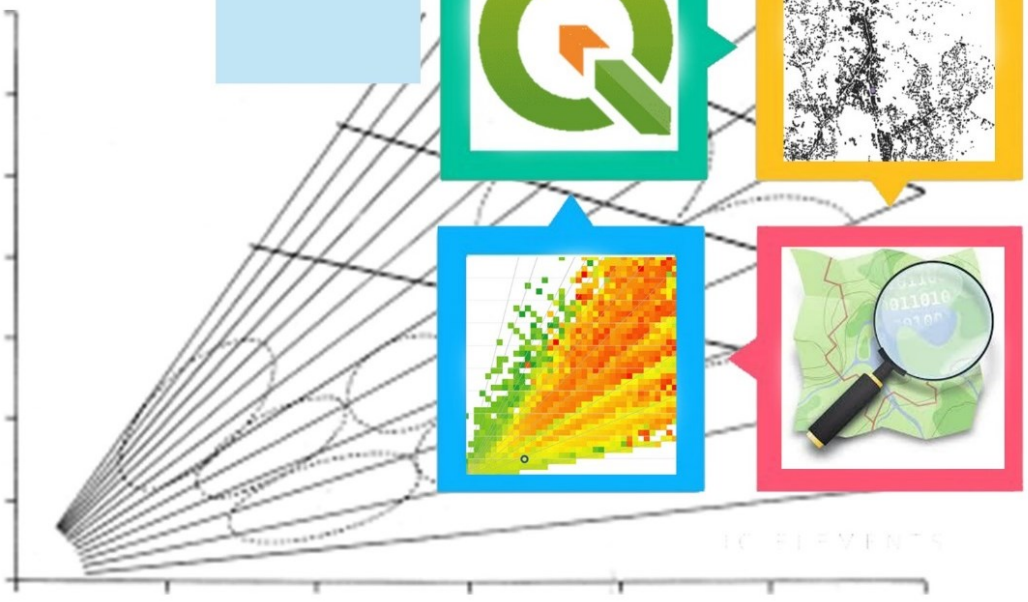
Teaching & Learning
Step-by-Step Guide:

Space Matrix



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Publisher

University of Moratuwa

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This book was produced with the valuable support of the Erasmus+ Capacity Building in Higher Education (CBHE) project 'Curricula Enrichment for Sri Lankan Universities delivered through the application of Location-Based Services to Intelligent Transport Systems' (LBS2ITS https://lbs2its.net/)

Project Number: 618657-EPP-1-2020-1-AT-EPPKA2-CBHE-JP
Programme: Erasmus+
Key Action: Cooperation for innovation and the exchange of good practices
Action Type: Capacity Building in Higher Education
Co-funding: Erasmus+ Programme of the European Union

This book was reviewed as an Open Education Resource for university students by Prof. Retscher Günther (Vienna University of Technology, Austria) under the LBS2ITS project.

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LBS2ITS

Curricula Enrichment delivered through the Application of Location-based Services to Intelligent Transport Systems

Co-funded by the Erasmus+ Programme of the European Union

Edition

First Edition - May 2025

ISBN 978-955-9027-94-2 (ebook)

Citation

Jayasinghe, A., Dharmakeerthi, S., & Madusanka, S. (2025). *Teaching & learning step-by-step Guide: Space matrix* (1st ed.). University of Moratuwa.

Publisher

University of Moratuwa

PREFACE

This book serves as open educational material for both undergraduate and postgraduate degree programs, offering a step-by-step guide to analyzing building density utilizing GIS technology. Designed to equip readers with not only theoretical but also practical skills, this guide provides sequential instructions for conducting building density analysis for beginners and advanced users alike.

This Offers in-depth guidance on data collection employing an open street map, utilizing the qgis software for data preparation and data analysis, and interpreting the data to understand the building density category of the city as well as use it as one layer to analyze the urbanity level of the city. This book serves as an invaluable resource for students, researchers, and professionals seeking to understand and analyze building density within urban environments using GIS technologies.

Whether you are a student aiming to study the building density of the built environment or measure the urbanity level of a town area, a teacher looking for robust educational tools, or a practitioner in need of refining your technical expertise, this book offers invaluable guidance and support. It ensures that users at all levels gain proficiency in leveraging modern level technologies to explore the building density category of the city and study the spatial dynamics of its environment effectively.

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1. INTRODUCTION

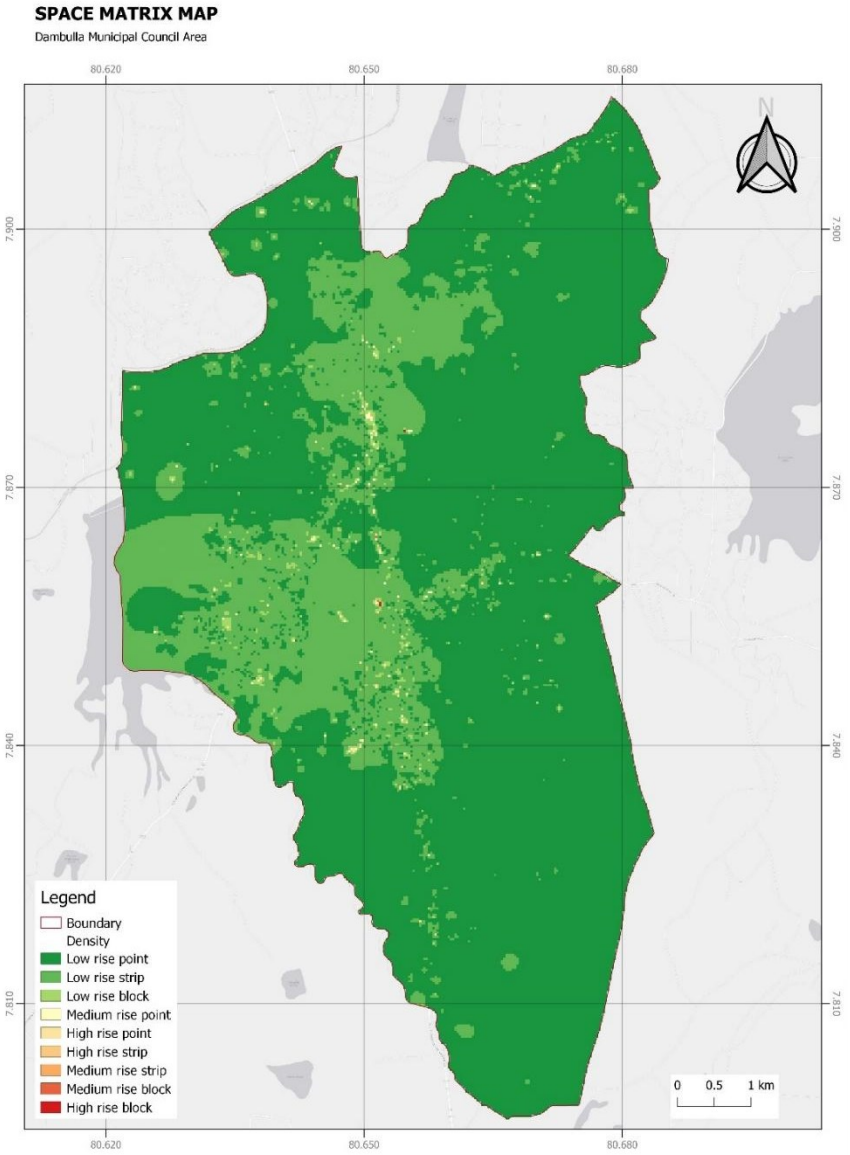


Figure 1: Space Matrix Map

The space matrix map assesses the building density of the selected area by categorizing the built environment into 9 density categories based on the number of floors of the building and the building's form. There, the buildings are divided into low-rise, mid-rise, and high-rise based on the number of floors while it separates different building types as point, strip, and block based on the building's form. In this map, each color indicates a different type of building density as the dark green color indicates the lowest building density while the red color indicates the highest building density. This space matrix map can be used to understand the building density of the selected area as well as to analyze the urbanity level of the particular area as one of the layers.

2. PROCESS

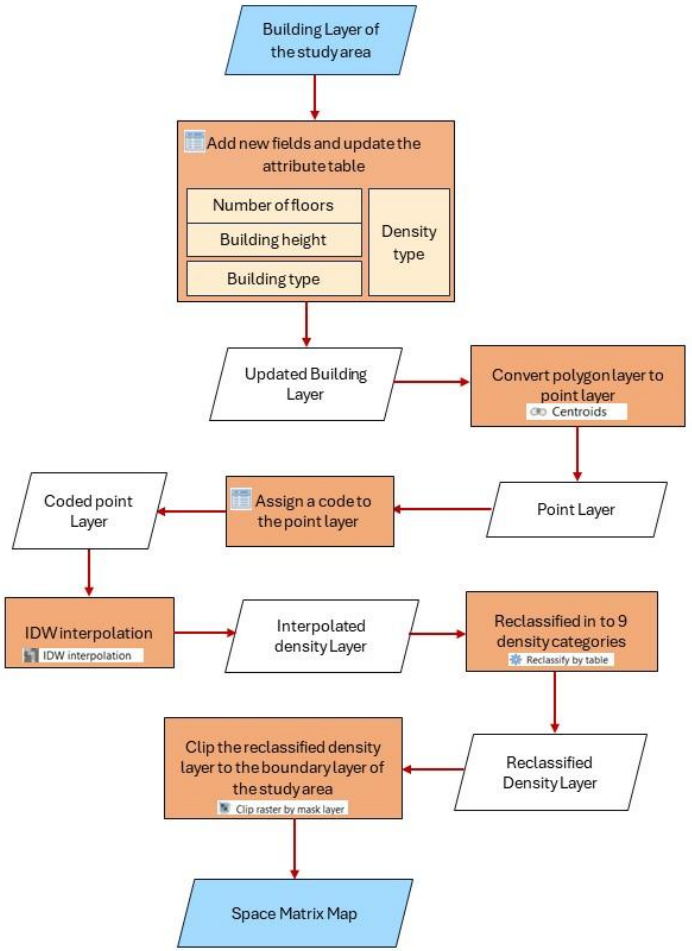


Figure 2: Process.

3. REQUIRED TOOLS / SOFTWARE AND EQUIPMENT

QGIS Software 	• Open-source GIS software • Use to analyze and visualize the building density. • Internet connection- required for the work with “quickmapservices” tool.
Open Street Map 	• Free open geographic database • Use to prepare the dataset of your building layer • An Internet connection is required.
Google Maps 	• Web mapping platform • Use to collect data about the number of floors. • An Internet connection is required.

Table 1 -Required tools for the study.

4. SPACE MATRIX METHOD

The space matrix method contributes to assessing the building density as well as some other variables such as built intensity, compactness, non-built space, and building height. In this space matrix method, the built environment is categorized into 9 density categories based on the number of floors of the building and the building's form. The correct method of space matrix needs the Plot coverage data (GSI), FAR data (FSI), and Building Height Data with a zoning layer to assess the building density of your study area. If you follow the correct method of space matrix using these data, you can get the following chart as the final output and you can categorize your study area into the following 9 density categories. From that, you can find out what density category your city belongs to.

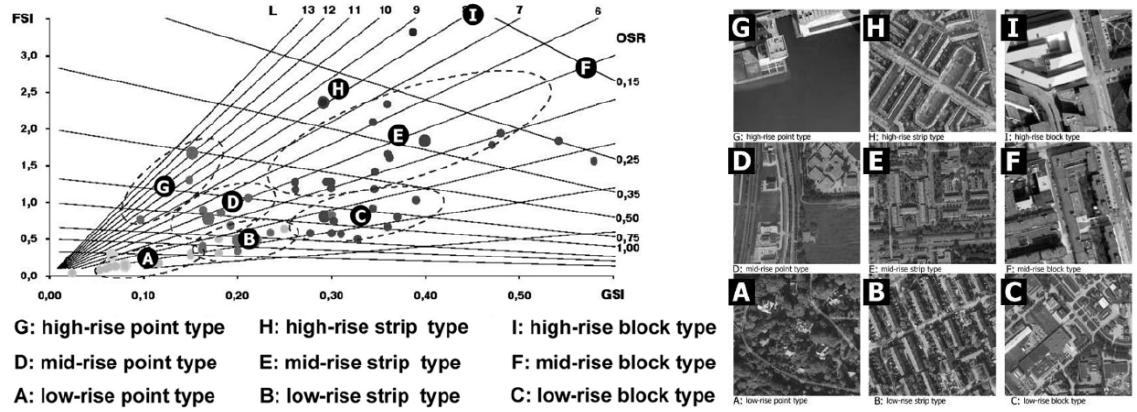


Figure 3: The FSI-GSI chart of Space Matrix (Left) and examples of density types (Right)

Alternative Method for Space Matrix

For this case study, we used the following alternative method to do the space matrix due to the limitations of the data. This analysis was done without using plot coverage data and FAR data. Here we used the building height data and Building types of data to categorize the building density.

5. STEPS

5.1 Data Preparation

Here you need to prepare a dataset of a building layer by updating its attribute table. For that, you can follow the steps given below.

5.1.1. Preparation of the building layer

You can prepare the building layer for your study area in two ways as follows.

- Download the building layer of your case study area from Quick OSM and update it with a base map.
- Take a building layer for your study area from a relevant agency like UDA, DS office, etc., and update the remaining data with a base map.

Download the building layer of your case study area from "OpenStreetMap" and update it with a base map.

Step 1

Open the Google Chrome browser and search "OpenStreetMap" as follows. There you can click on the following mentioned name and open it.

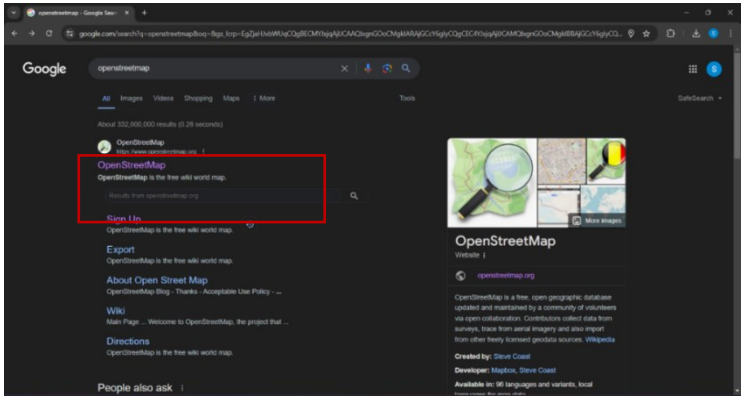


Figure 4 – OpenStreetMap

Then the following page will appear.

Step 2
Search your study area as follows.

There, type the name of your study area and click on the “Go” icon to search it.

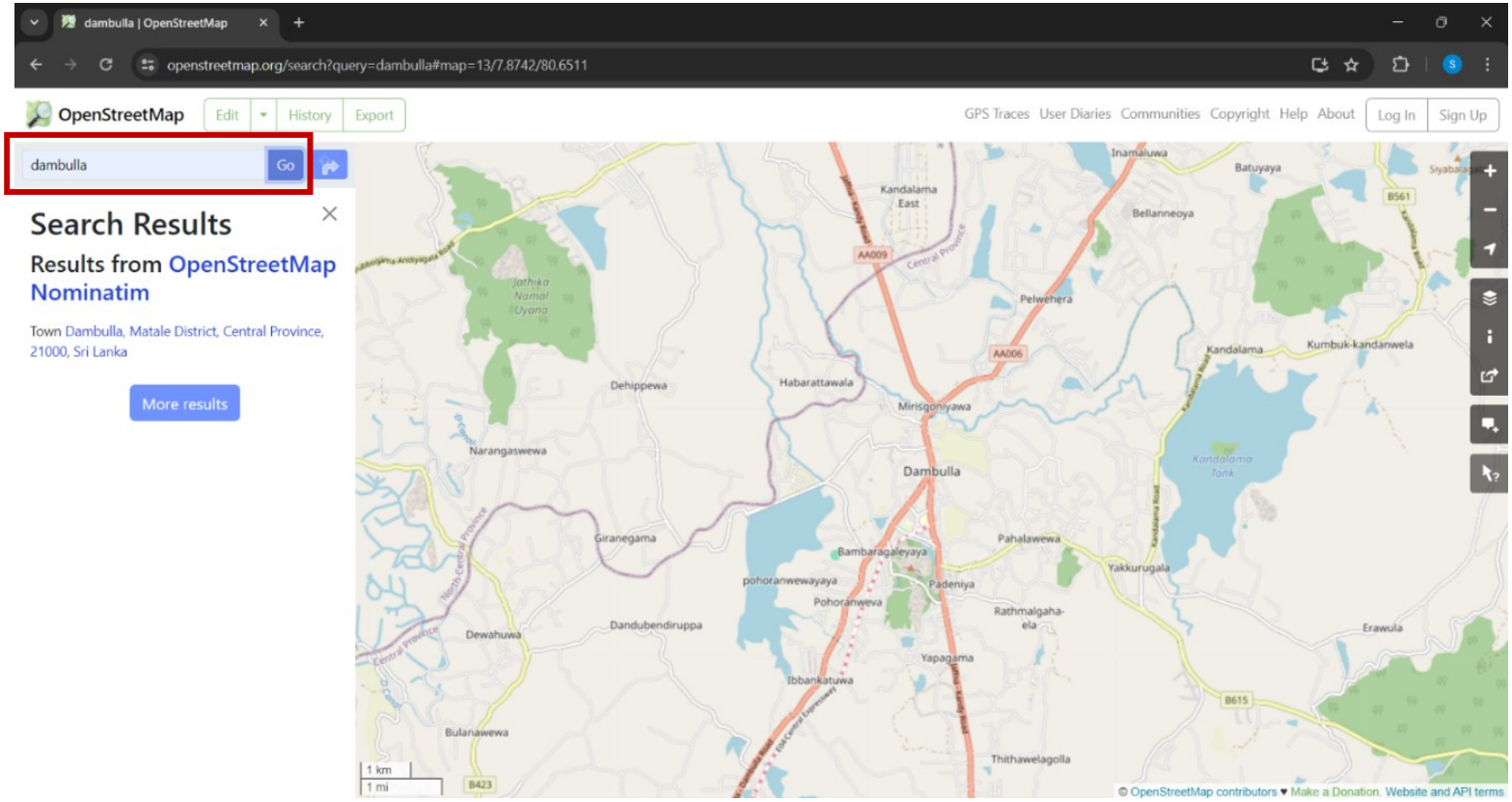


Figure 5 – Open Street Map

Step 3

Select your study area extent and download the data.

1. Click on the “Export” icon.
2. Click on the following phrase named “Manually select a different area” to select your area extent.

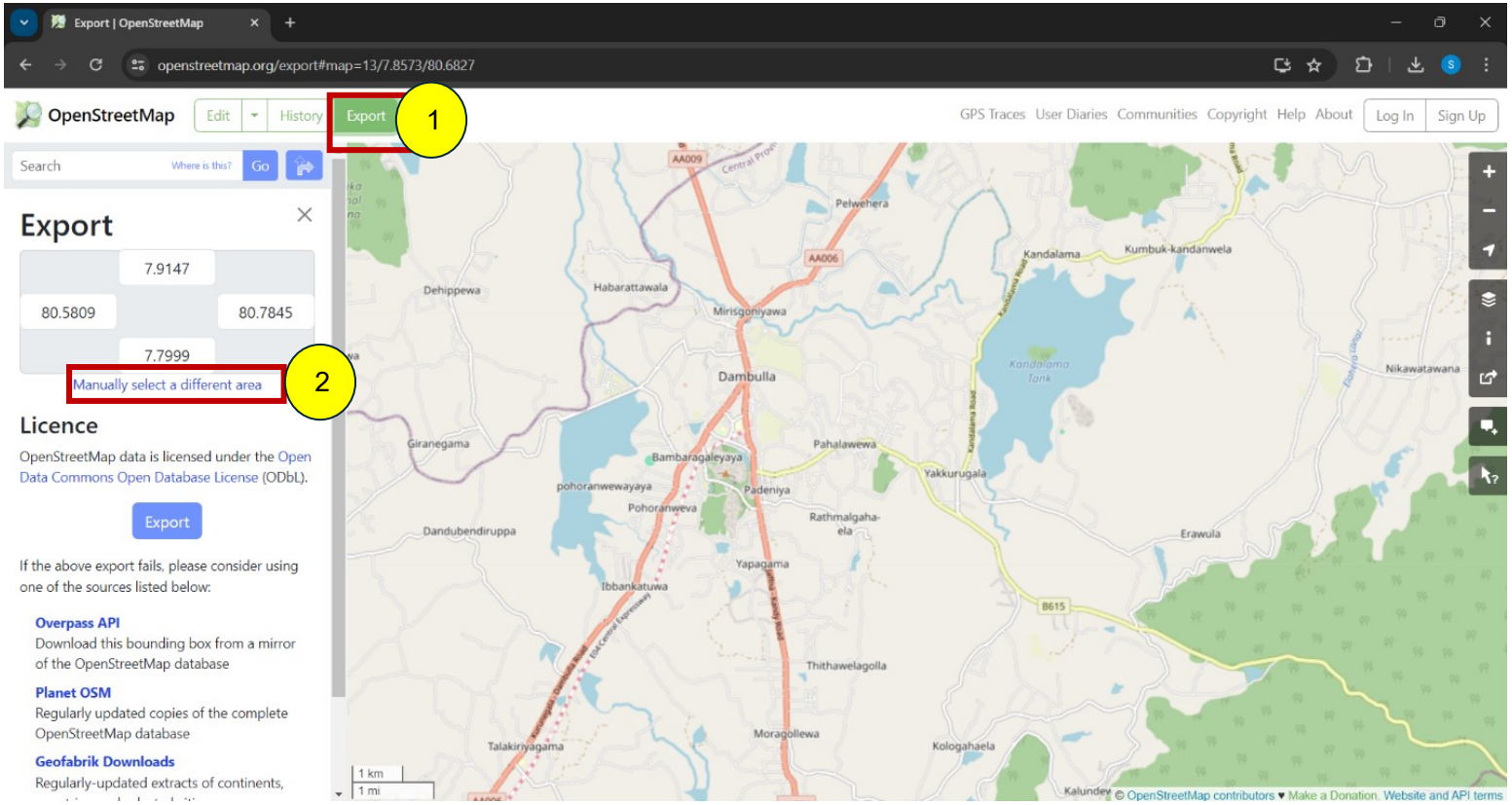


Figure 6 -Export

Then a box will appear as follows.

3. There, click and drag the corners of the appeared box to adjust your area extent as you need.

Here, you have to select a smaller area extent as the data that can be downloaded is limited.

4. Click on the “Export” icon to download the data.

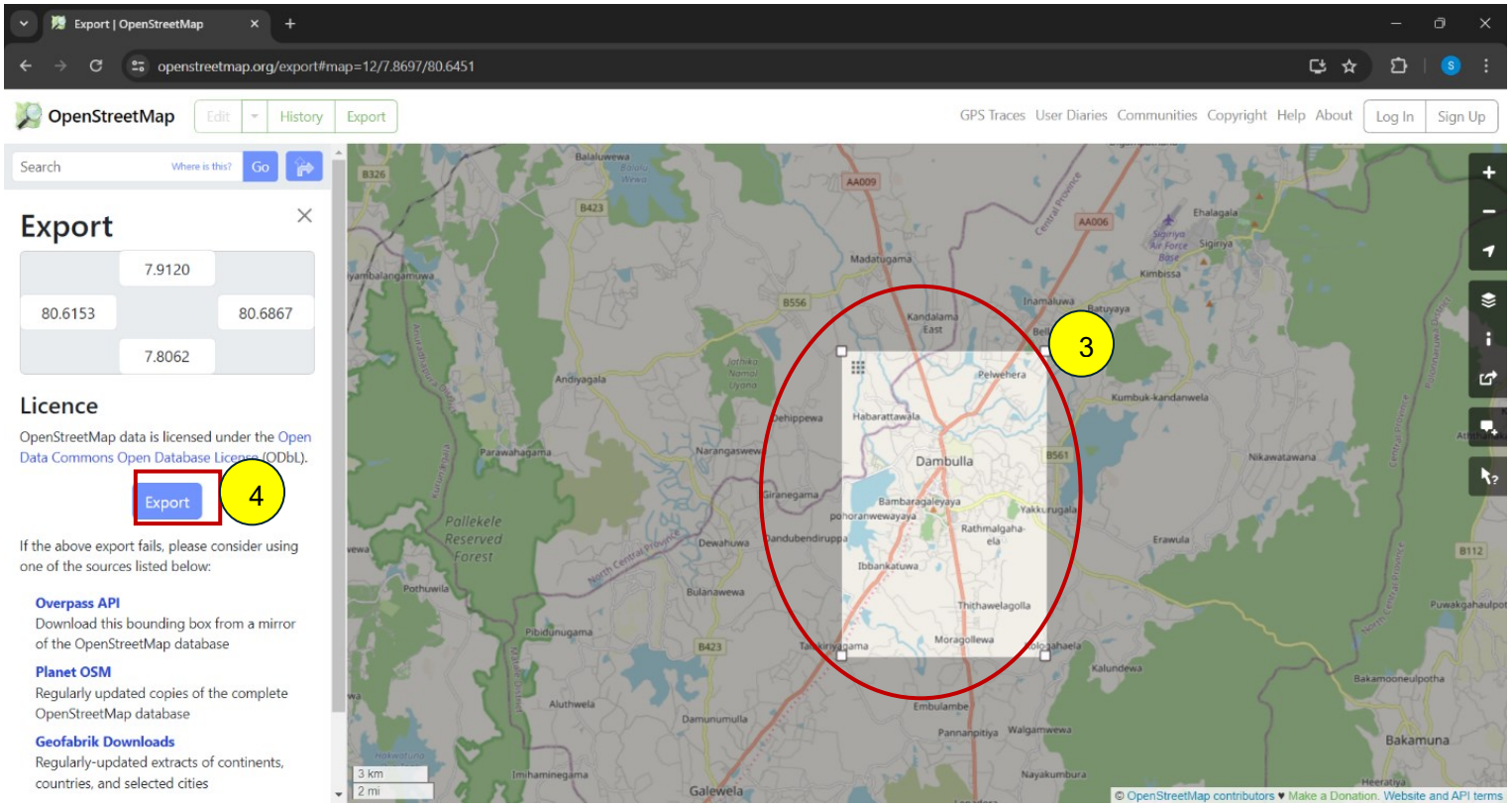


Figure 7 - Download the data.

Error

There can be occurred an error after clicking on the “Export” icon, due to exceeding the size of the data limit that can be downloaded.

If this error occurs you must select a smaller area than it and click on the “export” icon again to download it.

The data will be downloaded in the following format.

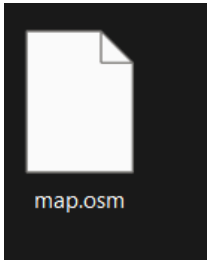


Figure 8 -Map.OSM

Note

The downloaded data file has not only the building layer but also some other data. You have to select the relevant data when you add it to the project and delete the other unwanted layers from your attribute table.

Step 4

Open a new project in QGIS.

1. Double-click on this Icon to open the QGIS.

2. Double-click on here to open a new project.

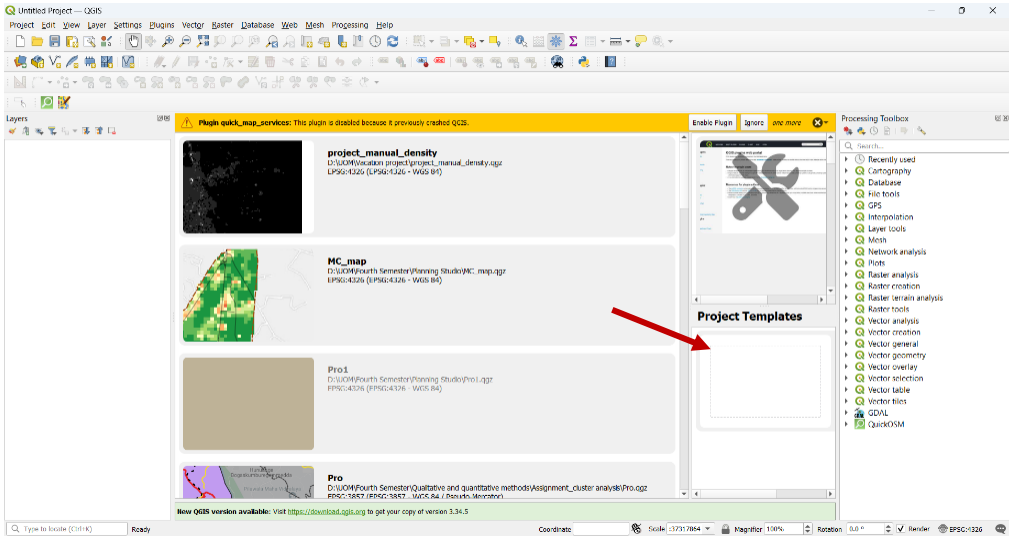


Figure 10 - New project in QGIS.

Step 5

Add the downloaded data to the project.

Step 5.1- Go to Layer>>>Add Layer>>>Add Vector Layer.

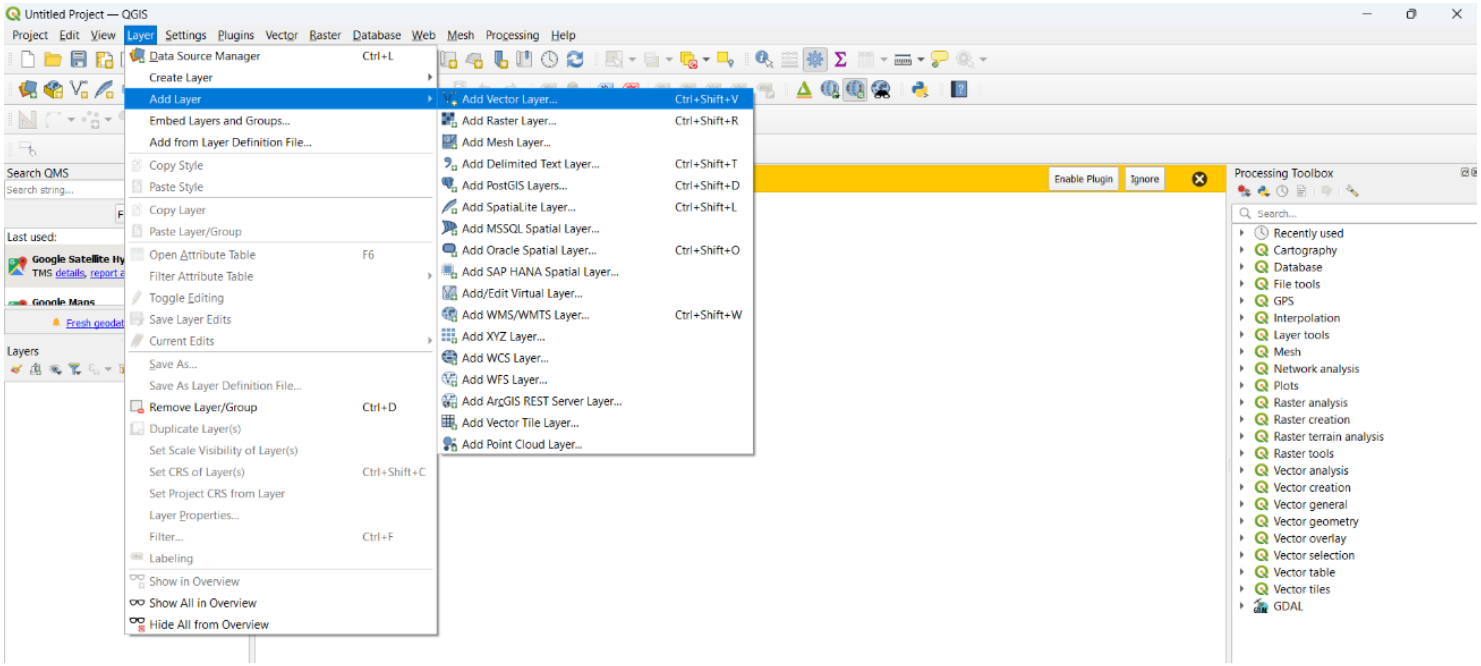


Figure 11 - Add the downloaded data

Step 5.2 - Click on the following icon to find your downloaded data file.

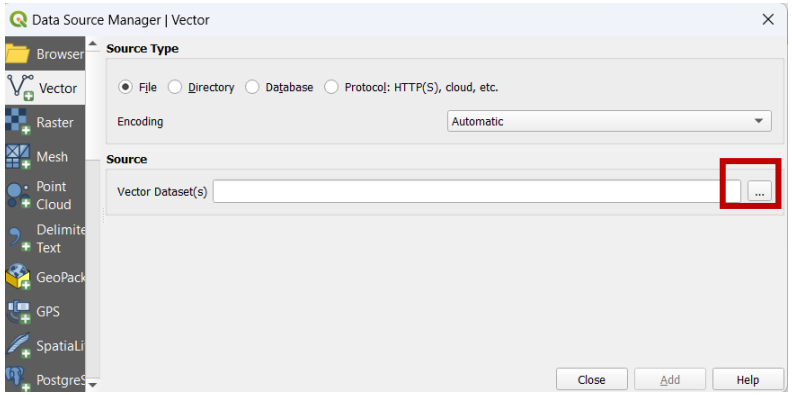


Figure 12 -Find your downloaded data file

Step 5.3 - After finding it you can click on the “Add” icon to add it to the project.

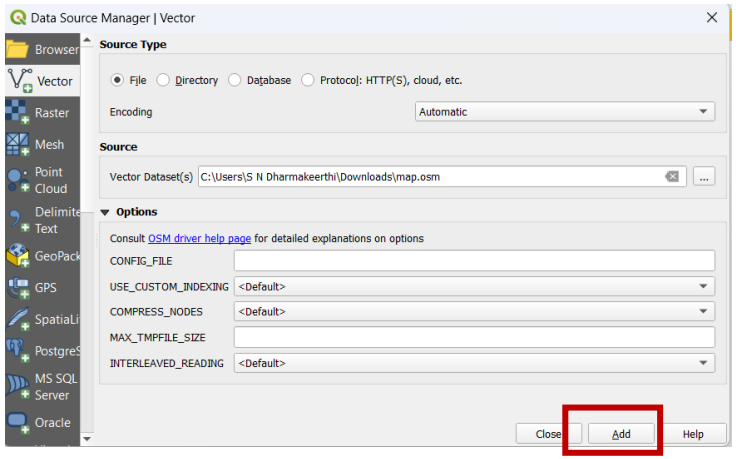


Figure 13 -Add

Step 5.4 - Then a Box will appear as follows. As you need to add only the building layer, you can choose its format, Polygon. Therefore, you can select the "MultiPolygon" and click on "Add Layers".

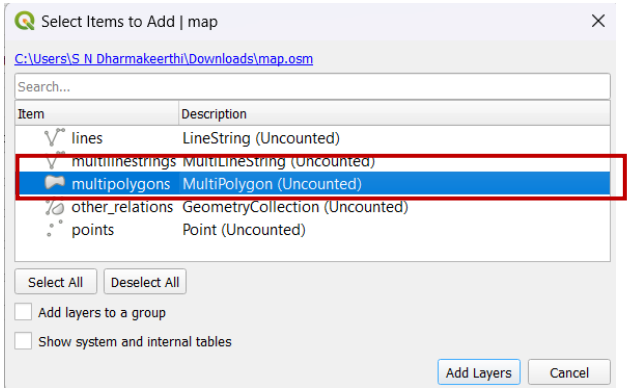


Figure 14 - Add building layer

Step 5.5 - The data will be added to the project as follows.

