



Methodological demonstration for **Chapter 13** – [\*“Stakeholder based road assessment: a multiple criteria analysis for designing cycle routes with differing target populations”\*](#) (pp.225-242)






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### Disclaimer

This document is an addendum to the chapter mentioned above which is part of the book [\*GIS in Sustainable Urban Planning and Management: A Global Perspective\*](#). The purpose of this document is to demonstrate the application of the methods described in that chapter using QGIS 3.x along with the data available [here](#). This document is licensed under a [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](#). Different license terms may apply for the data. If that is the case, a file containing the license terms is included with the data.

### How to use this document

Most of the steps described are illustrated with screenshots. Bear in mind that what the screenshot depicts and what you see in your computer might differ slightly depending on the QGIS version you are using and the way your toolbars and add-ons are arranged. Along the text you will see different icons. The key for these icons is as follows:

-  Data or external resource to download;
-  A software action you are supposed to do;
-  Information specific about QGIS.
-  Additional or complementary scientific information;
-  An important concept which you may want keep in mind;

[1] An operation that is referenced in the flowchart of operations.

Additionally, for the sake of readability, the following style conventions are used:

- A reference to dataset or a layer uses `this style`;
- A QGIS command, or any clickable button is noted using **this style**.
- A QGIS menu or section is highlighted using *this style*.

At the end of the document, a diagram depicting the workflow described in these pages can be seen. It is advisable to look at it first and/or refer to it as you proceed.

## Outline

The book chapter describes how population preferences can be weighted to systematically highlight the bicycle-friendly scores of all junctions and segments along a route according to the perception of various target populations.

For this demonstration we provide two sets of segments and two sets of junctions representing two distinct bike routes. These come in the form of shapefiles (.shp) whose attribute table already has the weighting values for each criteria calculated according to the methodology described by the authors of the chapter.

From here a series of weighed average calculations are performed. The result is then styled to highlight the key characteristics of each route and also which is the best cycle route.

## Getting started

📁 Download the data; the data consists of the following files:

- `Christchurch.qgs` – a QGIS project preloaded with the layers;
- `Route_1_junctions.shp` – line features representing route segments of route 1;
- `Route_1.shp` – point features representing route junctions of route 1;
- `Route_2_junctions.shp` – line features representing route segments of route 2;
- `Route_2.shp` – point features representing route junctions of route 2;
- `Route_1_junctions.qml` – style definition file;
- `Route_1.qml` – po style definition file;
- `Route_2_junctions.qml` – style definition file;
- `Route_2.shp` – style definition file.

➤ Start QGIS and open `Christchurch.qgs` (Figure 1).

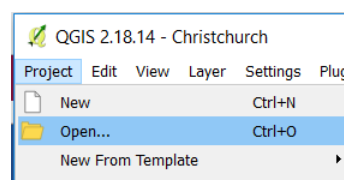


Figure 1 – opening a project

➤ From the *Layers panel*, **right-click** on a layer and access the attribute table to examine it. Repeat the procedure for the other layers (Figure 2).

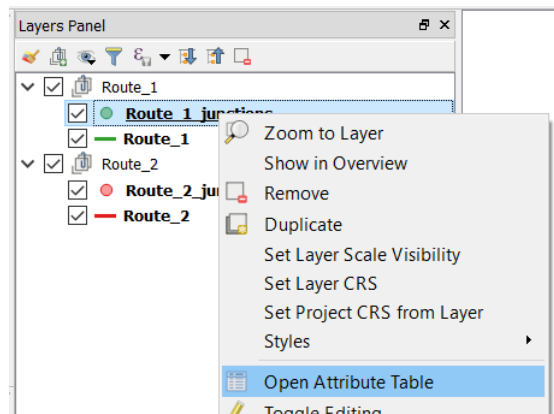


Figure 2 – assessing attribute table

### Calculating the weighted averages [1]

The attribute tables contain the values assigned to each criteria. Based on that information we can calculate the weighted average value to each of the features of the layer(s).

- ▶ From the *Layers panel*, **right-click** on a layer and access the layer **Properties**. In the *Layer Properties* dialog click on the **Fields** tab and from there click on the **Field calculator** (Figure 3).

