1 Exercise 3

Overall Objectives:

To determine the ratio of the slum population that is at risk from flooding in Dakar, Senegal.

1. Background

This is an instructor led exercise that explores the concept of population at risk of flooding. Flooding is a complex phenomenon with many variables to be considered, but in this exercise, we restrict our focus on the contribution of elevation to flood risk. Essentially, we make use of a digital elevation model obtained from SRTM that has a spatial resolution of 30m. A mask is created on the digital elevation model whereby areas that have an elevation of less than 10 meters are considered to have high susceptibility of flooding. Next, the number of people living in deprived areas that are within the flood risk areas are determined. Similarly, the total population of deprived areas is extracted. Finally, the proportion of population living in deprived areas and at risk of flooding is computed for each department.

1.2 Data

The data used for this exercise are:

a) Digital Elevation Model (file name: **Elevation.tif**) [1]
b) Deprived areas derived from a land-use map at the street block level (**file name: Deprived_areas.tif**) [2]
c) An administrative disaggregation of Dakar (file name: **Departments.shp**) [3]
d) Population data in raster format (file name: **Population.tif**) [4]

1.3 Software

The software used in this exercise is QGIS 3.4 [3].

1.4 Methods

1.4.1 Importing and Visualizing Elevation Data

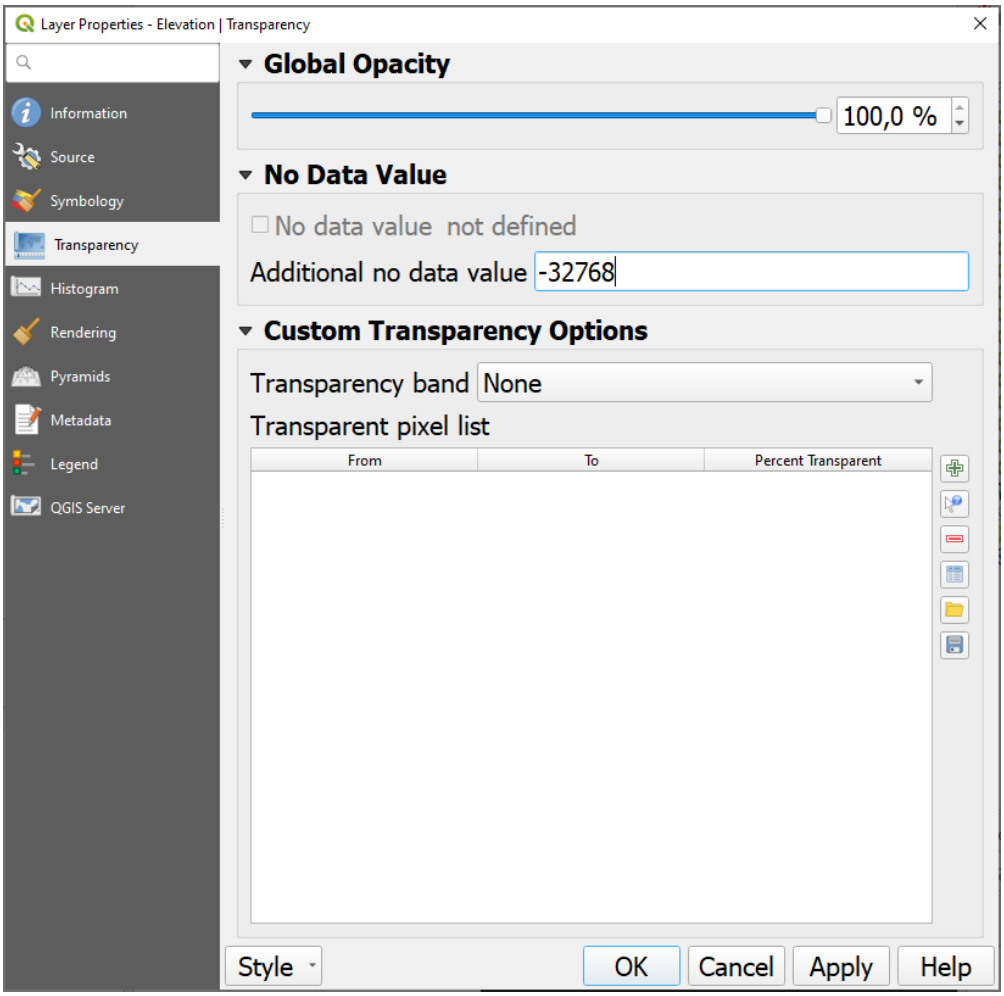
First, launch QGIS 3.4 and navigate to the folder containing data for the exercise (…../Exercise_3/Exercise_Data) and import the '**Elevation.tif' l**ayer.

Browser ► Navigate to the exercise files ► Right click on the 'Elevation' file ► Add Layer to Canvas

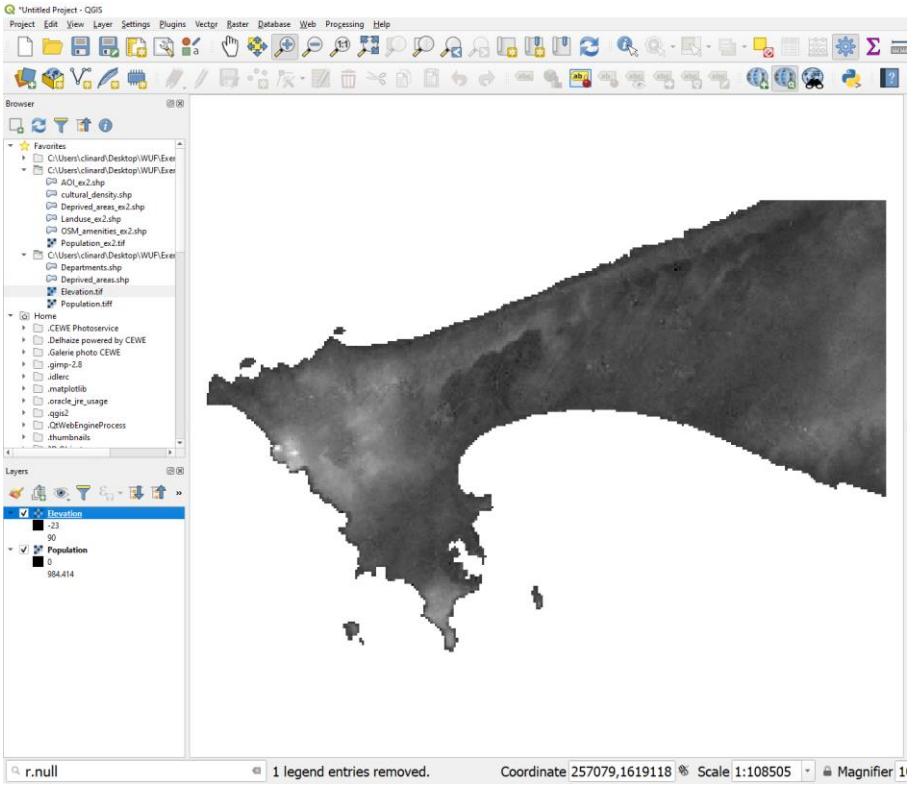
Alternatively, to import it, you may a) double click on the file or b) by a 'drag and drop' fashion.

