



SMT201
Geographic Information Systems for Urban Planning
AY 2023/24, Term 1



**A Case Study on Urban Flood
Disaster Mitigation and Management**
(Flood of Derna City, Libya in September 2023)

Project Report & Documentation
Theme 2: GIS-based Accessibility Analysis and
Mapping of Emergency Evacuation Centres and Medical Services

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Executive Summary

Our project revolves around the theme of GIS-based Accessibility Analysis and Mapping of Emergency Evacuation Centres and Medical Services of Derna City, Libya. On Sunday the 10th of September 2023, Storm Daniel, the deadliest Medicane (Mediterranean Tropical Storm) hit Libya. The rain it brought pushed two dams in the Derna district of Libya to their limits, causing their collapse, leading to a massive flood that led to large-scale damage and destruction of buildings and infrastructure with thousands of casualties.

Casualty from disasters is tragic. Evacuation Centres and Medical facilities exist to mitigate its impact, yet any disaster has the potential to reduce their effectiveness. This motivates us to analyse and assess the accessibility of Derna City's evacuation centres and medical services to evaluate the changes in the extent of such facilities effectiveness in rendering aid and medical services in an aftermath of a disaster such as the flood. To prevent further loss of life, our analysis seeks to find out how disaster-proof and accessible Derna's Evacuation Centres and Medical Facilities are.

We prepared pre- and post-flood data of Derna City's evacuation centres, medical facilities, and road network. We analyse the accessibility using QNEAT3 Plugin in QGIS, Network Analysis Toolbox utility Iso-Areas as Polygons (from Layer) to measure the accessibility of buildings to the Evacuation Centres and Medical Facilities. To easily visualise accessibility, categorised polygons with colour ramps representing degrees of accessibility were created.

We also used various geoprocessing tools like merge and dissolve, to group common data together for a more comprehensive finding.

Overall, we found that Derna's Evacuation Centres and Medical Facilities are not very disaster-proof and accessibility decreased by a huge proportion even though only a small area of Derna City was destroyed by Storm Daniel.

1. Introduction

With climate change, the frequency and intensity of natural disasters has increased. In September 2023, the Mediterranean region faced the deadliest tropical storm (or ‘Medicane’) in history, Storm Daniel (BBC Verify, 2023). The intensity of the storm pushed two dams in the Derna district of Libya to their limits, resulting in their collapse on 10th September 2023, causing a massive flood that led to large-scale damage and destruction of buildings & infrastructure and thousands of casualties.

Considering the damage brought about by the disaster, in this project, we will be using Geographic Information (GI) technologies, such as satellite imagery and image processing techniques to study how the accessibility of Derna City’s Emergency Evacuation Centres and Medical Services affected the effectiveness of its recovery and relief efforts.

2. Motivation & Objectives

Casualties from disasters are tragic. Evacuation Centres & Medical facilities exist to mitigate its impact, yet any disaster has the potential to reduce their effectiveness. Considering the high casualty count following the Derna City floods in September 2023, we decided to analyse and assess the accessibility of Derna City’s evacuation centres and medical services to evaluate the changes in their effectiveness in rendering aid and medical services following the damage brought about by the disaster as seen in **Figures 1 and 2**.



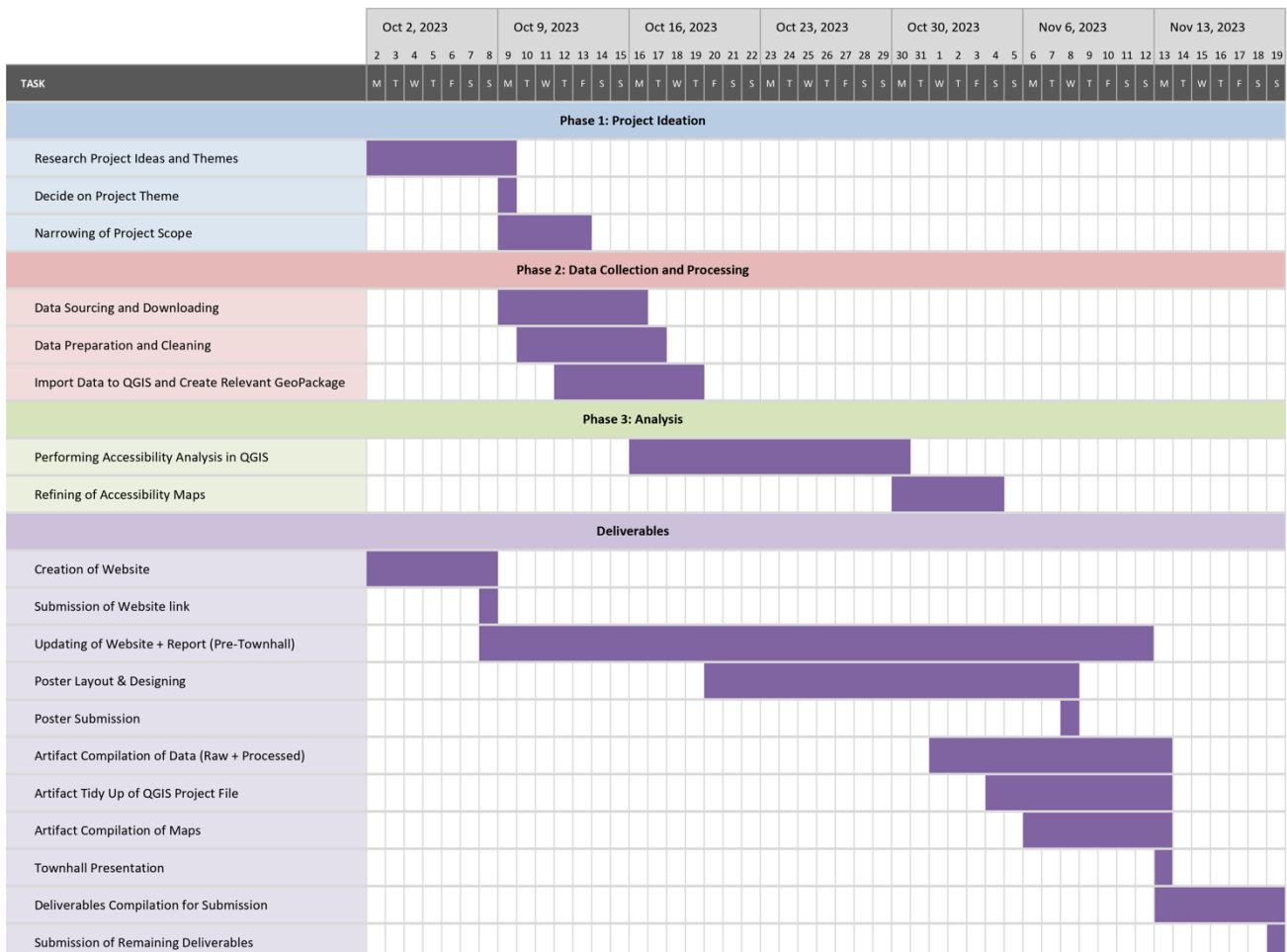
Figure 1: Satellite Image of East of Derna City Before (Left) and After (Right) the Flood (Smith, 2023)



Figure 2: Aerial Damage in Derna City after the Flood on 12 September 2023 (Magdy, 2023)

Based on our motivation, our objective for the project is to find out - How Disaster-Proof and Accessible are Derna's Evacuation Centres and Medical Facilities?

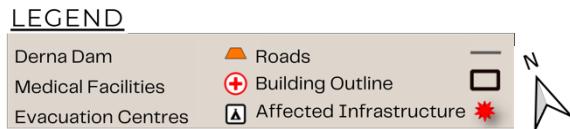
3. Project Schedule & Scope of Work



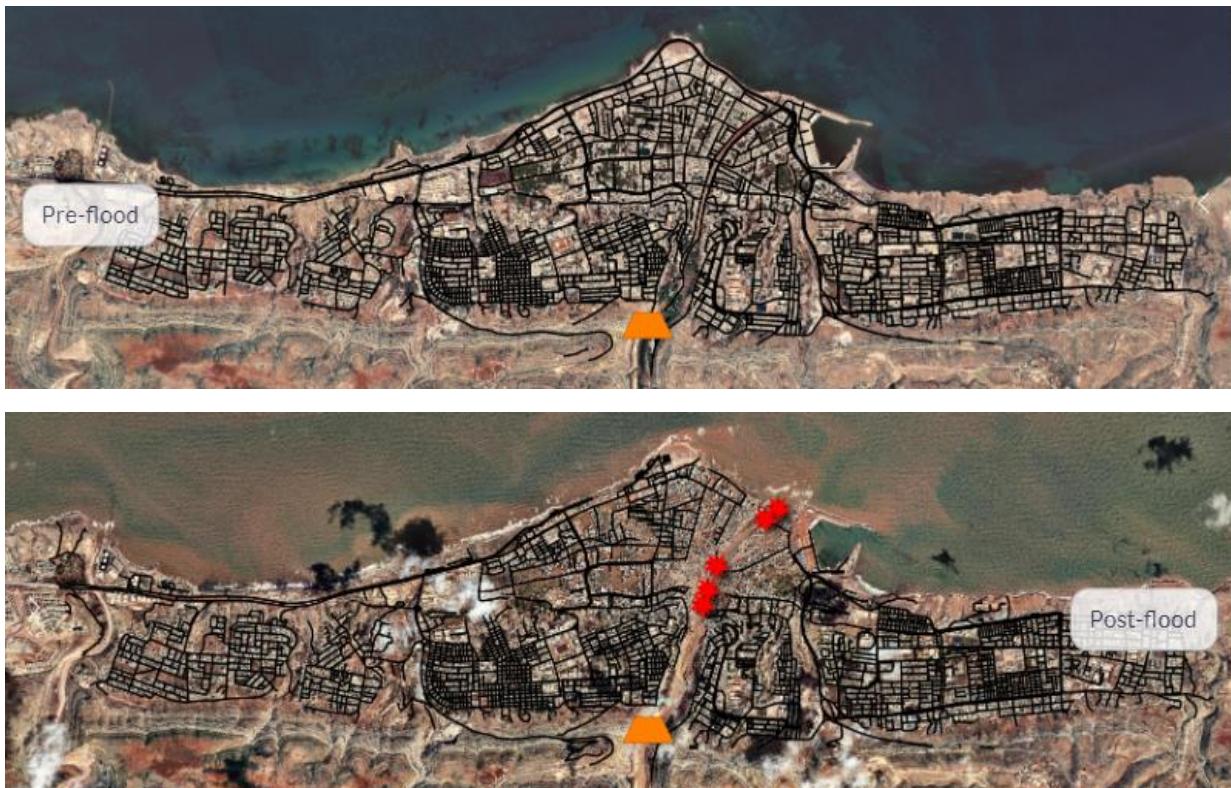
4. Analysis Results & Discussion

4.1 Analysis Results

The pre-flood maps below are satellite imagery of Derna City on *01 July 2023* and *13 September 2023* for post-flood (*within 3 days of flood occurrence*).



4.1.1 Road Network



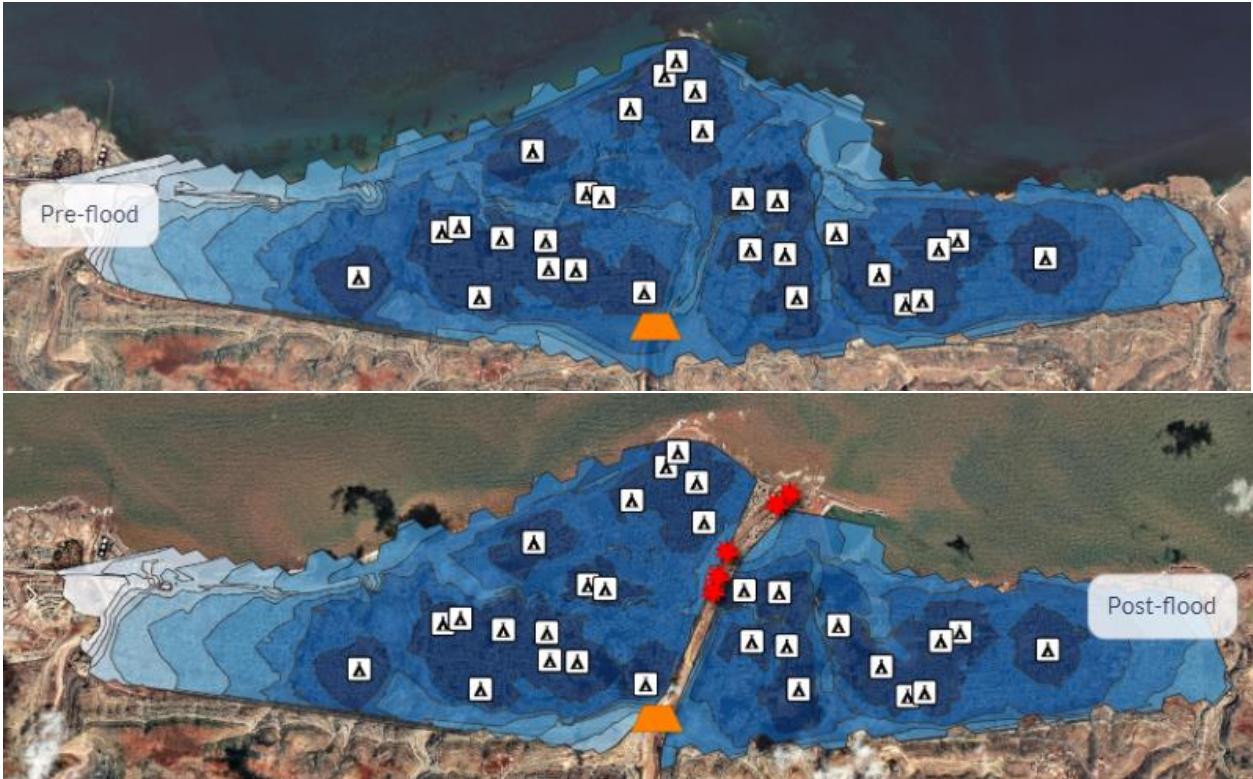
Road networks connecting the East and West of Derna City were completely cut off as the massive flood waters destroyed the road networks near the river, evident from the satellite imagery. This would likely reduce the accessibility of evacuation centres and medical facilities between the East from the West part of Derna City.

4.1.2 Buildings



Many buildings near the river and north part of Derna City were destroyed after the flood, evident from the amount of bare land observed from the satellite imagery post-flood as compared to pre-flood. Derna City's accessibility to emergency facilities, especially in these areas, would be very important and accessibility is likely to drop due to a reduction in the number of buildings (being demand points served by evacuation centres and medical facilities).

4.1.3 Accessibility to Evacuation Centres

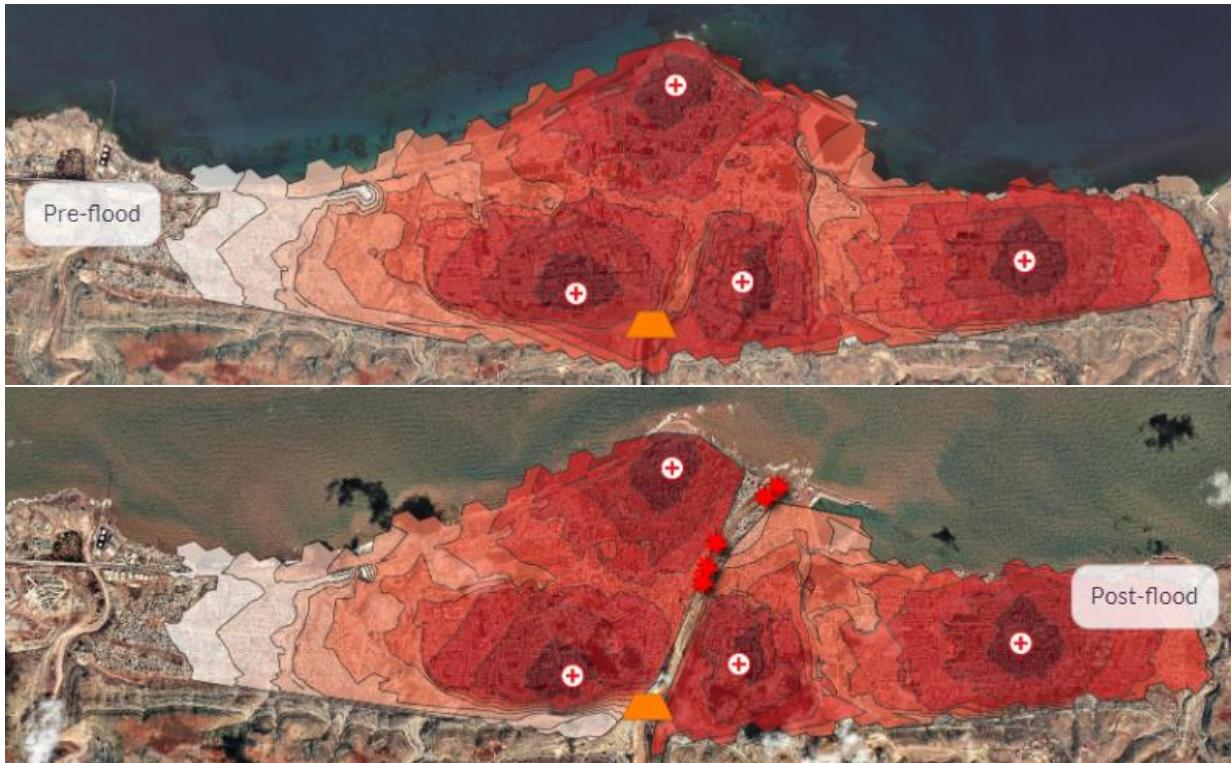


Distance from Evacuation Centers within (m)	Number of buildings		
	Pre-Flood	Post-Flood	Change (%)
500	9540	6066	-36.42%
1000	18008	10803	-40.01%
1500	20227	12023	-40.56%
2000	21105	12651	-40.06%
2500	21497	12916	-39.92%
3000	21869	13163	-39.81%
3500	22085	13269	-39.92%
4000	22207	13386	-39.72%
4500	22288	13402	-39.87%
5000	22347	13423	-39.93%

- For evacuation centers, we isolated out schools, universities, and places of worship to be used for our analysis. These places had large, sheltered halls suitable to house large numbers of evacuees and store aid supplies. (More details can be found in **5. Methodology** below)
- Access between the East and West of Derna City was completely cut off as the massive flood waters destroyed the bridges connecting both sides, also observed in **4.1.1 Road Network**. This reduced the overall accessibility of evacuation centres between the East and the West part of Derna City
- From the accessibility map, initially, areas surrounding the river were within 1km from an evacuation centre. However, after the flood, it is no longer accessible due to the destroyed bridges which are part of Derna City's road network

- From the table, we can also observe that around 40% of the buildings that were present are either destroyed or became inaccessible to evacuation centres after the flood.

4.1.4 Accessibility to Medical Facilities



Distance from Medical Facilities within (m)	Number of buildings		
	Pre-Flood	Post-Flood	Change (%)
500	1961	1303	-33.55%
1000	8117	4683	-42.31%
1500	13636	8176	-40.04%
2000	18055	10415	-42.32%
2500	19162	11258	-41.25%
3000	20168	11834	-41.32%
3500	20594	12275	-40.40%
4000	20697	12312	-40.51%
4500	21096	12621	-40.17%
5000	21409	12854	-39.96%

- For medical facilities, hospitals are used for our analysis. (More details can be found in **5. Methodology** below)
- Like evacuation centres' accessibility, East and West of Derna City became isolated, reducing the overall accessibility of medical facilities between the East and the West part of Derna City.
- From the accessibility map, even with the dam being within 1.5km of two medical facilities, the region surrounding the dam is totally inaccessible after the flood due to the loss in road network within the area.

- From the table, we can also observe that there is almost an aggregate of 40% loss of Derna City's building's accessibility to medical facilities, with the buildings either being destroyed or becoming isolated due to the flood that occurred, which is not ideal in such massive disaster.

4.2 Discussion

4.2.1 State of Buildings

From our GIS analysis, both evacuation centres and medical facilities' accessibility show a significant and drastic drop, especially in areas near the river.

Our findings are further backed by our tabular data showing a fall in the service quantity of both evacuation centres and medical facilities. The drop in service quantity is due to buildings either being destroyed or becoming isolated from any existing road networks.

4.2.2 Drop in Accessibility

A small area concentrated within the flood extent near the river had their accessibility to evacuation centres and medical facilities compromised. Yet despite its small area, it led to almost a 40% decrease in accessibility of these places, across the entirety of Derna City.

4.2.3 Need for Reinforced Infrastructures

From the results, we can safely conclude that the bridges that were destroyed in Derna due to the flood played a significant role in affecting accessibility. Thus, in order for the accessibility to such emergency facilities to be more disaster proof, Libya would need to ensure that its road network, especially key connecting infrastructure like bridges, are able to better withstand such disasters, which would only increase in frequency and intensity due to climate change (Nasr et al., 2019).

With the same findings, considerations can be made to focus on the need to repair and reconnect the road networks between the East & West of Derna City for a more effective and efficient emergency response. This could help lower any further loss of life and hasten recovery efforts.

4.3 Conclusion

In response to our objective of how Disaster-Proof and Accessible Derna's Evacuation Centres and Medical Facilities are, it is analysed that accessibility to Derna city's evacuation centres and medical services drops after the flood, with accessibility being least disaster-proof at areas near the river and a huge part of the flood extent.

Ultimately, while emergency facilities (evacuation centres and medical facilities) should ideally be accessible to all, there will undoubtedly be areas with better and poorer accessibility due to their relative distance from such centres and facilities. However, through usage of GIS software, severely underserved areas can be better identified, and improvements in accessibility to such areas can be made.

5. Methodology

The below lists out the step-by-step approach taken by the team to attain the analysis:

5.1 Data Sourcing and Downloading

For the project, multiple data sources will be used. The following data will be used:

5.1.1 From Libya Floods at [Humanitarian Data Exchange \(HDX\) portal](#)

5.1.1.1 Derna City 250m Hexagons

- Download from [Libya - 250m hexagonal grid and grid centres over city of Derna](#)
 - The file of interest is  Derna_city_250m_hexagon.shp
 - This data file contains what is encompassed of Derna City and its boundary in 250m hexagonal grids

5.1.1.2 Derna City Building Footprint



[open_buildings_v3_polygons.Libya_Derna_floods.csv.gz](#) (2.6M)

Updated: 15 September 2023

Buildings footprint of area impacted by flooding in Derna, Libya. Footprint as of May 2023.

- Download [Footprint: Derna Flooding](#) from [Libya Buildings](#)

- The file of interest is  open_buildings_v3_polygons.your_own_wkt_polygon
 - This data file contains the building outlines of Derna City pre-flood
 - For this, you may need to download the external software [7-Zip](#) to extract the .csv file within the folder

4.1.1.3 Flood Impact Assessment



[FL20230912LBY_SHP.zip](#)

Updated: 13 September 2023

- Download [Zipped shapefile](#) from [Flood impact assessment in Derna City, East Province, Libya](#)

- The files of interest are:

-  PHR_20230913_FloodExtent_Derna.shp > This data file consists of the extent of the flood in Derna City (**Dated 13 September 2023**)
-  S2_20230912_AffectedInfrastructure_Derna.shp > This data file consists of the locations of infrastructure in Derna City affected by the flood such as bridges (**Dated 12 September 2023**)

-  PHR_20230913_AffectedStructure_Derna.shp > This data file consists of the locations of the buildings in Derna City affected by the flood (**Dated 13 September 2023**)

4.1.1.4 Dam Locations



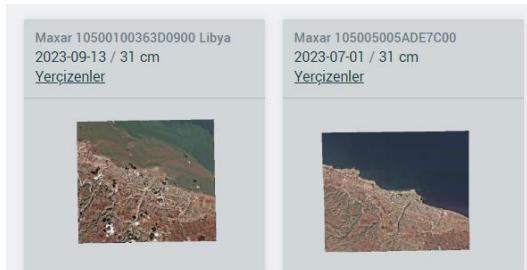
- Download Dam locations East Libya from [East Libya - Location of Dams](#)
 - Upon clicking on Download, you will be directed to a [webpage](#), right click on the webpage >



- The file of interest is  libya-dams.geojson
- This data file consists of the locations of the dams in Derna City

5.1.2 From [OpenAerialMap](#)

5.1.2.1 Satellite Pre-& Post Flood



- Download both satellite images: [here \(post-flood\)](#) and [here \(pre-flood\)](#)
- The files of interest are  6502b20a0906de000167e692 **(Pre-flood)** and  6502980d0906de000167e682 **(Post-flood)**

5.1.3 From [OSM Libya Geofabrik](#)

5.1.3.1 Derna OpenStreetMap Data

- Download [Pre-flood OSM data \(23-09-01\)](#)  libya-230901-free.shp and [Post-flood OSM data \(23-10-01\)](#)  libya-231001-free.shp
 - The files of interest are; and they contain the locations of:
 - Buildings  gis_osm_buildings_a_free_1.shp (For Post-flood only, for Pre-Flood, Building Footprint will be used instead)

- Points-of-Interest  gis_osm_pois_a_free_1.shp (Evacuation Centres & Medical Facilities)
- Places-of-Worship  gis_osm_pofw_a_free_1.shp (Evacuation Centres)
- Road Networks  gis_osm_roads_free_1.shp

5.2 Data Preparation and Cleaning

5.2.1 Start Project

Start a new QGIS project, save the project as File name ‘**EvacuConnect**’ under file type **QGIS files (*.qgs *.QGS)**, save it into the Project folder



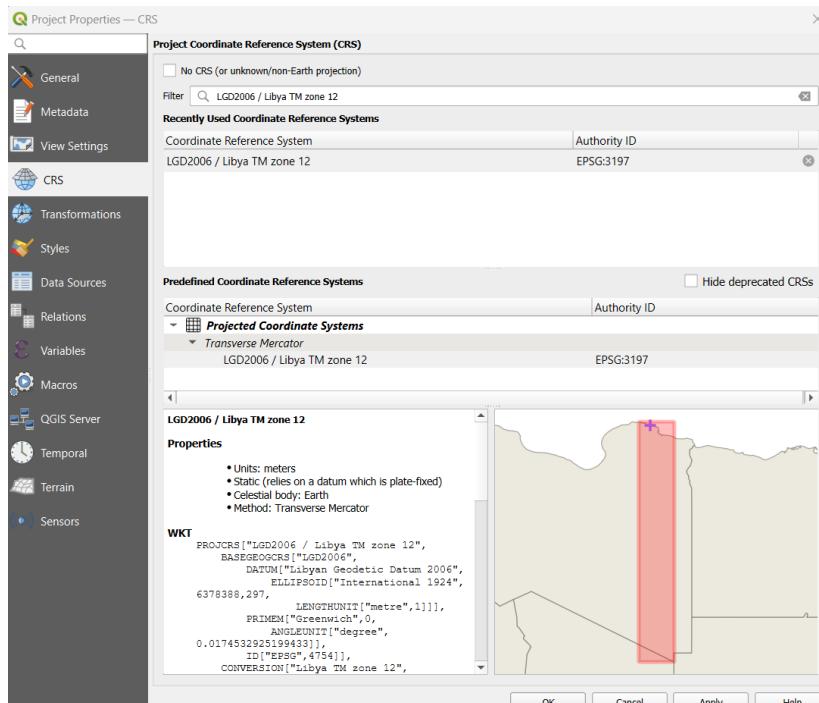
5.2.2 Setting the Projection

Click on the CRS button beside the Render checkbox



The **Project Properties - CRS** dialog box opens

- For Filter, search for and select ‘**LGD2006 / Libya TM zone 12**’ which has **EPSG: 3197**
- Click on **Apply**, then click **OK**



- Your CRS should reflect the change:



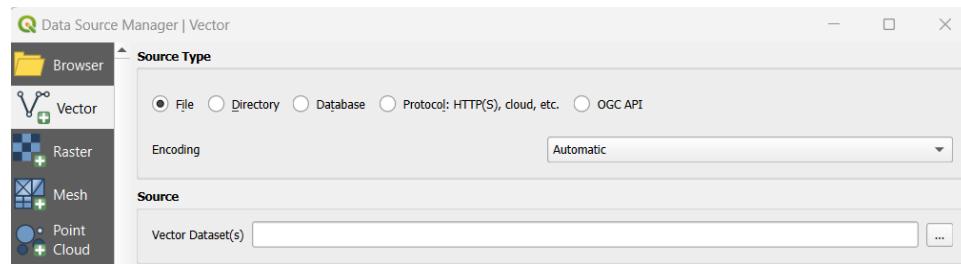
5.2.3 Importing Data Layers

5.2.3.1 Derna City 250m Hexagons

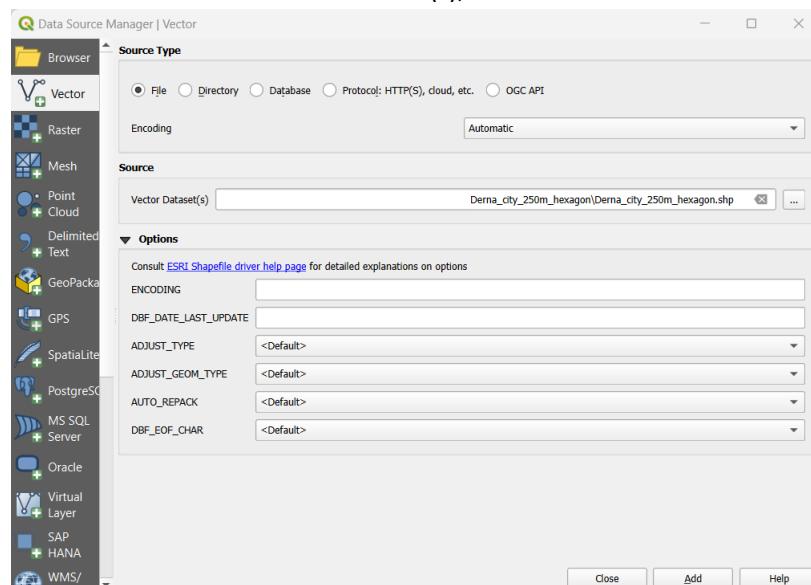
Click on Layer → Add Layer → Add Vector Layer...



The Data Source Manager | Vector dialog box opens

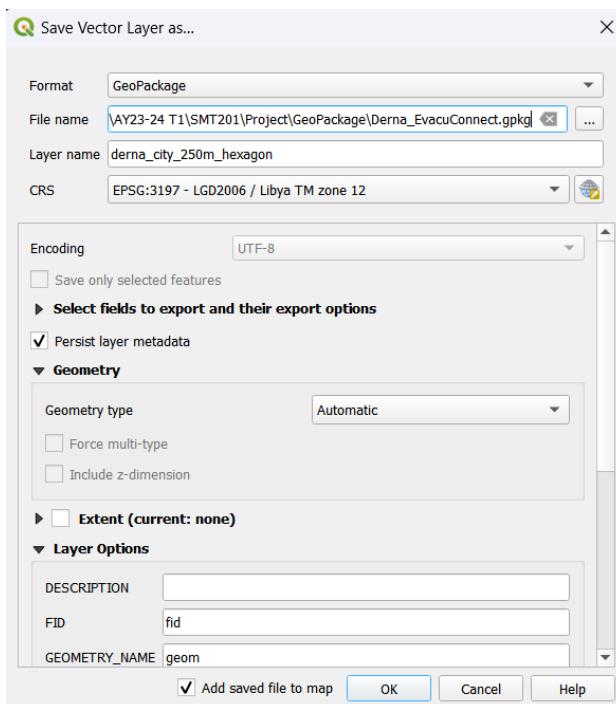


- Under Source > Vector Dataset(s), select Derna_city_250m_hexagon.shp



- Click Add once done

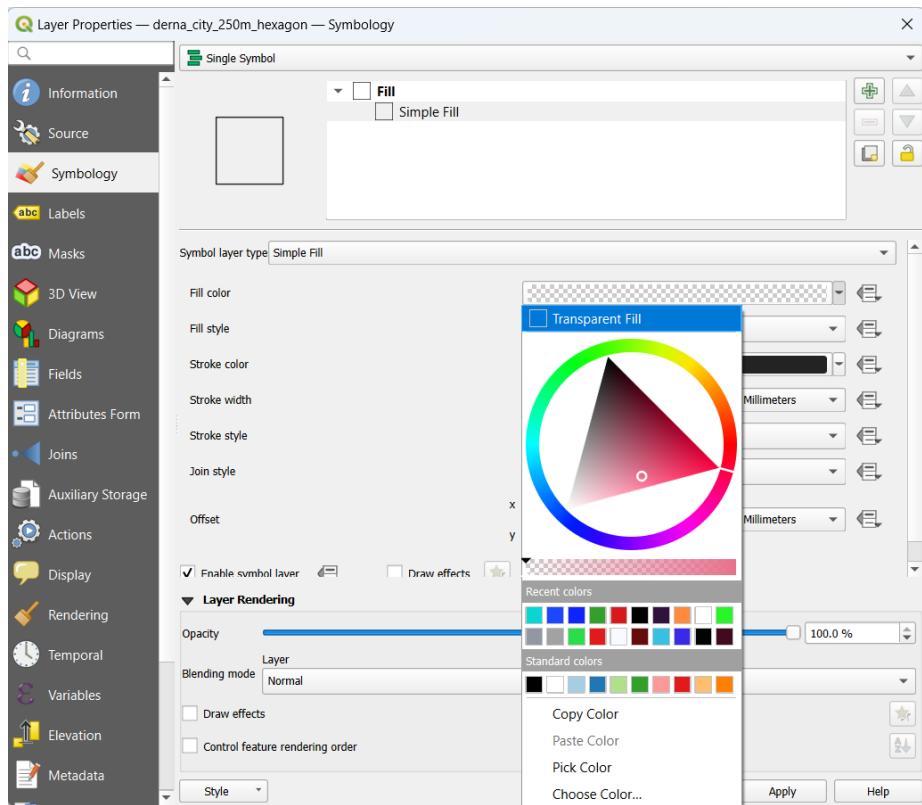
- Save the layer into GeoPackage. Call it '**EvacuConnect**'.
 - For **CRS**, select EPSG:3197 – LGD2006 / Libya TM zone 12
 - For **Layer name**, use 'derna_city_250m_hexagon'
 - Click on **OK** once done



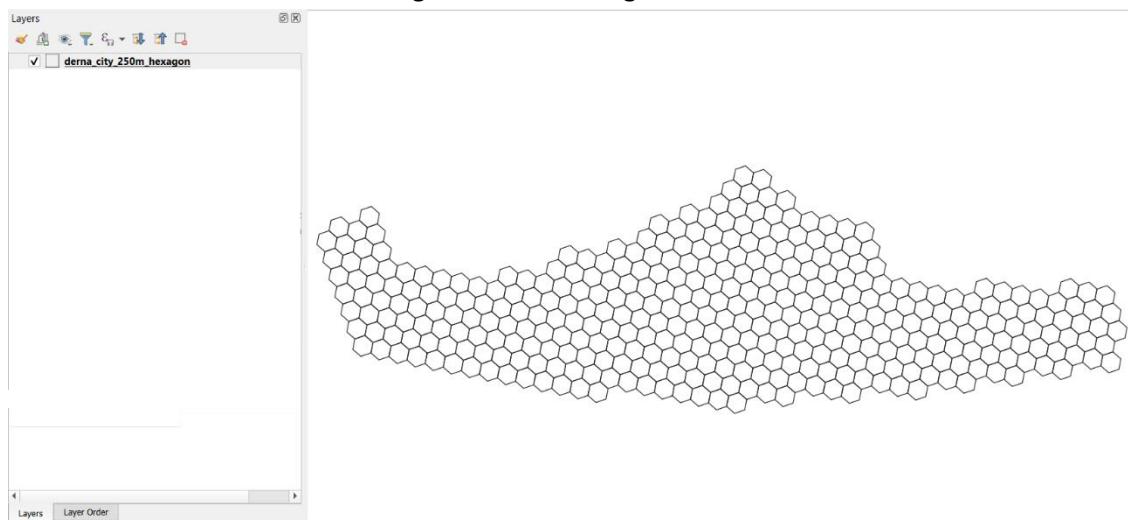
Right click on the layer → **Properties...**

The **Layer Properties** dialog box opens

- Click on **Symbology**
- Click on **Simple Fill**
- Under **Fill color**, set the fill to **Transparent Fill**
- Click on **Apply**, then **OK** once done



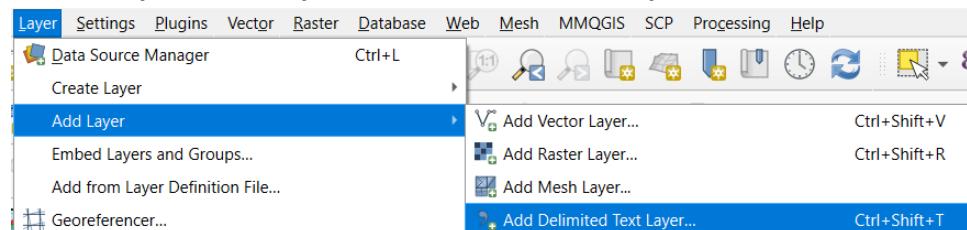
Your screen should look something like the following:



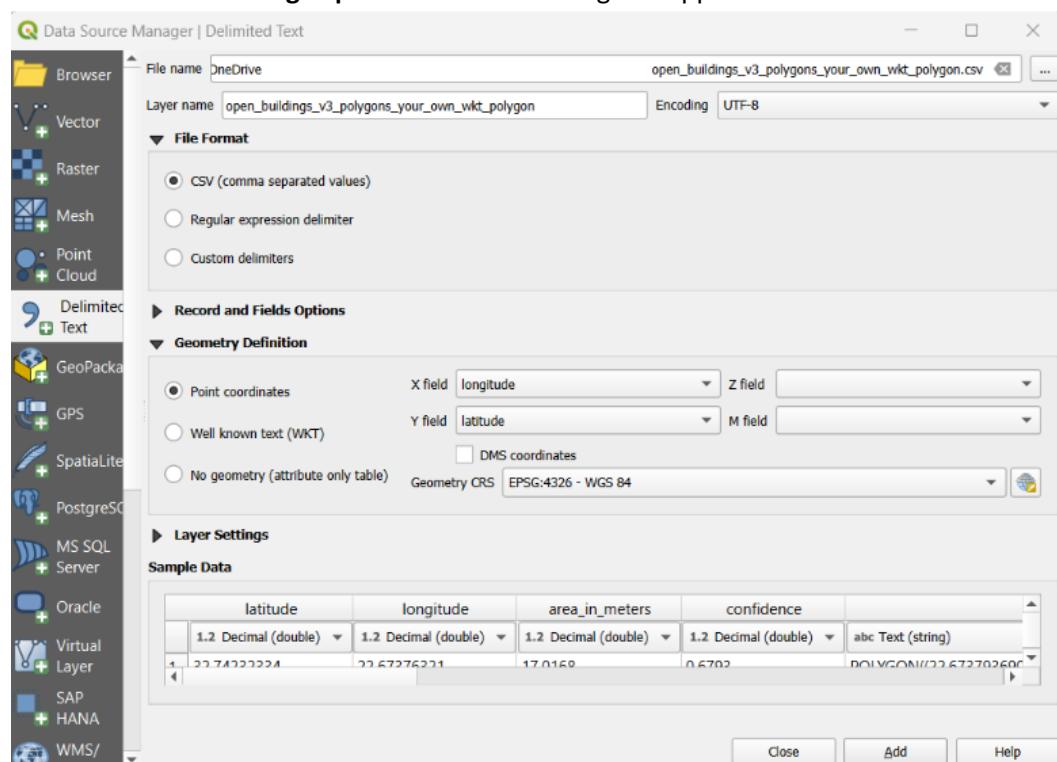
5.2.3.2 Derna City Building Footprint

Building Centroids (Pre-Flood)

Click on Layer → Add Layer → Add Delimited Text Layer...

