Exercises: Using InsSAFE for disaster impact assessment

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List of Abbreviations

DEM	Digital Elevation Model
GFDRR	Global Facility for Disaster Reduction and Recovery
LIDAR	Light Detection And Ranging
MLUH	Ministry for Land Use and Housing

1 Introduction

InaSAFE is plugin for QGIS to perform disaster impact assessments. It facilitates analyses such as *Which structures and to what level are affected by a flood.* Each layer/dataset used in InaSAFE falls in one of the following three categories:

- Hazard
- Exposure
- Aggregation

The user has to assign one of these categories to each datasets to be used in an InaSAFE analysis. This is done by using the *Keywords Creation Wizard* covered at a later stage during this exercise. Once the categories have been assigned InaSAFE facilitates impact assessment analyses by performing on a single mouse-click what otherwise would require numerous steps using the standard GIS tools available.

InaSAFE was initially developed by the Indonesian National Disaster Management Agency (BNPB), the Australian Government and the World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR). To date it has a very active user and developer community.

Download and install the InaSAFE plugin trough the *Manage and Install Plugins* dialog (menu *Plugins*). Enter InaSAFE in the search field and install the plugin (Figure 1)

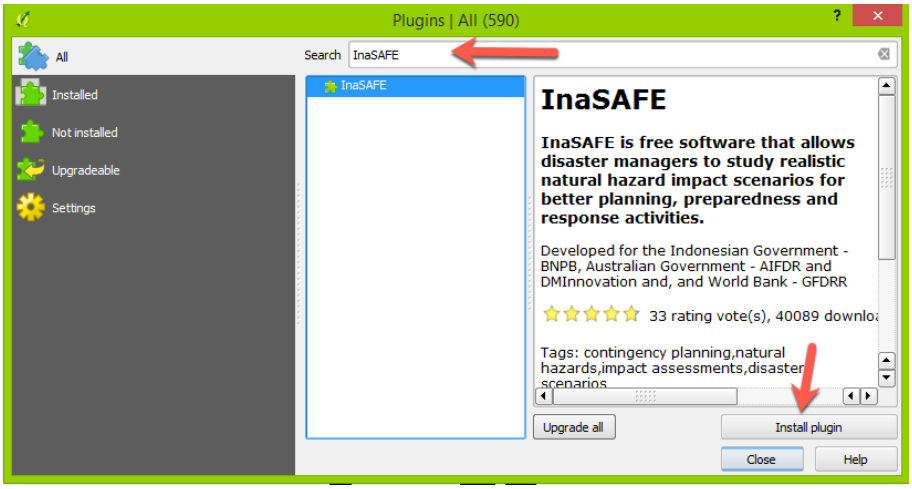

Figure 1: Installing InaSAFE

2 Preparing the hazard data

2.1 Loading the DEM

From the *Data/DEM* folder load the the Digital Elevation Model (DEM) for Mahe (*Mahe_DEM.tif*). The DEM is a raster datasets and hence, needs to be loaded through the *Add Raster Layer* tool of QGIS. The DEM was generated from Light Detection And Ranging (LIDAR) data and reflects the elevation of the terrain above mean sea level. QGIS will automatically assign an appropriate style to visualise the elevation range of the DEM (Figure 2). Be aware that the DEM reflects the situation from 2011. Any landfill or excavation work done since then is of course not covered.

You can use the *Identify Features* tool of QGIS to get information about the individual heights in the DEM. Activate the tool and click somewhere in the DEM. The way the DEM is currently styled makes it hard to get a good idea of the terrain's shape. A much better way to visualise that is a so called hillshade image. Select the *Hillshade* tool from the *Raster:Terrain Analysis* menu. Leave the settings as shown in Figure 3 and click OK. Depending on your computer's performance generating the hillshade image might take a few seconds.

Experiment with the z-factor and illumination settings and create a few hill-

Figure 2: DEM of Mahe

shade images to see how these settings are reflected. The z-factor can be used to visualise even small differences in elevation and is in a way an "exaggeration-factor".

