

# Assessing Flood Risk in Refugee Camp Settings

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## NASA ARSET Training – Hands-On Exercise

### Overview

This document contains links to data and instructions to carry out the practical exercise in *Part 1 – Assessing Flood Risk in Refugee Camp Settings* of the NASA ARSET *Earth Observations for Humanitarian Applications* training programme. The practical exercise is a simple flood exposure and risk assessment for refugee camps in Ethiopia and is a simplified analysis based on the approaches and findings of the research paper [Unknown risk: assessing refugee camp flood risk in Ethiopia](#).

The practical exercise is split into two parts. In the first part, a simple flood exposure analysis is conducted for 24 refugee camps in Ethiopia. In the second part, a simple risk assessment is carried out in a single camp to identify structures exposed to flood risk within the camp. A further (optional) homework exercise is included, where participants can replicate the camp risk assessment for two other camps in Ethiopia. This practical exercise should take between **30-60 minutes** to complete.

### Prerequisites

This exercise is conducted entirely in the geospatial information system (GIS) software QGIS. QGIS can be downloaded for free from the following [link](#). The data to conduct the exercise can be downloaded from the following [Zenodo repository](#). This repository contains documentation for conducting the analysis, data on camp boundaries and structures (which have been extracted from a [repository](#) accompanying the original paper on which the analysis is based) as well as a 100-year return period global flood map (v2) developed by [Fathom Global](#), which has been clipped to Ethiopia for the purpose of this training.

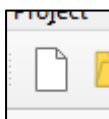
## Exercise 1: assessing camp flood exposure nationally.

### Overview

In the first exercise we will be conducting a flood exposure assessment for 24 refugee camps in Ethiopia using a 100-year return period flood map. This exposure analysis will allow us to identify highly exposed camps for further detailed analysis.

### Step 0: Open QGIS and start new project

- Open QGIS
- Create a new project by clicking the button below (located on the top left portion of the window).



### Step 1: load camp boundaries

- In the QGIS menu bar, click on “Layer” -> “Add Layer” -> “Add Vector Layer...”
- In the window that opens, click on the “...” button.
- Navigate to the folder provided for this exercise. Open “Camps” and then select “camp\_boundaries\_Ethiopia.shp” file.
- **Note: it is important to make sure you are selecting the file with the correct extension.**
- Click “Open” and “Add”. The layer should now be loaded in your QGIS workspace.
- Right click on the layer and click “Properties”.
- In the window that opens, click on “Symbolology” and then on “Simple Fill”. For the option “Fill Style” choose “No Brush”. This will change the styling of the camp boundaries so only the boundaries are visible. You can change the thickness of the camp boundaries using the “Stroke width” option.

### Step 2: load flood map

- In the QGIS menu bar, click on “Layer” -> “Add Layer” -> “Add Raster Layer...”
- In the window that opens, click on the “...” button.
- Navigate to the folder provided for this exercise. Open “Flood” and then select “fluvial\_pluvial\_rp100.tif” file.
- Click “Open” and “Add”. The layer should now be loaded in your QGIS workspace.

### Step 3: apply a style file to flood map

- Right click on the “fluvial\_pluvial\_rp100” layer in the Layers window in QGIS.
- Click on “Properties”
- In the window that opens, select the “Symbolology” tab on the navigation pane on the left.
- In the bottom left of this window click on the “Style” button and then click “Load Style”
- Navigate to the folder provided for this exercise. Open “Flood” and then select “flood\_depth\_style” file.
- Click “Open” then “OK” and the flood map should now have a new style applied. You can adjust this however you want in the “Symbolology” window.

### Step 4: count flooded cells in each camp using Zonal Statistics

- Open the “Processing Toolbox” in QGIS toolbox.
- This can be opened by clicking the button below. This will open a window on the right-hand side of the screen.

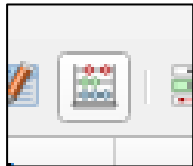


- In the “Processing Toolbox” search for “Zonal statistics” and open the tool with the same name.
- This tool allows you to calculate simple statistics on a raster layer in areas where it overlaps with a vector layer.
- We are going to count the number of flooded cells from the flood map fall within each refugee camp boundary.