In order to better visualize the elevation layer, it is useful to assign “NoData” values to the background pixels. This step is useful because background pixels will then be ignored in calculations. An easy way of doing it is to specify the NoData values in “Layer Properties-Transparency”.

Right click on Elevation layer► Properties ► Transparency tab



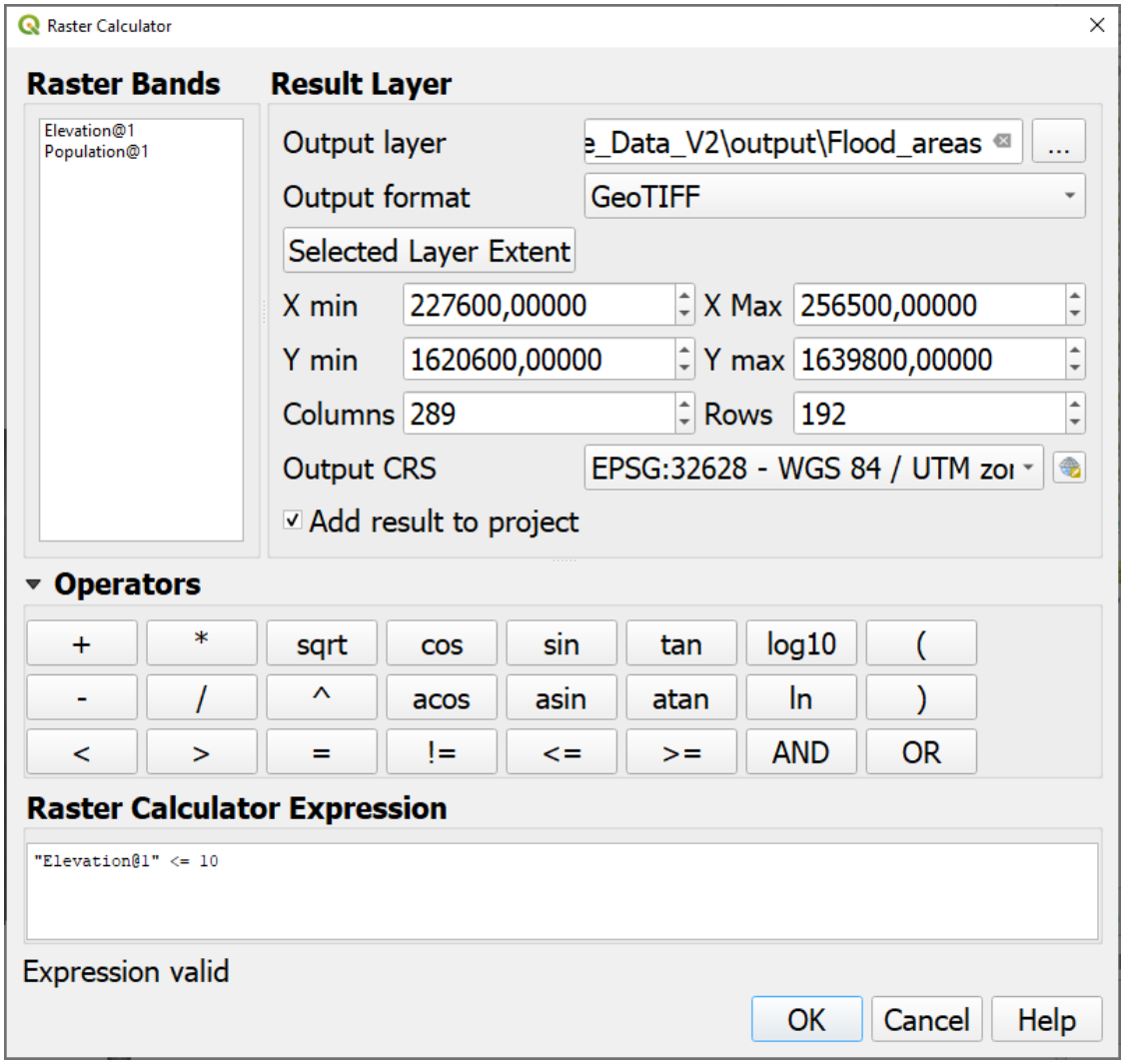
Now you can better visualize the topography of Dakar:



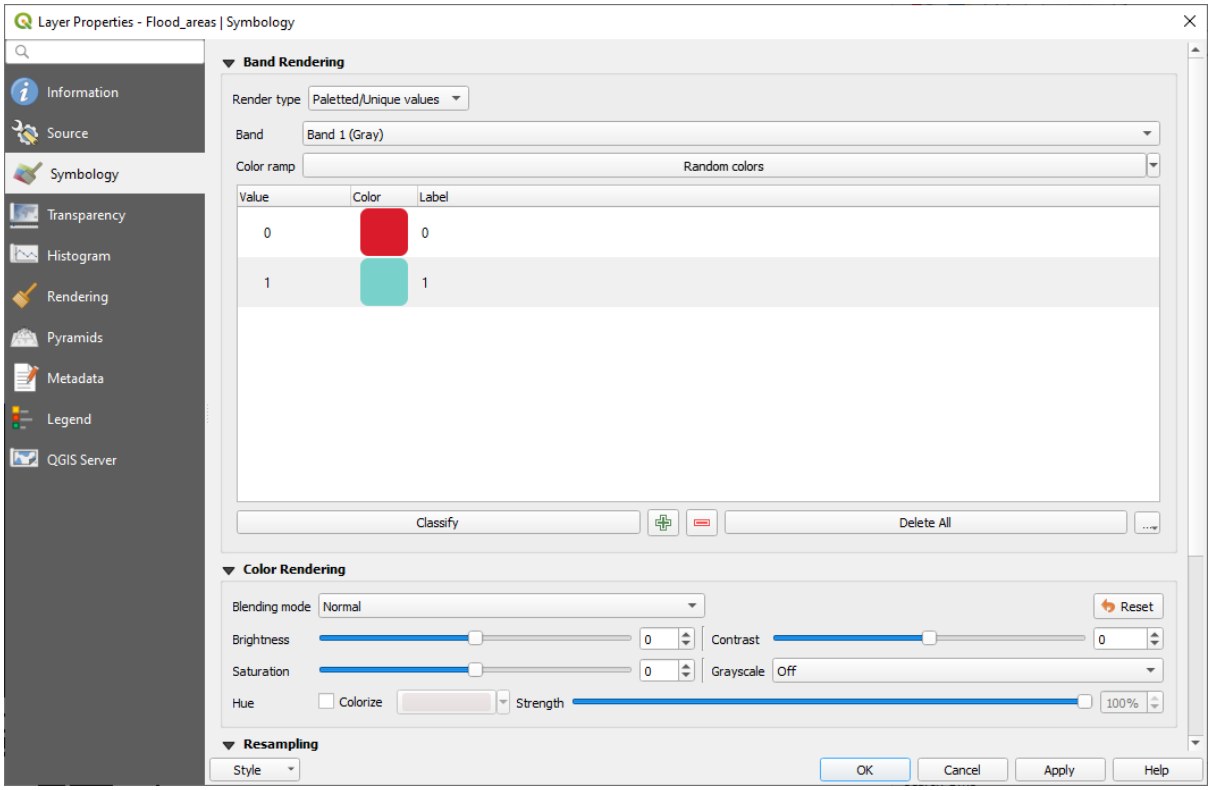
1.4.2 Creation of a flood risk map

A flood risk mask will now be created from the elevation layer. A threshold is applied such that the areas that are lower than 10 meters are at flood risk. Use the **raster calculator** and the following formula: `"Elevation@1" <= 10`

Raster ► Raster calculator



You can then change the colors in the **Symbology** tab to obtain a nice visualization of flood-prone areas (in blue here):


Layer Properties - Flood_areas | Symbology
Information
Source
Symbology
Transparency
Histogram
Rendering
Pyramids
Metadata
Legend
QGIS Server
Band Rendering
Render type
Paletted/Unique values
Band
Band 1 (Gray)
Color ramp
Random colors
Value
Color
Label
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Classify
Delete All
Color Rendering
Blending mode
Normal
Reset
Brightness
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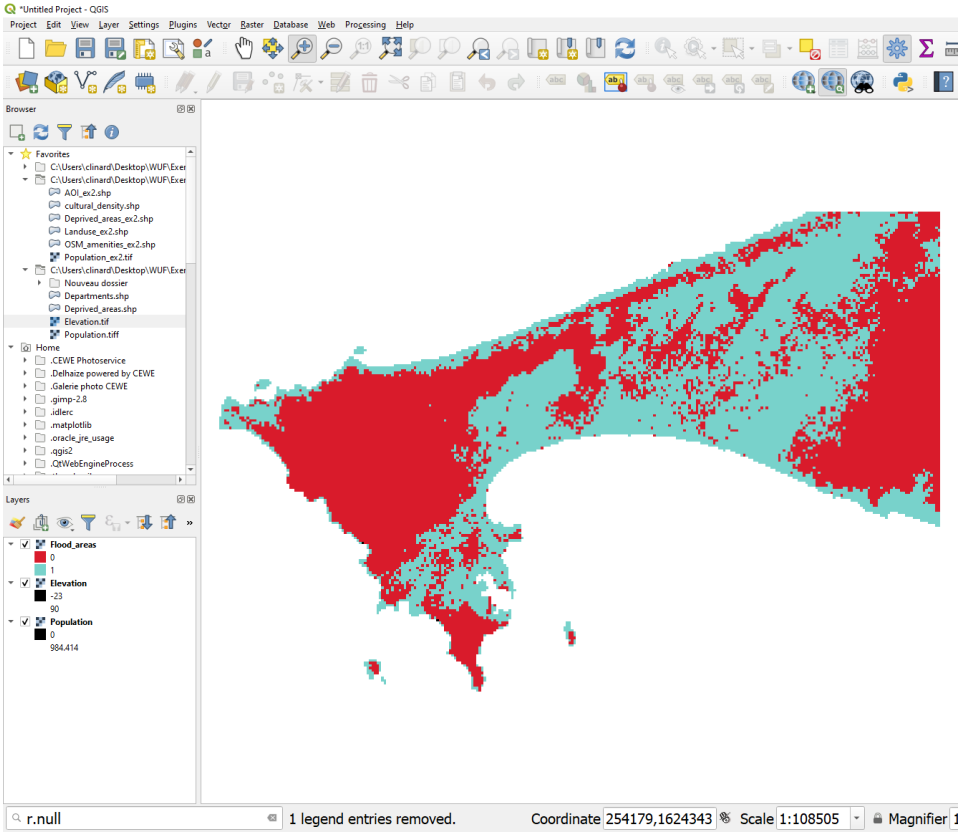
*Untitled Project - QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help
Browser
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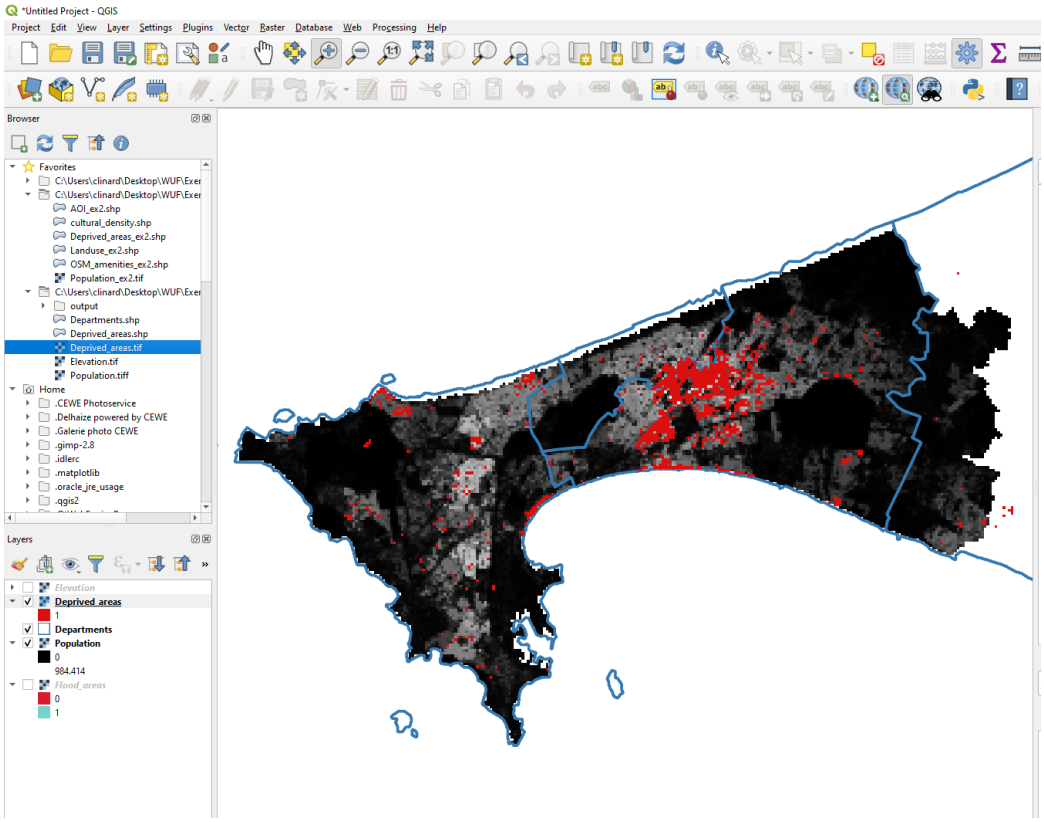
Layers
Flood_areas
Elevation
Population
r.null
1 legend entries removed.
Coordinate 254179,1624343
Scale 1:108505
Magnifier

