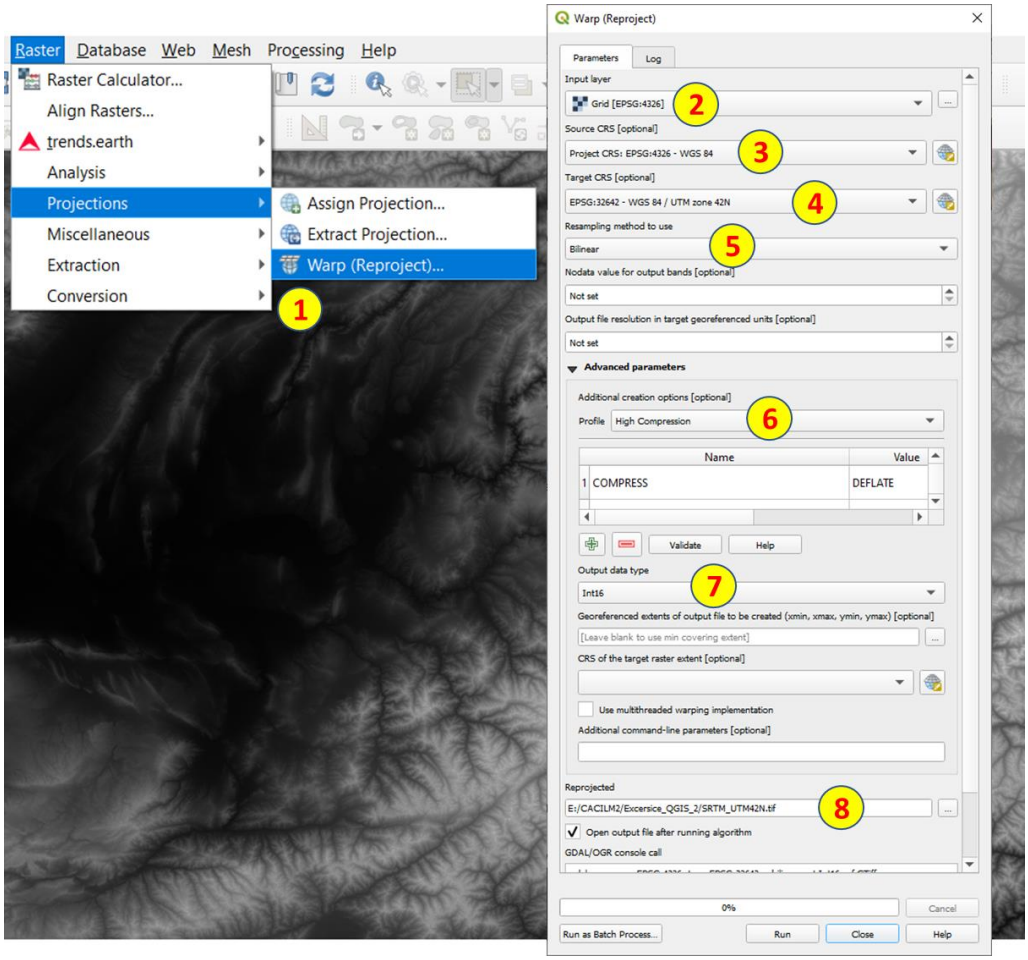
The tool **(1)** is very simple to use, just choose the **Input grids** by clicking in **… (2),** then in the new windows check the 2 SRTM tiles and click **OK.** We will need to specify the pixel size of the output image **(3)** you can check in **Properties** -> **Information** the value of the original tiles and paste it here (**0.000833** for this case). Set **Fit** to "**cells**" **(4).** And press **Run** to get a new file with both tiles merged. A new image called "**Grid**" should have appeared. Sometimes an error message appears but do not worry, if the grid was created, the process most probably worked well.

Every time you run a tool you will be producing a new raster file. So be aware that large areas and file sizes duplicate every time you **Run** a process. In this last case we didn't select name and location of a file, so **a temporary file** was produced and if not saved it will later be automatically erased when you close QGIS. Before saving it, we will project the new grid in a plane and choose a coordinate system for that. The downloaded images are in a geographic projection, where the units are degrees (EPSG: 4326) and we need to have both the vector layer (Tajikistan_Admin_L4) and the STRM images with the same coordinate system to make operations among them.

5.4 Reproject

Now that we have a single image for the whole area (called “grid” by default), we are going to transform it into the coordinate system we have been using for the study area: **WGS 84/ UTM42N** (EPSG: 32642).

For this we are going to use another tool “**Warp (Reproject)**” which comes from GDAL. You can find it in the Toolbox as the previous time or in the top menu: **Raster** -> **Projections (1)**. Select the last image, “Grid” as the Input layer **(2)**. The source reference system (CRS) is optional but easy to fill **(3)**, the target CRS is important so please select or search **(4)** for **EPSG:32642** or **WGS84/UTM zone 42N**. There are many **Resampling methods** to use for this process, fell free to explore them, I selected **Bilinear (5)** and I am quite happy with the result.
Points **(6)** and **(7)** in Advanced parameters are also optional. But if you would like to save some Mb of storage you can choose High Compression **(6)** and Int16 **(7)** in the case of this DEM. Please this time choose to **“Save to File…”** in the **… dots** of step **(8)** and save the result in your working folder with the file name of: “**SRTM_UTM42N**”.

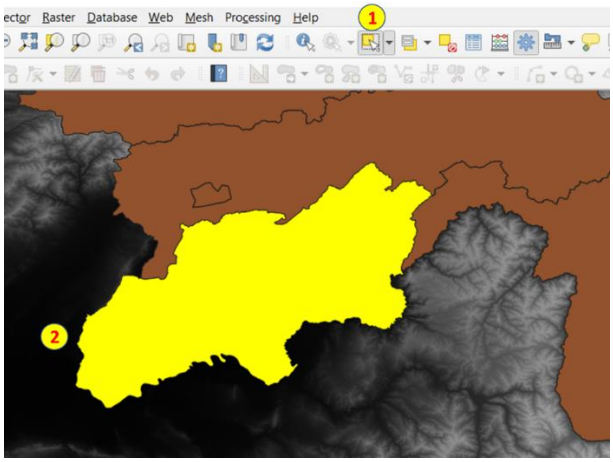


Great!! So far DEM tiles where downloaded, stitched and reprojected, it is time to cut our region of interest. In this case the **Khatlon Province.**

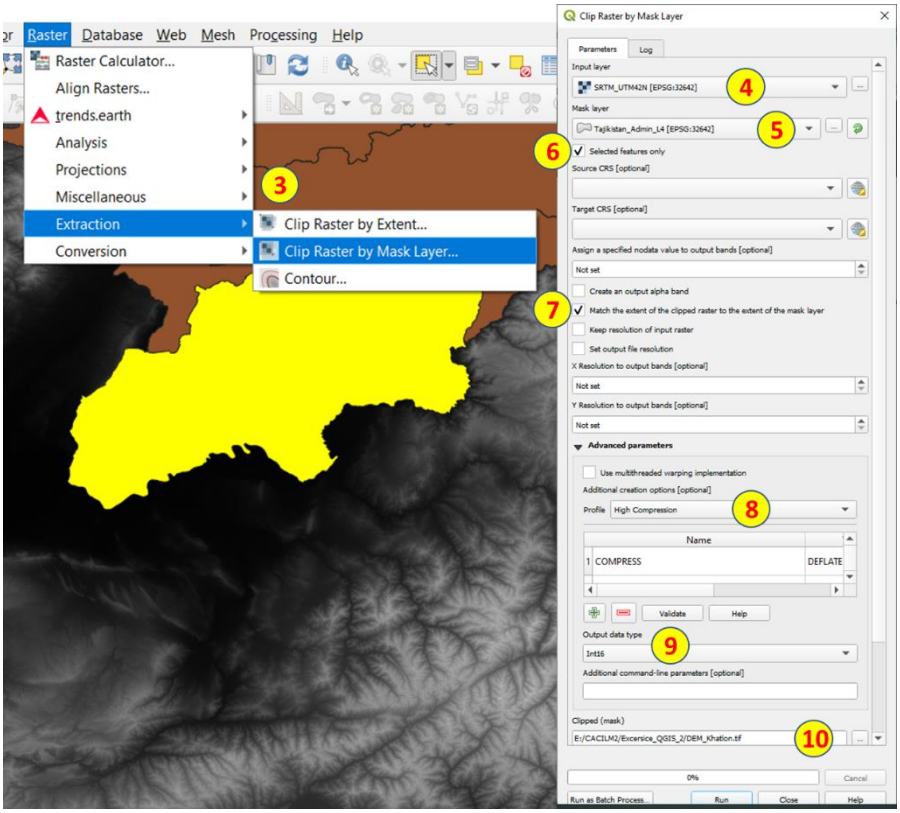
5.5 Cutting out the region of interest (Khatlon Province)

This requires we do 2 things**:**

First Select **Tajikistan_Admin_L4** in the **Layer Panel** and then use the **Select Features** tool from the **Toolbar (1).** Then you can click **(2)** on the Khatlon polygon (South East of Tajikistan) to select it.



Once the province is selected, to extract the area of interest to a new image we will use the "**Clip Raster by Mask Layer…**" tool **(3)**. The input layer is our "SRTM_UTM42N" layer we just created **(4)**. We will cut that image using as mask the **Tajikistan_Admin_L4** layer **(5).** This will cut using all the Tajikistan provinces except we check the option "**Selected features only**" **(6)**, please do not forget to mark that! Please also check the "**Match the extent …**" box **(7)** in order to reduce the extent of the output layer. Steps **(8)** and **(9)** are optional but will help with the file size (feel free to try). Please choose to **"Save to File…"** in the **… dots** of step **(8)** and save the result in your working folder with the file name of: "**DEM_Khatlon**".



Your result should look something like:

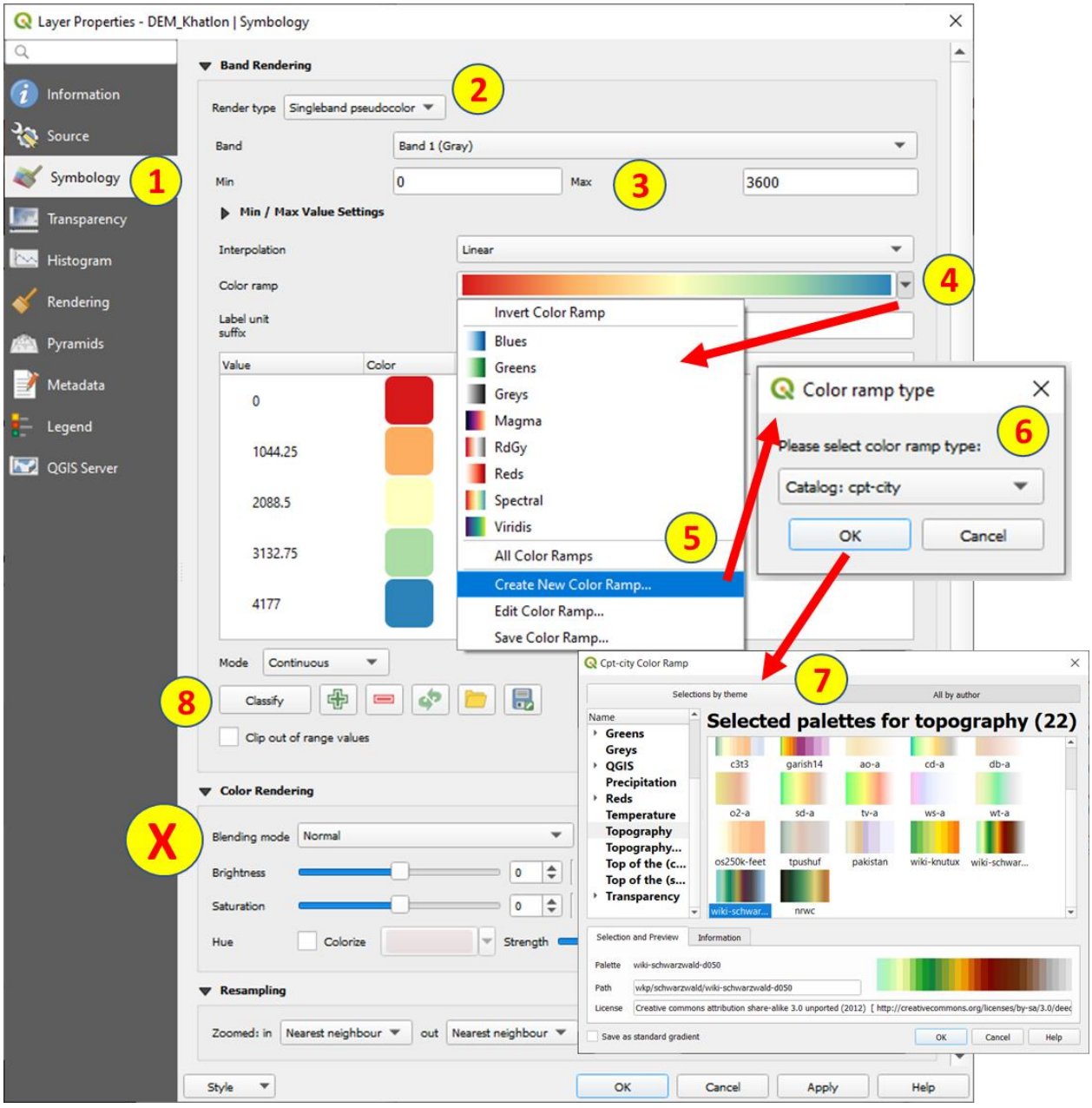
The result is not very appealing, but it will look better if we adjust the style. You can also use the  **Identify feature** tool to explore what data is stored in those pixels.