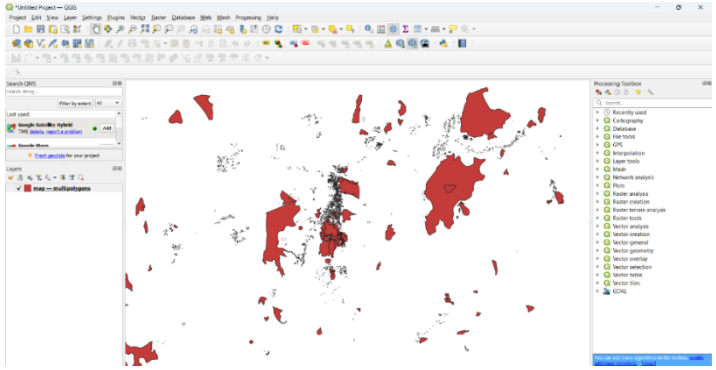


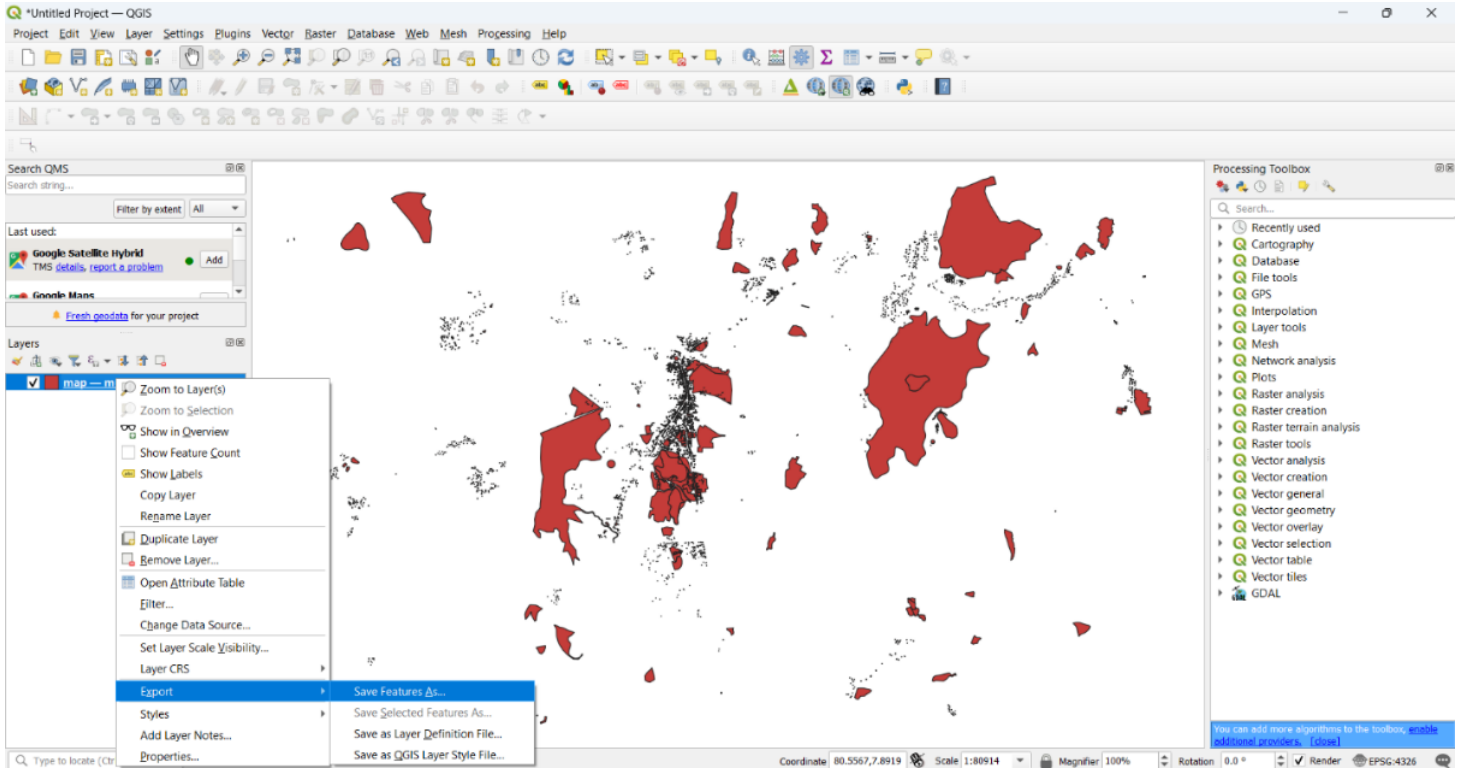
Figure 15: The downloaded polygon layer from the open street map

Step 6

Export the data as a shapefile.

As the downloaded layer is an OSM file you cannot edit it. Therefore, you have to save it as a shapefile. For that,

Step 6.1- Right-click on the downloaded layer. Go to Export>>>Save features as…



Then the following box will appear.

Step 6.2 - Fill the box as follows.

1. Give the Format as “Esri Shapefile”.
2. Click on the following icon to give a location and a name to your shapefile of the building layer. Here I save the layer as “**Buildings**”.
3. Give the “Polygon” as the Geometry Type. (As the buildings belong to polygon geometry type.)
4. Click OK

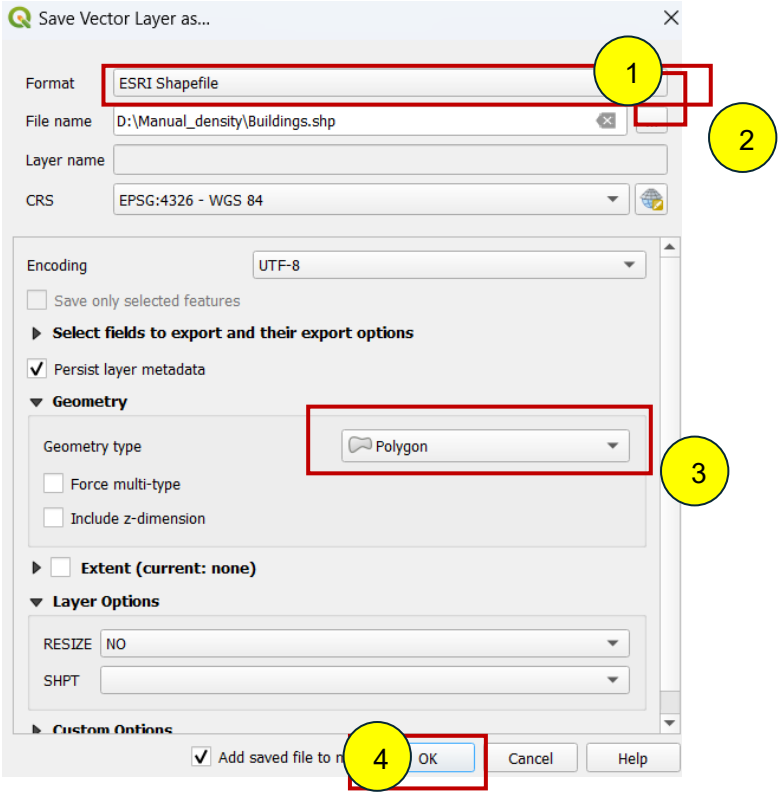


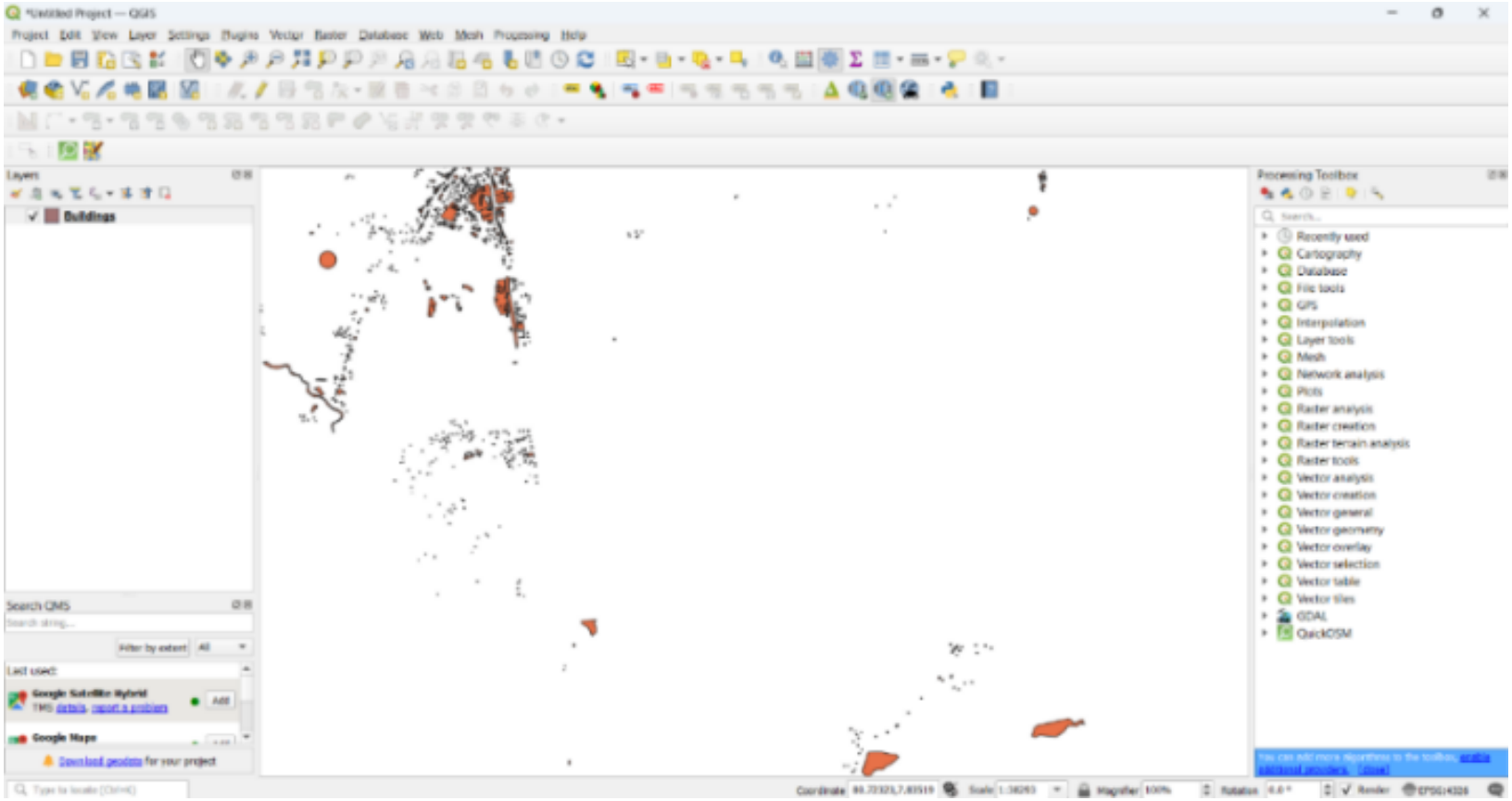
Figure 17: Save the layer as a shapefile

Note

Note that, you can’t have spaces when you give a name to a shapefile. There, you can use “_”as space.

Eg: building_Layer

Now you can edit the following saved shapefile layer (Buildings).



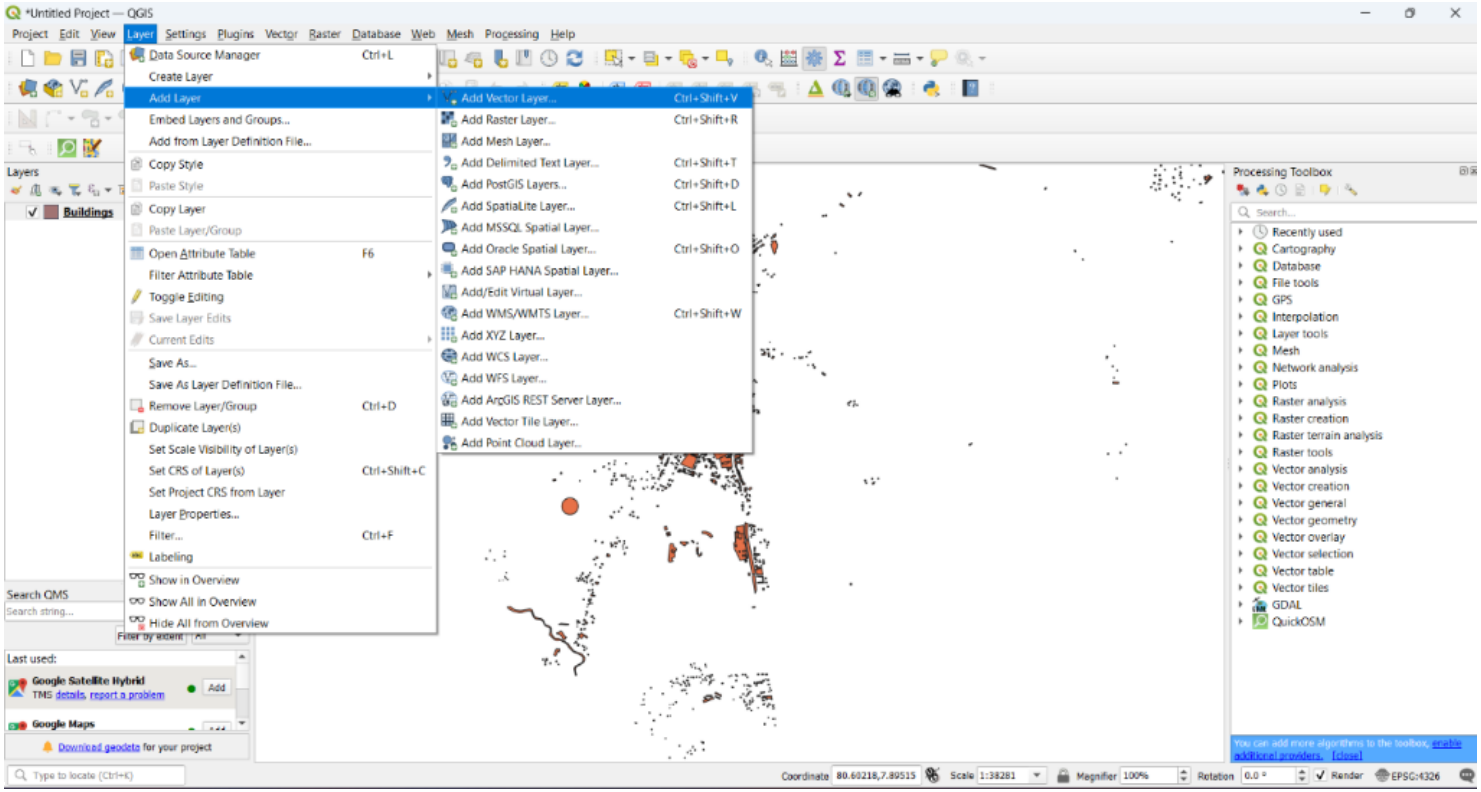
Step 7

Clip the building layer to the boundary layer of your study area.

You need a shapefile for the boundary of your study area.

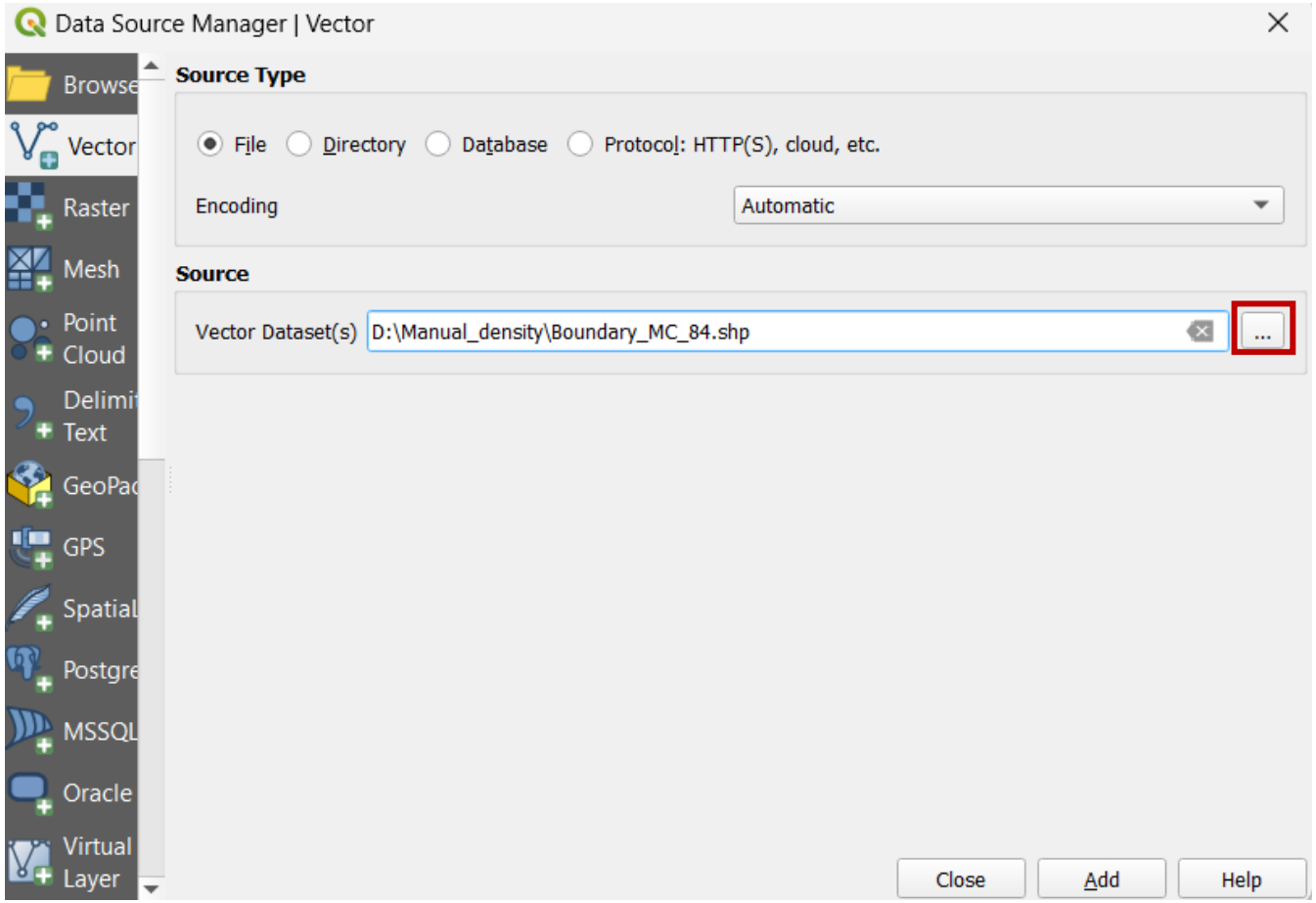
Step 7.1 - Add the shapefile of the boundary to the project.

- Go to Layer>>>Add Layer>>>Add Vector Layer



The following box will appear.

- There you can give the location of your shapefile of the boundary by clicking on the following icon. Here, the shapefile of the boundary is “Boundary_MC_84”
- Click on “Add”



Step 7.2 - Clip the building layer with your boundary layer.

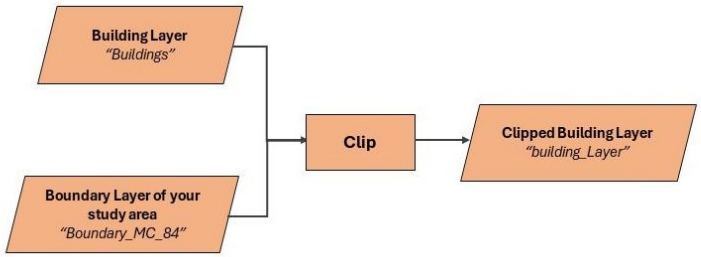
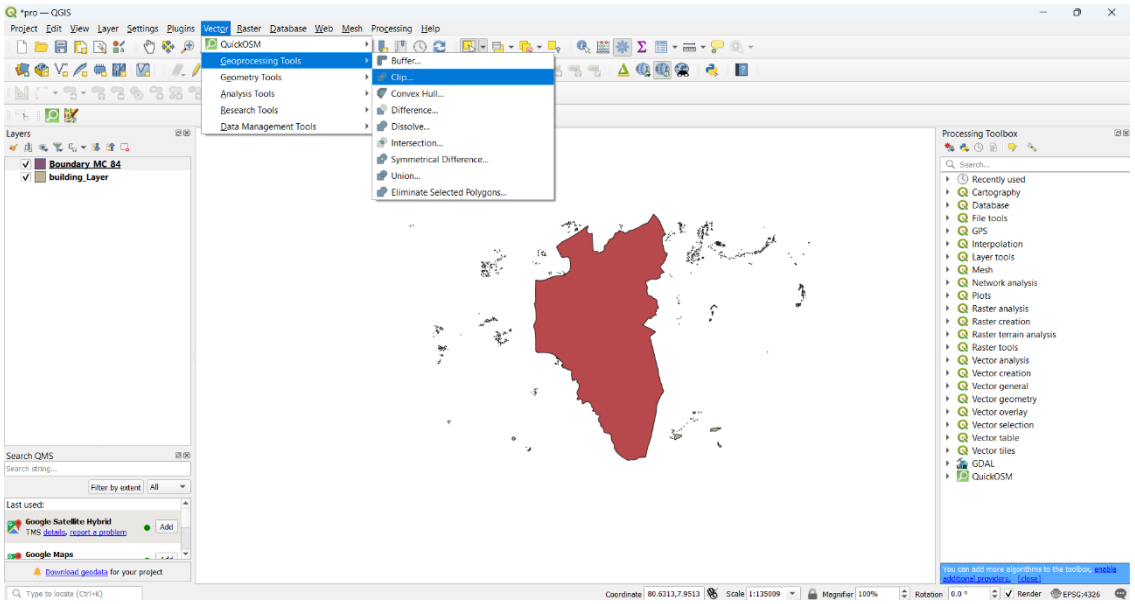


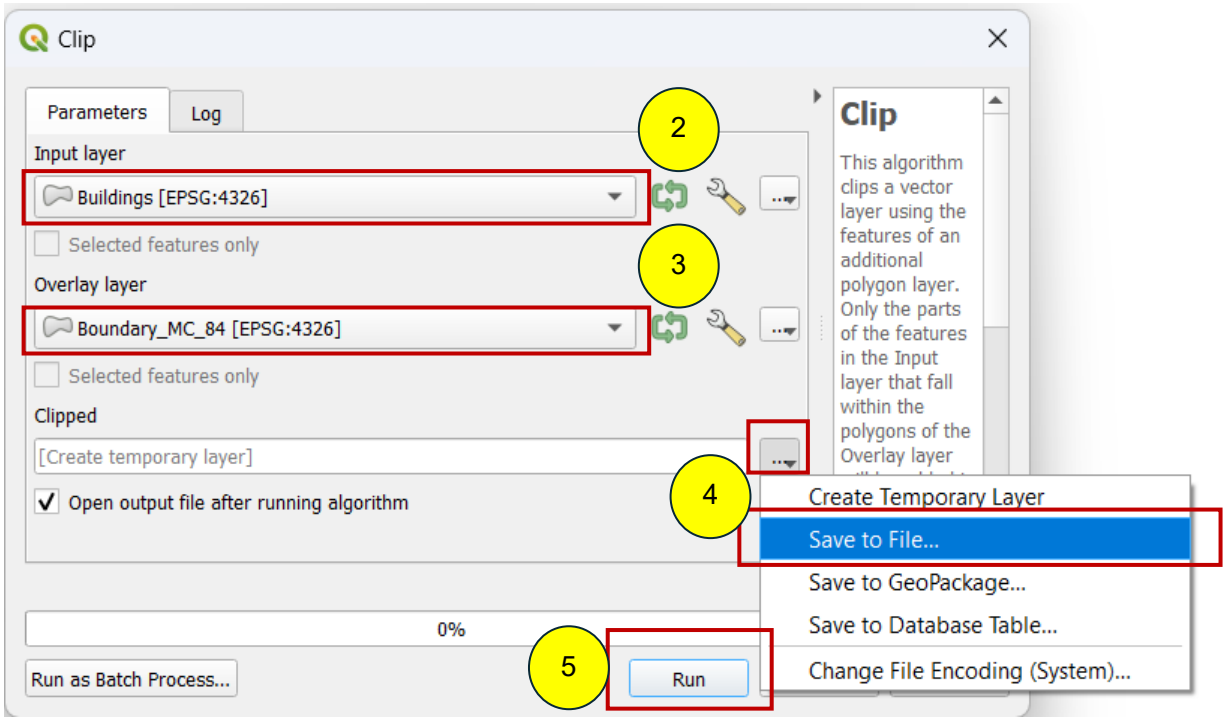
Figure 21: Flow chart for clipping the building layer with the boundary layer

1. Go to Vector>>>Geoprocessing tool>>>Clip



Then the following box will appear. There,

2. Give your building layer as the input layer
3. Give your boundary layer of the study area as the overlay layer.
4. Click on the drop-down icon and then click on “Save to File” to give a location to save the clipped layer.
5. Click on “Run”



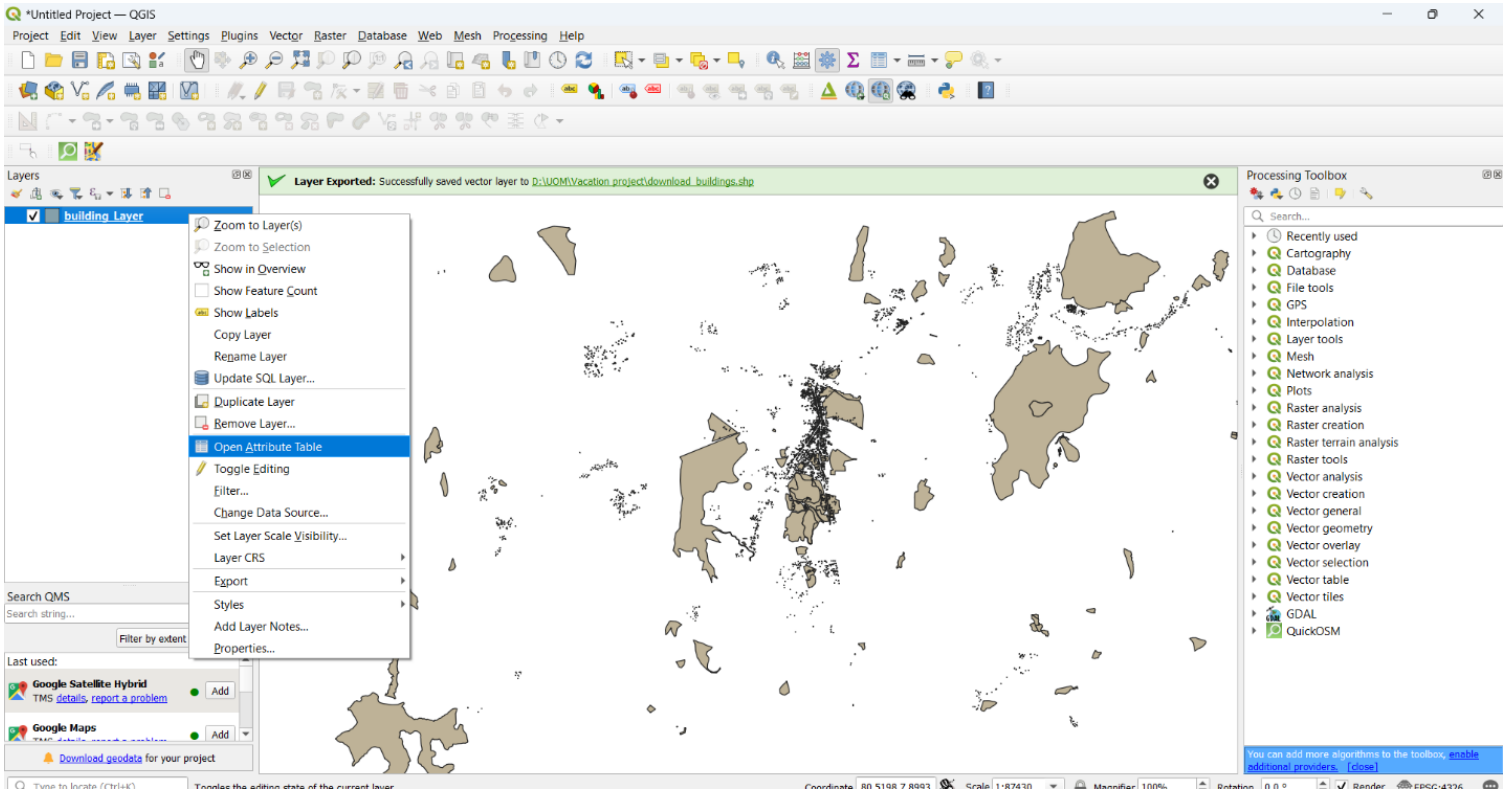
Now you have a shapefile of a building layer for your study area named “building_Layer”

Step 8

Delete the other unwanted data layers from your building layer.

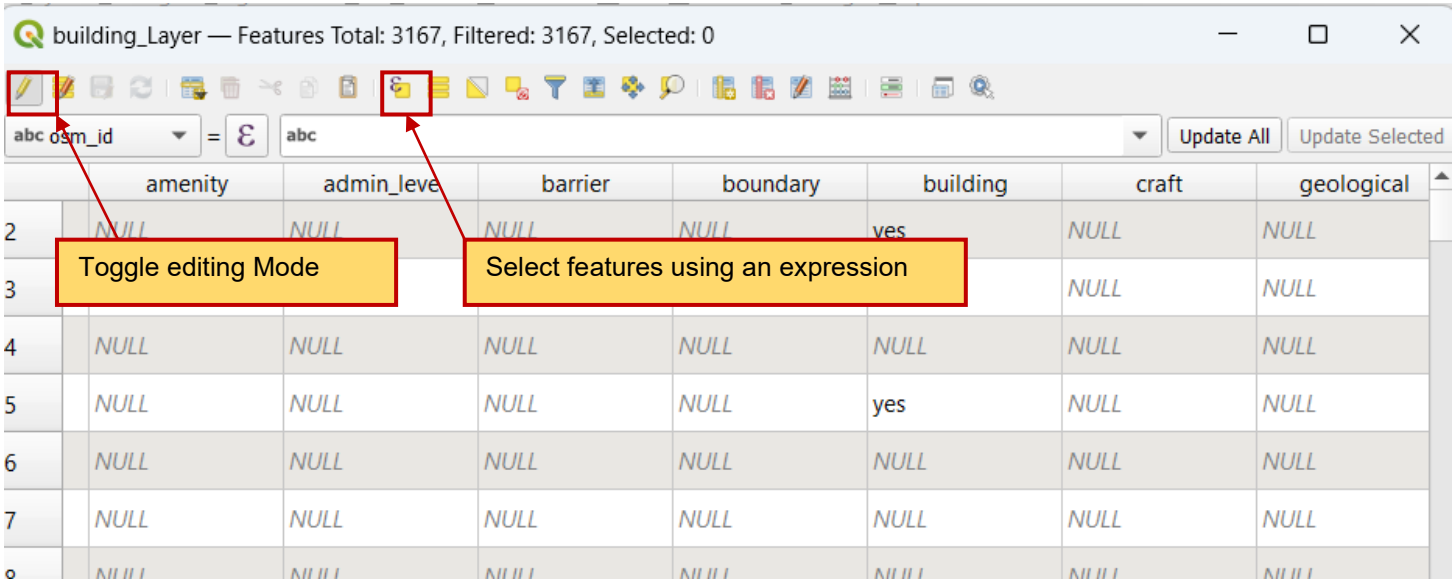
The layer has not only the buildings but also some other layers such as natural water bodies, Rock, etc. As you need only the building layer for this analysis you can delete other layers from your attribute table as follows.

Step 8.1 - Right-click on your layer and open the attribute table.



Step 8.2 - Click on the “Toggle editing mode” tool as follows to ‘On’ the editor mode of the relevant layer.

Step 8.3 - Click on the “select features using an expression” tool to select the unwanted features.



	amenity	admin_leve	barrier	boundary	building	craft	geological
2	NULL	NULL	NULL	NULL	yes	NULL	NULL
3						NULL	NULL
4	NULL	NULL	NULL	NULL	NULL	NULL	NULL
5	NULL	NULL	NULL	NULL	yes	NULL	NULL
6	NULL	NULL	NULL	NULL	NULL	NULL	NULL
7	NULL	NULL	NULL	NULL	NULL	NULL	NULL

Figure 25 - Select features using an expression

Then the following box will appear. The features that are not buildings have been given as “NULL” in the “building” field of the attribute table. Therefore, you can select them here as follows.for that,

1. Click on “Fields and Values”
2. Double-click on the “building” field.
3. Click on “All Unique”
4. Type “is”
5. Double-click on “NULL”
6. Click on “Select features”

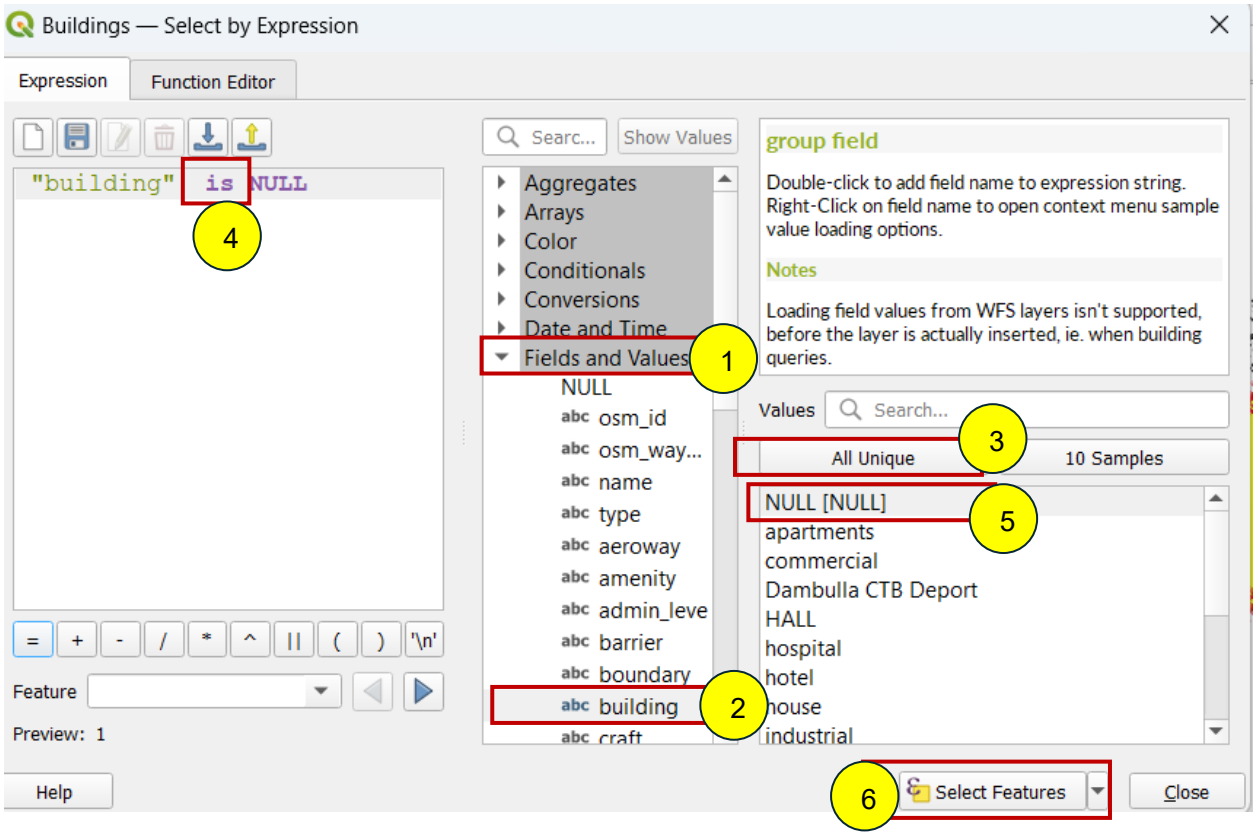


Figure 26: Select the features that are not buildings

Step 8.4 - Click on the “Delete” icon to delete the selected features.

Step 8.5 - Click on the “toggle editing mode” tool to Save the edits.