1.4.3 Importing and visualizing other data layers

Now you can import the other data layers: **'Population.tif', 'Departments.shp' and 'Deprived_areas.tif'**.

Browser ► Navigate to the exercise files ► Right click on each file ► Add Layer to Canvas

Note that these files have been pre-processed and a color style has been prepared in advance to save you some time.



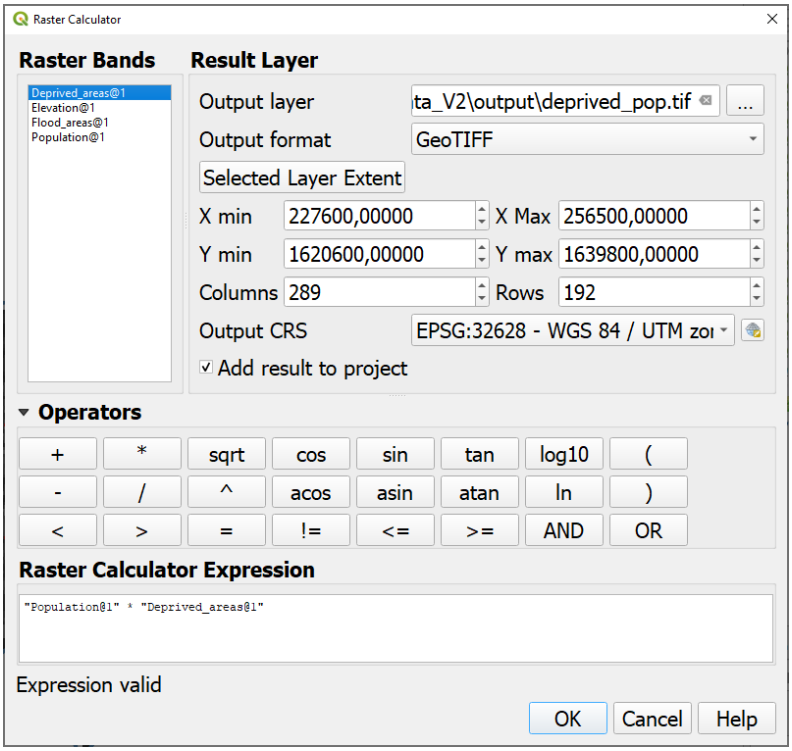
We now have 3 raster layers that will be used to calculate the proportion of slum population at risk of flooding in each department:

- Deprived areas (1 = deprived; 0 = not deprived)
- Flood areas (1 = risk of flood; 0 = no risk)
- Population (number of people per pixel)

1.4.4 Calculate the proportion of slum population at risk of flooding in each department

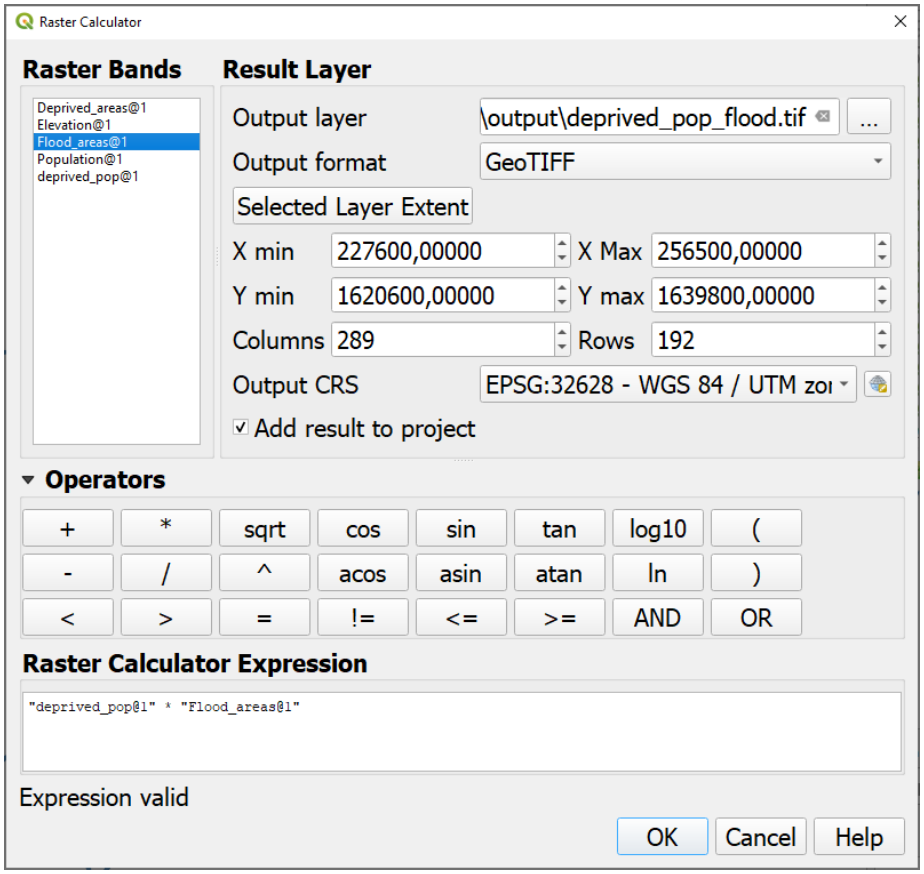
We first perform a raster multiplication to obtain a 'deprived' population layer