2.2 Creating the inundation layer

Let's assume the sea level would rise 6m as a result of a Tsunami for example. You will now create an inundation map based on that assumption. From the mathematical point of view you will subtract the current terrain elevations from an assumed 6m-plane. Open the *Raster Calculator* from the *Raster* menu. The *Raster Calculator* will automatically list all raster bands it currently finds in the table of contents. In the *Raster calculator expression* field type "6-" and then double-click the *Mahe_DEM@1* layer to add it to the expression field. Leave all other settings as they are and click OK (Figure 4).

The result is a raster map with positive heights for all inundated areas and negative heights for those not inundated. Keep in mind that this is a simplified approach. If you had a terrain situation as shown in Figure 5 the sea water would never reach the B-section. However, your current calculation would show that area as inundated.

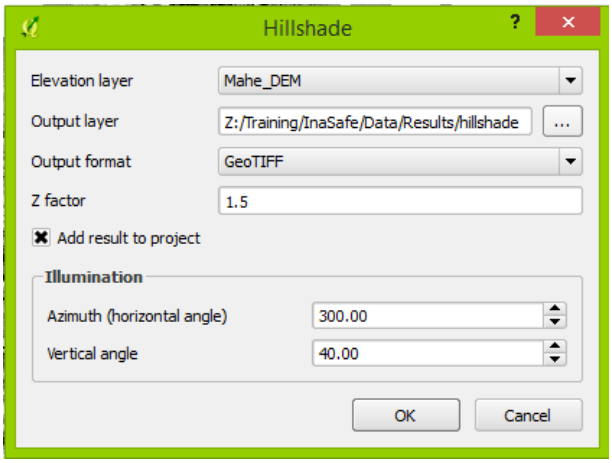

Figure 3: Settings for hillshade image

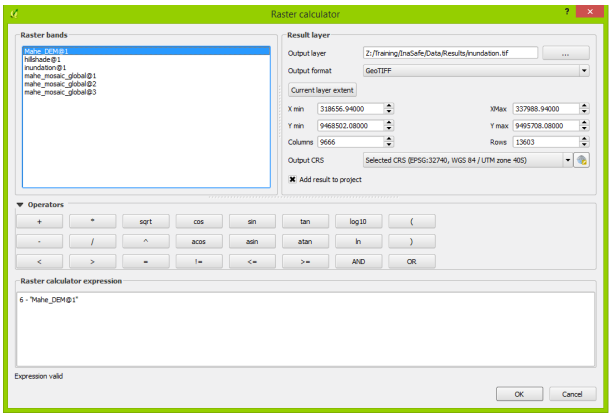

Figure 4: Raster Calculator settings

For (much) faster analyses with InaSAFE you should reduce the resolution of the inundation layer to 50%. The current resolution resulting from the original DEM is 2m/pixel. You should reduce it to 4m/pixel. You can use the *Warp* tool from the *Raster:Projections* menu. Use the settings as shown in Figure 6.