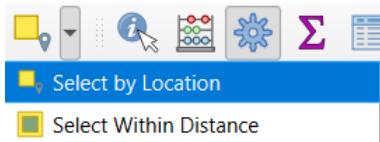


The Data Source Manager | Delimited Text dialog box appears

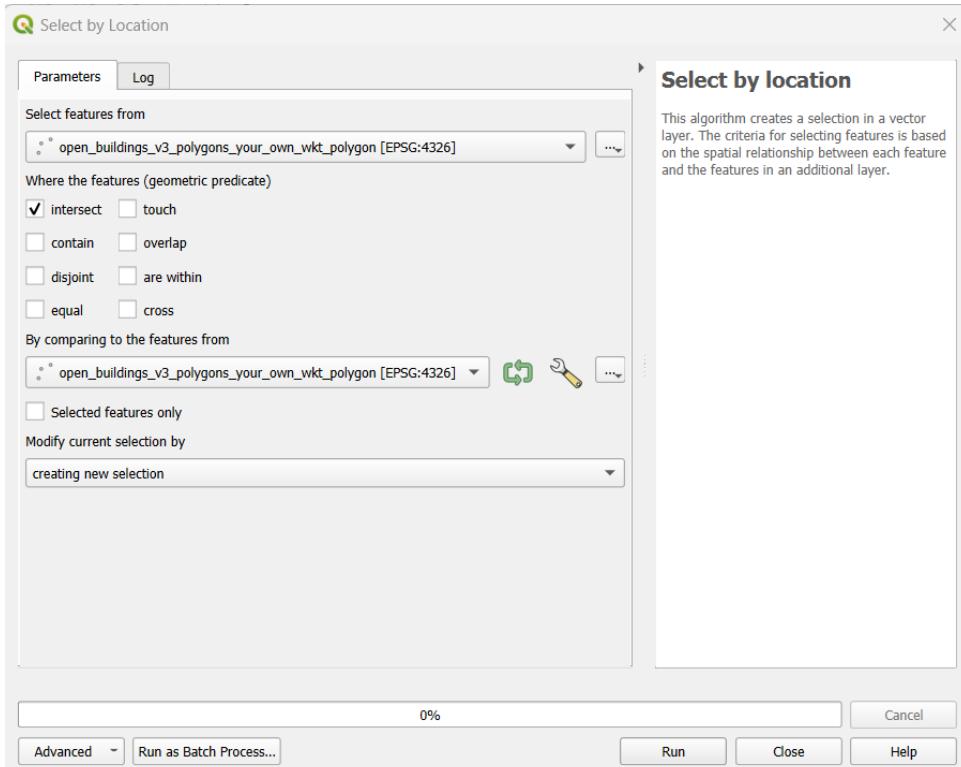


- For File name, click on and select open_buildings_v3_polygons_your_own_wkt_polygon
- Under **Geometry Definition**, select **Point coordinates**, the fields should autofill accordingly
- For **Geometry CRS**, select **EPSG: 4236 – WGS 84**
- Click **Add** once done

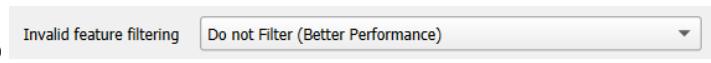
Click on **Select by Location**



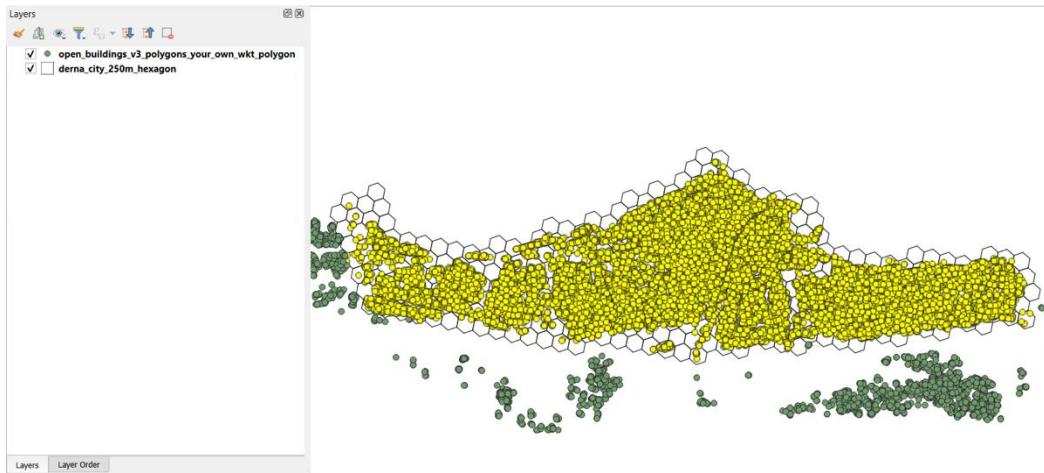
The **Select by Location** dialog box opens:



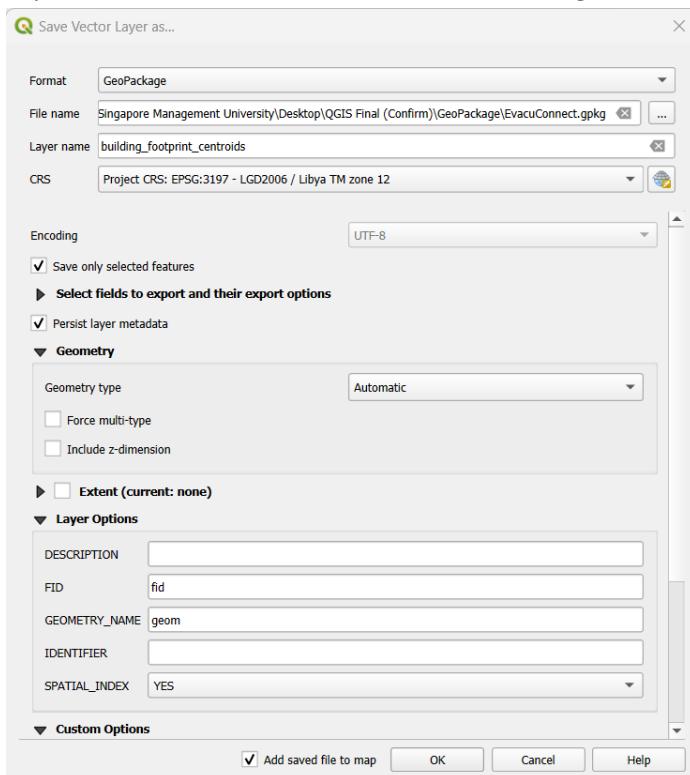
- For **Select features from**, select the **open_buildings_v3_polygons_your_own_wkt_polygon [EPSG:4326]** point layer
- For **where the features (geometric predicate)**, select **intersect**
- For **By comparing to the features from**, select the **derna_city_250m_hexagon [EPSG:3197]** layer
 - Click on  , change to
- Click **Run** once done. It will take some time to load



Your screen would look something like below:

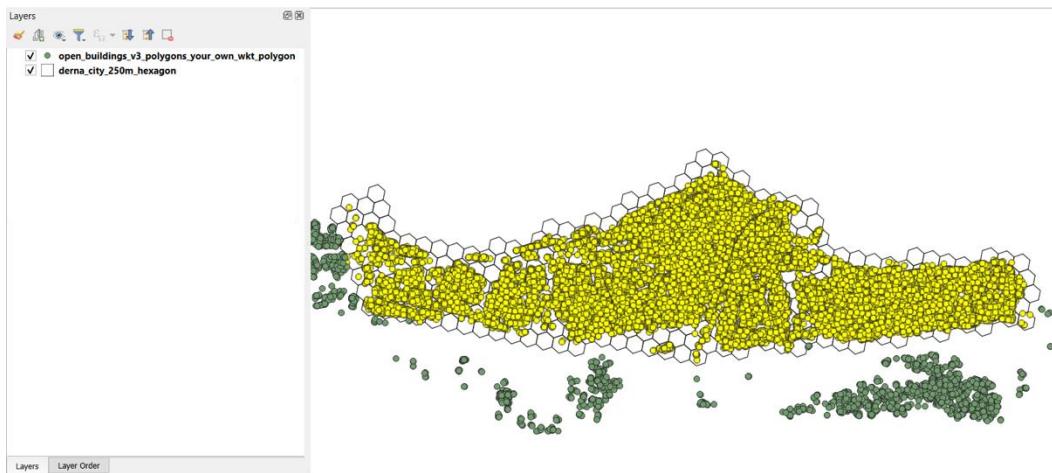


Export the Selected Features into the GeoPackage:



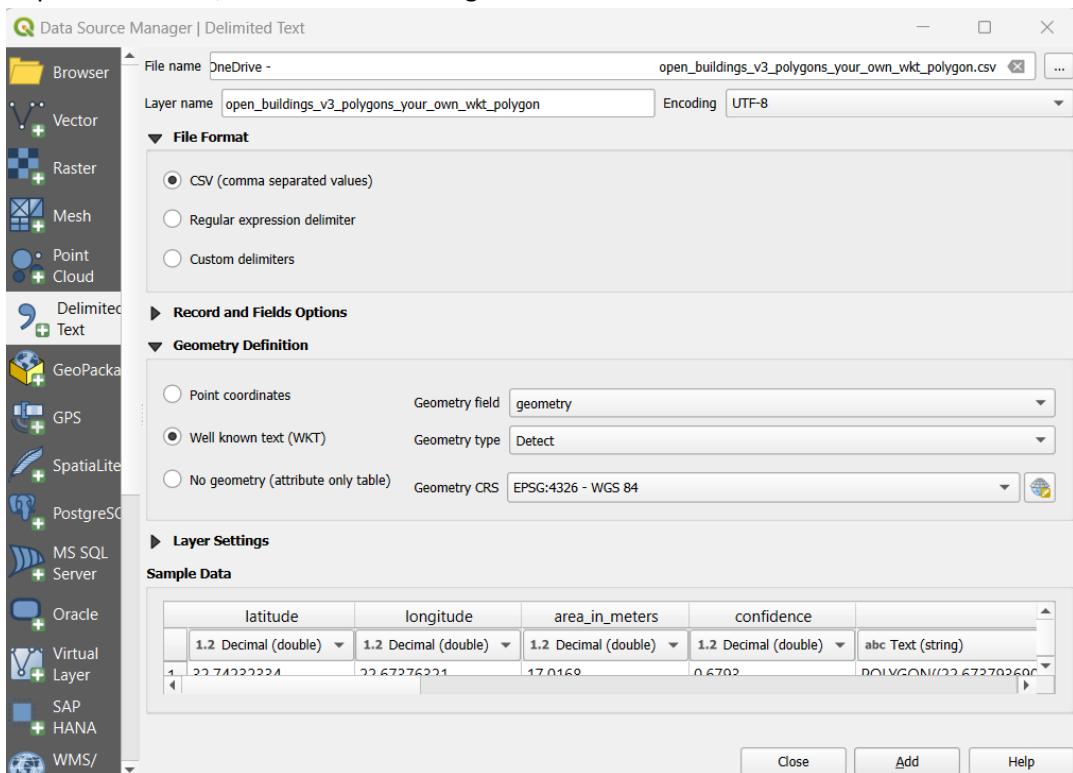
- For Layer name, use '**building_footprint_centroids**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Ensure that the **Save only selected features** checkbox is selected
- Click **OK**

Your screen would look something like below:



Building Polygons (Pre-Flood)

Repeat the above, this time for buildings.



	latitude	longitude	area_in_meters	confidence	geometry
1	32.74322224	22.67376221	17.0169	0.6702	POLYGON((22.673762600...

Close

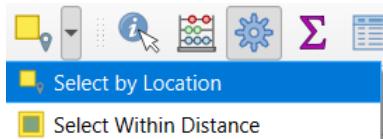
Add

Help

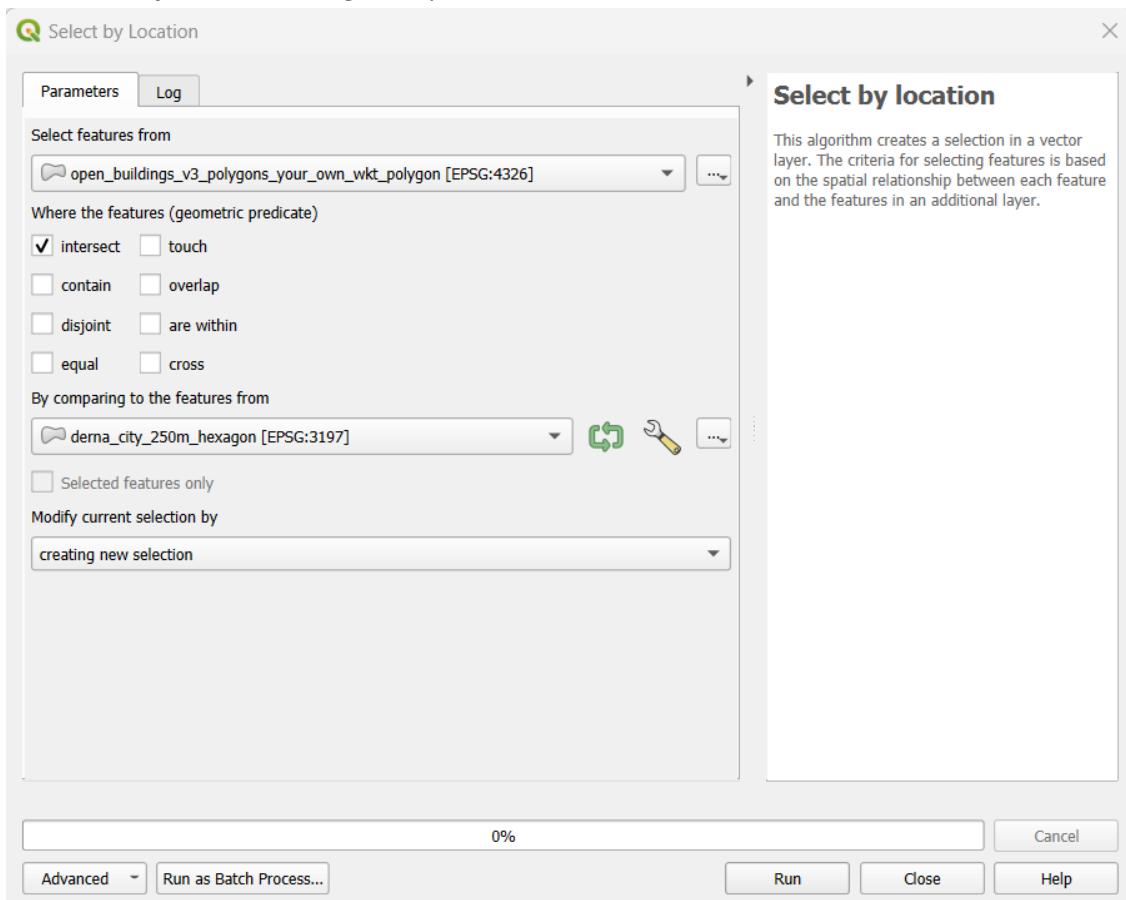
- For File name, click on and select open_buildings_v3_polygons_your_own_wkt_polygon
- Under **Geometry Definition**, select **Well known text (WKT)**
- For **Geometry field**, select **geometry**
- For **Geometry type**, select **Detect**

- For **Geometry CRS**, select **EPSG: 4236 – WGS 84**
- Click **Add** once done

Click on **Select by Location**

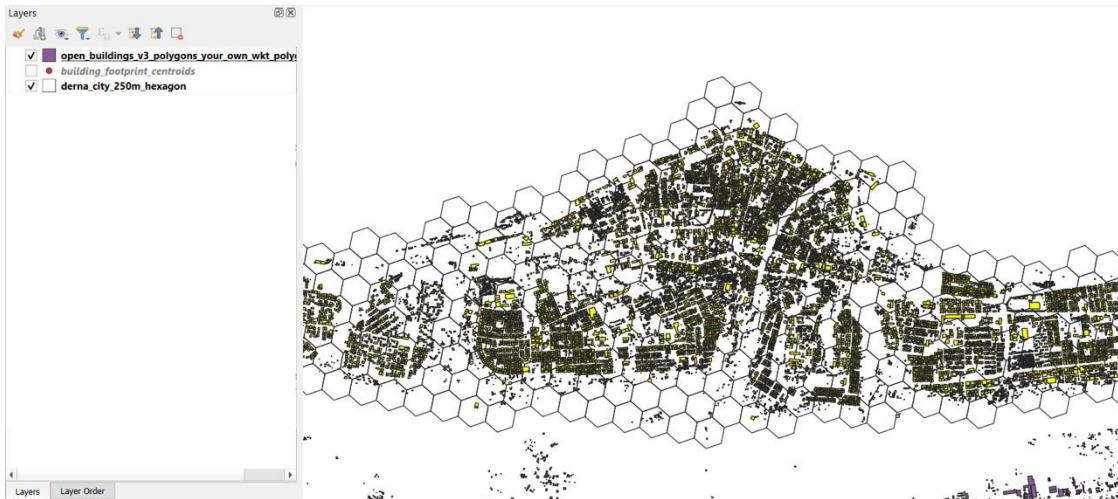


The **Select by Location** dialog box opens:

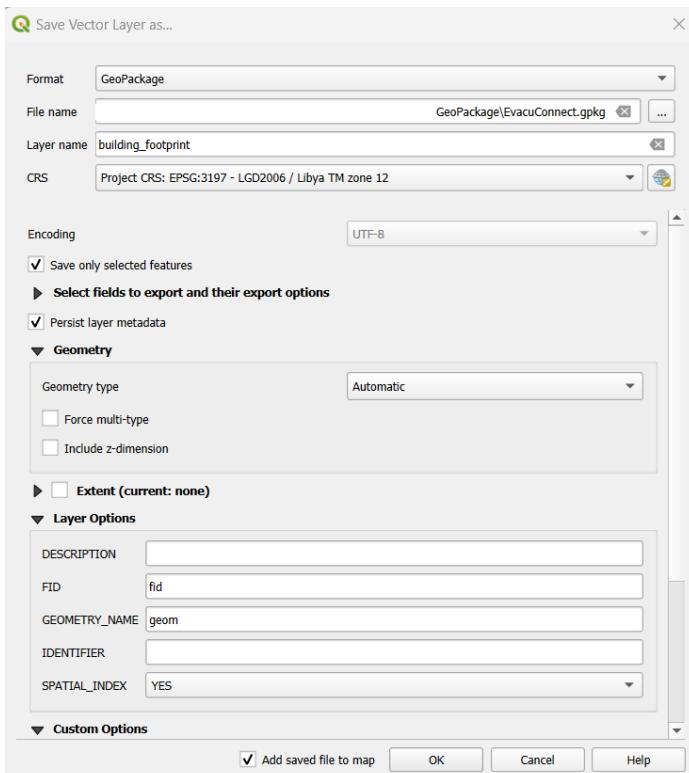


- For **Select features from**, select the **open_buildings_v3_polygons_your_own_wkt_polygon [EPSG:4326]** layer
- For **By comparing to the features from**, select the **derna_city_250m_hexagon [EPSG:3197]** layer
 - Click on , change to
- Click **Run** once done, it will take some time to load

Your screen should like something like this:



Export the Selected Features into the GeoPackage:



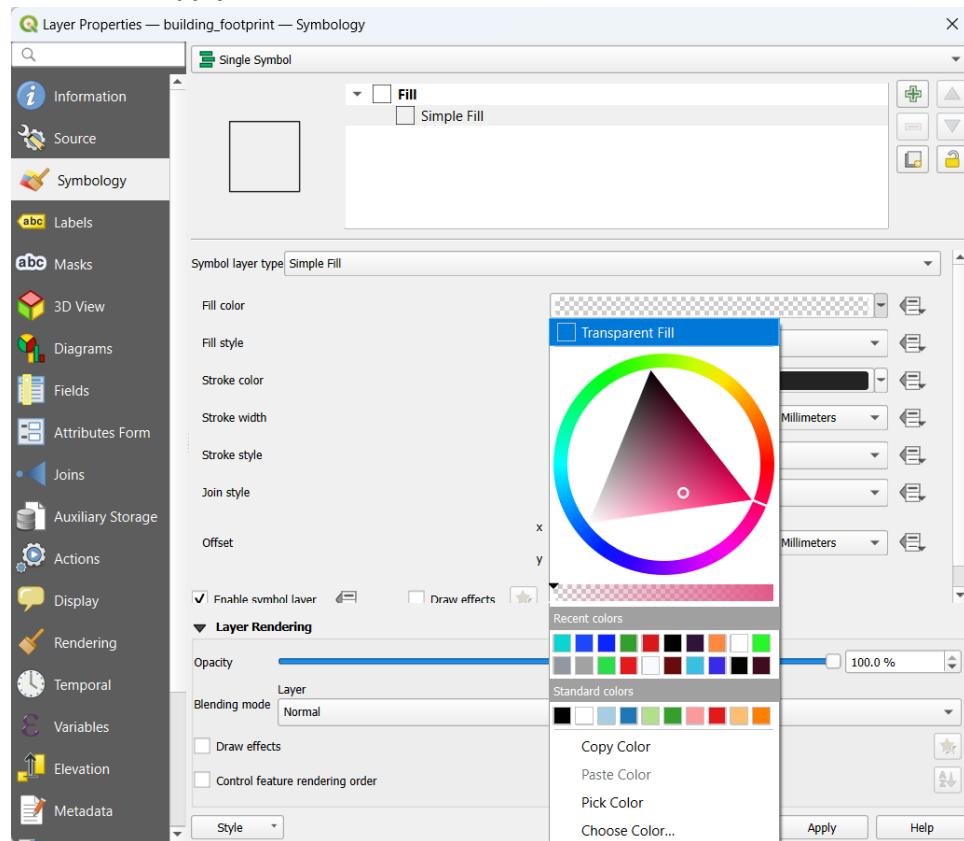
- For Layer name, use '**building_footprint**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Ensure that the **Save only selected features** checkbox is selected

- Click **OK**

Right click on the layer > **Properties...**

The **Layer Properties** dialog box opens

- Click on **Symbology**
- Click on **Simple Fill**
- Under **Fill color**, set the fill to **Transparent Fill**
- Click on **Apply**, then **OK** once done



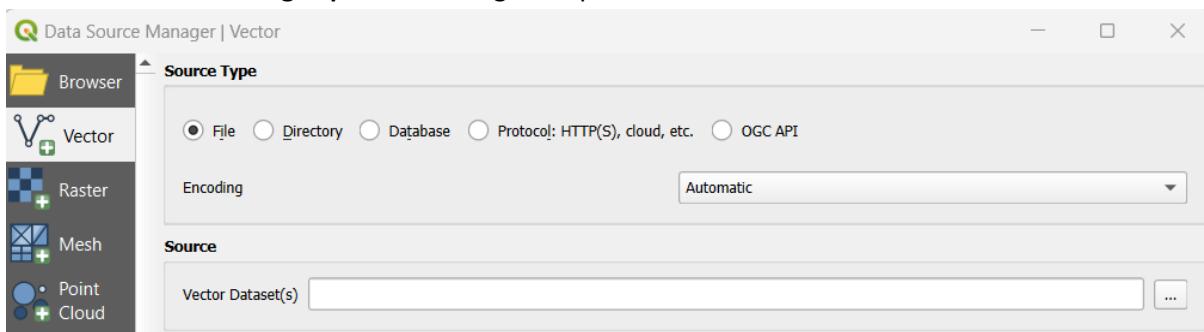
5.2.3.3 Flood Impact Assessment

Flood Extent

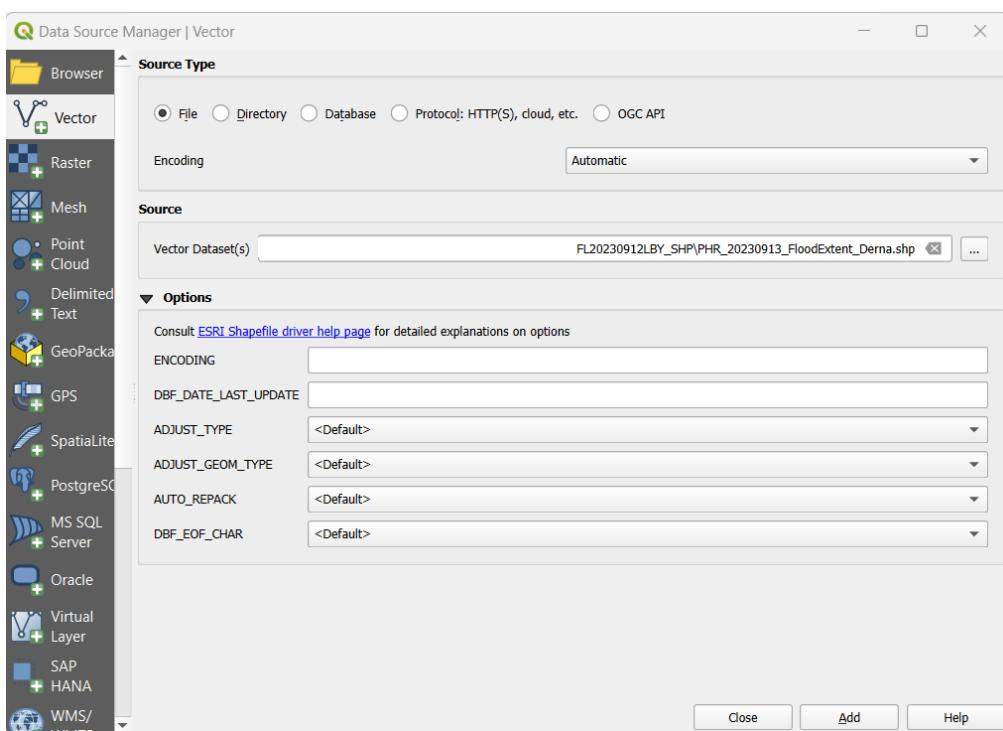
Click on Layer → Add Layer → Add Vector Layer...