5.6 Styles for better visualization of a DEM

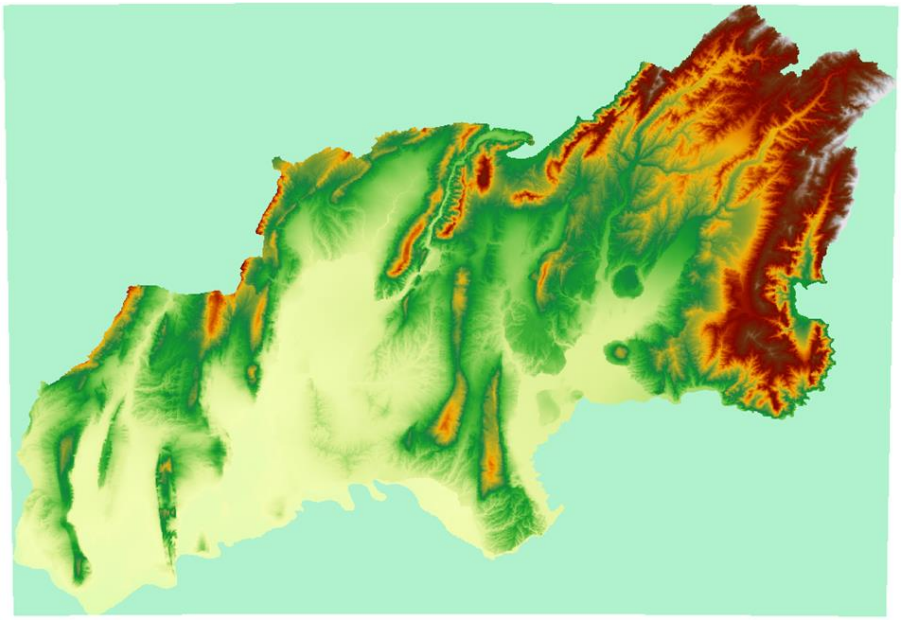
To change the style of a raster layer you have to also visit the **Properties** -> **Symbology** menu that is found in the layer's **Context menu.**

In **Symbology (1)** choose "**Singleband Pseudocolor**" in Render type **(2).** Then we will adjust the minimum and maximum value we want to visualize in the palette in this case from 0 to 3600+ **(3).** Now is time to choose a nice color ramp, click on the arrow **(4)** to see more options, then click on "Create New Color Ramp…" **(5).** A new window will open **(6)** please choose the "**cpt-city**" palettes and press **OK**… yet other windows will open **(7)** and choose from the "**Topography**" group the one called **Wiki-scharzwald** and press **OK.** Then please update the values by pressing "**Classify**" **(8)** button.

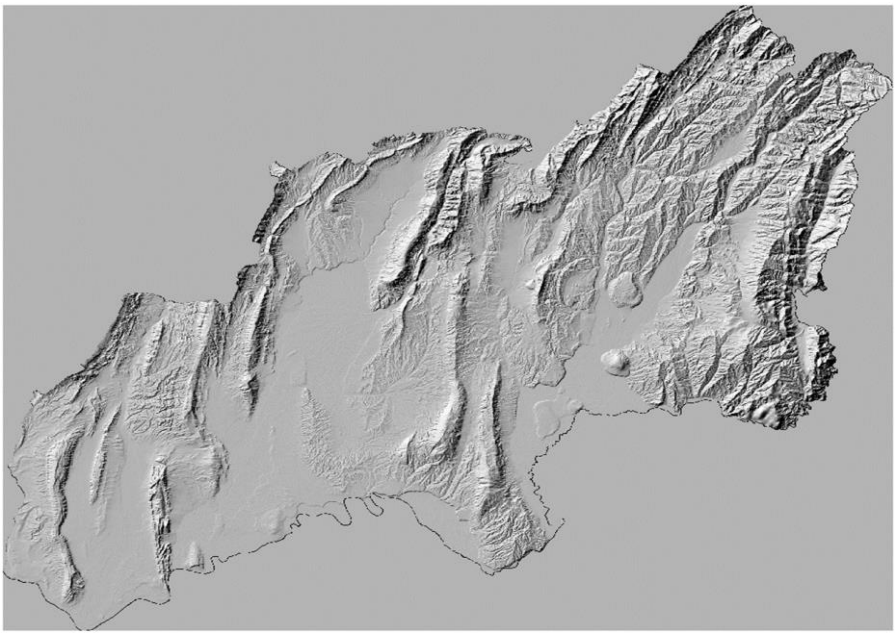
For now, do not worry about the **X** and leave Blending mode in "**Normal**", but remember where the option is for later. Just click **OK** and let's see the result.



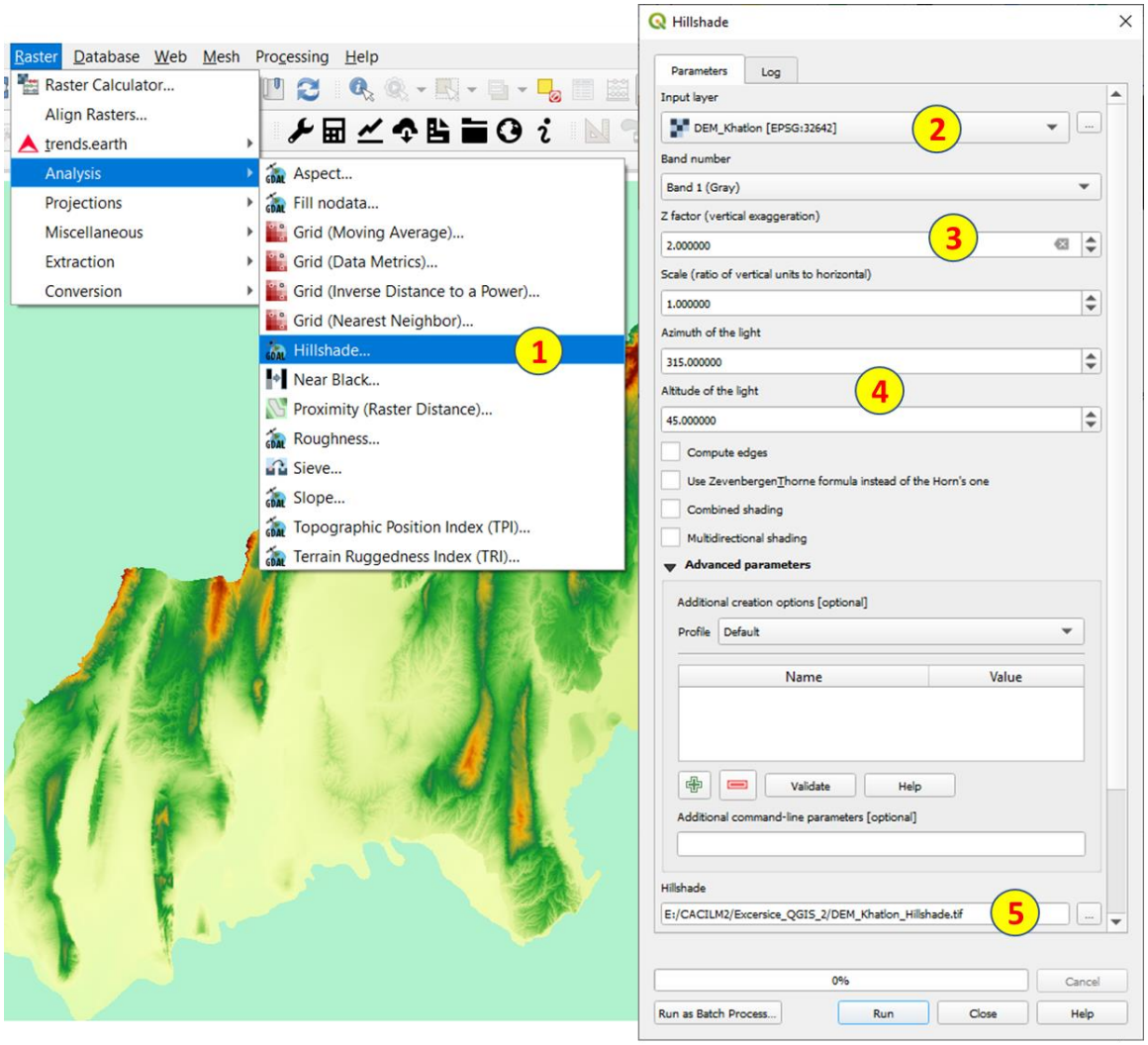
You should now see something like this:



Let´s do a solid version too:



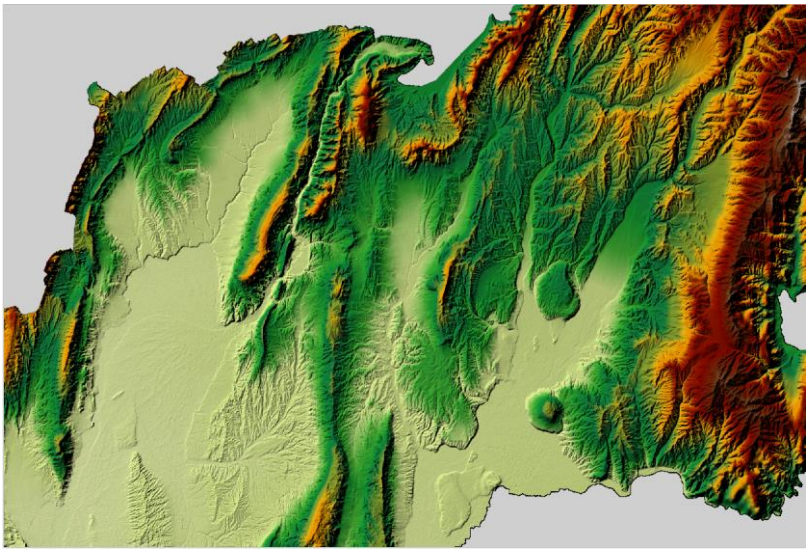
The solid version is called “Hillshade” and it is actually a rendering based in a light source. The steps to build it are very simple:



Choose Hillshade Tool from the menu **(1),** use the **DEM_Khatlon** as Input Layer **(2)**. One of the parameters is the **Z-Factor (3),** this regulates the vertical exaggeration to make more evident changes in the terrain, lets use 2 for this exercise. Other parameters are **Azimuth** and **Altitude (4)** that simulate the location of the Sun in the sky, for example: Azimuth of 0 will be North and Altitude of 90 is the Sun straight Up. Please choose to **"Save to File…"** in the **… dots** of step **(5)** and save the result in your working folder with the file name of: "**DEM_Khatlon_Hillshade**". Click **Run** and the new Layer should automatically appear.