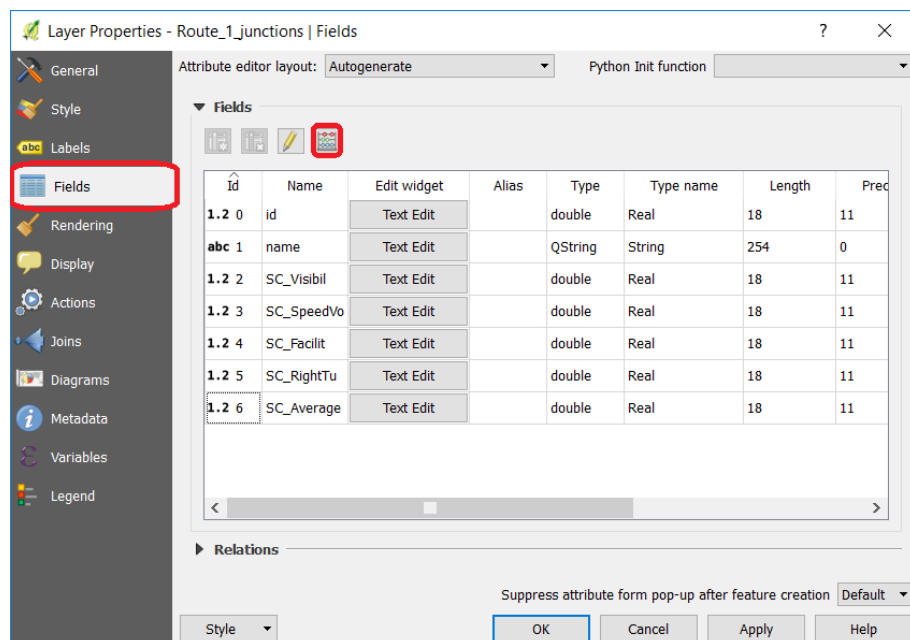


Figure 3 – assessing the Field calculator

- 💡 To perform a weighted average, the weight by which each variable has to be multiplied has to be defined. Because the data is already normalized the multiplication factor can be any value between 0 and 1 as long as the sum of the denominators does not add up to more than 1.

- Create a new field and name it `w_average`. Make sure it's data domain is of type **Decimal number** and allow a **Precision** of 2 decimals. Enter the Weighted average expression and press **Ok** (Figure 4).

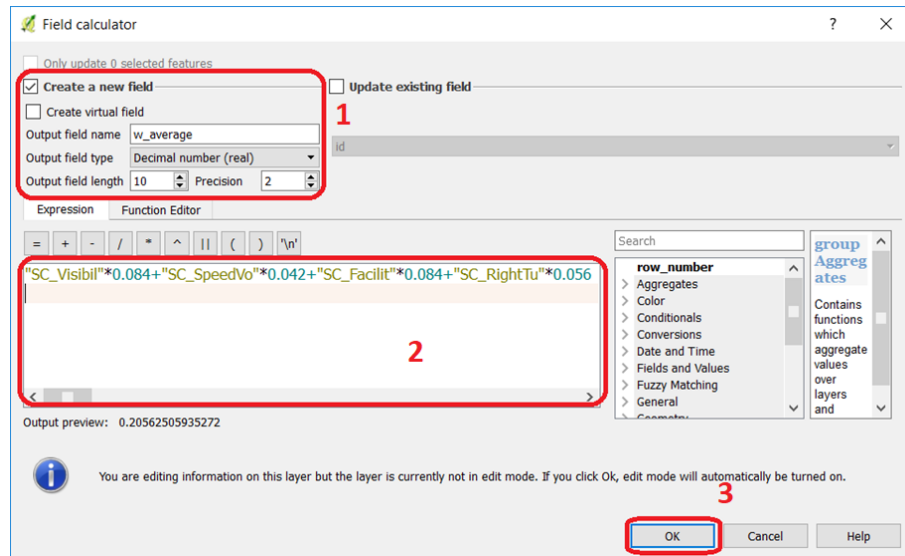


Figure 4 – Create a new field and fill it with the weighted average

As for the formulas you can copy it from this document<sup>1</sup>. For the Junctions use:

```
"SC_Visibil"*0.084+"SC_SpeedVo"*0.042+"SC_Facilit"*0.084+"SC_RightTu"*0.056
```

And for the segments:

```
"SC_Nonslip"*0.035+"SC_Roughne"*0.07+"SC_Traffic"*0.041+"SC_EffectW"*0.082+"SC_DetourF"*0.028+"SC_Busstop"*0.047+"SC_Art_Par"*0.047+"SC_Lightin"*0.047+"SC_Populat"*0.070+"SC_Destina"*0.070+"SC_Length"*0.093
```

- 🟢 When you add a new a field to a table like you just did, QGIS will automatically activate editing mode in order to allow changes to layer to be committed. Therefore to finalize the operation you have to **toggle editing mode off** and **Save** the changes that you just made (Figure 5).

