1 Exercise 2: Enriching slum characterization with open data from other sources

1.1 Overall Objective

Exercise 2 explores ways of producing indicators and maps for characterizing slum-like areas using open data. This is an instructor-led exercise.

Based on a land-use layer and a population layer derived from satellite imagery on one hand, and on OpenStreetMap data on the other hand, you will characterize deprived areas according to the density of cultural amenities (i.e., in this case, libraries, schools and places of worship) per 10 000 inhabitants.

The same type of analysis can be replicated for producing indicators and maps relating to other thematics, such as WaSH (Water, Sanitation and Hygiene), healthcare, road networks etc.

1.2 Data

The datasets used in Exercise 2 cover a subset of the city of Dar es Salaam, Tanzania. Here are the layers that you will use (do not load them now in QGIS now; you will load them during the exercise):

a) A layer with a single polygon, representing the extent of the Area of Interest covered by this exercise (file name: **AOI_ex2.shp**).
b) A layer of polygons representing the land use in city blocks. This layer was produced semi-automatically with machine learning, based on very-high resolution satellite images (file name: **Landuse_ex2.shp**). [1]
c) A layer of polygons representing deprived areas extracted from the land use layer (**file name: Deprived_areas_ex2.shp**).
d) A layer of points representing the amenities, downloaded from OpenStreetMap (file name: **OSM_amenities_ex2.shp**). [2]
e) A raster layer (i.e., a matrix of pixels), where the value of each pixel is a population estimation. This layer was produced using a model that disaggregates coarser population data available at the administrative level, thanks to variables derived from remote sensing (file name: **Population_ex2.tif**). [3]

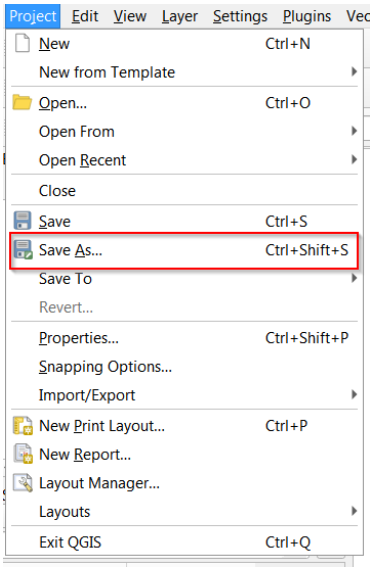
1.3 Software

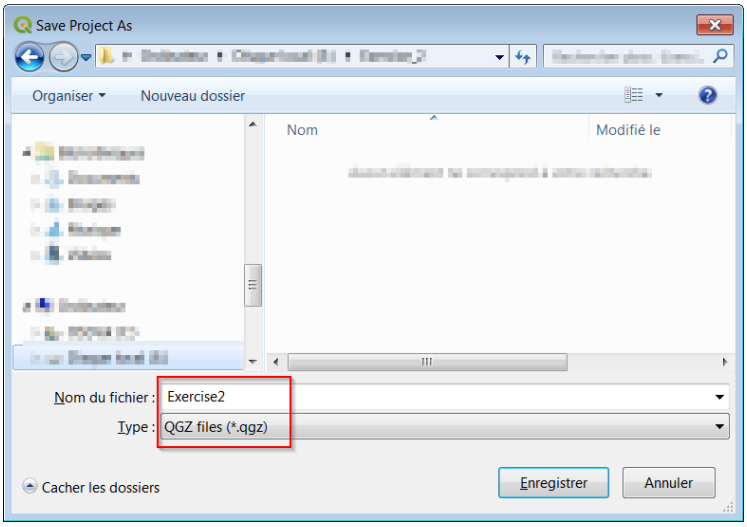
The software used in this exercise is QGIS 3.4 [4].

1.4 Methods

- **Open a new project**

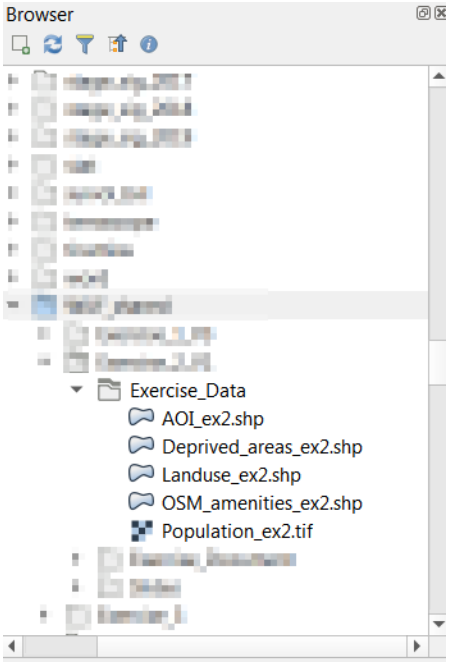
Open a new project (**MENU Project ► New**) and save it as a .qgz file in the folder that contains the material for Exercise 2 (**MENU Project ► Save As…**) (**…\Exercise_2\Exercise2.qgz**).

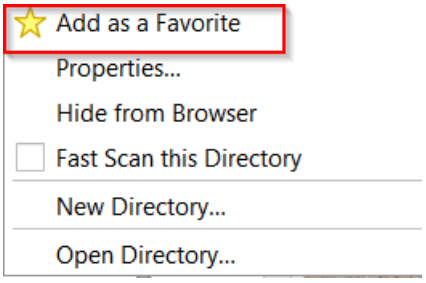




- **Add the folder containing the data as a favorite**

In the **Browser panel**, navigate to the folder containing the data for this exercise (**…\Exercise_2\Exercise_data**). Right click on that folder and select **Add as a favorite** from the drop down menu.

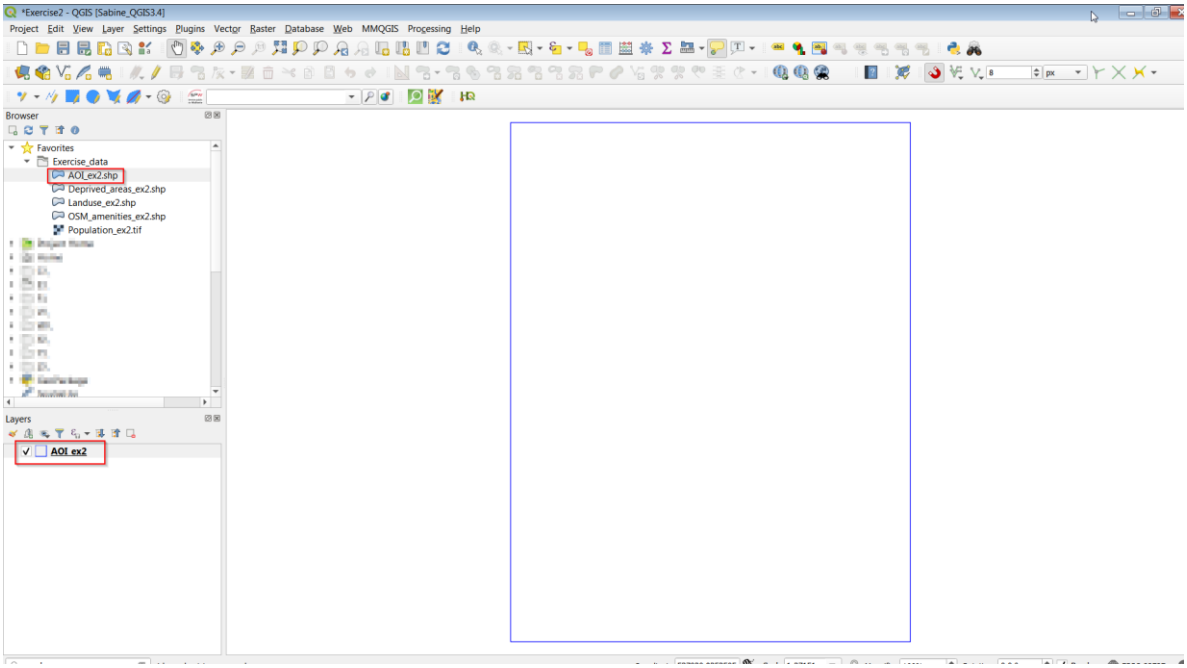




This will allow you to find the data more easily in the next steps, as the **Favorites** appear on top of the list of folders.

- **Add the area of interest**

In the **Browser panel**, select the layer **AOI_ex2.shp**. Drag and drop it on the **Canvas**. It should now be visible in the **Layers list** that shows all the layers loaded in the project.