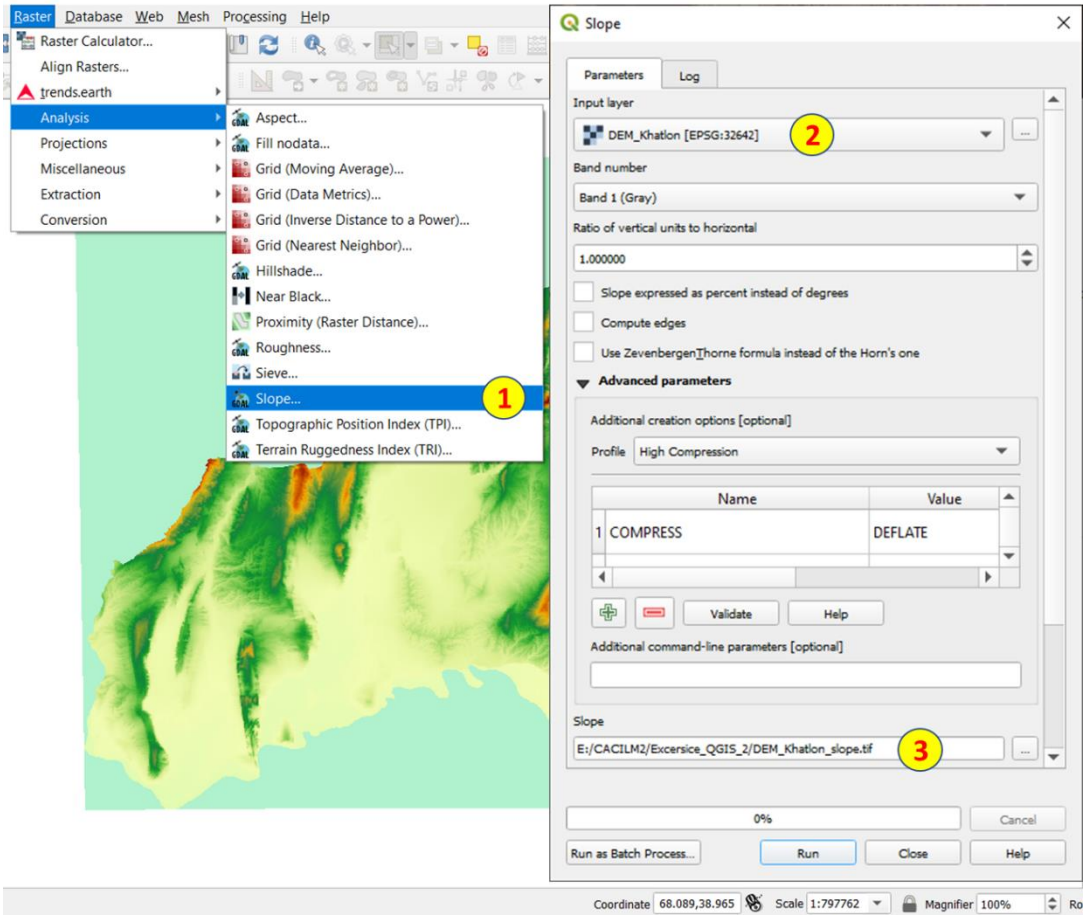
Wouldn't it be fun to make a combination of this to maps? Merging the solid appearance of the Hillshade with the colorful altitude of the DEM? Remember the **X**?

If you set the Blending Mode to **Multiply** in the **DEM** and put it **on top** of the **Hillshade** it produces the combination. See:

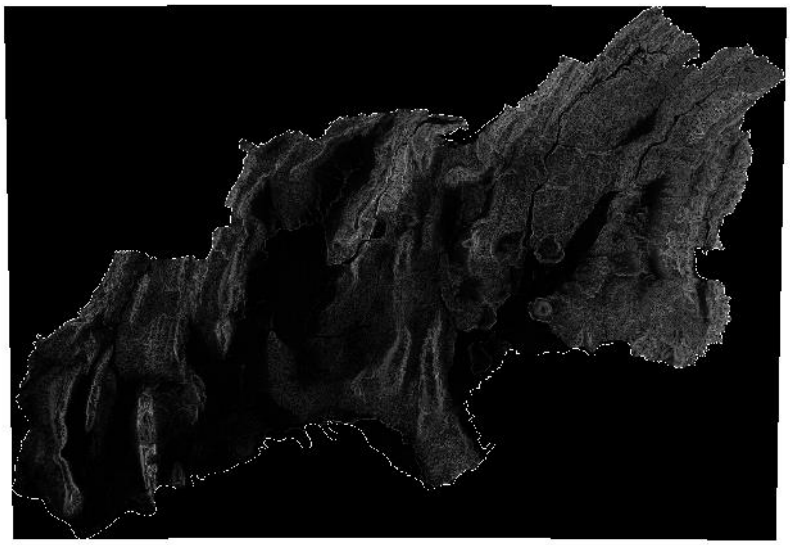


This is nice, but let's do something more useful:

5.7 Making a Slope Map

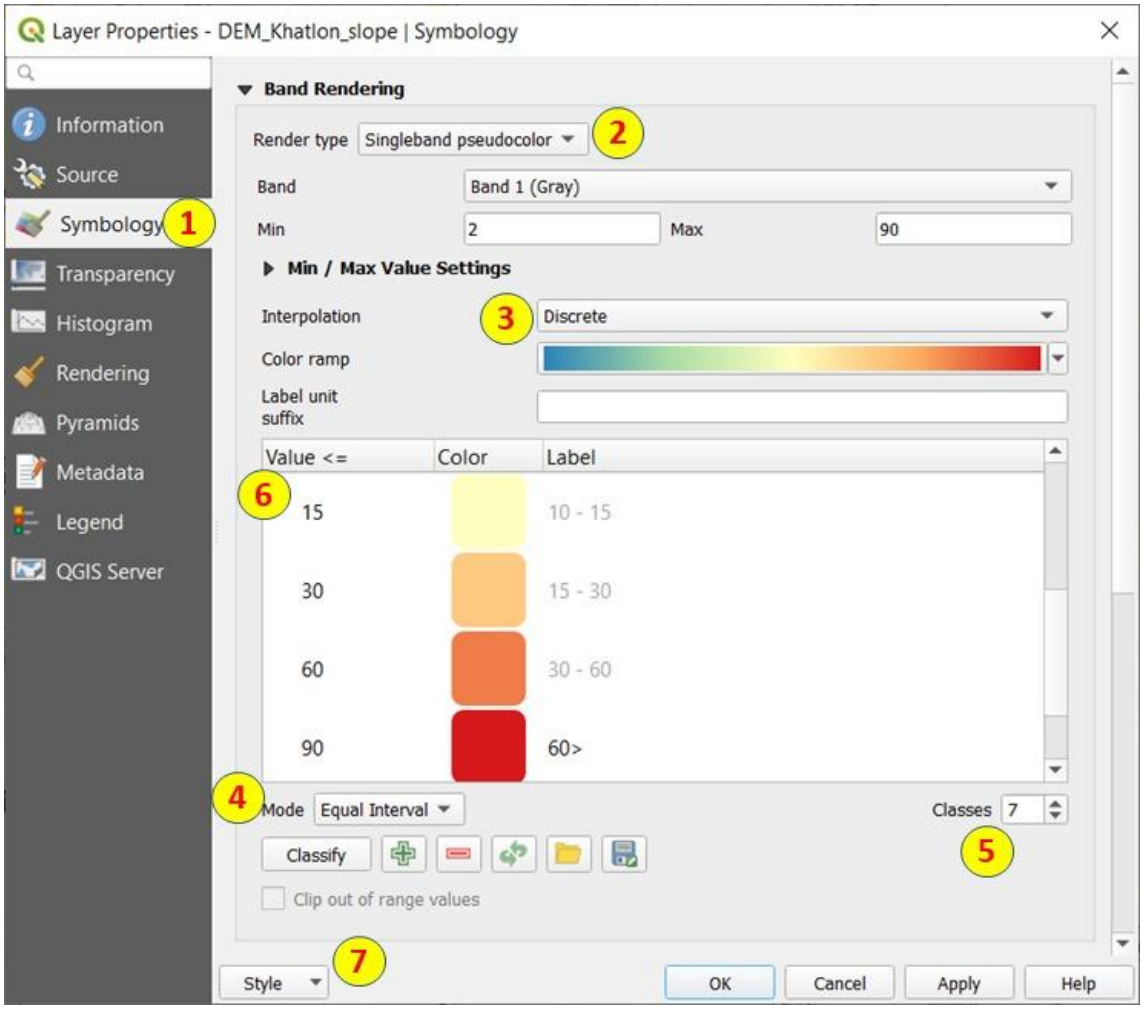


This is a very useful and easy to make map. Just open the **Slope** tool **(1)**, set the **DEM_Khatlon** as Input Layer and save it as: "**DEM_Khatlon_slope".** This will get you a black and white map with the Slope calculated in Degrees:



We can also use a categorical classification with the following criteria:

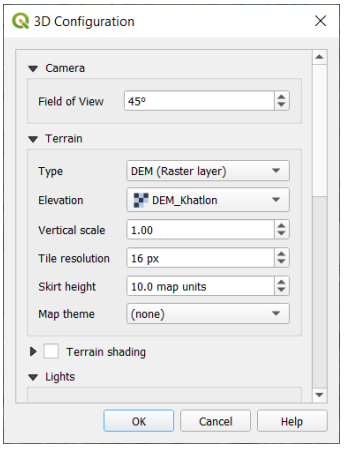
Class	Class Description	Degrees
1	Flat to Very gently sloping	0-2
2	Gently sloping	2-5
3	Sloping	5-10
4	Strongly sloping	10-15
5	Moderately steep	15-30
6	Steep	30-60
7	Very steep	60+

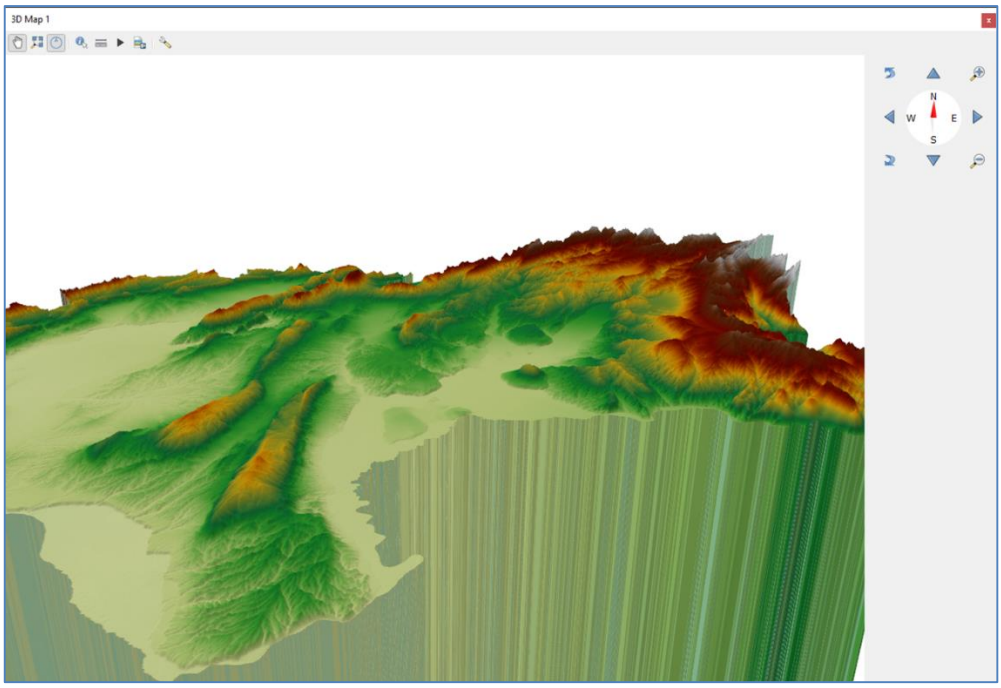


In **Symbology (1)** choose "**Singleband Pseudocolor**" in Render type **(2).** Choose **Discrete** in Interpolation **(3),** choose **Equal Interval** as Mode **(4) and** set **Classes** to **7 (5).** Then use the Double Click to start changing the values **(6)** using the criteria previously described in the table**.** Remember that you can save the Style for latter use **(7)** before saving.

