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Teaching & Learning Step by -Step Guide: Space Matrix

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Publisher

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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.

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				ļ

The data will be downloaded in the following format.



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.

Figure 8 -Map.OSM

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.

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Image: Second strange Image: Second strange <td< th=""><th>Add Layer Add Iayer Embed Layers and Groups Add from Layer Definition File © Copy Style Paste Style © Copy Layer Paste Layer/Group © Open Attribute Table If Toggle Editing Save Layer Clits Current Edits Save As Save As Save As Layer/Group Duplicate Layer(s) Set Scale Visibility of Layer(s) Set Project CRS from Layer Layer Coperties Filter</th><th>→ F6 → Ctrl+D Ctrl+F Ctrl+F</th><th>Add Vector Layer Add Raster Layer Add Delimited Text Layer Add Delimited Text Layer Add DotsGIS Layers Add Oracle Spatial Layer Add MSS/WMTS Layer Add WCS Layer Add VZ Layer Add VZ Layer Add VZ Layer Add VC Layer Add Vector Tile Layer Add Point Cloud Layer Add Point Cloud Layer</th><th>Ctrl+Shift+V Ctrl+Shift+R Ctrl+Shift+D Ctrl+Shift+D Ctrl+Shift+U Ctrl+Shift+O Ctrl+Shift+W</th><th></th><th></th><th>Enable Plugin Jynore 6</th><th>Processing Toolbox 28</th></td<>	Add Layer Add Iayer Embed Layers and Groups Add from Layer Definition File © Copy Style Paste Style © Copy Layer Paste Layer/Group © Open Attribute Table If Toggle Editing Save Layer Clits Current Edits Save As Save As Save As Layer/Group Duplicate Layer(s) Set Scale Visibility of Layer(s) Set Project CRS from Layer Layer Coperties Filter	→ F6 → Ctrl+D Ctrl+F Ctrl+F	Add Vector Layer Add Raster Layer Add Delimited Text Layer Add Delimited Text Layer Add DotsGIS Layers Add Oracle Spatial Layer Add MSS/WMTS Layer Add WCS Layer Add VZ Layer Add VZ Layer Add VZ Layer Add VC Layer Add Vector Tile Layer Add Point Cloud Layer Add Point Cloud Layer	Ctrl+Shift+V Ctrl+Shift+R Ctrl+Shift+D Ctrl+Shift+D Ctrl+Shift+U Ctrl+Shift+O Ctrl+Shift+W			Enable Plugin Jynore 6	Processing Toolbox 28
	Show in Overview Show All in Overview Hide All from Overview							Q Vector table Q Vector tiles GDAL

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.

🔇 Data Source	e Manager Vector			×
📛 Browser	Source Type			
V Vector	• File O Directory	Database O Protocol: HTTP(S), cloud	, etc.	
Raster	Encoding	Auto	omatic	•
Mesh	Source			
Point Cloud	Vector Dataset(s) C:\Use	s\S N Dharmakeerthi\Downloads\map.osm	1	
Delimite	▼ Options			
+ Text	Consult OSM driver help p	age for detailed explanations on options		
🥰 GeoPack	CONFIG_FILE			
GPS	USE_CUSTOM_INDEXING	<default></default>		Ŧ
Spatial in	COMPRESS_NODES	<default></default>		•
1	MAX_TMPFILE_SIZE			
Postgres	INTERLEAVED_READING	<default></default>		•
MS SQL Server				
			Close	Help

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".

Q Select Items to Add	map		×
C:\Users\S N Dharmakeert	hi\Downloads\map.osm		
Search			
Item	Description		
√ [∞] lines	LineString (Uncounted)		
multilinestrings	MultiLineString (Uncounted)		
📁 阿 multipolygons	MultiPolygon (Uncounted)		
other_relations	GeometryCollection (Uncounted)		
° points	Point (Uncounted)		
Select All Deselect A	1		
Add layers to a group			
Show system and inter	nal tables		
		Add Layers	Cancel

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".
- 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".
 Give the "Polygon" as the Geometry Type. (As the buildings belong to polygon geometry type.)
- 4. Click OK