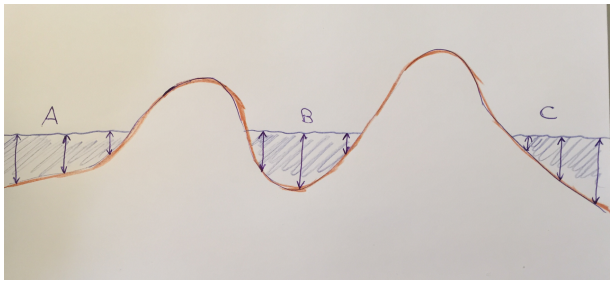

Figure 5: Simplified calculation approach

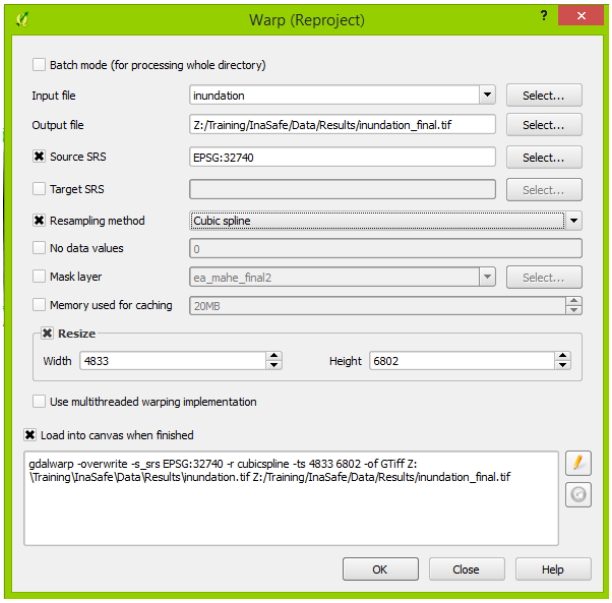

Figure 6: Resampling the inundation raster

3 Preparing the exposure data

Load the *road* and *building* layers from the *Data/Shapefiles* folder into QGIS. InaSAFE supports categorising the buildings and roads by type in the impact assessment results. Both layers need to have one attribute that represents their type. For buildings these types are supported by InaSAFE:

- Residential
- Education

- Health
- Transport
- Place of Worship
- Government
- Commercial
- Recreation
- Public Facility
- Other

For roads the types as follows are supported:

- Motorway
- Primary
- Secondary
- Local
- Path
- Other

The *road* layer has categories already assigned (attribute *CATEGORY*) while the *building* layer does not. In the *Data/Shapefiles* folder you will find a file *road_categories.csv* with a description of the categories. For the *building* layer you have to populate the categories yourself. Add a new column of type *integer* to the layer and name it *TYPE*. Define a number for each of the ten building types supported by InaSAFE as shown above. Health care and education relating buildings you can identify using two existing layers *medical_facility* and *school* in the *Data/Shapefiles* folder. These layers have point geometry but you can use a

spatial query to relate them with the original *building* layer and assign the building features the numeric codes you defined for the *Health* and *Education* categories. This approach will give you categories for very few buildings only. To the remaining ones you could randomly assign one of the other eight categories using the same methodology you used in the previous workshop to assign dates to the Dengue cases. At the end of this exercise each building should have a category/type assigned.

4 Preparing the aggregation layer

Load the *district* layer from the *Data/Shapefiles* folder into QGIS. It will allow you to aggregate the impact assessment results by district. No other preparation is required for the aggregation layer.

5 Assigning keywords

You now have to assign categories to the exposure, hazard and aggregation data so that InaSAFE knows what role the datasets have in the impact analysis.

5.1 Exposure layers

Select the *building* layer in the table of contents and click the *Keyword Creation Wizard* button on the InaSAFE toolbar. Select *Exposure* as the keyword (Figure 7). In the next step select *Structure*. Click *Next* twice and select *TYPE* as the attribute containing the classes of structure/building (Figure 9).

Assign the numeric type values to the structure classes defined in InaSAFE by dragging the numeric values and dropping them on the structure classes (Figure 10). Click *Next* until you reach the end of the *Keyword Creation Wizard*.

Repeat the same steps for the *road* layer and select the *CATEGORY* attribute this time as the one containing the road classes.

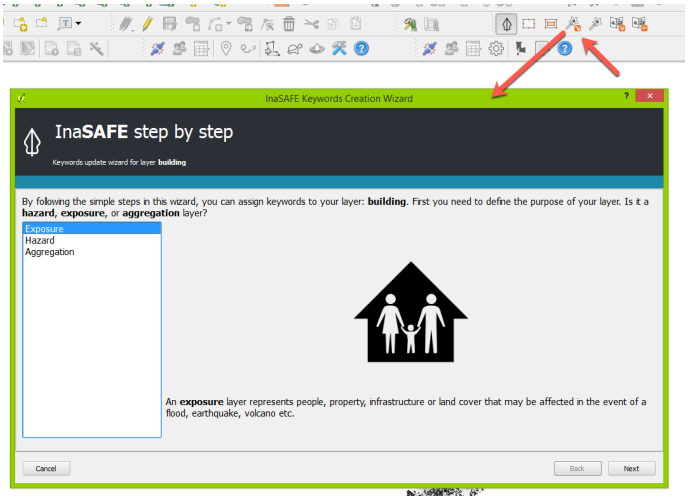

Figure 7: Declaring building layer as Exposure dataset

5.2 Hazard layer

Select the *inundation_final* layer in the table of contents and run the *Keyword Creation Wizard*. Select *Hazard* in the first step and *Tsunami* in the second. Select *Single event* in the third step and *Continuous* in the forth one. Select *Metres* as the unit for the inundation data. Click *Next* until you reach the end of the *Keyword Creation Wizard*.