5.7 Bonus Track: 3D map view

If you still like to play a little bit, you can go to **View** -> **New 3D Map View** and play a bit with that tool to make 3D representations. In the options make sure to indicate your DEM_Khatlon as source of terrain:

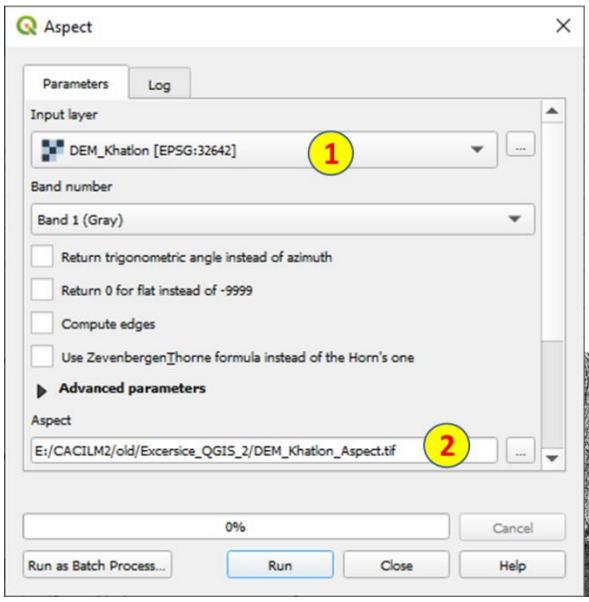


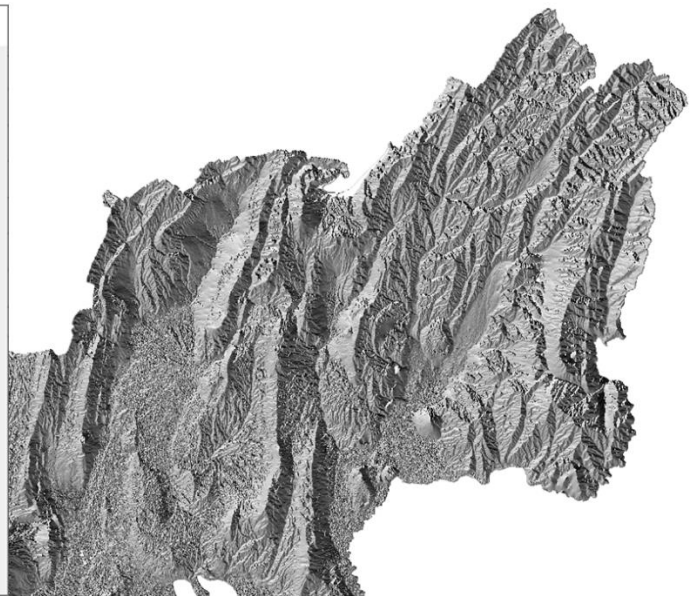


5.8 Aspect calculation

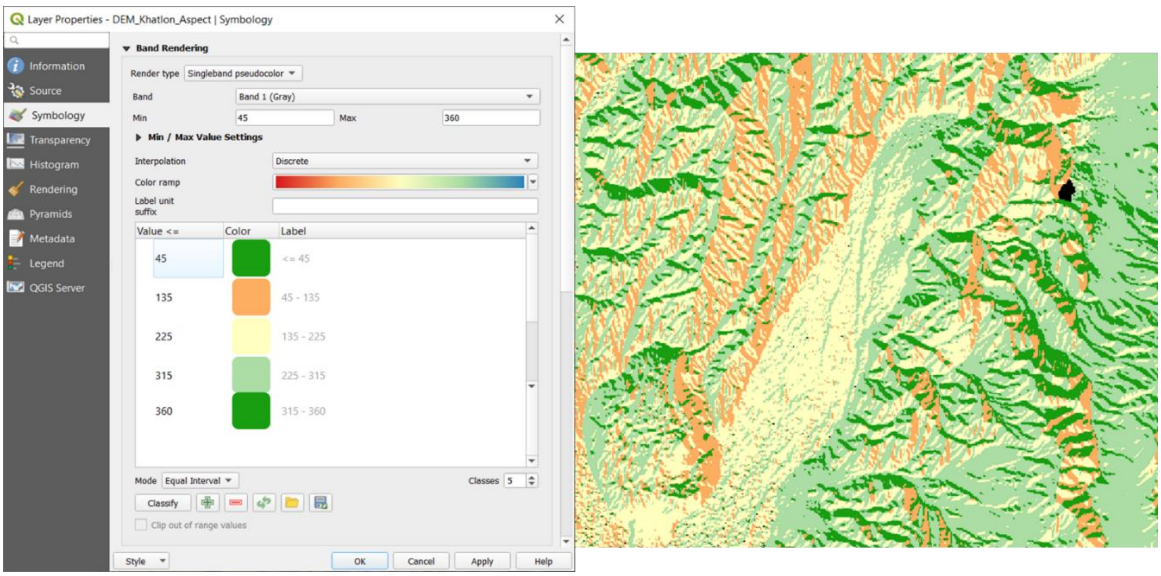
Aspect is a very important factor describing the slope orientation. This is of great importance in many regions since light patterns or wind/humidity could be correlated to a certain direction.

In **Raster** -> **Analysis** -> **Aspect**… you can run the process by adding the "**DEM_Khatlon**" as Input layer **(1)**. Save the result as "**DEM_Khatlon_Aspect**" **(2)**. The result should look like the map below.





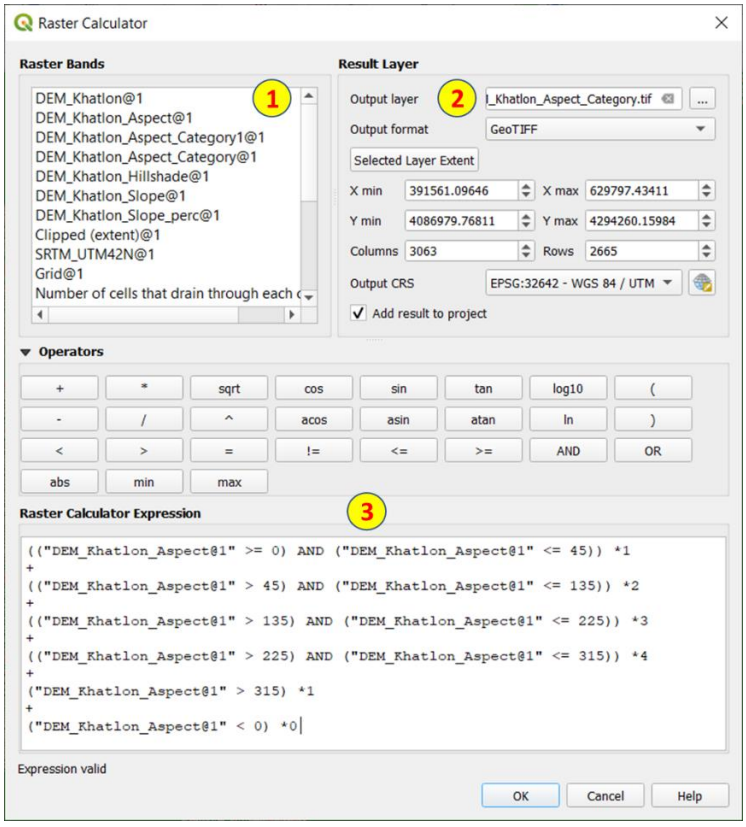
You can improve the visualization by adding ranges to the orientation:



Many times, it is useful to transfer these categories to the pixel values, this is called **Reclassification**.

5.9. Raster Reclassification

In the Raster Menu, you can find the Raster calculator. This allows many different operations at pixel level.



You can select any available Raster from the list **(1)** define the output layer **(2)** and use different operators to build your expressions **(3)** that can be mathematical or logical. In this case we use a combination of both.

Let´s see a hypothetical example:

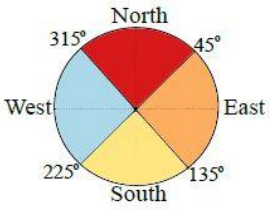
(RasterLayer > 1) * 2

→ Here what we mean is that if what is inside the brackets () is true, then it is replaced by 1. In this case this means that if pixel values in RasterLayer are greater than 1 (and therefore the statement is true) then the logic operator is (1) * 2 = 2

→ on the contrary, if the statement inside brackets is false, it is replaced by 0. In this case it means that if the value in the pixel is equal or smaller than 1 then (0) * 2 = 0

So, we can use the same classification criteria for Aspect layer in order to create a categorical Aspect using the following criteria:

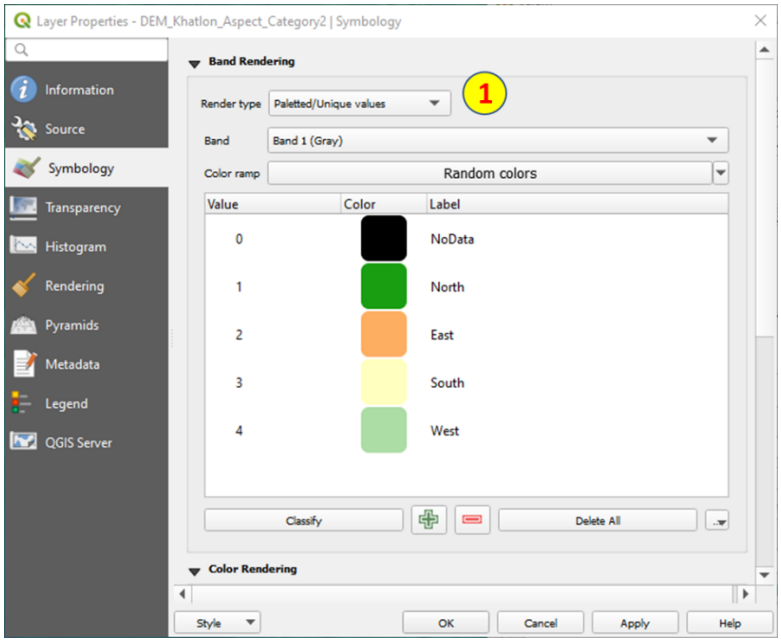
Reclassification of aspect values:
North, 315-45 degrees;
East, 45-135 degrees;
South, 135-225 degrees;
West, 225-315 degrees



For this, you can copy and paste the following expressions in the Raster Calculation Expression:

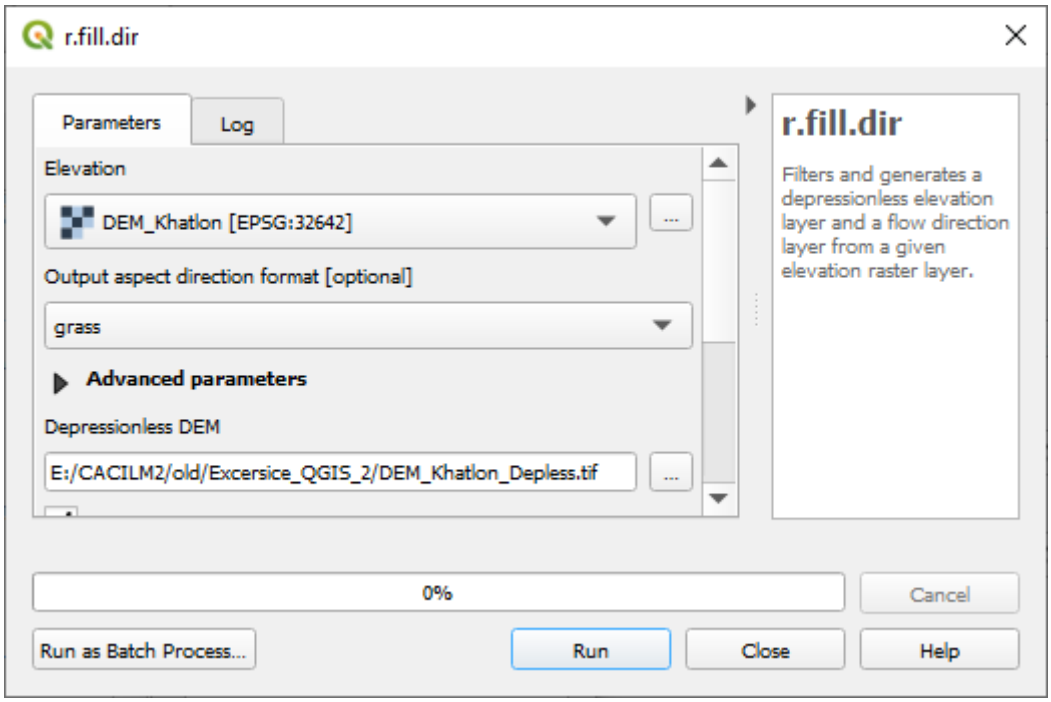
```
(("DEM_Khatlon_Aspect@1" >= 0) AND ("DEM_Khatlon_Aspect@1" <= 45)) *1
+
(("DEM_Khatlon_Aspect@1" > 45) AND ("DEM_Khatlon_Aspect@1" <= 135)) *2
+
(("DEM_Khatlon_Aspect@1" > 135) AND ("DEM_Khatlon_Aspect@1" <= 225)) *3
+
(("DEM_Khatlon_Aspect@1" > 225) AND ("DEM_Khatlon_Aspect@1" <= 315)) *4
+
("DEM_Khatlon_Aspect@1" > 315) *1
+
("DEM_Khatlon_Aspect@1" < 0) *0
```

Please, save the result as "**DEM_Khatlon_Aspect_Category**". Your new Layer should now have only 5 values. You can use the following **Unique values (1)** styling criteria:



5.10 Watershed delineation

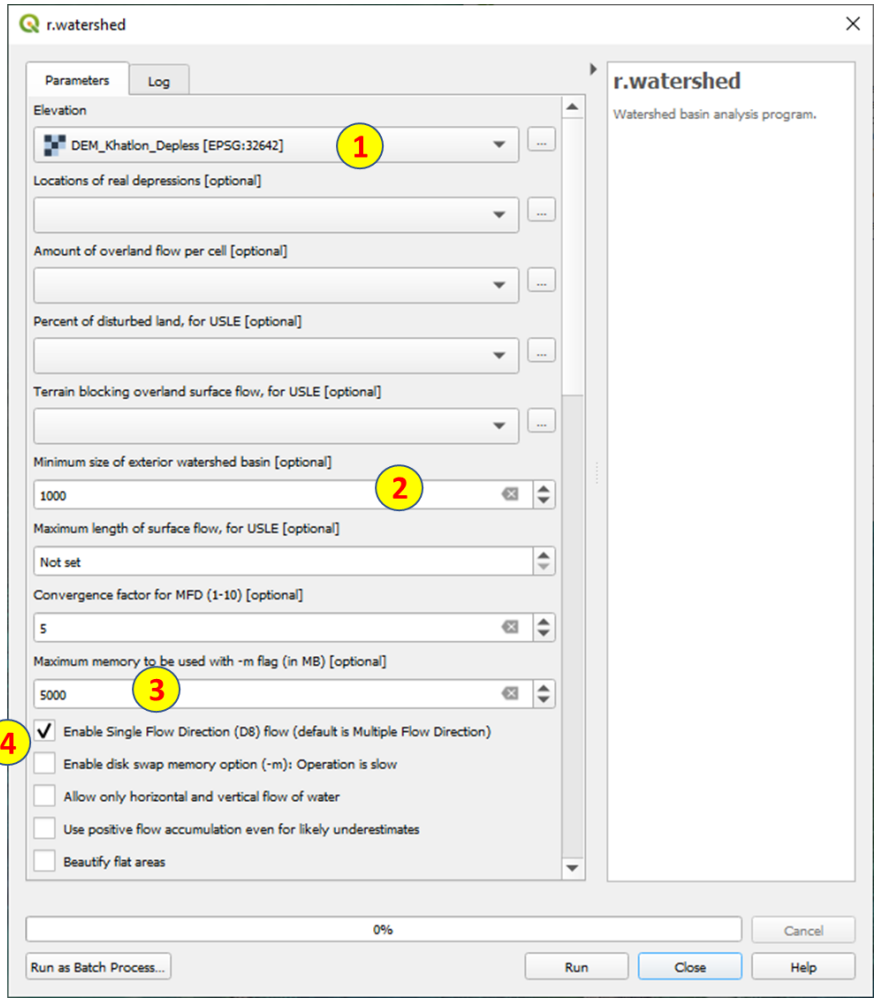
Watershed delineation is a process that yields a lot of different Layers and requires many different tools. The tools also require several parameters that have to be finetuned with observation, trial and error and criteria. So basically, you have to play around with it since every place is different and there is no one solution that fits all cases.



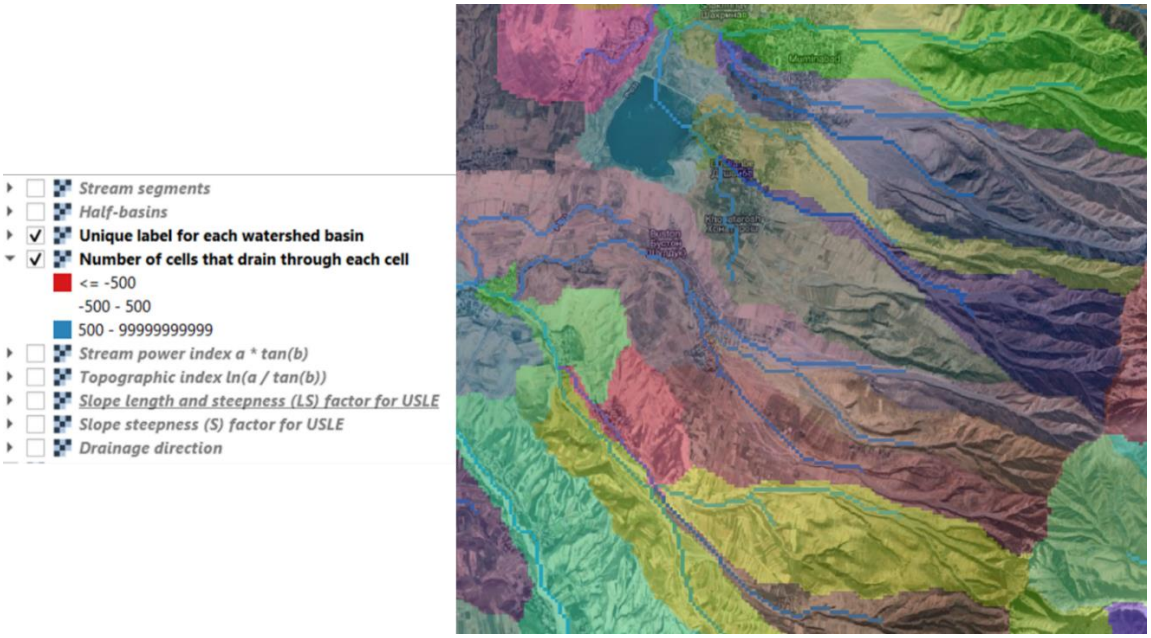
If you are not interested in water bodies (accumulation) and want to get a drainage network that goes all the way out of your DEM, then you run a Fill tool to get rid of imperfections (pits

and holes). You can run the **r.fill.dir** or any other that could generate depressionless Raster. Please name it "**DEM_Khatlon_Depless**".

The next tool will be **r.watershed.** Use as Elevation the **DEM_Khatlon_Depless (1)**, set the Minimum size of exterior watershed basin to **1000 (2).** If you have memory available put some to work 😊 **(3)** to speed up the process. Click the Enable Single Flow direction **(4)** to get smoother results.

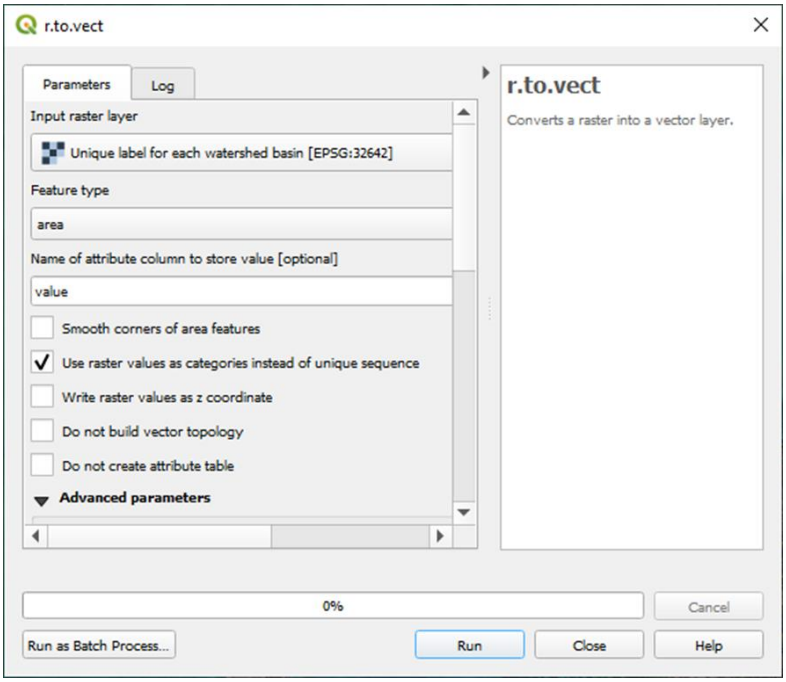


This tool will produce a lot of results, so explore and play with the colors to understand it:

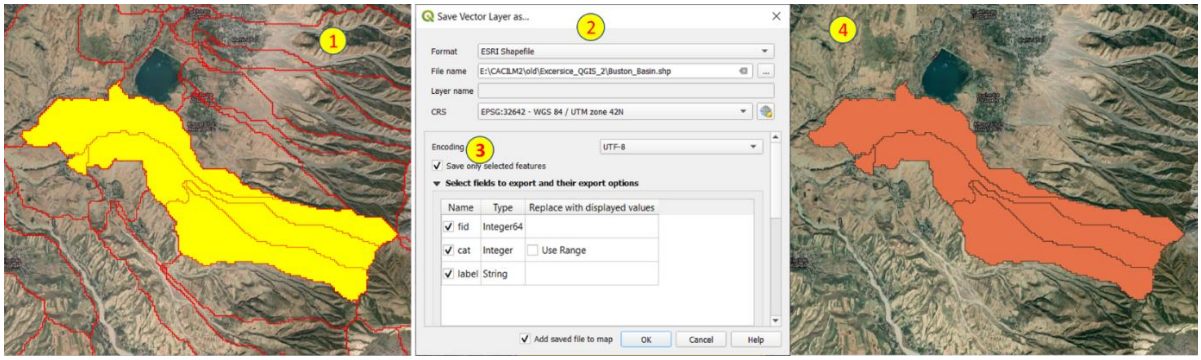


If you decide you like the Basin delineation you see in the Raster "**Unique label for each watershed basin**", or that it has potential to be adapted you can convert it to Vector to manage it better. We are interested in a basin that goes to the town of **Buston**, located south of **Muminabad**, in the west of the **Khatlon** province.