Raster ► Raster calculator ► Population * Deprived_areas



Then we perform a second multiplication to obtain a layer representing the deprived population at risk of flood

Raster ► Raster calculator ► Deprived_pop * Flood_areas


Raster Calculator
Raster Bands
Deprived_areas@1
Elevation@1
Flood_areas@1
Population@1
deprived_pop@1
Result Layer
Output layer
\output\deprived_pop_flood.tif
Output format
GeoTIFF
Selected Layer Extent
X min
227600,00000
X Max
256500,00000
Y min
1620600,00000
Y max
1639800,00000
Columns
289
Rows
192
Output CRS
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Add result to project
Operators
+ * sqrt cos sin tan log10 (
- / ^ acos asin atan ln)
< > = != <= >= AND OR
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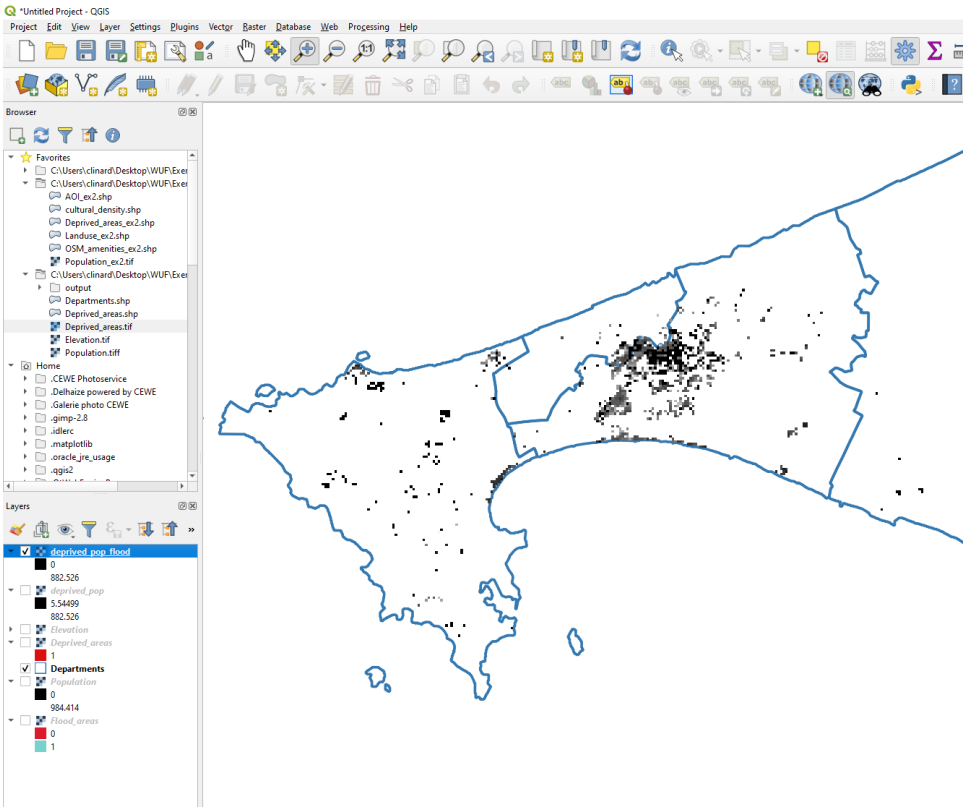
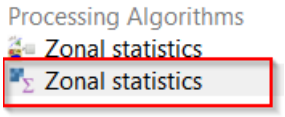
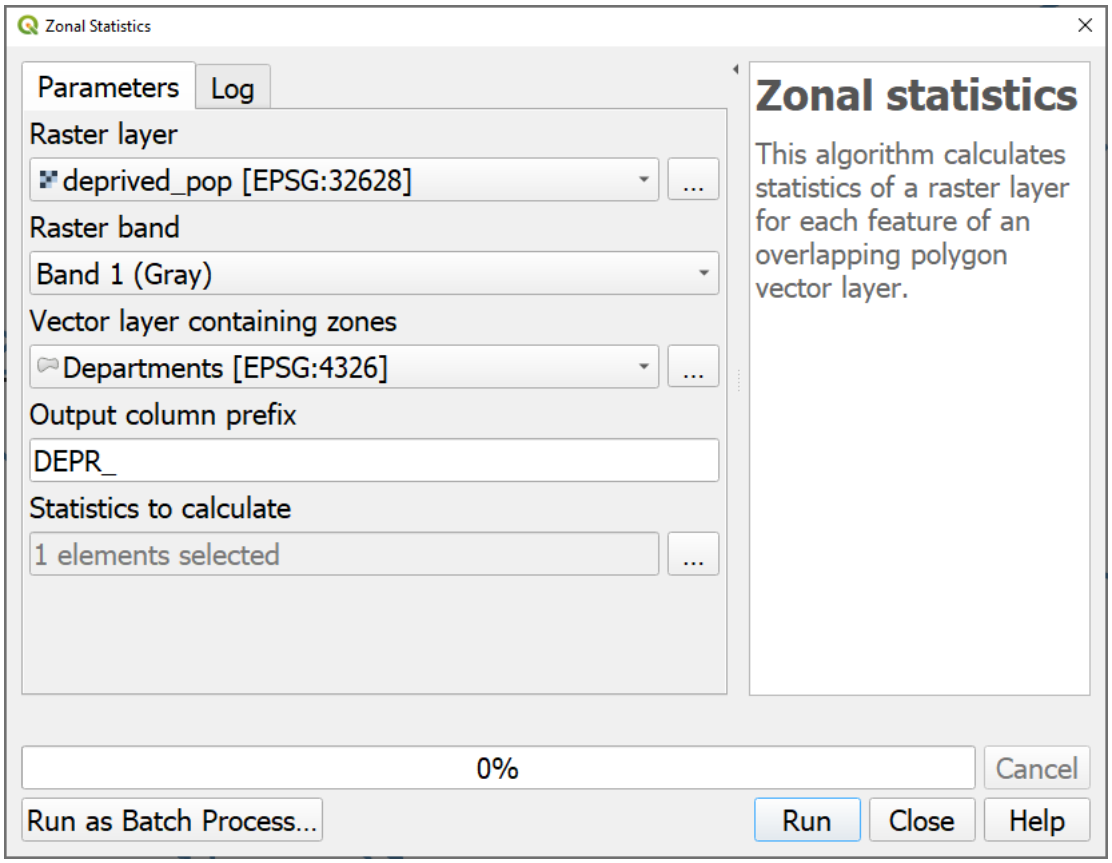
"deprived_pop@1" * "Flood_areas@1"
Expression valid
OK
Cancel
Help