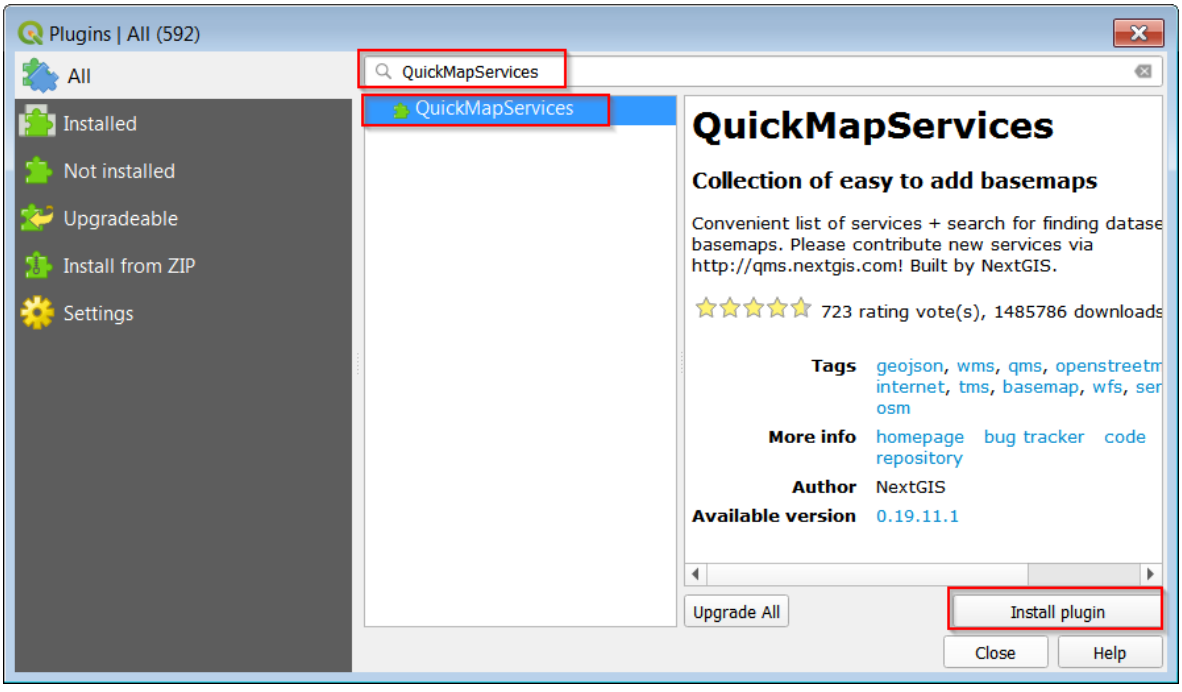


- **Display a basemap: 1/ Install the QuickMapServices plugin**

(Display a basemap only if you have an internet connection. If it is not the case, it is not a problem; the exercise will also work without displaying a basemap.)

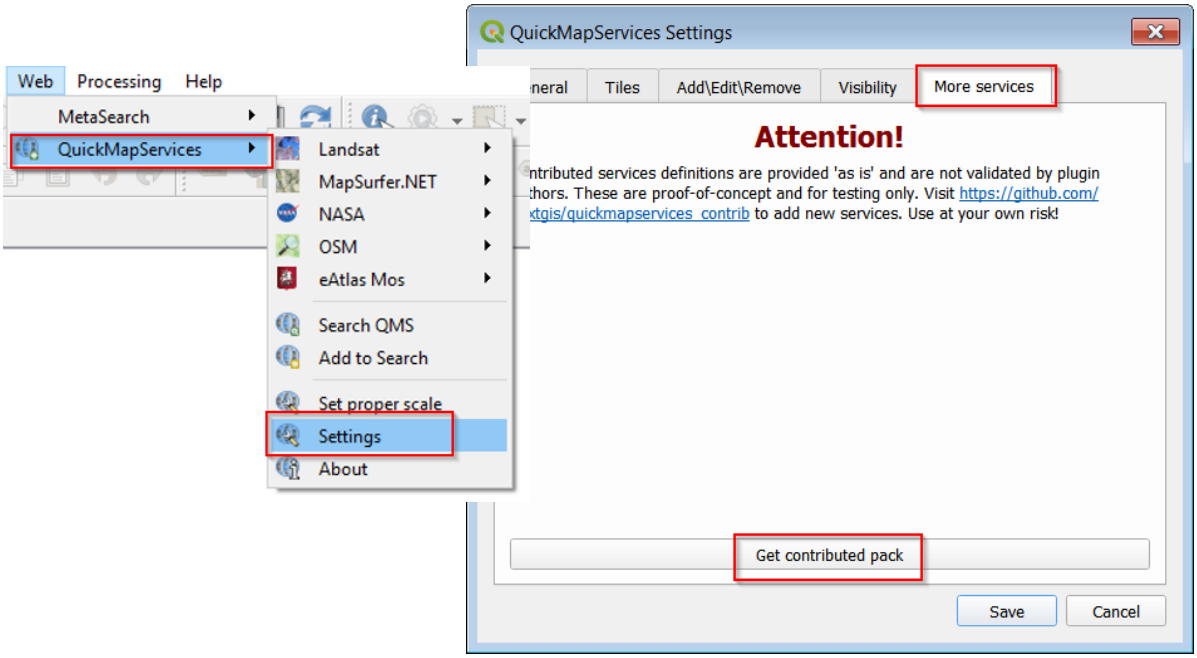
Install the QuickMapServices plugin: **MENU Plugins ► Manage and Install Plugins**

In the **Plugins window**, type '**QuickMapServices**' in the search bar. Click on '**QuickMapServices**' to select it and then click on **Install Plugin.** Once done, close the **Plugins window**.



- **Display a basemap: 2/ Add contributed pack to QuickMapServices**

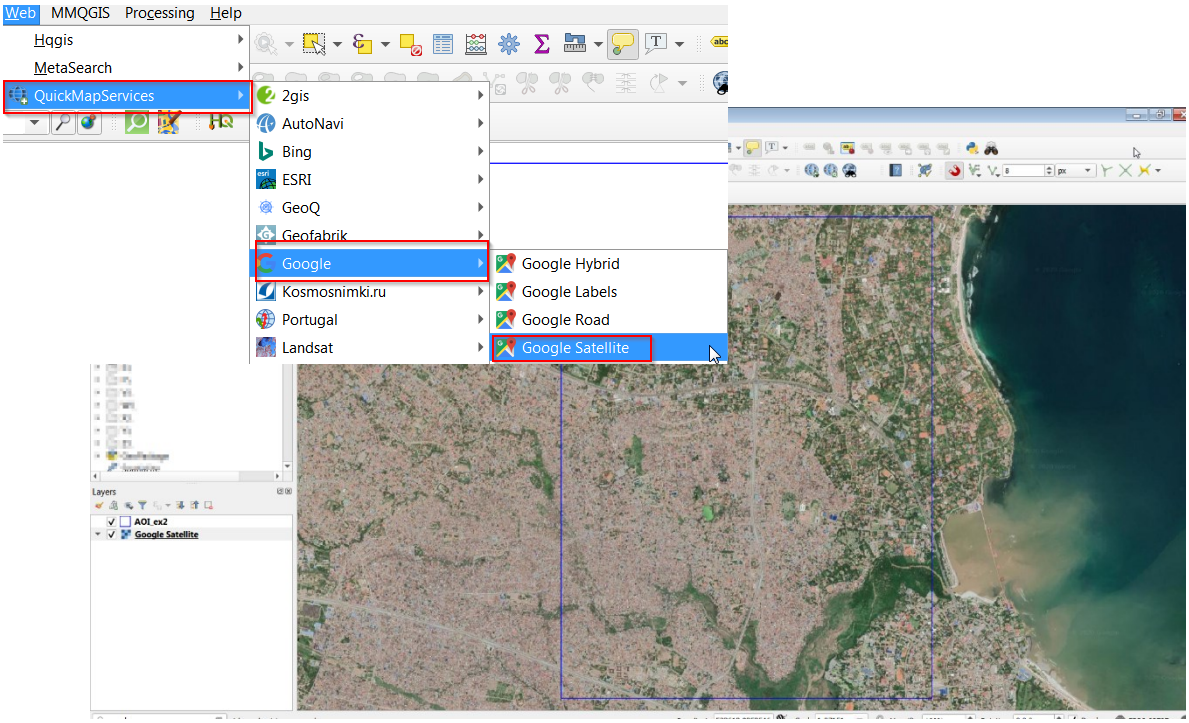
Click on **MENU Web ► QuickMapServices► Settings**
In the **QuickMapServices Settings window**, select the **More services** tab and click on **Get contributed pack.**



In the window that pops up ('Last version of contrib pack was downloaded!'), click **OK**. Click **Save** to close the **QuickMapServices Settings window.**

- **Display a basemap: 3/ Add satellite imagery as a basemap**

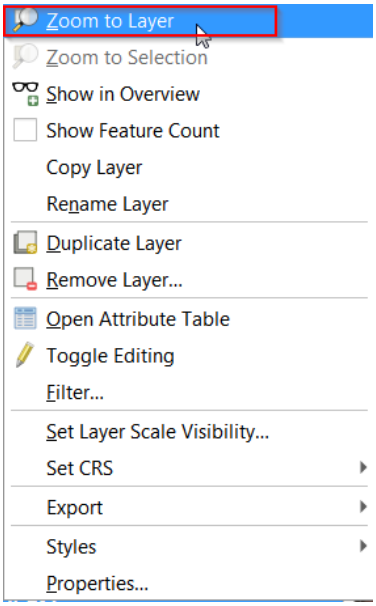
Add satellite imagery as a basemap (**MENU Web ► QuickMapServices ► Google ► Google Satellite**).