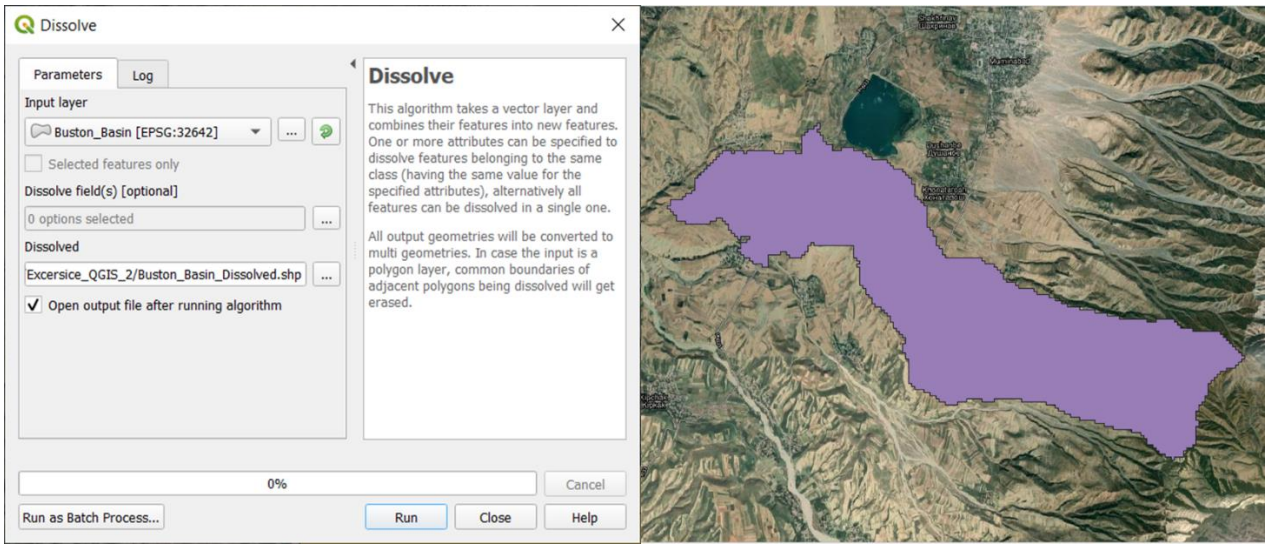
Use the **r.to.vect** tool to transform that raster into a Polygon layer:



Then is easier to look in the resulting polygons and select the basins of interest **(1),** you can then Export **(2)** and Save a new layer (clicking the Option **(3) Save only selected features**) that only contains polygons of the desired watersheds (**4).** Please Name it as "**Buston_basin**"

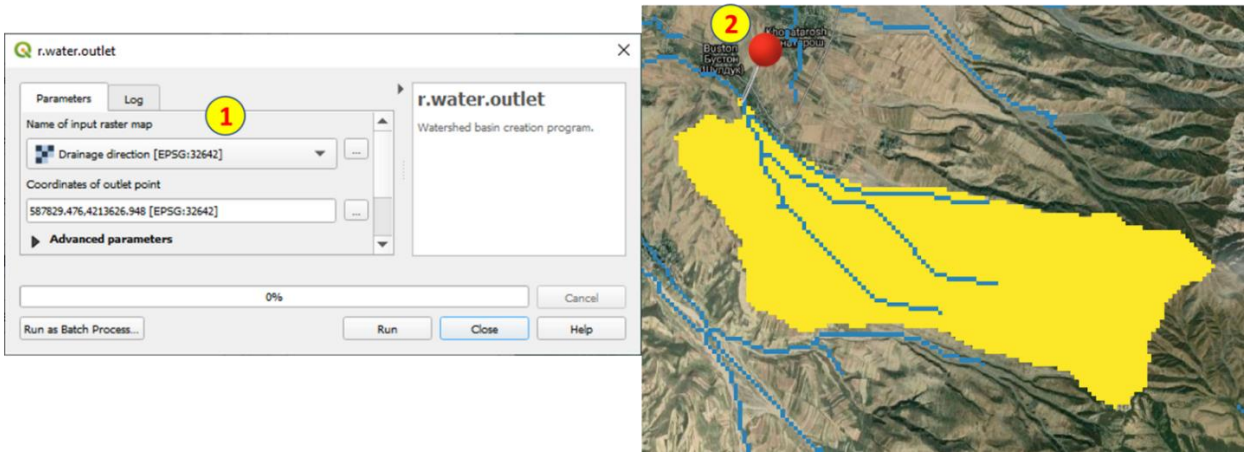


Now if you want to merge all these polygons into one you can simply use the **Dissolve Tool**:



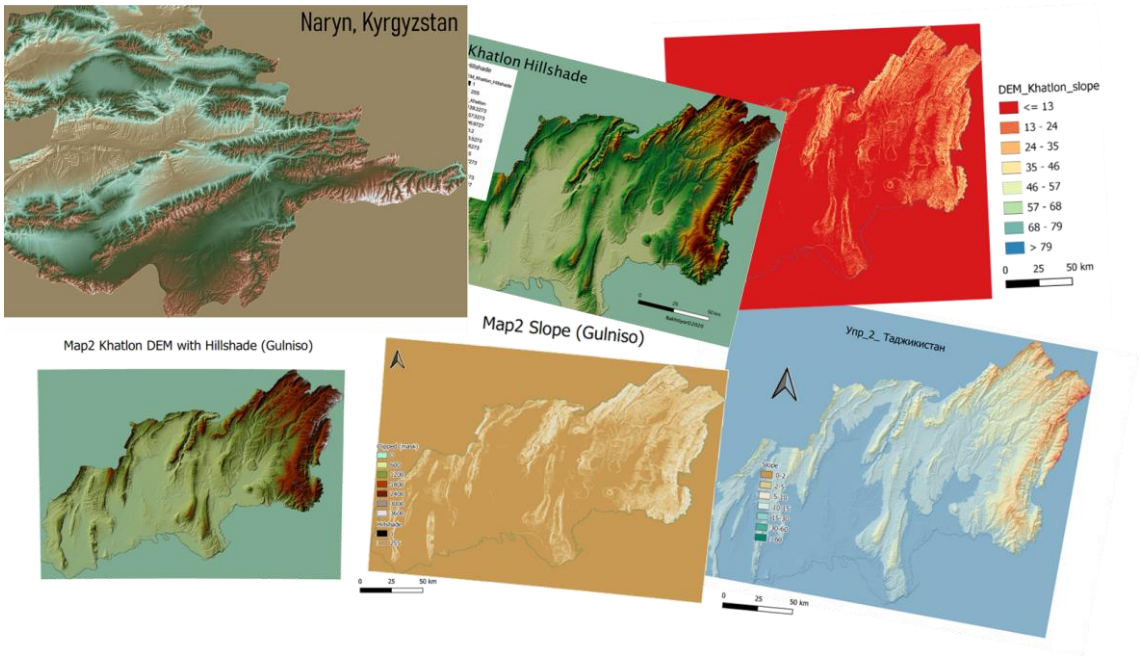
5.11 Alternative Basin delineation with output coordinate

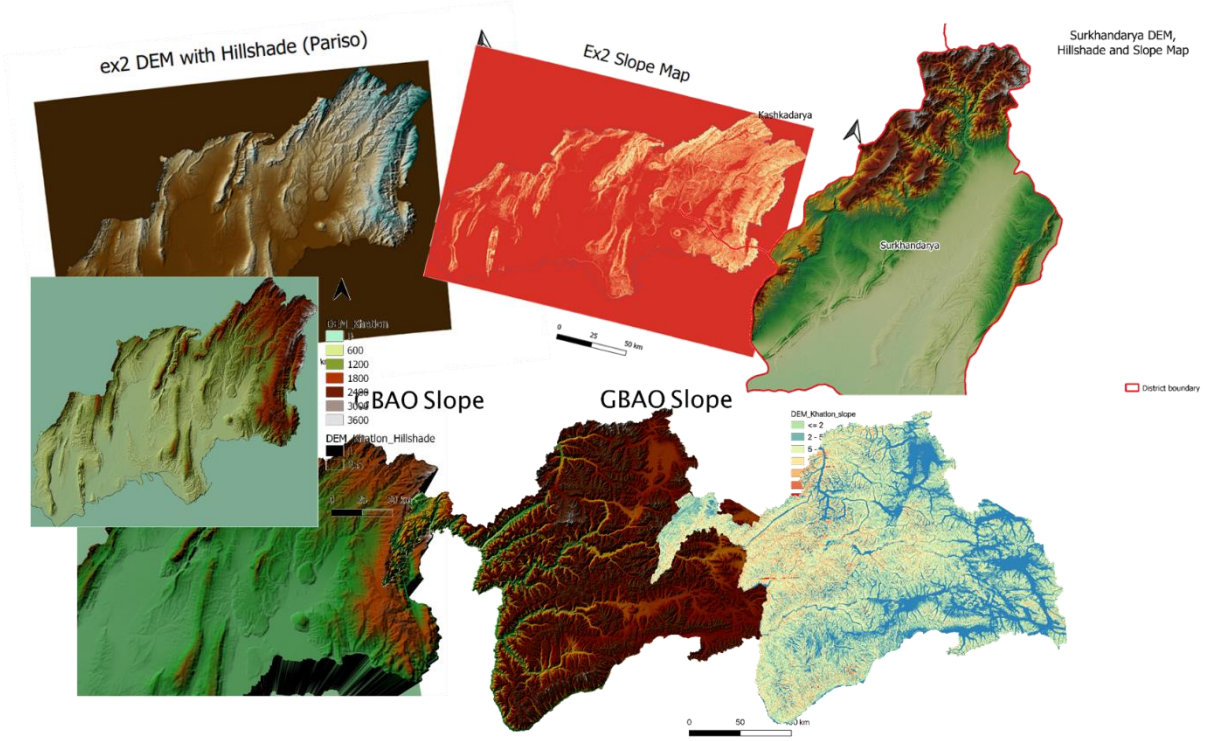
Once you have performed the **r.watershed** tool you can also use the **r.water.outlet** tool. This requires that on of the output raster layer called **Drainage direction (1)** and that you specify the coordinates that you want to use for closing the Basin **(2)**. It is recommended to choose one point that falls on a river, you can use **Stream segments** or **Number of cells that drain through each cell** to help you choose.