*Untitled Project - QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help
Browser
Layers
deprived_pop_flood
Departments

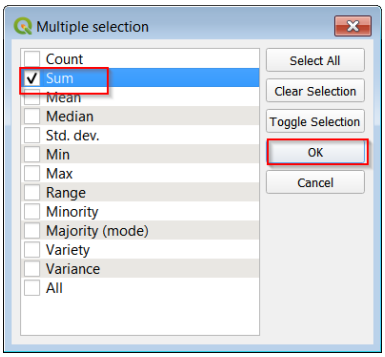
The next step involves the extraction of the deprived population at risk and the total deprived population for each department using the Zonal statistics tool. In the **Locator bar** (the 'search bar', at the bottom left of the interface), type **'Zonal statistics' (Enter)** to open the window.



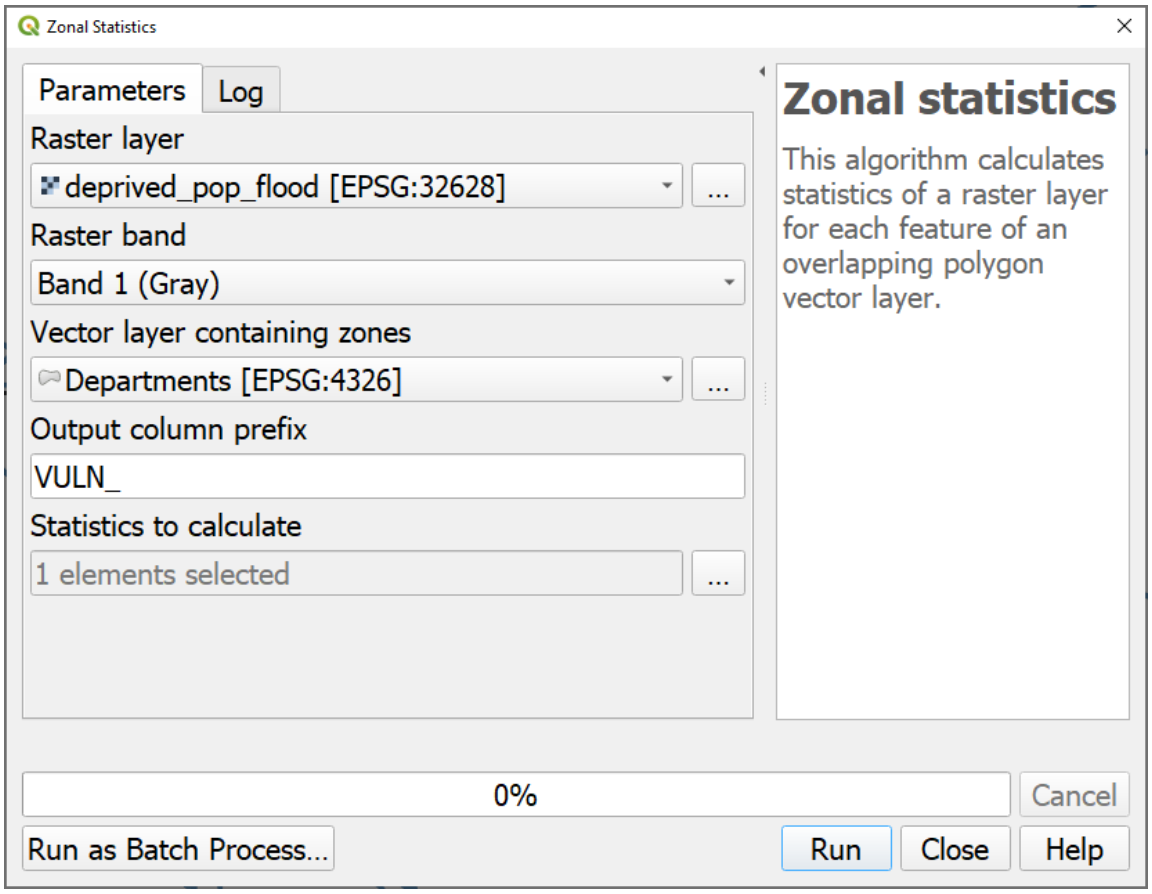
- Calculate first the deprived population by department