- **Explore the area of interest**

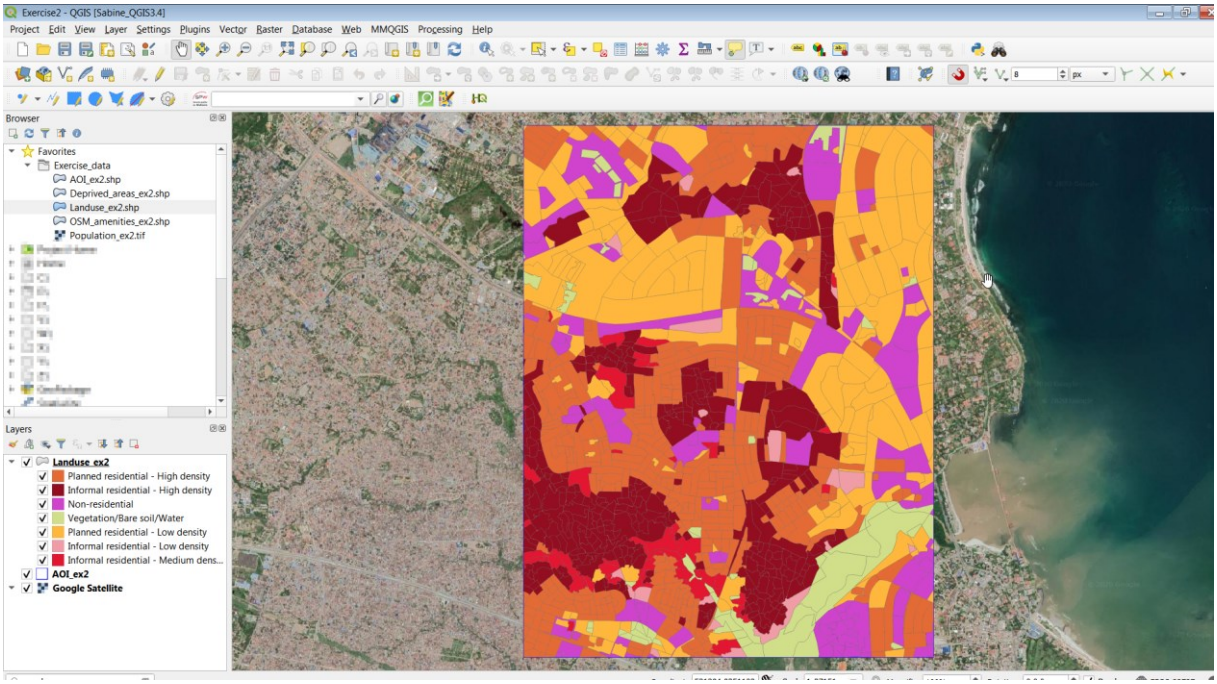
Zoom in and out  , and pan  to explore the area.

Next, display the full area of interest again: right click on **AOI_ex2** in the **Layers list** and select **Zoom to layer** in the drop down menu.



- **Add the land use layer**

In the **Browser panel**, select the layer **Landuse_ex2.shp**. Drag and drop it on the **Canvas**.

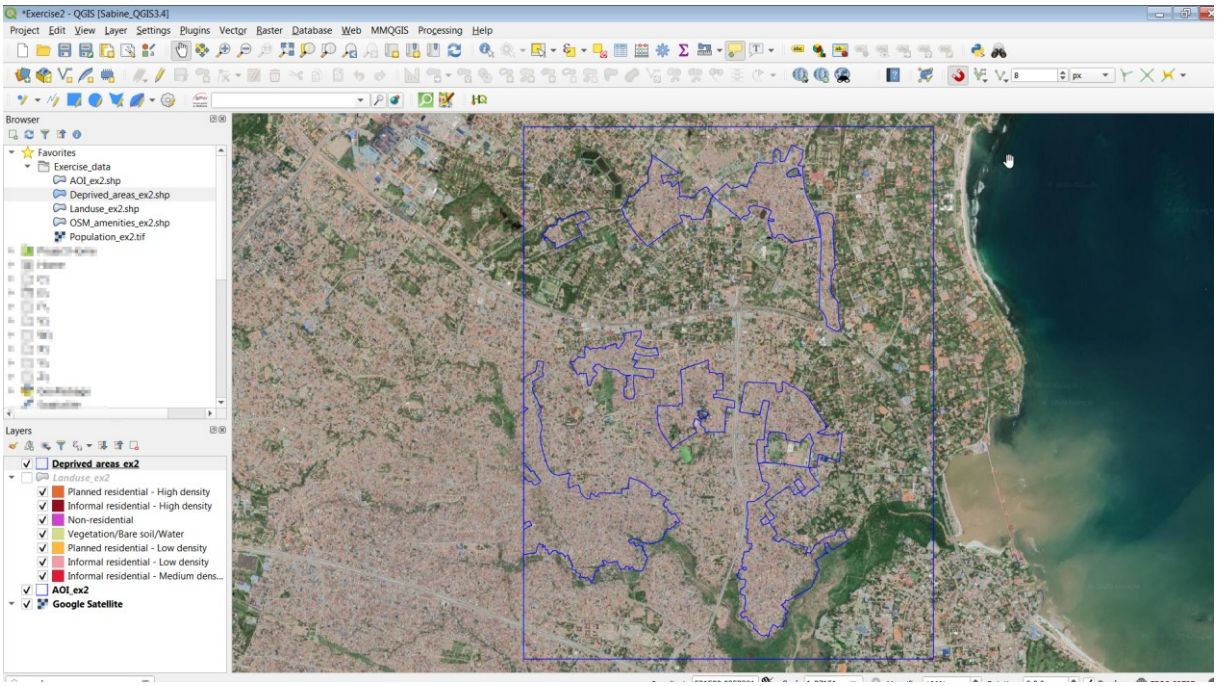


In the **Layers list,** you can see that the city blocks are classified into seven land-use classes, among which the class 'Informal residential – High density'.

- **Add the deprived area layer**

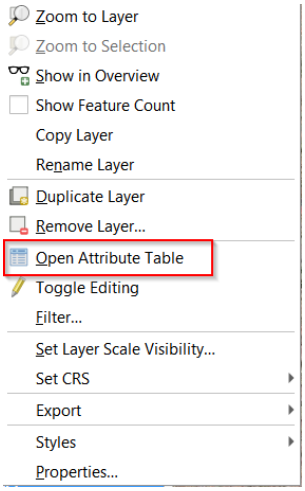
In the **Browser panel**, select the layer **Deprived_areas_ex2.shp**. Drag and drop it on the **Canvas**.

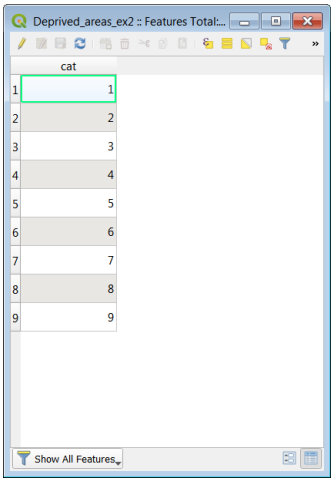
In the **Layers list,** uncheck the **Landuse_ex2** layer so that it is no longer displayed in the canvas. The nine polygons representing deprived areas were extracted from the land use layer, as a selection of city block classified as 'Informal residential – High density'.



- **View the attribute table of the deprived area layer**

In the **Layers list,** right click on **Deprived_areas_ex2** and select **Open Attribute Table** from the drop-down menu to see what it contains.

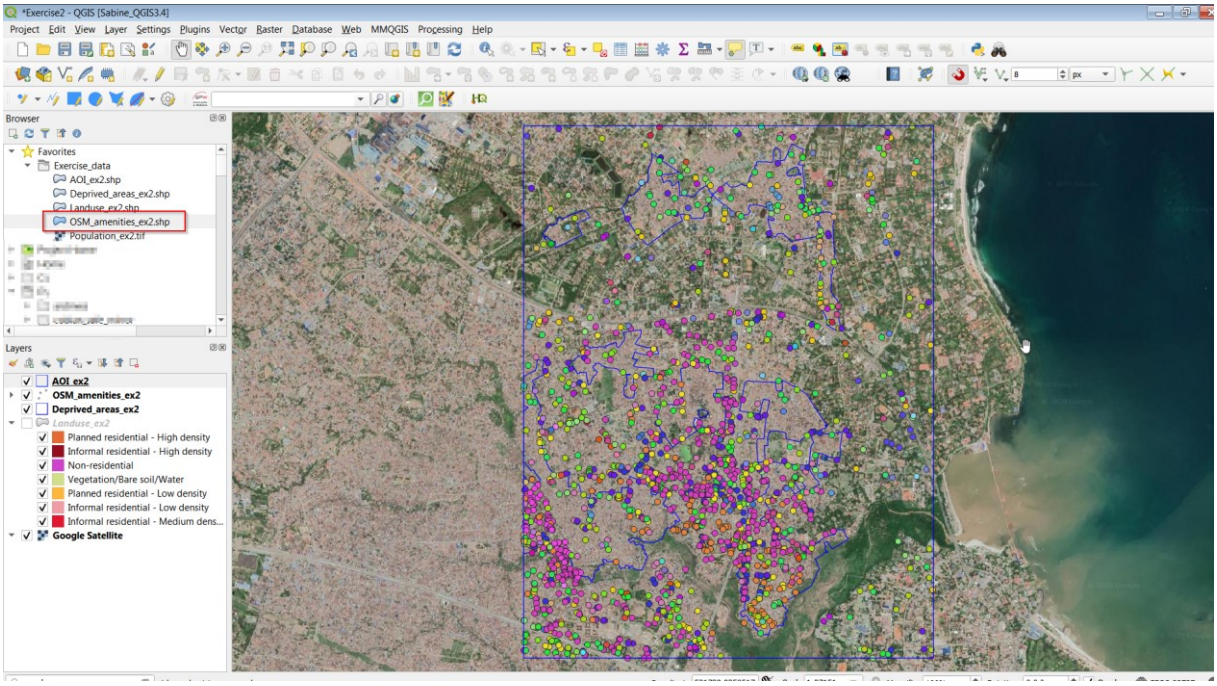




Each line in the table corresponds to a polygon. There is only one field (i.e., one column) in the table (named 'cat'), and it contains sequential numbers that identify the polygons. You can sort the values in ascending/descending order by clicking on 'cat'.
Close the attribute table.