6.10 Do it yourself!

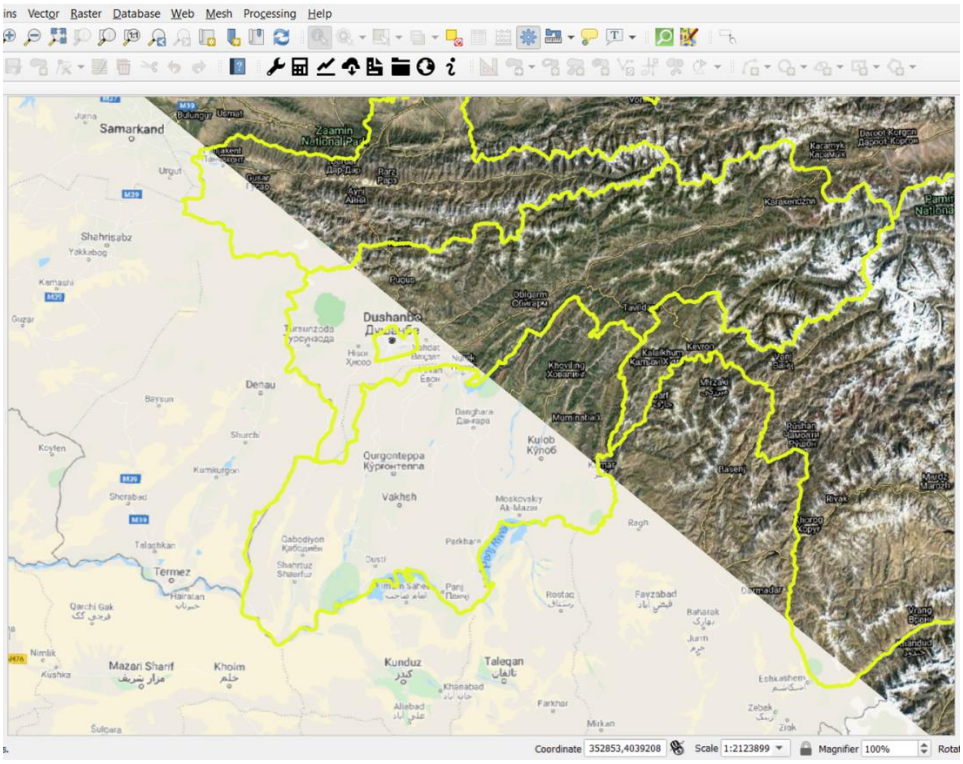
Now it is time to make a nice printed map with the DEM and/or the Slope. Here are some of the results from the participants:



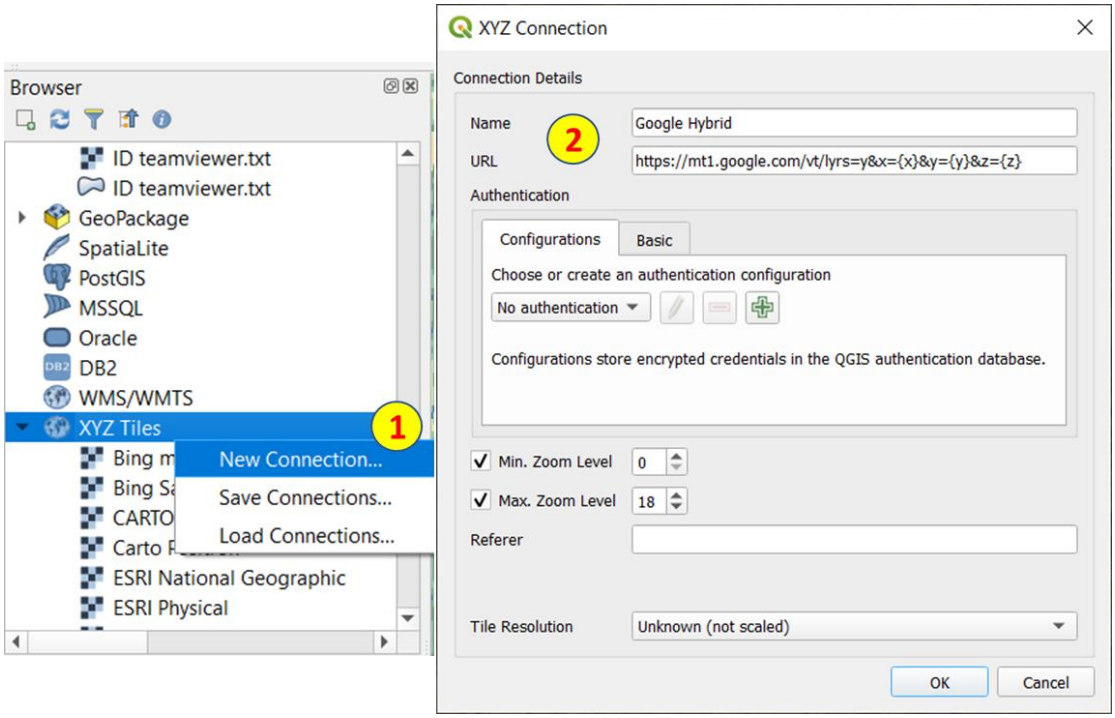


6. XYZ TILES

Wouldn't it be cool to have in our projects background maps and images? Like Google Satellite or Google Maps:



Then XYZ Tiles is your best option. Go to the Browser and **Right Click** for **New Connection (1)**:



Then you simply need to give it a **Name** and the **URL** of the background map **(2)**.

Here is a list of **URL** to load many different ones that you can use, once you press ok it will be available for you every time you open QGIS.

- **Google Maps**: https://mt1.google.com/vt/lyrs=r&x={x}&y={y}&z={z}
- **Google Satellite:** http://www.google.cn/maps/vt?lyrs=s@189&gl=cn&x={x}&y={y}&z={z}
- **Google Hybrid:** https://mt1.google.com/vt/lyrs=y&x={x}&y={y}&z={z}
- **Google Terrain:** https://mt1.google.com/vt/lyrs=t&x={x}&y={y}&z={z}
- **Google Traffic:** https://mt1.google.com/vt?lyrs=h@159000000,traffic|seconds_into_week:-1&style=3&x={x}&y={y}&z={z}
- **Google Roads:** https://mt1.google.com/vt/lyrs=h&x={x}&y={y}&z={z}
- **OpenStreetMap:** http://a.tile.openstreetmap.org/{z}/{x}/{y}.png
- **OpenStreetMap Mapnick:** http://tile.openstreetmap.org/{z}/{x}/{y}.png
- **OSM Cycle Map:** http://tile.thunderforest.com/cycle/{z}/{x}/{y}.png
- **OSM Black and White:** http://tiles.wmflabs.org/bw-mapnik/{z}/{x}/{y}.png
- **OSM2World/3:** http://tiles.osm2world.org/osm/pngtiles/n/{z}/{x}/{y}.png
- **Bing maps:** http://ecn.dynamic.t0.tiles.virtualearth.net/comp/CompositionHandler/{q}?mkt=en-us&it=G,VE,BX,L,LA&shading=hill
- **Bing Satélite**: http://ecn.t3.tiles.virtualearth.net/tiles/a{q}.jpeg?g=0&dir=dir_n'
- **ESRI Imagery/Satellite:** https://server.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer/tile/{z}/{y}/{x}
- **ESRI National Geographic**: http://services.arcgisonline.com/ArcGIS/rest/services/NatGeo_World_Map/MapServer/tile/{z}/{y}/{x}
- **ESRI Physical:** https://server.arcgisonline.com/ArcGIS/rest/services/World_Physical_Map/MapServer/tile/{z}/{y}/{x}
- **ESRI Streets:** https://server.arcgisonline.com/ArcGIS/rest/services/World_Street_Map/MapServer/tile/{z}/{y}/{x}
- **ESRI Terrain:** https://server.arcgisonline.com/ArcGIS/rest/services/World_Terrain_Base/MapServer/tile/{z}/{y}/{x}
- **ESRI Topo:** https://server.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer/tile/{z}/{y}/{x}
- **ESRI Transportation:** https://server.arcgisonline.com/ArcGIS/rest/services/Reference/World_Transportation/MapServer/tile/{z}/{y}/{x}
- **Stamen Terrain:** http://a.tile.stamen.com/terrain/{z}/{x}/{y}.png
- **Stamen Toner**: http://tile.stamen.com/toner/{z}/{x}/{y}.png
- **Stamen Watercolor:** http://tile.stamen.com/watercolor/{z}/{x}/{y}.jpg

7. DOWNLOADING OPEN STREET MAP DATA

The original site is https://www.openstreetmap.org/

You can only download small section but there are many sites that will provide an access to the OSM data.

GEOFABRIK

This site stores data at Continental level and Country level. Data can be downloaded in **pbf** and **shp** formats, both can be opened in QGIS.

Link: https://download.geofabrik.de/

https://download.geofabrik.de/asia.html

OSMaxx

This is short for "OpenStreetMap Arbitrary Excerpt Export" https://osmaxx.hsr.ch/

You can select whole countries or personal regions. You can also choose different output formats, like:

- Esri File Geodatabase
- Esri Shapefile
- GeoPackage
- SpatiaLite
- Garmin navigation & map data
- OSM Protocolbuffer Binary Format

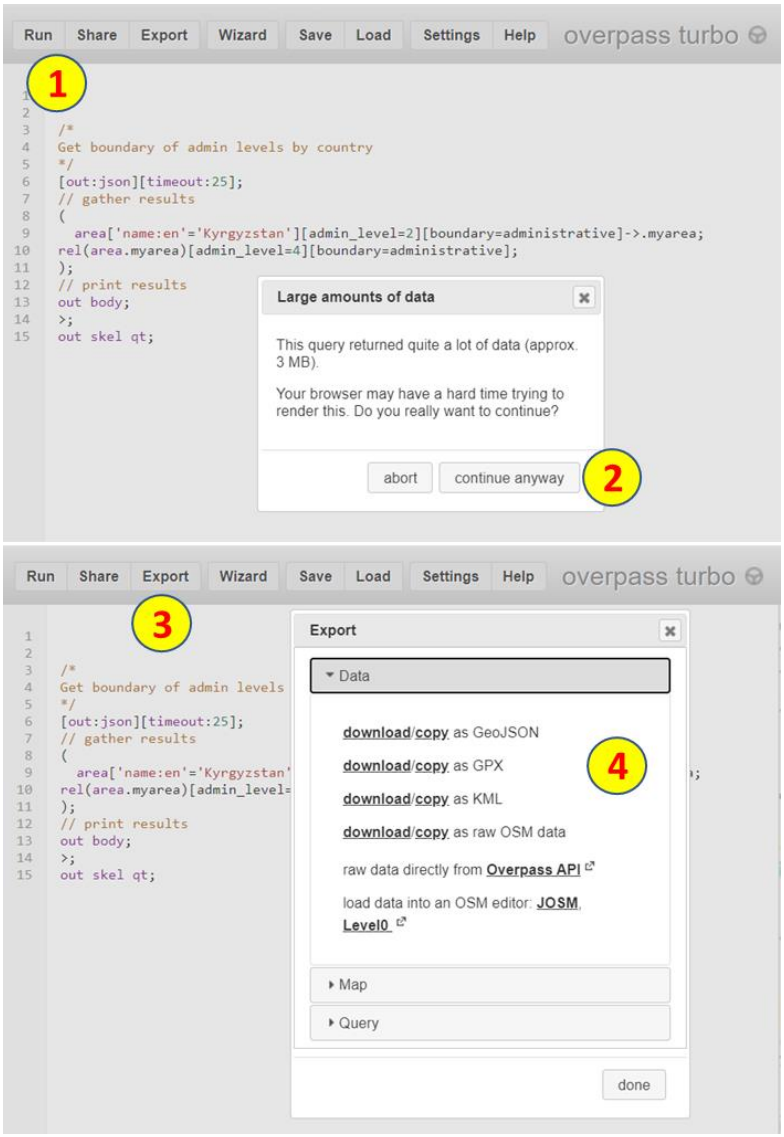
And allows for different coordinate systems conversion too.

OVERPASS

This site let's you use an API to place queries and make personalized filter. You can either use the Wizard or write your own Query.

The Link is: https://overpass-turbo.eu/

Here some examples of How it works:



Paste the example scripts in the window and change the name of the **country** and **admin_level** is required, then click on **RUN (1)** and when the windows appear **(2)** choose **Continue anyway.** Once you see the result on the map, clik **Export (3)** and choose the type of file **(4)** KML is usually the smallest file size and **GeoJSON** is the other option that open directly in QGIS with Drag and Drop.