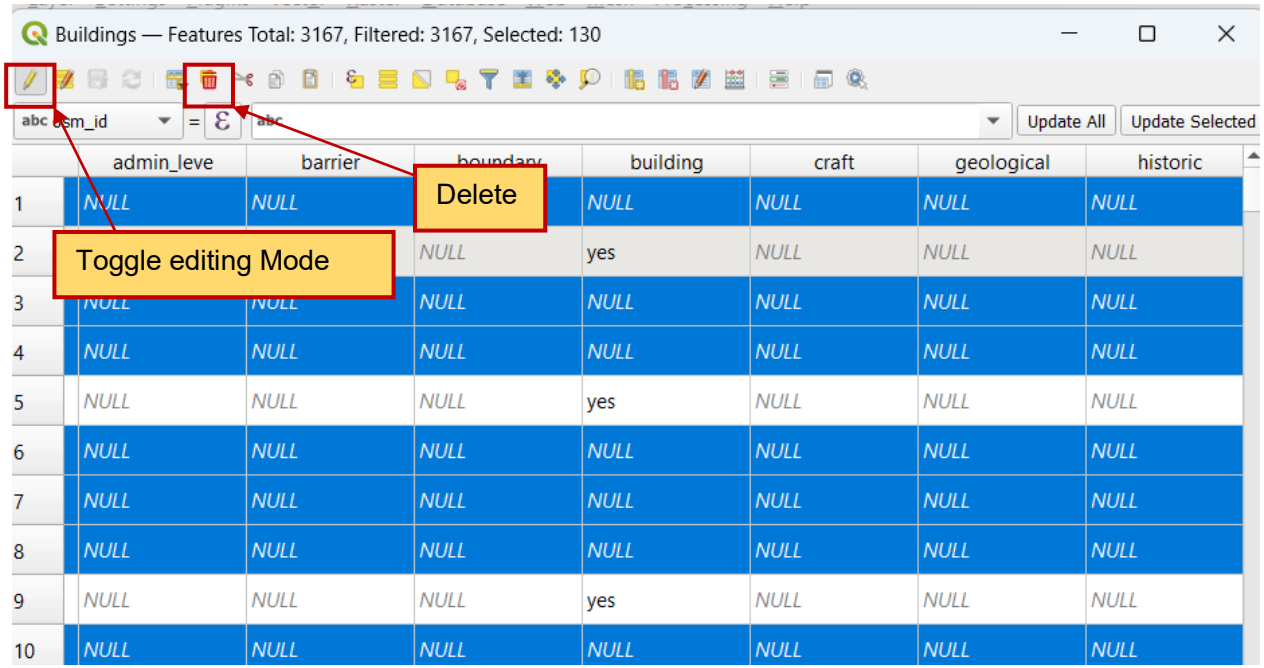


Figure 27: Selection of the features that are not buildings

Then a box will appear as follows. There, click on the “Save” icon to save the edits.

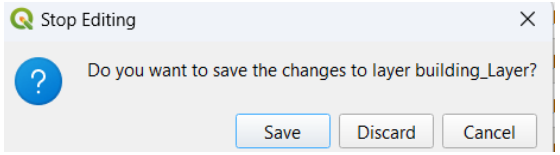


Figure 28 -Stop Editing

Now you have a layer with only the buildings as follows.

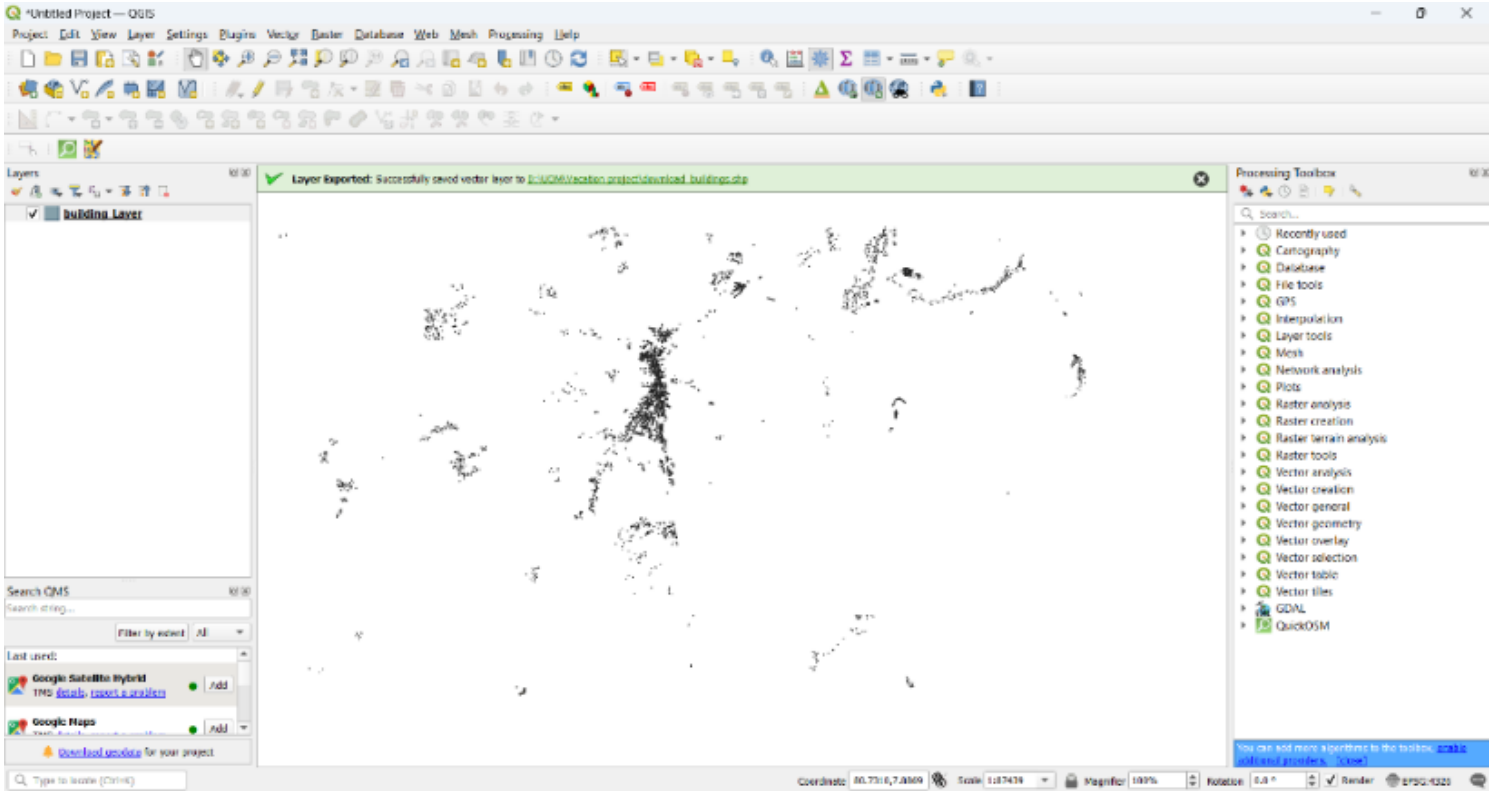


Figure 29: The shape of the building layer

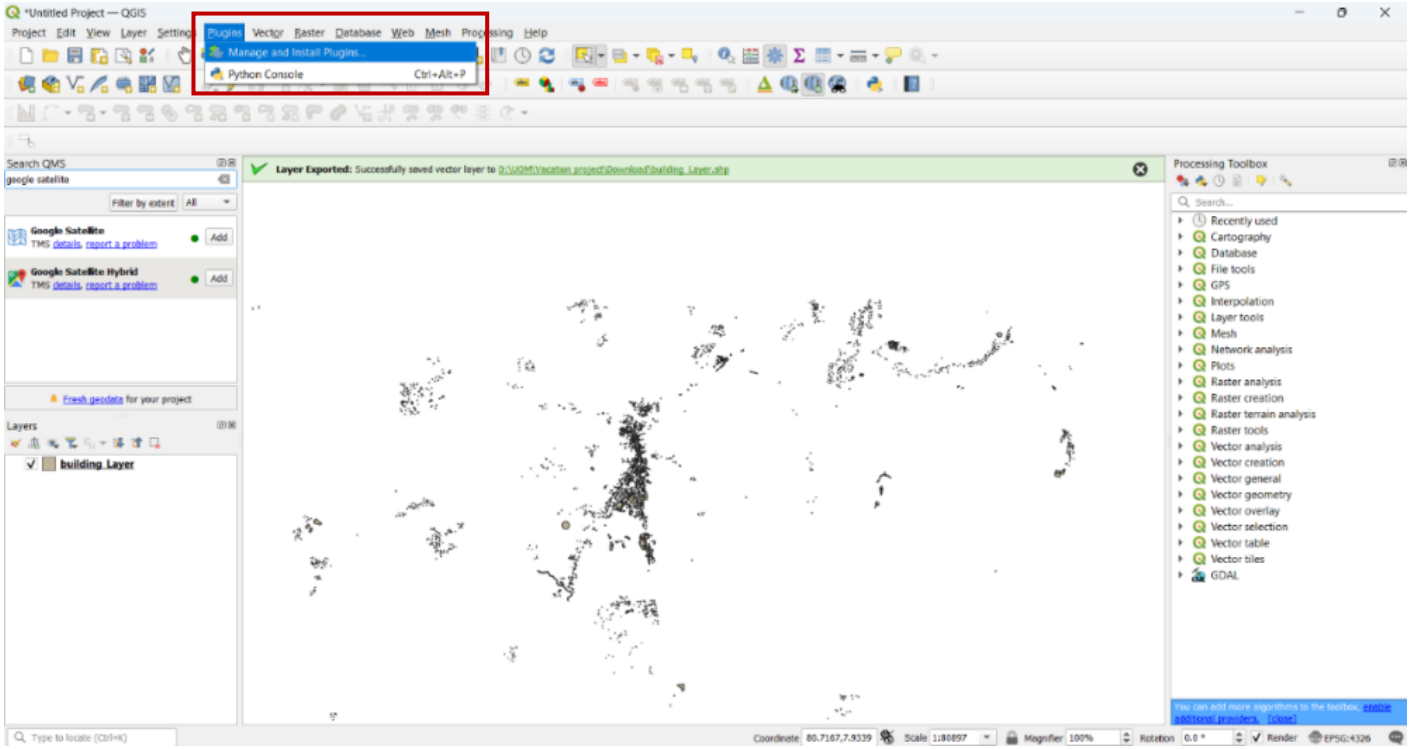
Step 9

Add the relevant buildings and update your building layer.

Step 9.1 - Add a base map to the project.

Here you have to use “QuickMapServices” plugin to add the Base map. For that, install the “QuickMapServices” plugin as follows.

- Go to Plugin>>>Manage and Install Plugins



Then the following box will appear. There,

1. Type “quickmapsevices” on the search bar.
2. Click on the relevant name to open it.
3. Click on “Install Plugin” to install that plugin.

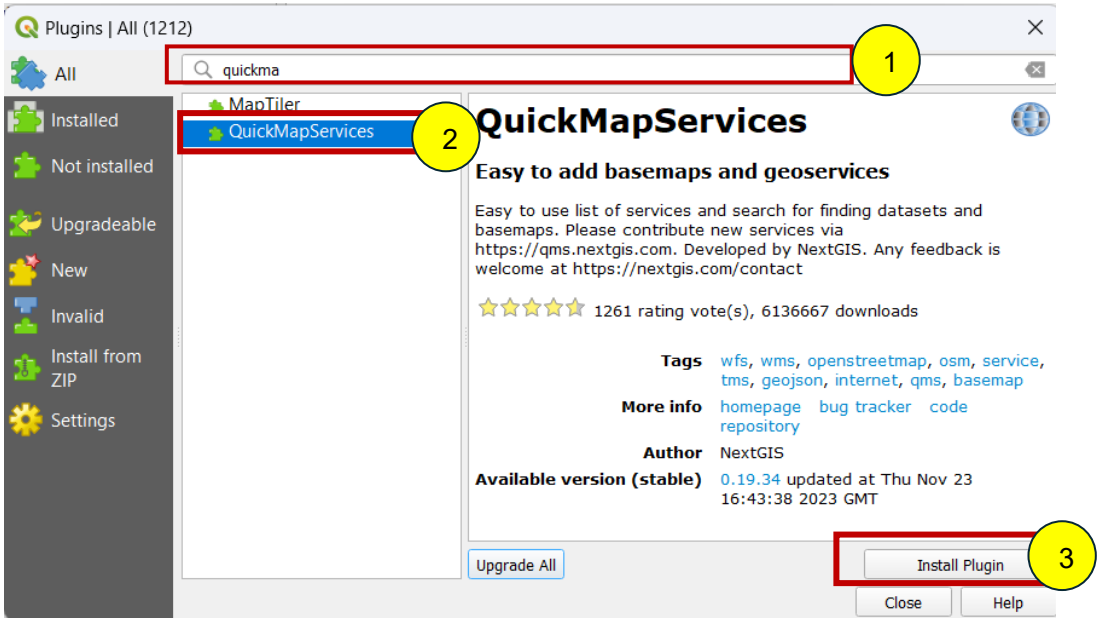


Figure 31: Install QuickMapServices plugin

After installing that plugin, you can follow the steps for adding a base map as given below.

- Go to Web>>>QuickMapServices>>>Search QMS or you can open it by clicking on the following icon in the red color box.

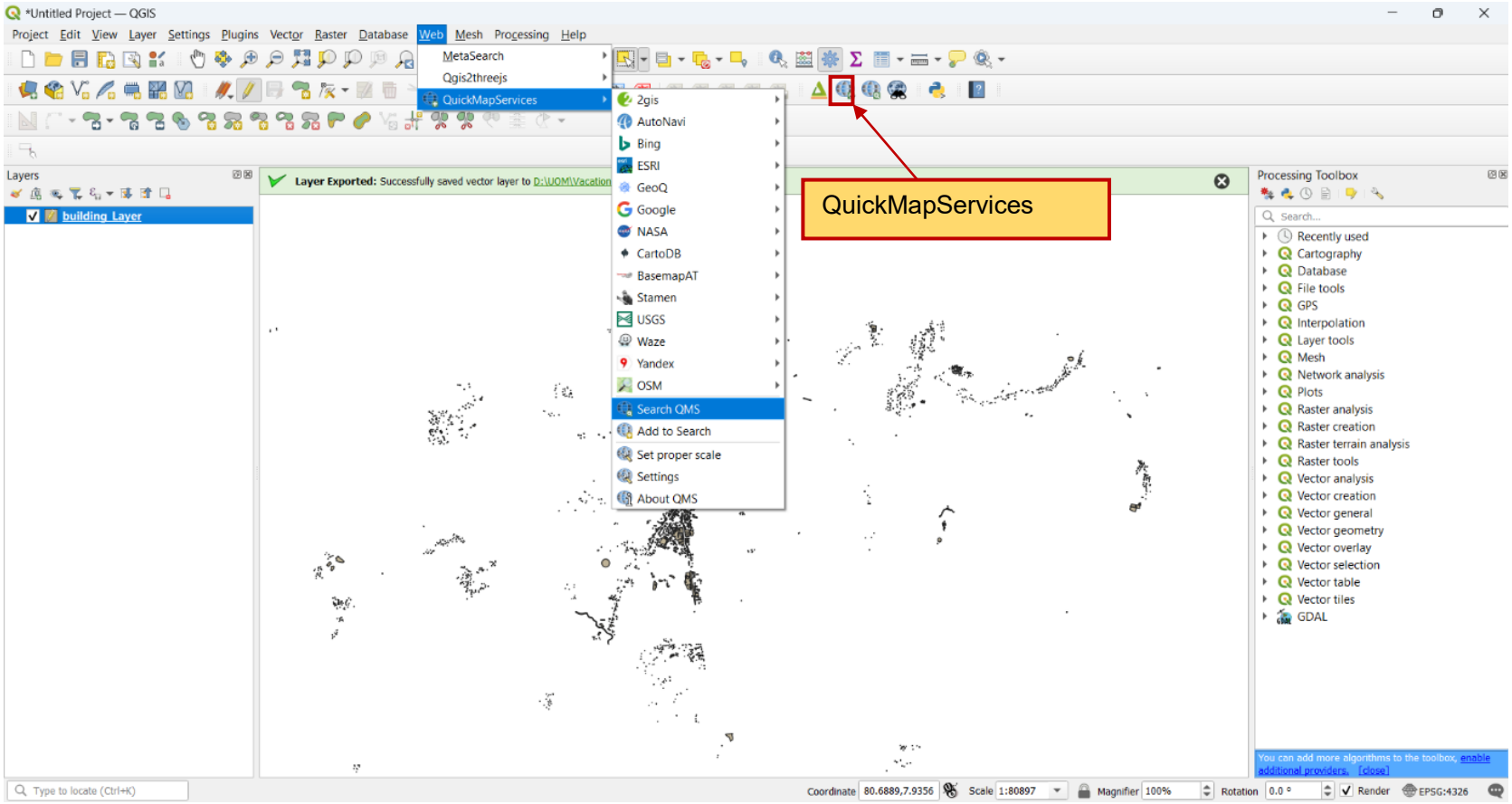


Figure 32 - QuickMapServices

- It will appear as follows. You can search the “Google satellite hybrid” map here. There, you can search the “Google Satellite hybrid” map. If you prefer to use the “Google Maps” as your base map you can add that as your base map.

- Click on the “Add” icon to add the relevant map.

> **NOTE**
>
> Make sure that your internet connection is “On” to display the base map.

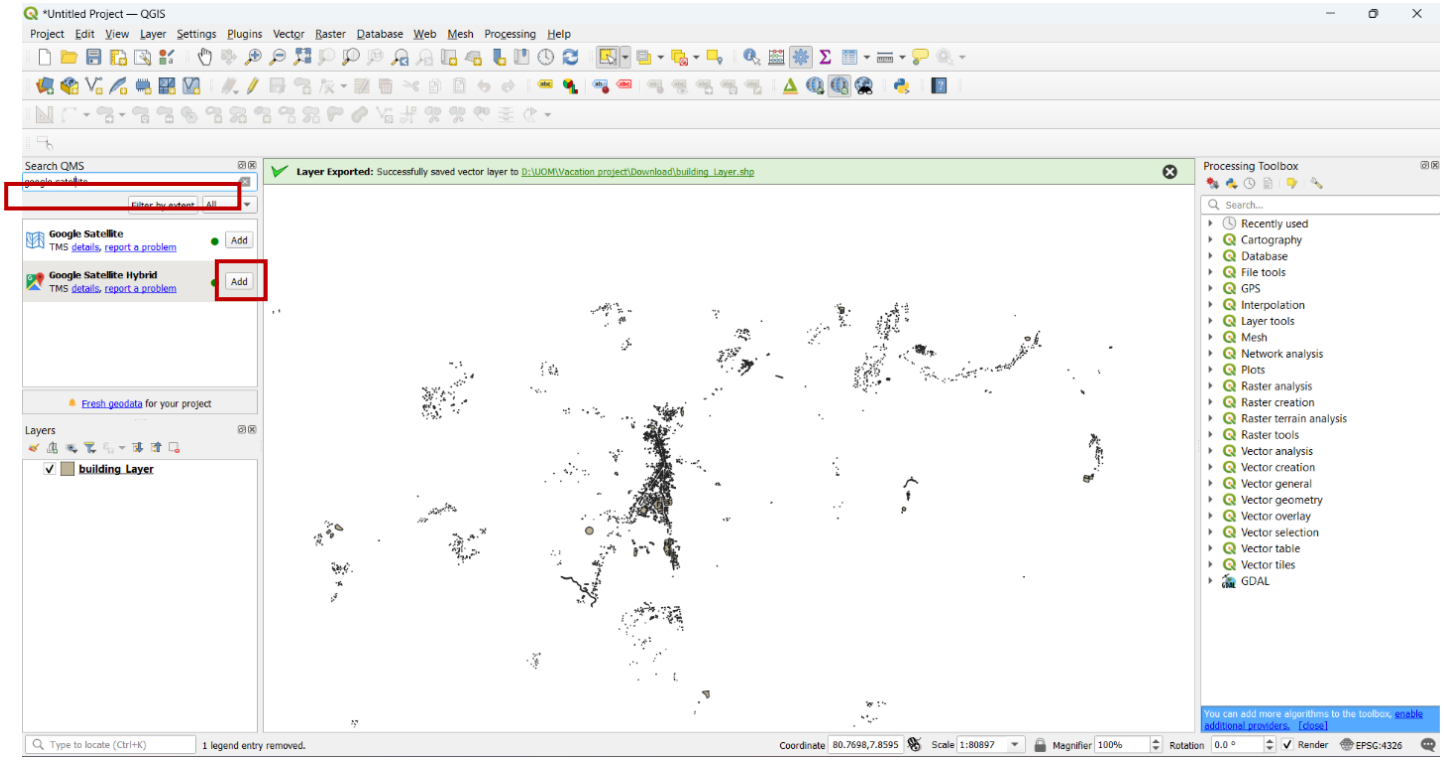


Figure 33: Add the "Google Satelite Hybrid" map

- The Base map layer appears as follows.

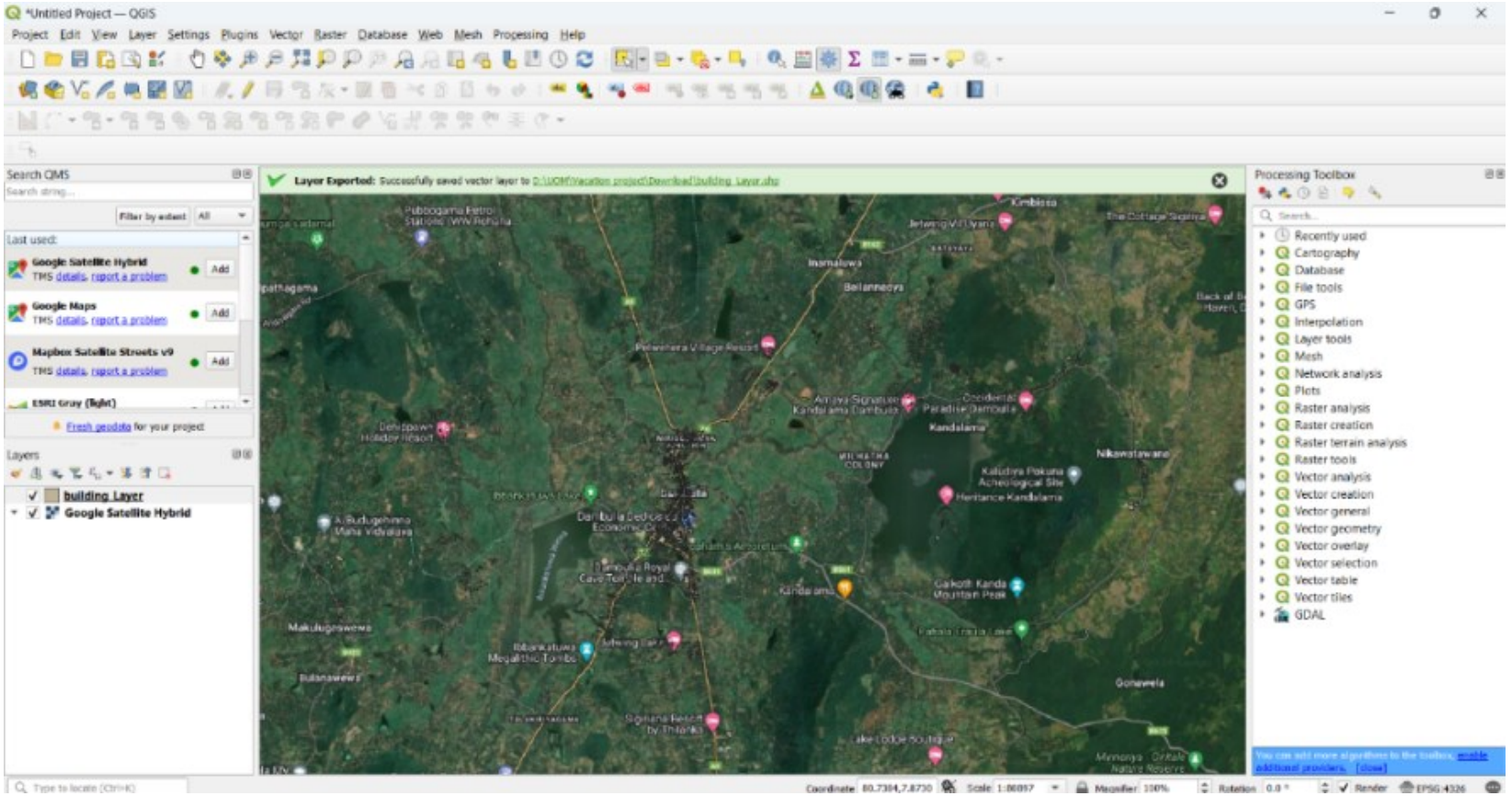


Figure 34 - Base map layer

Step 9.2 - Click on the “Toggle editing mode” tool to “On” the editor mode of your building layer.

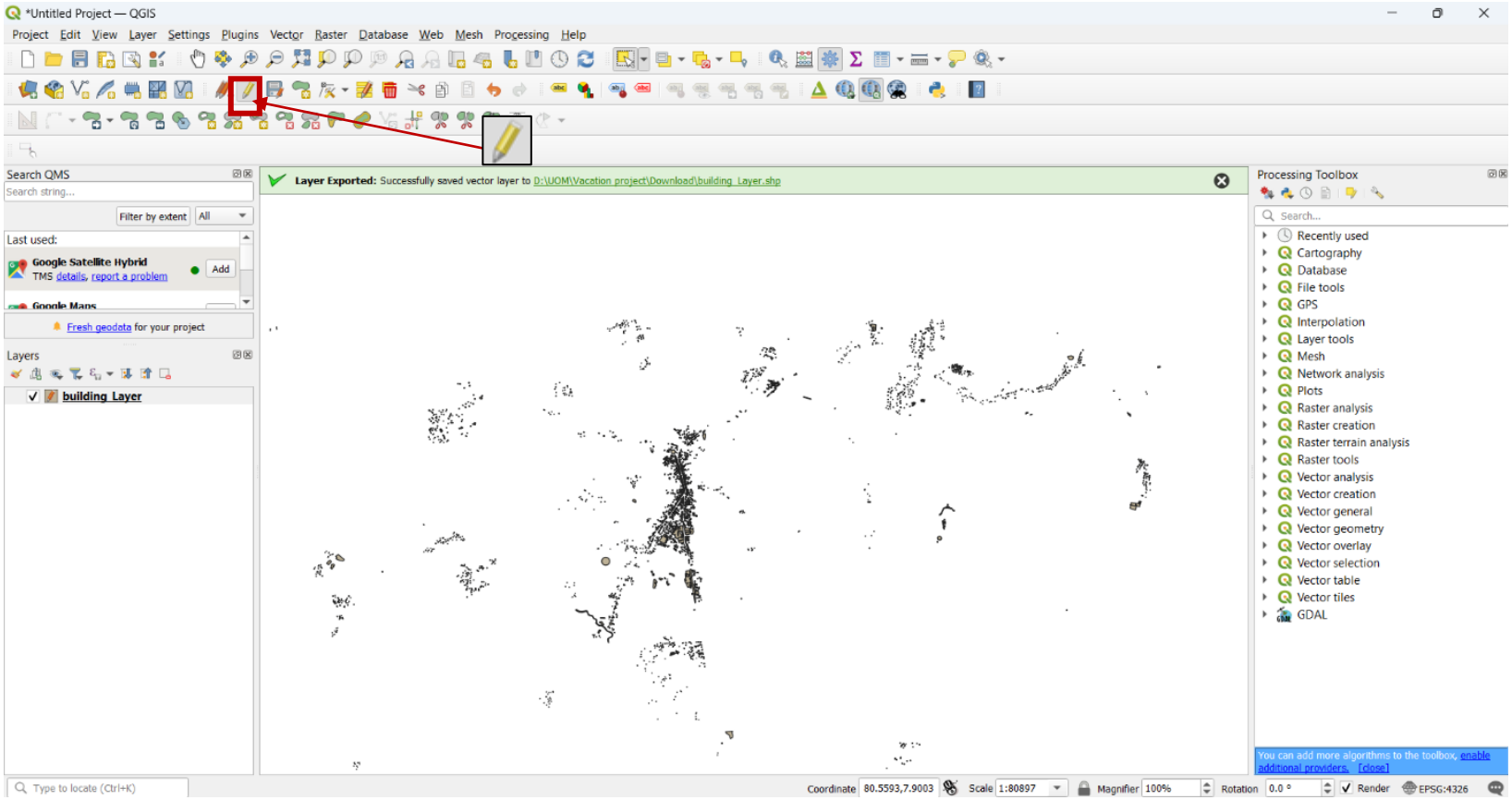


Figure 35 - Toggle editing mode

Step 9.3 - Zoom in to a relevant location.

- Click on the “Zoom In” tool.
- Draw a rectangle by clicking on the relevant location that needs to zoom in. The rectangle shown in blue color as follows.

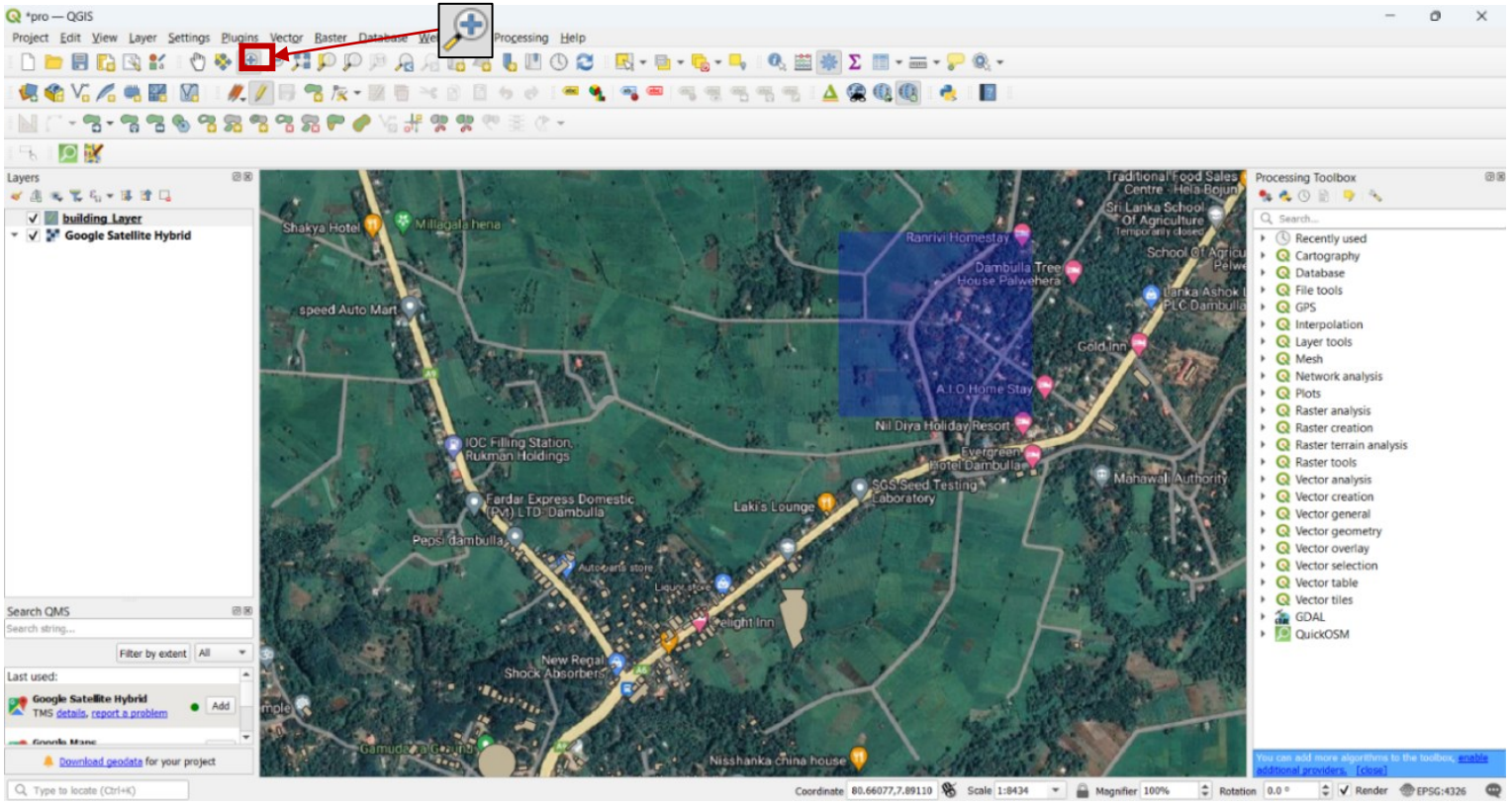


Figure 36: Zoom in to a location

Then it will Zoom in as follows.

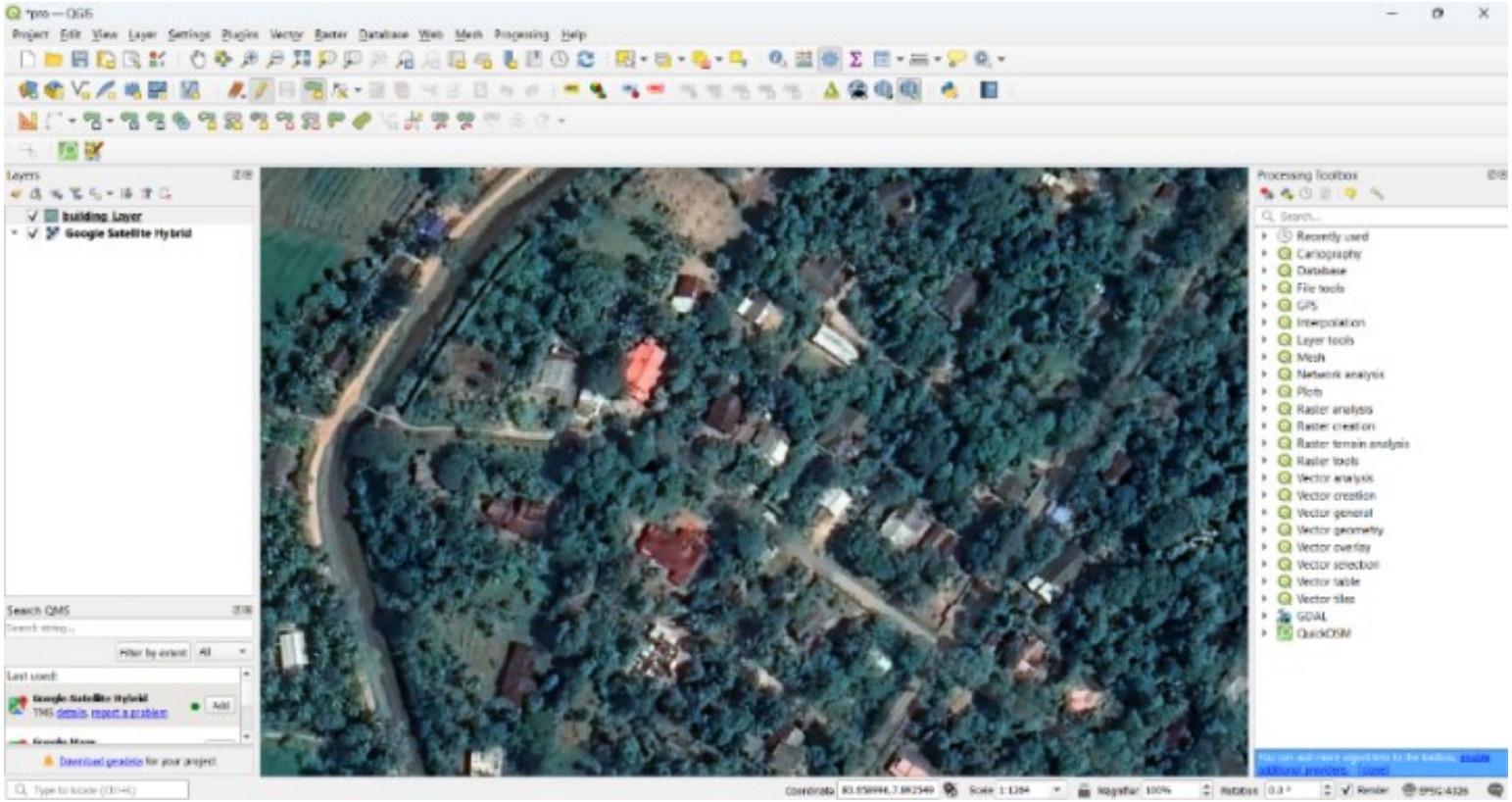


Figure 37 -Zoom-In

Step 9.4 - Click on the “Add Polygon Feature” tool to create polygons.