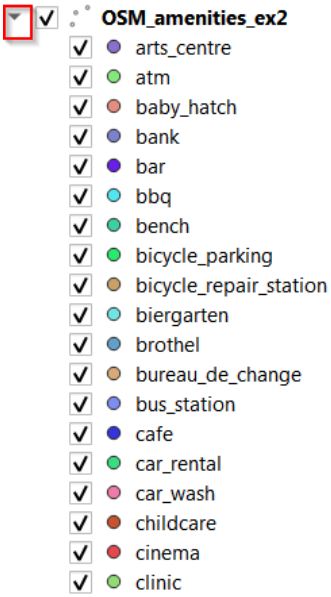
- **Add the OSM amenities layer**

In the **Browser panel**, select the layer **OSM_amenities_ex2.shp**. Drag and drop it on the canvas. This layer was extracted from OSM data that are free and available online.



- **View the point labels**

In the **Layers list,** click on the arrow next to the layer name **OSM_amenities_ex2** to expand the list of labels (or 'classes', or 'tags'). They are listed in alphabetical order.



Among them, the labels 'library', 'school' and 'place_of_worship' will be useful for mapping cultural amenities of deprived areas in the next steps.

Click on the arrow again to collapse the list.

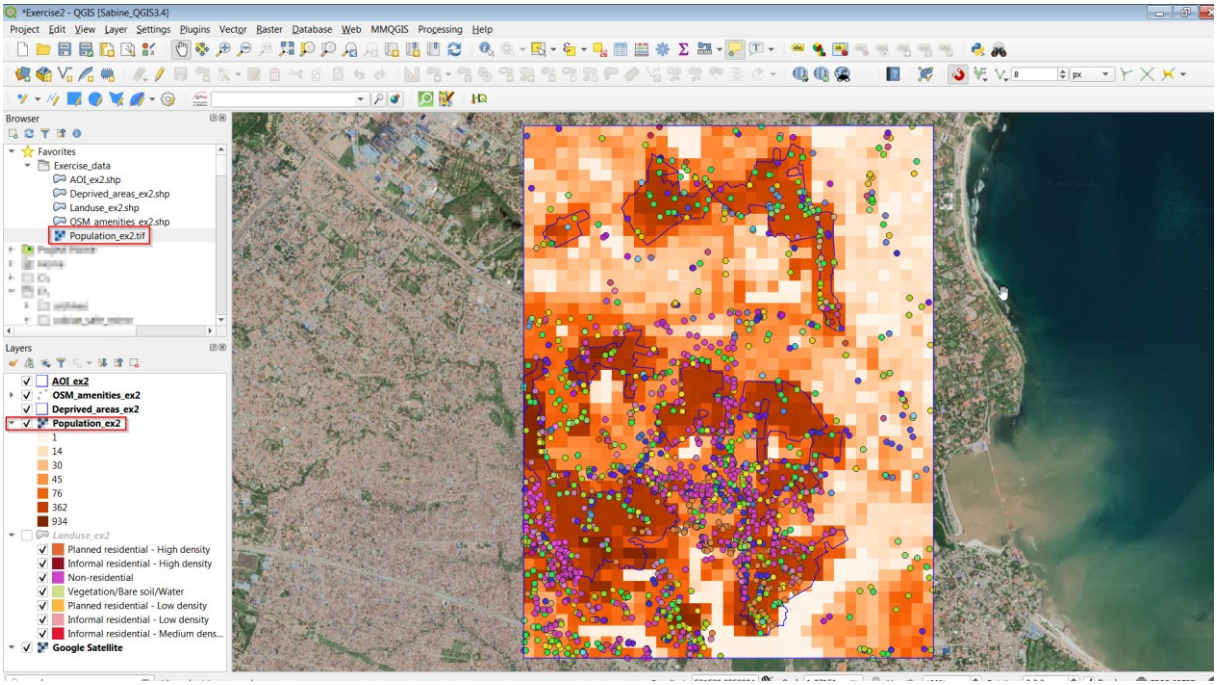
- **Add the population layer**

In the **Browser panel**, select the layer **Population_ex2.tif**. Drag and drop it on the **Canvas**. Unlike the other layers that we have used up to now, the population layer is a raster, i.e., a layer of pixels. Each pixel represents an area of 100m*100m on the ground. The pixel value is an estimation of the population living in this area.

The order of the layers in the **Layers list** controls the order in which they are displayed in the **Canvas**.

In the **Layers list**, click on the layer **Population_ex2**, and drag and drop it below the layer **Deprived_areas_ex2**. Now you can see the polygons and the points again in the **Canvas**, they are no longer hidden by the population layer.

You can see that the population value is high in deprived areas.

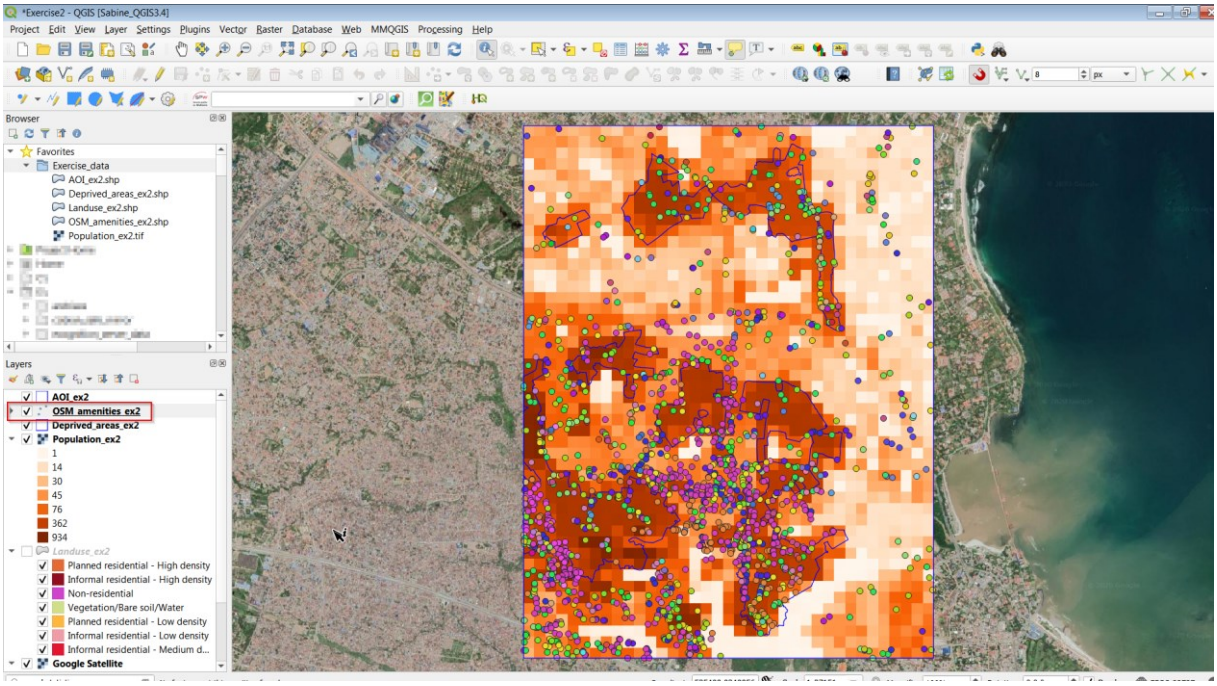


Save the project (**MENU Project ► Save** or click on this icon).

Now that you have added all the layers to the project, you can proceed with the analysis.