5.3 Aggregation layer

Select the *district* layer in the table of contents and run the *Keyword Creation Wizard*. Select *Aggregation* in the first step and *NAME* as the attribute containing the names of the aggregation areas in the second step.Click *Next* until you reach the end of the *Keyword Creation Wizard*.

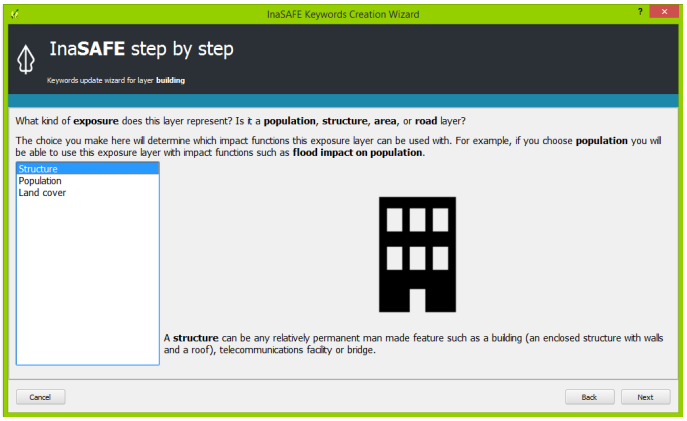

Figure 8: Assigning *Structure* keyword to building layer

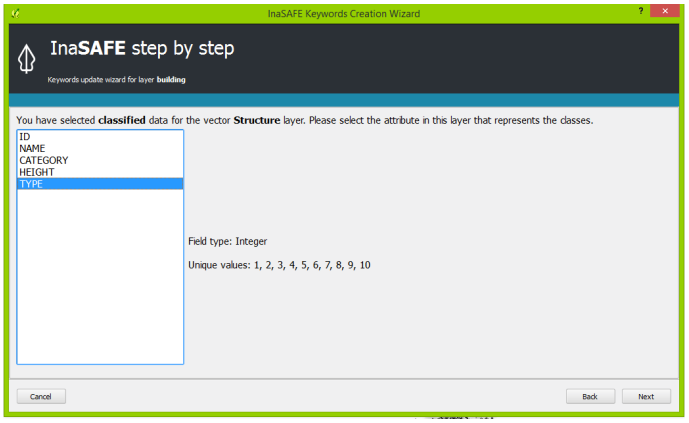

Figure 9: Selecting the attribute defining the building type

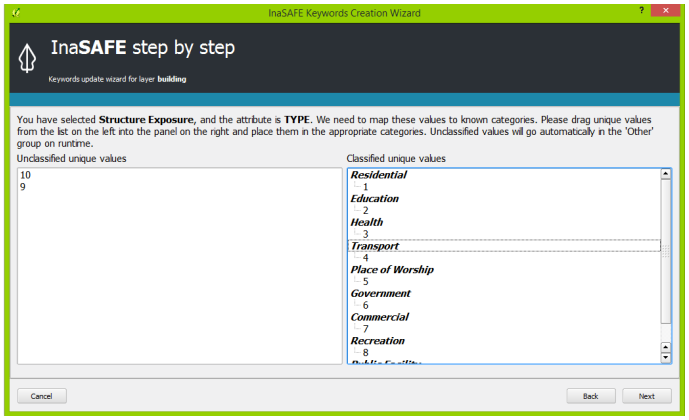

Figure 10: Relating codes to structure classes

6 Performing impact analyses

6.1 Identifying extent and level of the impact

Everything done so far was just preparation work for the actual impact analyses. Once the keywords are assigned to the datasets InaSAFE will offer the various analyses possible through its *Question* form (Figure 11).