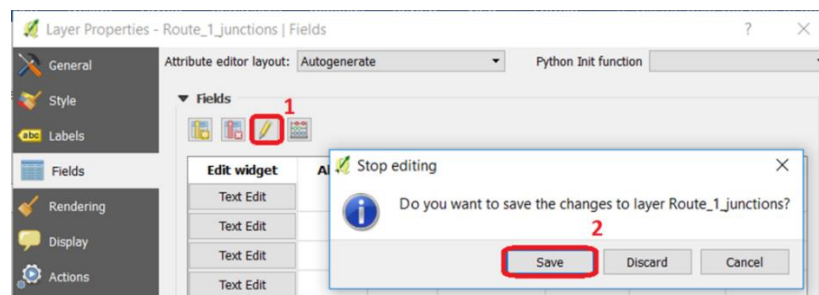


Figure 5 – Saving edits

<sup>1</sup> Refer to table 13-6 (page 239) in the article.

### Styling the routes [2]

The attribute tables of your layers now have the weighted average stored in a new column. In order to visualize the scores of the segments and junctions of the routes, we will style the layers based on the weighted average values.

- From the *Layers panel*, **right-click** on the layer `Route_1_Junctions` and access the layer **Properties**. In the *Layer Properties* dialog click on the **Style** tab and select **Graduated** using the `w_average` **Column**. Choose a **Color ramp**, define the number of **Classes** you want, press **Classify** and hit the **Apply** button to implement the style definitions. (Figure 6).

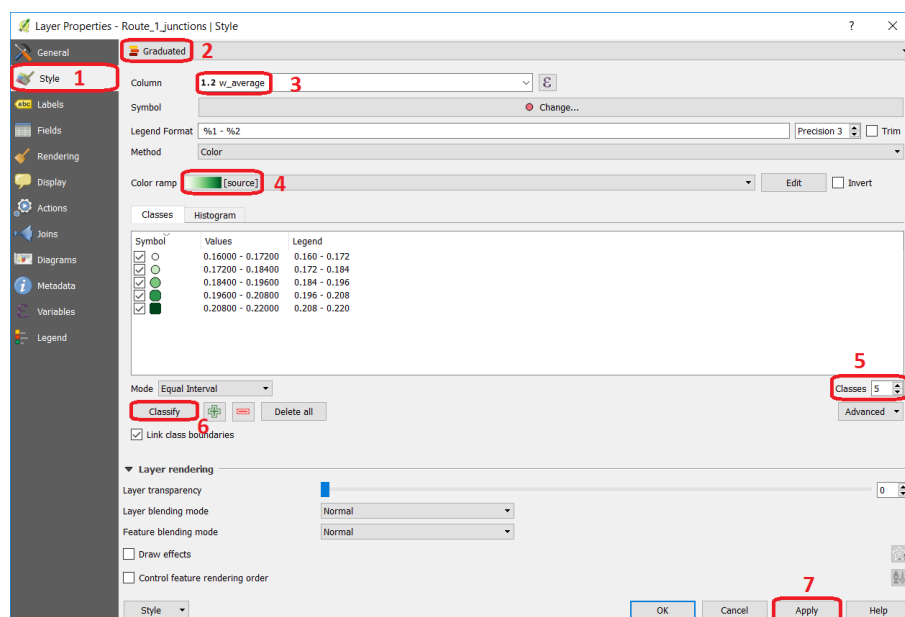


Figure 6 – Defining and applying a style

After the previous operation, the `Route_1_Junctions` layer is being represented using one variable – color. In order to enhance the representation of the differences in accessibility of each junction we will add another visual variable – size.

- From the **Style** tab double-click on the circle symbol. The **Symbol selector** menu will pop up and from there you can modify the **Size** of the. Repeat this step for the five classes. We suggest starting with a size of 2 using an increment of 0.5 so that the last class will have a size of 4 (Figure 7)
- Repeat the previous steps for `Route_2_Junctions` layer. Make sure to choose a different **Color ramp**. In the example depicted above, a green color ramp was used for `Route_1_Junctions`, we suggest a reddish **Colour ramp** for `Route_1_Junctions` in order to easily distinguish between the two routes.