- In the zonal statistics window:
  - For “*Input layer*” we select our refugee camp boundary layer “*camp\_boundaries\_Ethiopia*”
  - For “*Raster layer*” we select our flood map “*fluvial\_pluvial\_rp100*”
  - In “*Output column prefix*” write “flood\_”
  - In “*Statistics to calculate*” select “*Count*” only
  - You can either choose a location to save your results or click “*Run*” straight away and it will produce a temporary layer.
- Right click the new layer that the tool has created and click “*Open Attribute Table*”. You should now see an additional column with the statistics you have calculated for each of the refugee camps.

#### Step 5: calculate exposure statistics in each camp using Field Calculator

- Right click on the layer created by the Zonal Statistics tool and click on “*Open Attribute Table*”
- Open the *Field Calculator* by clicking on the abacus symbol (see below)



- In the window that opens, you want to select “*Create a new field*”
- In “*Output field name*” write “f\_exposed”
- In the “*Expression*” box we are going to write the following formula:
 
$$((\text{flood\_count} * 90 * 90) / \text{Area\_m2}) * \text{Population}$$
- What this formula is doing is multiplying the number of flooded cells (*flood\_count*) by the area of the flooded cells (90\*90). This is because the flood data we are using has an *approximate* resolution of 90 x 90 m. We are then dividing this by the area of the camp (*Area\_m2*) to calculate the proportion of camp area that is flooded. We then multiply this by the population of the camp (*Population*) to give us the number of people exposed to flooding in the camp. In this calculation we assume that the population in the camp is distributed evenly across the area of the camp.
- **Note: the above approach for calculating flooded area is a simplified approach. For detailed area calculations you will want to make sure you are in an appropriate map projection system for calculating areas (see this [article](#) for more details). Our flood data is in the WGS84 projection and is roughly 90 m in resolution at the equator (but becomes very different the further you are from the equator). For this tutorial, this is an appropriate simplification to make.**
- You now know the approximate population exposed in each camp. However, this is an absolute number and may be influenced by how many people live in each camp. Let’s also calculate the percentage of population exposed in each camp.
- We will repeat the steps above, this time creating a new output field “p\_exposed” and entering the following formula into the “*Expression*” box:

$(f\_exposed/Population)*100$

- **Note: in the “Expression” box the default field that is selected is “integer”. If you want more detailed numbers you need to change this field to “floating point”.**
- This formula divides the population exposed by the total population within the camp to calculate the proportion exposed, then multiplies it by 100 to calculate the percentage.
- To rank the camps by the magnitude of the population exposed to flooding or the percentage population exposed to flooding you can click on the column header for the respective column, and it will rank the rows based on the magnitude of the cells within that column. You can use this feature to identify the camps most at risk.

## Exercise 2: assessing flood risk in a camp using building footprints.

### Overview

In the second exercise we will conduct a flood risk assessment for the Barahle camp. We will introduce building footprints (extracted from OpenStreetMap) into the analysis to understand the risk exposure of structures within the camp. We will also introduce simple depth vulnerability thresholds to classify the flood map by the risk it may pose to camp inhabitants. We will then classify buildings based on the level of flood risk that they are exposed to. This analysis will allow us to identify buildings exposed to different levels of flood risk within the camp.

### Step 1: load building footprints

- In the QGIS menu bar, click on “Layer” -> “Add Layer” -> “Add Vector Layer...”
- In the window that opens, click on the “...” button.
- Navigate to the folder provided for this exercise. Open “Camps” -> “Footprints” and then select “Barahle\_OSM\_footprints.shp” file.
- Click “Open” and “Add”. The layer should now be loaded in your QGIS workspace.

### Step 2: assign risk thresholds to flood map

- To begin assessing risk within the camps we are going to apply simple depth vulnerability thresholds to the flood map.
- These thresholds are shown in the table below. This table is Table 1 from the following [paper](#).

Risk Category	Flood Depth (m)	Description
Low	< 0.15	Low immediate risk to life. Stagnant water at this depth could pose longer term health risks. Low-cost flood adaptation strategies could be effective.
Medium	0.15 - 0.5	Some risk to life for vulnerable groups (e.g. children, elderly, and disabled). Structural flood adaptation strategies could be effective.
High	0.5 - 1.5	Large immediate risk to life for all groups. Significant damage to structures within camp.
Very High	> 1.5	Substantial immediate risk to life. Structures within camp destroyed.