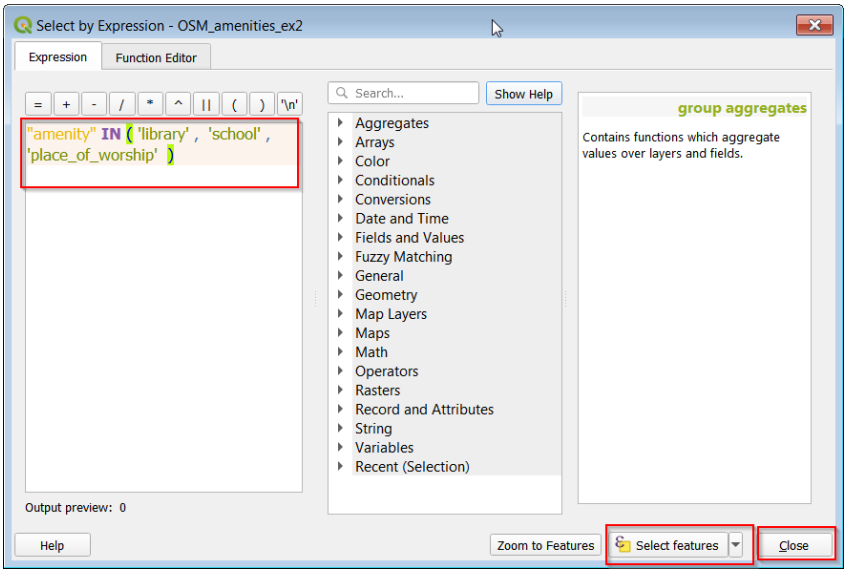
- **Select the relevant OSM amenities**

In the **Layers list,** click on **OSM_amenities_ex2** to select this layer. You will know that a layer is selected when it is highlighted (in blue or grey).



In the **Locator bar** (the 'search bar', at the bottom left of the interface), type **'Select by expression' (Enter)** to open the 'Select by expression' window.

In this window, type or copy-paste the following expression:
"amenity" IN ('library' , 'school' , 'place_of_worship')
Click on **Select features** and then on **Close**.

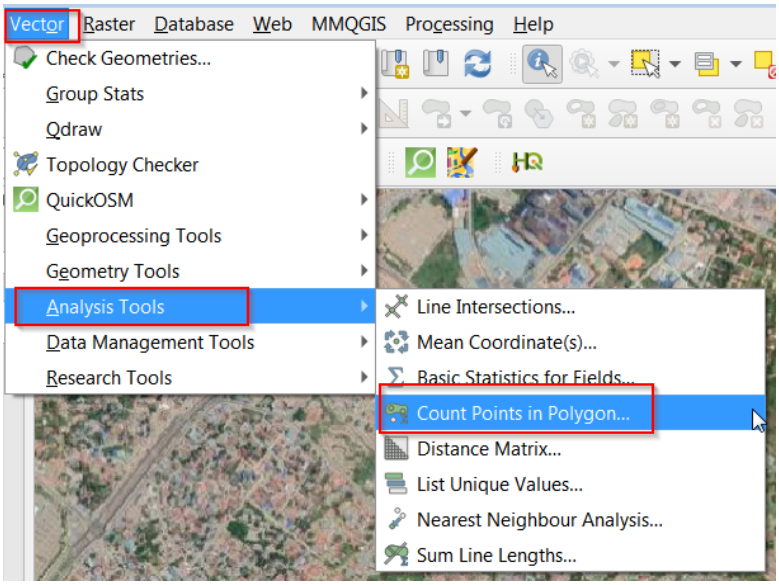


Doing this, you selected the points representing cultural amenities (libraries, schools and places of worship), and these should now be highlighted in bright yellow in the **Canvas**.

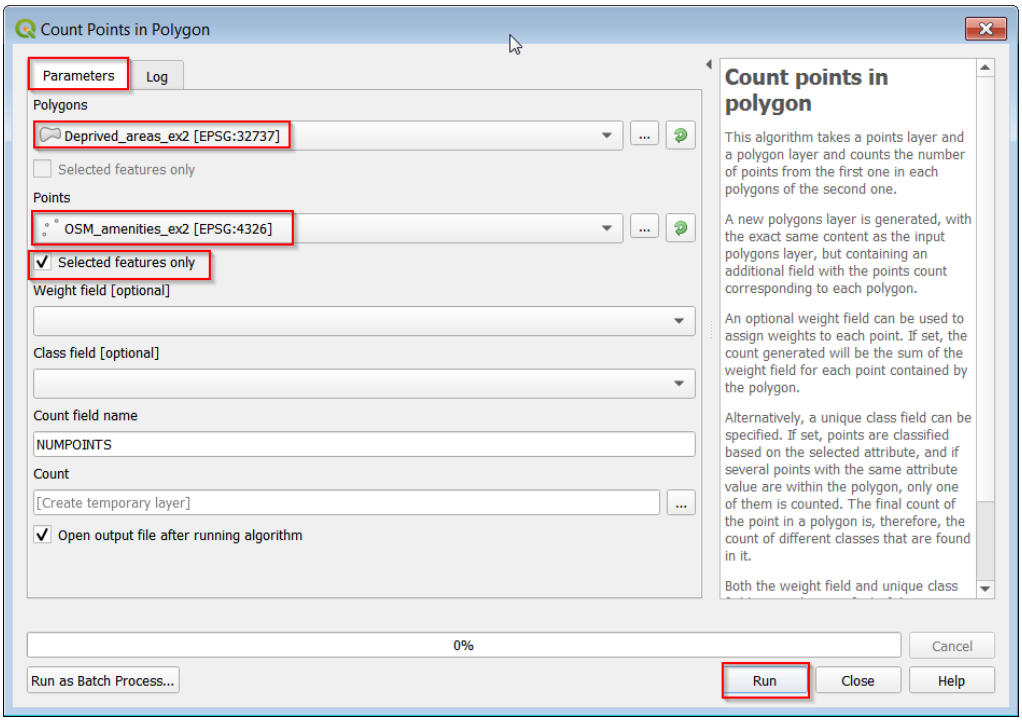
- **Let QGIS count the selected points in the deprived areas**

Among the points representing libraries, schools and places of worship that you have just selected, let QGIS count those that fall within the deprived areas:

MENU Vector ► Analysis Tools ► Count Points in Polygon…



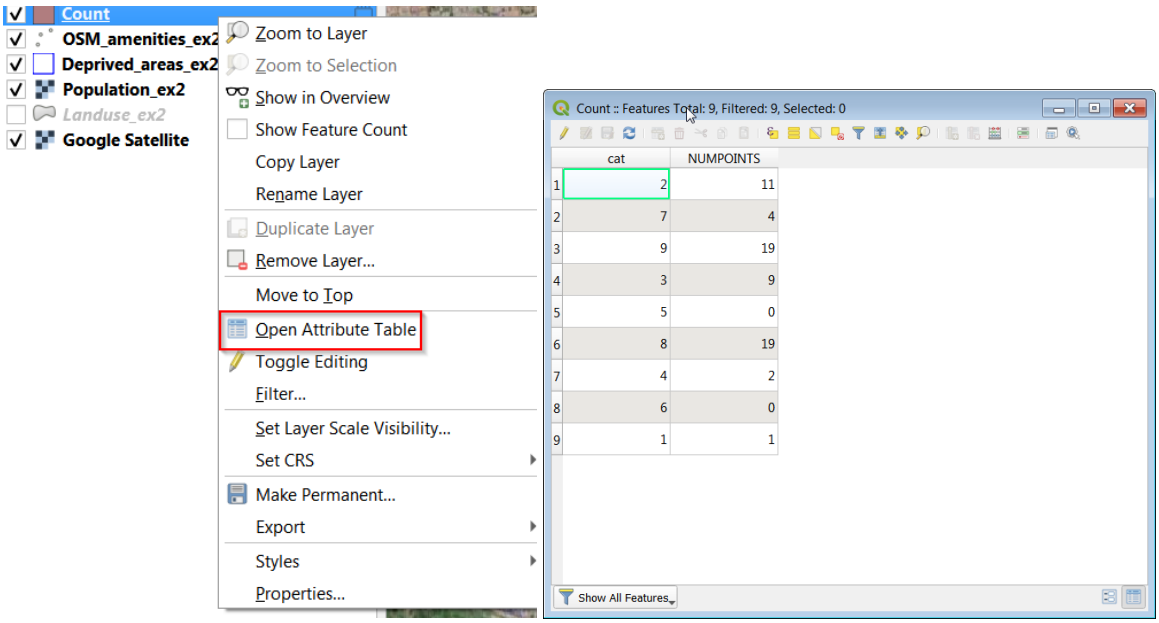
Fill out the fields in the **Count points in polygon** window as follows (do not forget to check the box **Selected features only**):



Click **Run** to generate a new polygon layer (named '**Count**' by default) with the same content as the input polygon layer (deprived areas), but with an additional field containing the points count. Close the window.

- **Open the attribute table of the new 'Count' layer**

In the **Layers** window**,** right click on **Count** and select **Open Attribute Table** from the drop-down menu to check that a column containing the number of points count was added ('NUMPOINTS').



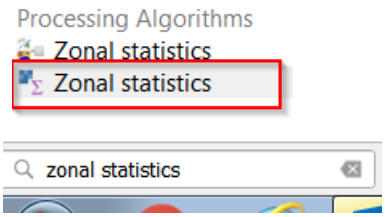
Close the attribute table.