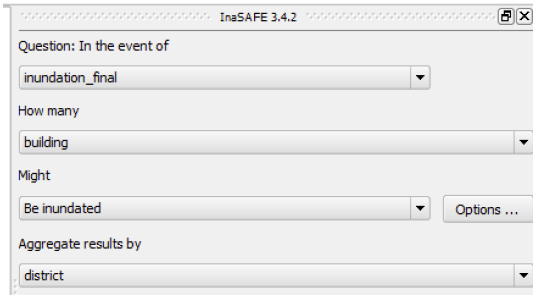

Figure 11: Question form listing the available analyses

Run the first analysis ("Impact Function" in the InaSAFE terminology) to identify the structures/buildings affected by inundation by clicking the *Run* button. Depending on your laptop's performance the analysis can take quite some time. Eventually a new layer will be added to the table of contents and a report be shown in the InaSAFE dock widget (Figure 12). The layer shows the buildings categorised by level of inundation. The result in numbers is shown in the report.

Check map and report to verify whether the results are credible. You will find buildings on Cerf Island classified as *Dry*. This is wrong. But for Cerf Island no inundation data was available and thus, InaSAFE just classified the buildings as *Dry*. To avoid such misclassification it is a good idea to delete buildings that are not covered by the inundation layer before performing the impact analysis. Just do that and repeat the analysis. Finally you can print the results to a PDF file by clicking the *Print* button on the InaSAFE dock widget. The *Print* button is enabled only when the result layer is selected in the table of contents. When printing you can select from several print templates. An appropriate one for your results would be *a3-portrait-orange* for example. This print could now be used by

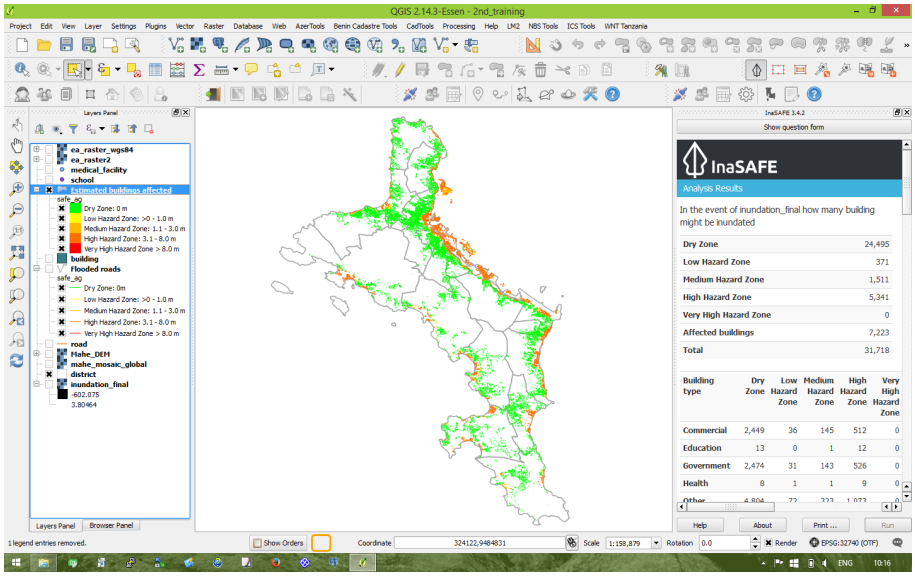

Figure 12: Impact analysis results for buildings

the authorities in charge to prepare evacuation measures and provision of support accordingly.

Run the second analysis to identify the roads affected by inundation (Figure 13). Although there are significantly less road features than building features the analysis takes considerable longer for some reason. Grab a cup of coffee meanwhile. Once the analysis has been completed verify that the results make sense.

For each impact function you can modify the configuration, usually to change some threshold values applied to the classification. Click the *Options* button in the *Question* form to open the *Configuration* dialog. In case of the impact function *Tsunami on buildings* it is the thresholds for the inundation levels that are used to identify the hazard levels (Figure 14). Change the threshold values and re-run the analysis.

6.2 Damage and loss assessment

Damage is commonly calculated as the replacement value of totally or partially destroyed physical assets. Loss on the other hand results from interrupted flows of economy caused by the temporary absence of damaged assets. Calculating loss