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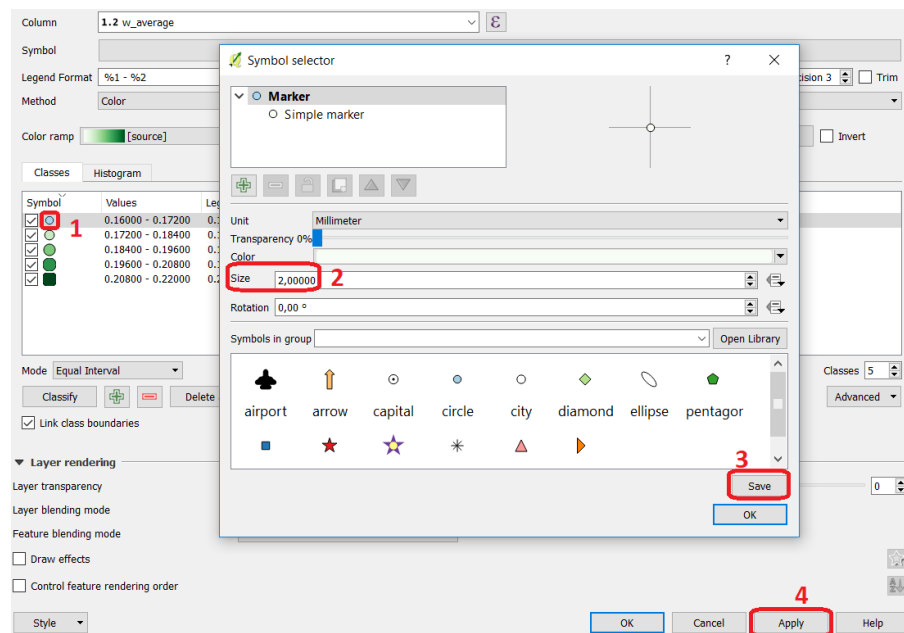


Figure 7 – Adjusting the symbol size

Your Route\_1\_Junctions and Route\_2\_Junctions should now look like this (Figure 8)

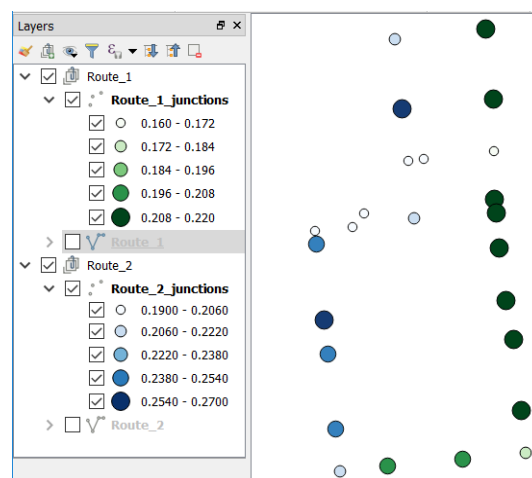


Figure 8 – Route\_1\_Junctions and Route\_2\_Junctions graduated styling by color and size

The same procedure described in the previous steps will be applied to the Route\_1 and Route\_2 layers. In order to ensure styling consistency and therefore facilitate the visualization of the data, the features of these layers will be styled also using graduated symbols distributed by 5 classes and using the same color ramps as the corresponding junctions.

- From the *Layers panel*, **right-click** on the layer Route\_1 and access the layer **Properties**. In the *Layer Properties* dialog click on the **Style** tab and select **Graduated** using the w\_average **Column**. Make sure the **Color ramp** you choose

is the same as the you used for `Route_1_Junctions`, define the number of **Classes** you want, press **Classify** and hit the **Apply** button to implement the style definitions. (Figure 9).

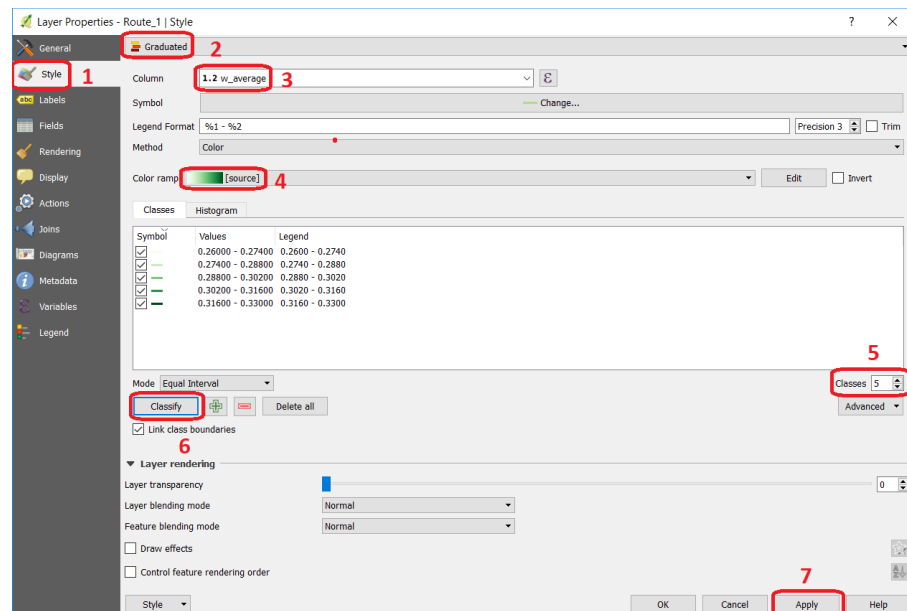


Figure 9 – Defining and applying a style

- From the **Style** tab double-click on the circle symbol. The **Symbol selector** menu will pop up and from there you can modify the **Size** of the. Repeat this step for the five classes. We suggest starting with a size of 0.5 using an increment of 0.5 so that the last class will have a size of 2.5 (Figure 10)