- We are going to use the Raster Calculator tool to reclassify our flood map into different risk categories, based on the modelled flood depths.
- In the QGIS menu bar, click on “*Raster*” -> “*Raster Calculator*”
- In window that opens there is an area for inputting formulas, called “*Raster Calculator Expression*”. In this area we are going to input the following formula:

```
("fluvial_pluvial_rp100@1"<0.15)*1+("fluvial_pluvial_rp100@1">=0.15 AND
"fluvial_pluvial_rp100@1"<0.5)*2+("fluvial_pluvial_rp100@1">=0.5 AND
"fluvial_pluvial_rp100@1"<1.5)*3+("fluvial_pluvial_rp100@1">=1.5)*4
```

- What this formula does is assign flooded cells with a depth less than 0.15 m a value 1; flooded cells with a depth between 0.15 m and 0.5 m a value of 2; flooded cells with a depth between 0.5 m and 1.5 m a value of 3; and flooded cells with a depth greater than 1.5 m a value of 4.
- Click on the “...” symbol, choose a folder to save the file, and a name for the map. In our tutorial we name the map “flood\_risk\_rp100.tif”
- Click on “*Run*” to run the tool, it may take a few minutes for the analysis to complete.

### Step 3: apply a style file to flood risk map

- Right click on the layer you just produced “flood\_risk\_rp100” in the Layers window in QGIS.
- Click on “*Properties*”
- In the window that opens, select the “*Symbolology*” tab on the navigation pane on the left.
- In the bottom left of this window click on the “*Style*” button and then click “*Load Style*”
- Navigate to the folder provided for this exercise. Open “*Flood*” and then select “flood\_risk\_style” file.
- **Note: if the flood risk styling is not working properly, make sure that you have correctly saved the layer in Step 2 and are not working with a temporary layer.**
- The raster layer should now be styled based on the risk thresholds calculated in the previous step.

### Step 4: calculate risk to individual buildings using Zonal Statistics

- Open the same “*Zonal Statistics*” tool we used earlier.
- This time, instead of counting the number of flood cells in each refugee camp, we are going to calculate the flood risk category each structure within the camp is exposed to.
- In the zonal statistics window:
  - For “*Input layer*” we select our building footprint layer “Barahle\_OSM\_footprints”
  - For “*Raster layer*” we select our flood risk map “flood\_risk\_rp100”
  - In “*Output column prefix*” write “risk”
  - In “*Statistics to calculate*” select “*Maximum*” only
  - You can either choose a location to save your results or click “*Run*” straight away and it will produce a temporary layer.

### Step 5: style building footprints based on level of risk

- Right click the layer you just created in the previous step and select “*Properties*”
- In the window that opens, select the “*Symbolology*” tab on the navigation pane on the left.
- In the bottom left of this window click on the “*Style*” button and then click “*Load Style*”
- Click on the “...” symbol and navigate to the folder provided for this exercise.
- Click on “*Camps*” and then “*Footprints*” and then select and open the file called “*footprint\_styling*”.
- Click on “*Load Style*” and then “*OK*” to apply the styling to the building footprints.
- **Note: for the styling to work properly the field needs to read *riskmax*. If the style is not working, make sure that in Step 4 you write just *risk* in the “*Output column prefix*” step or go to symbolology and in “*Value*” select the correct column that you want to style.**
- You can now inspect the different buildings within the camp that are exposed to flooding and these buildings will be colour coded based on the level of flood risk that they are exposed to.

## Homework Exercise (Optional)

### Overview

The homework exercise involves you replicating Step 4 and Step 5 in Exercise 2 for two other highly flood exposed camps in Ethiopia: Nguenyiel and Tierkidi. The camp data can be found in the data folder provided for this exercise in the folder called “*Homework*”. You will notice that there are two different building footprint layers provided for these camps (OpenStreetMap and [Google Open Buildings](#)). Run the analysis with both and explore the difference.

### Further Work (Optional)

The analyses described in this hands-on exercise are simplified versions of the analysis carried out in the paper [Unknown risk: assessing refugee camp flood risk in Ethiopia](#). All the camp-level data used in that paper can be downloaded from the following [Zenodo repository](#) if you are interested in conducting further flood risk analyses for refugee camps in Ethiopia.