- **Calculate the population living in each deprived area**

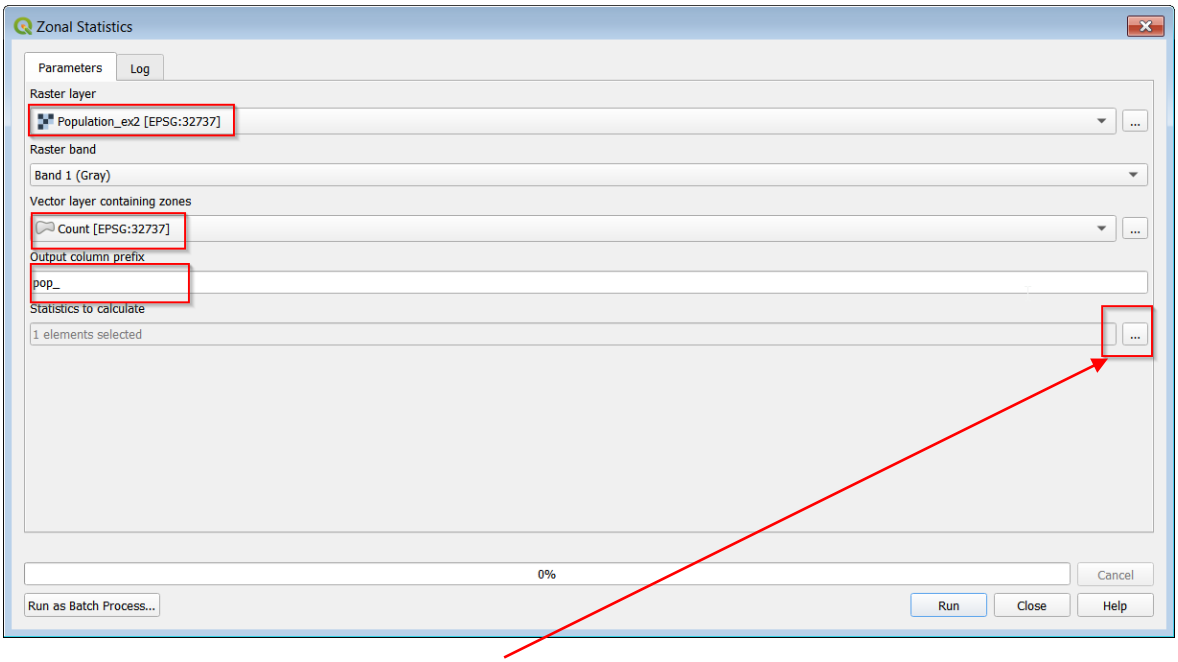
You could produce a map showing the number of libraries, schools and places of worship per deprived area. However, this would be 'unfair' to areas with a smaller population. Therefore, you are going to map their density per 10 000 inhabitants, rather than their absolute count.

The first step is to calculate the population living in each deprived area. You are going to sum the values of the pixels of the population layer that fall within each deprived area.

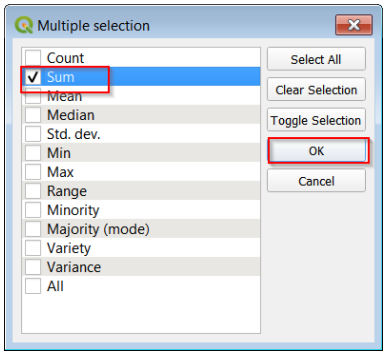
In the **Locator bar** (bottom left of the interface), type **'zonal statistics' (Enter)** and select the **Zonal statistics** algorithm (with the Σ symbol) from the list of processing algorithms.



Fill out the fields in the **Zonal statistics** window as follows :

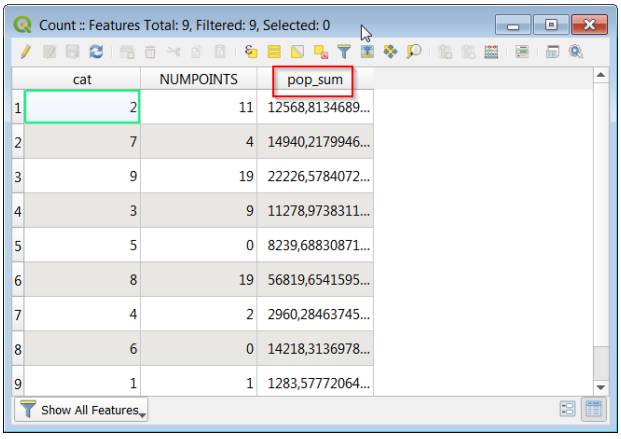


Under **Statistics to calculate**, click on **…** to open the **Multiple selection** window and uncheck **Count** and **Mean** to keep only **Sum**.:



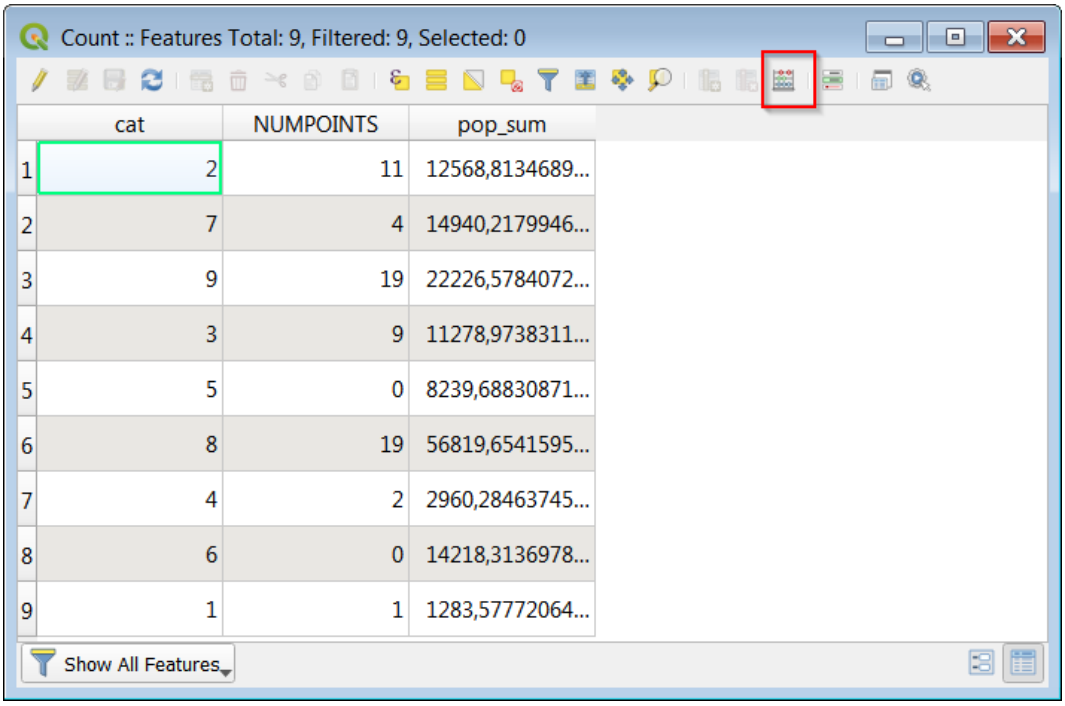
Click OK to close the **Multiple selection** window and then Run the algorithm (**Run** button). Close the **Zonal statistics** window.

In the **Layers list,** right click on **Count** and select **Open Attribute Table** from the drop-down menu to check that a column containing the population figures (pop_sum) was added.

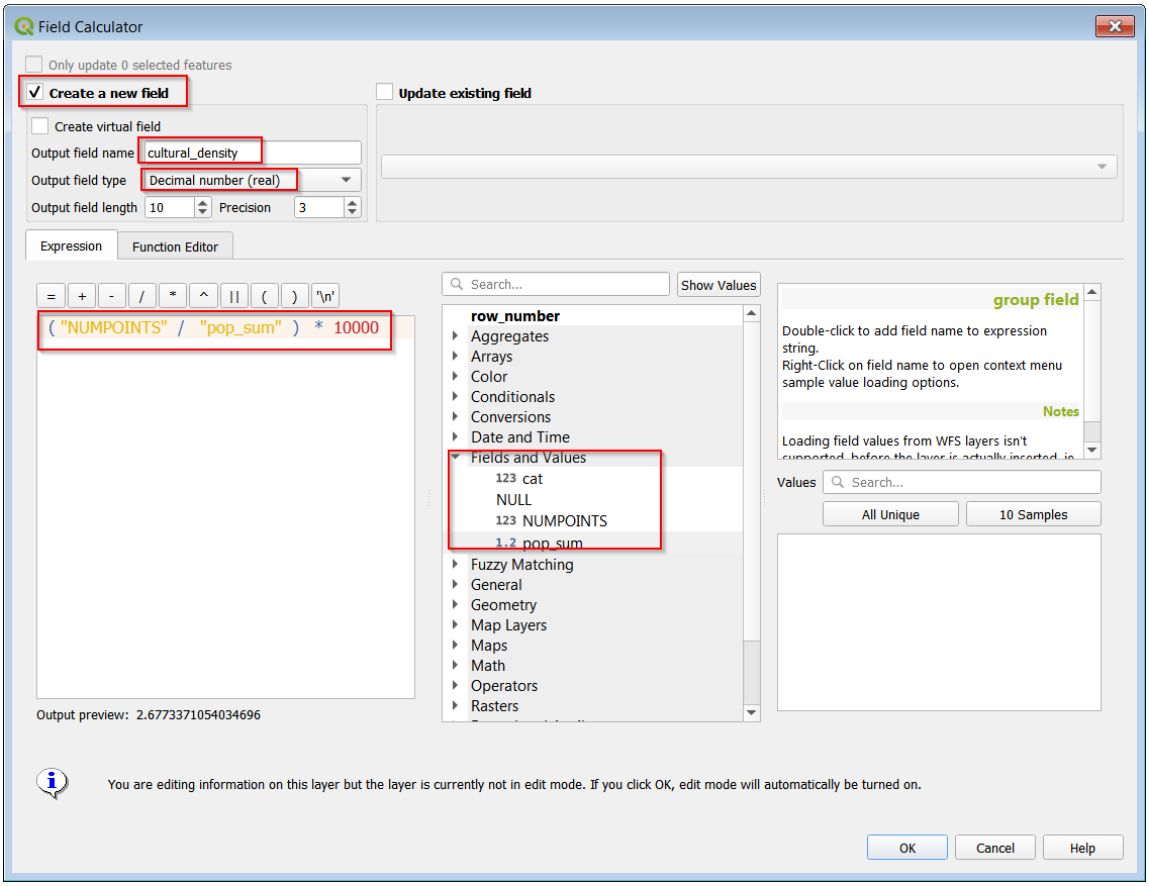


- **Calculate the density of cultural amenities per 10 000 inhabitants**

With the attribute table still open, open the **Field calculator** (the abacus icon).