Q Save Vector Layer as ×									
Format ESRI Shapefile									
File name	File name D:\Manual_density\Buildings.shp								
Layer name									
CRS EPSG:4326 - WGS 84 💌									
Encoding		UTF-8							
Save on	ly selected features								
 Select f Persist I 	 Select fields to export and their export options Persist layer metadata 								
▼ Geomet	try								
Geometry type									
Force	Force multi-type								
Includ	le z-dimension								
Ext	Extent (current: none)								
Layer Options									
RESIZE NO									
SHET									
Add saved file to r 4 OK Cancel Help									

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

Figure 17: Save the layer as a shapefile

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"

🔇 Data Source Manager Vector			
📙 Brows	Source Type		
V Vecto	● File ○ Directory ○ Database ○ Protocol: HTTP(S), cloud, etc.		
Raster	Encoding Automatic	•	
Mesh	Source		
Point Cloud	Vector Dataset(s) D:\Manual_density\Boundary_MC_84.shp	☑	
Delim			
餐 GeoPa			
🥊 GPS			
🍂 Spatia			
🖣 Postgr			
)) MSSQ			
📮 Oracle			
Virtual Layer	▼	Close <u>A</u> dd Help	

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.

Q	buil	lding_Layer — Feat	ures Total: 3167, Fil	tered: 3167, Selecte	ed: 0		-		<
/	ľ	821585	e 🖻 🛯 🗧 📔	s 🔩 🝸 🔳 🐥 y	0 🔓 🖪 🗶 🗮	= 🗐 🍳			
abc (med	_id 🔻 = 💌	abc				▼ Update	All Update Selec	cted
		amenity	admin_leve	barrier	boundary	building	craft	geological	-
2		NUL	NULL	NULL	NULL	ves	NULL	NULL	
3	T	oggle editing Mo	ode	Select features	using an express	sion	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	
0		NILILI	NUUL	NILILI	NILILI	NUUL	NUUL	NILILI	

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.

Q Buildings — Features Total: 3167, Filtered: 3167, Selected: 130										
	🗾 🗷 🗟 🗇 🛤 🗃 🛰 🖄 🖆 I 😼 🚍 💫 🧏 🍸 🗷 🏶 👂 I 🕼 🐘 🖉 🗮 I 🚍 🍭									
abc acm_id Vpdate All Update Selec										
	admin_leve	barrier	boundany	building	craft	geological	historic			
1	MILL	NULL	Delete	NULL	NULL	NULL	NULL			
2	Toggle editing Mode		NULL	yes	NULL	NULL	NULL			
3	NULL	NULL	NULL	NULL	NULL	NULL	NULL			
4	NULL	NULL	NULL	NULL	NULL	NULL	NULL			
5	NULL	NULL	NULL	yes	NULL	NULL	NULL			
6	NULL	NULL	NULL	NULL	NULL	NULL	NULL			
7	NULL	NULL	NULL	NULL	NULL	NULL	NULL			
8	NULL	NULL	NULL	NULL	NULL	NULL	NULL			
9	NULL	NULL	NULL	yes	NULL	NULL	NULL			
10	NULL	NULL	NULL	NULL	NULL	NULL	NULL			

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.



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.

building_Laye	r - Feature Attributes	×
osm_id	NULL	
osm_way_id	NULL	
name	NULL	
	OK Cancel	

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.

🔇 bu	Q building_Layer — Features Total: 14401, Filtered: 14401, Selected: 0									
	🕖 🖉 🗟 🚌 👼 🖂 🚳 🖆 😜 🔜 🧣 🍸 🕿 🍫 🗭 🛞 🎚 🖉 🗮 🖷 🔍									
1.2	1.2 Decale editing mode (Ctrl+5)									
	latitude	longitude	area_in_me	confidence	full_plus_					
1	85625609000	80.6518868099	314.041400000000010	0.7359	6MV2VM42+GQ27					
2	7.85650735000	80.6518897100	1935.51970000000057	0.9323	6MV2VM42+JQ27					
3	7 Toggle editi	ng mode 00	New Field 0018	0.8963	6MV2VM42+MHGX					
4	7.85643214000	80.6516089400	862.879299999999944	0.8323	6MV2VM42+HJH7					

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)".

🔇 Add Field								
N <u>a</u> me	Floors							
Comment								
Туре	Whole number (integer)							
Provider type	integer							
Length	10 \$							
	OK Cancel							

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.