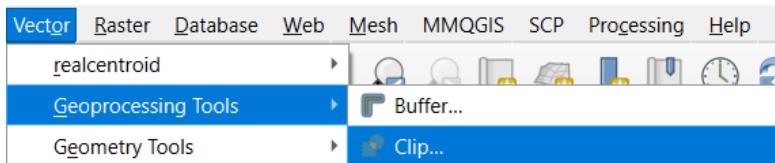
The Data Source Manager | Vector dialog box opens



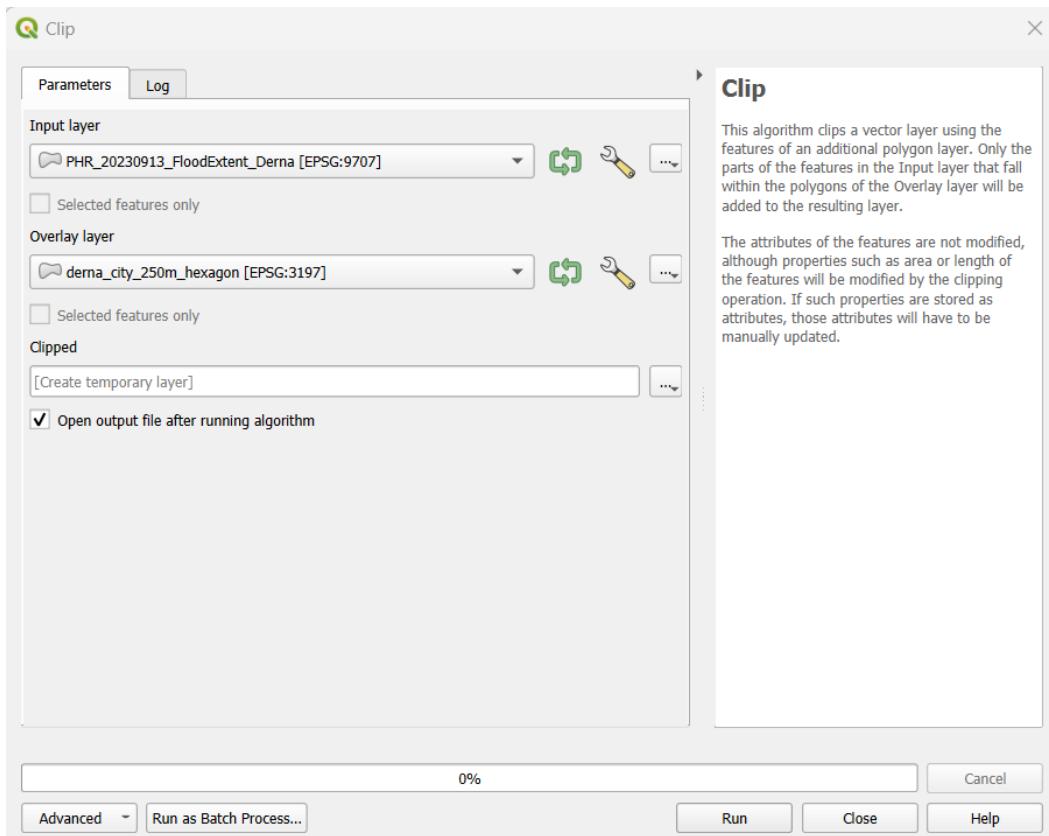
- Under Source > Vector Dataset(s), select PHR_20230913_FloodExtent_Derna.shp
- Click Add once done



Under **Vector**, select **Geoprocessing Tools > Clip**



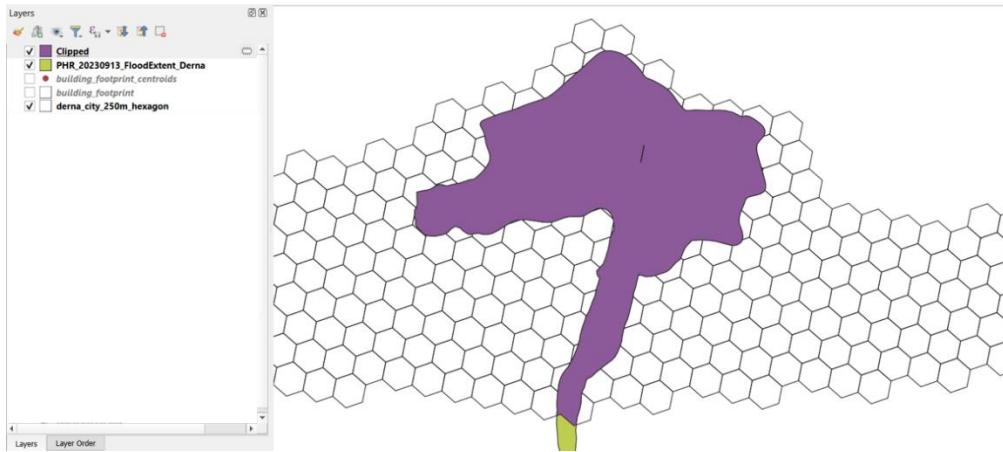
The **Clip** dialog box opens



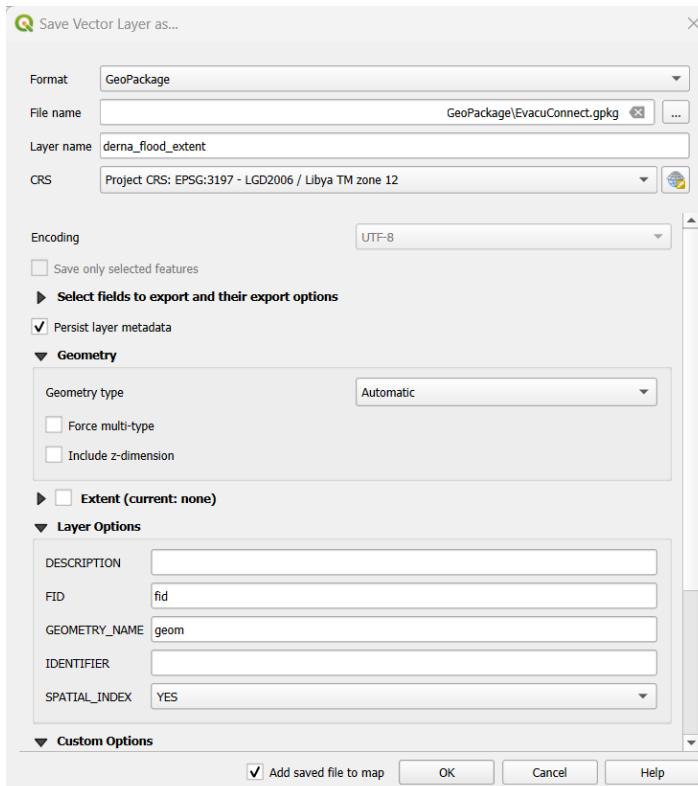
- For **Input layer**, select **PHR_20230913_FloodExtent_Derna [EPSG:9707]**
- For **Overlay layer**, select **derna_city_250m_hexagon [EPSG:3197]**

- Click on  , change to
- Click **Run** once done

Your screen would look something like below:



Export the **Clipped** layer into GeoPackage



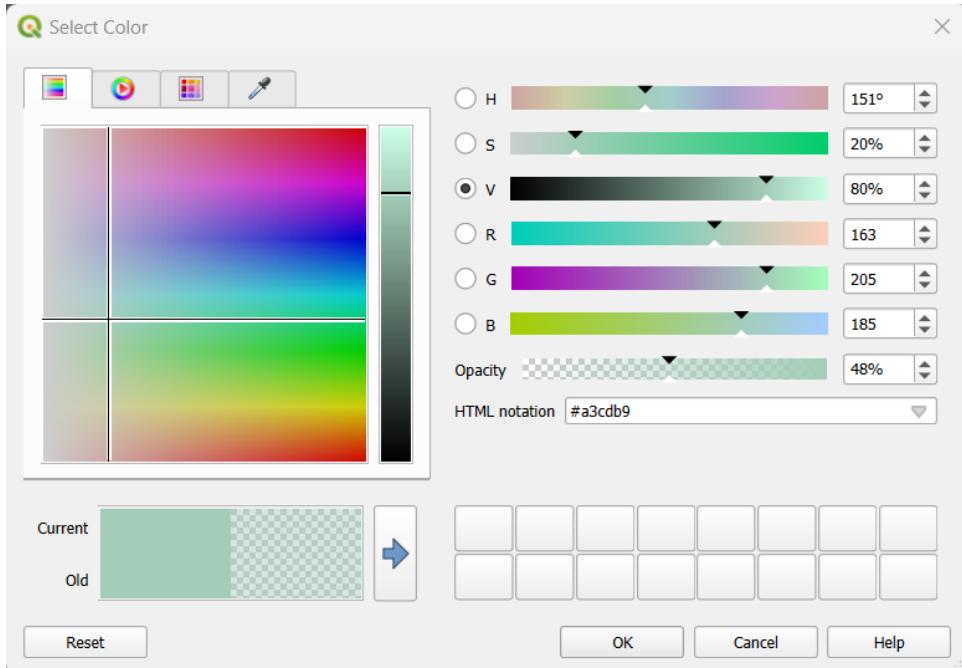
- For Layer name, use '**derna_flood_extent**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK** once done
- Remove the temporary **Clipped** layer and the **PHR_20230913_FloodExtent_Derna** layer

Right click on the layer > **Properties...**

The **Layer Properties** dialog box opens

- Click on **Symbology**
- Click on **Simple Fill**
- Under **Fill color**, select **Choose Color...**

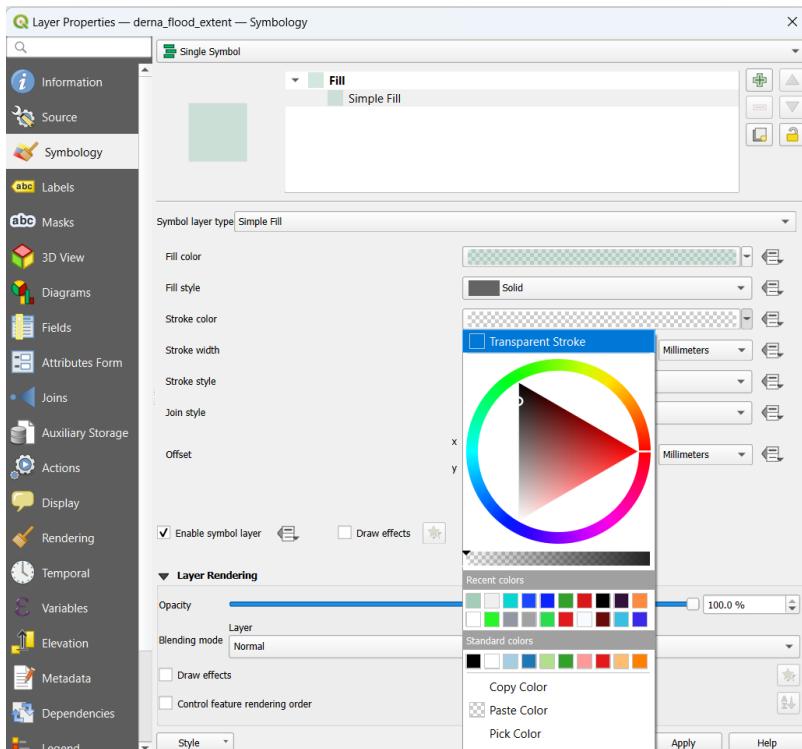
The **Select Color** dialog box opens:



- For **Opacity**, set to **48%**
- For **HTML notation**, type **#a3cdb9**
- Click **OK** once done

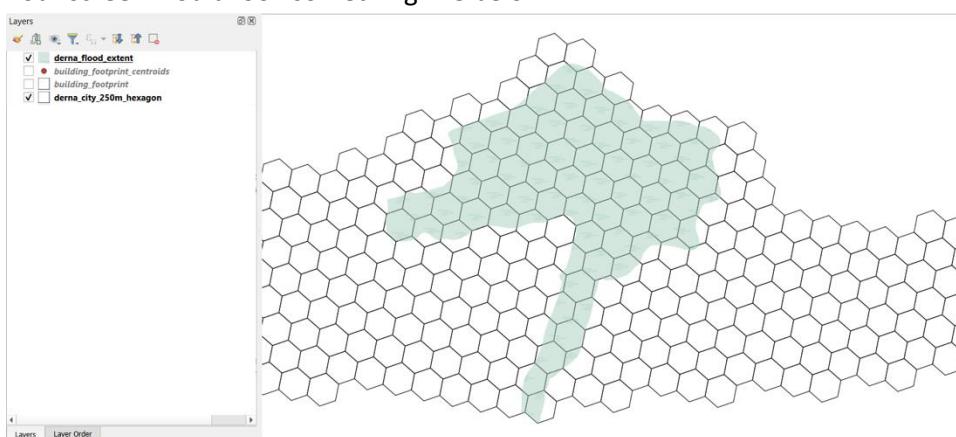
Back at the **Layer Properties** dialog box,

- Under **Stroke Color**, select **Transparent Fill**



- Click on **Apply** once done

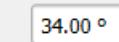
Your screen would look something like below:

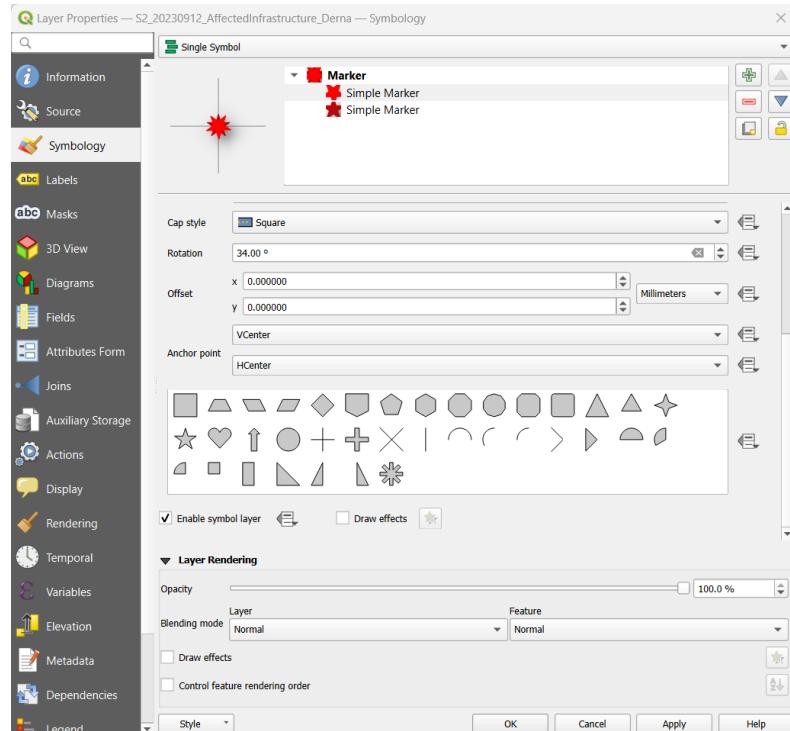


Affected Infrastructure

 S2_20230912_AffectedInfrastructure_Derna.shp > This data file consists of the locations of infrastructure in Derna City affected by the flood such as bridges (**Dated 12 September 2023**)

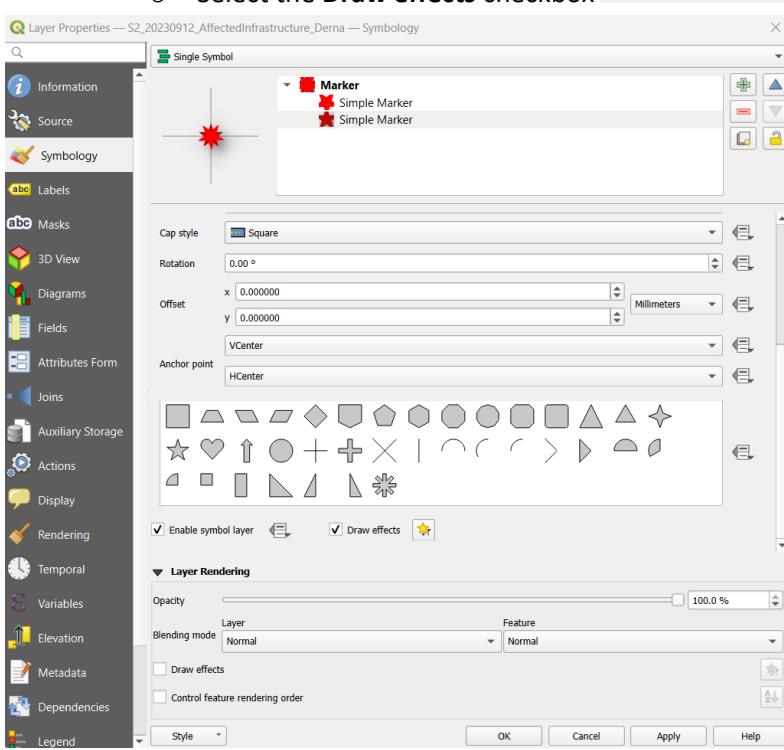
To symbolise the structure as damaged, right click the layer > **Properties** > **Symbology**

- Click the  twice to add 2 new Simple Markers
- For the first Simple Marker:
 - Set **Size** to **6**
 - For **Fill color** and **Stroke color**, click on the dropdown >  > set **HTML notation** to **#ff0000**  > Click **OK**
 - Set **Rotation** to **34.00** 
 - Select the star shape 



- For the second Simple Marker:

- Set **Size** to **5.5**

- For **Fill color** and **Stroke color**, click on the dropdown > **Choose Color...** > set **HTML notation** to **#b80808** **HTML notation #b80808** > Click **OK**
 - Set **Rotation** to **0.00**
 - Select the star shape 
 - Select the **Draw effects** checkbox  
- 
- Click **Apply** > **OK** once done

Affected Structure

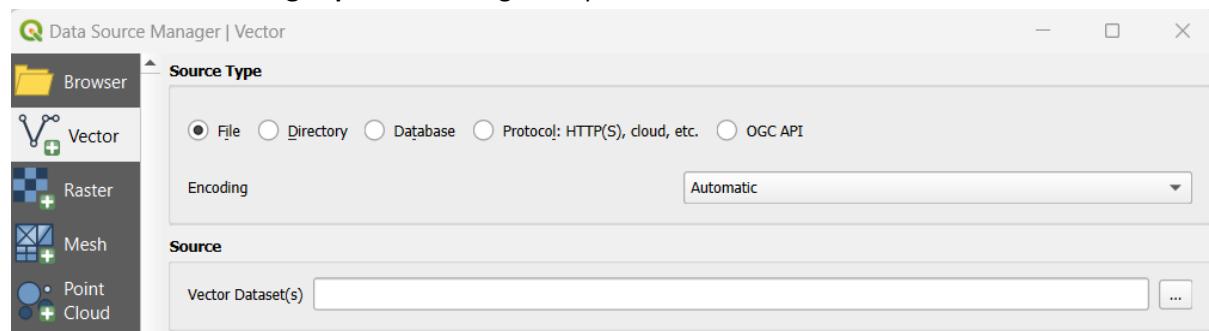
 **PHR_20230913_AffectedStructure_Derna.shp** > This data file consists of the locations of the buildings in Derna City affected by the flood (**Dated 13 September 2023**)

5.2.3.4 Dam Locations

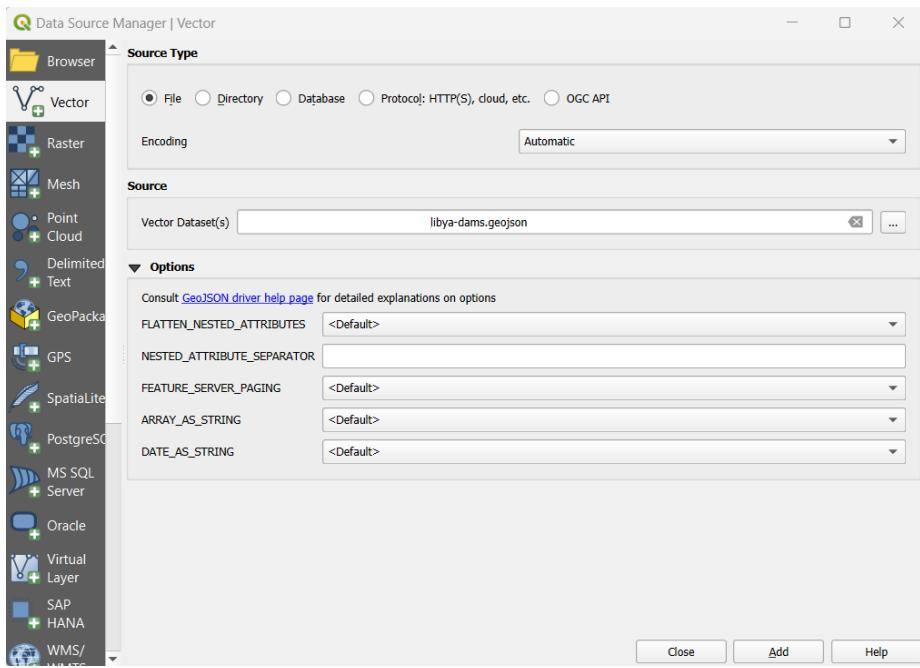
Click on Layer → Add Layer → Add Vector Layer...



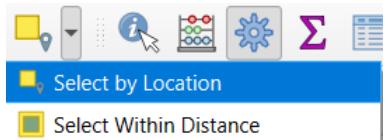
The Data Source Manager | Vector dialog box opens



- Under Source > Vector Dataset(s), select `libya-dams.geojson`
- Click **Add** once done

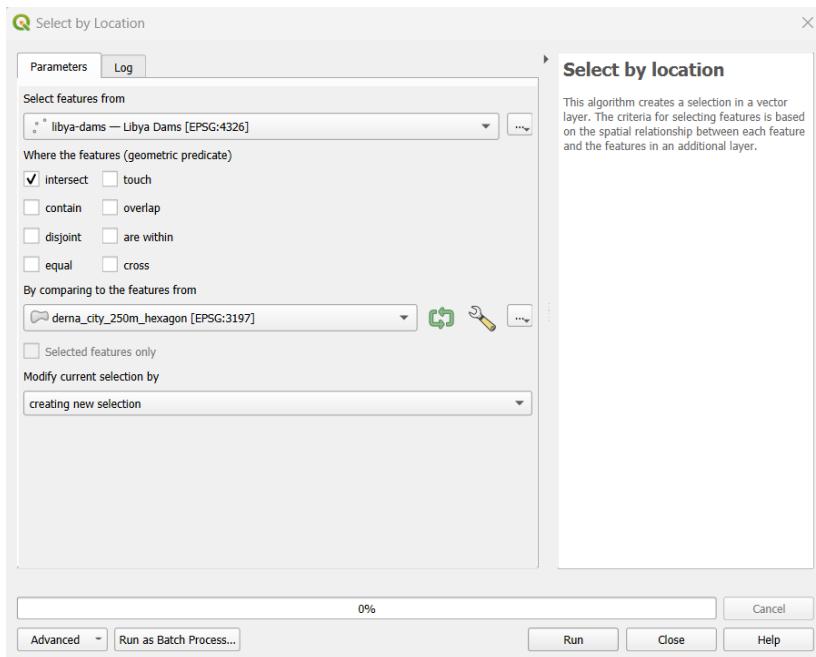


Click on **Select by Location**

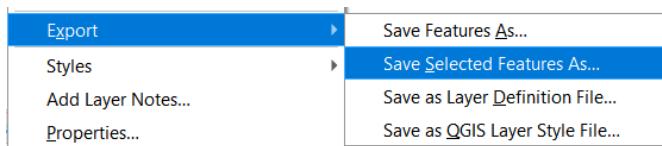


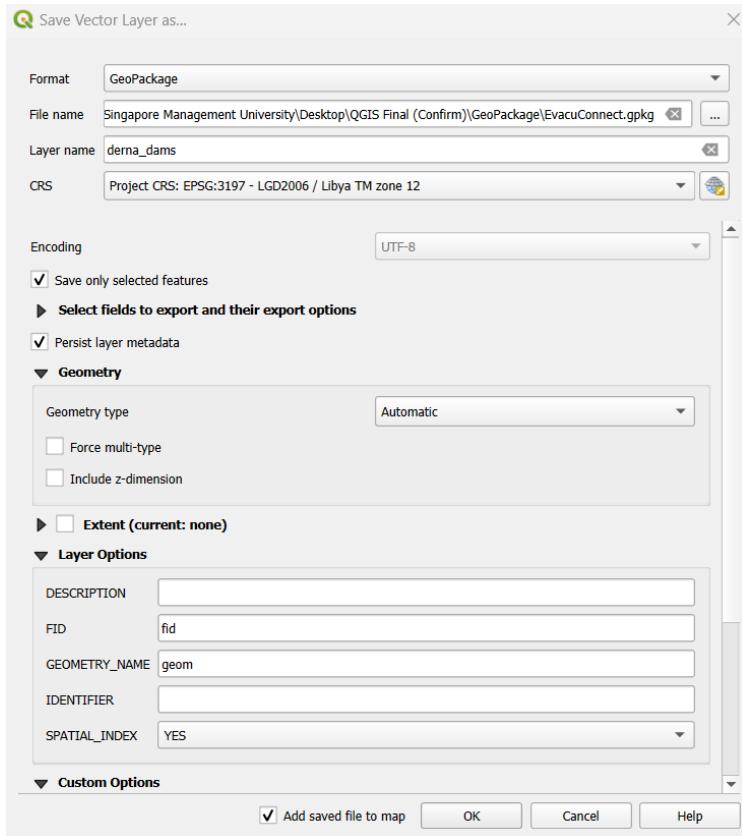
The **Select by Location** dialog box opens

- For **Select features from**, select the **libya-dams – Libya Dams [EPSG:4326]** layer
- For **By comparing to the features from**, select the **derna_city_250m_hexagon [EPSG:3197]** layer
 - Click on  , change to 
- Click **Run** once done



Export the Selected Features into the GeoPackage





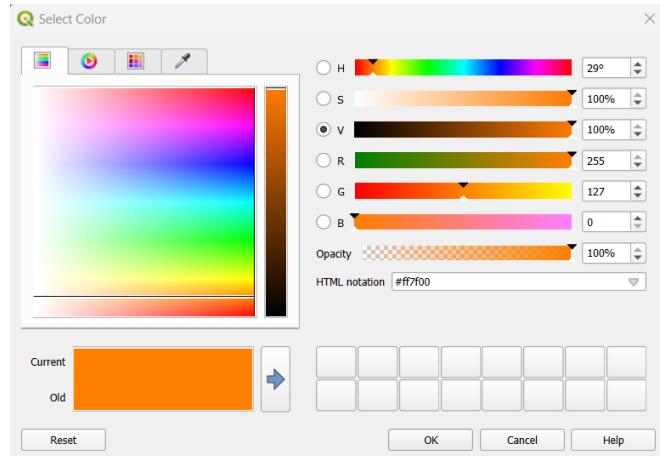
- For Layer name, use '**derna_dams**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Ensure that the **Save only selected features** checkbox is selected
- Click **OK**

Right click on the layer > **Properties...**

The **Layer Properties** dialog box opens

- Click on **Symbology**
- Click on **Simple Fill**
- Under **Fill color**, select **Choose Color...**

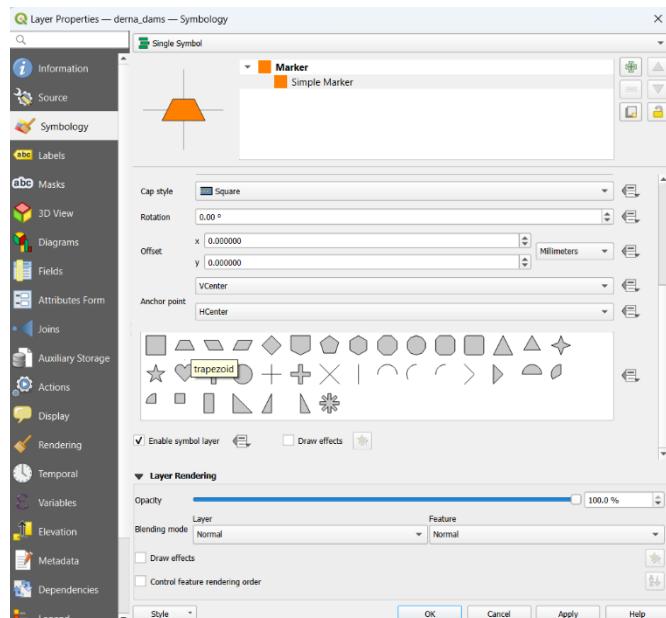
The **Select Color** dialog box opens:



- For **HTML notation**, type **#ff7f00**
- Click **OK** once done

Back at the **Layer Properties** dialog box,

- Select the **Trapezoid** shape
- Click **Apply** and then **OK** once done

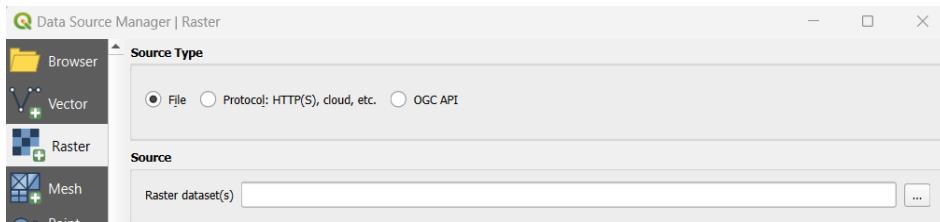


5.2.3.5 Satellite Pre- & Post-flood

Under **Layer > Add Layer > Add Raster Layer...**

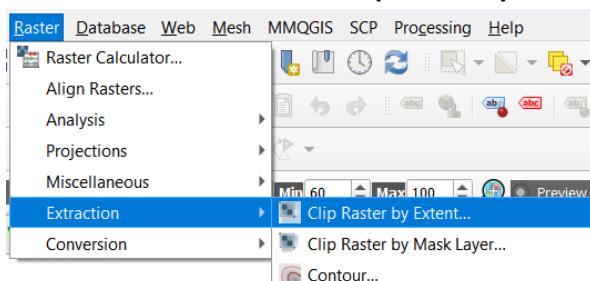


The Data Source Manager | Raster dialog box opens



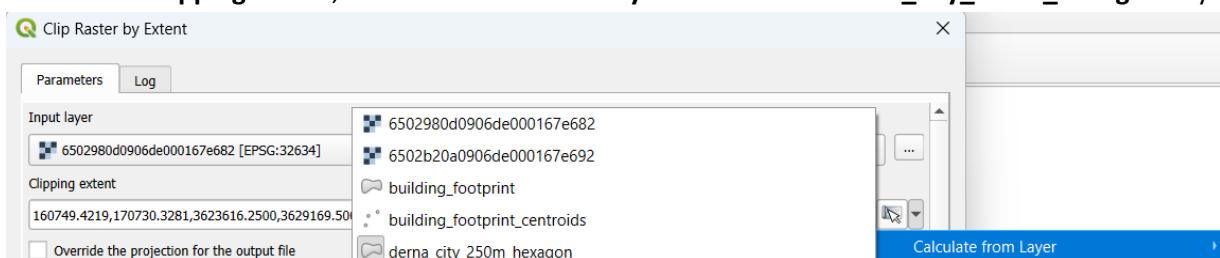
- For Raster dataset(s), select 6502b20a0906de000167e692 (Pre-flood) and 6502980d0906de000167e682 (Post-flood)

Under Raster > Extraction > Clip Raster by Extent...



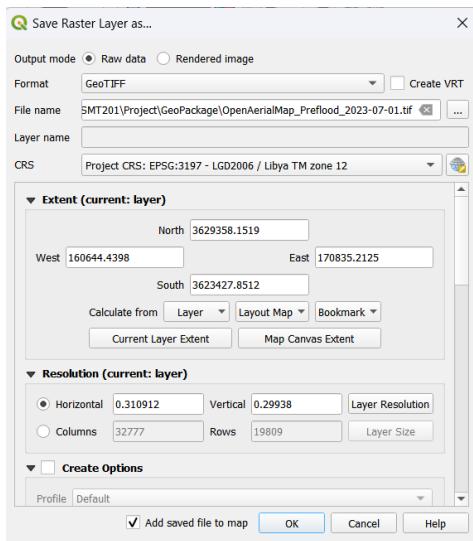
The Clip Raster by Extent dialog box opens

- For Input layer, select either the 6502b20a0906de000167e692 (Pre-flood) or the 6502980d0906de000167e682 (Post-flood) layer
- For Clipping extent, select Calculate from layer & select the 'derna_city_250m_hexagon' layer



- Click Run once done
- Repeat for the other layer

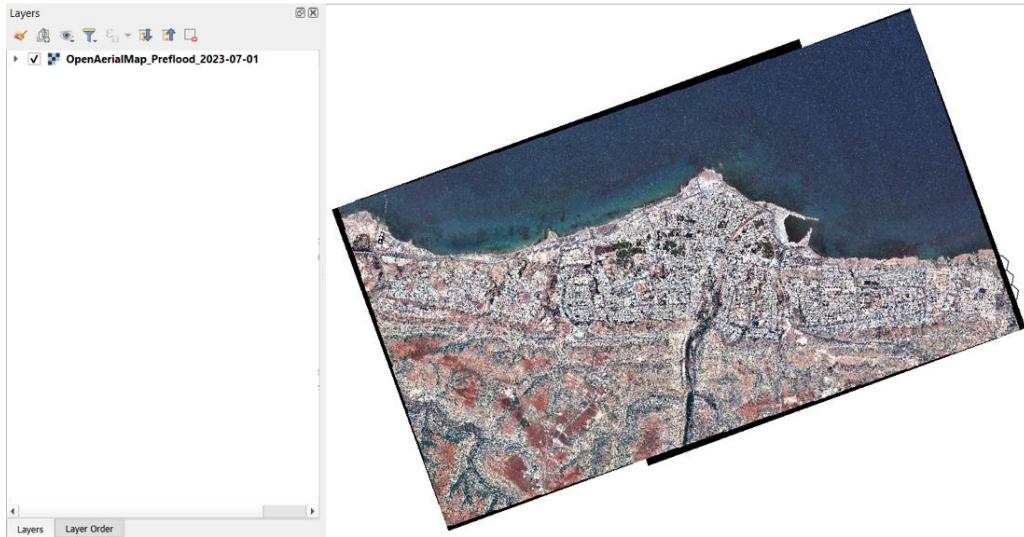
Export the Clipped (extent) Raster layers into GeoPackage



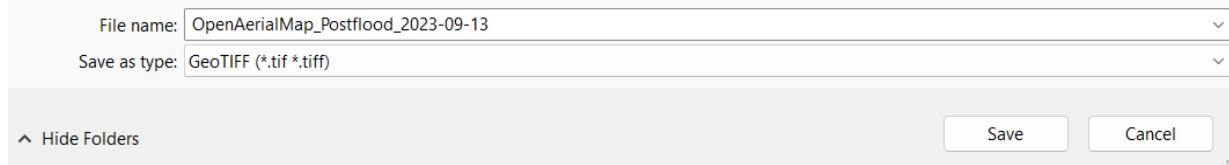
For File name, if it is the **(Pre-flood)** layer, use the name
'OpenAerialMap_Postflood_2023-07-01'



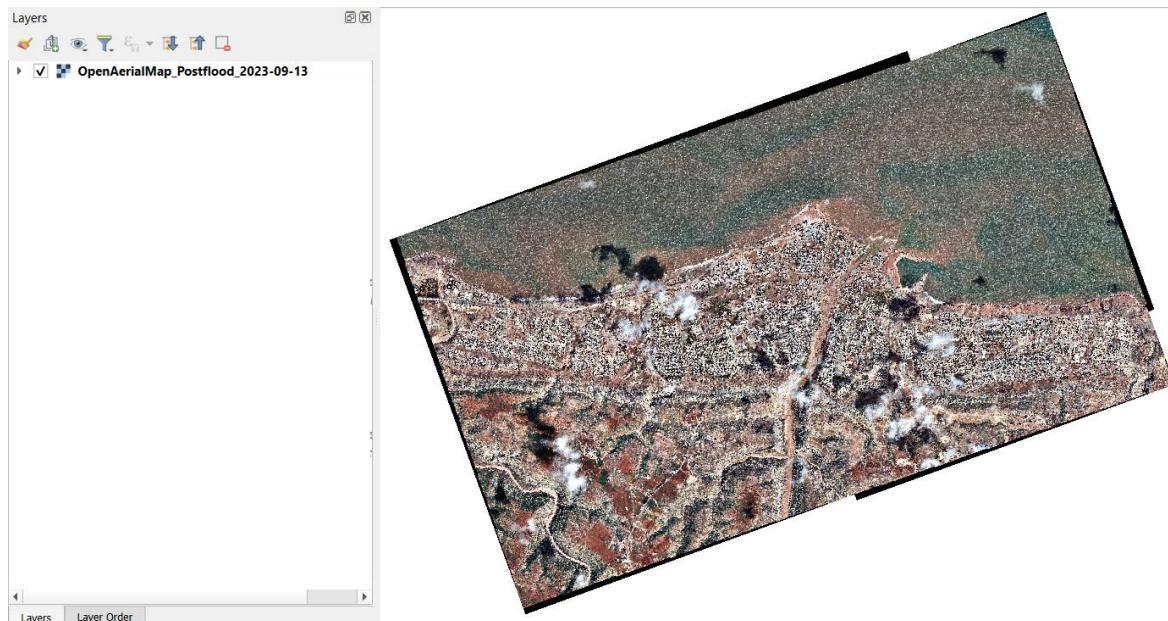
Your screen should look something like the following:



For File name, if it is the  6502980d0906de000167e682 **(Post-flood)** layer, use the name
'OpenAerialMap_Postflood_2023-09-13'



Your screen should look something like the following:



Note: The clipped Satellite imagery may look pixelated. This is normal and it is due to limitations of graphic processing when undergoing Raster Clipping. You will realize when you zoom in and compare to the original layer that the pixels are the same as the original and there is no compromise of quality due to the resolution being the same.

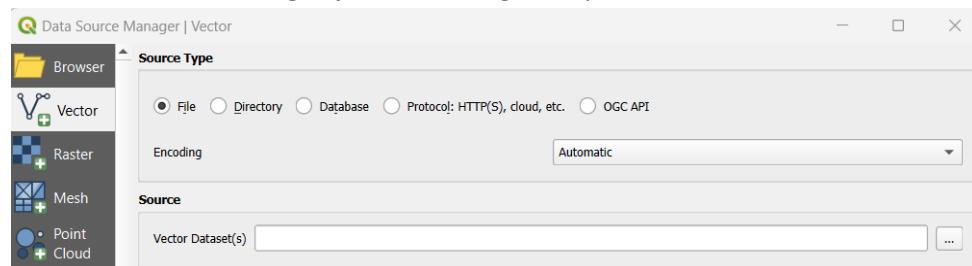
5.2.3.6 Derna OpenStreetMap Data

Road Networks (Pre-flood)

Click on Layer → Add Layer → Add Vector Layer...