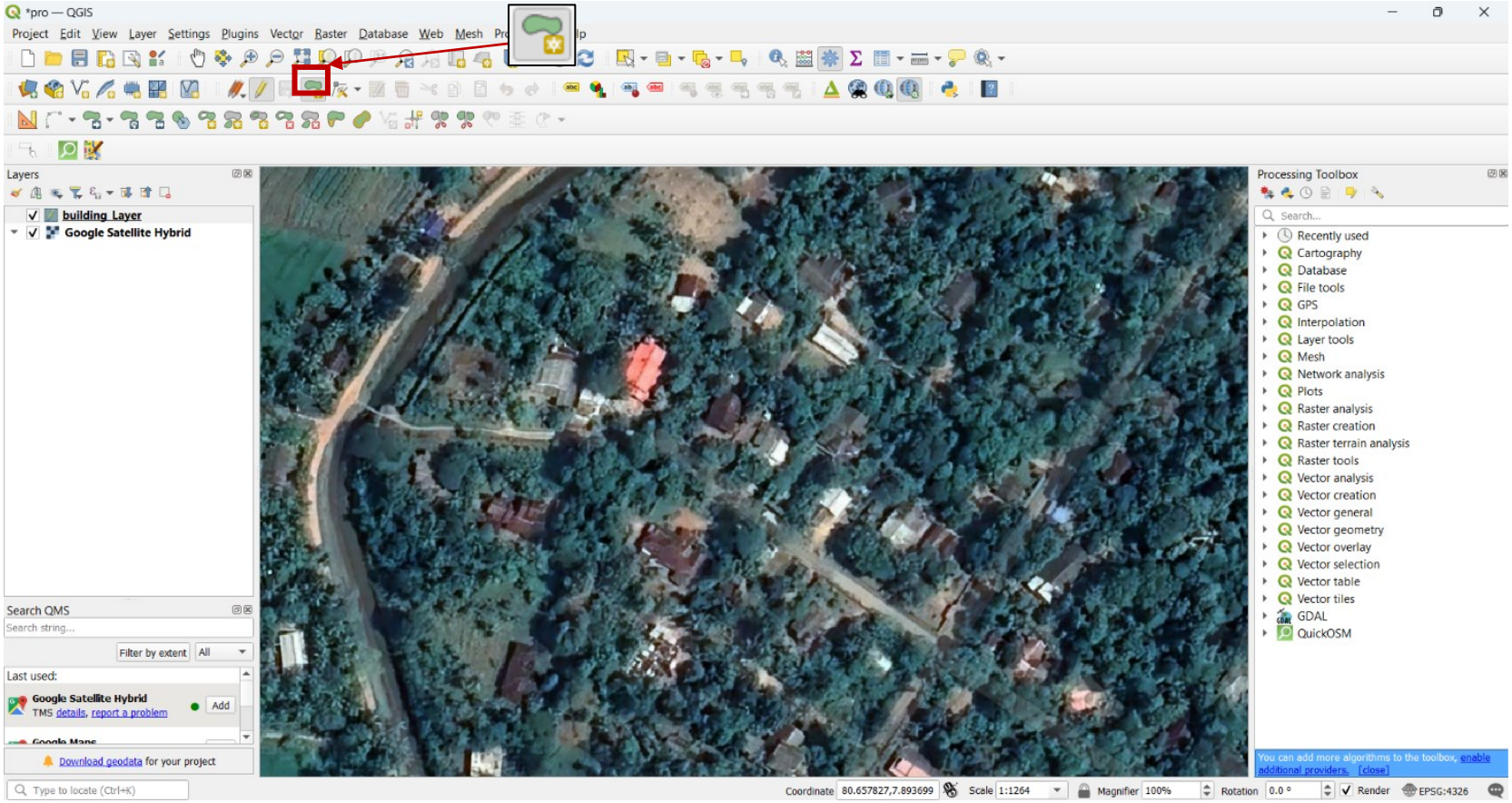


Figure 38 - Add Polygon Feature

Step 9.5 - Click on the corners of the building to draw the shapes and you can stop drawing a building with a right click.

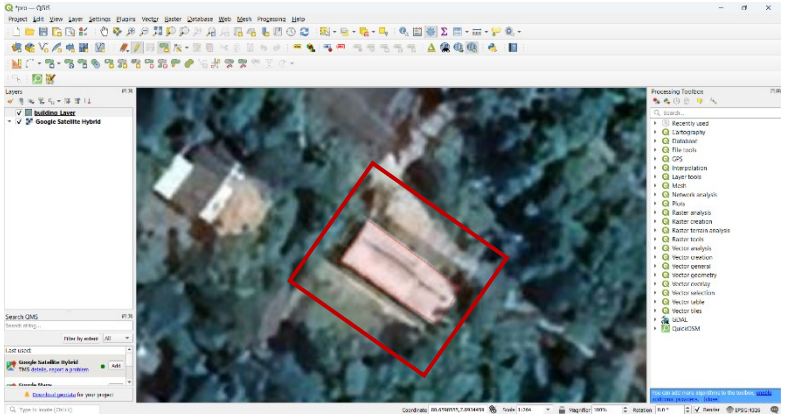


Figure 39: Drawing a Building

After right click, there will appear a box as follows.

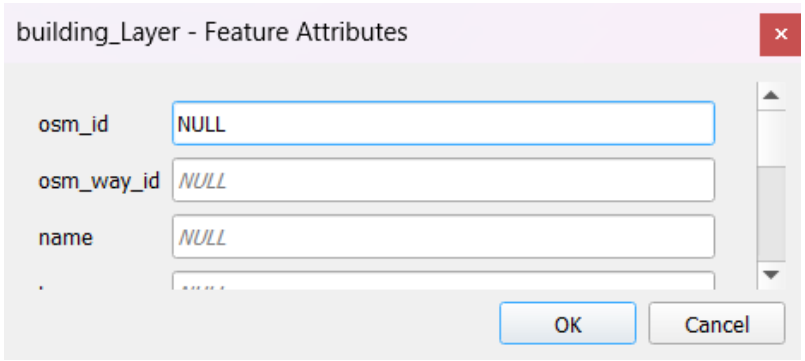


Figure 40 -Building Layer

There's no need to fill this. Therefore, you can click on "OK".

You can draw all the relevant buildings following that process. Now you have a completed building layer for your study area. ("**building_Layer**")

OR

In case you take the building layer from an agency,

You need to follow these steps.

1. Clip the building layer to your shapefile of the study area boundary in QGIS. Refer the ***step 7 on page 25.***

2. Update or edit the building layer in QGIS as you need. Refer the ***step 9 on page 34.***

5.1.2. Update the attribute table of the building layer.

Here, you have to add and update the fields of your building layer for the number of floors, building height, building type, and density type.

Step 1

Add a new field to update the number of Floors.

Step 1.1 - Right-click on the building layer to open the attribute table.

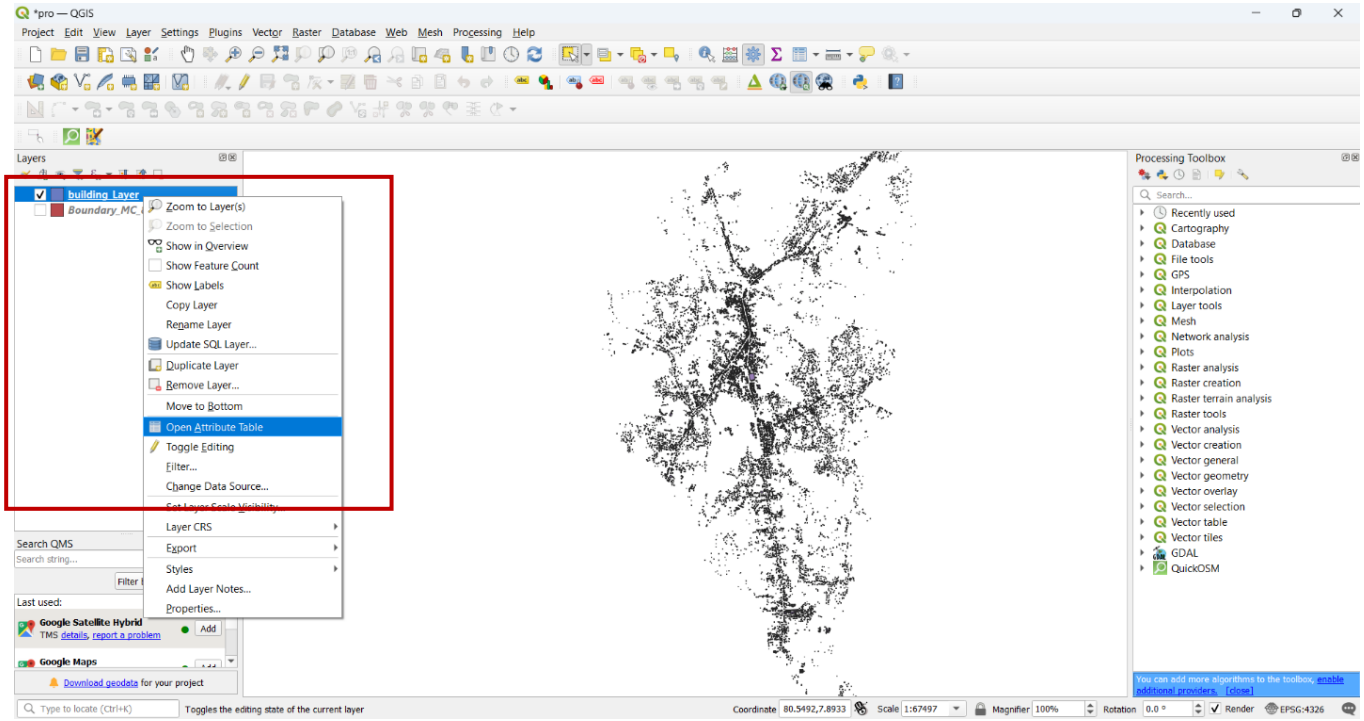


Figure 41- Building layer

Step 1.2 - Click on toggle editing mode and then click on new field to add a new field.

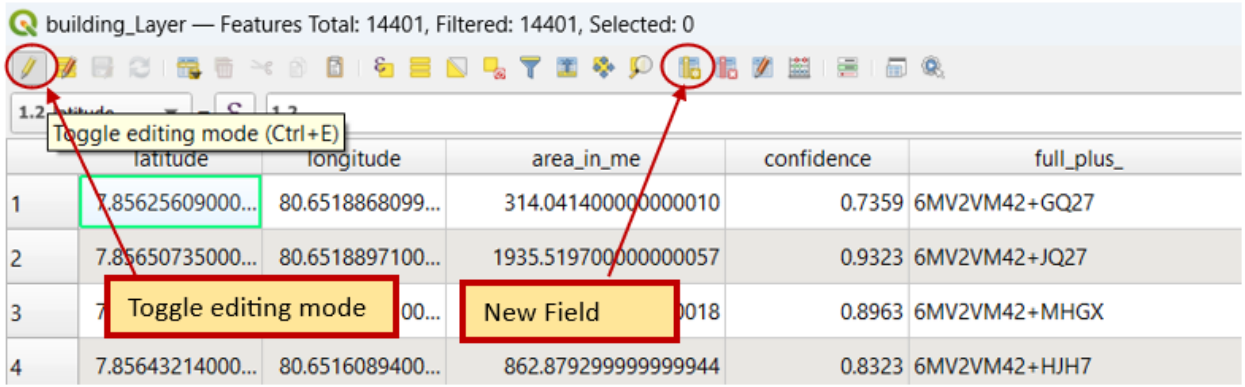


Figure 42 - Toggle editing

Step 1.3 - Fill the following box and click on OK

You can give a name and length as you need. As the floors will give in numbers the type should be given as “Whole number(integer)”.

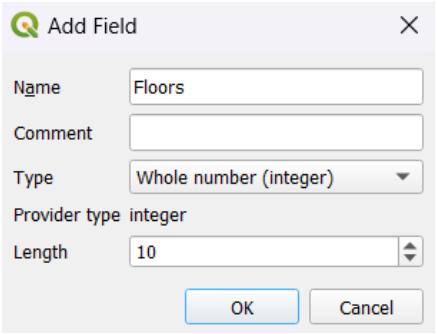


Figure 43: Add a new field for several floors

Step 2

Assign the values to the “Floors” field

You can use the street view of Google Maps to identify the number of floors of each building one by one and assign the values to the “Floors” field.

Step 2.1 - Open “Google Maps” in a Google Chrome browser.

There you can go to your study area by searching it.

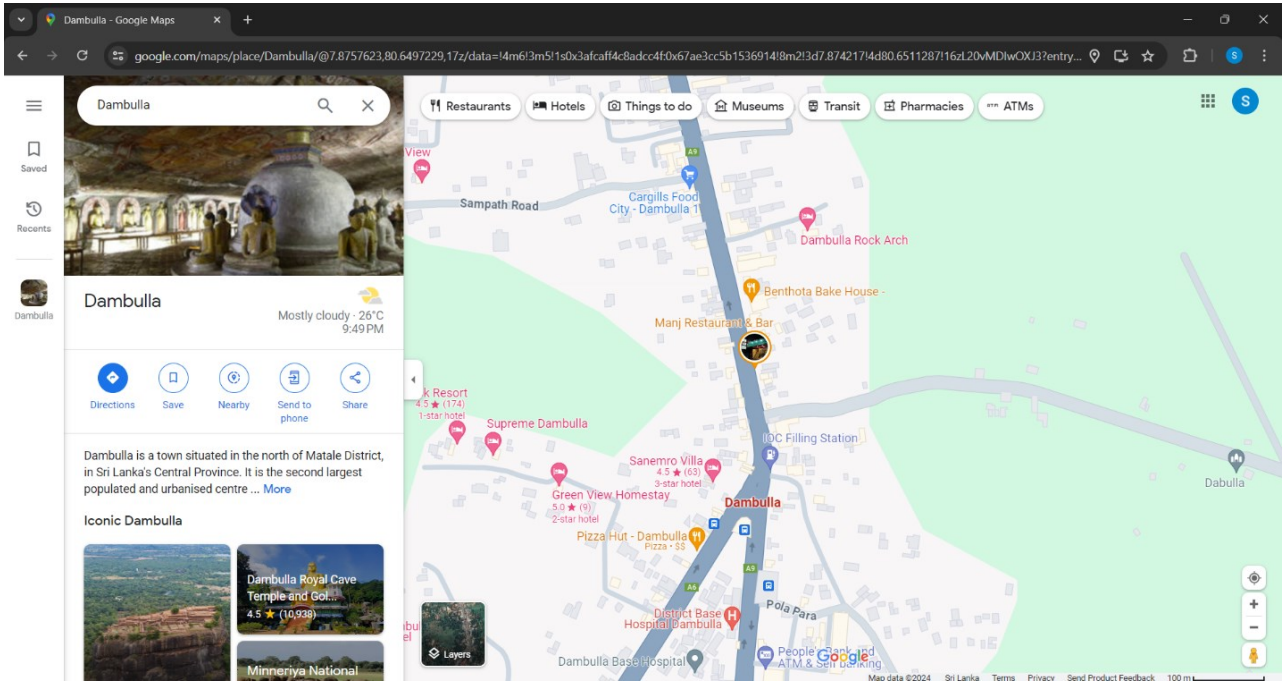


Figure 44: Google Maps

Step 2.2 - Add a base map to the project.

Refer the ***step 9.1***

Here you can add “Google Maps” as the base map.

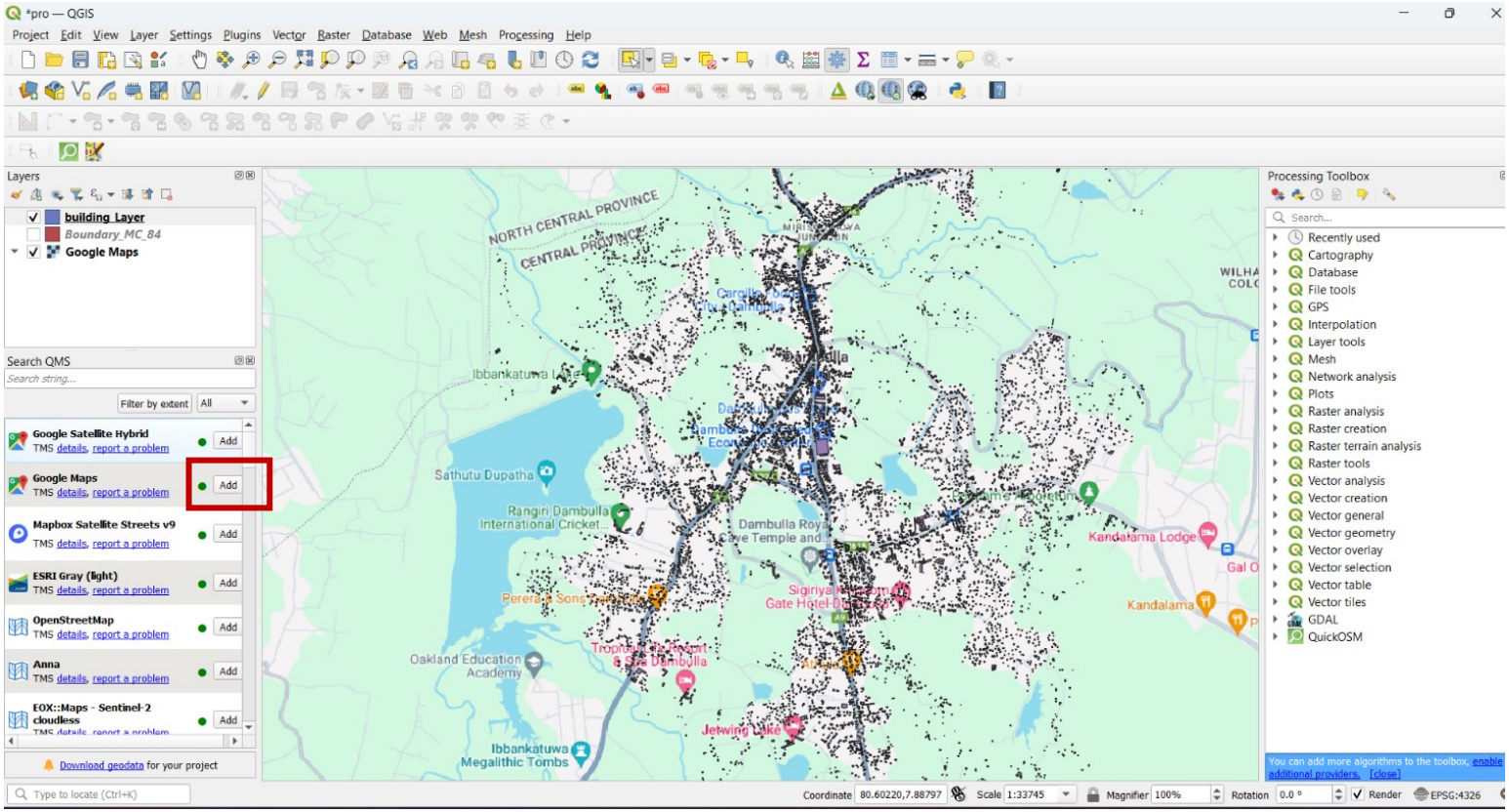


Figure 45 - Google Maps

Step 2.3 - Click on the “Select features by area” tool and click on a building to select it.

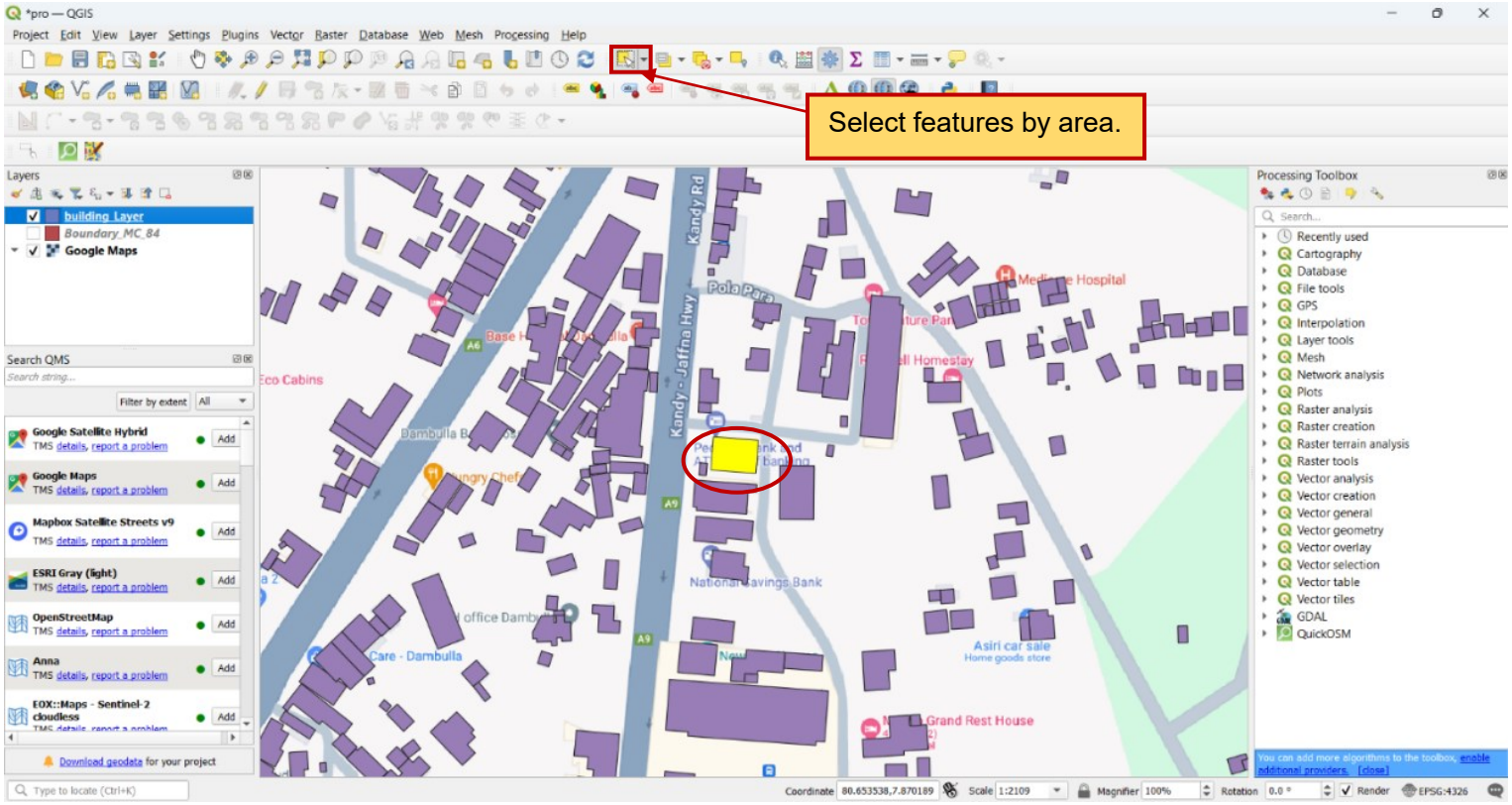


Figure 46: Select a building

Step 2.4 - Go to “Google Maps” and check the number of floors of that building.

- Go to “Google Maps” and identify that building.

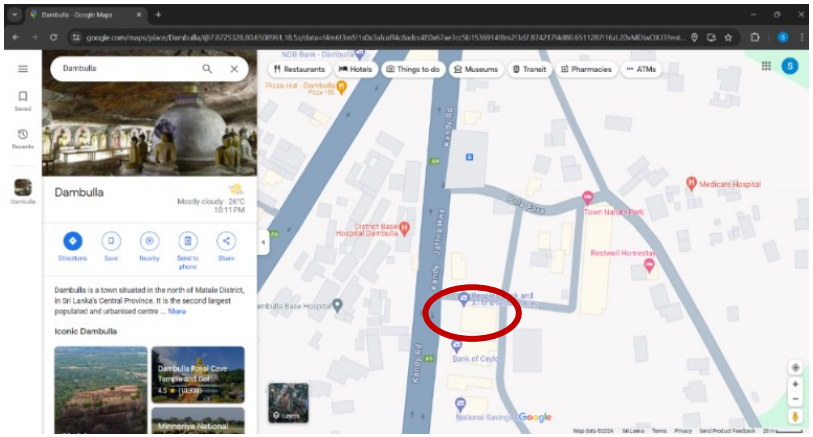


Figure 47 - Google Maps

- Go to Street View and check the number of floors of that building.

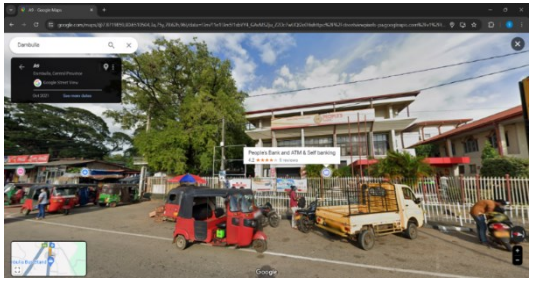


Figure 48: Street view of Google Maps

Here, you can see 2 floors in that building. Therefore, you can assign that value in QGIS.

Step 2.5 - Assign the values to the relevant buildings in the “Floors” field in the QGIS.

- Right-click on the building layer and open the attribute table

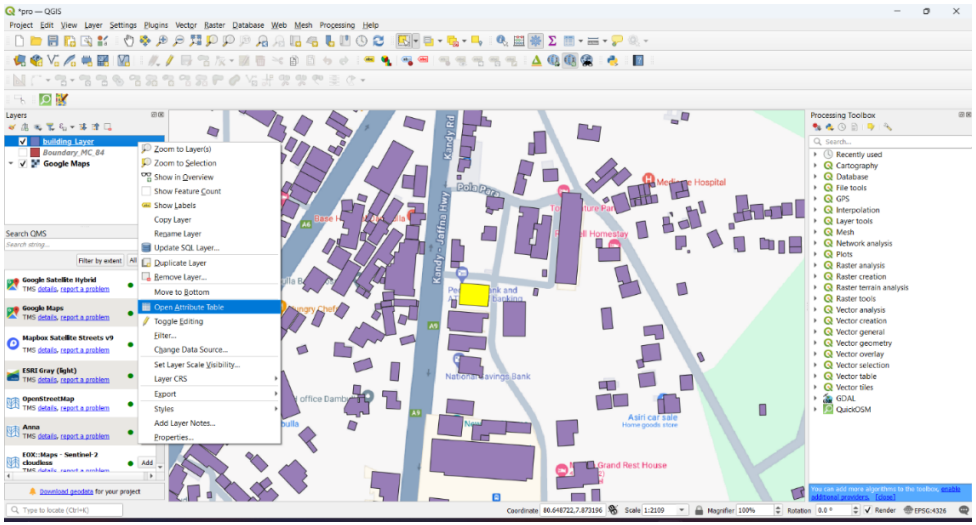


Figure 49: Open the attribute table

- Click on the “toggle editing Mode” tool.

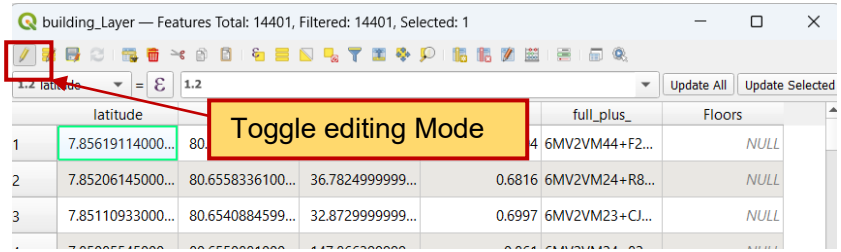


Figure 50 - Toggle editing Mode

- Click on the “Move selection to top” tool.

You can move the selected features to the top of the list as follows.

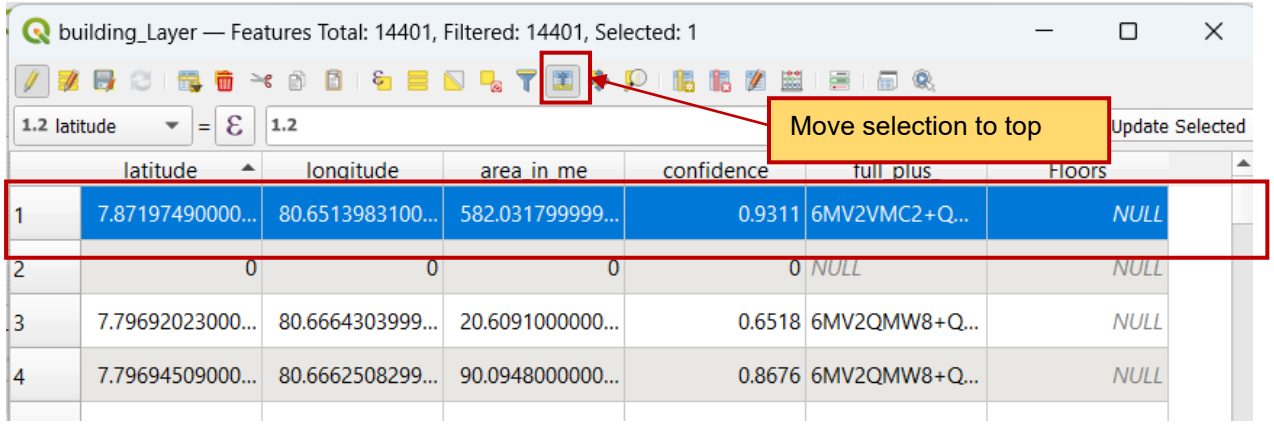


Figure 51: Move the selection to the top

- Give the identified value of the relevant building to the “Floors” field.

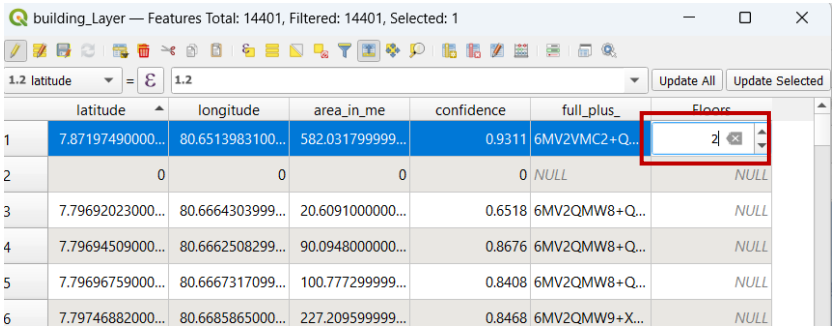


Figure 52: Assign the floor number

- Give the floor numbers to all the buildings following that method. (Repeat the **Step 2.3, Step 2.4 and Step 2.5**)
- You can save the edits by clicking on “Toggle editing Mode”

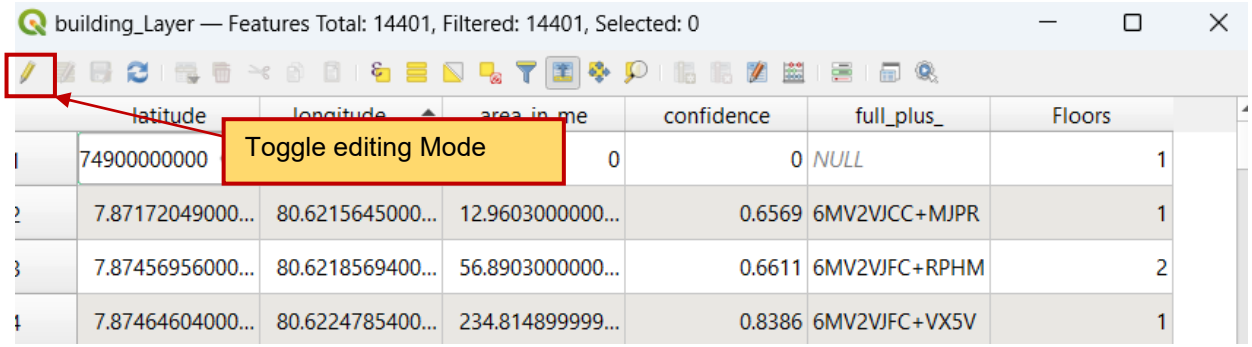


Figure 53 - Toggle editing Mode

- Then click on “Save” to save the edits as follows.

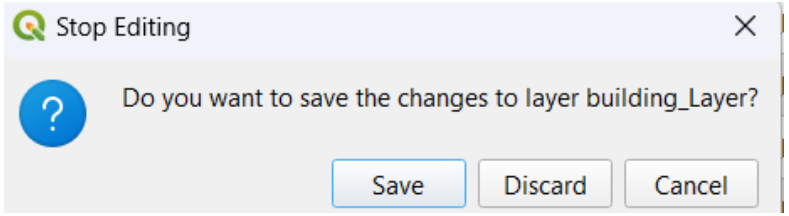


Figure 54 - Save

Step 3

Add a new field as “Height” and calculate the building height.

Step 3.1 - Click on the “toggle editing mode” tool as follows.

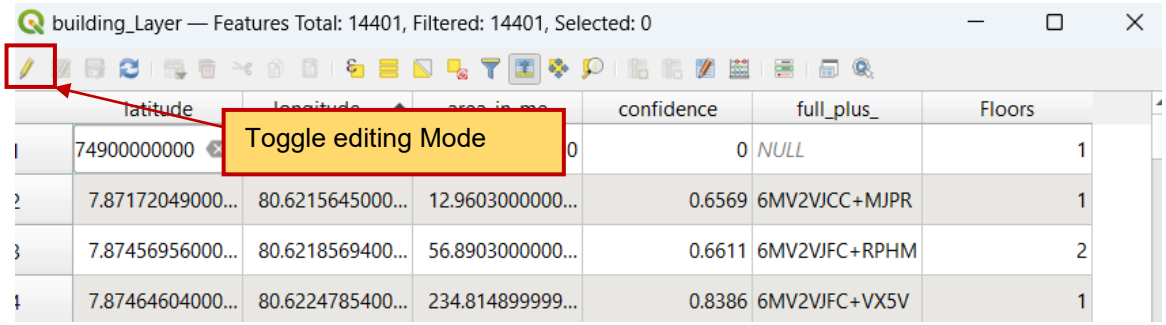


Figure 55 - Calculate the building height.

Step 3.2 - Click on the “New field” tool as follows.

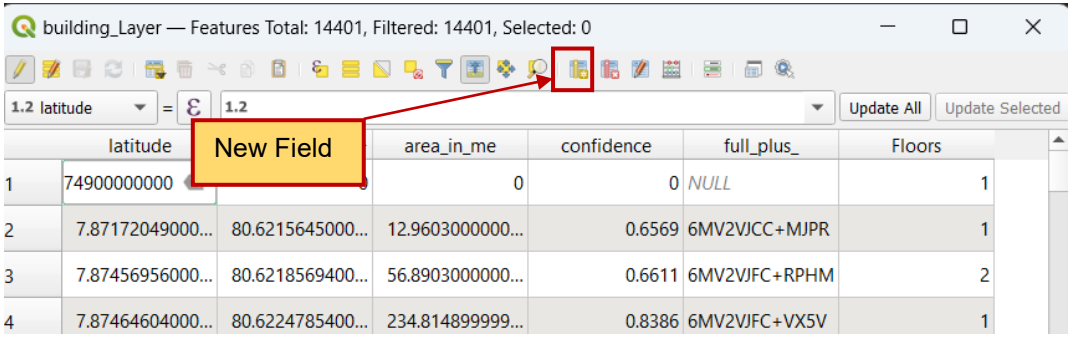


Figure 56 -Building Layer

Fill in the following box.

- As the building height is a value the Type should be given as “Whole number(integer)”
- You can give a name and Length as you need.
- Click “OK”

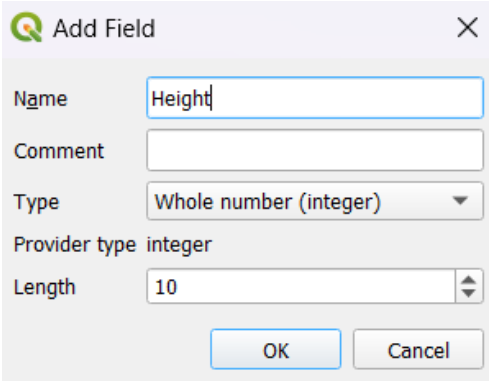


Figure 57: Add a new field for building height

Step 3.3 - Click on the “Open field Calculator.”

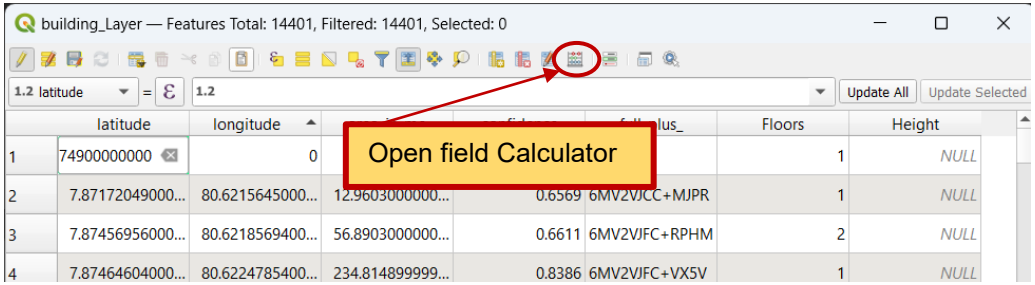


Figure 58: Open the “Open field Calculator”

It will appear as follows.

Step 3.4 - Fill the following box and give an expression.

Here we assumed that the height of one floor is 3m. Therefore, you can calculate the “Height” by multiplying the “Floors” field by 3 as follows. For that,

1. Tick on update existing field
2. Click on the dropdown and select your field for Height. Here, it is the “Height” field.