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.

🔇 bu	😪 building_Layer — Features Total: 14401, Filtered: 14401, Selected: 1 🦳 🦳 🗌									
X B 2 B 4 B 5 B 4 B 5 B 5 B 7 B 7 B 7 B 7 B 7 B 7 B 7 B 7										
1.2 latitude = E 1.2 Move selection to top Update										
	latitude 🔺	longitude	area in me	confidence	full_plus_	Floors				
1	7.87197490000	80.6513983100	582.031799999	0.931	1 6MV2VMC2+Q	NU	LL			
2	0	0	0	(0 NULL	NU				
3	7.79692023000	80.6664303999	20.6091000000	0.6518	8 6MV2QMW8+Q	NU	LL			
4	7.79694509000	80.6662508299	90.0948000000	0.8676	6 6MV2QMW8+Q	NU	LL			

Figure 51: Move the selection to the top

• Give the identified value of the relevant building to the "Floors" field.

🔇 bı	uilding_Layer — Fea	-		\times					
N 🖉 🖶 C 🛱 👼 🛰 O C 🖕 😑 N 🧠 Y 🔟 🗞 🗭 I 🖬 🕷 🗮 I 🗐 🔍									
1.2 lati	tude 💌 = 😢	1.2			•	Update All	Update	Selected	
	latitude 🔺	longitude	area_in_me	confidence	full_plus_	Eloor			
1	7.87197490000	80.6513983100	582.0317999999	0.9311	6MV2VMC2+Q	2	⊠ ‡		
2	0	0	0	0	NULL		NULL		
3	7.79692023000	80.6664303999	20.6091000000	0.6518	6MV2QMW8+Q		NULL		
4	7.79694509000	80.6662508299	90.0948000000	0.8676	6MV2QMW8+Q		NULL		
5	7.79696759000	80.6667317099	100.7772999999	0.8408	6MV2QMW8+Q		NULL		
6	7.79746882000	80.6685865000	227.209599999	0.8468	6MV2QMW9+X		NULL		

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"

🔇 bu	🞗 building_Layer — Features Total: 14401, Filtered: 14401, Selected: 0								\times
/	🖊 🕺 📑 😂 i 🖏 👼 🖂 🖄 🖬 i 省 🗮 💟 🔩 🍸 🔛 🏶 🗭 i 🕼 🕷 🗶 🗮 i 🗮 📾 🍭								
	latitude	longitude 🔺	area in me	e	confidence	full_plus_	Floors	;	4
	7490000000	Toggle editing M	ode 0		0	NULL	1		
2	7.87172049000	0 80.6215645000	12.96030000	00	0.6569	6MV2VJCC+MJPR		1	
}	7.87456956000 80.62185		. 56.8903000000		0.6611 6MV2VJFC+RPHM			2	
1	7.87464604000	0 80.6224785400	234.81489999	99	0.8386	6MV2VJFC+VX5V		1	

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.

🔇 bi	uilding_Layer — Fea	_		×					
🥖 🖉 📑 😂 👘 🖂 🖄 🖆 🐂 🎫 💊 🧣 🍸 🔟 🕸 🗭 💷 🔚 🕷 🎕									
	latitude	longitudo 🌲	oros in mo	confidence	full_plus_	Floor	s		
	7490000000 🛯	Toggle editing	Mode 0	0	NULL		1		
2	7.87172049000	80.6215645000	12.9603000000	0.6569	6MV2VJCC+MJPR		1		
}	7.87456956000	80.6218569400	56.8903000000	0.6611	6MV2VJFC+RPHM		2		
ţ	7.87464604000	80.6224785400	234.814899999	0.8386	6MV2VJFC+VX5V		1		

Figure 55 - Calculate the building height.