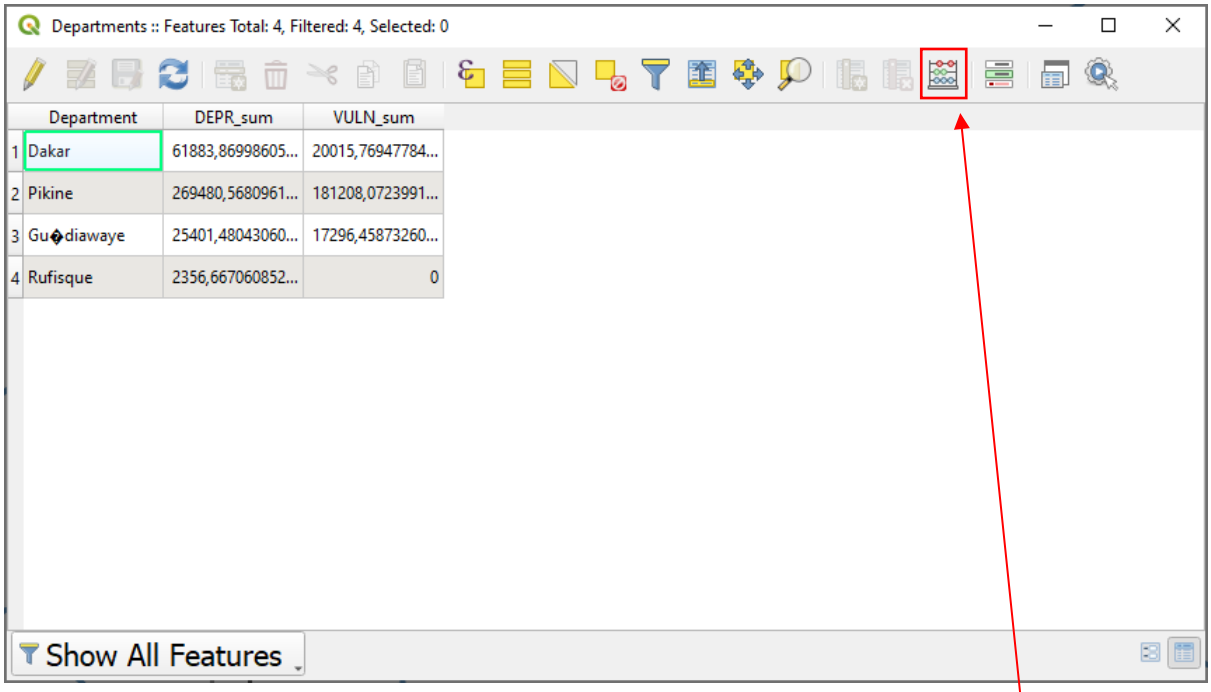
Under **Statistics to calculate**, click on **…** to open the **Multiple selection** window and uncheck **Count** and **Mean** to keep only **Sum**.:



- Second, calculate the deprived population at risk of flooding (vulnerable population) by department

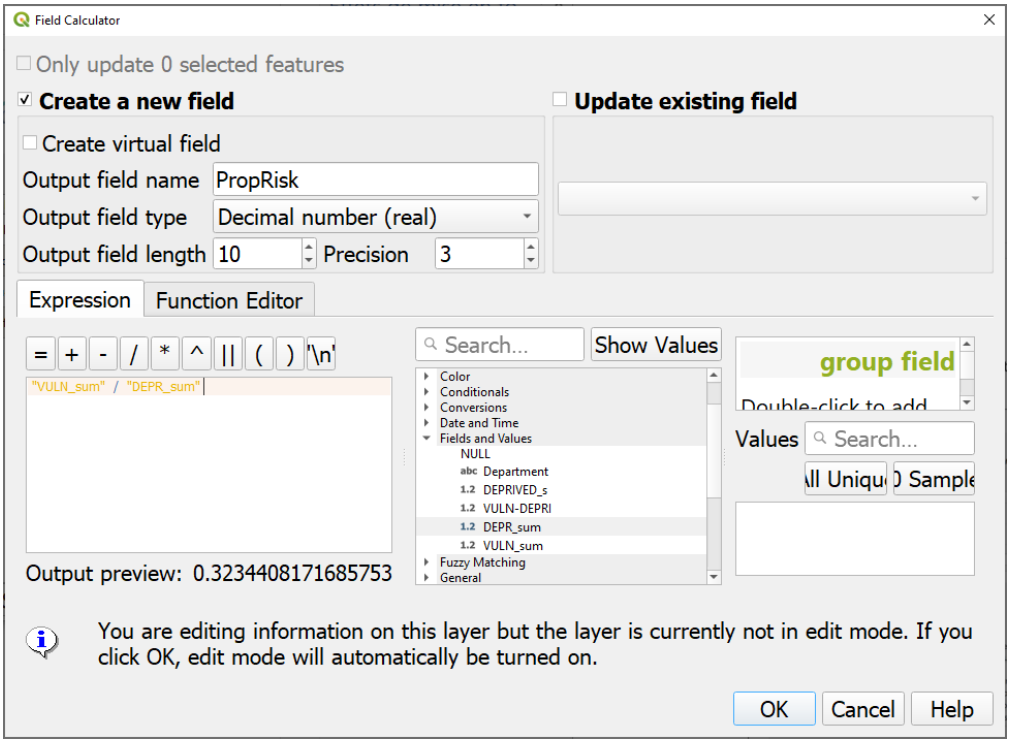


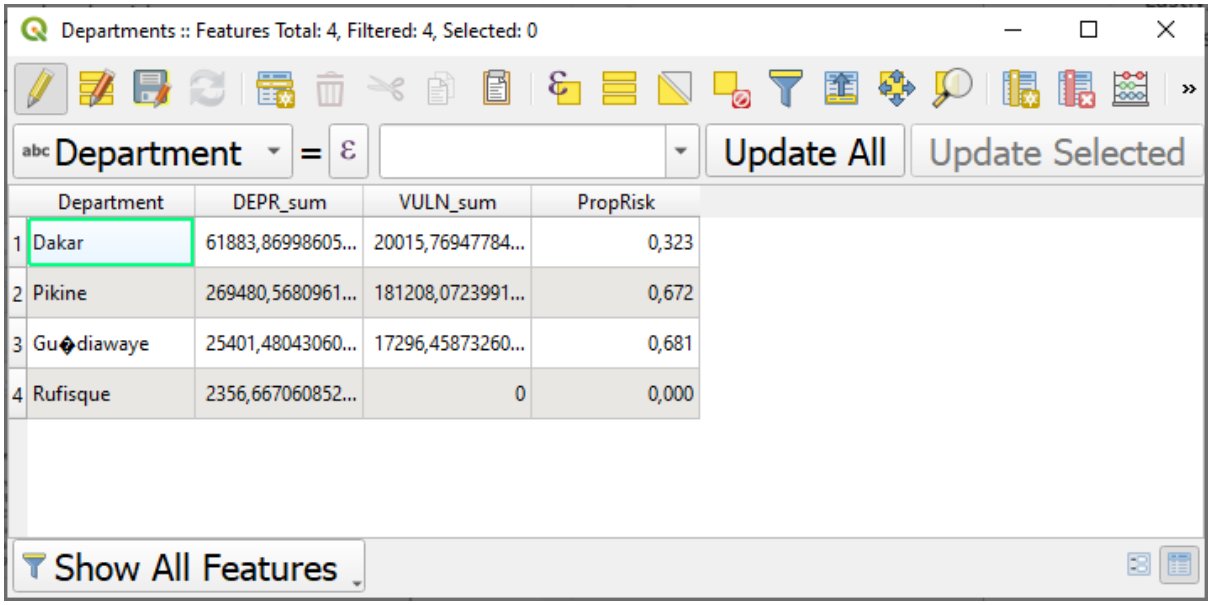
In the **Layers list,** right click on **Departments** and select **Open Attribute Table** from the drop-down menu to check that two columns have been added.