To give the expression,

3. Click on Fields and Values
4. Double click on “Floors”
5. Click on the ‘*’ icon.
6. Type “3”
7. Click “OK”

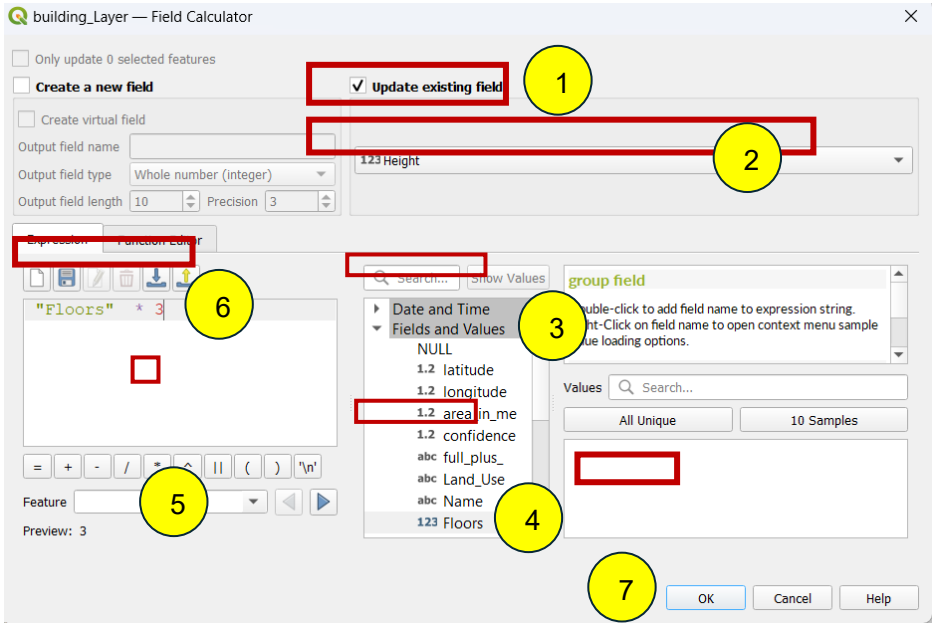


Figure 59: Calculate and assign the building height

Step 3.5 - Click on the “toggle editing mode” tool to save the edits.

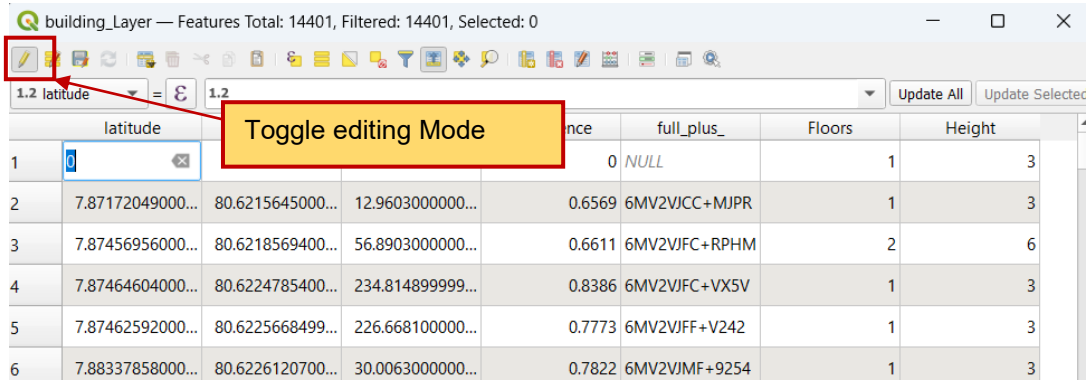


Figure 60 - Toggle editing Mode

Click on “Save” in the following box.

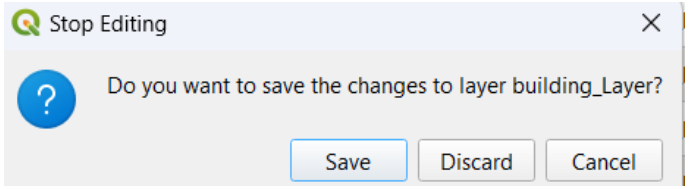


Figure 61 -Save

Step 4

Add a new field as “Type” and update the field with the building type.

Here, you have to add a field to update the building type of each building. Point, Strip, and Block are the building types based on their form.

Step 4.1 - Click on the “toggle editing mode” tool to on the editor mode.

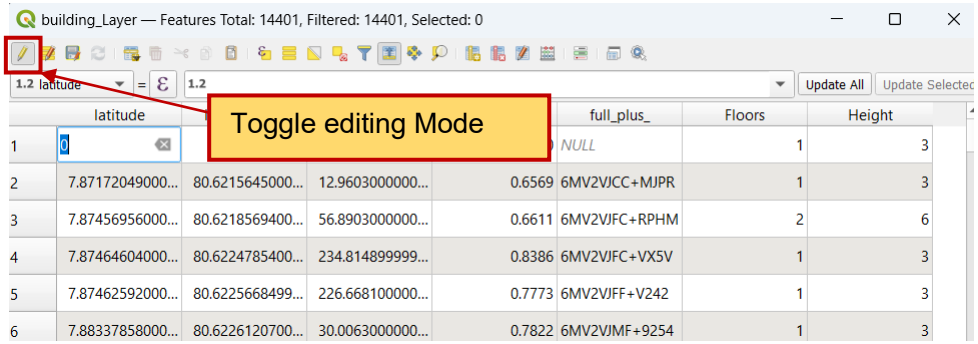


Figure 62 - Toggle editing mode

Step 4.2: Click on “New Field” to add a field.

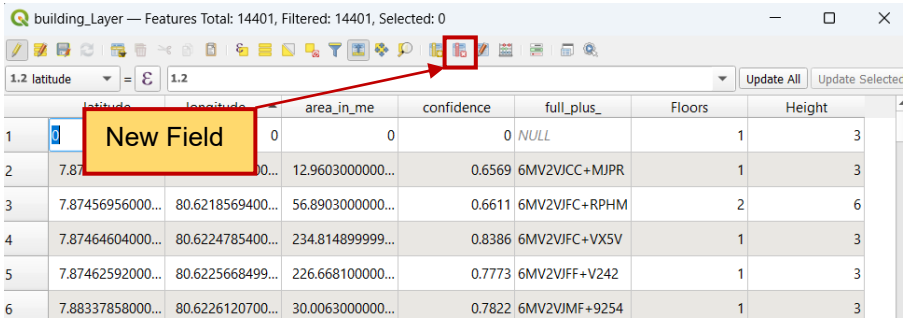


Figure 63 -New Field

Fill in the following box.

8. Give a name and length appropriately
9. As the building type is text you have to select the “Text (String)” for the Type
10. Click “OK”

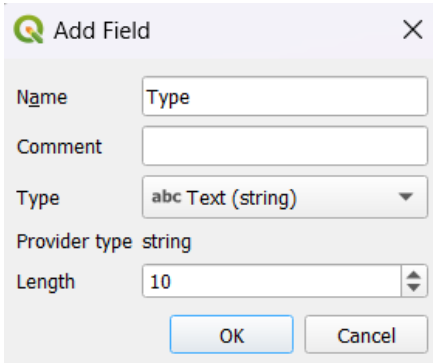
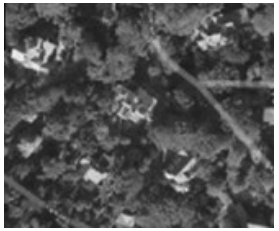


Figure 64: Add a new field to update the building type

Step 4.3 - Identify the building type and update the “Type” field.

There are three building types as follows.

1. Point type



Point-type buildings are individual buildings with a small footprint.

2. Strip type

These are elongated building structures with a long and narrow footprint. It may commonly be found along transportation routes.

3. Block type

Block-type buildings often occupy large building blocks with a significant portion. Those are commonly found in urban environments and contribute to the density and urban fabric of a city.

Identify the building type of the building and assign the building type in the “Type” field one by one. To identify the building type, you can use the building layer in the QGIS and the Google satellite map. Refer to the following **“*Example 1*”** to assign the building types.

1. If the “toggle editing mode” is not ‘On’ you should click on it to ‘On’ the editor Mode.

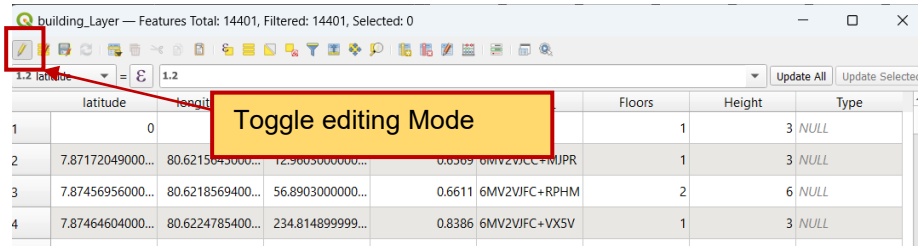


Figure 68 - Toggle editing Mode

2. Click on the “Select features by area” tool and click on a building to select a building

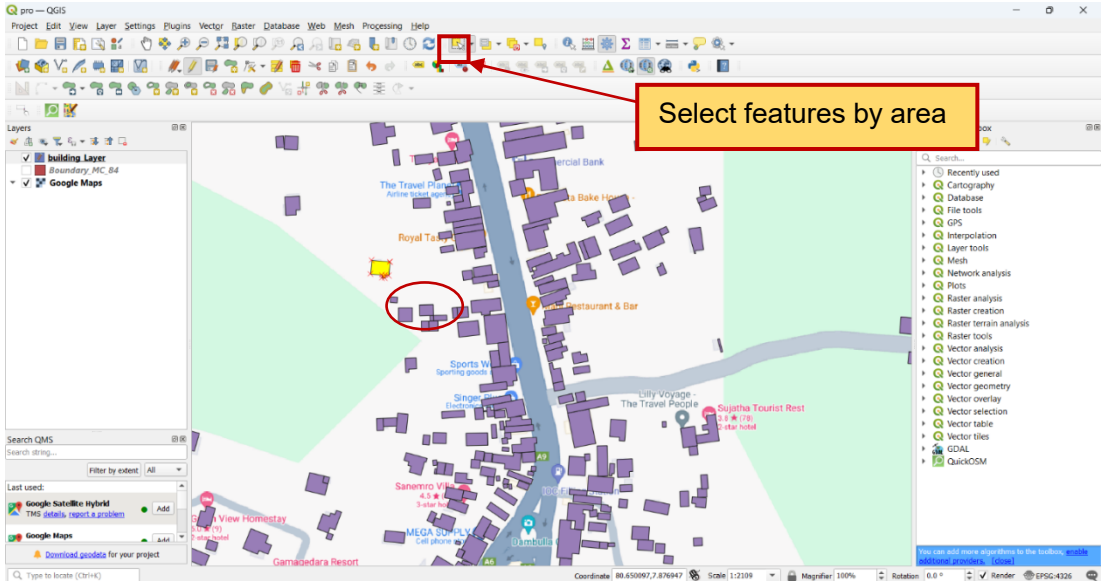


Figure 69 - Select features by area

3. Refer to the following ***“Example 1”*** to identify the building type.
4. Right-click on your building layer and open the attribute table.

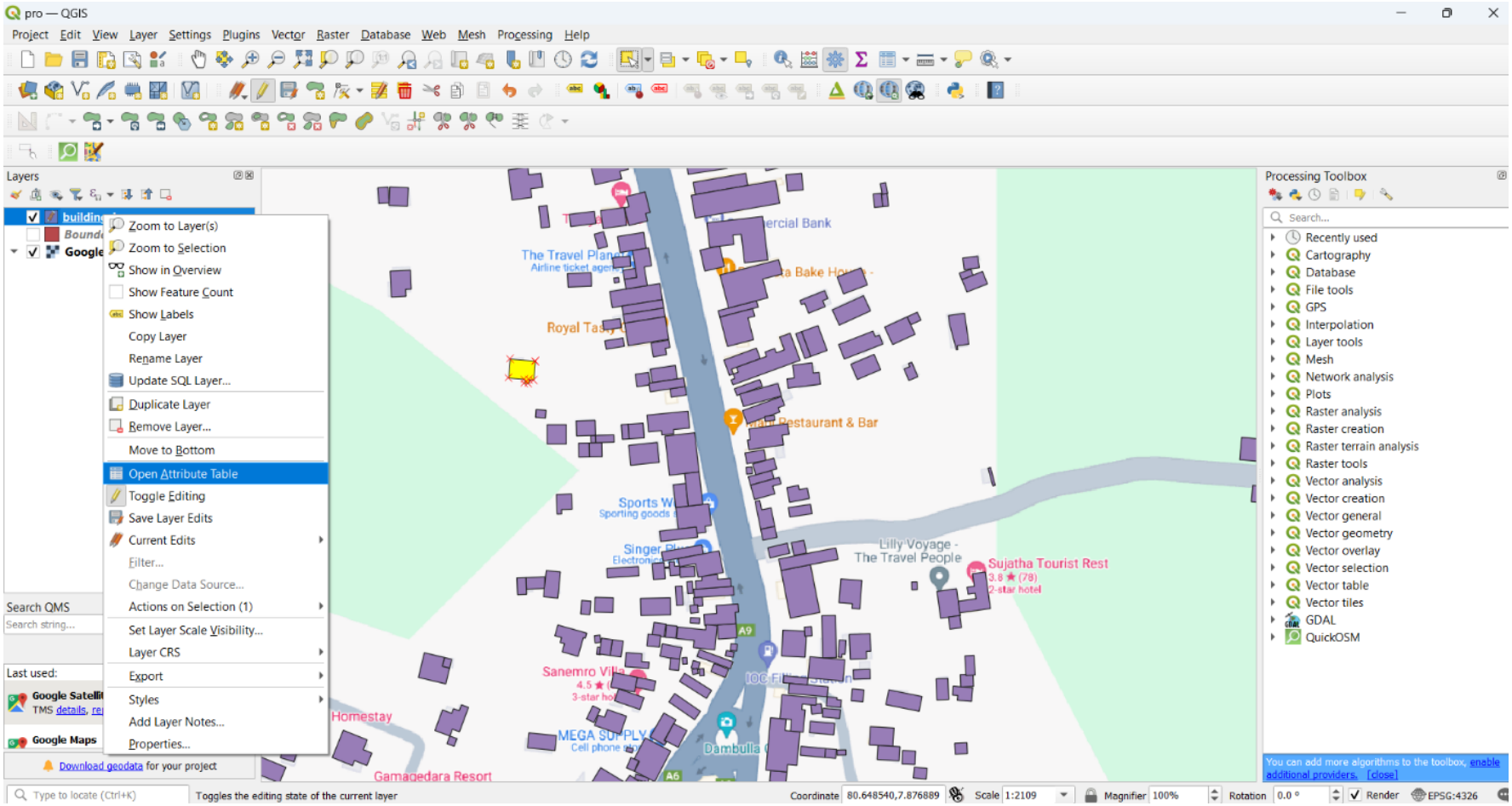


Figure 70 - Building layer

5. Click on the “Move selection to top” tool.

You can move the selected features to the top of the list as follows.

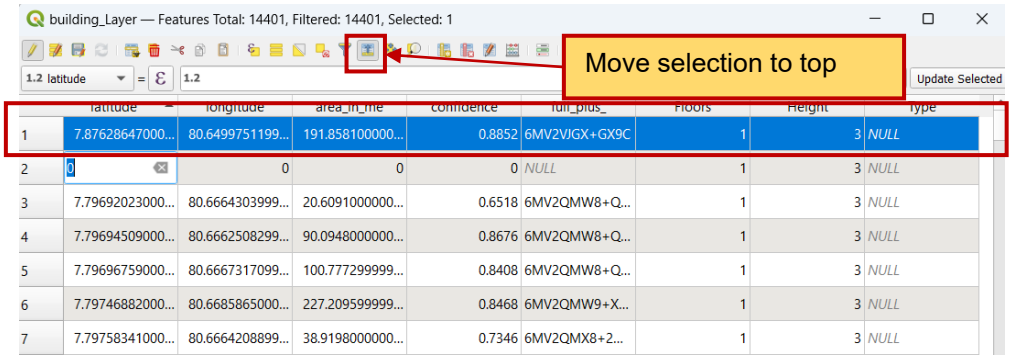


Figure 71 - Move the selection to the top

6. Give the relevant building type of the building as follows.

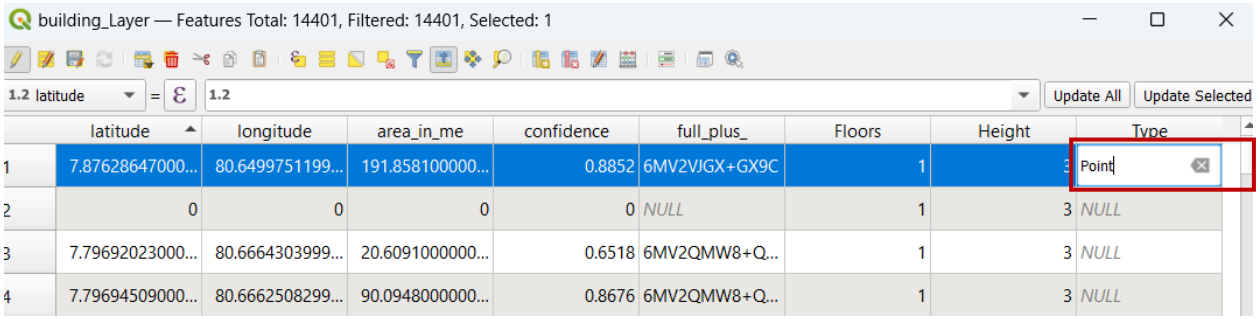


Figure 72: Assign the building type

Following that process, you can assign the building type of all the buildings individually.

7. Click on the “toggle editing mode” tool to save the edits.

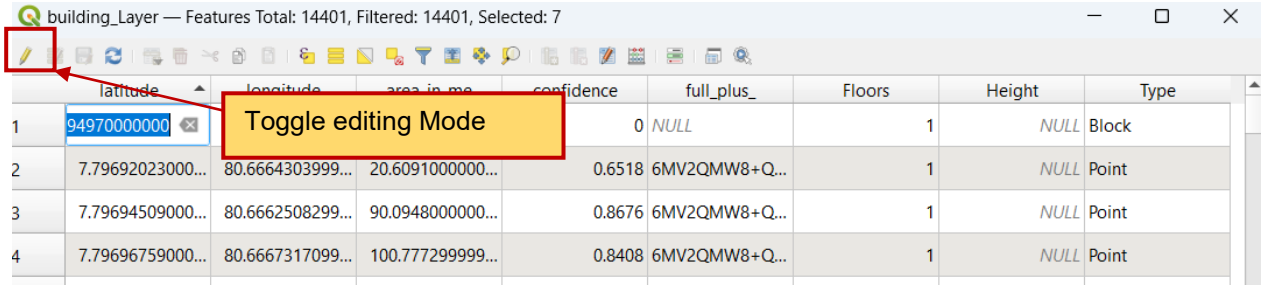


Figure 73 - Toggle editing Mode

Click on “Save”

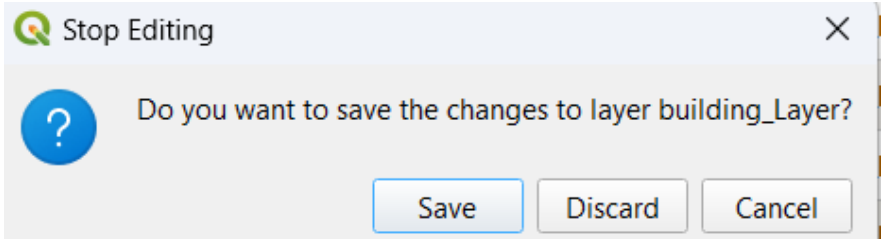
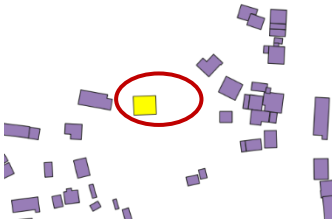


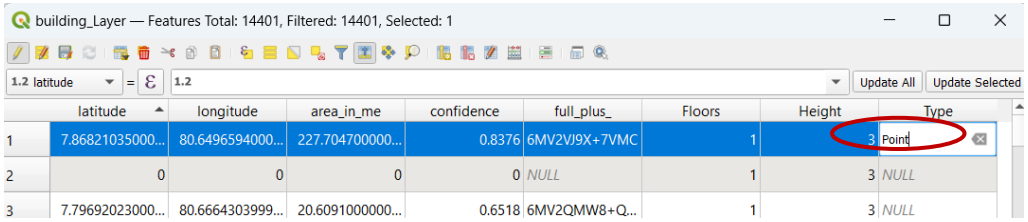
Figure 74 -Save

Example 1

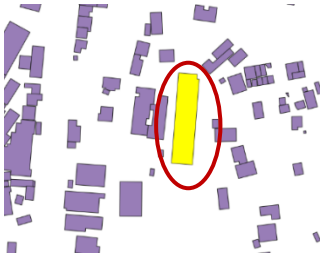
Point Type

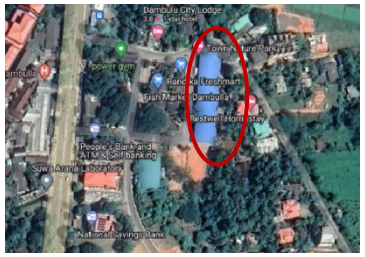
Building layer in QGIS | **Google Satellite Map** | **Given the building type for that building in the attribute table**

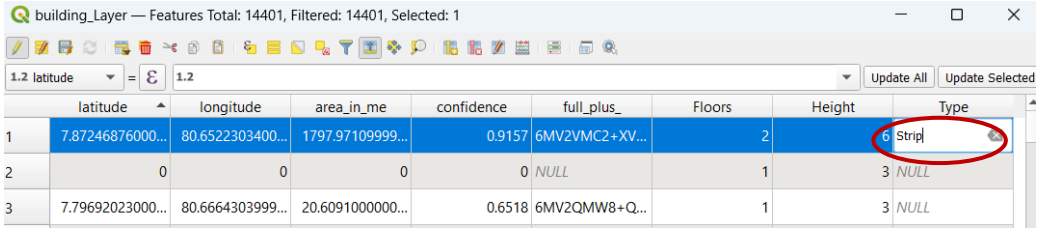




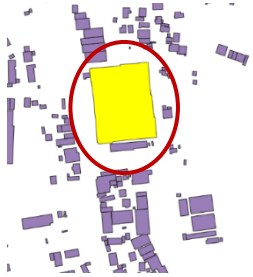
Strip Type

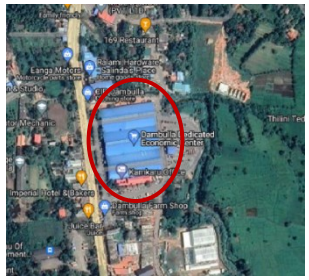


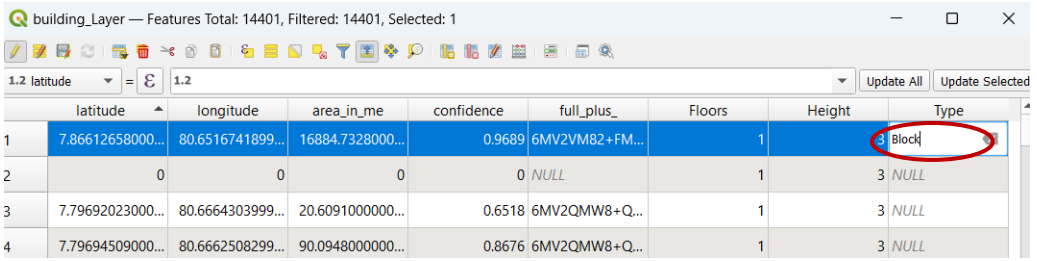




Block Type







Step 5

Add a new field and update the Density type.

Here, you have to assign the Density type considering the number of floors and the building type.

Refer to the following table for that.

Density Type	Number of floors	Building Type
Low rise Point	1	Point
Low rise Strip	1	Strip
Low rise Block	1	Block
Mid-rise Point	2 - 3	Point
Mid-rise Strip	2 - 3	Strip
Mid-rise Block	2 - 3	Block
High rise Point	4 and 4<	Point
High rise Strip	4 and 4<	Strip
High rise Block	4 and 4<	Block

Table 2 -Categorization of the Density Type

NOTE

As Dambulla has no high-rise or sky-scraping buildings the buildings are categorized according to the following values. But note that correctly, buildings are not classified according to these values of floors.

Step 5.1 - Refer to ***step 4.1 and step 4.2***

There, fill in the box as given below.

You can give the name and length as you need. As we give a text to the column of the “Density” the type should be given as “Text(string)”

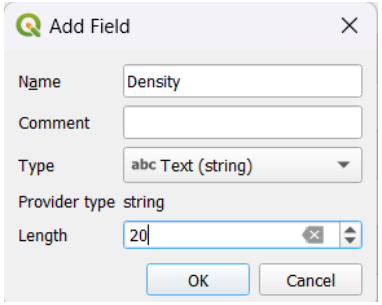


Figure 75: Add a new field to assign the density type

Click “OK”

Step 5.2 - Select the features.

1. Click on the “toggle editing mode” tool.
2. Click on the “Select features using an expression” tool.

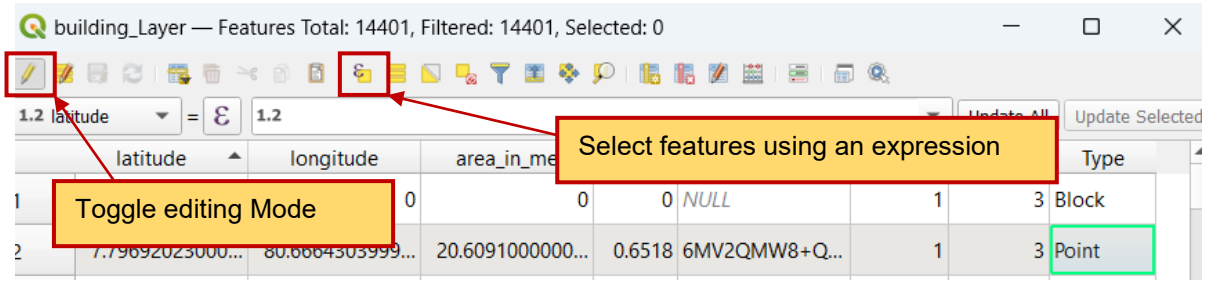


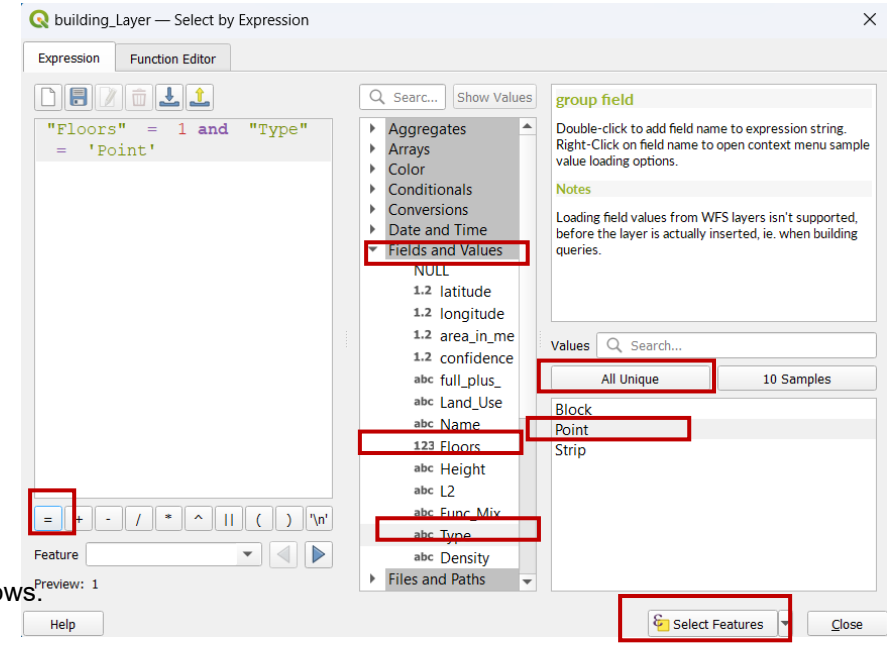
Figure 76 - Select features using an expression

The following box will appear.

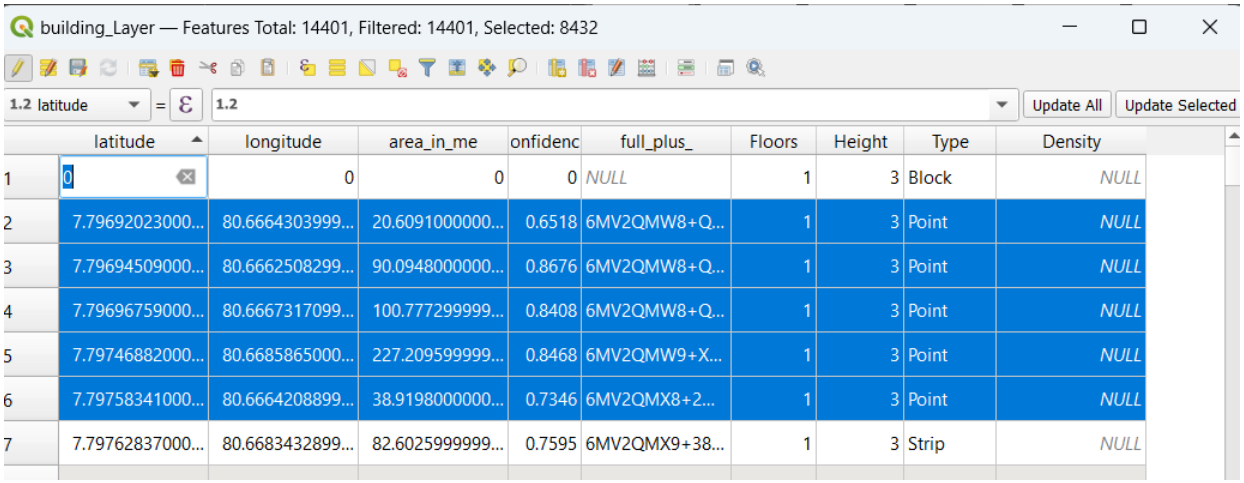
Consider you are going to select the “Low rise Point” Density type.

Refer to the above “***Table 2”*** and give an expression to select the density type as follows.

1. Click on "Fields and Values” and then double-click on “Floors”
2. Click on “=” icon.
3. Click on “All Unique” and double-click on “1”
4. Type “ and” on your keyboard.
5. Double-click on “Type”
6. Click on “=” icon.
7. Click on “All Unique” and double-click on “Point”
8. After giving that expression, click on the “Select features” tool.



Now you have the selection for the “Low rise Point” density type as follows.



	latitude	longitude	area_in_me	onfidenc	full_plus_	Floors	Height	Type	Density
1	0	0	0	0	NULL	1	3	Block	NULL
2	7.79692023000...	80.6664303999...	20.6091000000...	0.6518	6MV2QMW8+Q...	1	3	Point	NULL
3	7.79694509000...	80.6662508299...	90.0948000000...	0.8676	6MV2QMW8+Q...	1	3	Point	NULL
4	7.79696759000...	80.6667317099...	100.777299999...	0.8408	6MV2QMW8+Q...	1	3	Point	NULL
5	7.79746882000...	80.6685865000...	227.209599999...	0.8468	6MV2QMW9+X...	1	3	Point	NULL
6	7.79758341000...	80.6664208899...	38.9198000000...	0.7346	6MV2QMX8+2...	1	3	Point	NULL
7	7.79762837000...	80.6683432899...	82.6025999999...	0.7595	6MV2QMX9+38...	1	3	Strip	NULL

Figure 78: The Selection of the "Low rise point" buildings

Step 5.3 - Assign the density Type to the Selected buildings.

Assign the relevant density type to the selected buildings using the Open Field Calculator as given below. There,

1. Tick on the “update existing field”.
2. Select the relevant field that is to be updated. Here it is “Density”.
3. Type the selected Density type in the quotation mark as follows.
4. Click OK.

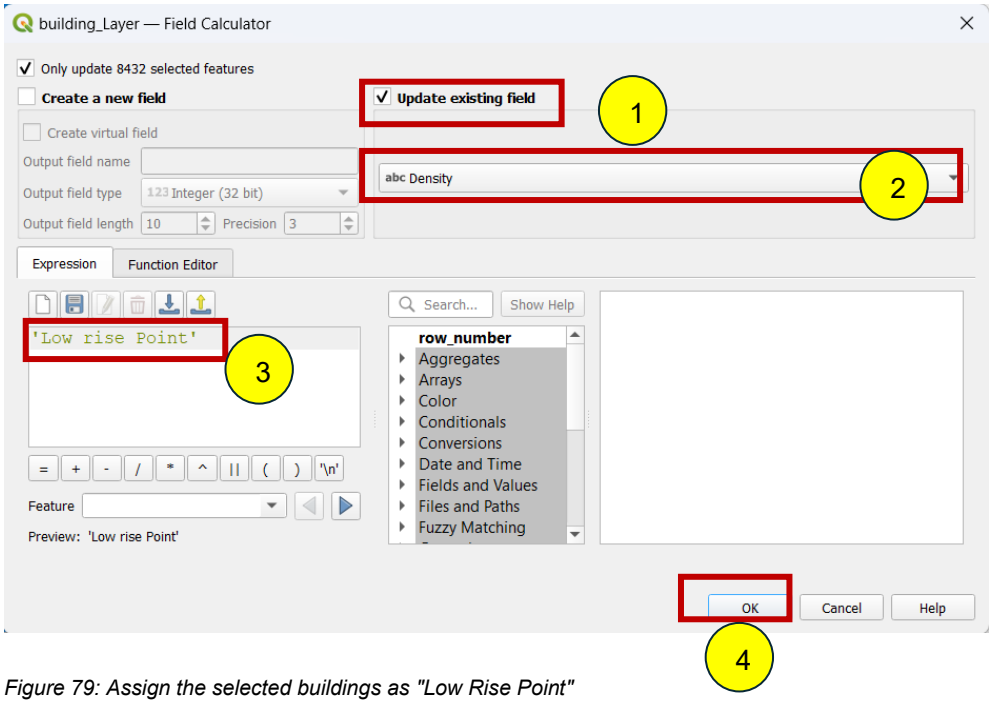


Figure 79: Assign the selected buildings as "Low Rise Point"

Following that process assign the 9 density types to all the buildings.

Step 5.4 - Click on the “toggle editing mode” tool to save the changes.

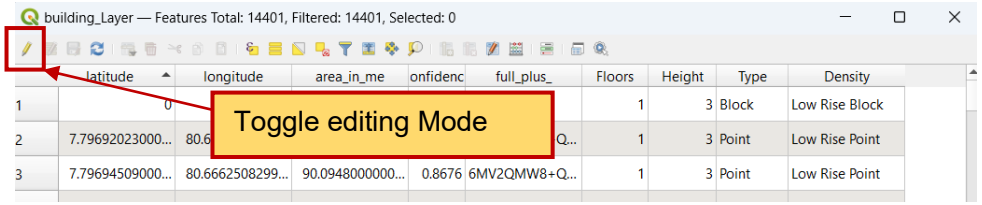


Figure 80 - Toggle editing mode

Click on Save

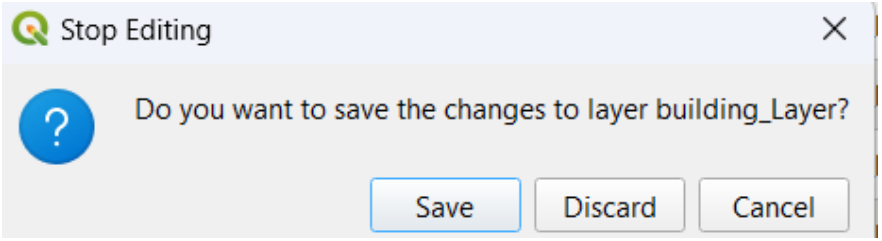


Figure 81 -Save

The updated building layer is completed through the above process and you can use this building layer for the data analysis part in the space matrix.

(“building_Layer”)

5.2 Data Analysis

You can use the same building layer from the above process for the data analysis. Here it is “building_Layer” and used for the data analysis by renaming it as “Buildings_Updated_MC_New”. Consider the “building_Layer” and “Buildings_Updated_MC_New” layers as the same layer.

Step 01

Convert the building layer to a point layer.