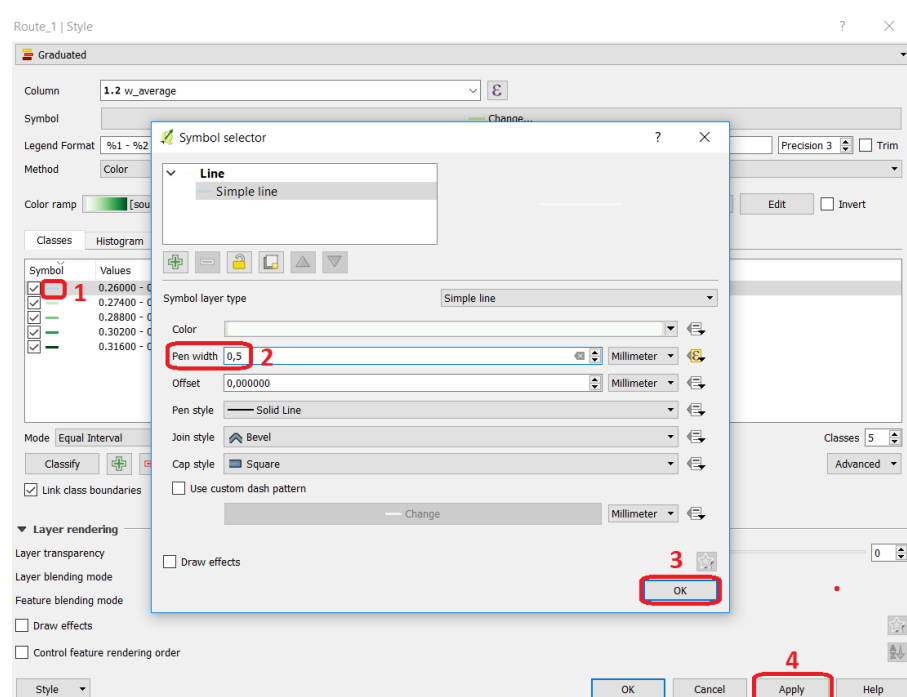


Figure 10 – Adjusting the symbol size

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- ▶ Repeat the previous steps for Route\_2 layer. Make sure you choose the same **Color ramp** You used for Route\_2\_Junctions.

Your Route\_1\_Junctions, Route\_2\_Junctions, Route\_1 and Route\_2 should now look like this (Figure 11)

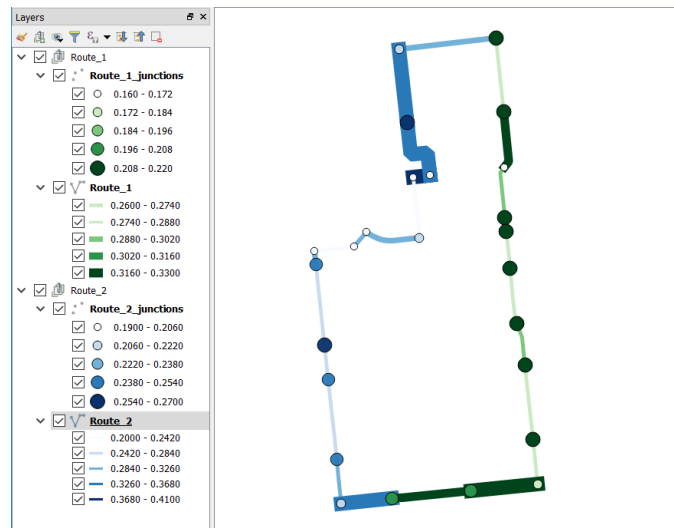


Figure 11 – Final result of styling operations over route and junction layers

- ▶ If you got lost in the steps described above, you can simply apply the style files we provide along with the data. The style files are named after the layer they are meant to be applied. To use these style files, from the *Layers panel*, **right-click** on the layer you want to style and access that layer's **Properties**. At any tab In the *Layer Properties* dialog click on the **Style** button, choose **Load Style** and point to the corresponding file. Finish by clicking on **Apply** (Figure 12)