The Data Source Manager | Vector dialog box opens

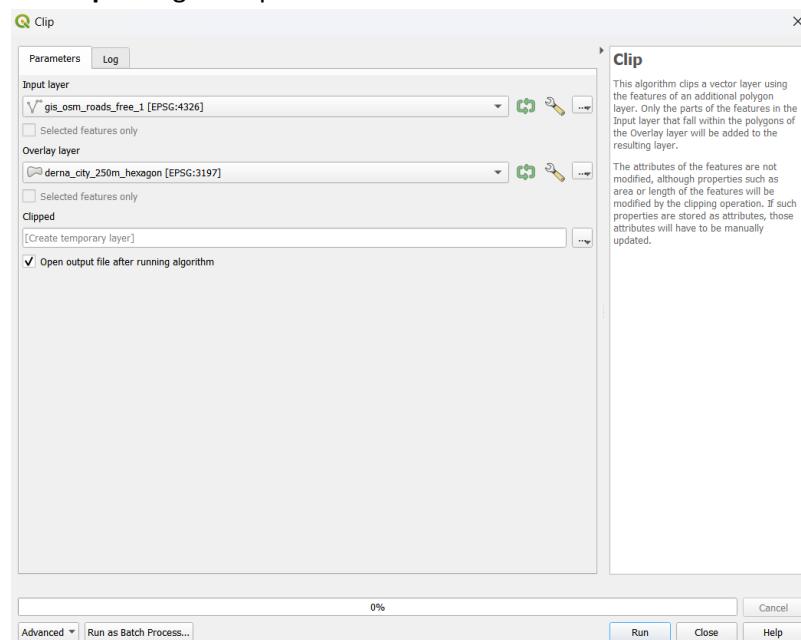


- Under Source > Vector Dataset(s), select gis_osm_roads_free_1.shp from libya-230901-free.shp

Under Vector, select Geoprocessing Tools > Clip



The Clip dialog box opens



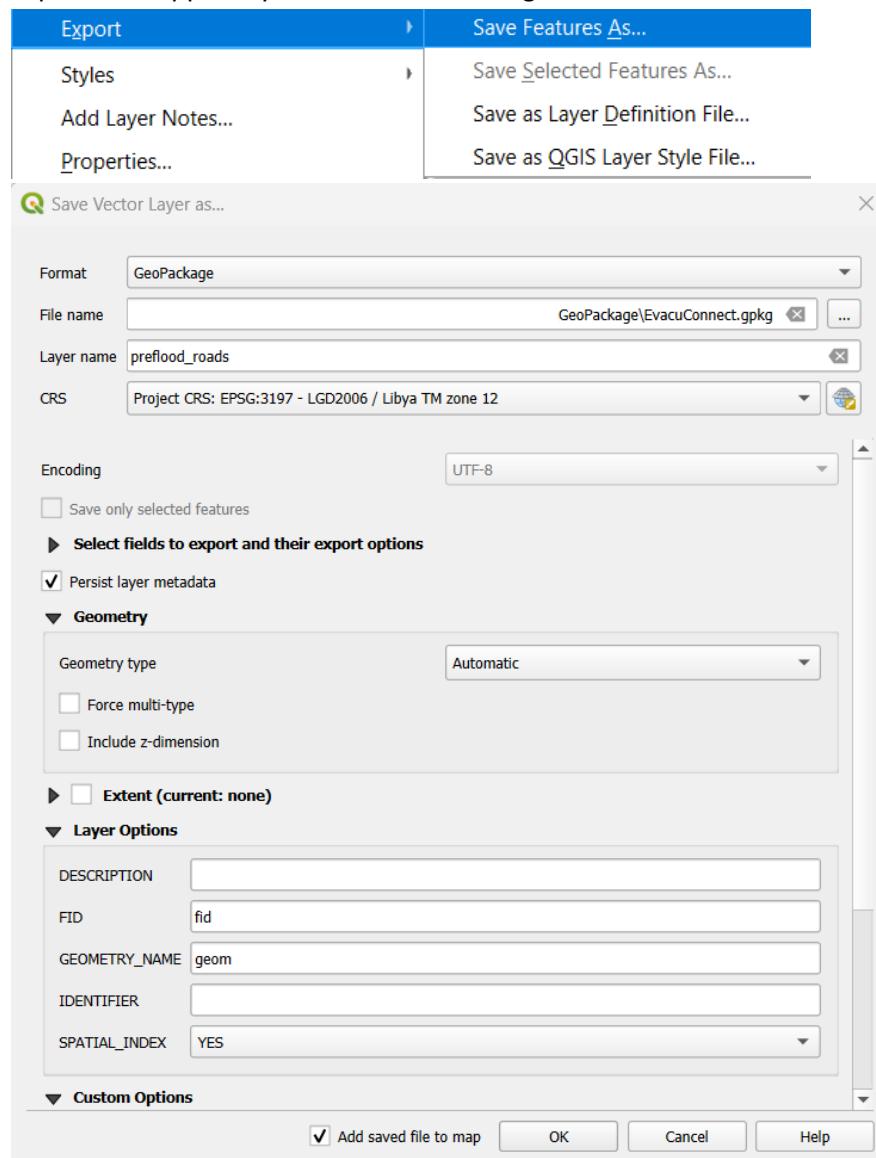
- For Input layer, select gis_osm_roads_free_1 [EPSG:4326]

- For **Overlay layer**, select **derna_city_250m_hexagon [EPSG:3197]**

○ Click on  , change to Invalid feature filtering Do not Filter (Better Performance) ▾

- Click **Run** once done

Export the Clipped layer into the GeoPackage



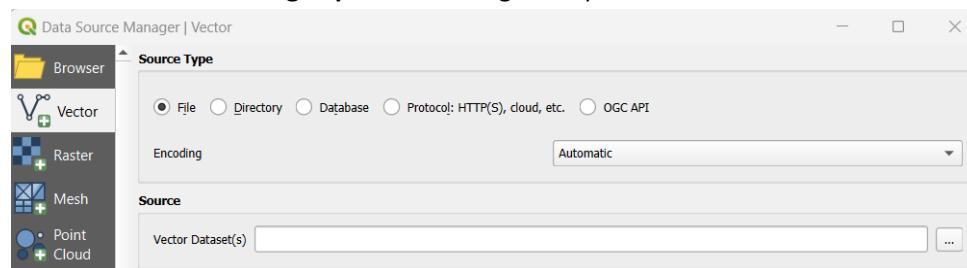
- For Layer name, use '**preflood_roads**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Evacuation Centres & Medical Facilities

Click on Layer → Add Layer → Add Vector Layer...



The Data Source Manager | Vector dialog box opens



- Under Source > Vector Dataset(s), select gis_osm_pois_a_free_1.shp from libya-231001-free.shp

Note:

- When comparing Pre-flood and Post-Flood OSM data, there is minimal difference. However, **Pre-flood (left)** data is missing a school which is found in **Post-flood (right)** data.

preflood_pois — Features Total: 22, Filtered: 22, Selected: 0					postflood_pois — Features Total: 23, Filtered: 23, Selected: 1				
fid	osm_id	code	fclass	name	fid	osm_id	code	fclass	name
1	28 971162121	2081	university	المعهد المتوسط...	1	28 971162121	2081	university	المعهد المتوسط...
2	26 971132894	2081	university	المعهد العالي لل...	2	26 971132894	2081	university	المعهد العالي لل...
3	24 909439985	2082	school	NULL	3	24 909439985	2082	school	NULL
4	21 785737378	2082	school	NULL	4	21 785737378	2082	school	NULL
5	20 785737377	2082	school	NULL	5	20 785737377	2082	school	NULL
6	17 785704111	2081	university	NULL	6	17 785704111	2081	university	NULL
7	12 785572272	2082	school	NULL	7	13 785572272	2082	school	NULL
8	11 785572271	2007	library	NULL	8	12 785572271	2007	library	NULL
9	10 785572270	2081	university	NULL	9	11 785572270	2081	university	NULL
10	9 785559385	2082	school	NULL	10	10 785559385	2082	school	NULL
11	8 785559384	2082	school	NULL	11	9 785559384	2082	school	NULL
12	7 785559383	2082	school	NULL	12	8 785559383	2082	school	NULL
13	5 785558245	2082	school	NULL	13	6 785558245	2082	school	NULL
14	41 1002574828	2082	school	NULL	14	49 12027908801	2082	school	مدرسة الصبا...
15	40 1002566681	2082	school	NULL	15	41 1002574828	2082	school	NULL
16	38 1002566668	2082	school	NULL	16	40 1002566681	2082	school	NULL
17	37 1002566666	2082	school	NULL	17	38 1002566668	2082	school	NULL
18	36 1002383928	2082	school	NULL	18	37 1002566666	2082	school	NULL
19	35 1002383927	2082	school	NULL	19	36 1002383928	2082	school	NULL
20	34 1002383926	2082	school	مدرسة اسماء الله...	20	35 1002383927	2082	school	NULL
21	33 1002383912	2082	school	NULL	21	34 1002383926	2082	school	مدرسة اسماء الله...
22	32 1002383911	2082	school	NULL	22	33 1002383912	2082	school	NULL
23					23	32 1002383911	2082	school	NULL

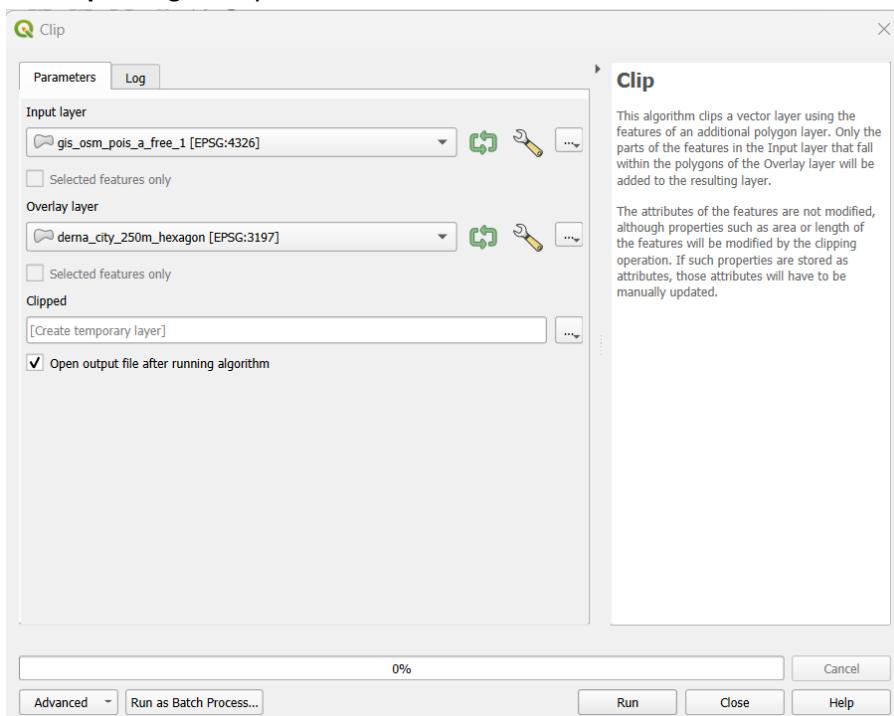
- As such, we will be using the Post-flood data to map the locations of Evacuation Centres and Medical Facilities.

- As confirmation, comparisons were made against Pre-flood and Post-flood satellite imagery and the locations where the POIS and POFW for both Pre-flood and Post-Flood OSM data were confirmed to be visibly intact.

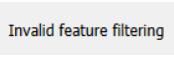
Under **Vector**, select **Geoprocessing Tools > Clip**



The **Clip** dialog box opens



- For **Input layer**, select **gis_osm_pois_a_free_1 [EPSG:4326]**
- For **Overlay layer**, select **derna_city_250m_hexagon [EPSG:3197]**

- Click on  , change to 
- Click **Run** once done

Medical Facilities - Hospitals

Right click on the temporary Clipped layer > **Open Attribute Table**

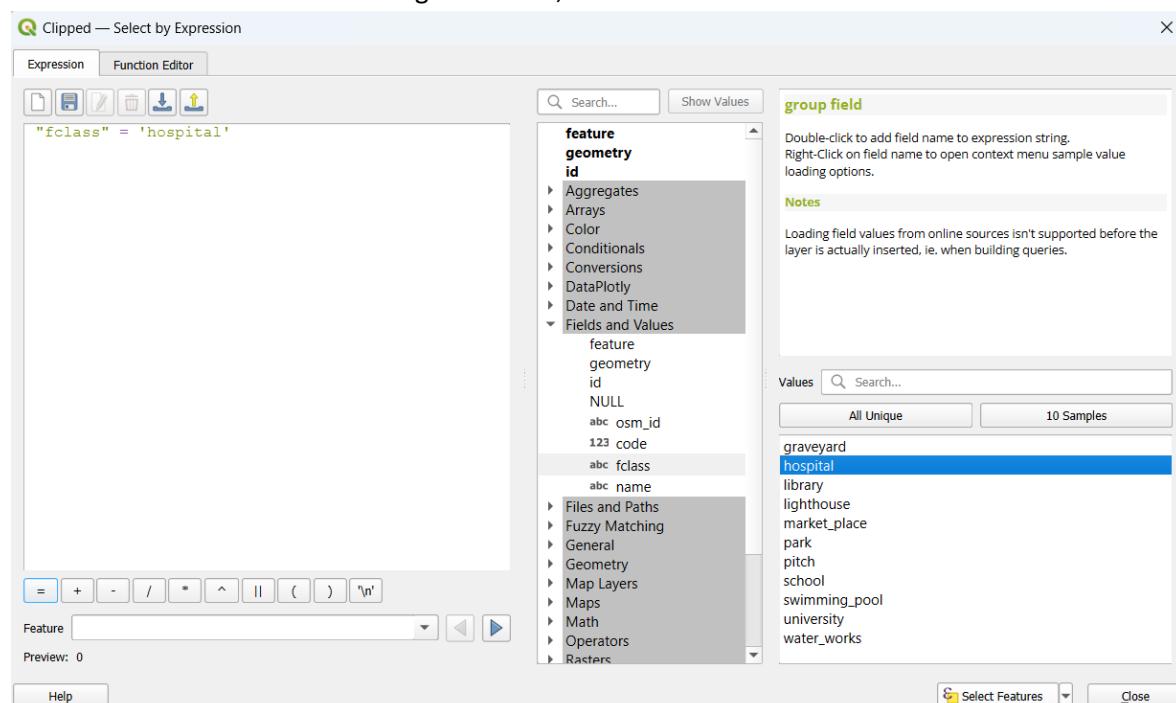
The Attribute Table for the Clipped layer opens > Click on the **Select features using an expression icon**

	osm_id	code	Select features using an expression
1	772867902	2964	water_works معملة...
2	1002566666	2082	school NULL
3	909439985	2082	school NULL
4	971132894	2081	university المعهد...
5	1002566668	2082	school NULL
6	785556503	2015	graveyard NULL
7	785572270	2081	university NULL
8	1085296939	2015	graveyard NULL
9	1002566681	2082	school NULL
10	1207908812	2256	stadium NULL

The **Select by Expression** dialog box opens

- Expand the '**Fields and Values**', select '**fclass**'
- Double click on '='
- Click on '**All Unique**'
- Double click on '**hospital**'

Your screen should look something like below, click on **Select features** once done



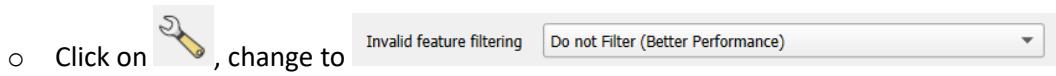
There should be 4 Features selected

Under **Vector > Geometry Tools > Centroids...**

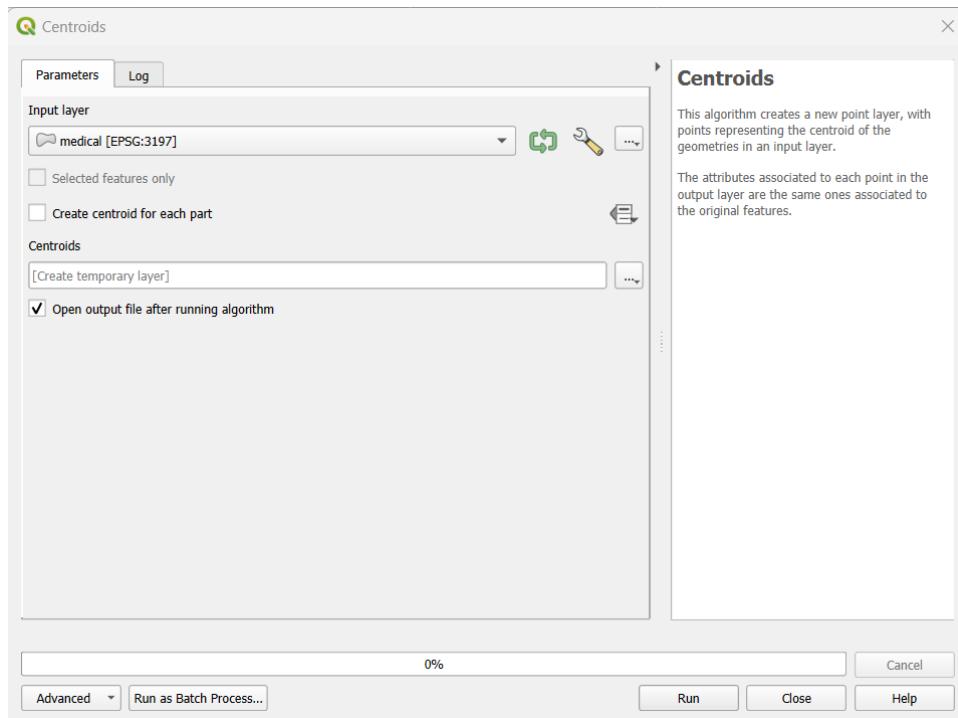


The **Centroids** dialog box appears

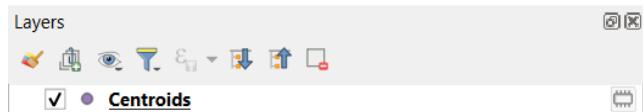
- For **Input layer**, select **medical [EPSG:3197]**



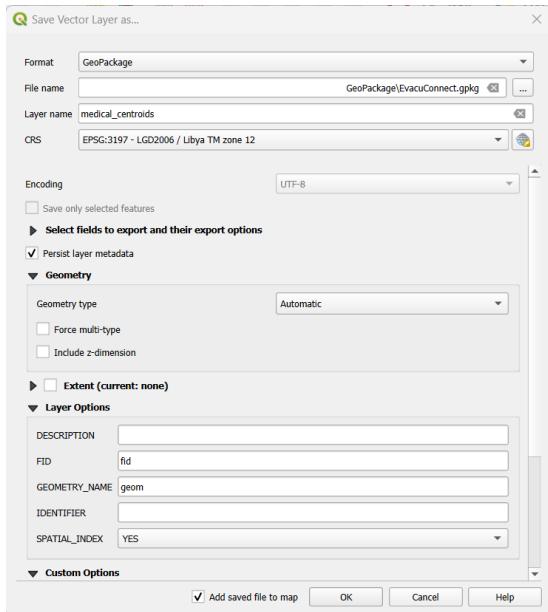
- Click **Run** once done



A new temporary **Centroids** layer appears



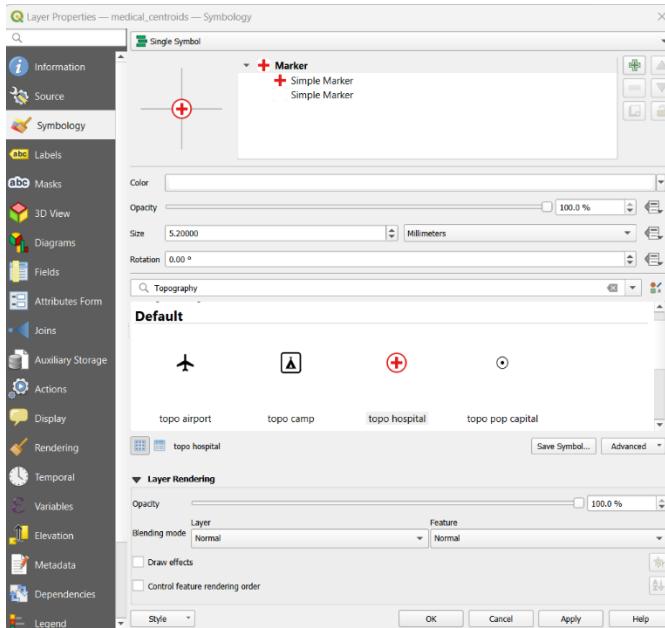
Export the **Centroids** layer into GeoPackage



- For Layer name, use '**medical_centroids**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Right click on the new **medical_centroids** layer > **Properties > Symbology**

- Select **topo hospital**
- Click **Apply > OK**



- For Layer name, use '**medical**'

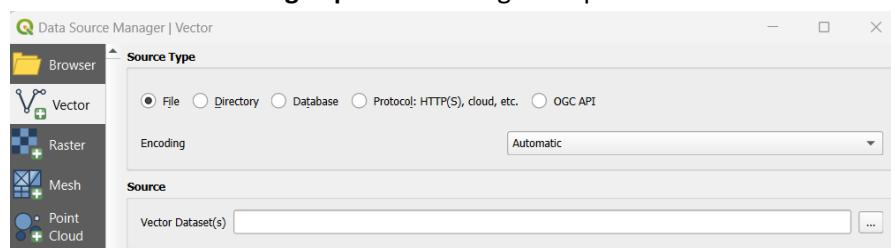
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Evacuation Centres – Places of Worship, Schools & University

Click on Layer → Add Layer → Add Vector Layer...



The Data Source Manager | Vector dialog box opens

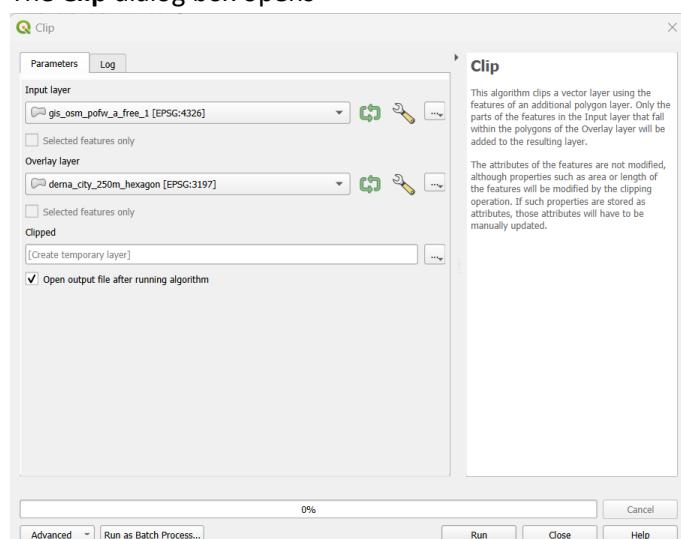


- Under **Source** > **Vector Dataset(s)**, select **gis_osm_pofw_a_free_1.shp** from **libya-231001-free.shp**

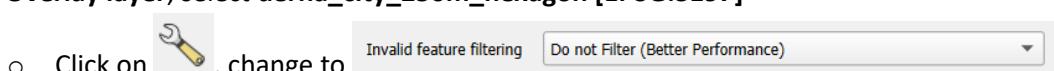
Under **Vector**, select **Geoprocessing Tools > Clip**



The **Clip** dialog box opens



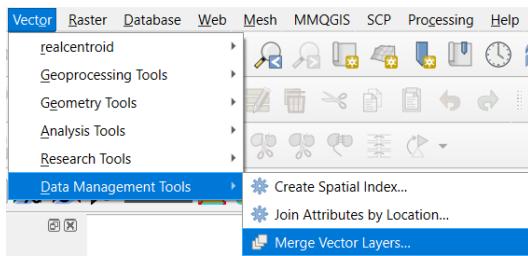
- For **Input layer**, select **gis_osm_pofw_a_free_1 [EPSG:4326]**
- For **Overlay layer**, select **derna_city_250m_hexagon [EPSG:3197]**



- Click **Run** once done

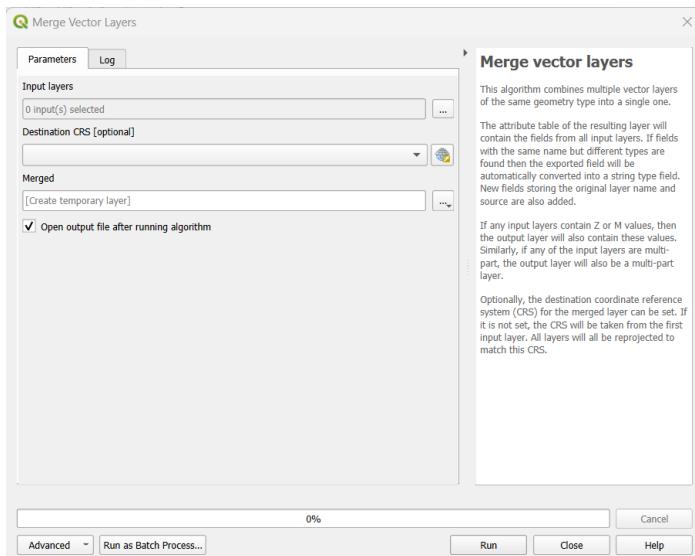
You will now have 2 temporary Clipped layers

Under **Vector > Data Management Tools > Merge Vector Layers**

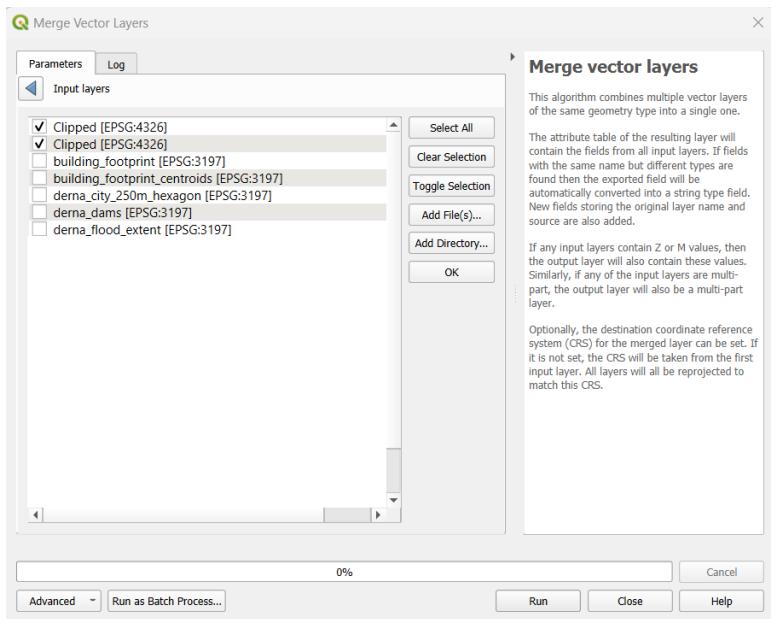


The **Merge Vector Layers** dialog box opens

- For **Input layers**, click on the icon



- Select the 2 **Clipped** layers and click **OK**
- Click **Run** once done



Right click on the temporary **Merged** layer > **Open Attribute Table**

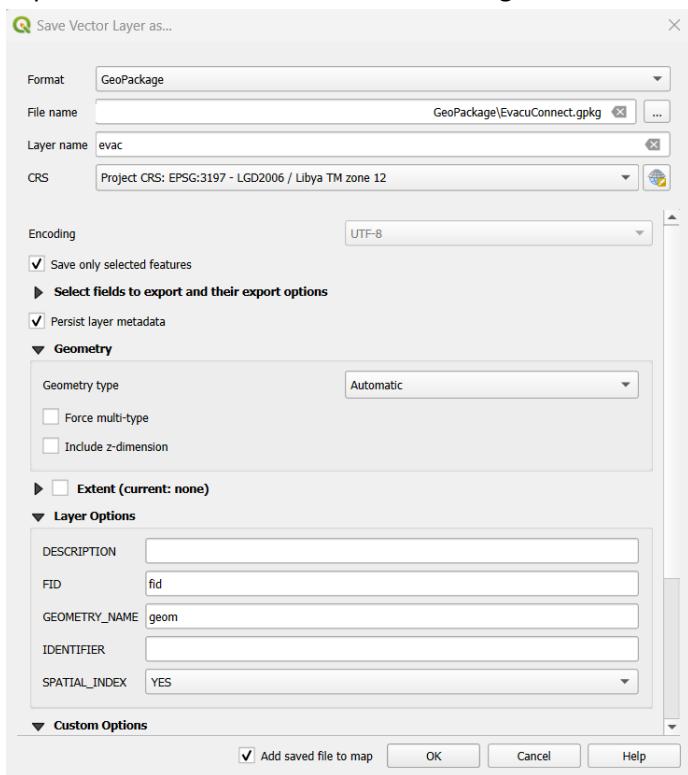
The Attribute Table for the **Merged** layer opens > Click on the **Select features using an expression** icon

osm_id	code	Select features using an expression	layer	path
1 909439206	3300 muslim	NULL	Clipped	MultiPolygon?...
2 785556502	3300 muslim	مسجد الصفا وال...	Clipped	MultiPolygon?...
3 1080621766	3300 muslim	NULL	Clipped	MultiPolygon?...
4 1002574824	3300 muslim	NULL	Clipped	MultiPolygon?...
5 909964184	3300 muslim	NULL	Clipped	MultiPolygon?...
6 909717808	3300 muslim	NULL	Clipped	MultiPolygon?...
7 1002383910	3300 muslim	مسجد فاطمة الز...	Clipped	MultiPolygon?...
8 772867902	2964 water_works	محطة تحلية الماء...	Clipped	MultiPolygon?...
9 1002566666	2082 school	NULL	Clipped	MultiPolygon?...
10 909439985	2082 school	NULL	Clipped	MultiPolygon?...

The **Select by Expression** dialog box opens

- Expand the '**Fields and Values**', select '**fclass**'
- Double click on '**=**'
- Click on '**All Unique**'
- Double click on '**university**'
- Type '**or**'
- Repeat the above, this time click on '**school**'
- Type '**or**'
- Repeat the above, this time click on '**muslim**'

Export the selected features to GeoPackage

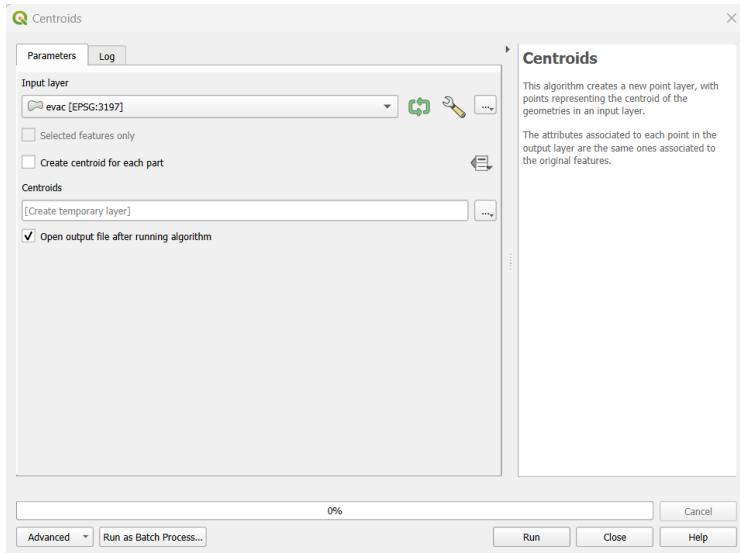


- For Layer name, use '**evac**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Under **Vector > Geometry Tools > Centroids...**



The **Centroids** dialog box appears

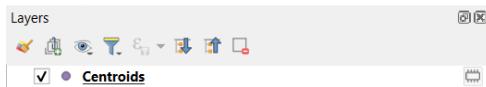


- For **Input layer**, select **evac [EPSG:3197]**

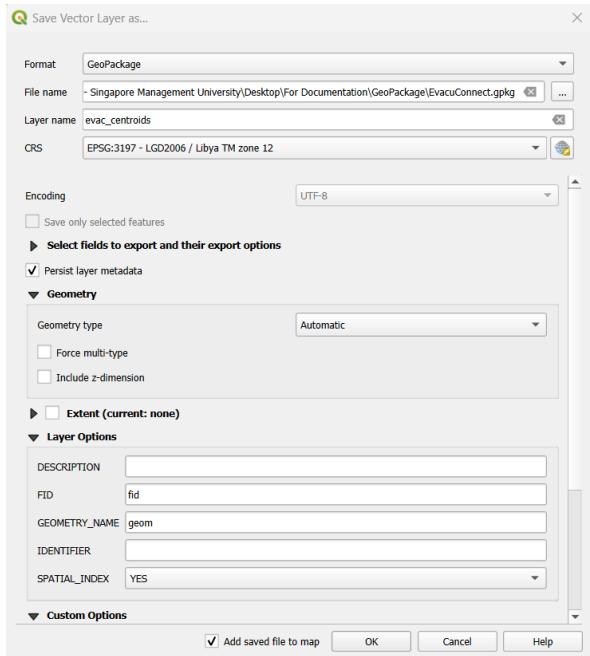
- Click on , change to **Invalid feature filtering** **Do not Filter (Better Performance)**

- Click **Run** once done

A new temporary **Centroids** layer appears



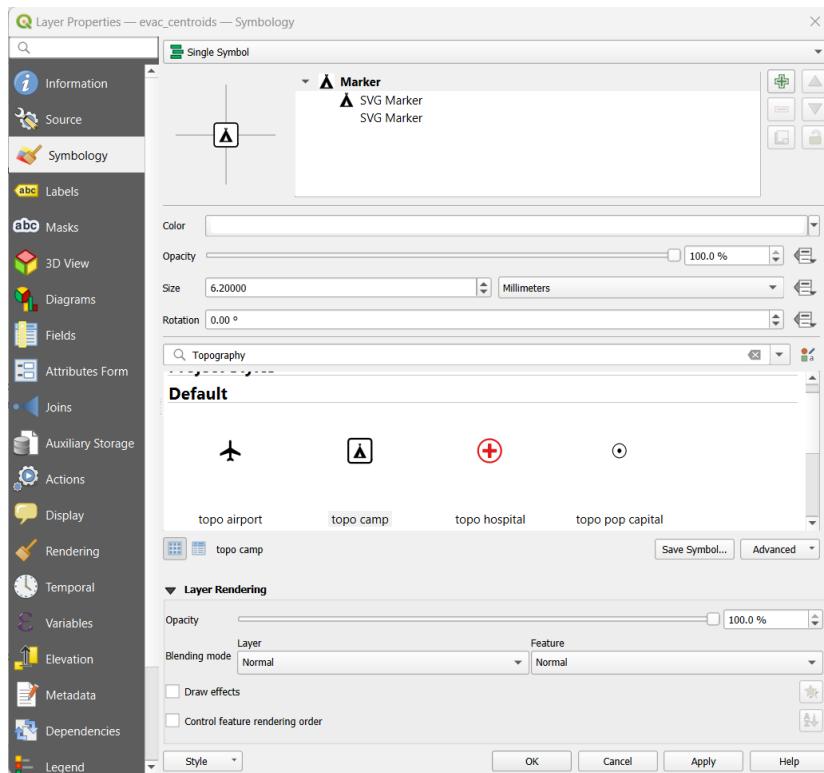
Export the **Centroids** layer into GeoPackage