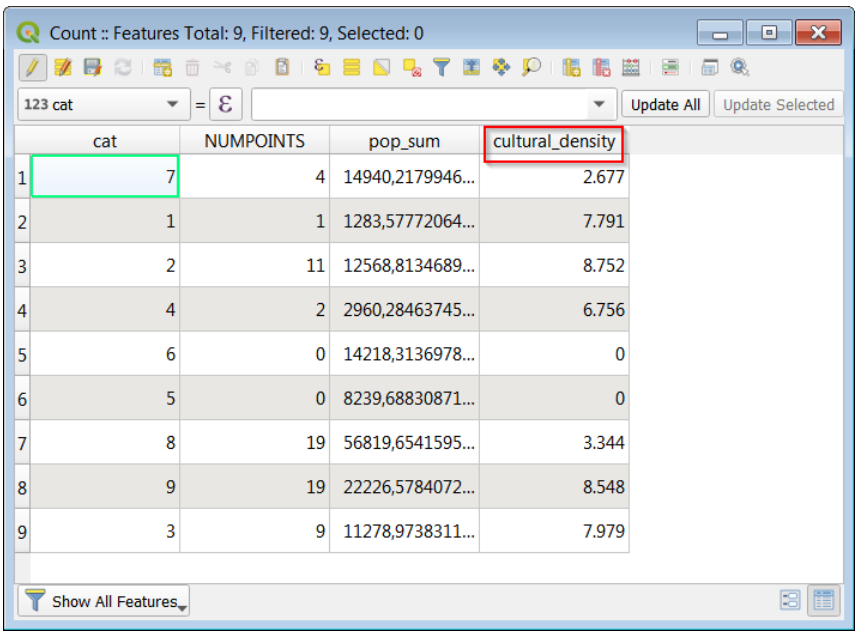


Fill out the fields in the **Field calculator** window as follows – you can use the **Fields and Values** to help you build the expression, or you can simply type it:
("NUMPOINTS" / "pop_sum") * 10000 . Click on **OK** to run the algorithm.



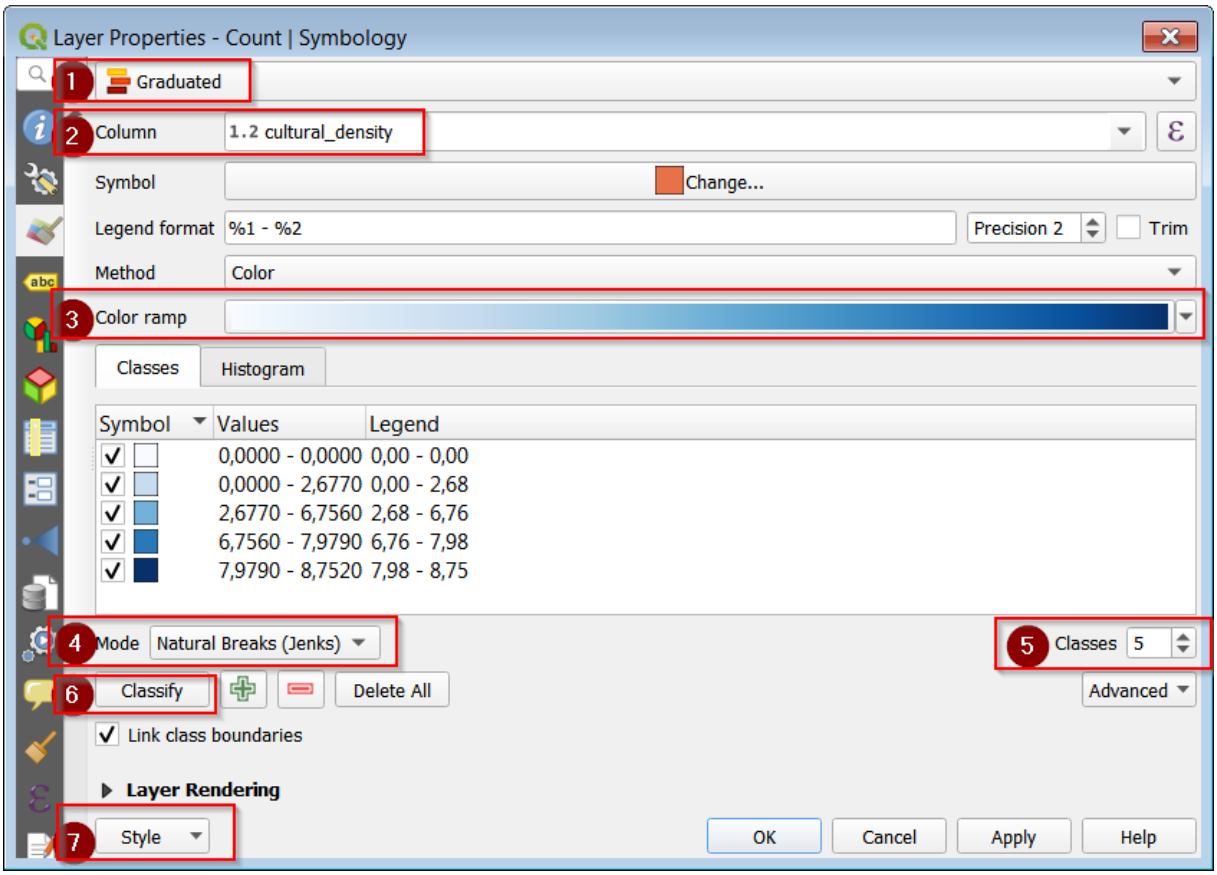
- **Map the density of cultural amenities per 10 000 inhabitants**

In the attribute table, a column was added with the density of cultural amenities, per 10 000 inhabitants. We will use it to produce a map with 5 classes of density.

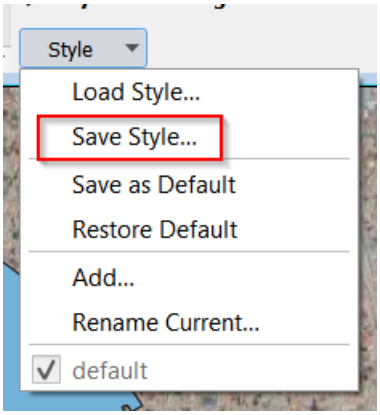


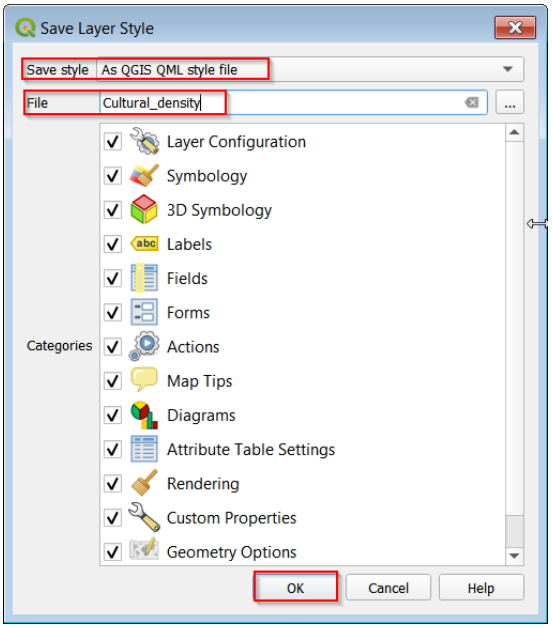
	cat	NUMPOINTS	pop_sum	cultural_density
1	7	4	14940,2179946...	2.677
2	1	1	1283,57772064...	7.791
3	2	11	12568,8134689...	8.752
4	4	2	2960,28463745...	6.756
5	6	0	14218,3136978...	0
6	5	0	8239,68830871...	0
7	8	19	56819,6541595...	3.344
8	9	19	22226,5784072...	8.548
9	3	9	11278,9738311...	7.979

Close the attribute table. In the **Layers** list**,** right click on **Count** and select **Properties…** from the drop-down menu. Open the **Symbology** tab and select the following options (note that the classes will only be displayed once you have clicked on **Classify**):