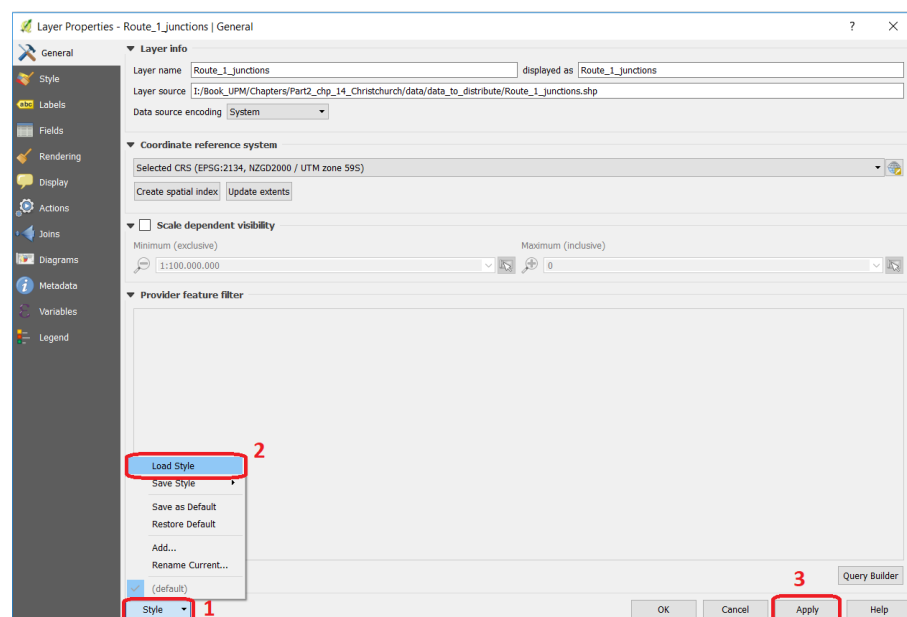


Figure 12 – Applying a style file



### Comparing the routes [3]

Currently both routes are styled in a way that provides a quick representation of which segments and junctions have a better score with respect to accessibility. However it is not possible to tell which of the routes has the best overall accessibility score.

💡 The total accessibility score is the result of adding the average of the weighted average scores of the junctions with the weighted average scores of the segments. This will result in a value between zero and one representing the total accessibility score.

- We will need spatial referencing functions to relate the accessibility scores of junctions and segments in order to obtain an overall accessibility score. Go to *Plugins > Manage and install plugins*, search by “reffunctions” and click on **Install plugin** (Figure 13).

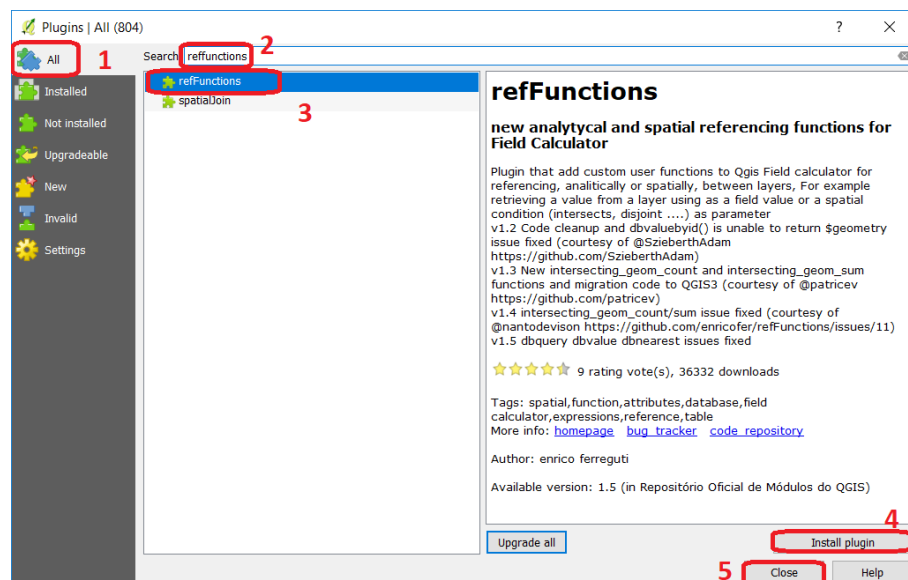


Figure 13 – Installing the reffunctions plugin

📍 In QGIS we can have data defined styles or labels. This means any data contained in the attribute table of a layer can be used directly or in conjunction with functions in order to build an expression that will determine how a label or style is rendered. The next steps are an example of this feature.