Here are some examples:

1) Administrative limits by country. Change 'name:en' with you country name. Change admin_level: 4-provinces, 6-Districts

```
/*
Get boundary of admin levels by country
*/
[out:json][timeout:25];
// gather results
(
  area['name:en'='Kyrgyzstan'][admin_level=2][boundary=administrative]->.myarea;
```

```
rel(area.myarea)[admin_level=4][boundary=administrative];
);
// print results
out body;
>;
out skel qt;
```

2) Get all the roads in a country. Change 'name:en' with you country name.

```
[out:json][timeout:25];
// gather results
(
  area['name:en'='Tajikistan'][admin_level=2][boundary=administrative]->.myarea;
way(area.myarea) ["highway"];
);
// print results
out body;
>;
out skel qt;
```

3) Get only some types of roads in a country. Change 'name:en' with you country name. Add or remove types in RED.

```
[out:json][timeout:25];
// gather results
(
   area['name:en'='Tajikistan'][admin_level=2][boundary=administrative]->.myarea;
way(area.myarea) ["highway"~"^(motorway|trunk|primary|secondary)$"];
);
out body;
>;
out skel qt;
```

3) Get Places for a country. Change 'name:en' with you country name.

```
[out:json][timeout:25];
(
 area['name:en'='Tajikistan'][admin_level=2][boundary=administrative]->.myarea;
node(area.myarea) ["place"];
);
out body;
>;
out skel qt;
```

8. ADDITIONAL TRAINING MATERIAL BASED ON QUESTIONS

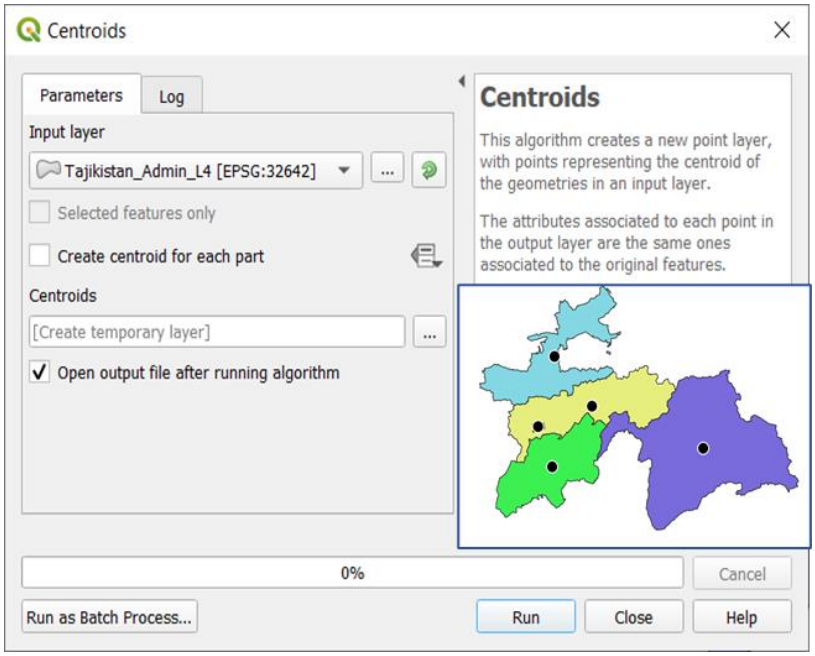
This material was prepared based on the questions from participants:

Is it possible to get polygon's latitude and longitude?

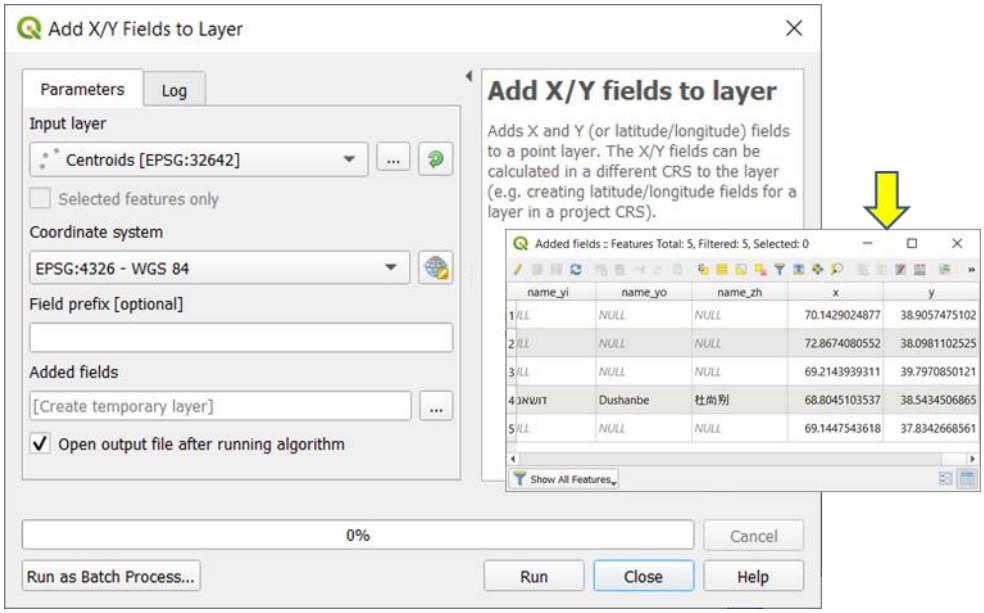
Also would be better to get list of latitude and longitudes of these borders

8.1 Getting the centroids and coordinates for a polygon.

To get the centroids you can use the tool called "Centroids"

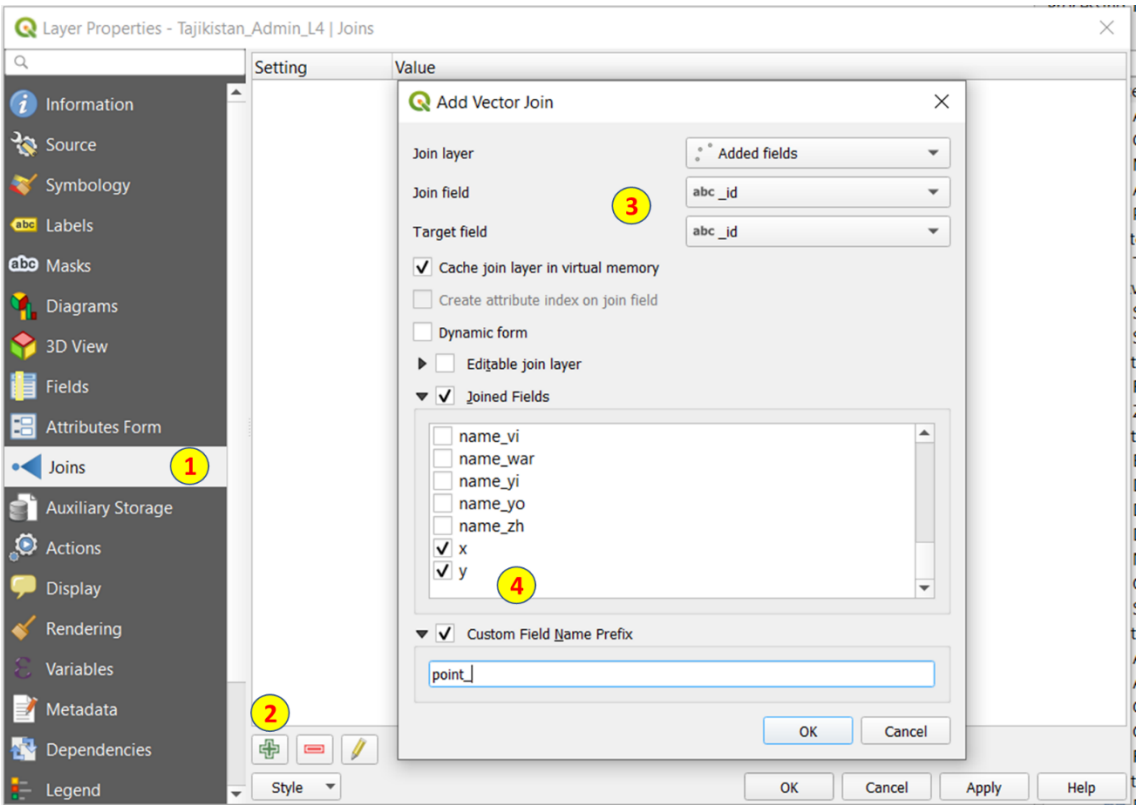


And to calculate the coordinates of each point you can use the tool



This will produce another Point Shapefile with additional columns for X and Y at the end. You can also choose the coordinate system for these columns, I normally use WGS84 for this one.

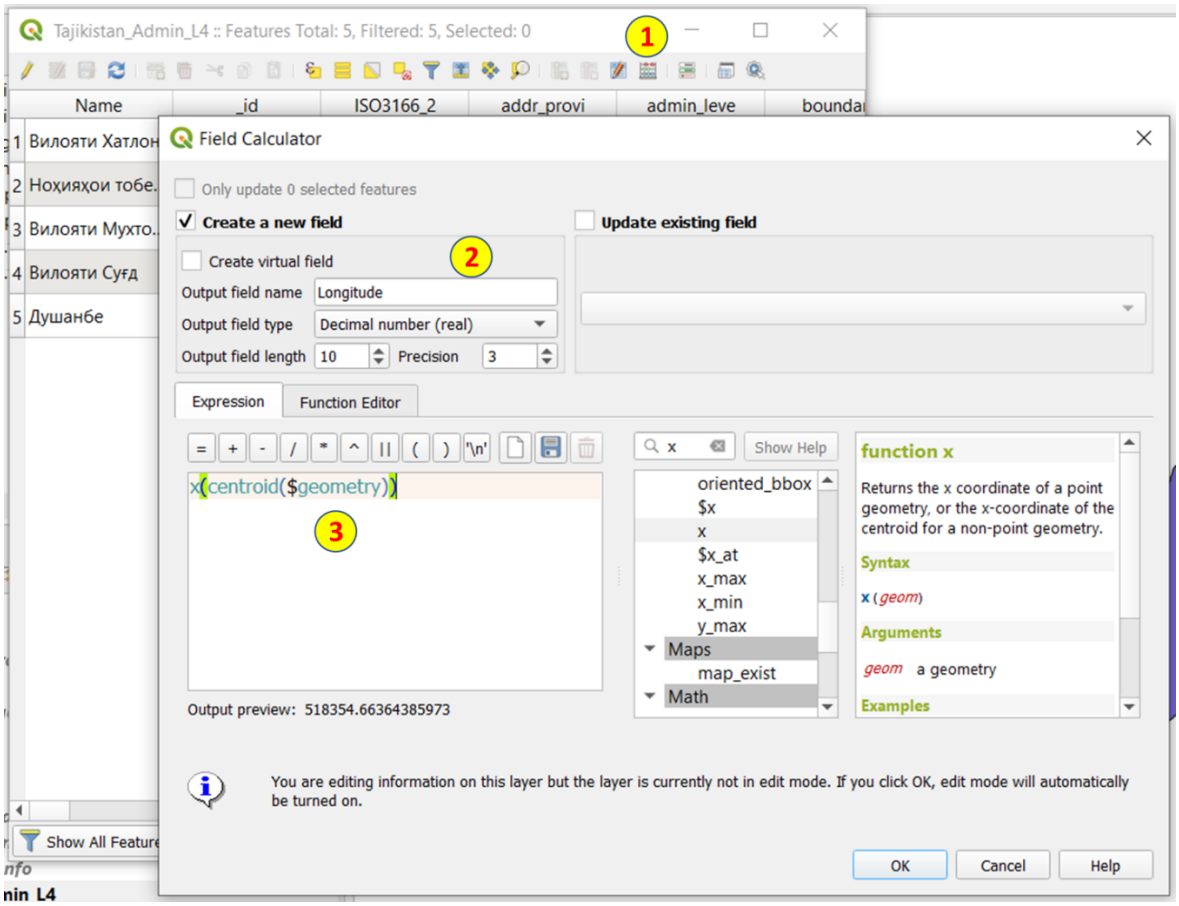
If you want you can add this information back into your polygon by making **Joins**:



Here you just go back to the polygon layer and in **Properties** -> **Joins (1)** you can click the **+ (2)** to add new information. Simply choose the Layer and the **Fields** for matching (3) then select what Fields you want to add to your polygon attributes **(4)** and the **Prefix** if you like.

Note: this Join is not changing your original Shp database, it only happens for this project. If you want to make it permanent you need to Export to a new Shp Layer.

Alternative: Also, you can add directly a new field to your original Layer by going to the attribute table and using the **Field Calculator… see next page:**



In the Context Menu, Open the attribute table and choose the Field Calculator (1), then you can decide Name and type of Data (2) and write the formula (3) in this case:

x(centroid($geometry)) → Meaning for every geometry take the centroid and get the x

x(centroid(transform($geometry,'EPSG:32642','EPSG:4326'))) →same but in WGS84 degree

$area → get the area of every geometry (in m2)

$area /1000000 → Same but in Km2

$perimeter → The perimeter of the geometry (in m)