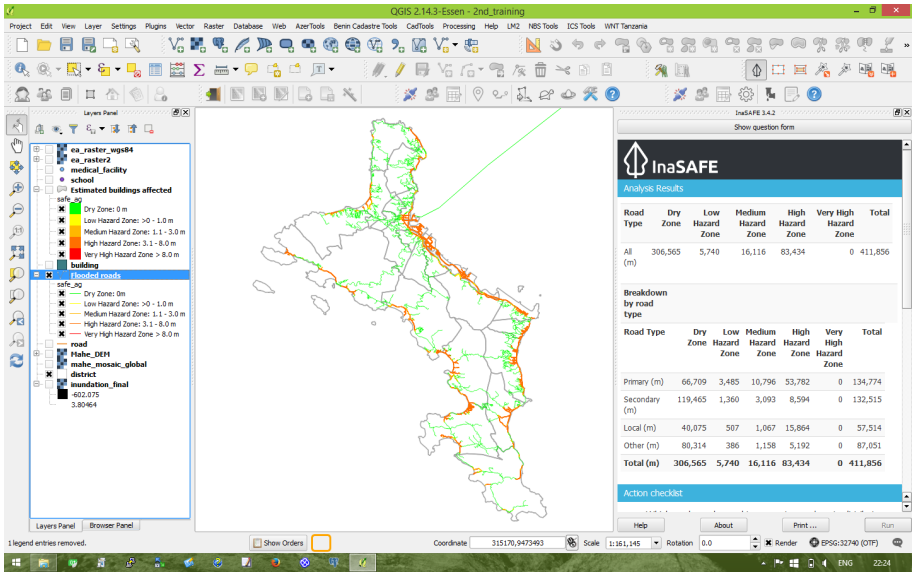

Figure 13: Impact analysis results for roads

is a lot more complex than calculating damage since numerous aspects play a role in loss assessment. Because of this the exercise will focus on damage assessment.

Open the file *ReplacementValues.xslx* from the *Data/ReplacementValues* folder. The file was provided by a quantity surveyor of the Ministry for Land Use and Housing (MLUH) and contains the replacement costs for many of the structure types. In this exercise we will focus on the damage of residential, health care and education relating buildings. You can see that the categories in the Excel file are a lot more detailed than the categories/types of buildings in the *building* layer. Thus, based on the Excel sheet we will just assume the base values as follows:

- Residential: 9,000 SCR/sqm
- Health: 14,000 SCR/sqm
- Education: 13,000 SCR/sqm

Based on the level of hazard the following factors shall be applied:

- Low: 10%

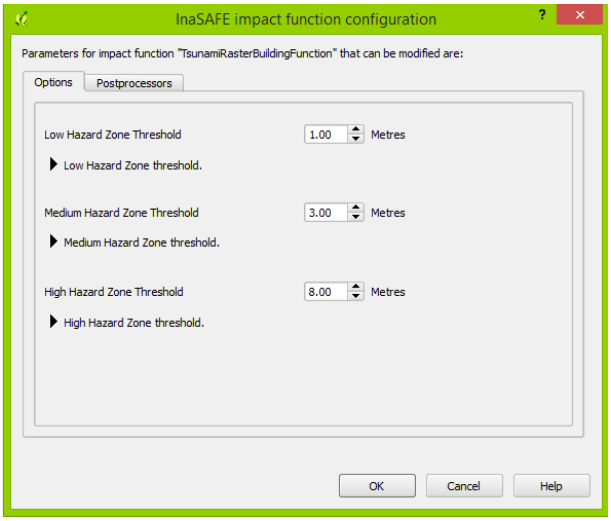

Figure 14: Changing threshold values of impact function

- Medium: 50%
- High/Very High: 100%

With these assumptions you can now use the *Field Calculator* and calculate the damage for each building in the result layer of your InaSAFE analysis. Based on the numeric codes you assigned for your building categories you will need to do an attribute query first to select residential buildings only. Then use the *Field Calculator* as shown in Figure 15.

The *safe_ag* field created by InaSAFE is used to apply the correct factor depending on the hazard (and damage) level.

Repeat the same steps for the health care and education buildings but select *Update existing field* in the *Field Calculator* since the *damage* field has already been created. Don't forget to adjust the base value in the formula. Finally select all remaining buildings (where *damage* IS NULL) and set the *damage* field to 0 (instead of NULL). This avoids issues when calculating statistics later on.