- From the *Layers panel*, **right-click** on the layer `Route_1` and access the layer **Properties**. In the *Layer Properties* dialog click on the **Labels**, make sure the option **Show labels for this layer** and click on the **Expression dialog** icon. In the *Expression dialog* enter this expression:

```
CASE WHEN $id =1 THEN
```

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```
median(geomtouches('Route_1_junctions','w_average'))+median("w_average")
END
```

Click **Ok** to dismiss the *Expression dialog* window and **Apply** to implement the label (Figure 14).

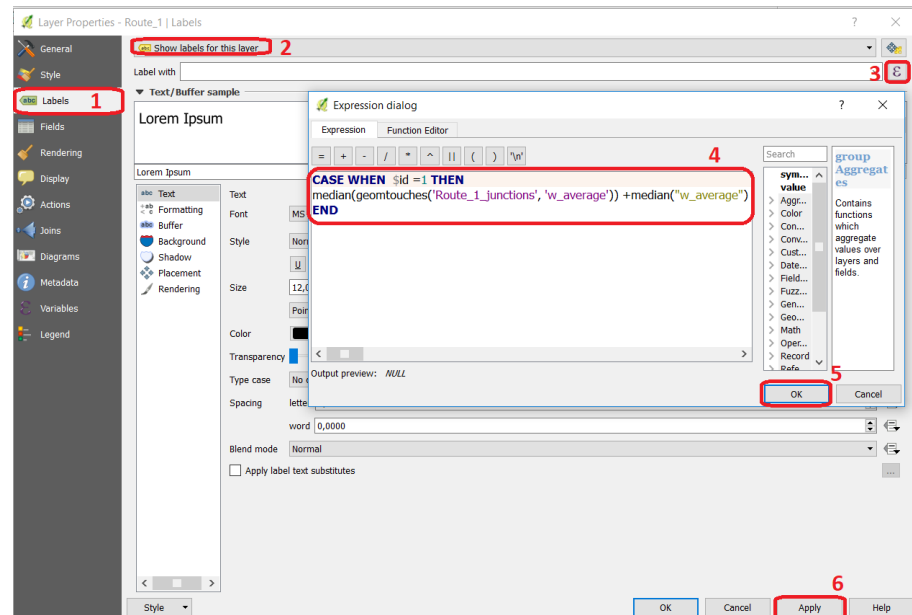
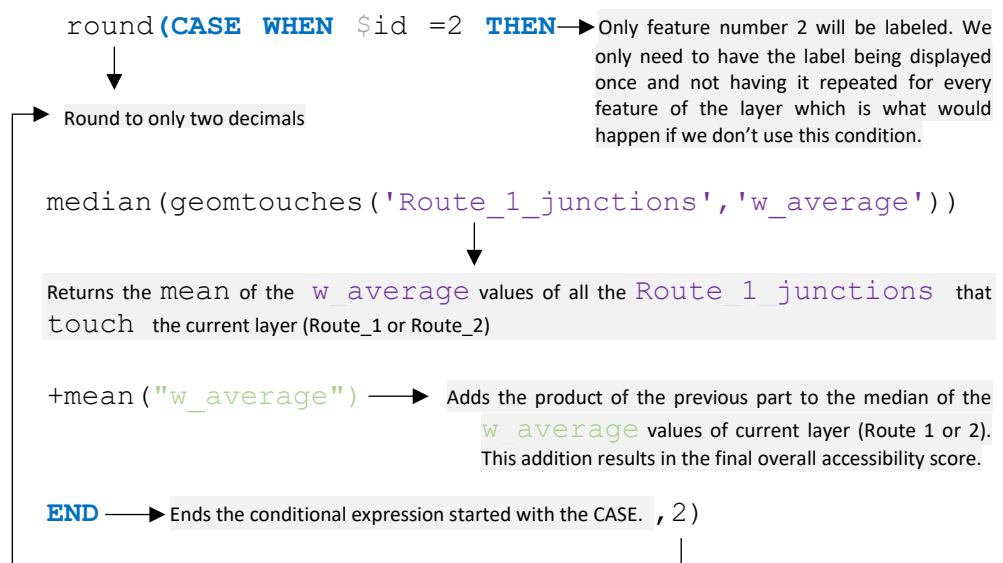


Figure 14 – Defining a label through an expression

- Repeat the previous step for *Route\_2* layer. Provide the following expression:

```
round (CASE WHEN $id =2 THEN
mean (geomtouches ('Route_1_junctions','w_average'))+mean
('w_average')
END, 2)
```

📌 Here is an explanation of what those expressions are doing:



You now see both routes labeled with the overall accessibility score - Route\_2 scores slightly better than Route\_1 (Figure 15).

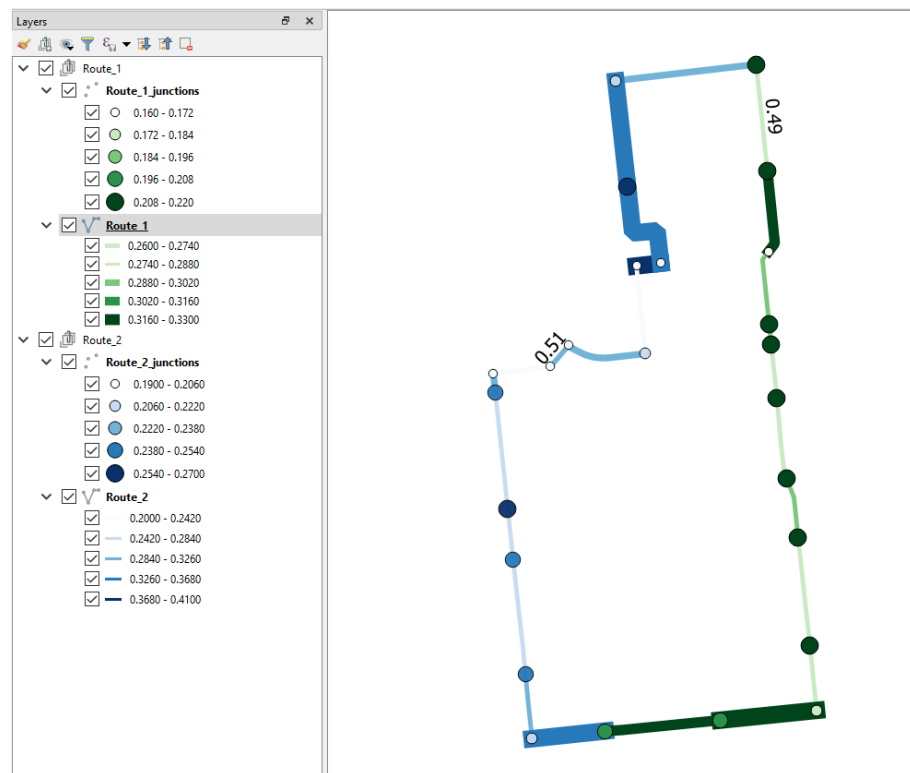


Figure 15 – Comparing Route\_1 and Route\_2

There are many ways to explore and represent the data, the one described here is just one of them. The labeling and styling might be adapted to focus on one particular variable or the weighted average values might be calculated with different coefficients depending on what is the target population or to better understand the influence a specific variable has in the final outcome (see next section).

### Sensitivity analysis [4]

Changing the weights assigned to each criterion can be an interesting approach to better understand how variables interact. Figure 15 and 16 depict, respectively, how the variables of Route\_1 and Route\_2 would score if they were all assigned the same weight. That is a starting point for an exploratory exercise you can conduct by simply (a) add new fields to the attribute table with the results of weighted averages using different coefficients and (b) exploratory styling of the data. Both can be achieved using the techniques described in the previous sections.

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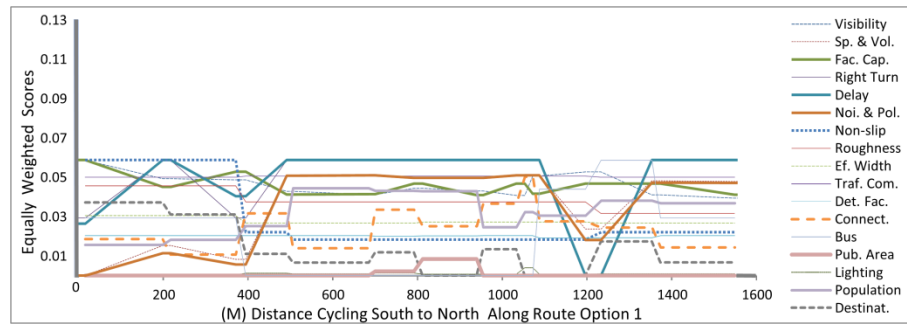


Figure 16 – Route 1 Sub-criteria Segment & Junction Scores when Equally Weighted

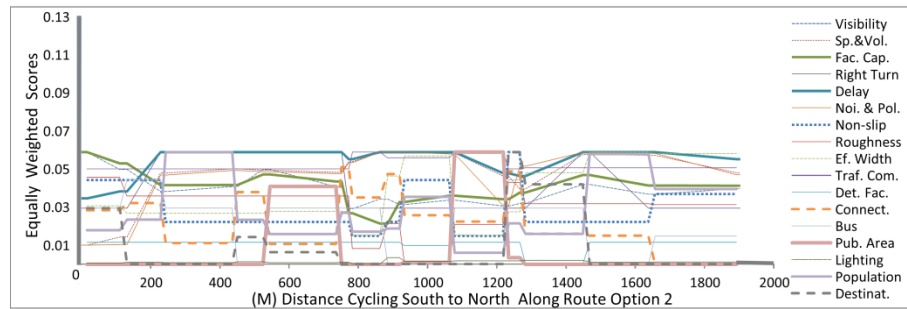


Figure 17 - Route 2 Sub-criteria Segment & Junction Scores when Equally Weighted

**Flowchart of operations**