- For Layer name, use '**evac_centroids**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Right click on the new **evac_centroids** layer > **Properties > Symbology**

- Select **topo camp**
- Click **Apply > OK**

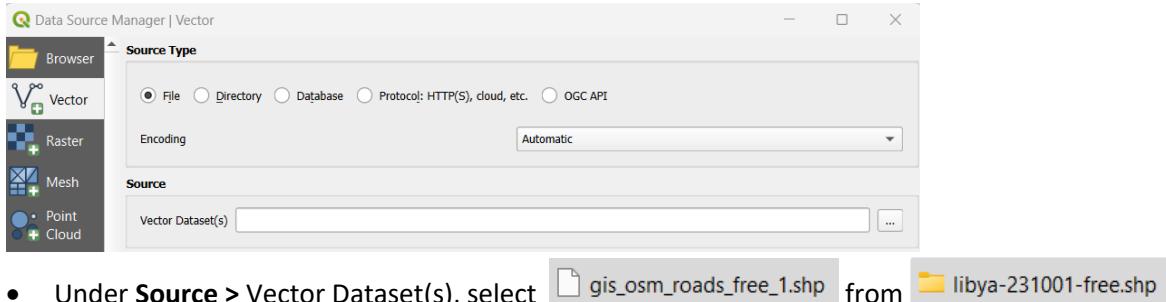


Road Networks (Post-flood)

Click on **Layer** → **Add Layer** → **Add Vector Layer...**



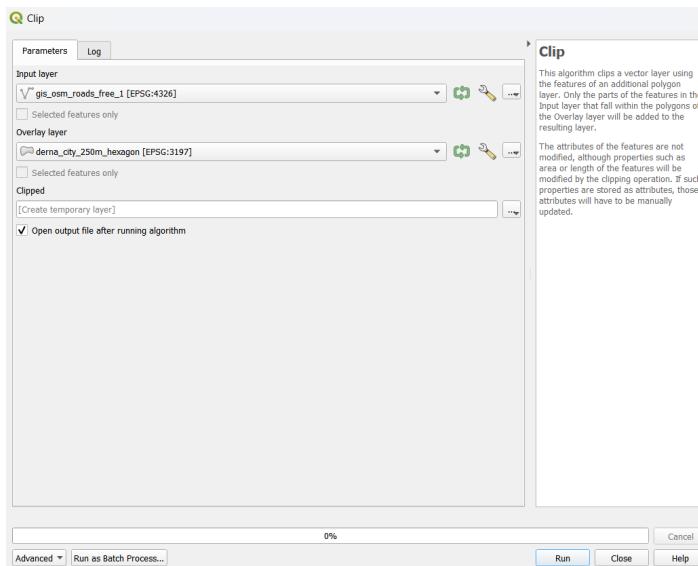
The Data Source Manager | Vector dialog box opens



Under Vector, select Geoprocessing Tools > Clip

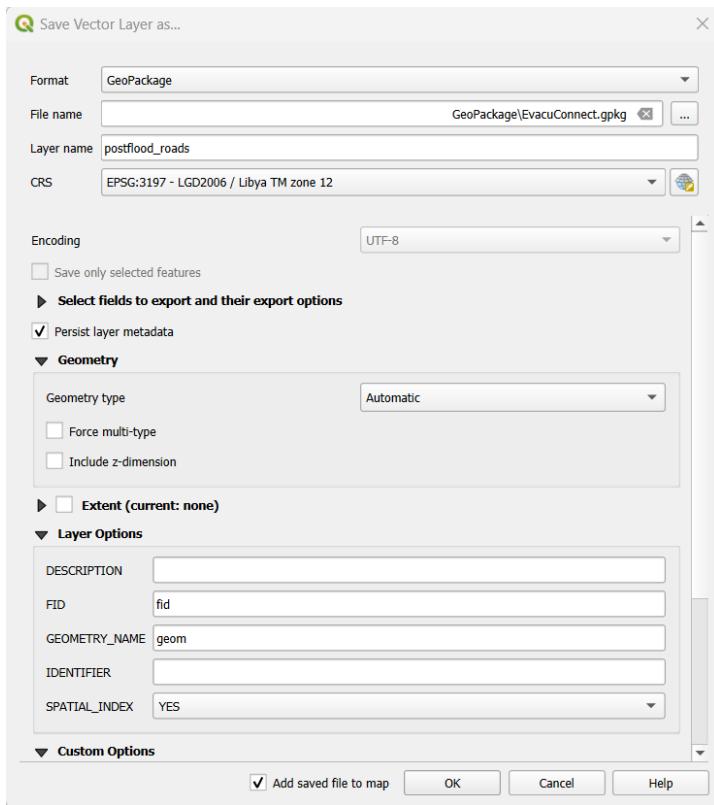


The Clip dialog box opens



- For **Input layer**, select **gis_osm_roads_free_1 [EPSG:4326]**
- For **Overlay layer**, select **derna_city_250m_hexagon [EPSG:3197]**
- For Layer name, use '**postflood_roads**', change to
 - Invalid feature filtering **Do not Filter (Better Performance)**
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12done**
- Click **OK**

Export the temporary **Clipped** layer into the GeoPackage



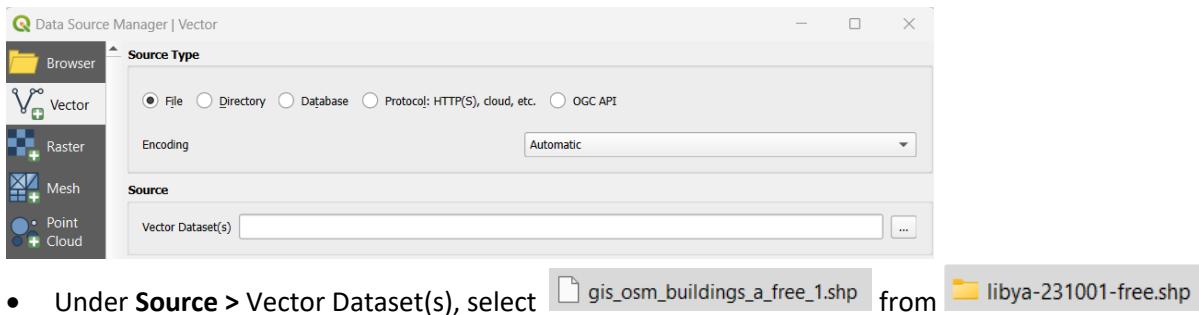
- For Layer name, use '**postflood_roads**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Buildings (Post-flood)

Click on Layer → Add Layer → Add Vector Layer...

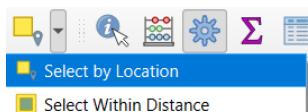


The Data Source Manager | Vector dialog box opens

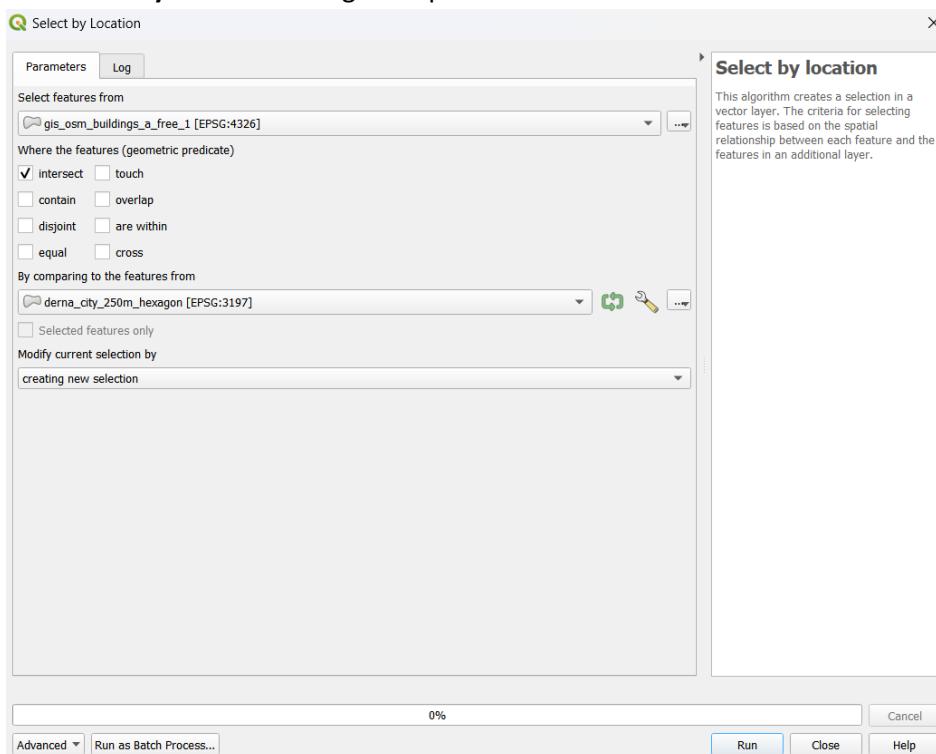


- Under Source > Vector Dataset(s), select gis_osm_buildings_a_free_1.shp from libya-231001-free.shp

Click on Select by Location

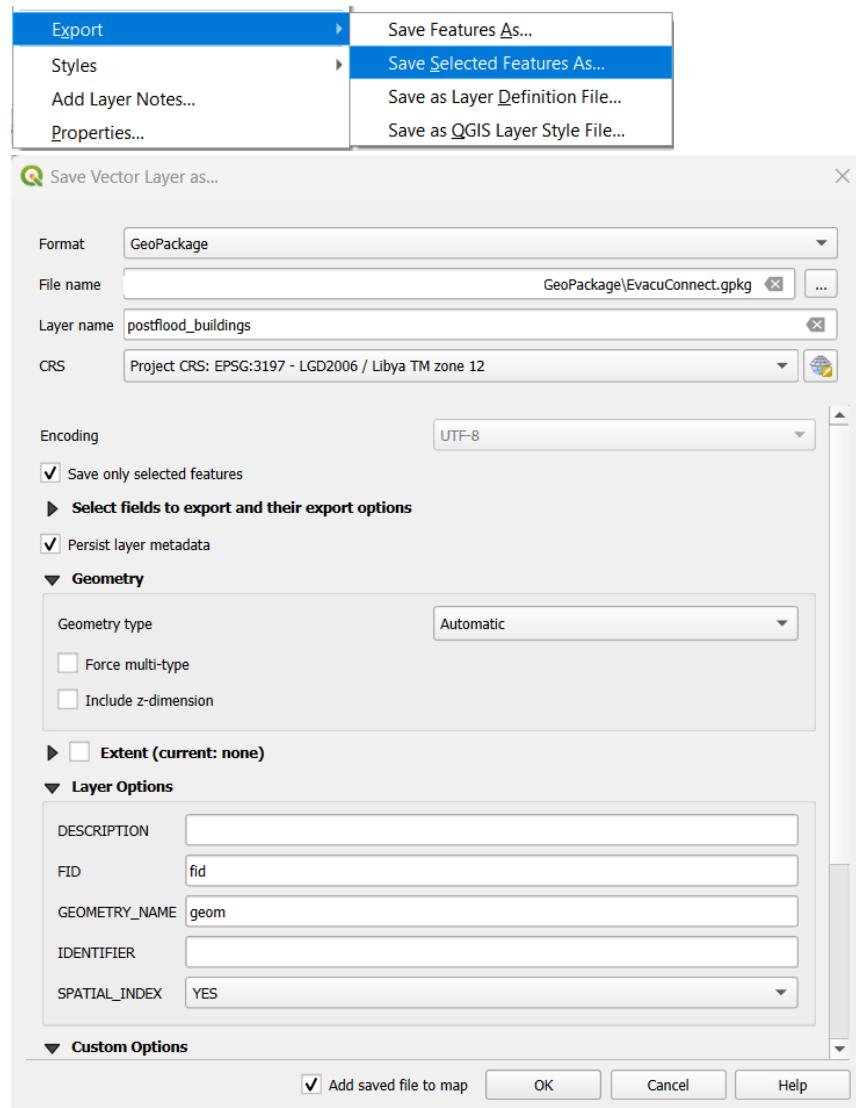


The Select by Location dialog box opens:



- For **Select features from**, select the **gis_osm_buildings_a_free_1 [EPSG:4326]** layer
 - For **Where the features (geometric predicate)**, select **intersect**
 - For Layer name, use '**postflood_buildings**', select the **derna_city_250m_hexagon [EPSG:3197]** layer
 - For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Invalid feature filtering
- Ensure that the **Save only selected features** checkbox is selected
 - Click **OK**

Export the Selected Features into the GeoPackage



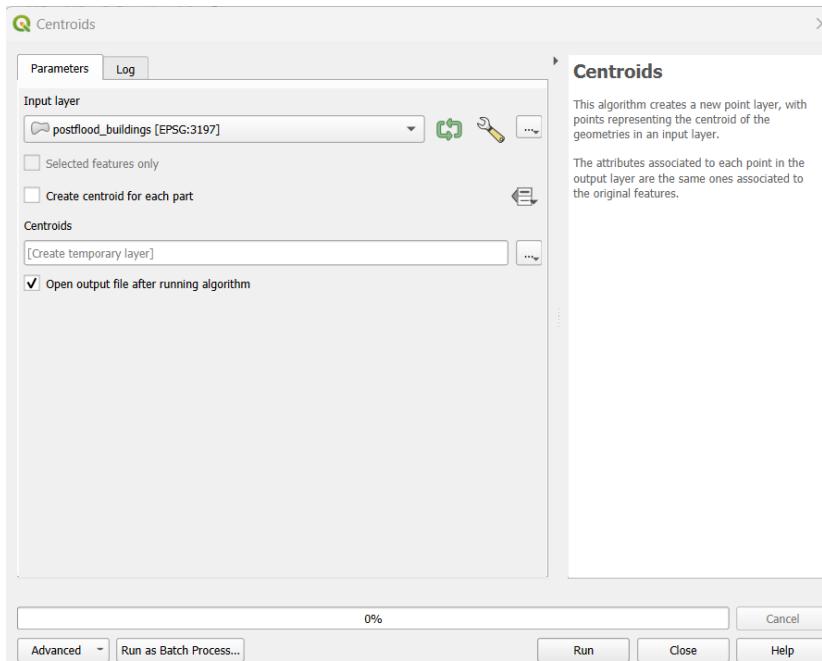
- For Layer name, use '**postflood_buildings**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**

- Ensure that the **Save only selected features** checkbox is selected
- Click **OK**

Under **Vector > Geometry Tools > Centroids**

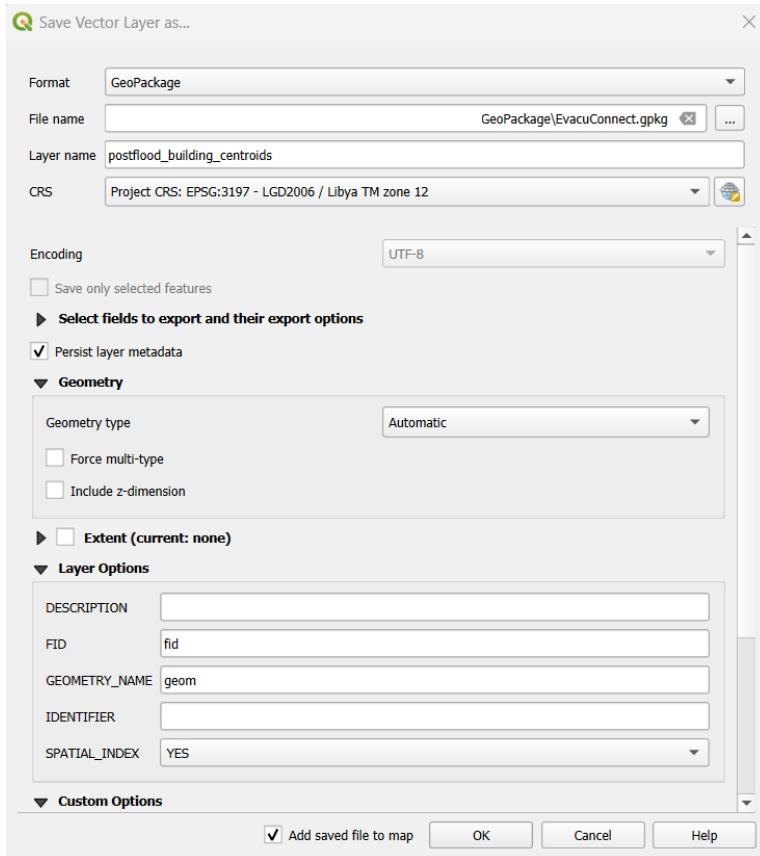


The **Centroids** dialog box appears:



- For Layer name, use '**postflood_buildings_centroids**', select **postflood_buildings**
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK** once done

Export the temporary Centroids layer into the GeoPackage



- For Layer name, use '**postflood_buildings_centroids**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

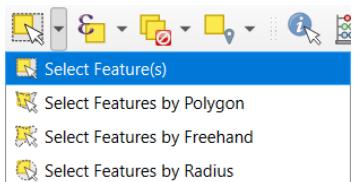
5.2.4 Data Cleaning

Using the layers in **5.2.3.5 Satellite Pre- & Post-flood**, conduct a visual cross-check that the data for **5.2.3.6 Derna OpenStreetMap Data** for the **Road Networks, Evacuation Centres, Medical Facilities and Buildings** are accurate

For those that are visibly destroyed – E.g.



- Using **Select Feature(s)**, select the features that are visibly destroyed but still reflected as existing structures

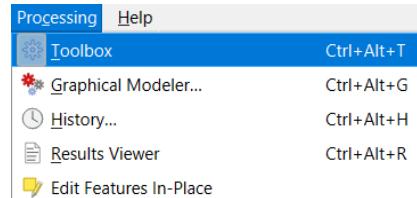


- Delete those selected features

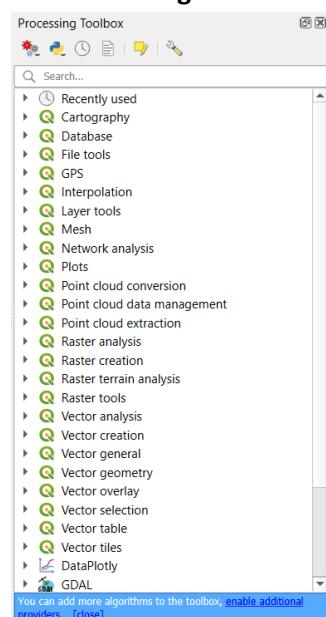
5.3 Network Accessibility Analysis using QNEAT3

5.3.1 Medical Facilities (Post-flood)

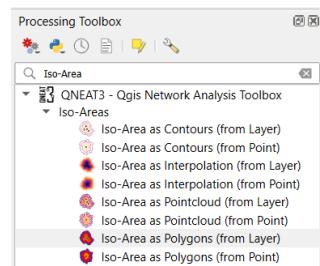
Under Processing > select **Toolbox**



The **Processing Toolbox** sidebar opens

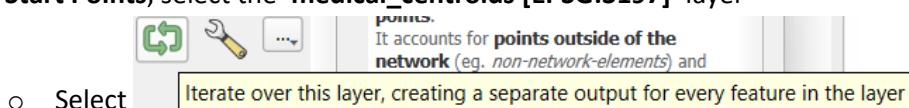


In the **Search...** bar, search for **Iso-Area as Polygons (from Layer)** and open it

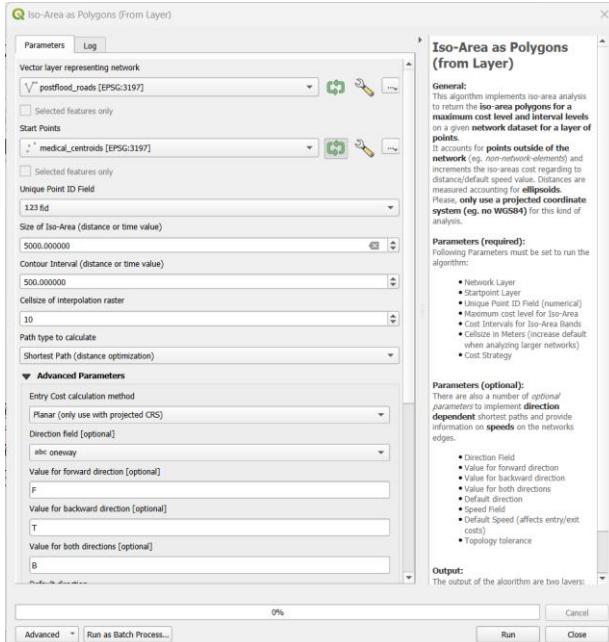


The **Iso-Area as Polygons (From Layer)** dialog box opens:

- For **Vector layer representing network**, select the '**postflood_roads**' layer
- For **Start Points**, select the '**medical_centroids [EPSG:3197]**' layer



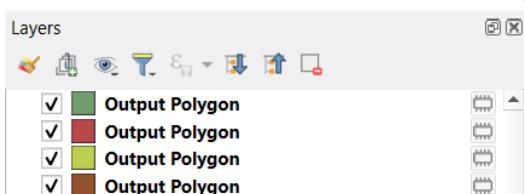
- For **Size of Iso-Area (distance or time value)**, change it to **5000**
 - For **Value for both directions [optional]**, type **B**
- For **Contour Interval (distance or time value)**, change it to **500**
- For **Direction field (optional)**, select **oneway**
- For **Value for forward direction [optional]**, type **F**
- For **Value for backward direction [optional]**, type **T**
- For **Value for both directions [optional]**, type **B**



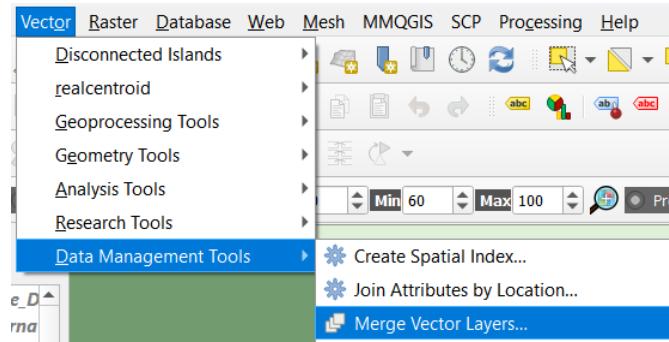
- Click **Run** once done

Note: 5,000 m is determined using the figures from the Netherlands, whereby hospitals are ideally within 5km (Statistics Netherlands, 2023)

You will notice that there will be 4 new **Output Polygon** layers, alongside their Output Interpolations

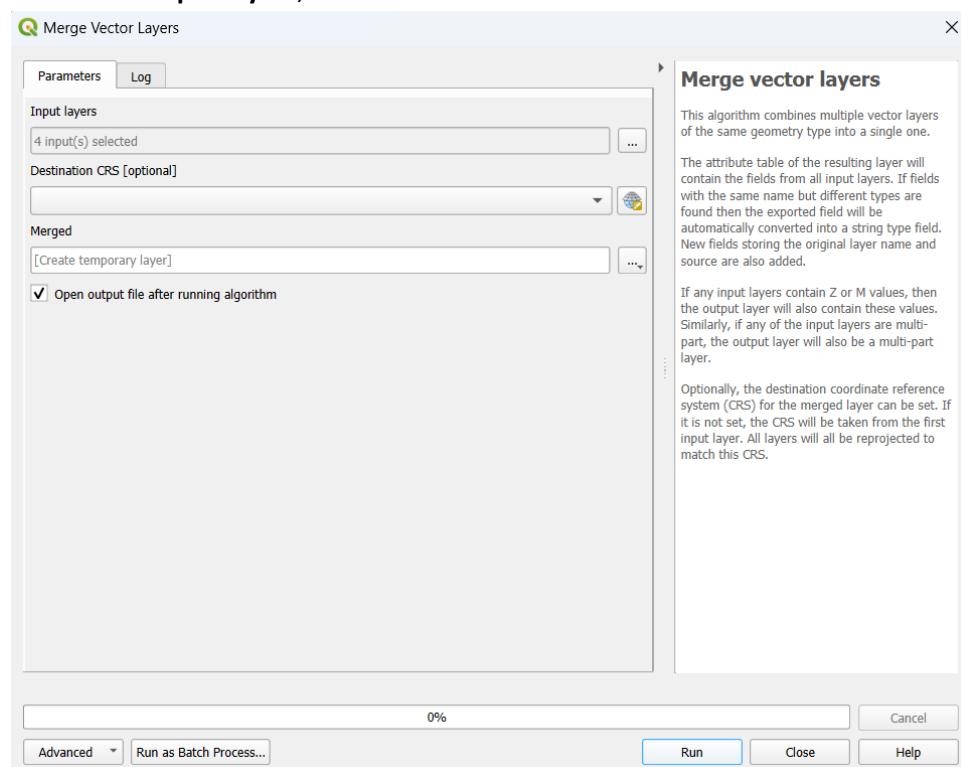


Under **Vector > Data Management Tools > Merge Vector Layers...**

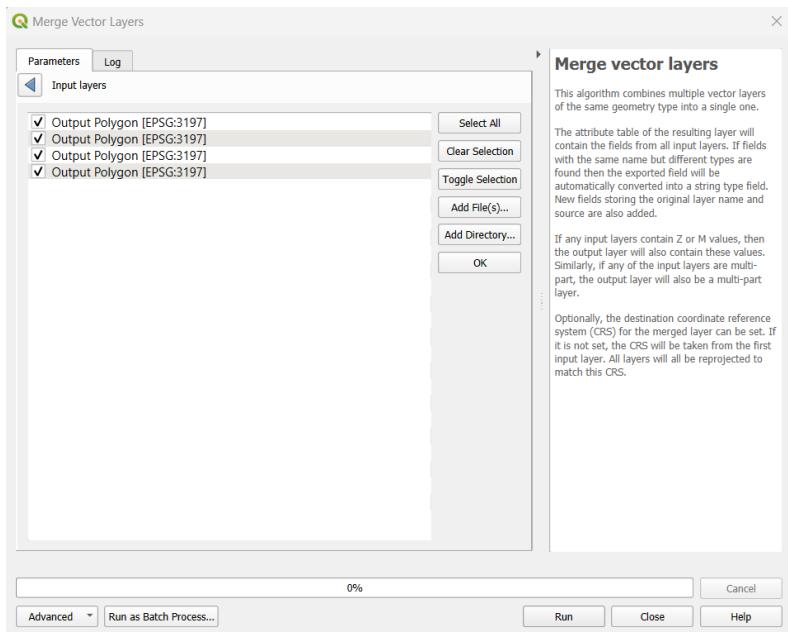


The **Merge Vector Layers** dialog box opens

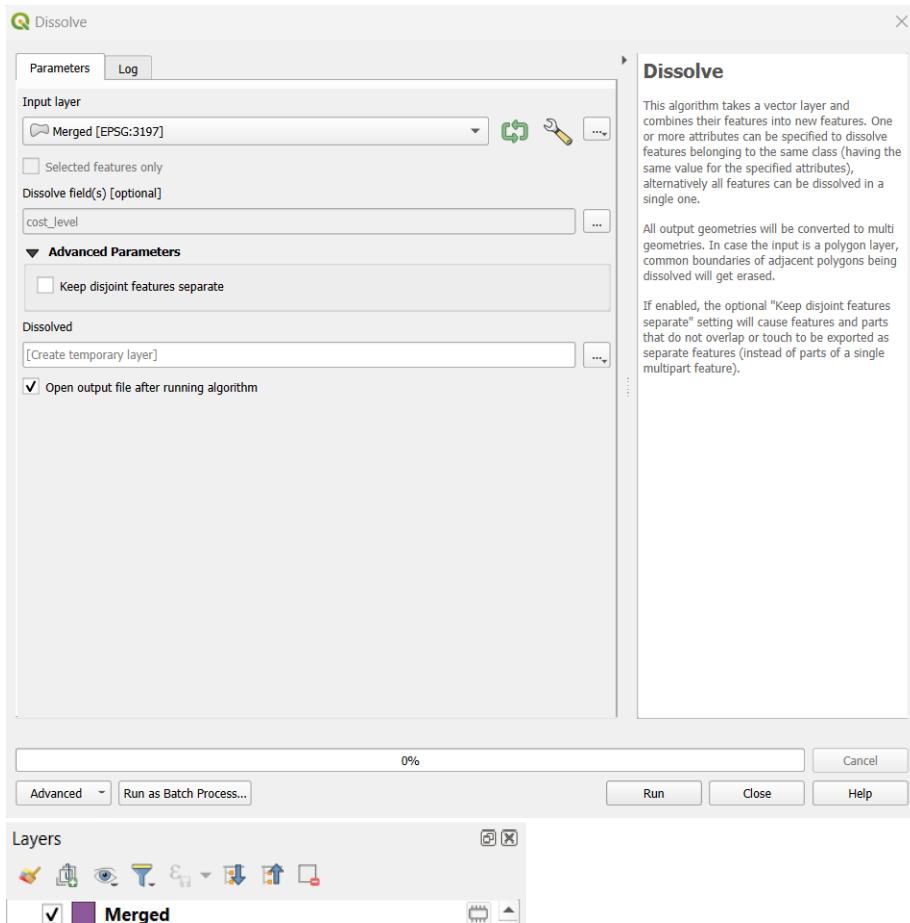
- For **Input layers**, click on the icon



- Select the **4 Output Polygons [EPSG:3197]**
- Click **OK**

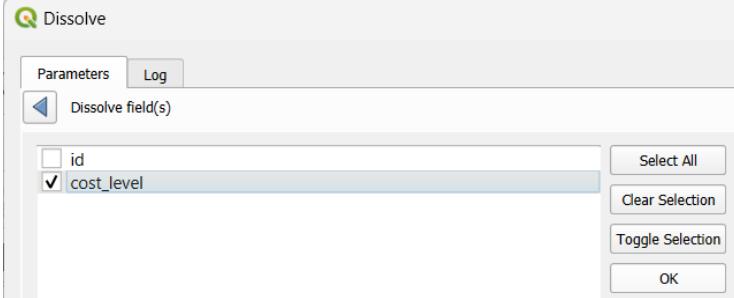


The Dissolve dialog box appears



- Click on , change to

- For Dissolve field(s) [optional], select **cost_level**



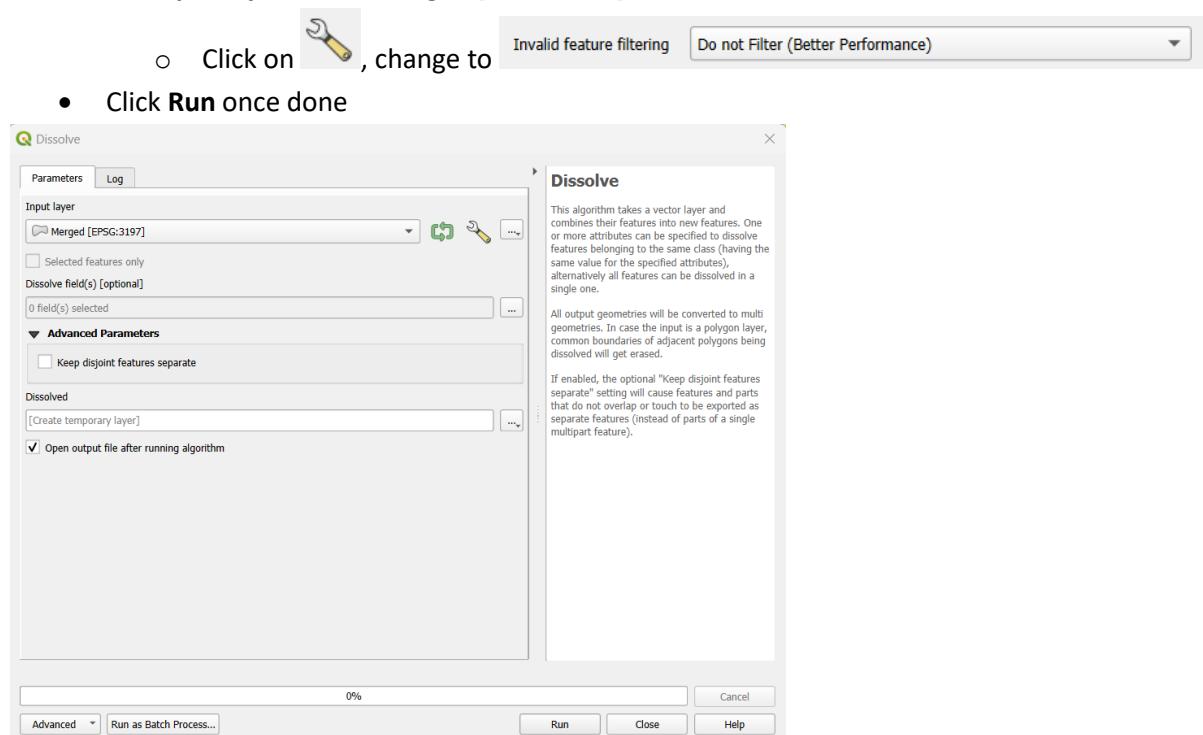
- Click **OK** once selected
- Click **Run** once done

- Ensure that this is unchecked



The **Dissolve** dialog box appears

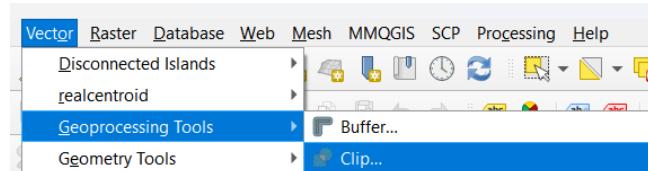
- For Input layer, select **Merged [EPSG:3197]**



A new **Dissolved** layer appears

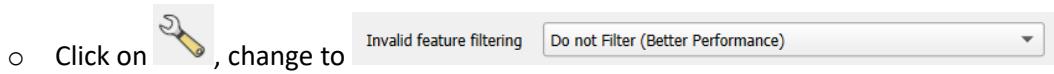


Under **Vector > Geoprocessing Tools > Clip...**

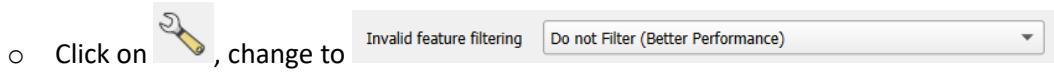


The **Clip** dialog box appears

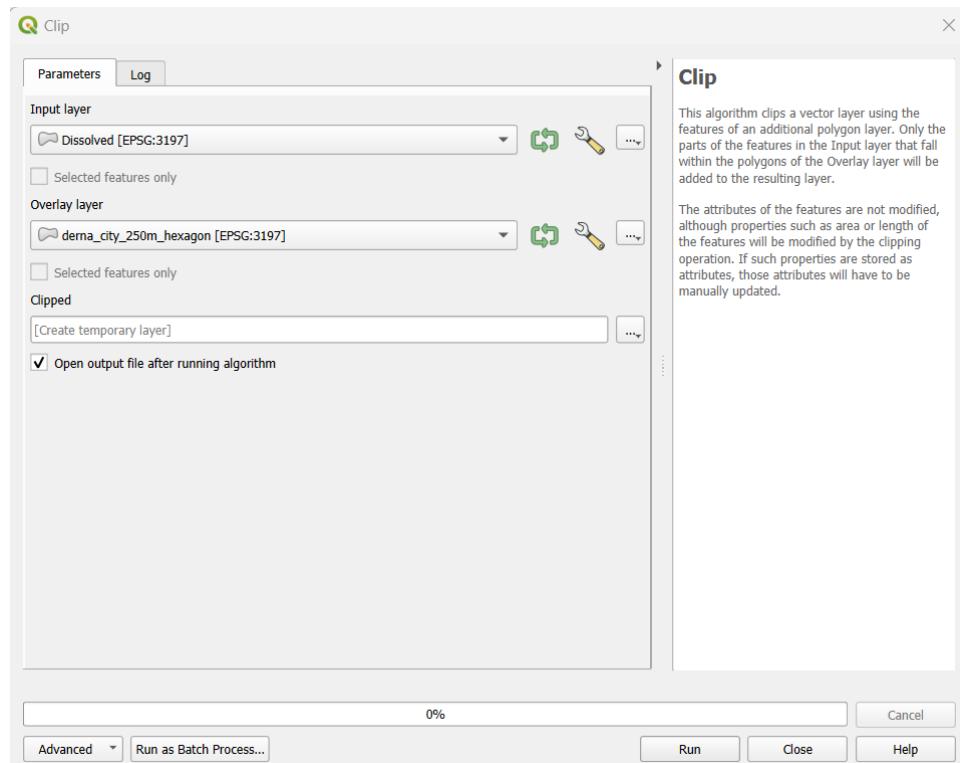
- For **Input layer**, select **Dissolved [EPSG:3197]**



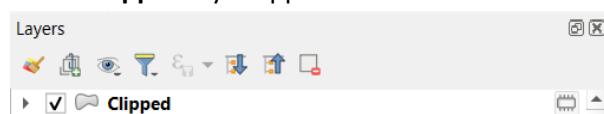
- For **Overlay layer**, select **derna_city_250m_hexagon [EPSG:3197]**



- Click **Run** once done



A new **Clipped** layer appears

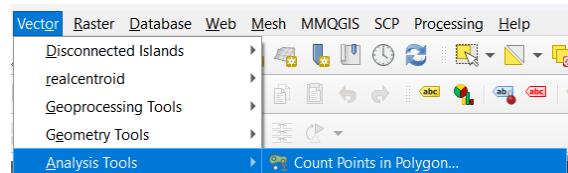


- Remove the temporary **Output Polygon**, **Output Interpolation**, **Merged** and **Dissolved** layers

5.3.1.1 Visualisation

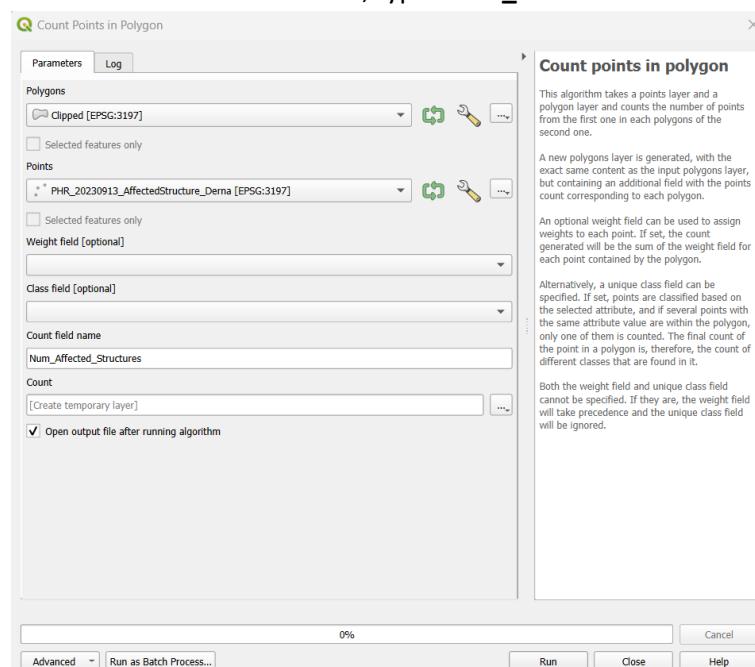
Number of Affected Buildings & Structures per 500m

Under Vector > Analysis Tools > Count Points in Polygon...