Now let's aggregate the damages per district to show how much each district is affected in terms of damage. You will use a spatial join to aggregate (sum) the damage values of the buildings and assign them to the districts. For the

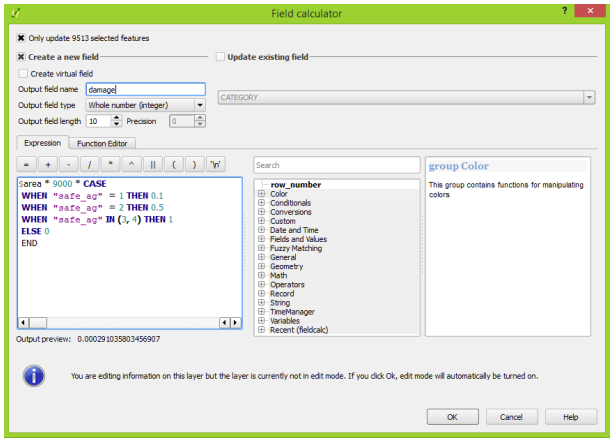

Figure 15: Formula to calculate damage of residential buildings

spatial join to work both layers (districts and affected buildings) have to have the same coordinate reference system. InaSAFE creates its result layers in WGS84 (EPSG:4326) while all your original Shapefile layers are in EPSG:32740. Thus, save the *Estimated buildings affected* layer to a new Shapefile with coordinate reference system EPSG:32740 and name it *buildings_affected_32740*. From menu *Vector:Data Management Tools* select the *Join Attributes by Location* tool. Apply the settings as shown in Figure 16. As a last step create a thematic map showing the districts by amount of damage. Your result might look similar to Figure 17.

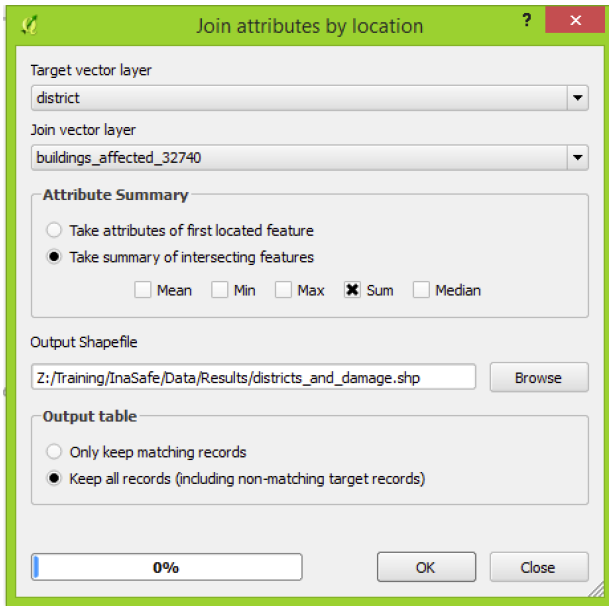

Figure 16: Performing a spatial join

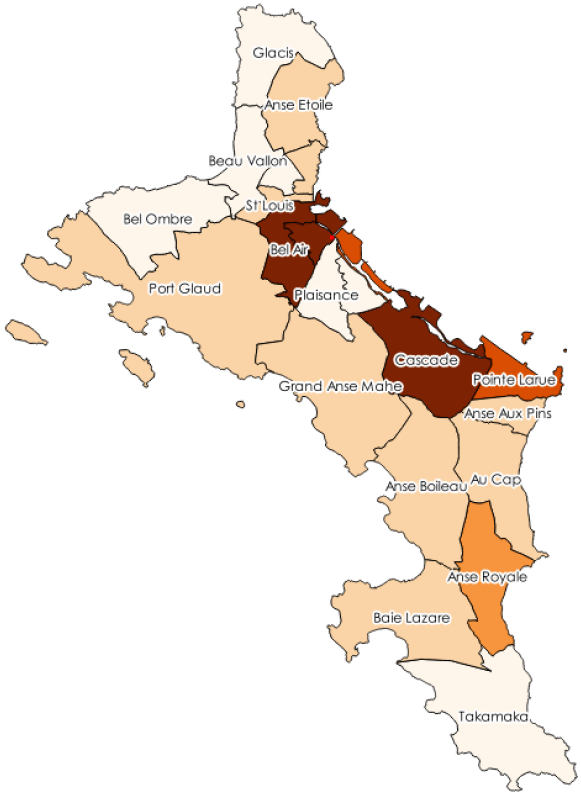

Figure 17: Districts by damage