To run the IDW interpolation tool, you need a point layer. For that, you can use the centroid tool to convert your building layer (Polygon type) into a point layer as follows.

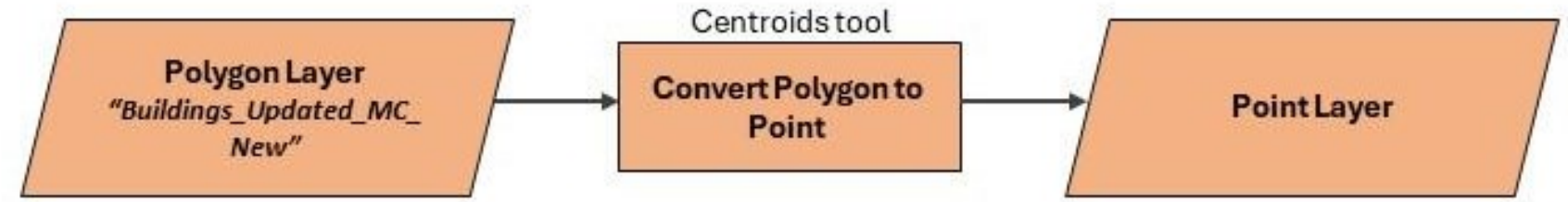


Figure 82: The flow chart for converting the building layer into a point layer

- Go to Vector>>>Geometry Tools>>>Centroids

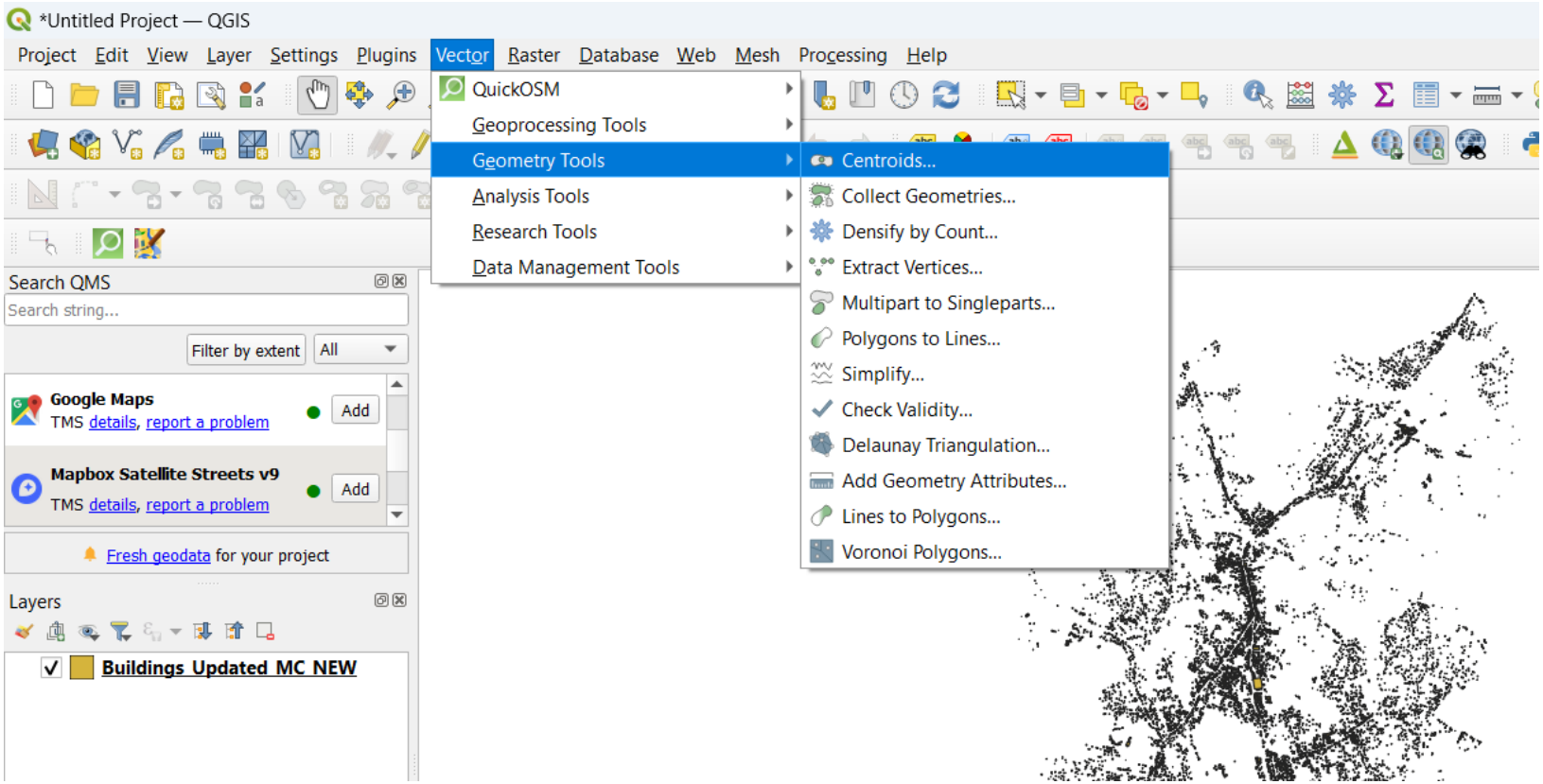


Figure 83 - Centroids

After clicking on the above centroids tool the following box will appear.

There,

1. Give your updated building layer as the input layer. Here it is “Buildings_Updated_MC_New”
2. Click on “Save to File” to give a location to save the centroids layer.
3. Click on “Run”

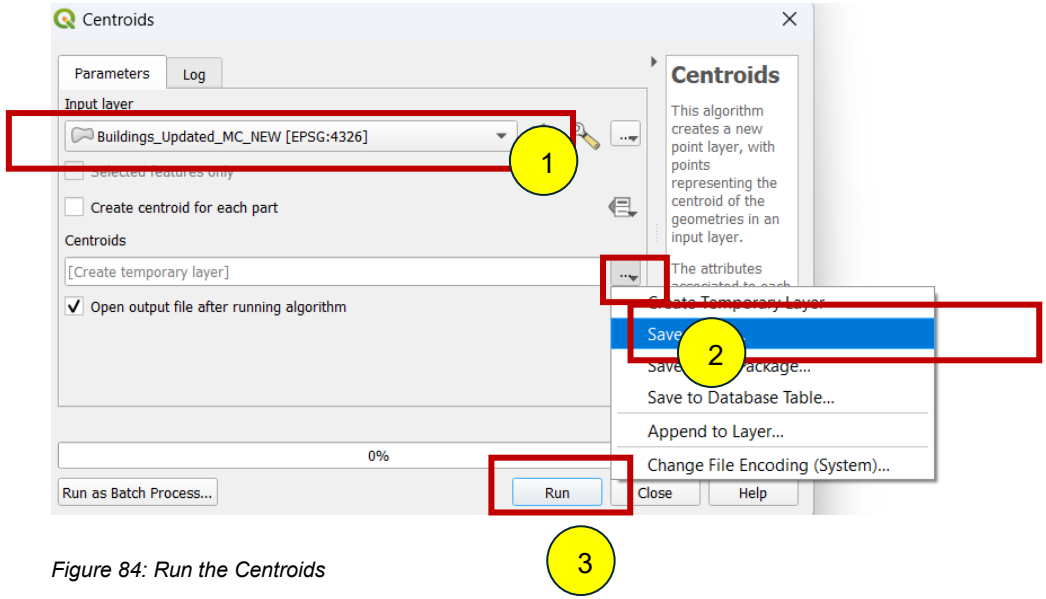
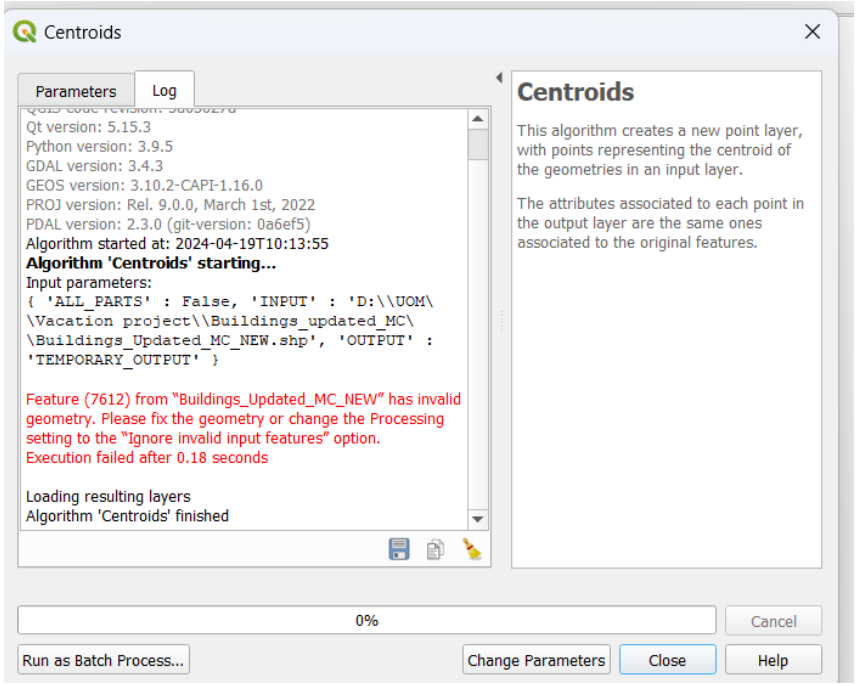


Figure 84: Run the Centroids

Error

There's an error as following figure which can occur after run this tool. It has occured due to an invalid



NOTE

If you need to, you can find the invalid geometry by using the check validity tool before running the fix geometries tool. You can find this tool by searching on the processing toolbox. Use of this tool is not necessary. You can fix the geometries without checking invalid geometries.

If this error occurs you can follow the process given below.

Step 01

0pen the processing toolbox as here. For that,

Go to Processing>>>Toolbox

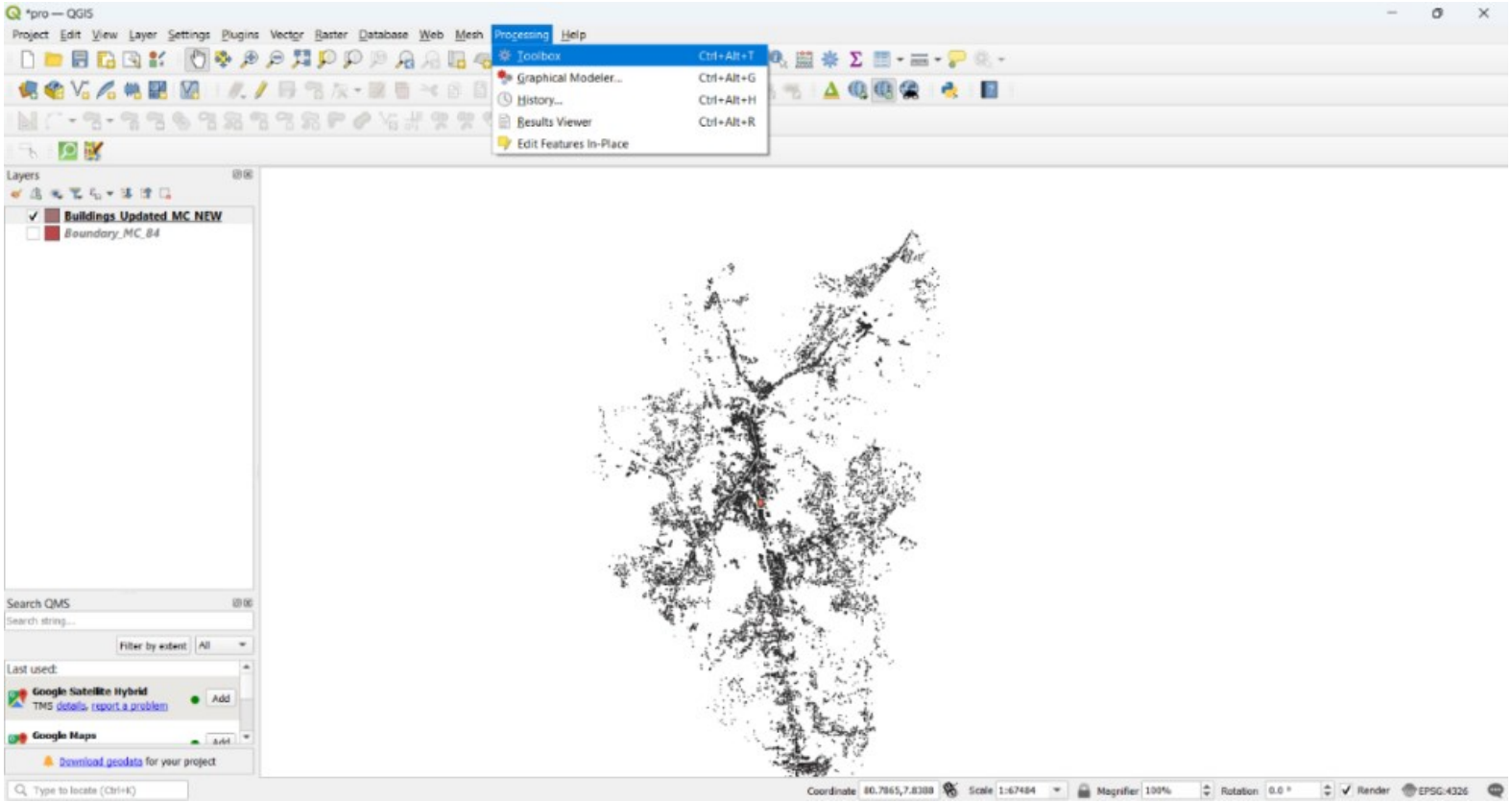


Figure 86 - Processing

Step 02 – Search the “Fix Geometries” tool and double-click on the tool to open it.

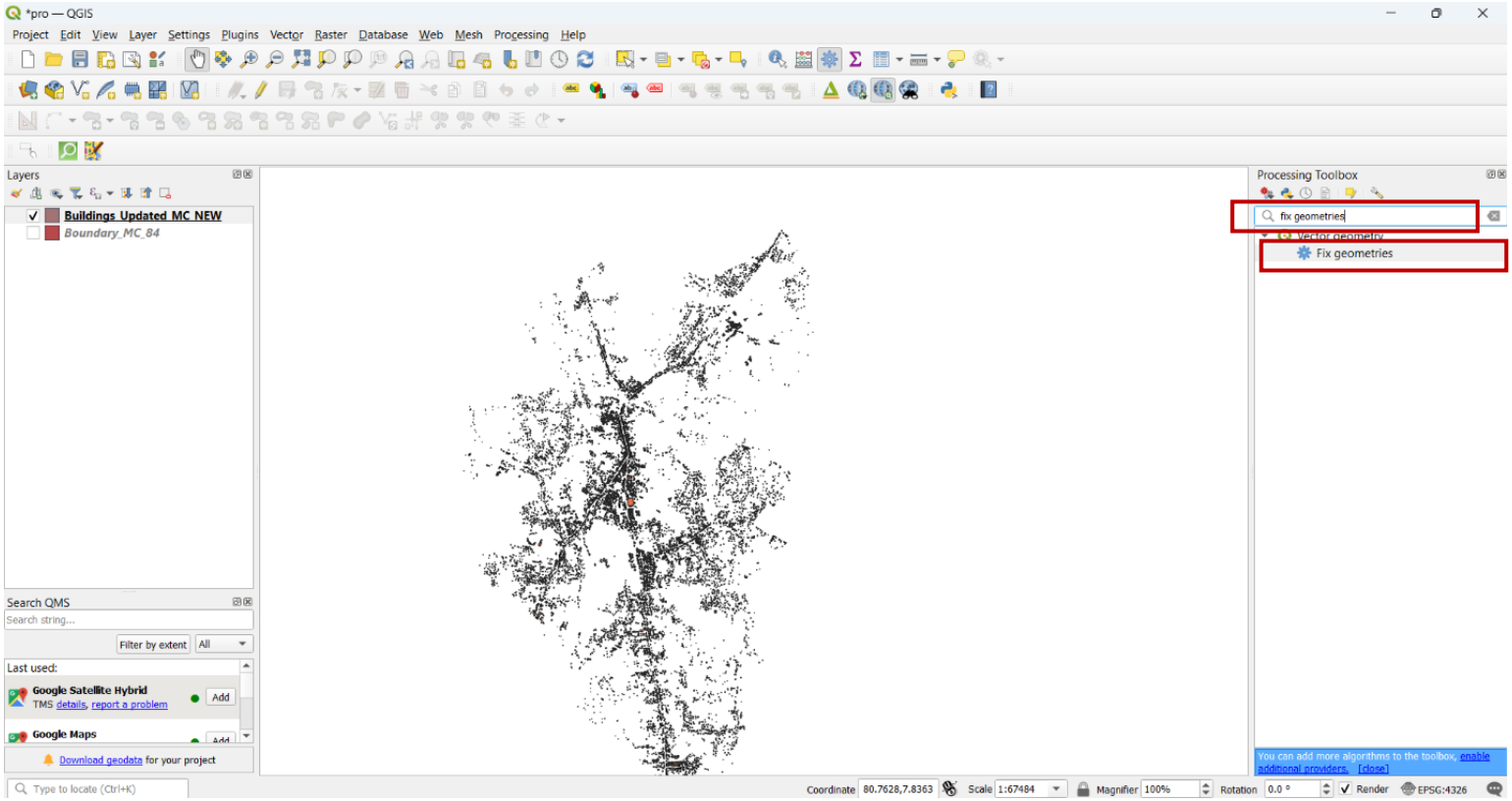


Figure 87 - Fix Geometries

The following box will appear. Here,

- Give your updated building layer as the input layer.

  Here it is “Buildings_Updated_MC_New”.

- Click on “Run”

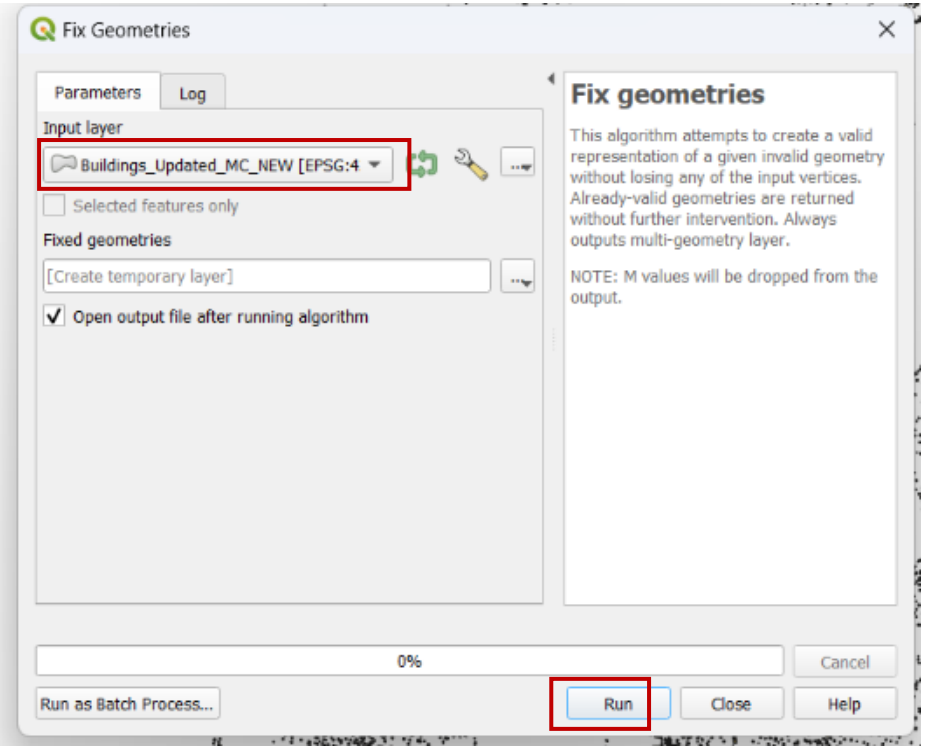


Figure 88: Run the fix geometries

(Using this tool, the invalid geometry can be fixed without losing any features.)

Step 02

Run the Centroids tool again using the fixed building layer

- Refer to the process of ***step 1 on page 77*** to Run this tool again.
- Give the “Fixed Geometries” layer instead of your updated building layer(“Buildings_Updated_MC_New”) as the Input Layer.
- Click on “Run”

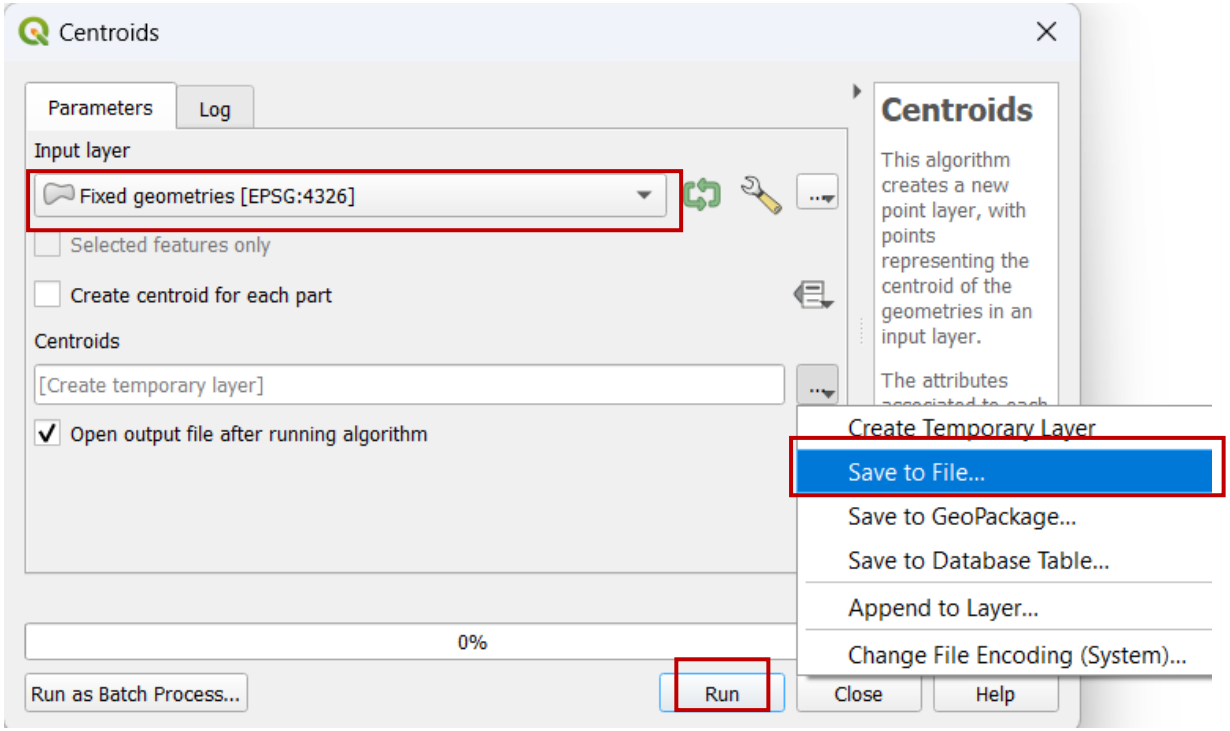


Figure 89 - Run the Centroids

After running the Centroid tool, you can see the following output.

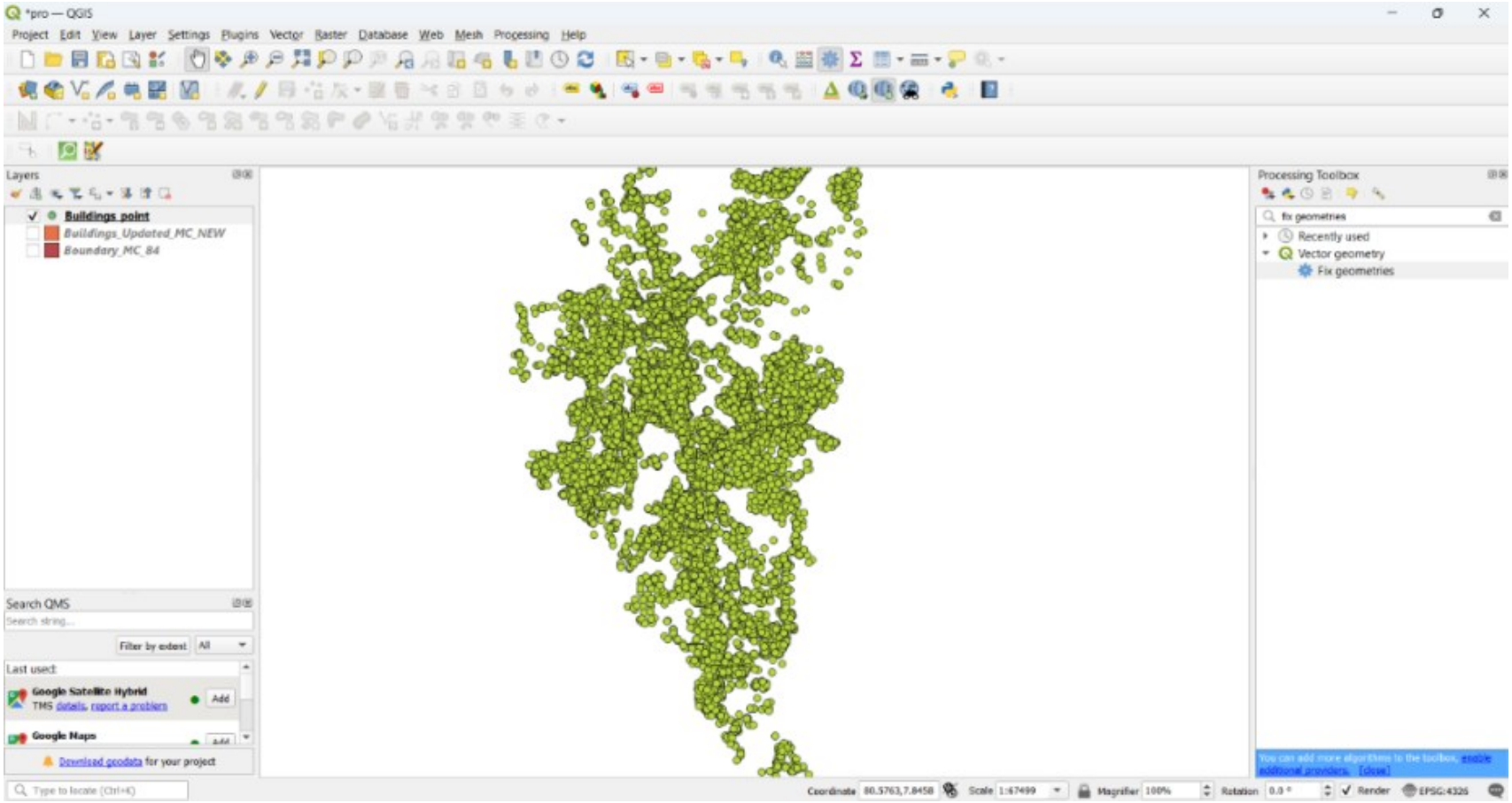


Figure 90: The point layer

Step 3

Give a Code to the point layer.

A value field needs to run the ÏDW Interpolation tool. Therefore, you need to add a new field and assign values to the 9 density categories.

Refer to the following table to assign the values.

Density Type	Code
Low rise point	1
Low rise strip	2
Low rise block	3
Medium rise point	4
High rise point	5
High rise strip	6
Medium rise strip	7
Medium rise block	8
High rise block	9

Table 3 -Code for the Density Type

Step 3.1 - Add a new field named “Code”.

- Right-click on the point layer and open the attribute table.

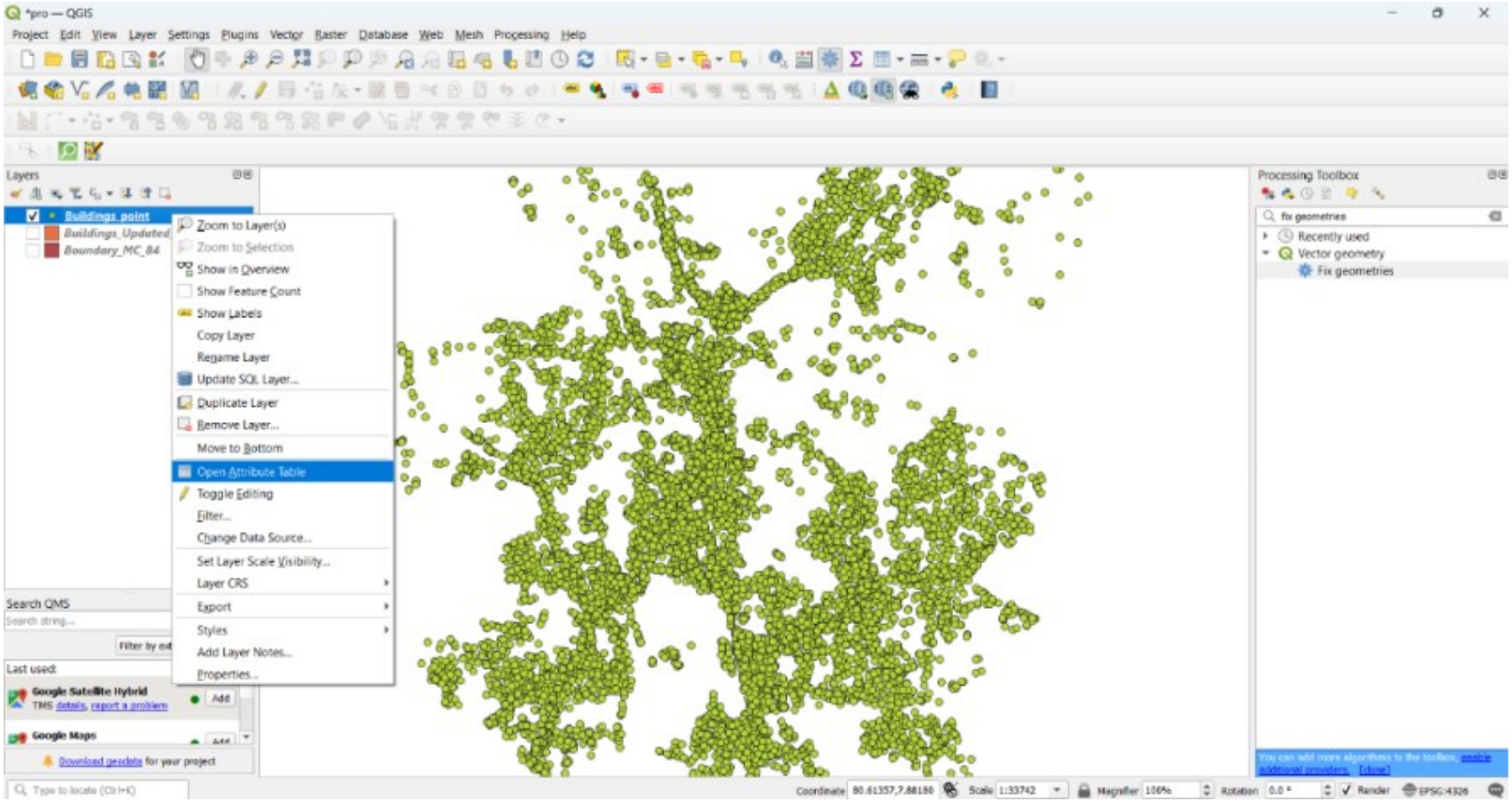
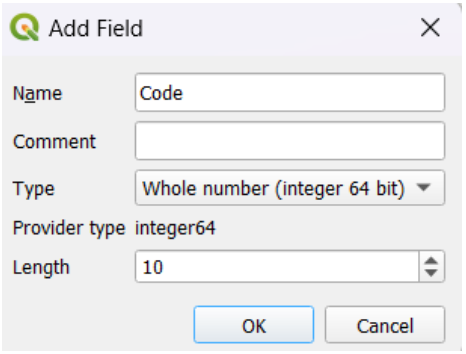


Figure 91 - Add a new field

Refer the ***Step 1 on page 45*** to add the field.

A box will appear as follows.

- Give a name and length as you need. Here the name is given as “Code”
- As the code is a number the Type should be given as “Whole number” and Click OK.



Step 3.2 - Select the features.

1. Click on the “Select features using an expression” tool.

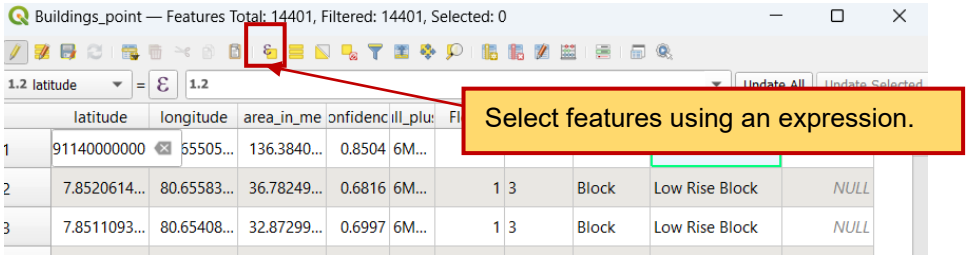
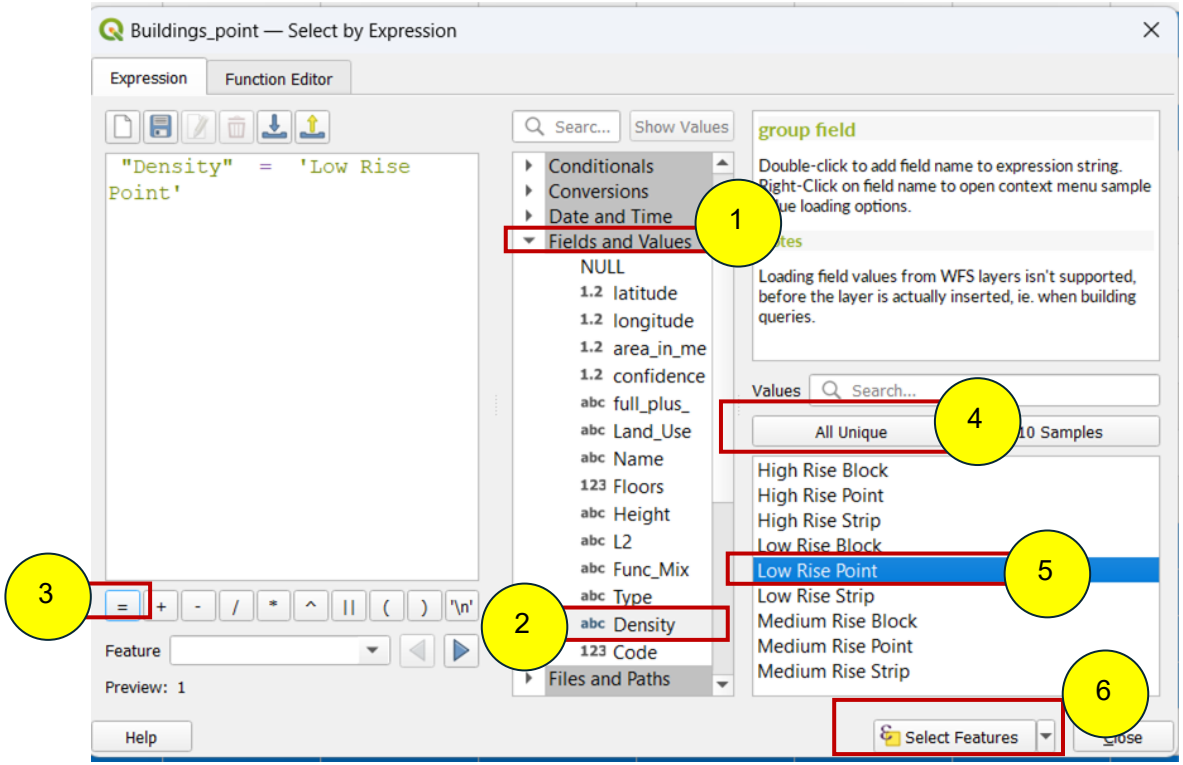


Figure 93 - Select features using an expression

The following box will appear. There,

1. Click on “Fields and Values”
2. Double-click on “Density”
3. Click on “=” icon.
4. Click on “All unique”
5. Double-click on “Low rise Point”
6. Click on “Select Features”



The selection of the “Low rise Point” is given below.