The Count Points in Polygon dialog box opens

- For Polygons, select the 'Clipped' layer
 - Click on , change to Invalid feature filtering Do not Filter (Better Performance)
- For Points, select 'PHR_20230913_AffectedStructure_Derna [EPSG:3197]'
- For Count field name, type 'Num_Affected_Structures'



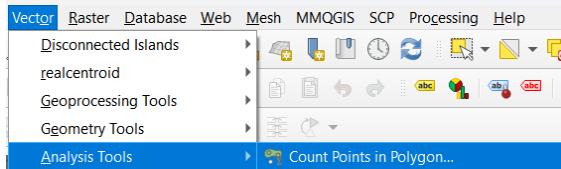
- Click Run once done

A new temporary Count layer appears



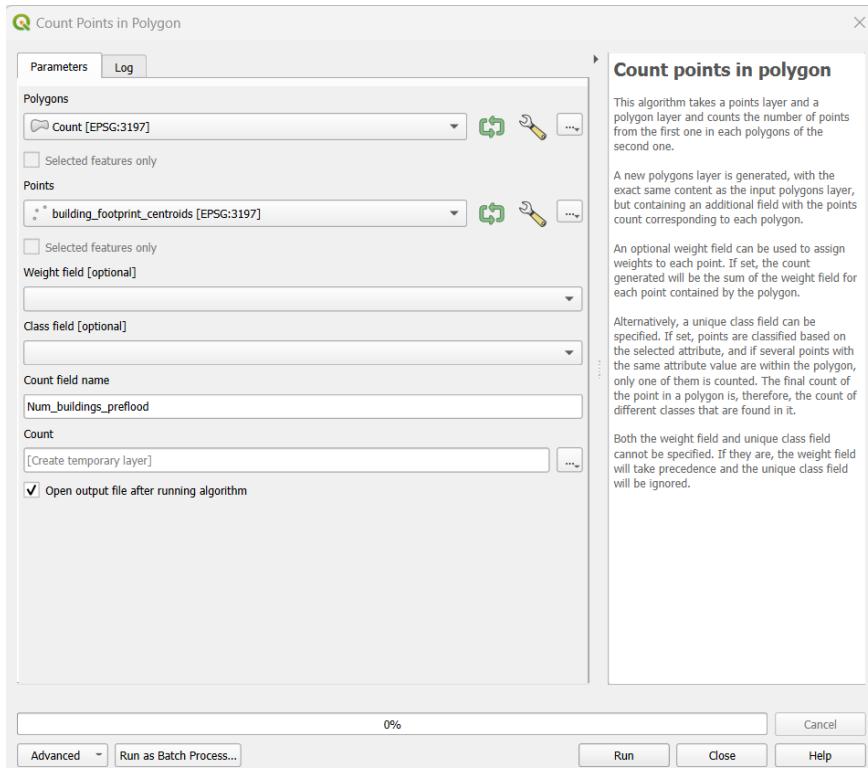
- Remove the temporary **Clipped** layer

Again, Under **Vector > Analysis Tools > Count Points in Polygon...**



The **Count Points in Polygon** dialog box opens. This time:

- For **Polygons**, select the '**Count**' layer
 - Click on , change to
- For **Points**, select '**building_footprint_centroids [EPSG:3197]**'
 - Click on , change to
- For **Count field name**, type '**Num_buildings_preflood**'

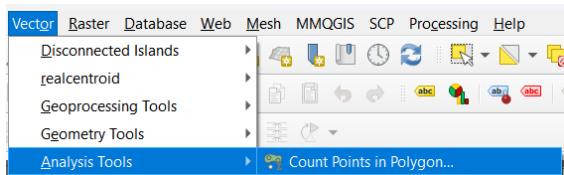


- Click **Run** once done

Another new temporary **Count** layer appears

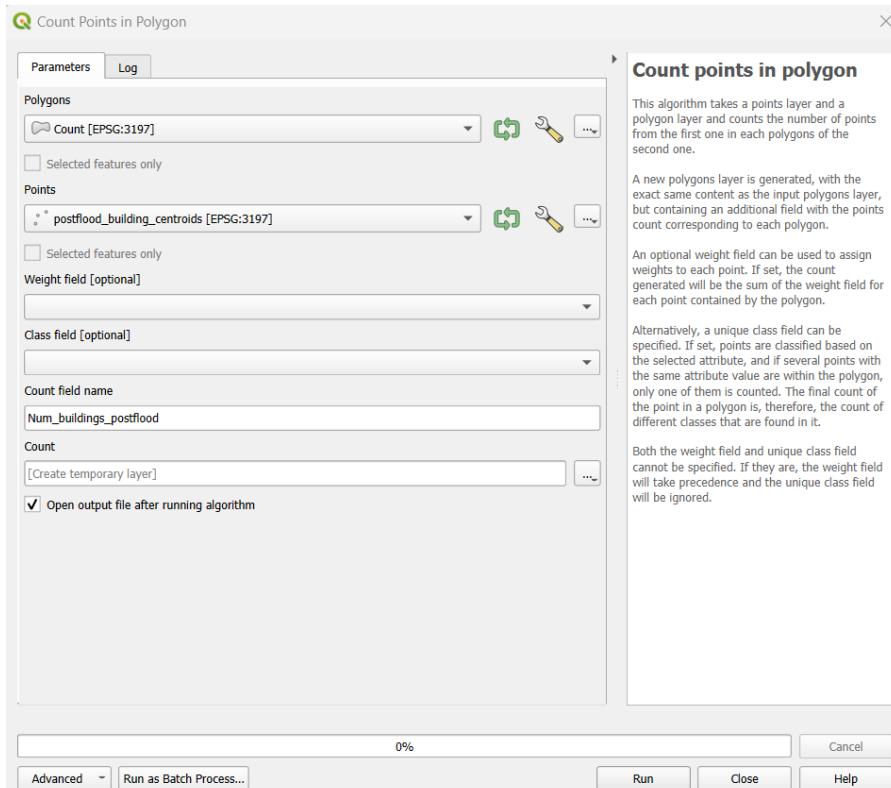
- Remove the previous **Count** layer

Again, Under **Vector > Analysis Tools > Count Points in Polygon...**



The **Count Points in Polygon** dialog box opens. This time:

- For **Polygons**, select the new '**Count**' layer
 - Click on , change to Invalid feature filtering Do not Filter (Better Performance)
- For **Points**, select '**postflood_building_centroids [EPSG:3197]**'
- For **Count field name**, type '**Num_buildings_postflood**'



- Click **Run** once done

Another new temporary **Count** layer appears

- Remove the previous **Count** layer

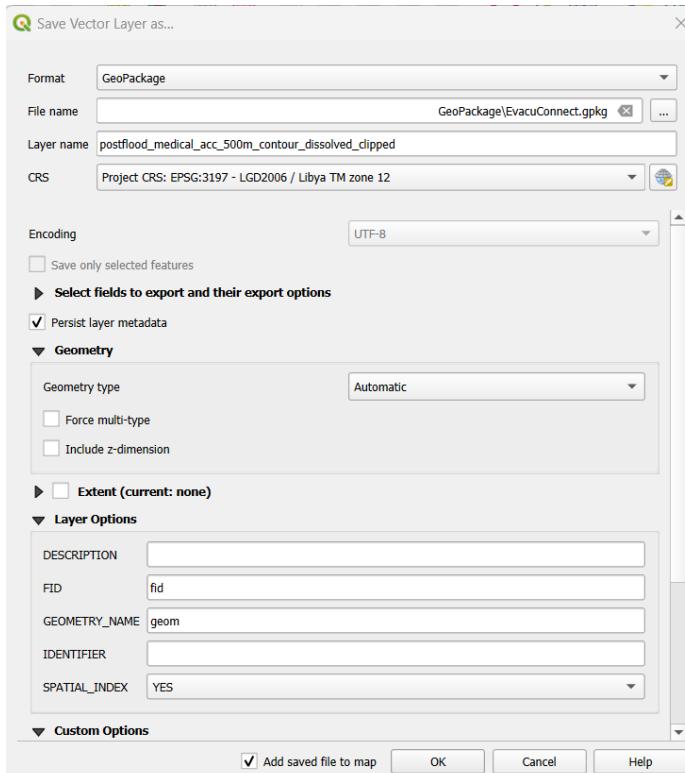
Right click on the newest **Count** layer > **Open Attribute Table**

- You will notice that there are 3 new columns:

Count — Features Total: 10, Filtered: 10, Selected: 0

	id	cost_level	layer	path	Num_Affected_Structures	Num_buildings_preflood	Num_buildings_postflood
1	9	5000.0000000	Output Polygon	Polygon?crs=EP...	1950	20650	12854
2	8	4500.0000000	Output Polygon	Polygon?crs=EP...	1945	20315	12621
3	7	4000.0000000	Output Polygon	Polygon?crs=EP...	1944	19863	12312
4	6	3500.0000000	Output Polygon	Polygon?crs=EP...	1939	19755	12275
5	5	3000.0000000	Output Polygon	Polygon?crs=EP...	1878	19094	11834
6	4	2500.0000000	Output Polygon	Polygon?crs=EP...	1738	17925	11258
7	2	1500.0000000	Output Polygon	Polygon?crs=EP...	1269	12645	8176
8	3	2000.0000000	Output Polygon	Polygon?crs=EP...	1591	16306	10415
9	1	1000.0000000	Output Polygon	Polygon?crs=EP...	800	7142	4683
10	0	500.0000000	Output Polygon	Polygon?crs=EP...	213	1820	1303

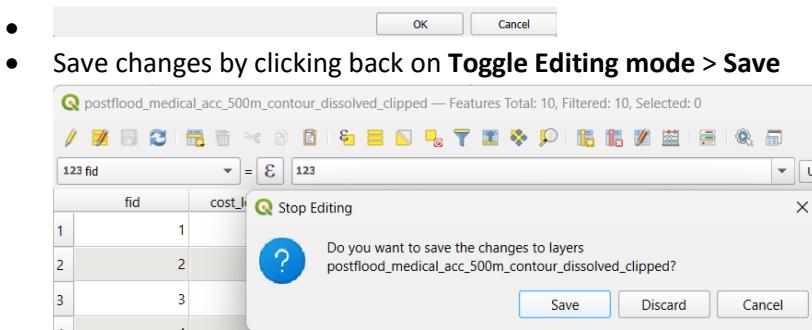
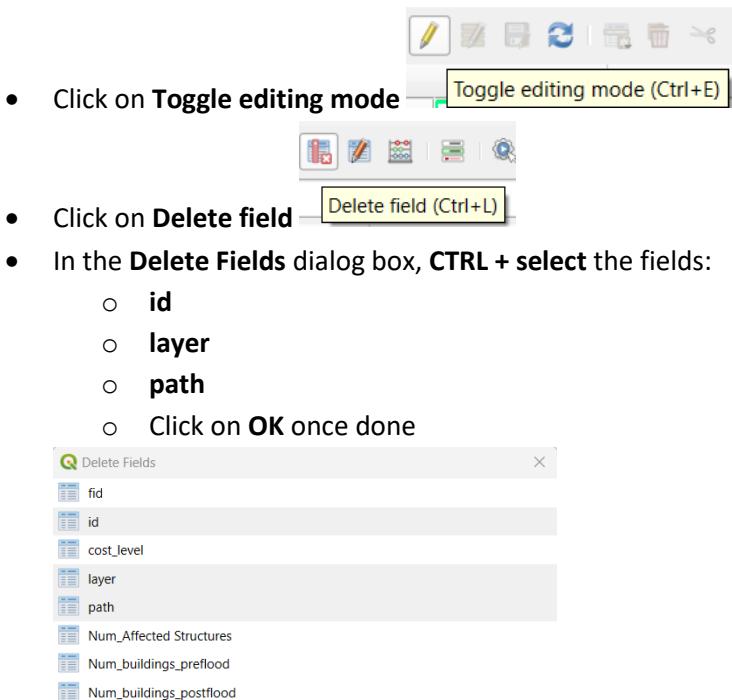
Export this temporary Count layer into GeoPackage



- For Layer name, use '**postflood_medical_acc_500m_contour_dissolved_clipped**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Right click on the **postflood_medical_acc_500m_contour_dissolved_clipped** layer >

| Open Attribute Table



The attribute table will now look something like this:

fid	cost_level	Num_Affected Structures	Num_buildings_preflood	Num_buildings_postflood
1	10	500	213	1820
2	9	1000	800	7142
3	8	2000	1591	16306
4	7	1500	1269	12645
5	6	2500	1738	17925
6	5	3000	1878	19094
7	4	3500	1939	19755
8	3	4000	1944	19863
9	2	4500	1945	20315
10	1	5000	1950	20650

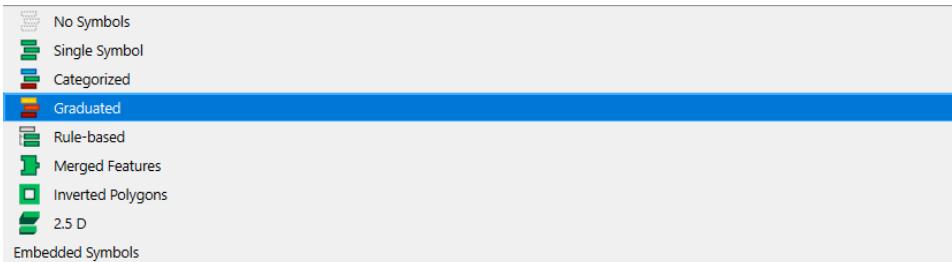
- The columns of interest are the **cost_level** and **Num_buildings_postflood**
- Colour Ramp for Accessibility via Distance Interval**

Right click on the **postflood_medical_acc_500m_contour_dissolved_clipped** layer >

Properties...

The **Layer Properties** dialog box appears > Select **Symbology**

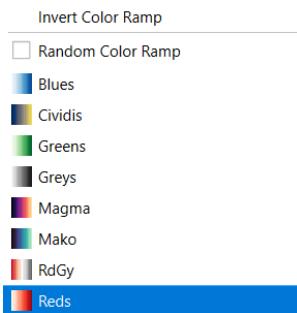
- Under the dropdown, select **Graduated**



- Under **Value**, select **cost_level**



- Select **Red** and **Invert Colour Ramp**



- Set **Opacity** to **70%**

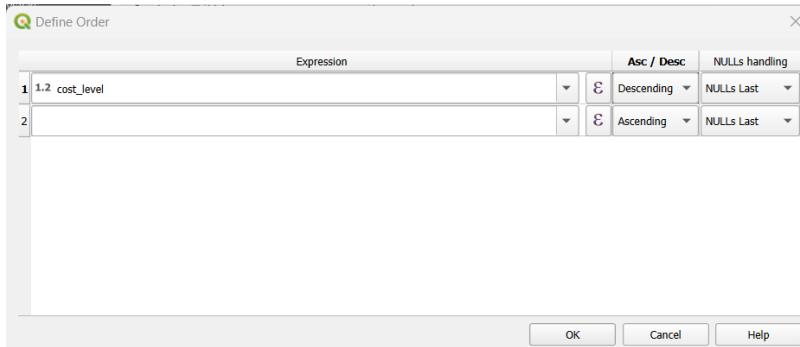
- Select the checkbox beside **Control feature rendering order** and click on
- For **Classes**, set to **10**

Classes **10**

- Manually edit the Classes Interval values to as follows:

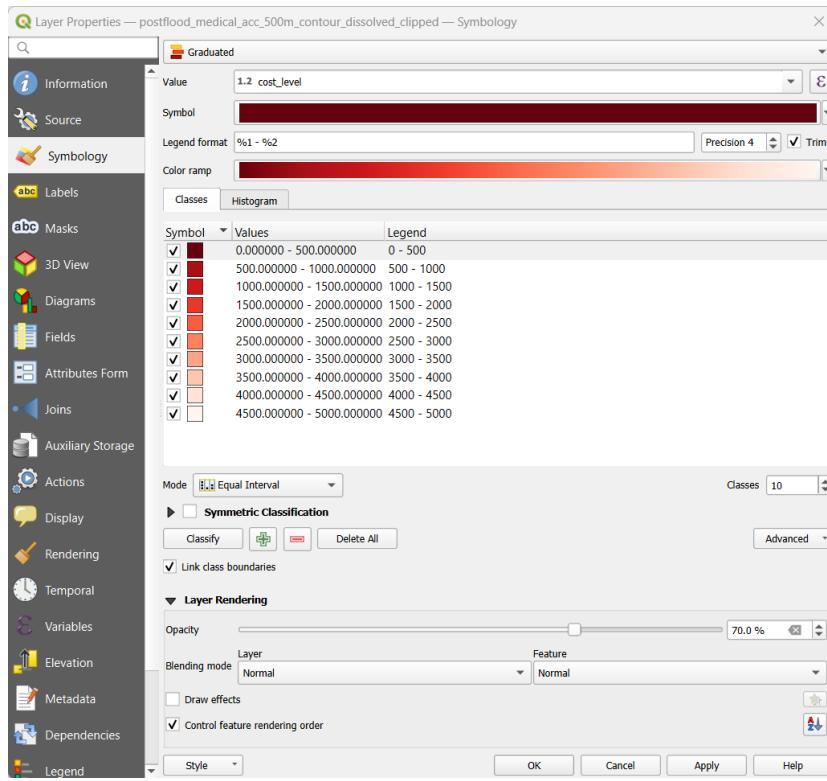
Symbol	Values	Legend
✓	0.000000 - 500.000000	0 - 500
✓	500.000000 - 1000.000000	500 - 1000
✓	1000.000000 - 1500.000000	1000 - 1500
✓	1500.000000 - 2000.000000	1500 - 2000
✓	2000.000000 - 2500.000000	2000 - 2500
✓	2500.000000 - 3000.000000	2500 - 3000
✓	3000.000000 - 3500.000000	3000 - 3500
✓	3500.000000 - 4000.000000	3500 - 4000
✓	4000.000000 - 4500.000000	4000 - 4500
✓	4500.000000 - 5000.000000	4500 - 5000

- Set **Opacity** for each to **70%**
- Select the checkbox beside **Control feature rendering order** and click on
- The **Define Order** dialog box appears
 - Select **cost_level** and set to **Descending**



- Click **OK** once done

Your screen should look something like below:

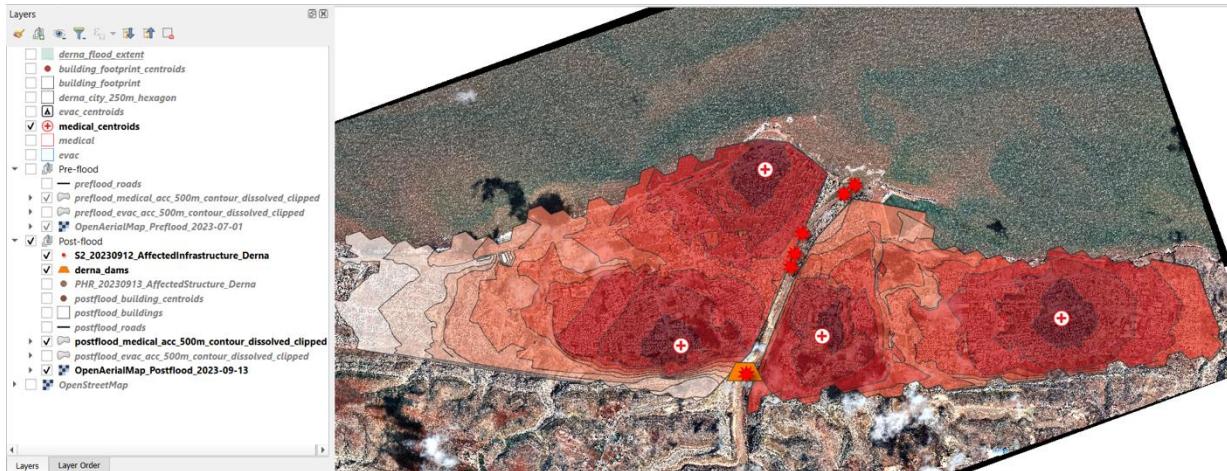


- Click **Apply** and **OK** once done

The map output would look something like the following:

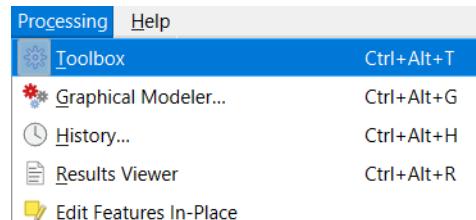
- Activate the following layers in this order, rearrange the layers if needed:
 - **medical_centroids**

- S2_20230912_AffectedInfrastructure_Derna
- derna_dams
- postflood_medical_acc_500m_contour_dissolved_clipped
- OpenAerialMap_Postflood_2023_09_13
- Set Rotation to -20.0

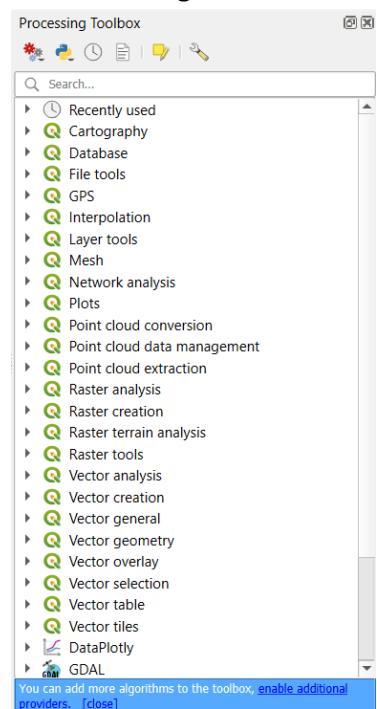


5.3.2 Evacuation Centres (Post-flood)

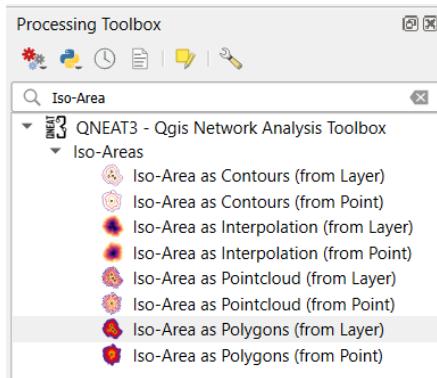
Under **Processing** > select **Toolbox**



The **Processing Toolbox** sidebar opens:

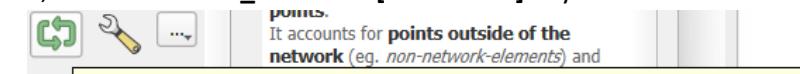


In the **Search...** bar, search for **Iso-Area as Polygons (from Layer)** and double click on it



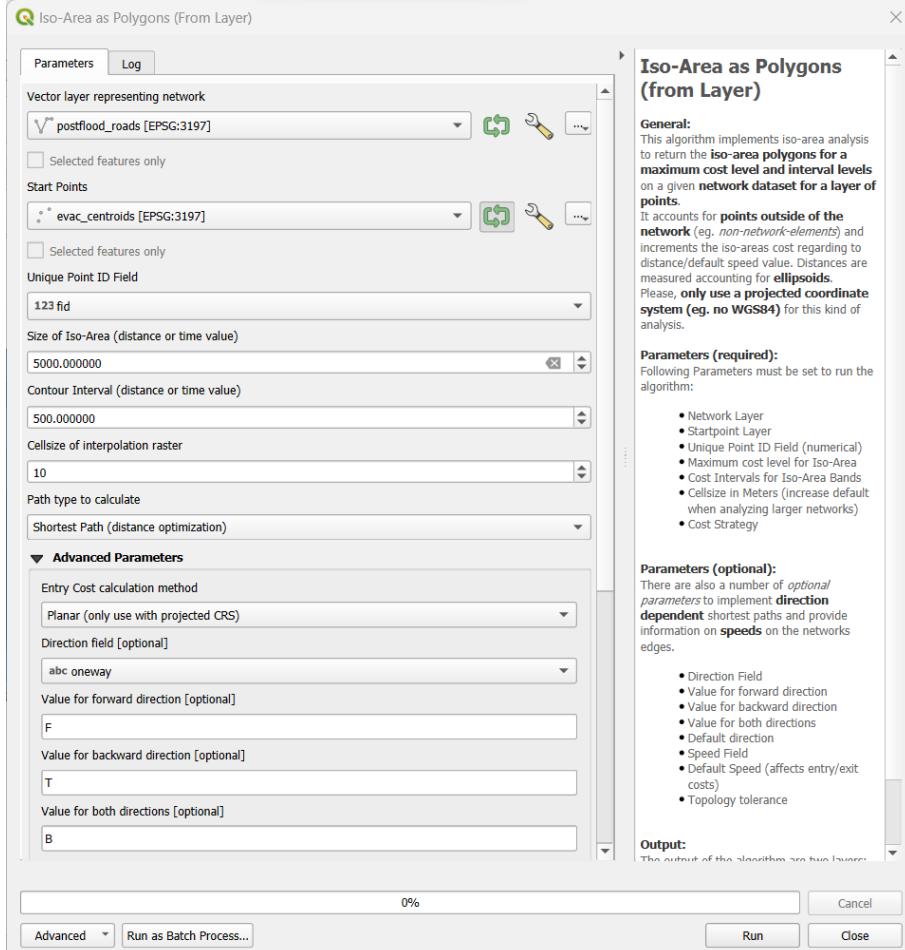
The Iso-Area as Polygons (From Layer) dialog box opens

- For Vector layer representing network, select the ‘postflood_roads’ layer
- For Start Points, select the ‘evac_centroids [EPSG:3197]’ layer

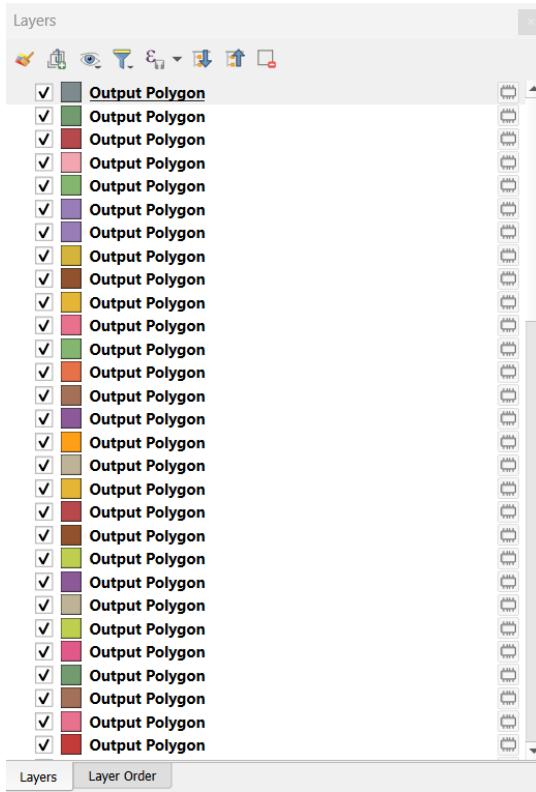


- Select Iterate over this layer, creating a separate output for every feature in the layer

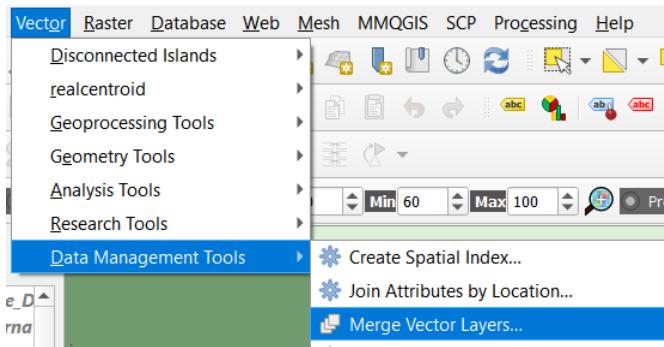
- For Size of Iso-Area (distance or time value), change it to 5000
 - For Value for both directions [optional], type B



You will notice that there will be 29 new Output Polygon layers

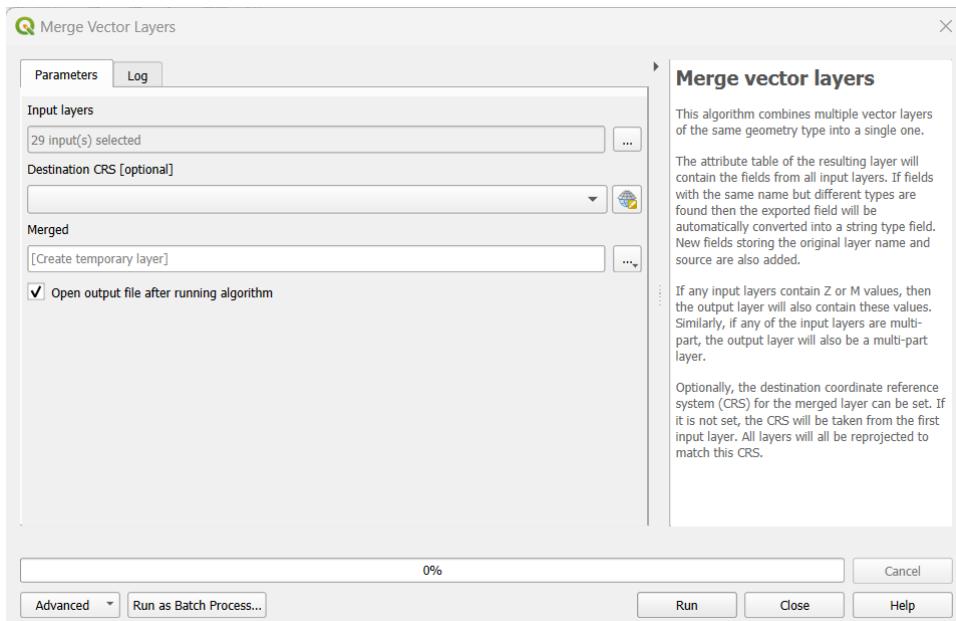


Under **Vector > Data Management Tools > Merge Vector Layers...**

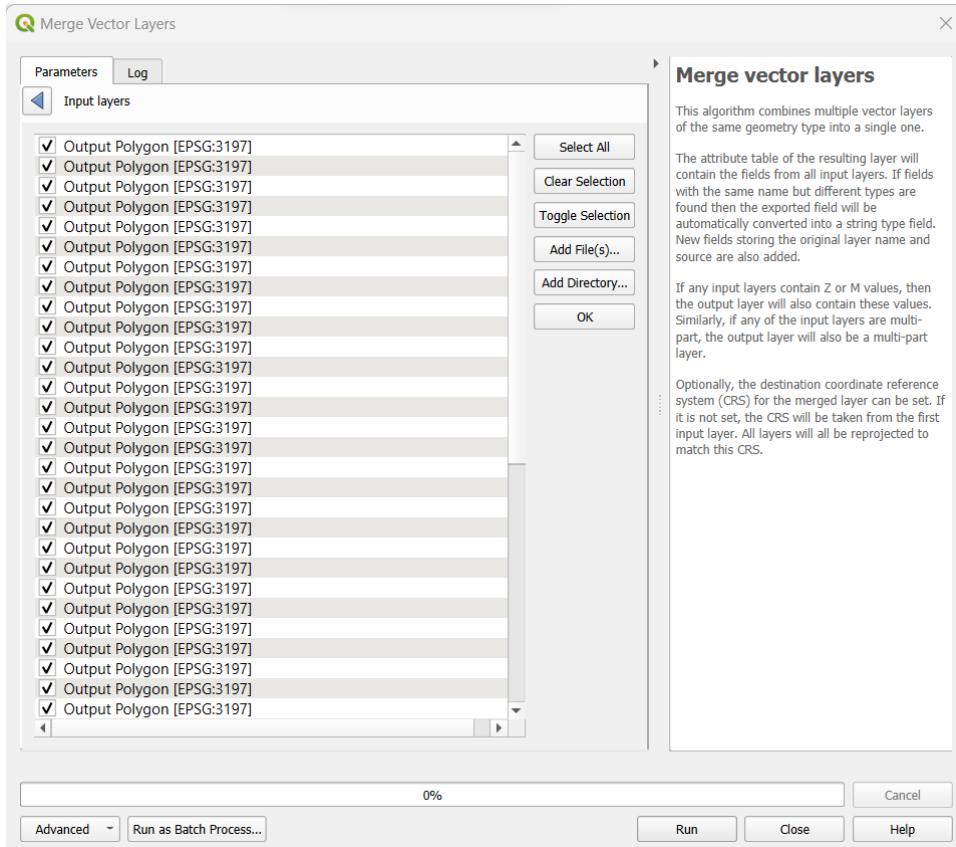


The **Merge Vector Layers** dialog box opens

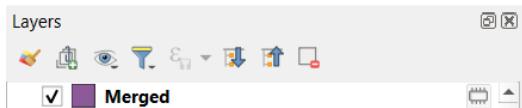
- For **Input layers**, click on the icon