Lastly, with the attribute table still open, open the **Field calculator** (the abacus icon) to compute the ratio of the deprived population that is at risk of floods in Dakar.

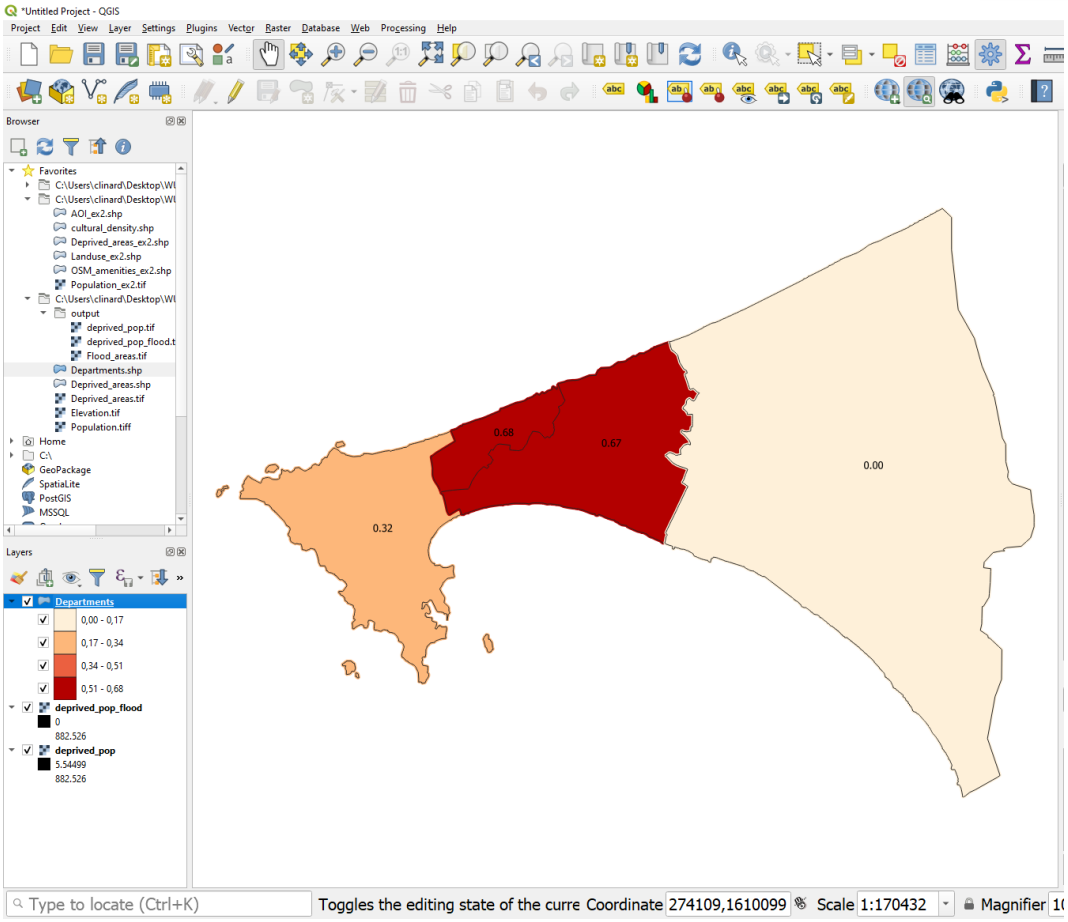
Fill out the fields in the **Field calculator** window as follows – you can use the **Fields and Values** to help you build the expression, or you can simply type it:
"VULN_sum" / "DEPR_sum" . Click on **OK** to run the algorithm.





1.5 Results and display

A map is created to visualize the results using an appropriate symbology. Since the computed ratio of population at risk of flooding is a ration number, a graduated symbol is used with Natural breaks applied to the data. This is of course subjective but there is a lot of available material that discusses ways of displaying population data.



Re-use the tools mentioned in the previous exercises or follow a more detailed tutorial on Map Composer[1] to make a good map. To save and print your map, access the **Layout Manager.**

Finally, you may save the current work as a project:

- **MENU Project ► Save as ► Type a fitting name for your project ►Save**

1.6 Conclusions

The departments with the highest deprived population at risk of flooding are Guediawaye and Pikine according to the analysis carried out. Indeed, these two departments experienced notable flooding events in Dakar. Measures are being taken to address flooding in these neighbourhoods. Production of such a map is a significant step towards deployment of mitigation strategies. The WorldBank website[2] describes how Guediawaye and Pikine were flooded in 2012 and how a strategy for flood mitigation and management was set up.

[1] https://www.qgistutorials.com/en/docs/making_a_map.html

[2] http://www.worldbank.org/en/news/feature/2016/02/03/sustainably-managing-flood-risks-in-dakars-outer-suburbs

1.7 References

[1] Elevation data (Digital elevation model- DEM) can be downloaded from the earth explorer website (https://earthexplorer.usgs.gov/). We used of the SRTM 1-arc resolution (30m) DEM that was resampled to 100m and aligned to the population map.
[2] The VHR land-use map is available from https://doi.org/10.5281/zenodo.1291388. The "deprived" land-use class was rasterized for this exercise.
[3] Administrative units are available from https://gadm.org/download_country_v3.html
[4] The gridded population layer produced in this study is accessible in a dedicated repository (CC-BY license): https://zenodo.org/record/2525672#.Xj1AfPZFwjg