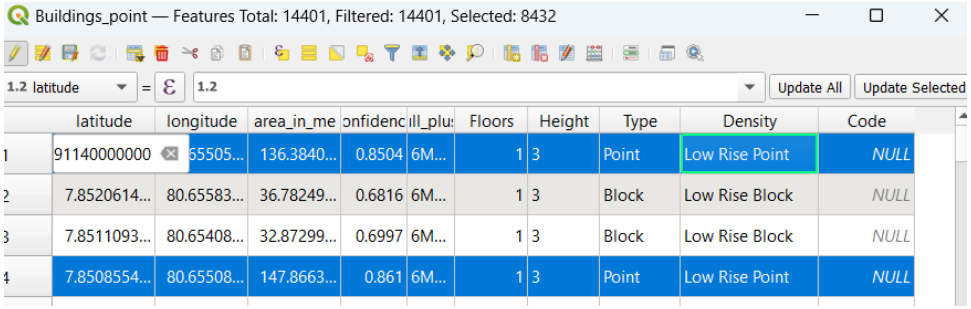


Figure 95: The selection of the rise point buildings

The selected features are the buildings that belong to the “Low rise Point” density category. According to ***Table 2***, assign the code for that selection as 1 in the next step.

Step 4.3 - Assign the relevant value to the “Code” field using the open field calculator.

Refer to ***Table 3 on page 82*** to assign the relevant value.

1. Click on “Open Field Calculator” as foll

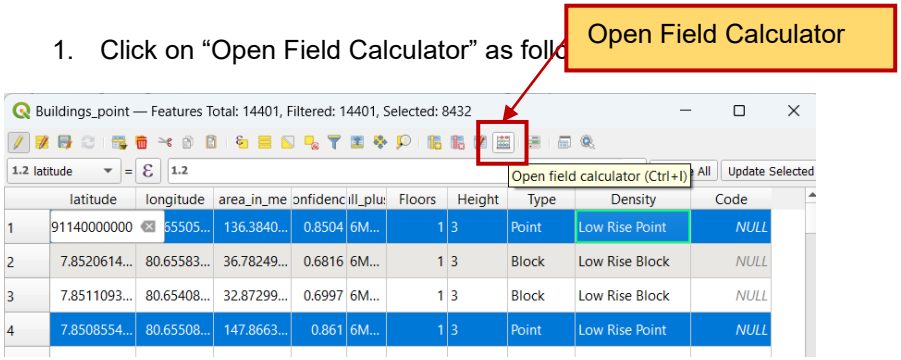


Figure 96 - Open Field Calculator

It will appear as follows.There,

1. Tick on update existing field.
2. Give your field that is to be updated. Here it is “Code”.
3. Type 1
4. Click “OK”

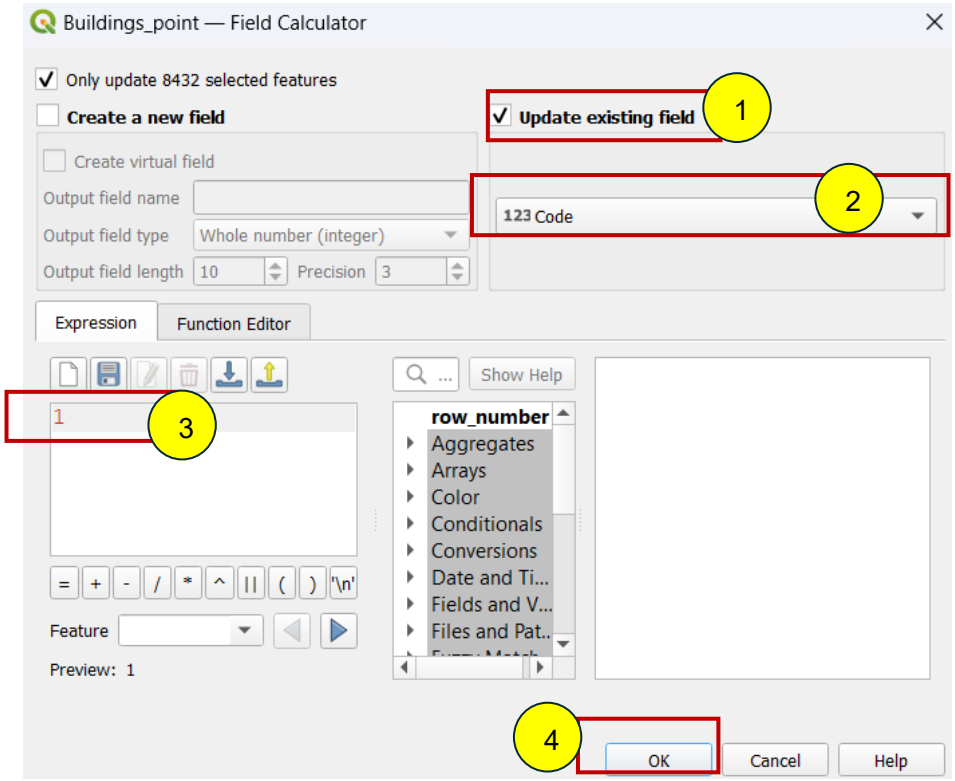
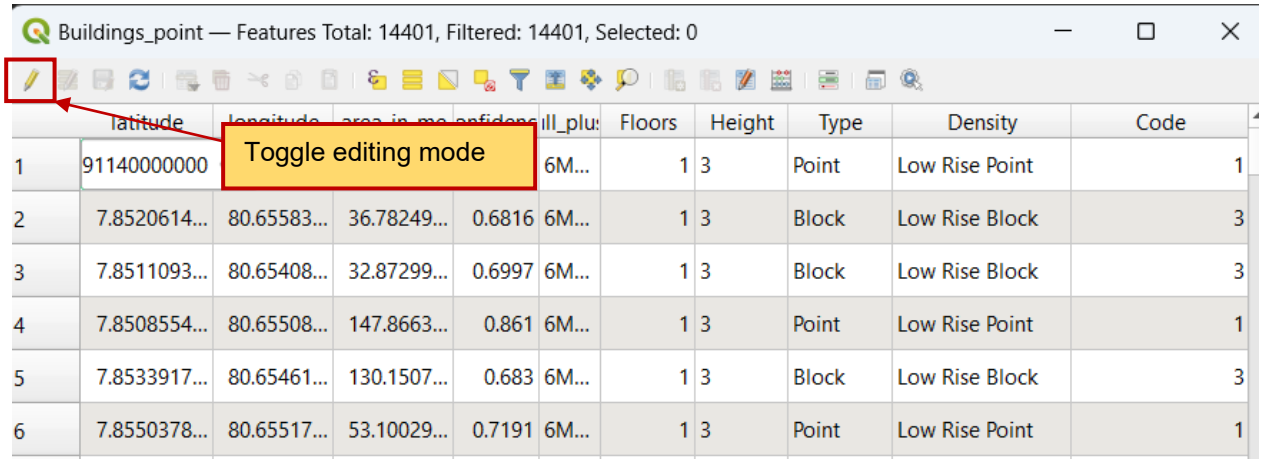


Figure 97 -Field Calculator

Step 4.4 - Give codes to all the density types by following the above process (**Step 4.2 and Step 4.3** accordingly).

Step 4.5 - Click on the “toggle editing mode” tool and Save the changes

- Click on the “toggle editing mode” tool.



	latitude	longitude	area_in_me	confidence	ll_plus	Floors	Height	Type	Density	Code
1	91140000000				6M...	1	3	Point	Low Rise Point	1
2	7.8520614...	80.65583...	36.78249...	0.6816	6M...	1	3	Block	Low Rise Block	3
3	7.8511093...	80.65408...	32.87299...	0.6997	6M...	1	3	Block	Low Rise Block	3
4	7.8508554...	80.65508...	147.8663...	0.861	6M...	1	3	Point	Low Rise Point	1
5	7.8533917...	80.65461...	130.1507...	0.683	6M...	1	3	Block	Low Rise Block	3
6	7.8550378...	80.65517...	53.10029...	0.7191	6M...	1	3	Point	Low Rise Point	1

Figure 98 - Toggle editing mode

- Click on “Save”

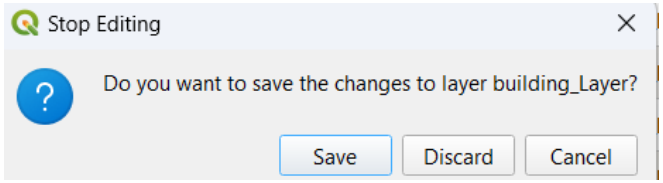


Figure 99 -Save

Step 5

Run the IDW interpolation tool

Step 5.1 - Search the “IDW interpolation” tool on the processing toolbox and open it.

- Search the “IDW interpolation” tool.
- After the search, the tool will appear.
- Double-click on the IDW interpolation to open it.

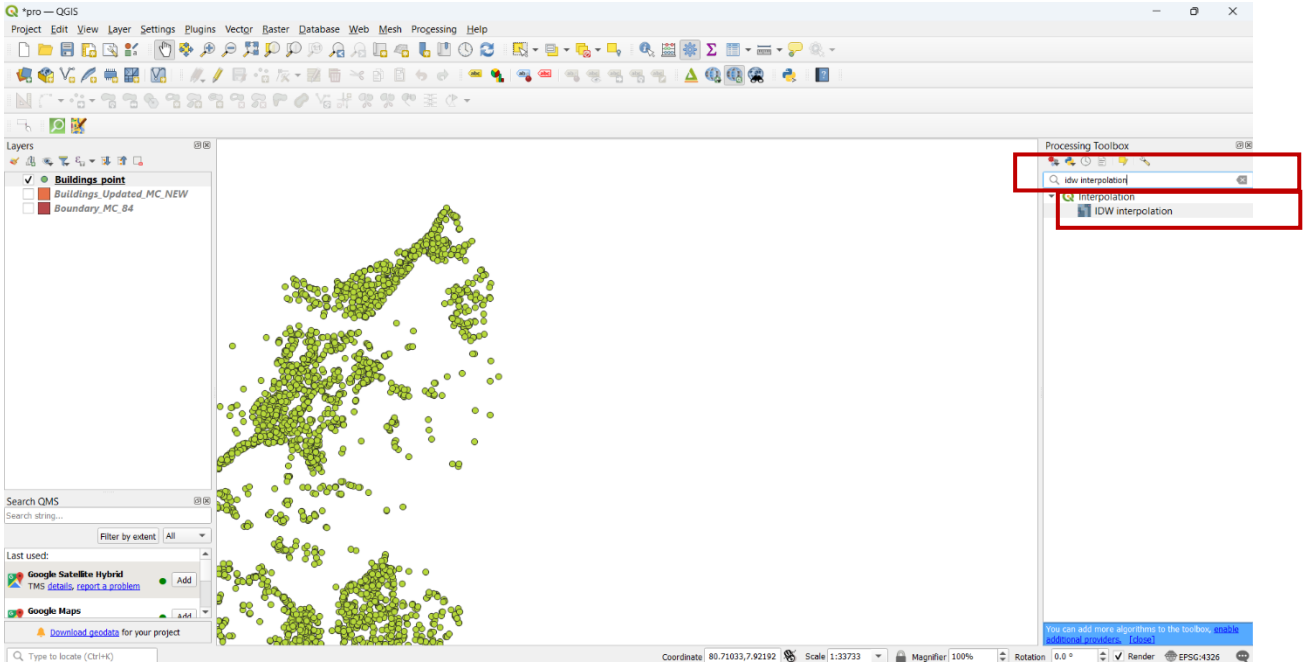


Figure 100 - IDW interpolation tool

The following box will appear.

Step 5.2 - Fill the following box according to the steps given below.

1. Give your point layer as the vector layer. Here it is “Buildings_Point”
2. Give your “Code” field as the Interpolation attribute
3. Click on the plus mark
4. Give your boundary layer of the study area as the extent. Here, it is “Boundary_MC_84”
5. Give the relevant pixel size. Here it is “0.000258”

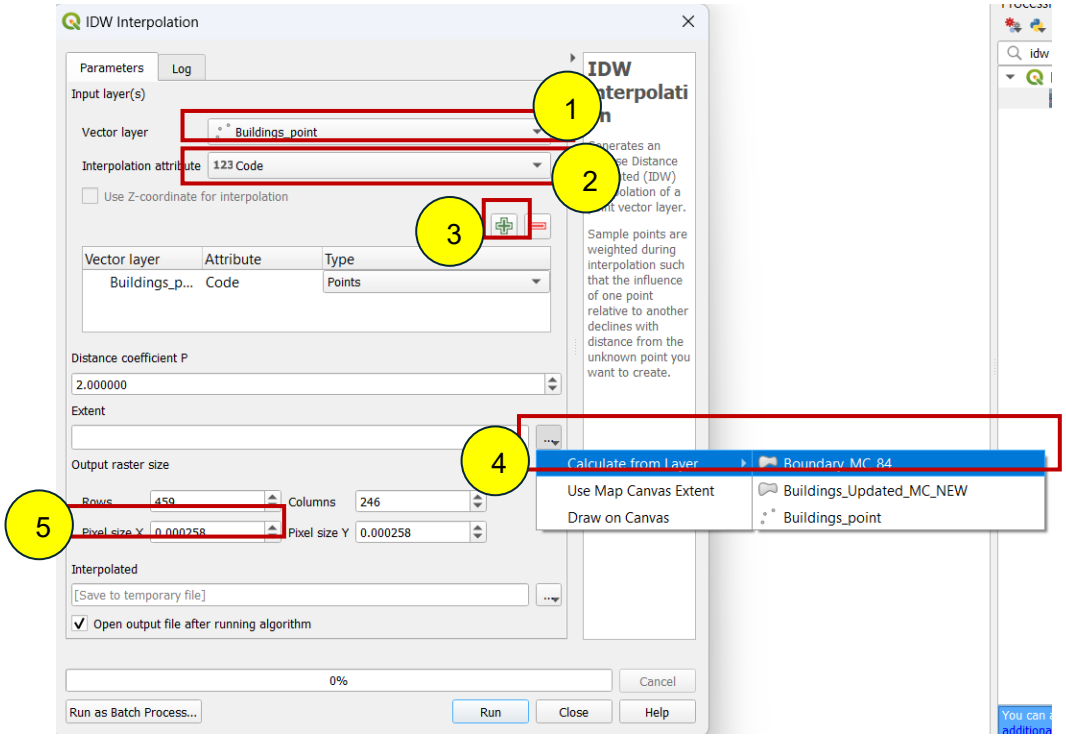


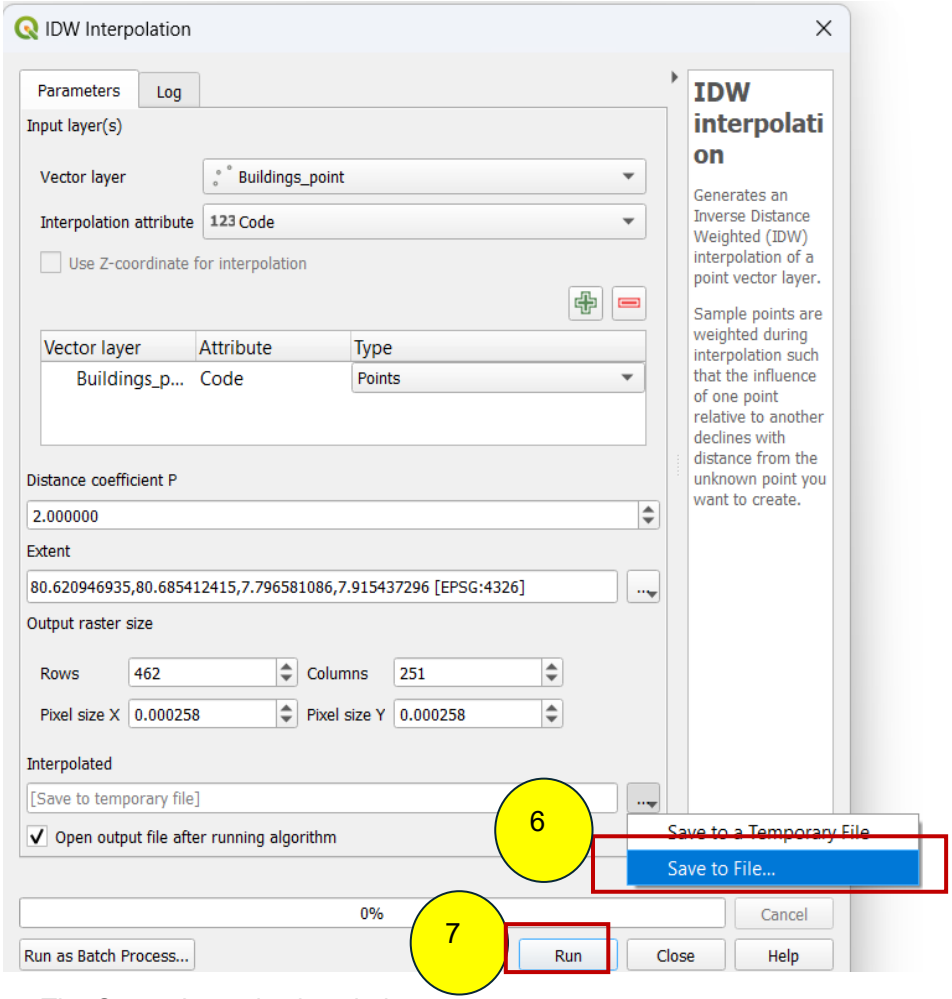
Figure 101: The IDW Interpolation

Note

If you do this analysis only for Building Density you can give the pixel size as you need. But if you do this analysis to use for the urbanity as well, the pixel size should be given the same as the Landuse mix layer and the Accessibility layer since these three layers have to overlay in the Urbanity analysis.

6. Click on “Save to File” to give a location to save the file as follows.

7. Click on Run



- The Output Layer is given below.

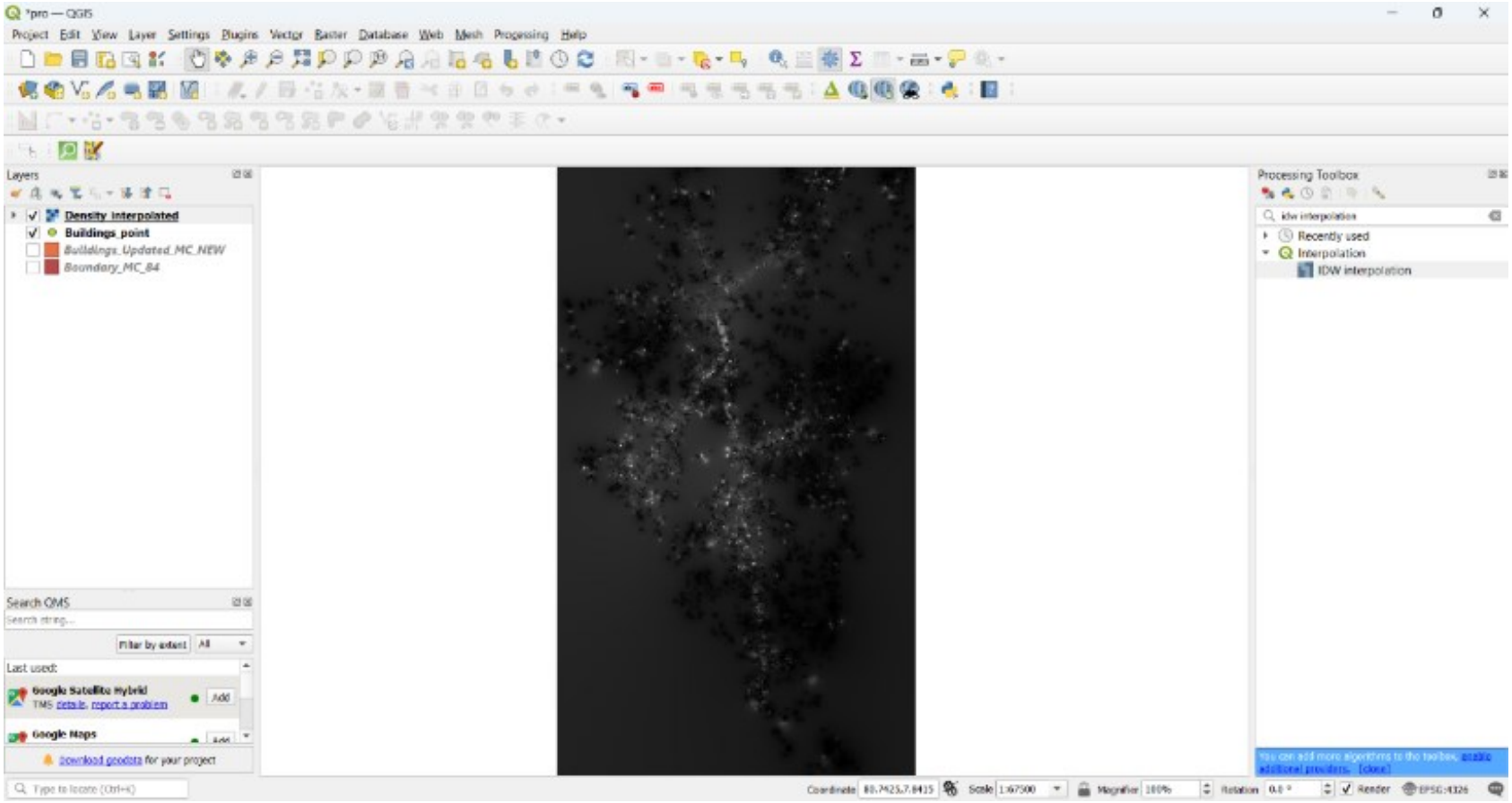


Figure 103: The Interpolated Density layer

Step 6

Change the Properties and classify the layer into 9 categories.

Step 6.1 - Open the properties

Right-click on the layer and open the properties as given below.

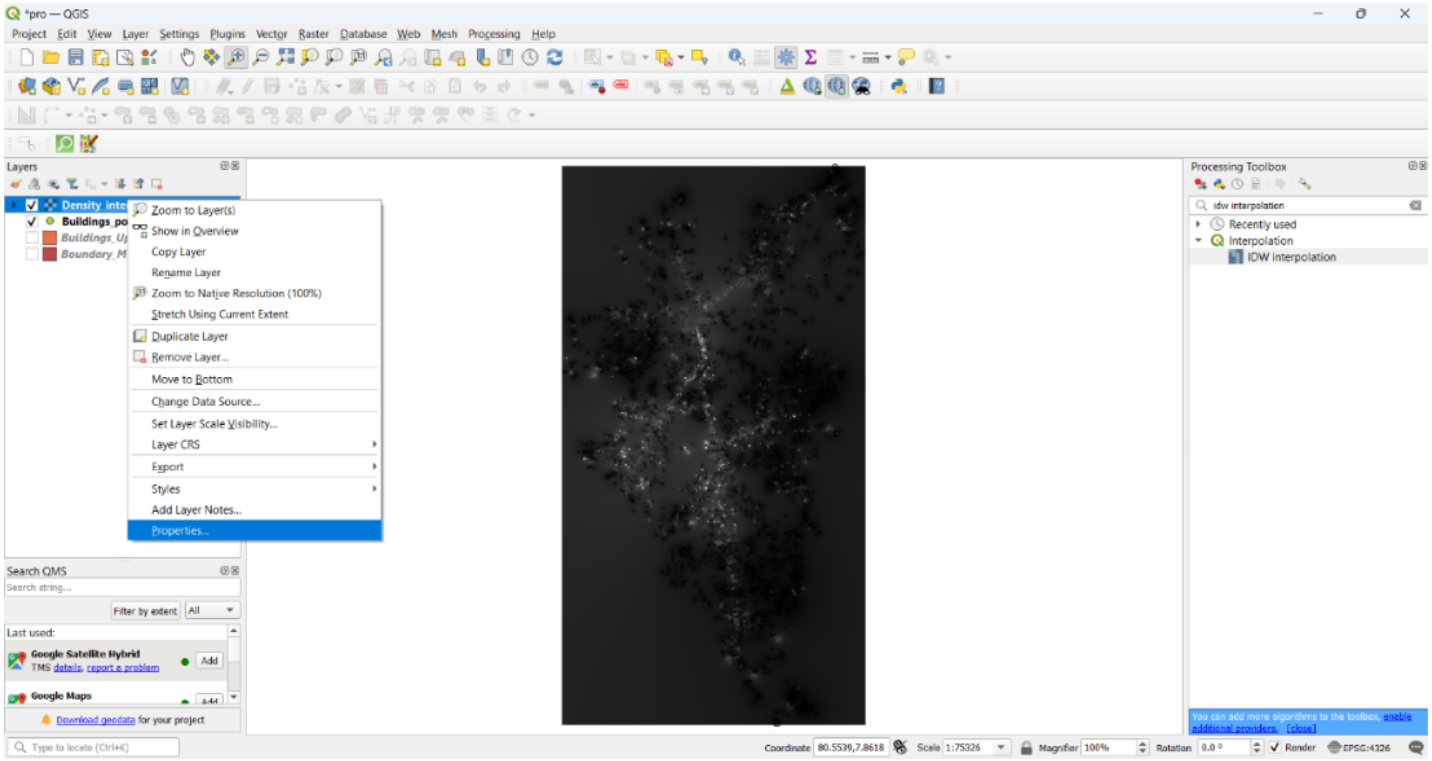


Figure 104 - Change the Properties and classify the layer

It will appear as follows.

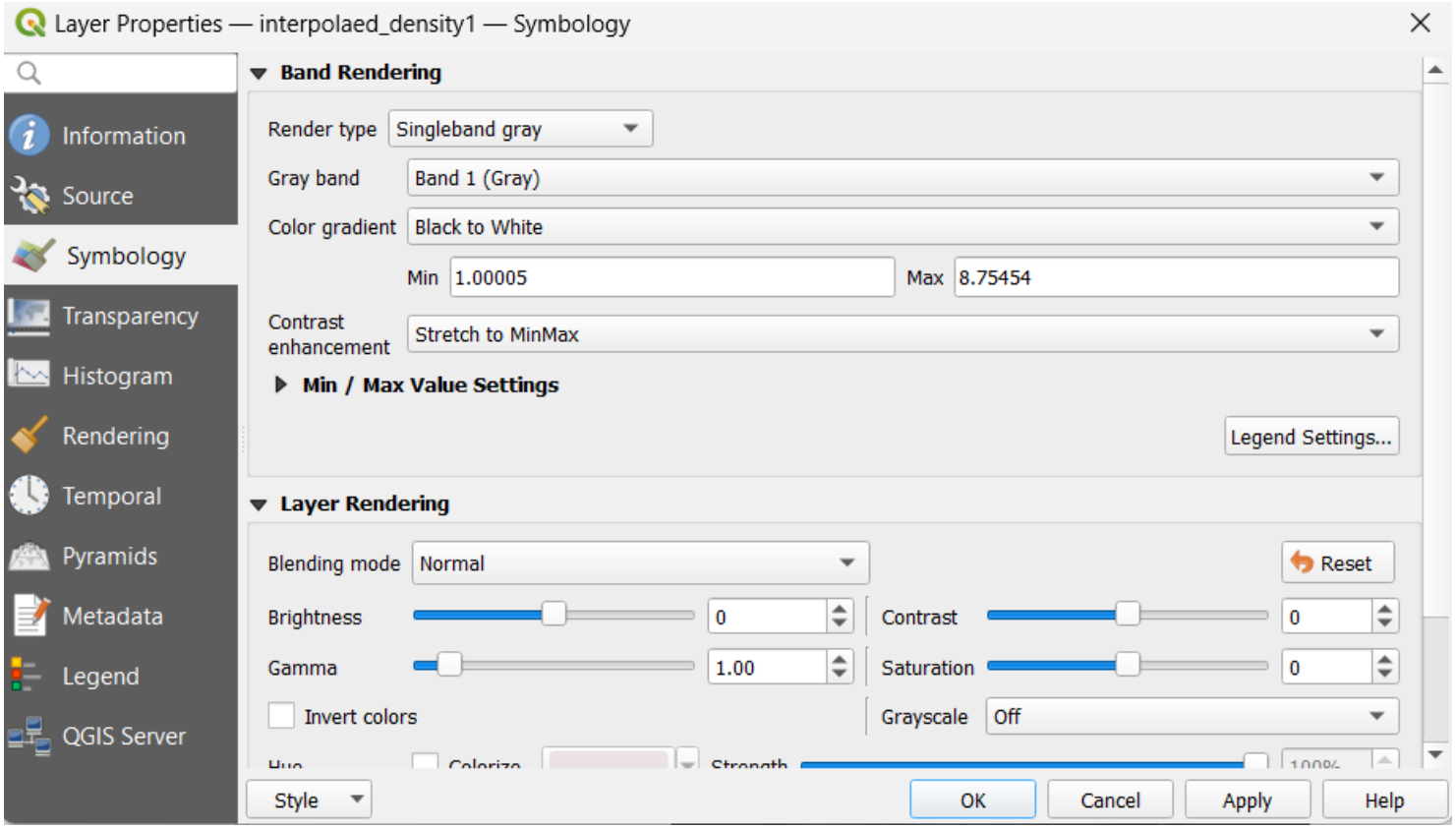


Figure 105: Layer Properties

Step 6.2 - Change the properties as given below.

1. Give the render type as “Singleband pseudocolor”
2. Change the Mode to “Equal interval”
3. Give the classes as “9”
4. Give the values that you have given to the “Code” field (1 to 9) and give the relevant label as well.
5. Click OK

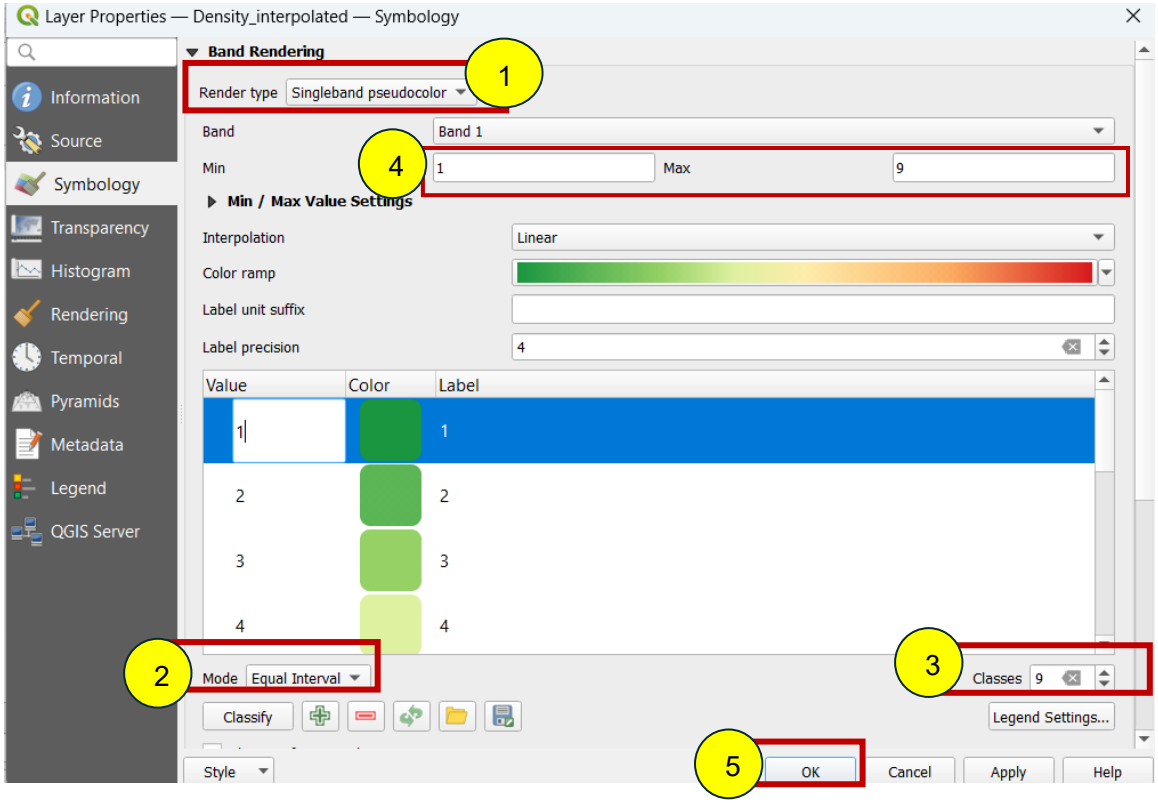


Figure 106: Change the layer properties

- Click on “Legend settings” to give a legend.

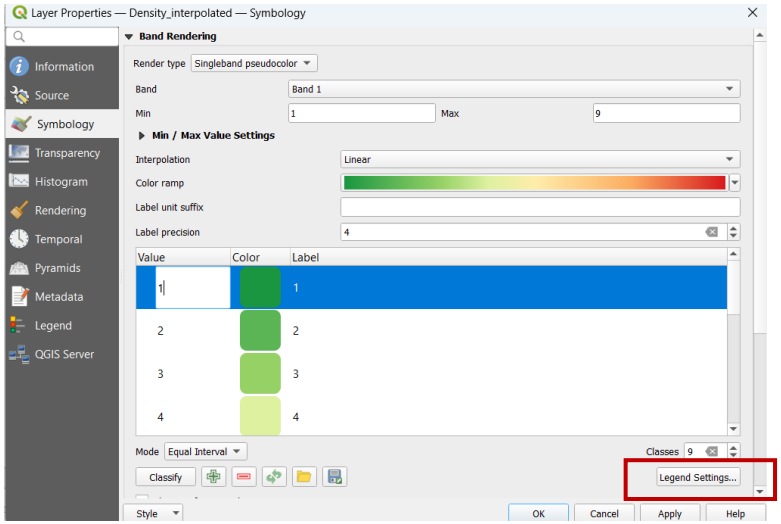
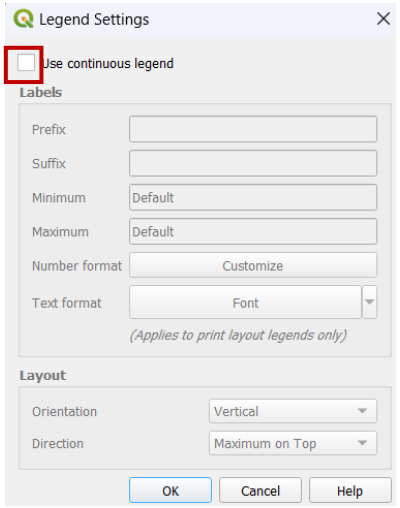


Figure 107 - Legend settings

The following box will appear. There, tick off the “use continuous legend” and Click OK.



The Output layer is given below.

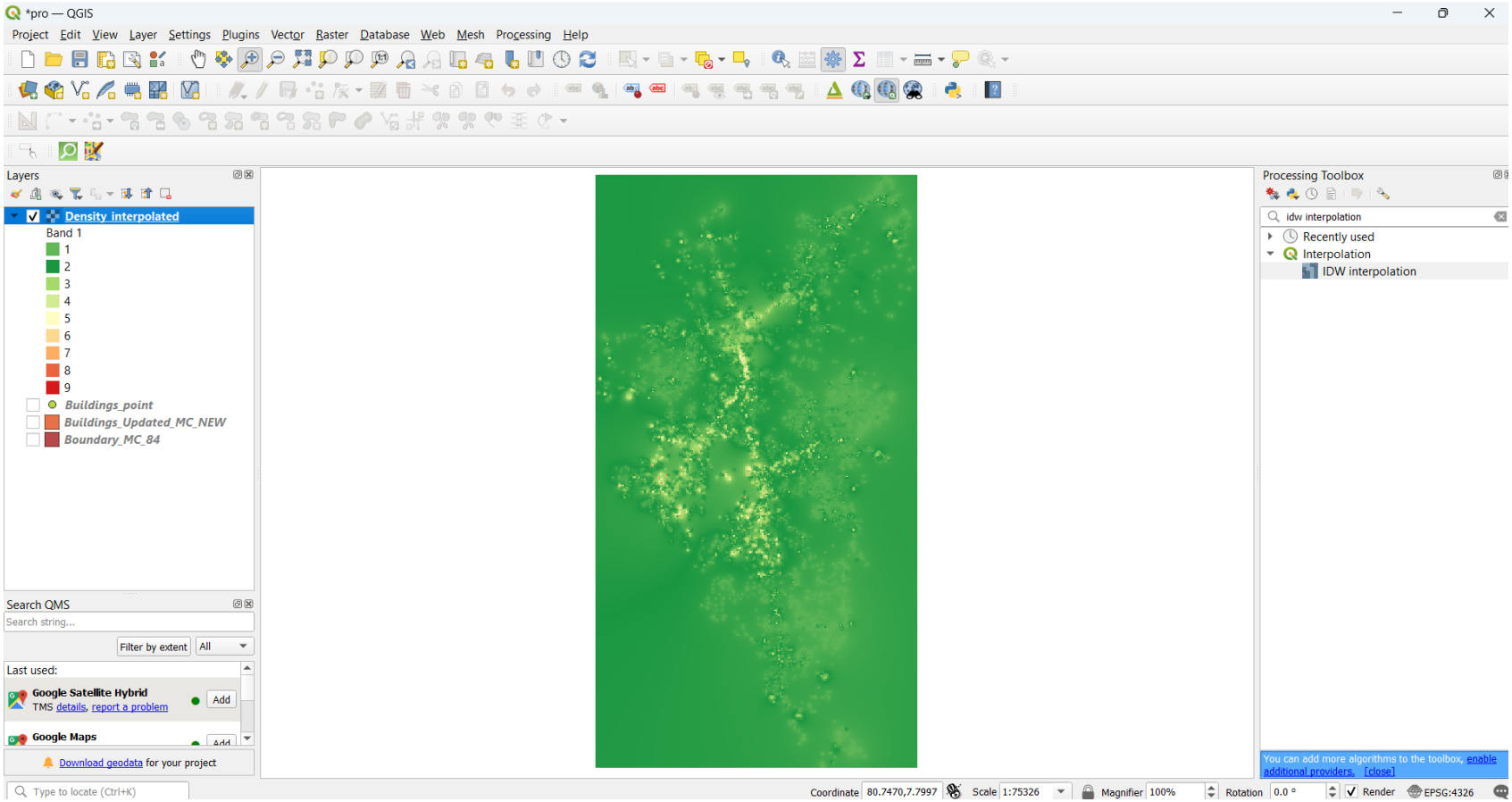


Figure 109: The Categorized Density layer

Step 7

Reclassify the interpolated raster layer.