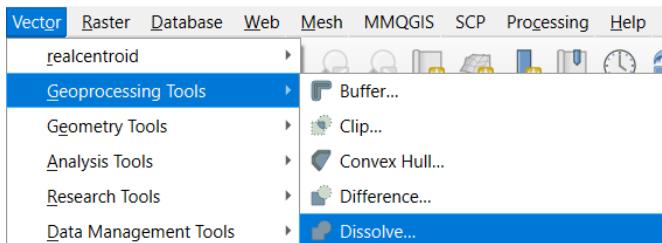
- Select the 29 Output Polygons [EPSG:3197]
- Click OK



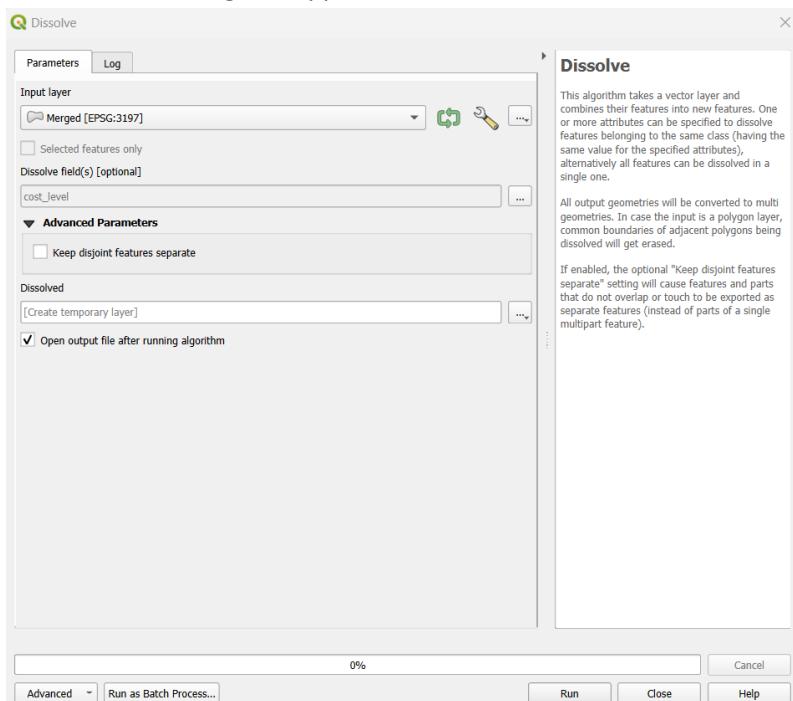
You will notice that a new **Merged** layer appears



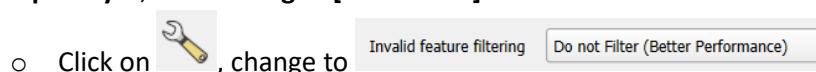
Under **Vector > Geoprocessing Tools > Dissolve**



The **Dissolve** dialog box appears



- For **Input layer**, select **Merged [EPSG:3197]**



- For **Dissolve field(s) [optional]**, select **cost_level**

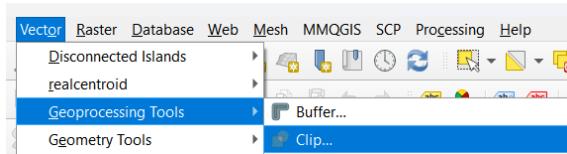


- Click **OK** once selected
- Click **Run** once done

A new **Dissolved** layer appears

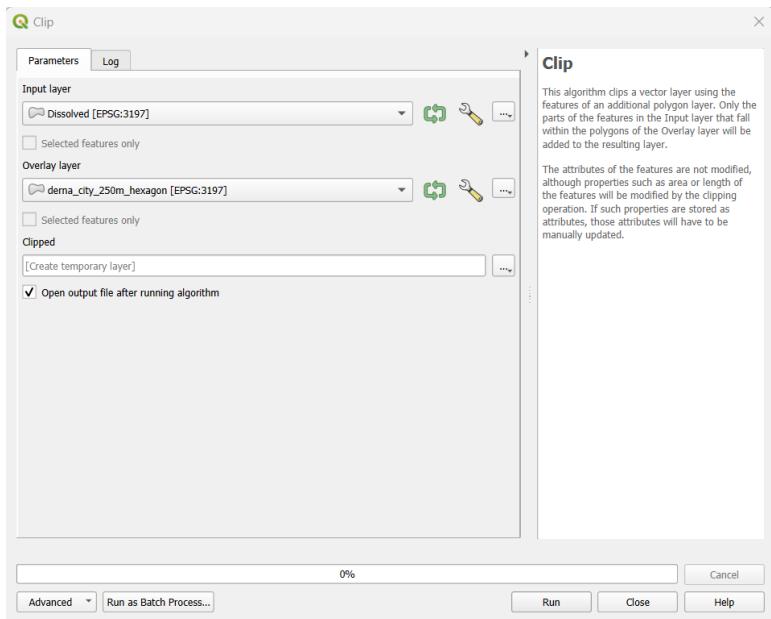


Under **Vector > Geoprocessing Tools > Clip...**



The **Clip** dialog box appears

- For **Input layer**, select **Dissolved [EPSG:3197]**
 - Click on , change to
- For **Overlay layer**, select **derna_city_250m_hexagon [EPSG:3197]**
 - Click on , change to
- Click **Run** once done



A new **Clipped** layer appears

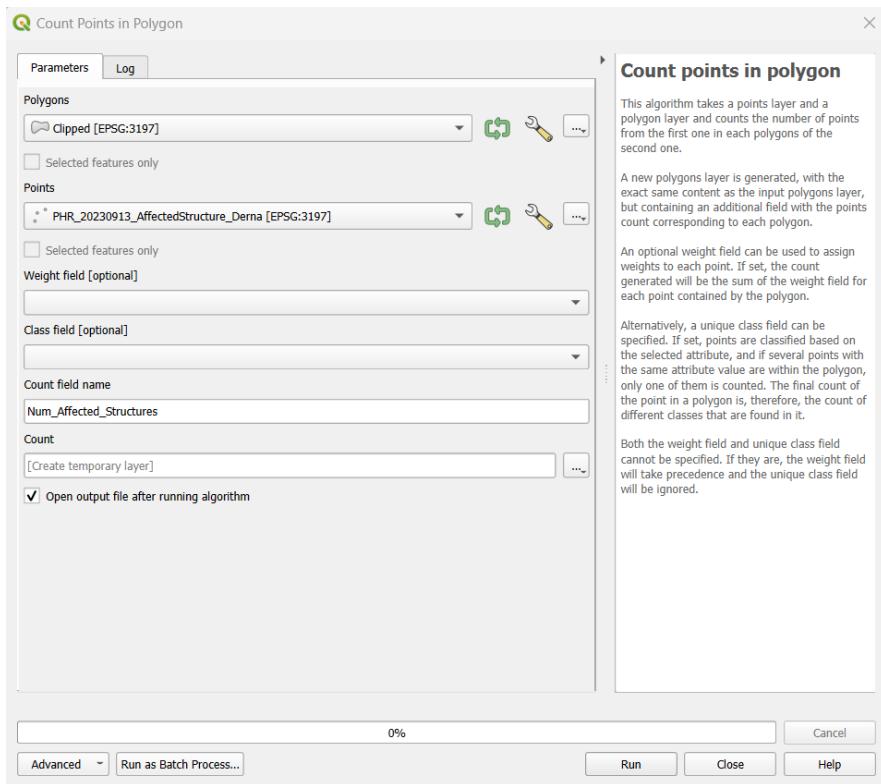


5.3.2.1 Visualisation

Number of Affected Buildings & Structures per 500m

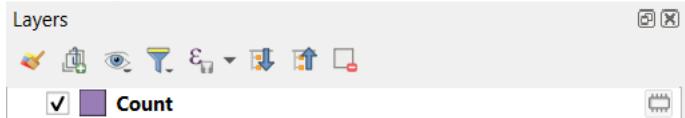
The **Count Points in Polygon** dialog box opens

- For **Polygons**, select the '**Clipped**' layer
 - Click on  , change to
- For **Points**, select '**PHR_20230913_AffectedStructure_Derna [EPSG:3197]**'
 - Click on  , change to
- For **Count field name**, type '**Num_Affected Structures**'



- Click **Run** once done

A new temporary **Count** layer appears



- Remove the temporary **Clipped** layer

Again, Under **Vector > Analysis Tools > Count Points in Polygon...**



The **Count Points in Polygon** dialog box opens. This time:

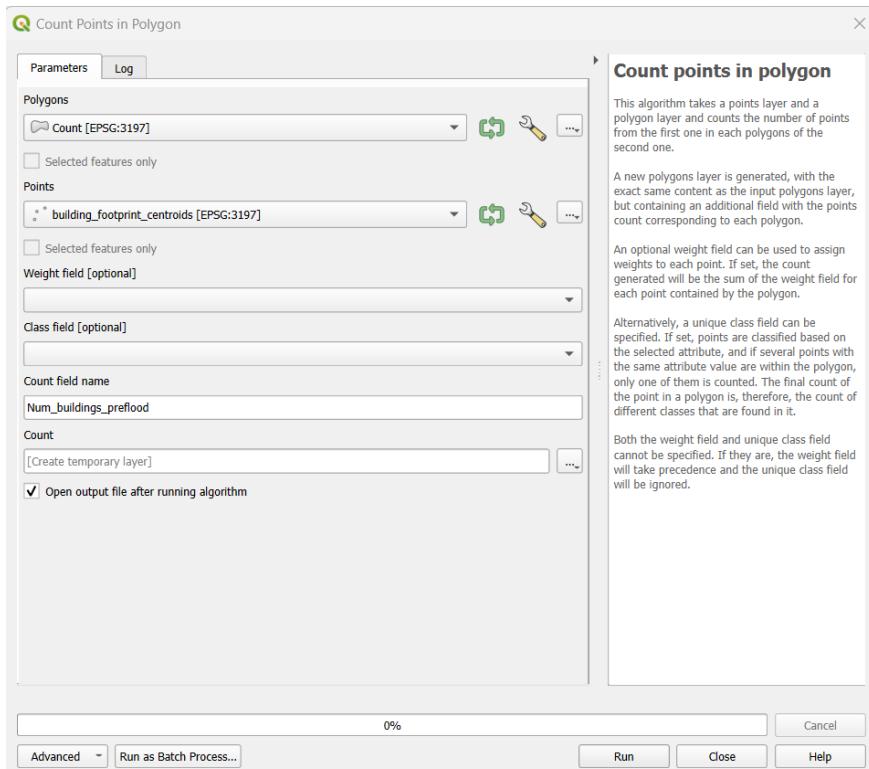
- For **Polygons**, select the '**Count**' layer

- Click on , change to

- For Points, select 'building_footprint_centroids [EPSG:3197]'

- Click on , change to

- For Count field name, type 'Num_buildings_preflood'



- Click **Run** once done

Another new temporary **Count** layer appears

- Remove the previous **Count** layer

Again, Under **Vector > Analysis Tools > Count Points in Polygon...**



The **Count Points in Polygon** dialog box opens. This time:

- For **Polygons**, select the new '**Count**' layer

○ Click on , change to

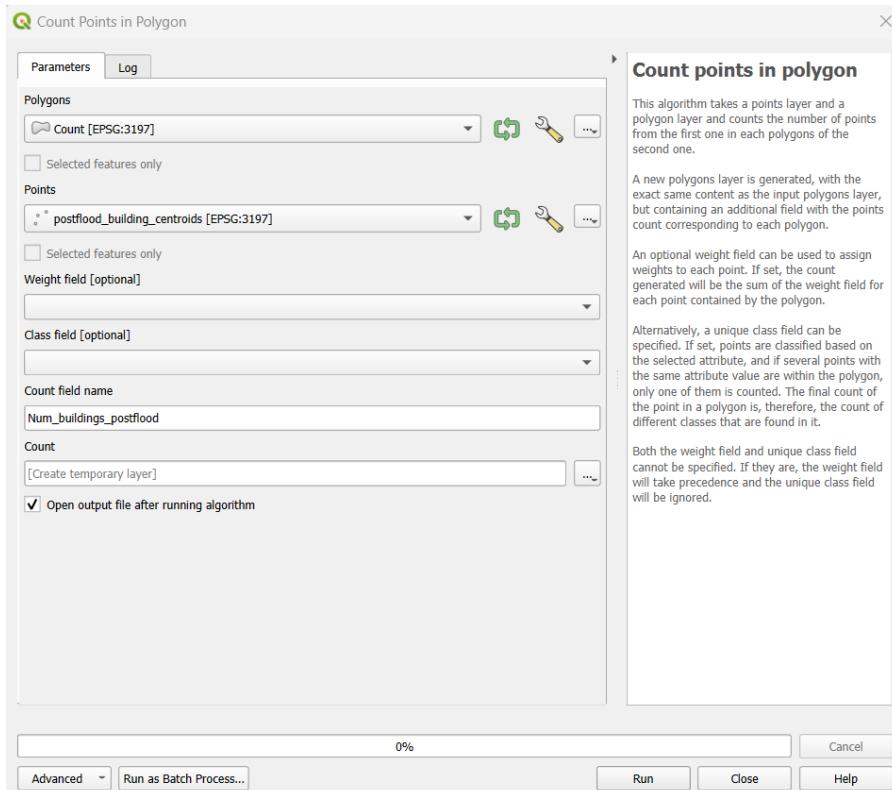
Invalid feature filtering Do not Filter (Better Performance)

- For **Points**, select '**postflood_building_centroids [EPSG:3197]**'

○ Click on , change to

Invalid feature filtering Do not Filter (Better Performance)

- For **Count field name**, type '**Num_buildings_postflood**'



- Click **Run** once done

Another new temporary **Count** layer appears

- Remove the previous **Count** layer

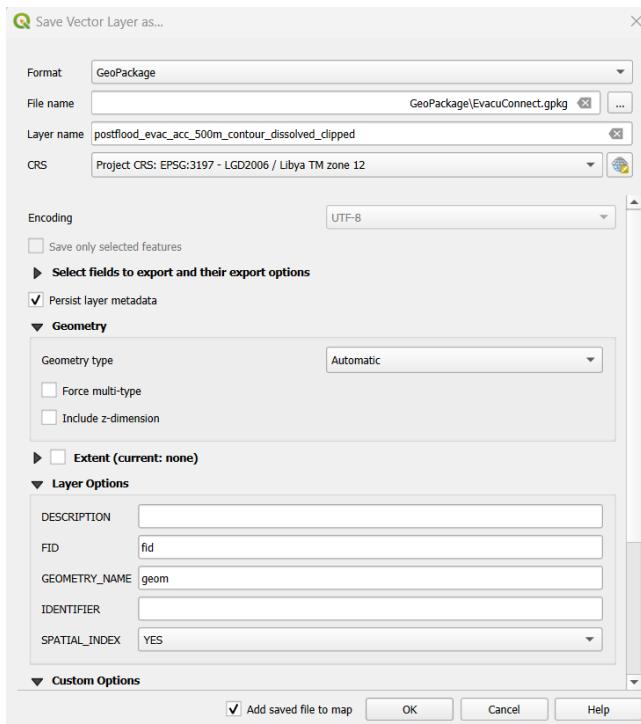
Right click on the newest **Count** layer > **Open Attribute Table**

- You will notice that there are 3 new columns:

Count — Features Total: 10, Filtered: 10, Selected: 0

				Num_Affected_Structures	Num_buildings_preflood	Num_buildings_postflood
id	cost_level	layer	path			
1	9	5000.0000000 Output Polygon	Polygon?crs=EP...	1959	21612	13423
2	8	4500.0000000 Output Polygon	Polygon?crs=EP...	1956	21548	13402
3	7	4000.0000000 Output Polygon	Polygon?crs=EP...	1951	21512	13386
4	6	3500.0000000 Output Polygon	Polygon?crs=EP...	1945	21298	13269
5	5	3000.0000000 Output Polygon	Polygon?crs=EP...	1941	21099	13163
6	4	2500.0000000 Output Polygon	Polygon?crs=EP...	1940	20687	12916
7	3	2000.0000000 Output Polygon	Polygon?crs=EP...	1938	20301	12651
8	2	1500.0000000 Output Polygon	Polygon?crs=EP...	1851	19306	12023
9	1	1000.0000000 Output Polygon	Polygon?crs=EP...	1585	17100	10803
10	0	500.0000000 Output Polygon	Polygon?crs=EP...	746	9014	6066

Export this temporary Count layer into GeoPackage



- For Layer name, use '**postflood_evac_acc_500m_contour_dissolved_clipped**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Right click on the **postflood_medical_acc_500m_contour_dissolved_clipped** layer >

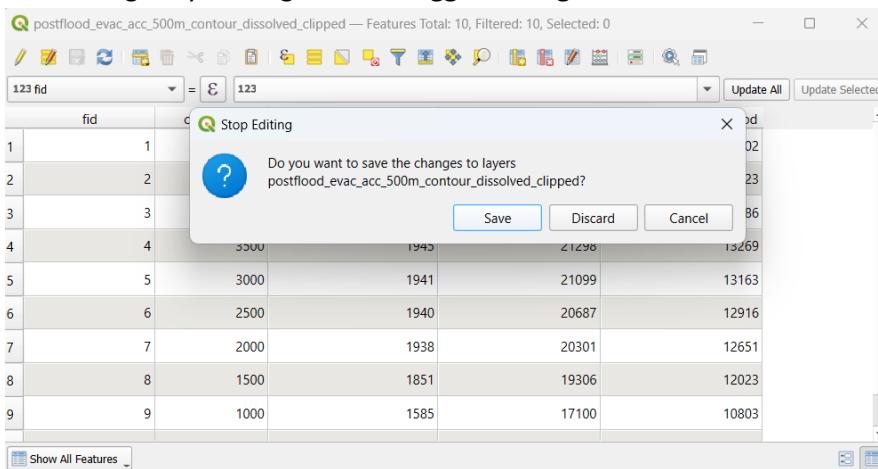
Open Attribute Table



- Click on **Toggle editing mode**
- Click on **Delete field**
- In the **Delete Fields** dialog box, **CTRL + select** the fields:
 - id**
 - layer**
 - path**
- Click on **OK** once done



- Save changes by clicking back on **Toggle Editing mode > Save**



The attribute table will now look something like this:

Q postflood_evac_acc_500m_contour_dissolved_clipped — Features Total: 10, Filtered: 10, Selected: 0

fid	cost_level	Num_Affected_Structures	Num_buildings_preflood	Num_buildings_postflood
1	10	500	746	9014
2	9	1000	1585	17100
3	8	1500	1851	19306
4	7	2000	1938	20301
5	6	2500	1940	20687
6	5	3000	1941	21099
7	4	3500	1945	21298
8	3	4000	1951	21512
9	2	5000	1959	21612
10	1	4500	1956	21548

- The columns of interest are the **cost_level** and **Num_buildings_postflood**

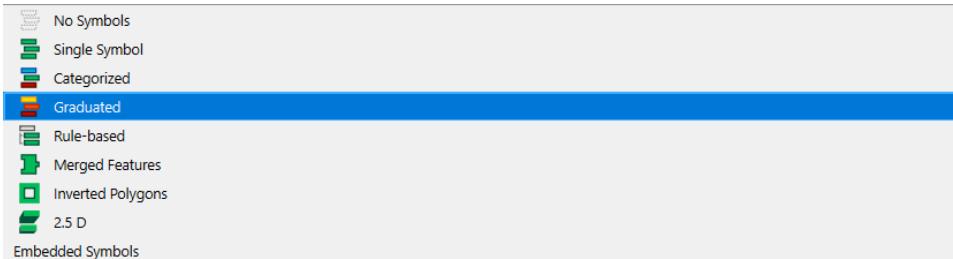
Colour Ramp for Accessibility via Distance Interval

Right click on the **postflood_evac_acc_500m_contour_dissolved_clipped** layer >

Properties...

The Layer Properties dialog box appears > Select Symbology

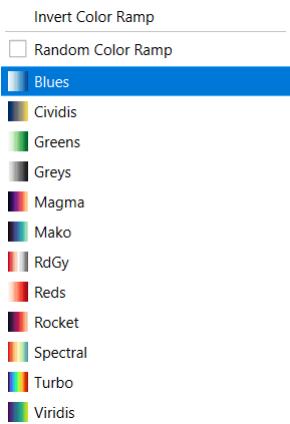
- Under the dropdown, select **Graduated**



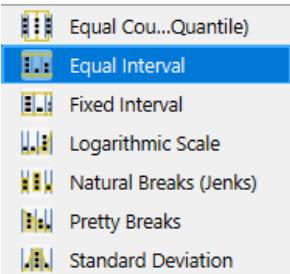
- Under Value, select **cost_level**



- Under Color ramp, select **Blues** and **Invert Colour Ramp**



- For Mode, select **Equal Interval**



- For Classes, set to **10**

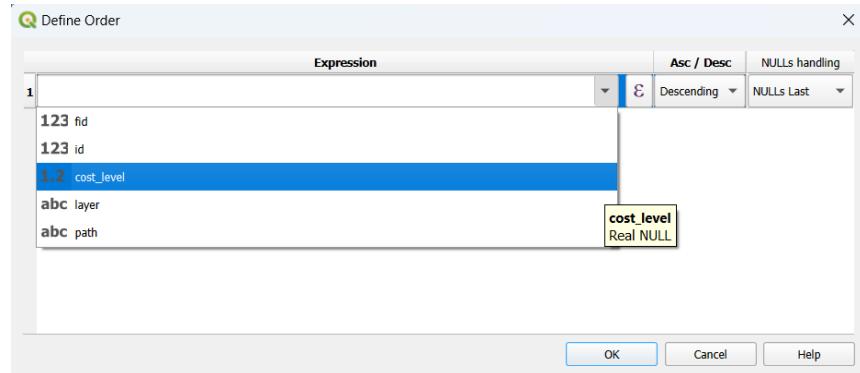
Classes

- Manually edit the Classes Interval values to as follows:

Symbol	Values	Legend
✓	0.00 - 500.00	0 - 500
✓	500.00 - 1000.00	500 - 1000
✓	1000.00 - 1500.00	1000 - 1500
✓	1500.00 - 2000.00	1500 - 2000
✓	2000.00 - 2500.00	2000 - 2500
✓	2500.00 - 3000.00	2500 - 3000
✓	3000.00 - 3500.00	3000 - 3500
✓	3500.00 - 4000.00	3500 - 4000
✓	4000.00 - 4500.00	4000 - 4500
✓	4500.00 - 5000.00	4500 - 5000

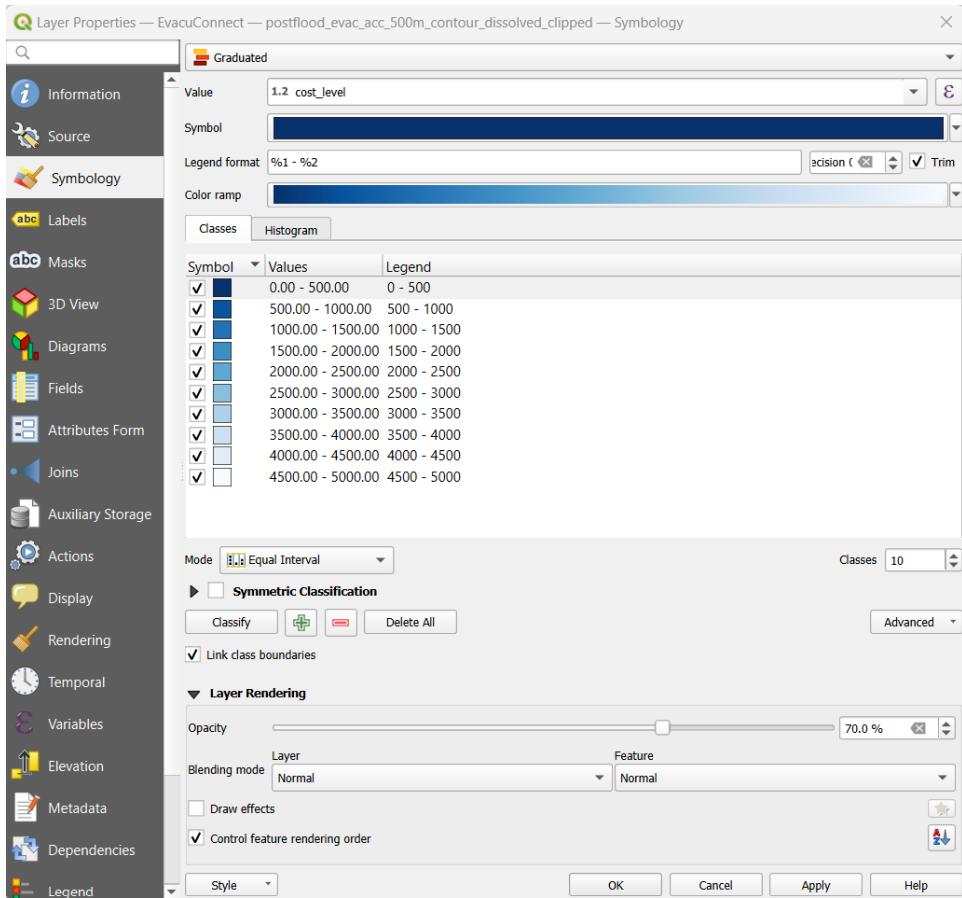
- Set **Opacity** to **70%**

- Select the checkbox beside Control feature rendering order and click on
- The **Define Order** dialog box appears
- In the drop-down menu, select **cost_level**
- Set to **Descending**
- Click **OK** once done



Your screen should look something like below:

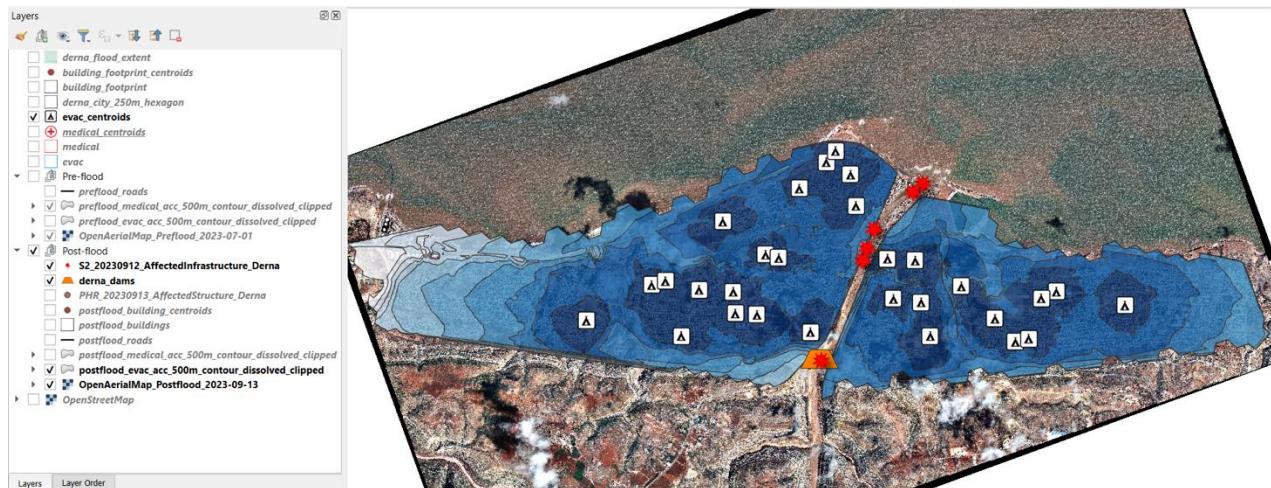
- Click **Apply** and **OK** once done



The map output would look something like the following:

- Activate the following layers in this order, rearrange the layers if needed:
 - **derna_dams**
 - **evac_centroids**
 - **S2_20230912_AffectedInfrastructure_Derna**

- `postflood_medical_acc_500m_contour_dissolved_clipped`
- `OpenAerialMap_Postflood_2023_09_13`
- Set Rotation to **-20.0** Rotation **-20.0 °**



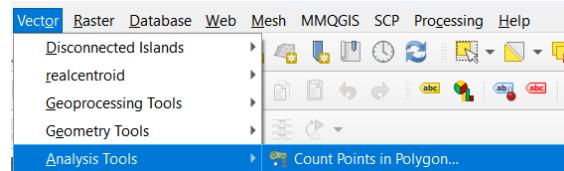
5.3.3 Medical Facilities (Pre-flood)

Repeat the steps in **5.3.1 Medical Facilities (Post-flood)**, this time using **preflood_roads** instead for **Vector layer representing network**

5.3.3.1 Visualisation

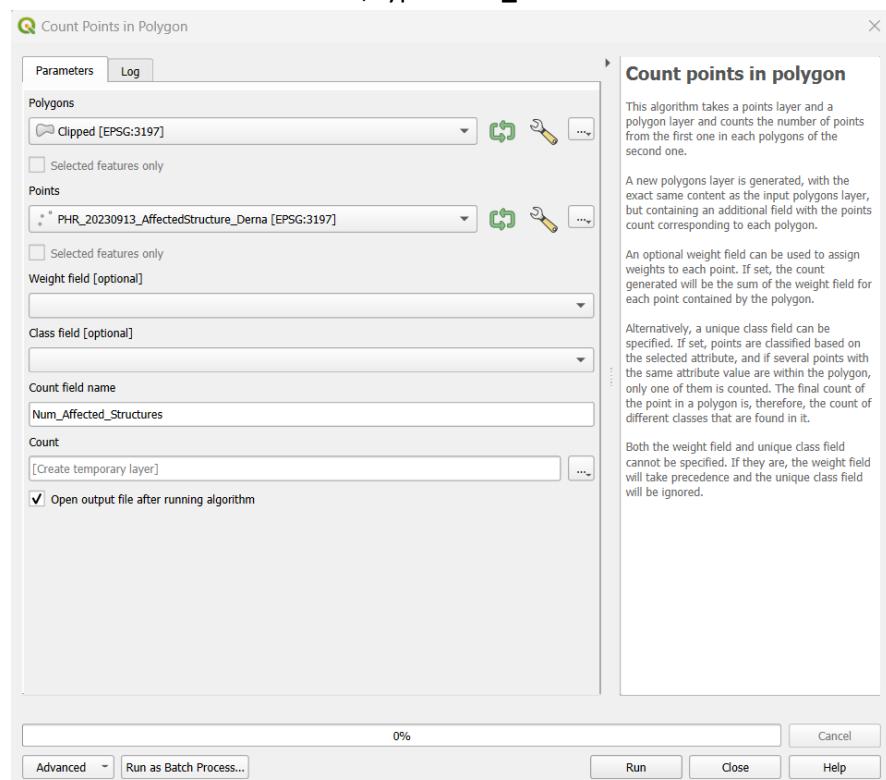
Number of Affected Buildings & Structures per 500m

Under **Vector > Analysis Tools > Count Points in Polygon...**



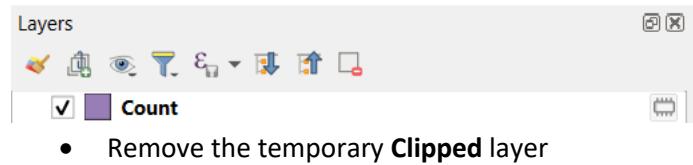
The **Count Points in Polygon** dialog box opens

- For **Polygons**, select the 'Clipped' layer
 - Click on , change to Invalid feature filtering **Do not Filter (Better Performance)**
- For **Points**, select '**PHR_20230913_AffectedStructure_Derna [EPSG:3197]**'
 - Click on , change to Invalid feature filtering **Do not Filter (Better Performance)**
- For **Count field name**, type '**Num_Affected_Structures**'



- Click **Run** once done

A new temporary **Count** layer appears

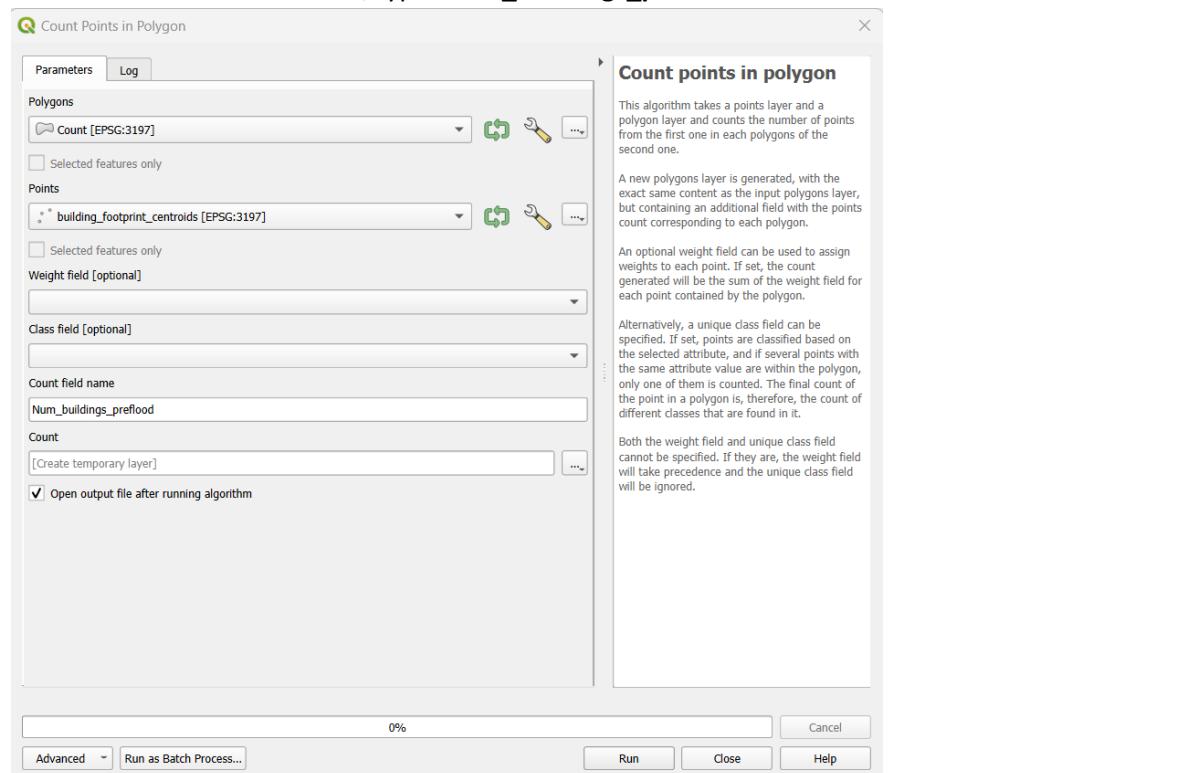


Again, Under **Vector > Analysis Tools > Count Points in Polygon...**



The **Count Points in Polygon** dialog box opens. This time:

- For **Polygons**, select the '**Count**' layer
 - Click on , change to
- For **Points**, select '**building_footprint_centroids [EPSG:3197]**'
 - Click on , change to
- For **Count field name**, type '**Num_buildings_preflood**'

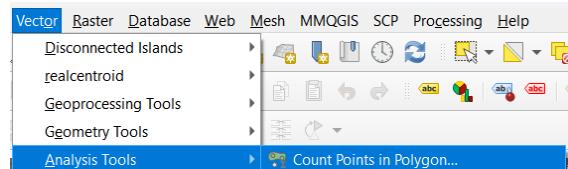


- Click **Run** once done

Another new temporary **Count** layer appears

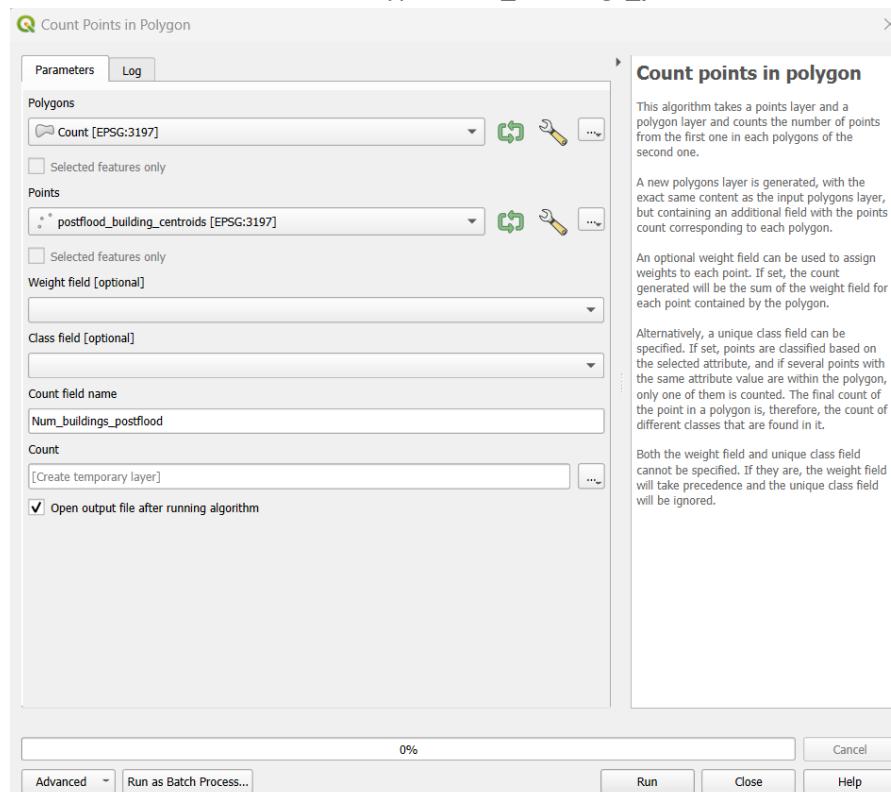
- Remove the previous **Count** layer

Again, Under **Vector > Analysis Tools > Count Points in Polygon...**



The **Count Points in Polygon** dialog box opens. This time:

- For **Polygons**, select the new '**Count**' layer
 - Click on , change to
- For **Points**, select '**postflood_building_centroids [EPSG:3197]**'
- For **Count field name**, type '**Num_buildings_postflood**'



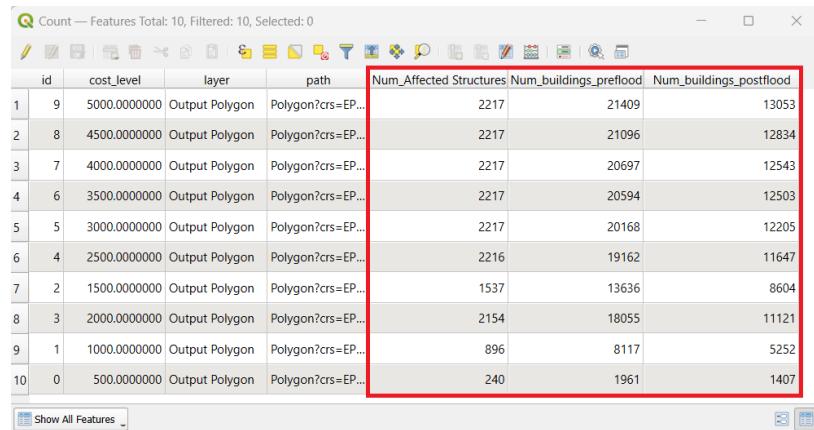
- Click **Run** once done

Another new temporary **Count** layer appears

- Remove the previous **Count** layer

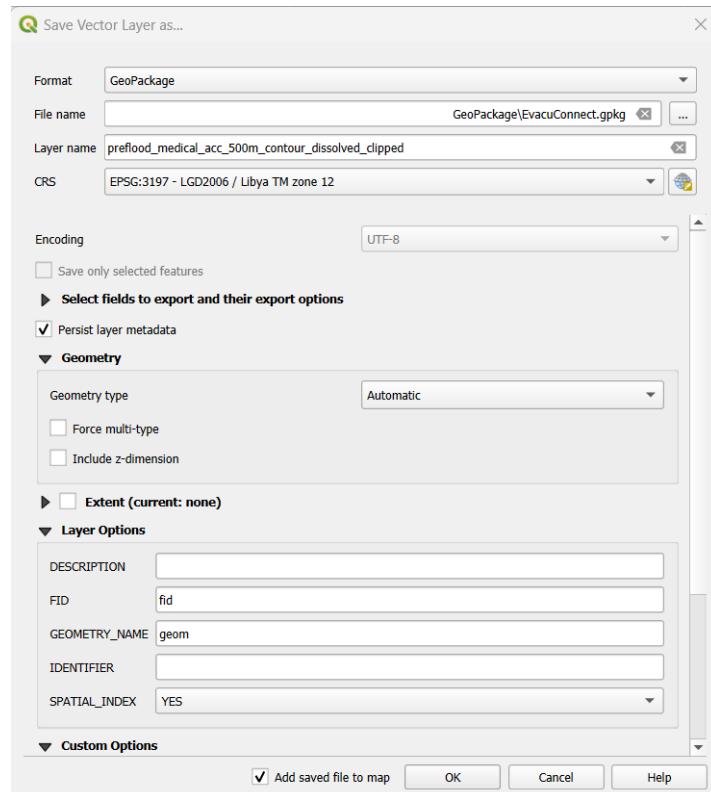
Right click on the newest **Count** layer > **Open Attribute Table**

- You will notice that there are 3 new columns:



				Num_Affected_Structures	Num_buildings_preflood	Num_buildings_postflood
1	9	5000.0000000 Output Polygon	Polygon?crs=EP...	2217	21409	13053
2	8	4500.0000000 Output Polygon	Polygon?crs=EP...	2217	21096	12834
3	7	4000.0000000 Output Polygon	Polygon?crs=EP...	2217	20697	12543
4	6	3500.0000000 Output Polygon	Polygon?crs=EP...	2217	20594	12503
5	5	3000.0000000 Output Polygon	Polygon?crs=EP...	2217	20168	12205
6	4	2500.0000000 Output Polygon	Polygon?crs=EP...	2216	19162	11647
7	2	1500.0000000 Output Polygon	Polygon?crs=EP...	1537	13636	8604
8	3	2000.0000000 Output Polygon	Polygon?crs=EP...	2154	18055	11121
9	1	1000.0000000 Output Polygon	Polygon?crs=EP...	896	8117	5252
10	0	500.0000000 Output Polygon	Polygon?crs=EP...	240	1961	1407

Export this temporary **Count** layer into GeoPackage

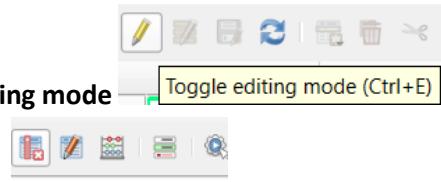


- For Layer name, use '**preflood_medical_acc_500m_contour_dissolved_clipped**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Right click on the **preflood_medical_acc_500m_contour_dissolved_clipped** layer >

| Open Attribute Table

- Click on **Toggle editing mode**



- Click on **Delete field**

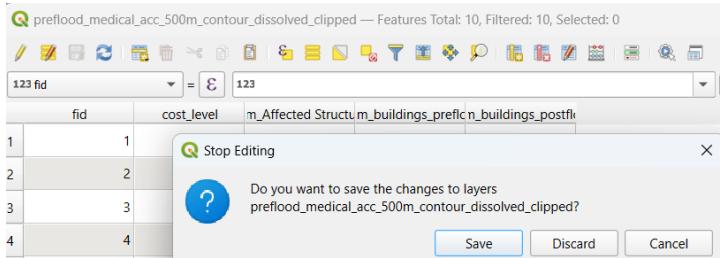
| Delete field (Ctrl+L)

- In the **Delete Fields** dialog box, **CTRL + select** the fields:

- id**
- layer**
- path**
- Click on **OK** once done



- Save changes by clicking back on **Toggle Editing mode** > **Save**



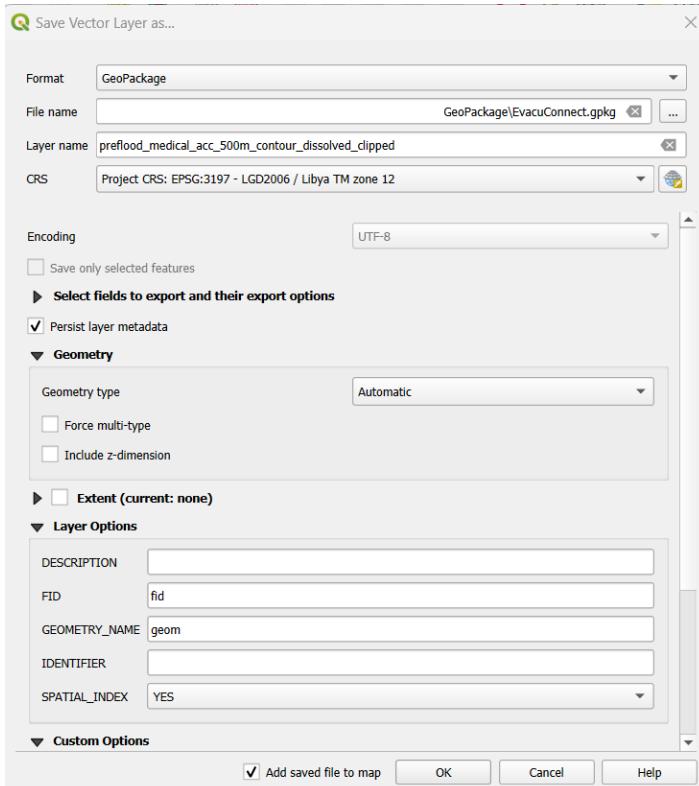
The attribute table will now look something like this:

fid	cost_level	Num_Affected Structures	Num_buildings_preflood	Num_buildings_postflood
1	10	500	240	1961
2	9	1000	896	8117
3	8	2000	2154	18055
4	7	1500	1537	13636
5	6	2500	2216	19162
6	5	3000	2217	20168
7	4	3500	2217	20594
8	3	4000	2217	20697
9	2	4500	2217	21096
10	1	5000	2217	21409

- The columns of interest are the **cost_level** and **Num_buildings_preflood**

Colour Ramp for Accessibility via Distance Interval

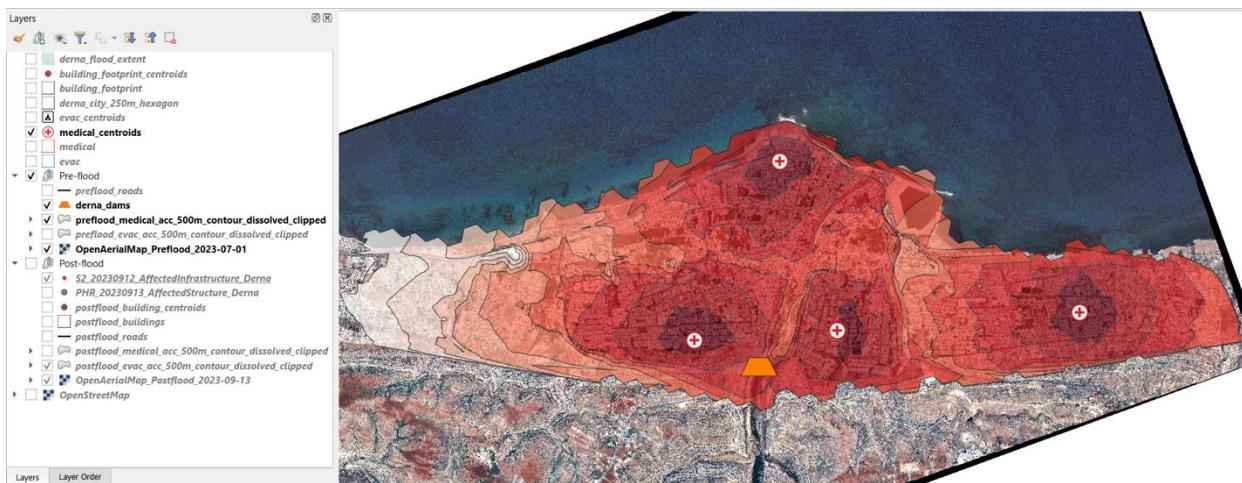
- When exporting to GeoPackage, for Layer name, use
'preflood_medical_acc_500m_contour_dissolved_clipped'



The map output would look something like the following:

- Activate the following layers in this order, rearrange the layers if needed:
 - medical_centroids**

- **derna_dams**
- **preflood_medical_acc_500m_contour_dissolved_clipped**
- **OpenAerialMap_Preflood_2023_07_11**
- Set Rotation to -20.0 Rotation -20.0 °



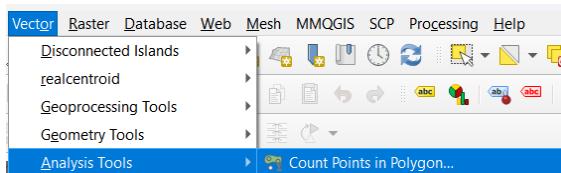
5.3.4 Evacuation Centres (Pre-flood)

Repeat the steps in **5.3.2 Evacuation Centres (Post-flood)**, this time using **preflood_roads** instead for **Vector layer representing network**

5.3.4.1 Visualisation

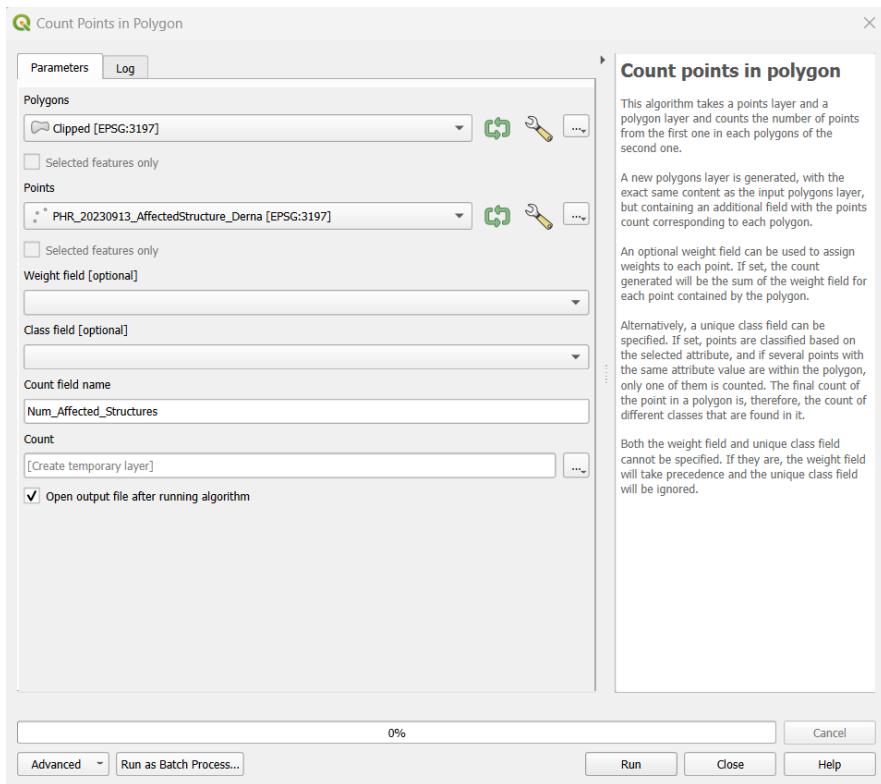
Number of Affected Buildings & Structures per 500m

Under **Vector > Analysis Tools > Count Points in Polygon...**



The **Count Points in Polygon** dialog box opens

- For **Polygons**, select the '**Clipped**' layer
 - Click on , change to
- For **Points**, select '**PHR_20230913_AffectedStructure_Derna [EPSG:3197]**'
 - Click on , change to
- For **Count field name**, type '**Num_Affected Structures**'



- Click **Run** once done

A new temporary **Count** layer appears



- Remove the temporary **Clipped** layer

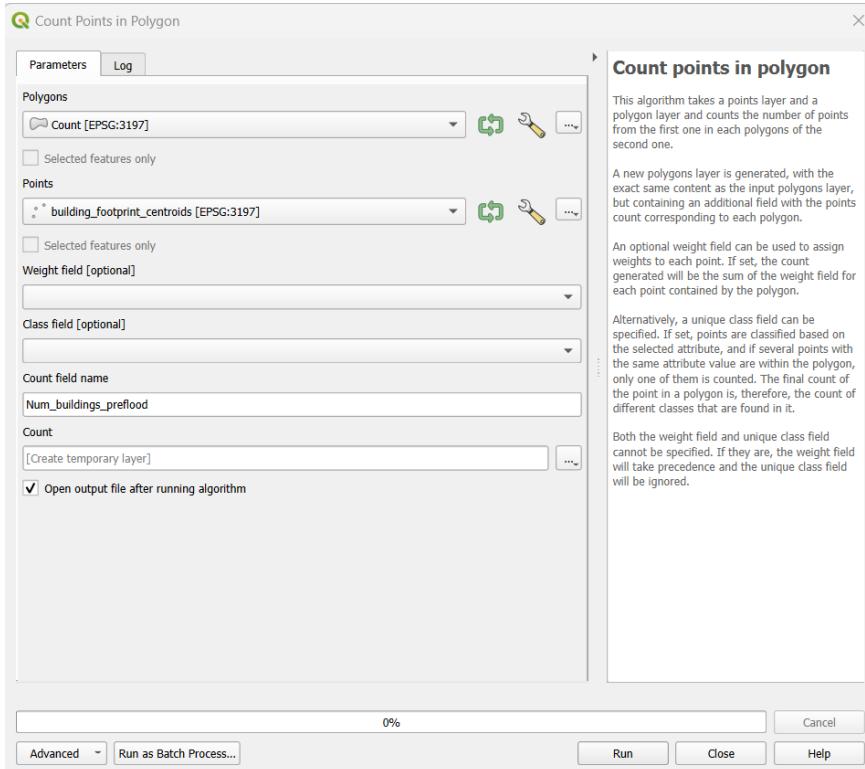
Again, Under **Vector > Analysis Tools > Count Points in Polygon...**



The **Count Points in Polygon** dialog box opens. This time:

- For **Polygons**, select the '**Count**' layer
 - Click on , change to
- For **Points**, select '**building_footprint_centroids [EPSG:3197]**'
 - Click on , change to

- For Count field name, type '**Num_buildings_preflood**'



- Click **Run** once done

Another new temporary **Count** layer appears

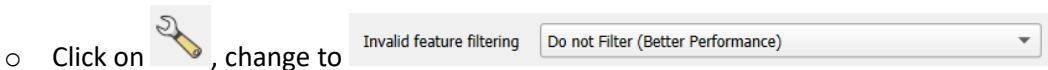
- Remove the previous **Count** layer

Again, Under **Vector > Analysis Tools > Count Points in Polygon...**

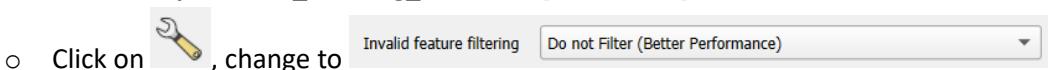


The **Count Points in Polygon** dialog box opens. This time:

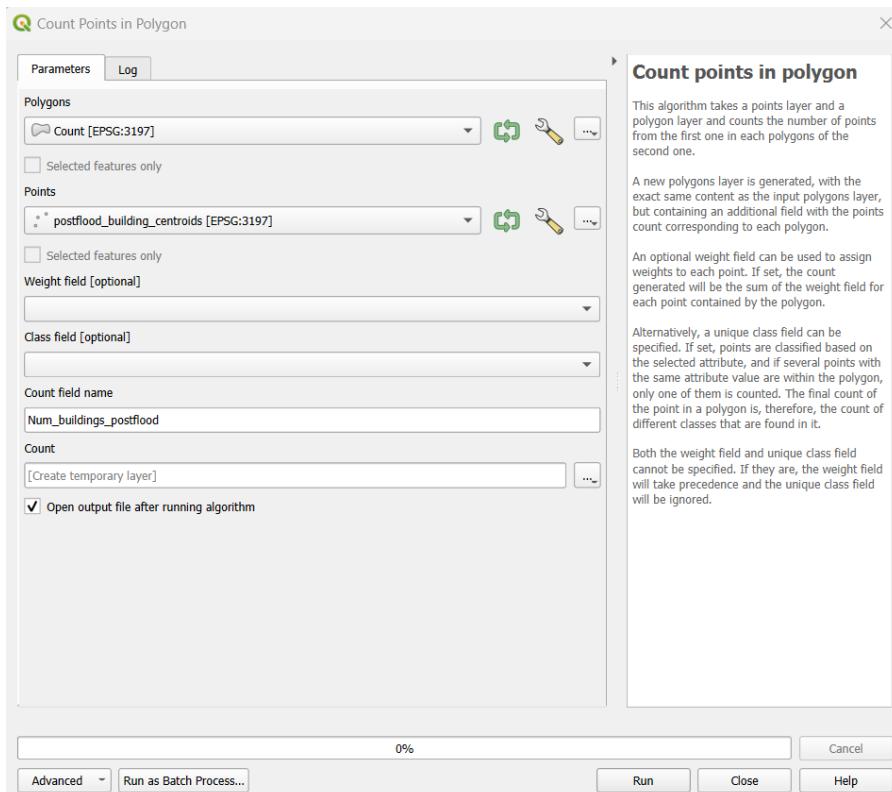
- For **Polygons**, select the new '**Count**' layer



- For **Points**, select '**postflood_building_centroids [EPSG:3197]**'



- For **Count field name**, type '**Num_buildings_postflood**'



- Click **Run** once done

Another new temporary **Count** layer appears

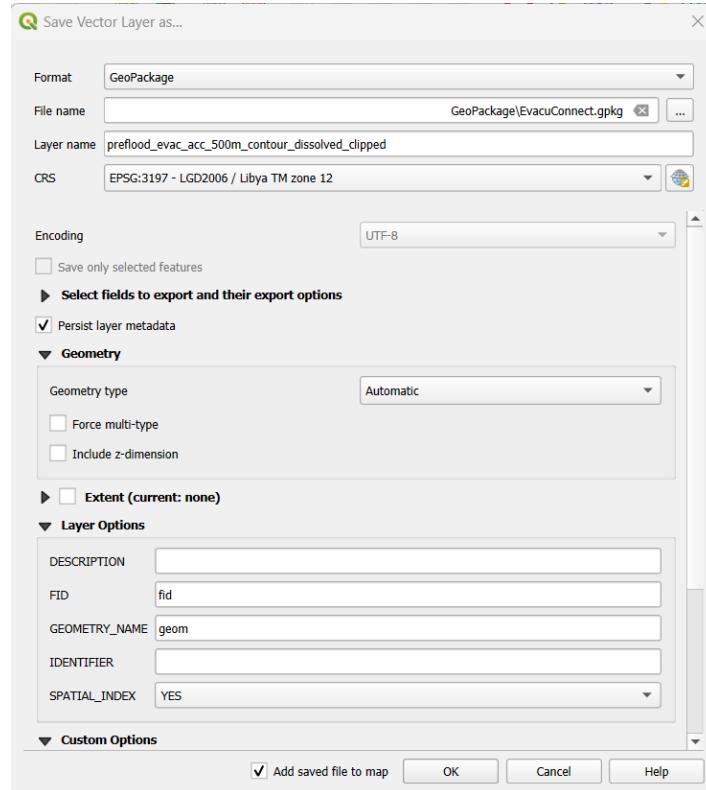
- Remove the previous **Count** layer

Right click on the newest **Count** layer > **Open Attribute Table**

- You will notice that there are 3 new columns:

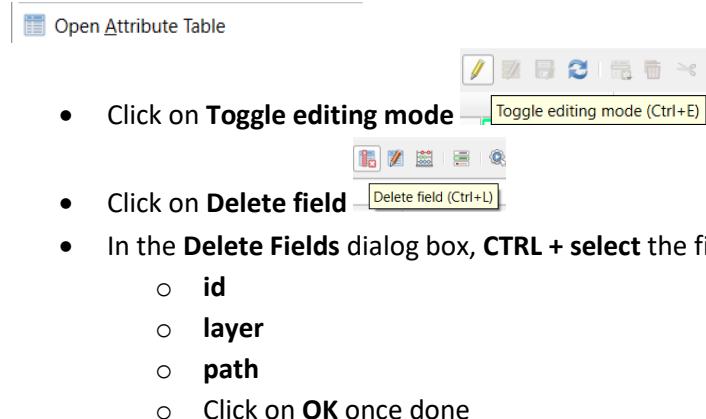
				Num_Affected_Structures	Num_buildings_preflood	Num_buildings_postflood
id	cost_level	layer	path			
1	9	5000.0000000	Output Polygon	Polygon?crs=EP...	2217	22347
2	8	4500.0000000	Output Polygon	Polygon?crs=EP...	2217	22288
3	7	4000.0000000	Output Polygon	Polygon?crs=EP...	2217	22207
4	6	3500.0000000	Output Polygon	Polygon?crs=EP...	2217	22085
5	5	3000.0000000	Output Polygon	Polygon?crs=EP...	2217	21869
6	4	2500.0000000	Output Polygon	Polygon?crs=EP...	2217	21497
7	3	2000.0000000	Output Polygon	Polygon?crs=EP...	2217	21105
8	2	1500.0000000	Output Polygon	Polygon?crs=EP...	2205	20227
9	1	1000.0000000	Output Polygon	Polygon?crs=EP...	2049	18008
10	0	500.0000000	Output Polygon	Polygon?crs=EP...	940	6243

Export this temporary Count layer into GeoPackage



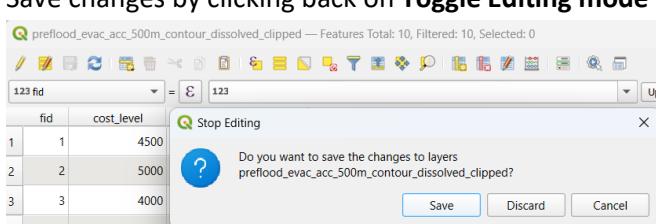
- For Layer name, use '**preflood_evac_acc_500m_contour_dissolved_clipped**'
- For CRS, select the **Project CRS: EPSG:3197 – LGD2006 / Libya TM zone 12**
- Click **OK**

Right click on the **preflood_evac_acc_500m_contour_dissolved_clipped** layer >





- Save changes by clicking back on **Toggle Editing mode > Save**

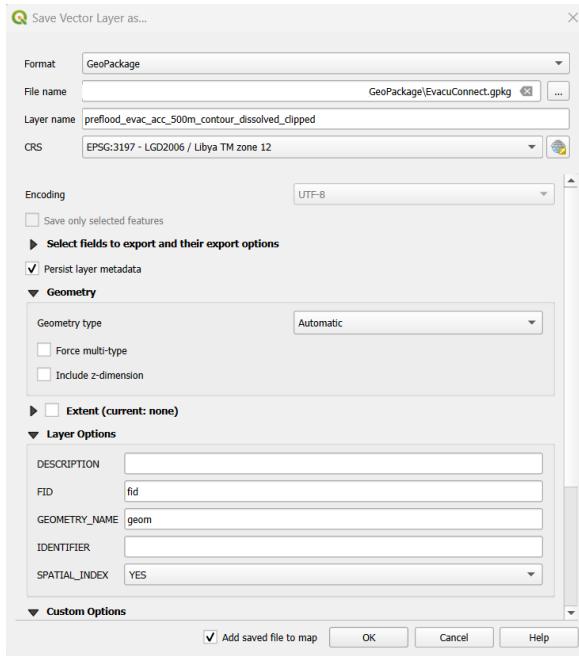


The attribute table will now look something like this:

fid	cost_level	Num_Affected_Structures	Num_buildings_preflood	Num_buildings_postflood
1	10	500	940	9540
2	9	1000	2049	18008
3	8	1500	2205	20227
4	7	2000	2217	21105
5	6	2500	2217	21497
6	5	3000	2217	21669
7	4	3500	2217	22085
8	3	4000	2217	22207
9	2	5000	2217	22347
10	1	4500	2217	22288

- The columns of interest are the **cost_level** and **Num_buildings_preflood**

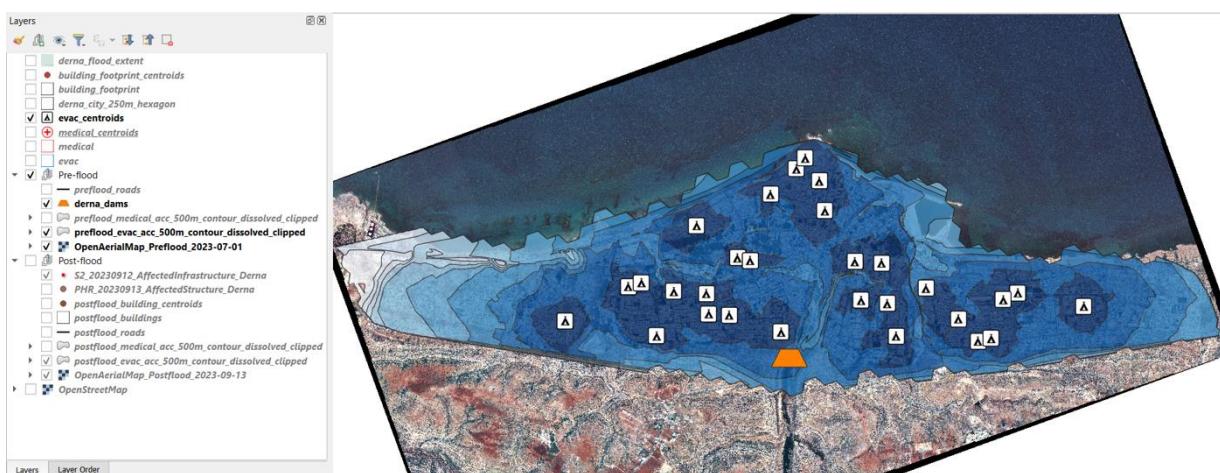
Colour Ramp for Accessibility via Distance Interval



- When exporting to GeoPackage, for Layer name, use '**'preflood_evac_acc_500m_contour_dissolved_clipped'**'

The map output would look something like the following:

- Activate the following layers in this order, rearrange the layers if needed:
 - **evac_centroids**
 - **derna_dams**
 - **preflood_evac_acc_500m_contour_dissolved_clipped**
 - **OpenAerialMap_Preflood_2023_07_11**
- Set Rotation to **-20.0**



5.4 Visualisation – Tabular Data

5.4.1 Evacuation Centres (Pre- & Post-flood)

Using external software (e.g. Excel), consolidate the values into a table in accordance with the colours in the contoured map

- For ease, the HTML colour codes are:
 - **500m:** #08306b
 - **1000m:** #0a549e
 - **1500m:** #2272b5
 - **2000m:** #3e8ec4
 - **2500m:** #60a6d2
 - **3000m:** #89bedc
 - **3500m:** #afdf1e7
 - **4000m:** #cde0f1
 - **4500m:** #e2edf8
 - **5000m:** #f7fbff
- Also calculate the change in %

E.g.

Distance from Evacuation Centers within (m)	Number of buildings		
	Pre-Flood	Post-Flood	Change (%)
500	9540	6066	-36.42%
1000	18008	10803	-40.01%
1500	20227	12023	-40.56%
2000	21105	12651	-40.06%
2500	21497	12916	-39.92%
3000	21869	13163	-39.81%
3500	22085	13269	-39.92%
4000	22207	13386	-39.72%
4500	22288	13402	-39.87%
5000	22347	13423	-39.93%

5.4.2 Medical Facilities (Pre- & Post-flood)

Using external software (e.g. Excel), consolidate the values into a table in accordance with the colours in the contoured map

- For ease, the HTML colour codes are:
 - **500m:** #67000d
 - **1000m:** #a91016
 - **1500m:** #cc191d
 - **2000m:** #ea372a
 - **2500m:** #f85d42
 - **3000m:** #fc8161
 - **3500m:** #fca486
 - **4000m:** #fdc6af
 - **4500m:** #fee3d6
 - **5000m:** #ffff5f0
- Also calculate the change in %

E.g.

Distance from Medical Facilities within (m)	Number of buildings		
	Pre-Flood	Post-Flood	Change (%)
500	1961	1303	-33.55%
1000	8117	4683	-42.31%
1500	13636	8176	-40.04%
2000	18055	10415	-42.32%
2500	19162	11258	-41.25%
3000	20168	11834	-41.32%
3500	20594	12275	-40.40%
4000	20697	12312	-40.51%
4500	21096	12621	-40.17%
5000	21409	12854	-39.96%

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