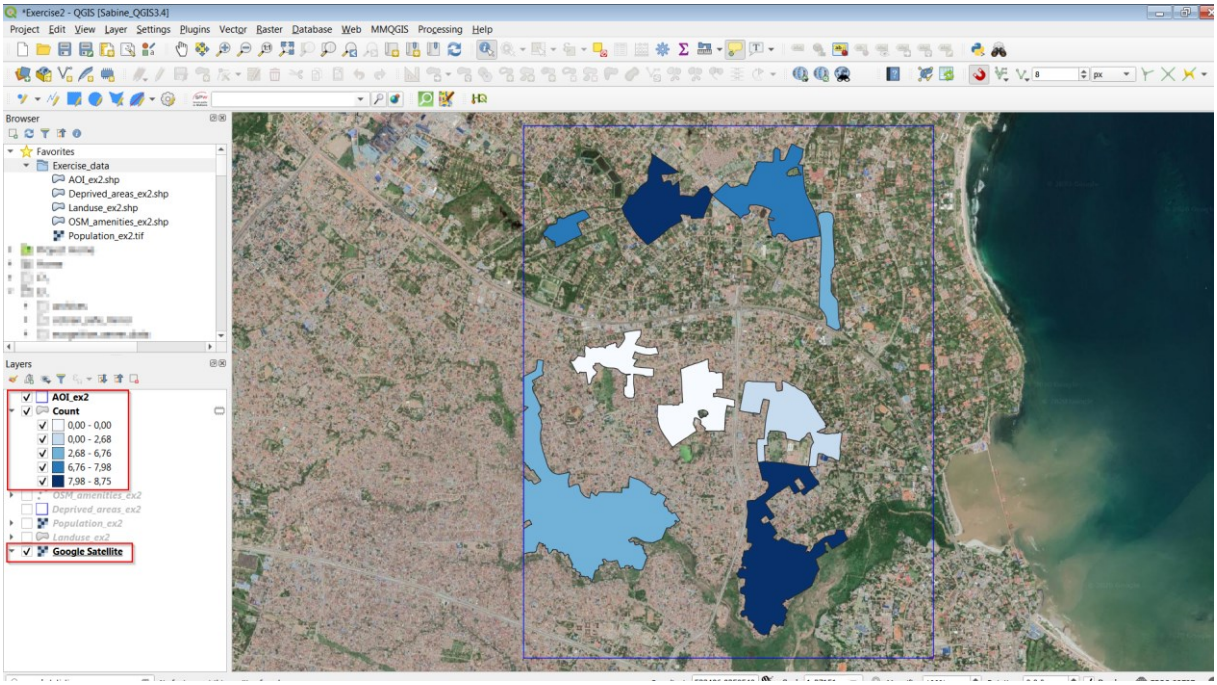


From the **Style** drop down menu, select **Save Style…** to save the symbology of this layer (i.e., the classes, colours…) as a .qml style file, in the folder where the data are stored. This will allow you to use it in other QGIS projects if needed. Name the file **Cultural_density**.





In the **Layers** list**,** check the layers that you want to display, e.g.:

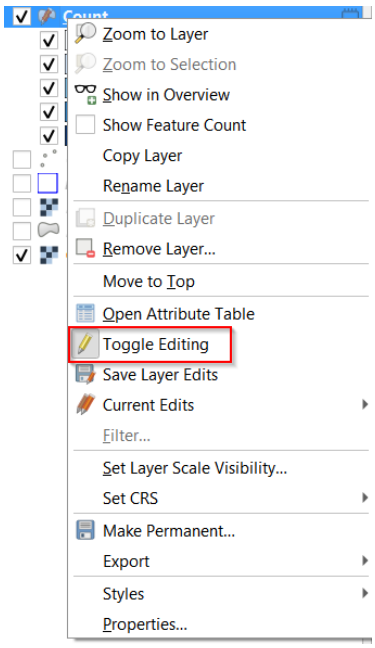


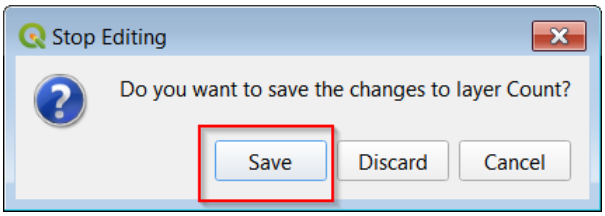
Note: You can view information on a feature (e.g., a polygon) by selecting the relevant layer in the **Layers list,** clicking on the **Identify features** icon  and then on a feature.

Once done, click on the Pan icon again  .

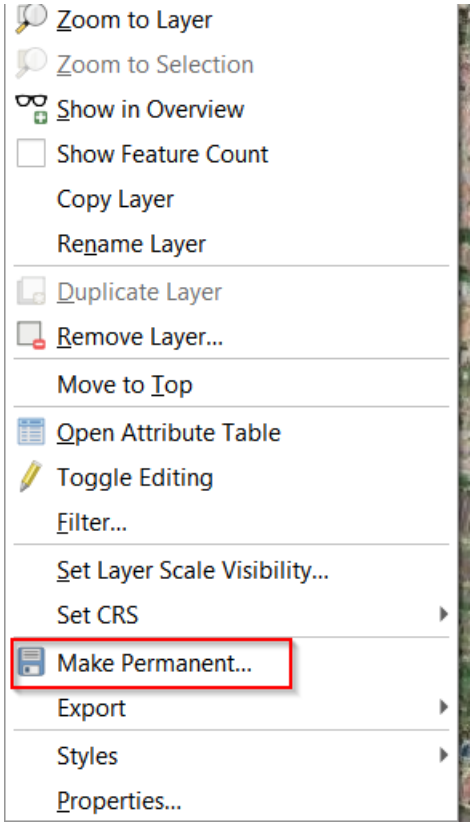
- **Save the Count layer**

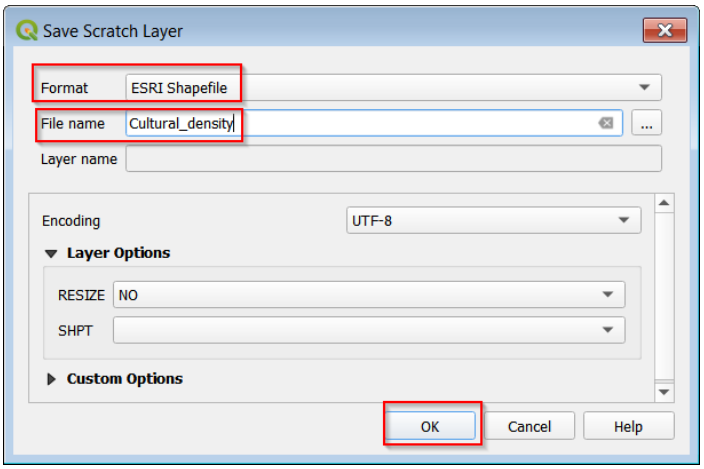
In the **Layers list**, right click on the **Count** layer and click on **Toggle Editing** to close the editing mode and save your edits.





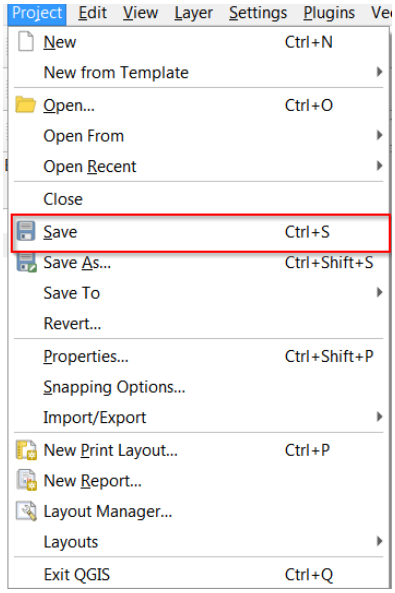
Right click on the **Count** layer again, and click on **Make permanent** to save the layer. Select the **ESRI_Shapefile** format, and name the file **Cultural_density**. Click on **OK**.





- **Save the QGIS project**

Save the project (**MENU Project ► Save**)



You have completed Exercise 2. Well done!

1.5 Conclusion

Using boundaries of slum-like areas extracted from a land-use map derived from satellite imagery, along with other open data, simple analyses in QGIS allow users to calculate indicators and produce maps. Such output may be very useful, e.g., for stakeholders, decision-makers and community members.

The limit is data availability.

The layers that are being produced from satellite imagery in the MAUPP, REACT and SLUMAP research projects are made available as open data.

Besides, OSM is constantly expanding thanks to input from its contributors. You can become a contributor yourself. Check this link for more information on how to contribute: https://wiki.openstreetmap.org/wiki/How_to_contribute.

1.6 References

[1] The **land-use** layer of Dar es Salaam will be made available online in the next months. In the meantime, it is available upon request from ULB/DGES/ANAGEO (contact: Stefanos Georganos email: sgeorgan@ulb.ac.be).

[2] OpenStreetMap (OSM) **amenities** can be downloaded with the QGIS plugin QuickOSM. Alternatively, use http://download.geofabrik.de/ for downloading the full OSM dataset for a country.

[3] The **population** layer on of Dar es Salaam at a resolution of 100 m will be made available online in the next months. In the meantime, it is available upon request from ULB/DGES/ANAGEO (contact: Stefanos Georganos email: sgeorgan@ulb.ac.be).

[4] https://docs.qgis.org/3.4/en/docs/