Step 7.1 - Search the “Reclassify by table” tool in the processing toolbox.

Step 7.2 - Double-click on the tool and open it.

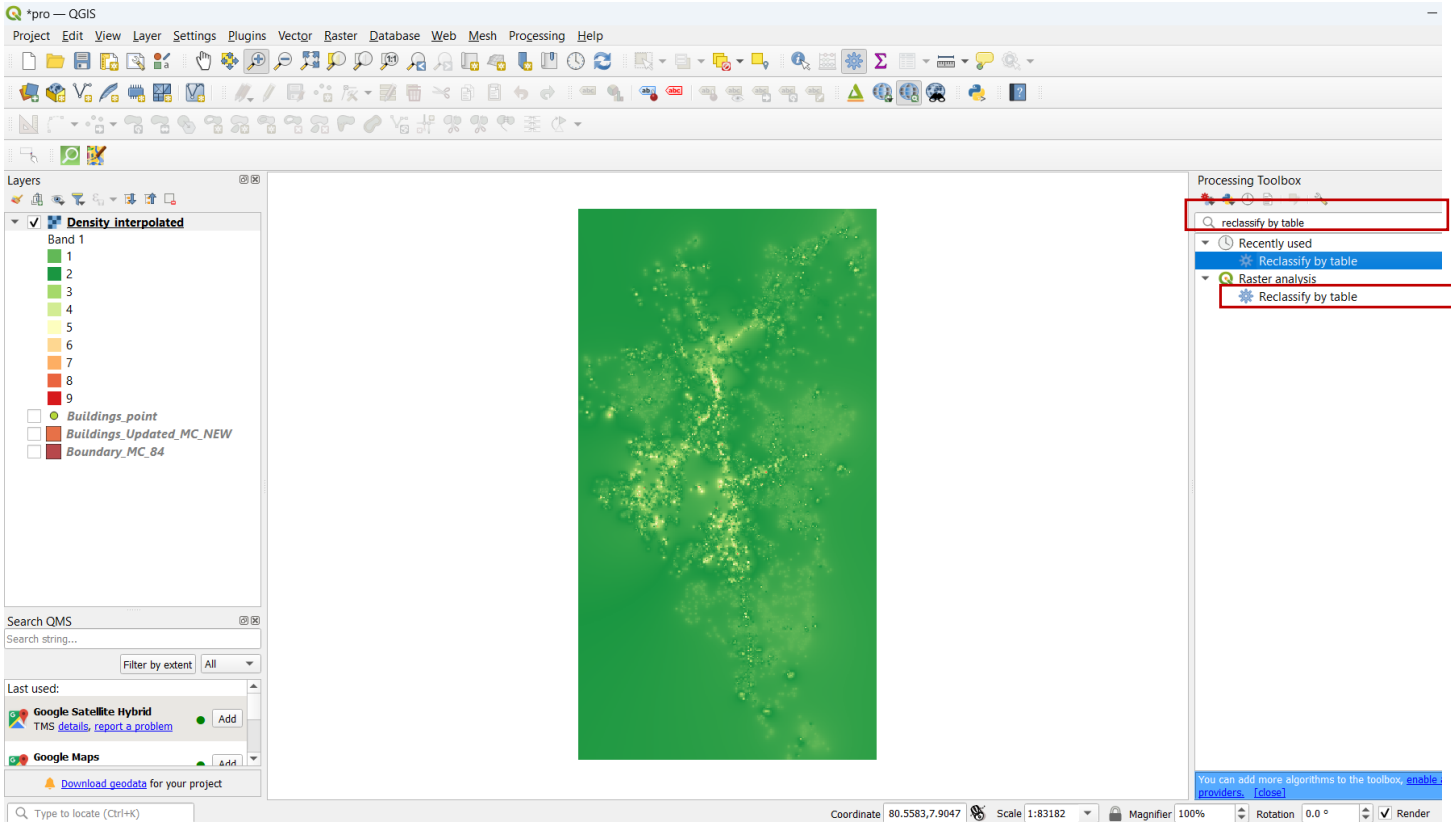


Figure 110 - Reclassify the interpolated raster layer

The following box will appear.

Step 7.3 - Give your interpolated layer as the raster layer. Here it is “Density_interpolated”.

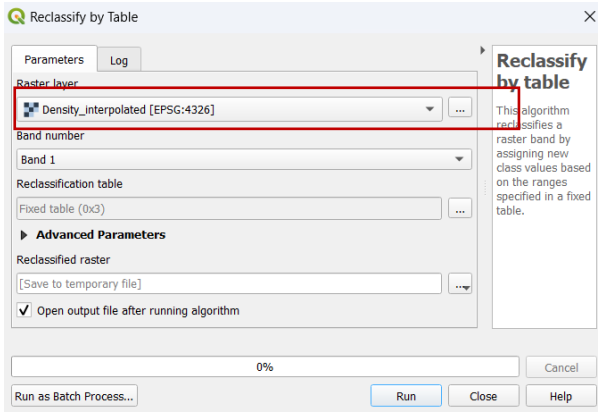


Figure 111 -Reclassify by table

Step 7.4 - Fill the reclassification table as given below.

Click on the following icon to open it.

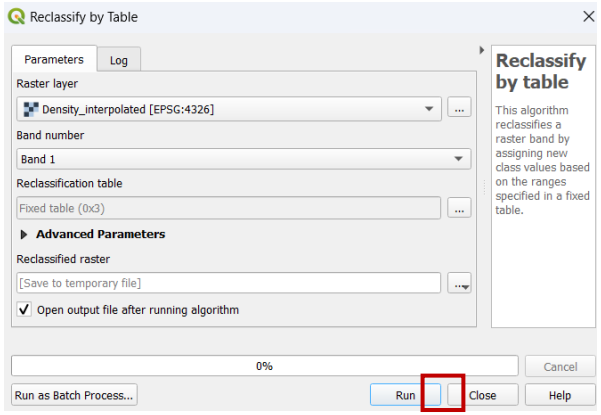


Figure 112 - Fill the reclassification

It will appear as follows. There,

1. Click on “Add the row” and add 9 rows to the table one by one. (As the density has 9 categories, you can add 9 rows to the table.)

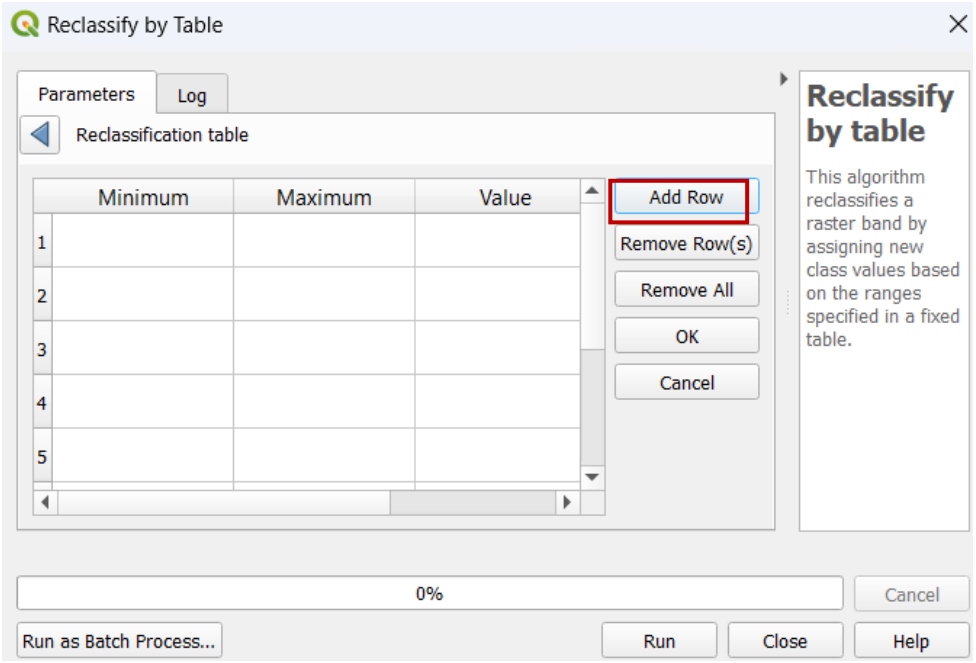


Figure 113 - Add the row

2. Fill the table according to the values in the “code” field of your layer and give the relevant number of the density category as the ‘Value’ as follows.
3. Click OK.

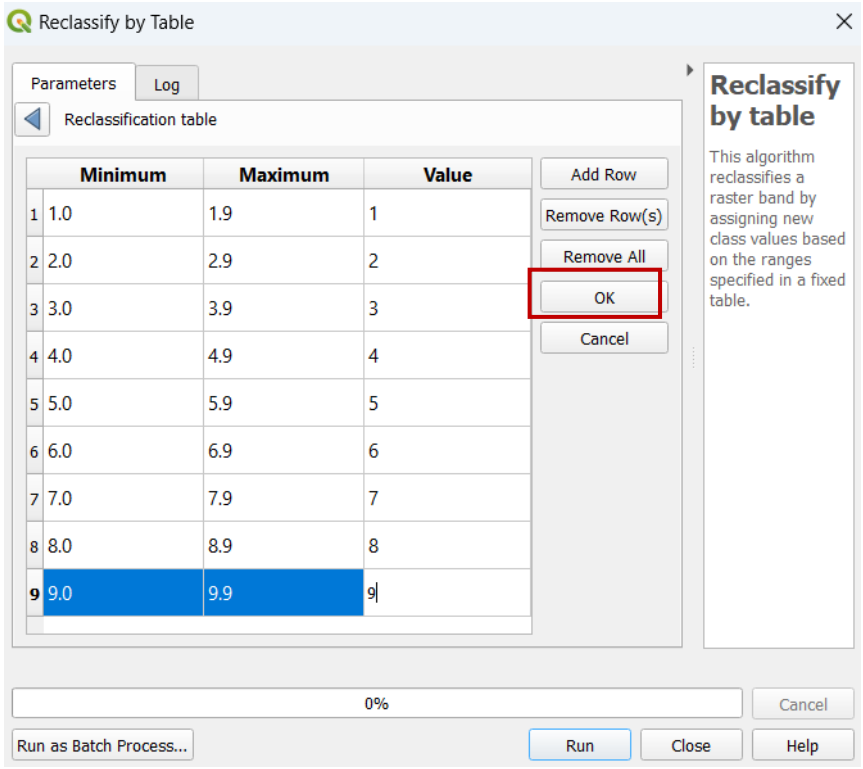


Figure 114: Reclassification table

Step 7.5 - Click on “Save to File” to give a location to save the file and click on “Run”.

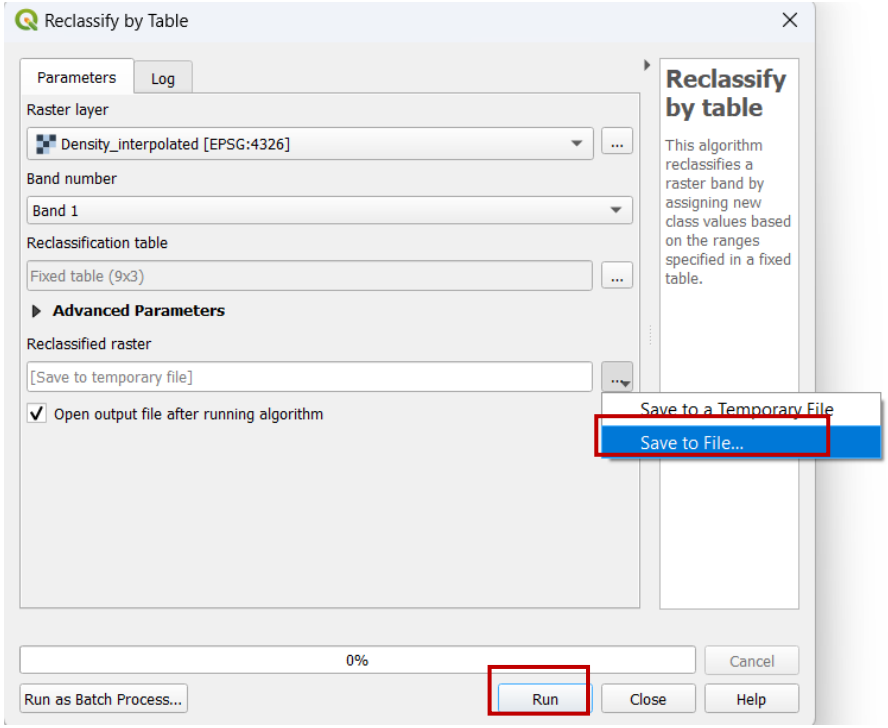


Figure 115 - Save to File

The output layer is given below.

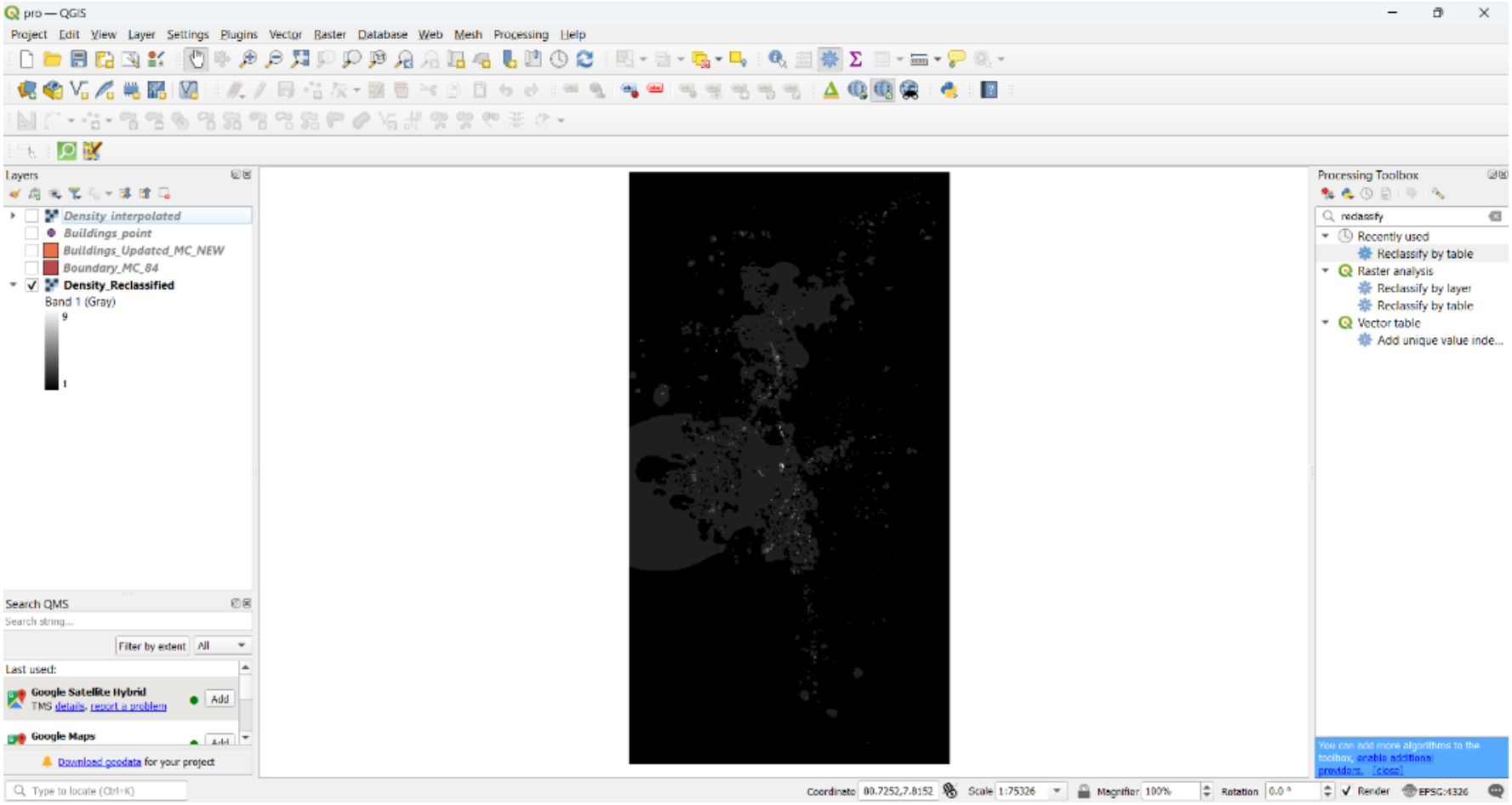


Figure 116: The Reclassified density layer

Step 8

Clip the reclassified layer with your boundary.

Step 8.1 - Search the “Clip raster by mask layer” tool to clip the raster layer.

Double-click on the “Clip raster by mask layer” tool to open it.

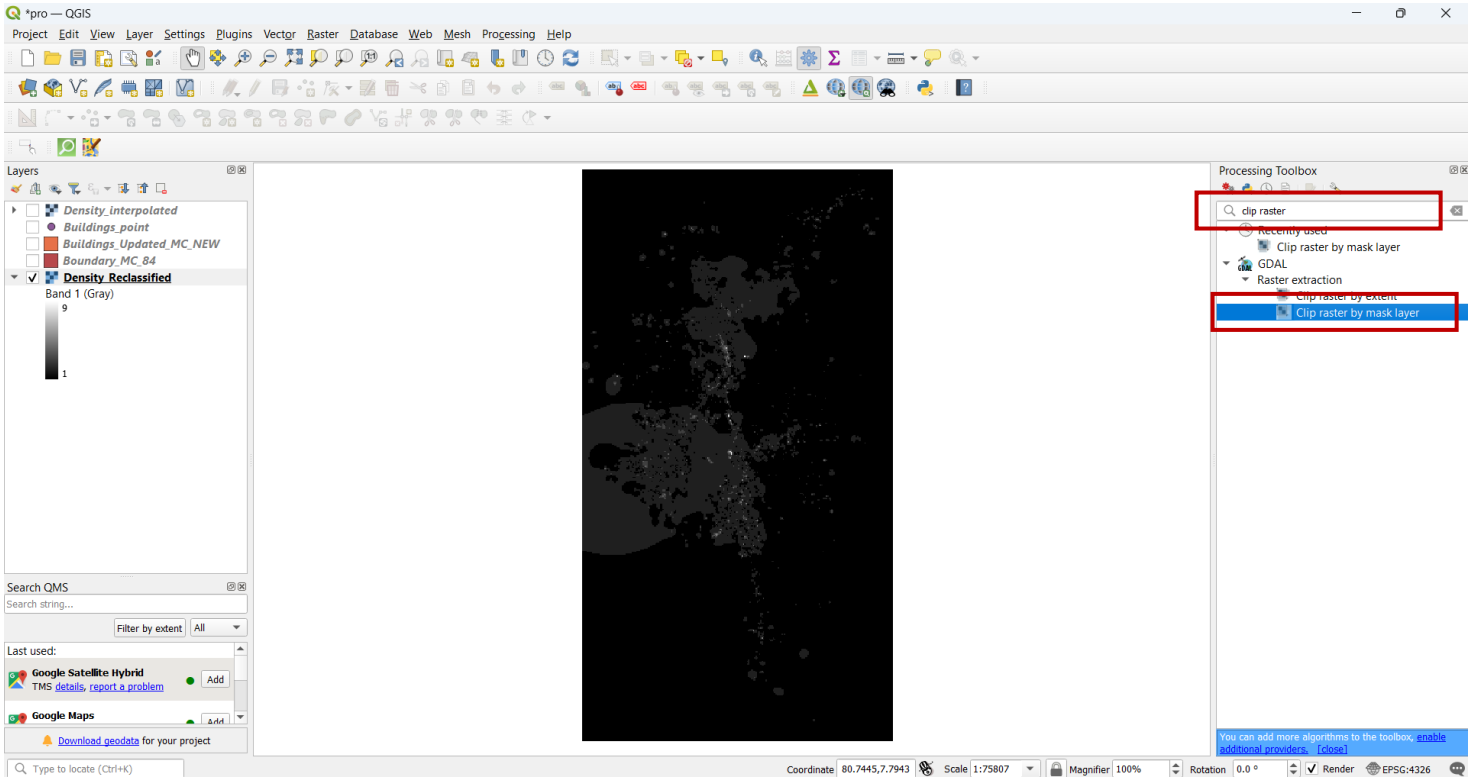


Figure 117 - Clip the reclassified layer

The following box will appear.

Step 8.2 - Fill that box as follows.

1. Give your reclassified layer as the input layer.
2. Give your boundary layer for your study area as the Mask layer. Here it is “Boundary_MC_84”
3. Click on “Save to File” to give a location to save the file.
4. Click on Run.

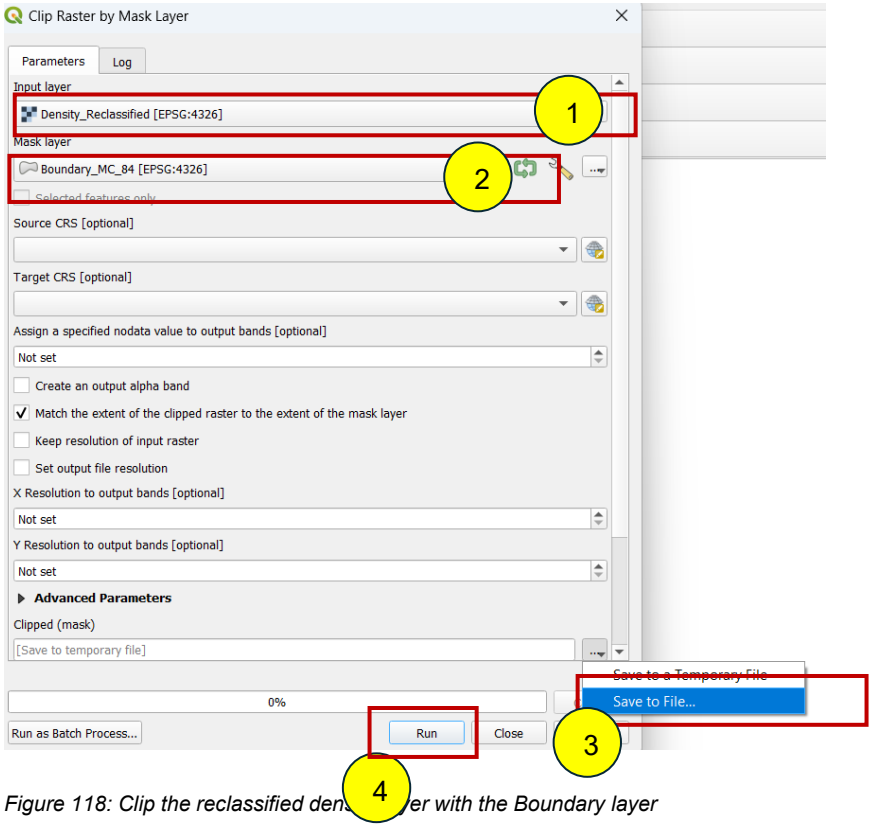


Figure 118: Clip the reclassified density layer with the Boundary layer

The output layer is given below.

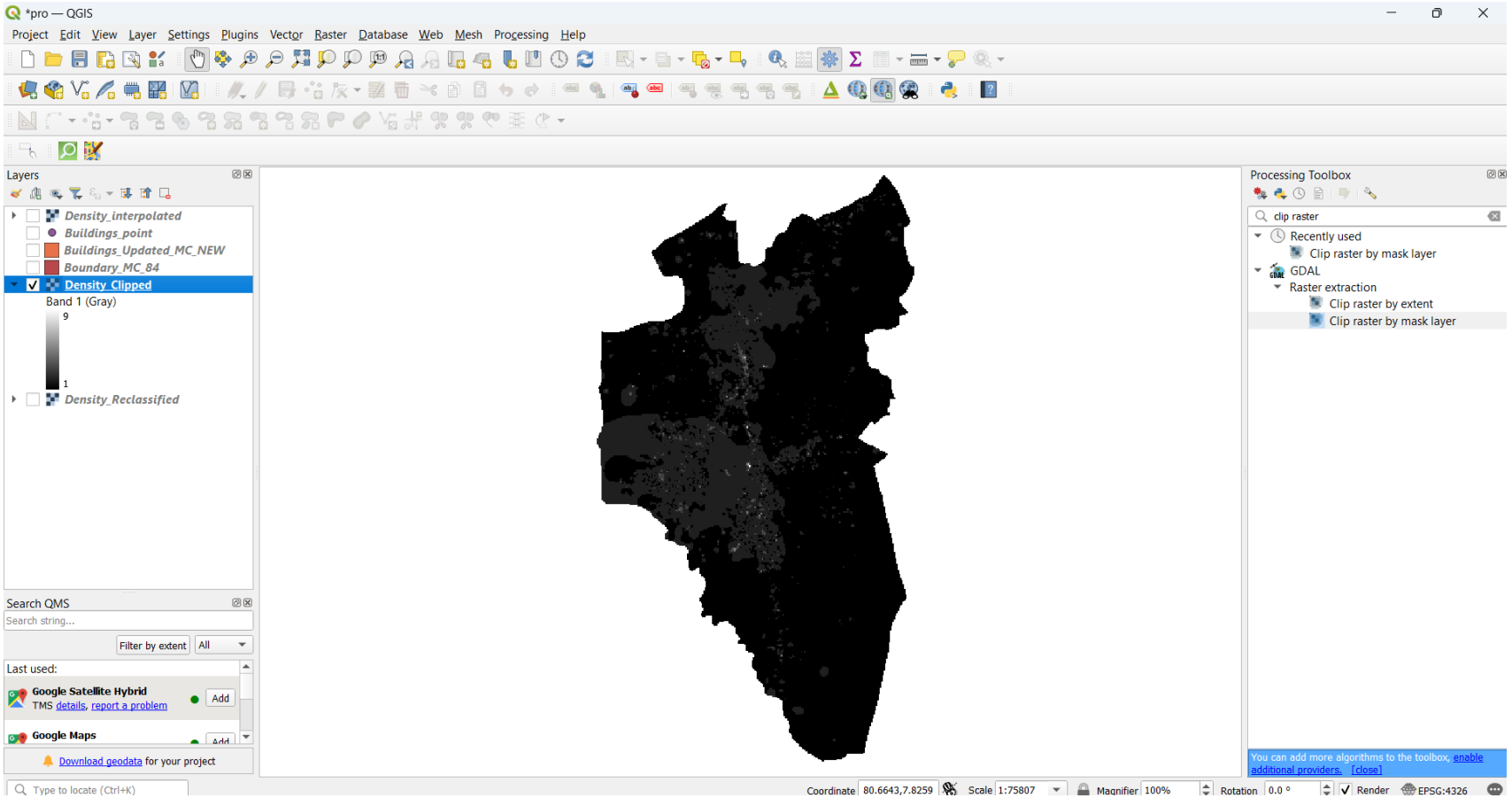


Figure 119: The Reclassified density layer of the study area

Step 8.3 - Change the properties of the clipped raster layer.

Refer the ***step 6.2***

The final layer for the building density is given below.

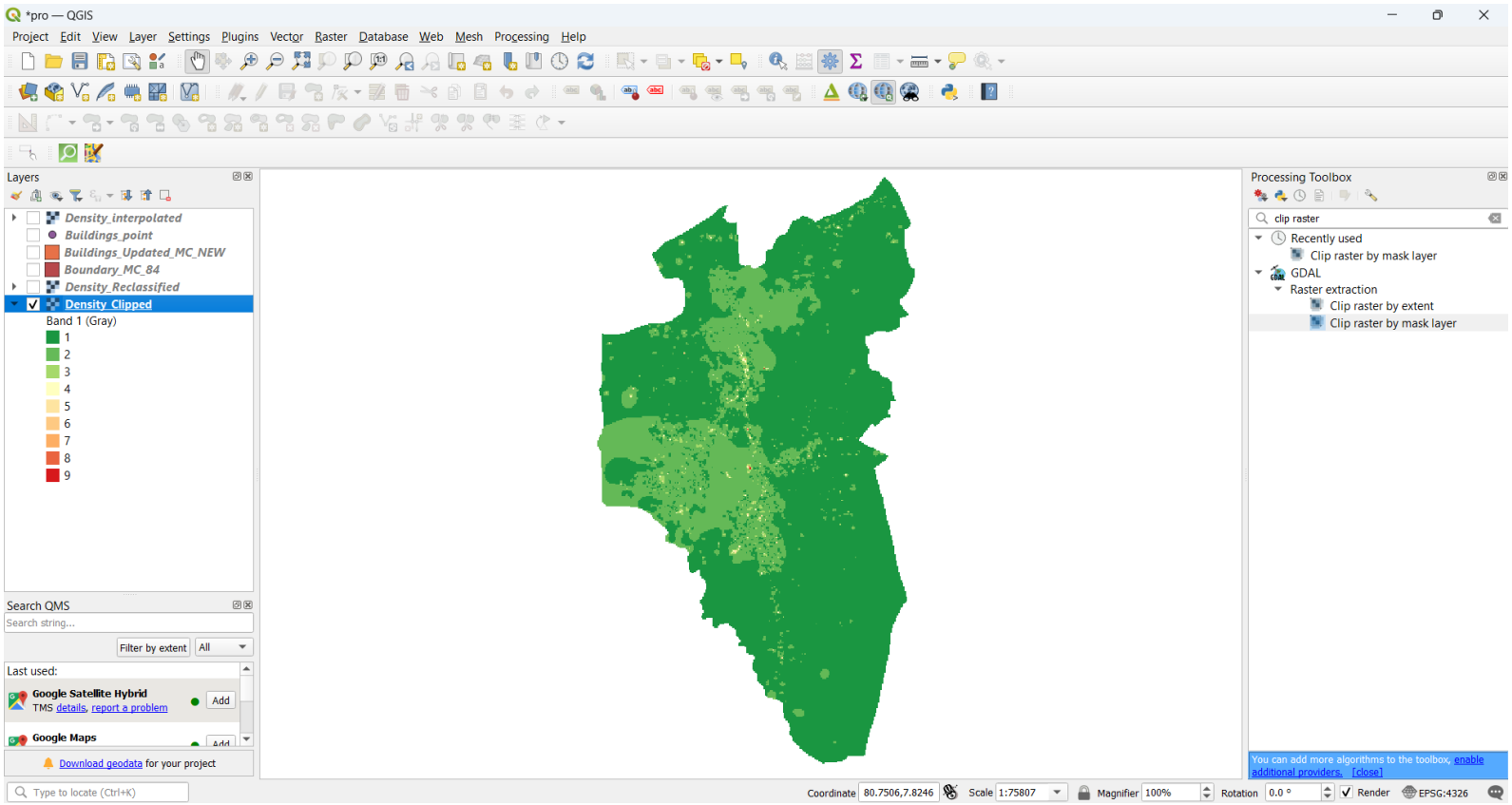


Figure 120: The final Building density layer of the study area

6. MAP OUTPUT

Space Matrix Map

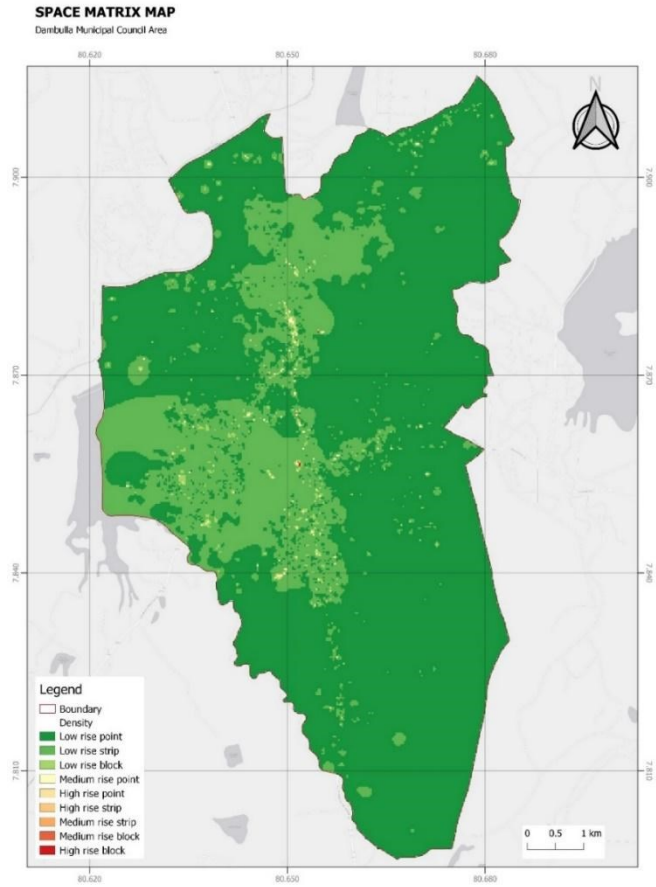


Figure 121: Space Matrix Map

7. PREPARATION OF MAPS

Use Suitable Colors & Symbols

Show adjacent administration boundaries.

Maximum utilization of map space

Show the Graticule Network with appropriate grid size.

Show the basic elements in the map.

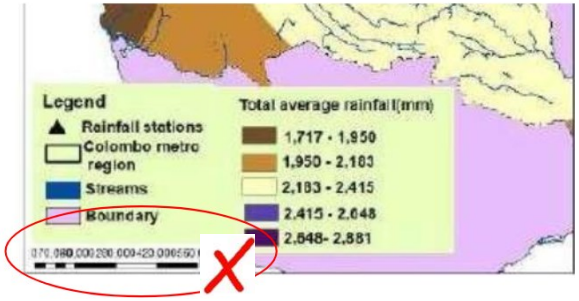
- Transportation Networks
- Water Bodies

Prepare a descriptive map.

- Label notable features.
  - Major Road Types
  - Major Rivers
  - GN Boundaries

Examples

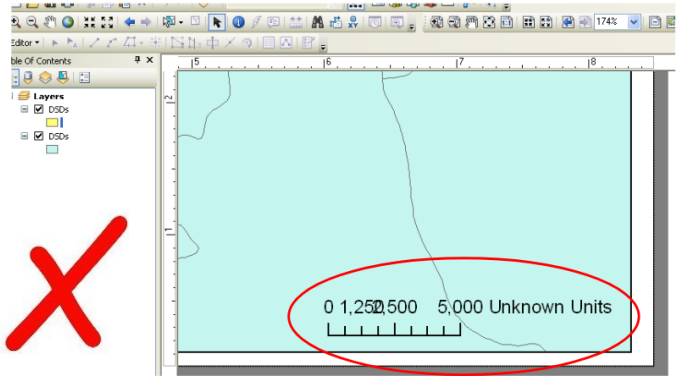
Maximum utilization of map space



Check the units of the scale bar.

Mention the correct sources.

in the



Check the text given in the legend.

AFTERWORD

Building density is a critical indicator of urban form and function, influencing everything from urban planning to quality of life. This manual provides readers with the knowledge and related tools to analyze building density effectively using accessible GIS technologies and open-source data.

By integrating both theoretical foundations and hands-on guidance, we hope this resource supports deeper understanding of urban spatial structures and encourages informed, data-driven planning. May it serve as a catalyst for continued learning, research, and innovation in the field of urban analysis.

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618657-EPP-1-2020-1-AT-EPPKA2-CBHE-JP