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

Q bi	uilding_Layer — Fe	_		\times					
📝 🗶 🖯 1 🏗 10 🗠 10 10 19 🗮 💫 🧠 🍸 🗷 🍫 臭 🎼 🏦 🗶 🗮 10 19 19 19 10 10 10 10 10 10 10 10 10 10 10 10 10									
1.2 latitude Vupdate All Update Selected									
latitude New Field			area_in_me	confidence	full_plus_	Floors		4	
1	74900000000		0	0	NULL		1	_	
2	7.87172049000	80.6215645000	12.9603000000	0.6569	6MV2VJCC+MJPR		1		
3	7.87456956000	80.6218569400	56.8903000000	0.6611	6MV2VJFC+RPHM		2		
4	7.87464604000	80.6224785400	234.8148999999	0.8386	6MV2VJFC+VX5V		1		

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"

🔇 Add Field							
N <u>a</u> me	Height						
Comment							
Туре	Whole number (integer)						
Provider type	integer						
Length	10	\$					
	OK Cance	el					

Figure 57: Add a new field for building height

Step 3.3 - Click on the "Open field Calculator."

Q building_Layer — Features Total: 14401, Filtered: 14401, Selected: 0										×
// 🔰	/ ※ 号 ご 霧 筒 ~ ② 国 ~ 目 12 見 ~ 丁 国 冬 12 16 能 変(語) 用 の									
1.2 lat	.2 latitude ▼ = 8 1.2 ▼ Update All Update Selected									
	latitude	longitude 🔺	Floors					Height		4
1	7490000000 🖾	0	Open f	Open field Calculator			1		NULL	
2	7.87172049000	80.6215645000	12.9603000000	0.6569	6MV2VJCC+	MJPR	1		NULL	
3	7.87456956000	80.6218569400	56.890300000	0.6611	6MV2VJFC+F	RPHM	2		NULL	
4	7.87464604000	80.6224785400	234.814899999	0.8386	6MV2VJFC+V	VX5V	1		NULL	

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"

🔇 building_Layer — Field Calculator	×
Only update 0 selected features Create a new field	✓ Update existing field
Create virtual field Output field name Output field type Whole number (integer) Output field length 10 Precision 3	123 Height 2
Expression Factor control "Floors" * 3 6 • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • • •	Q search snow Values group field Date and Time Fields and Values NULL 1.2 latitude 1.2 latitude 1.2 latitude 1.2 confidence abc Kall Use and Use All Unique 10 Samples 4 In the stand Use In the stand Us
	7 ОК Сапсе Неір

Figure 59: Calculate and assign the building height

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

🔇 bu	Q building_Layer — Features Total: 14401, Filtered: 14401, Selected: 0 —										
🥖 🛿	🕖 😹 🖶 〇日 🏗 🖷 🖂 🚳 🖆 旨 ы 🖳 🍸 🔳 🍫 🔎 日間 🏗 🖉 🗮 日三日 📾 🍳										
1.2 lat	1.2 latitude = E 1.2 Update All Update Selected										
	latitude	Toggle e	diting Mode	;	nce	full_plus_	Floors	Hei	ght	4	
1	0 🛛				0	NULL	1		3		
2	7.87172049000	80.6215645000	12.9603000000		0.6569	6MV2VJCC+MJPR	1		3		
3	7.87456956000	80.6218569400	56.8903000000		0.6611	6MV2VJFC+RPHM	2		6		
4	7.87464604000	80.6224785400	234.8148999999		0.8386	6MV2VJFC+VX5V	1		3		
5	7.87462592000	80.6225668499	226.668100000		0.7773	6MV2VJFF+V242	1		3		
6	7.88337858000	80.6226120700	30.0063000000		0.7822	6MV2VJMF+9254	1		3		

Figure 60 - Toggle editing Mode

Click on "Save" in the following box.

🔇 Stop	Editing			×
?	Do you want to sav	ve the change	es to layer bui	lding_Layer?
		Save	Discard	Cancel

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"

🔇 Add Fiel	d	×
N <u>a</u> me	Туре	
Comment		
Туре	abc Text (string)	•
Provider type	string	
Length	10	\$
	ОК	Cancel

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.

						_	-	_	_			_
🔇 bi	uilding_Layer — Fea	tures Tota	l: 14401,	Filtered: 14401, Sele	ected: 0					-		×
1	8 8 6 -	< 🖻 🚺	ء 🖻	S 🔩 🍸 🗷 🍫 J	P 📙 🖪 🖉 🖽	E 🗊 🔍						
1.2 lat	2 latitude v = E 1.2 V Update All Update Selecte											
	latitude	longit	_					Floors	Height		Туре	
1	0		To	ggle editi	ng Mode			1	3	NULL		
2	7.87172049000	80.6215	043000	12.9005000000	0.0509		JPR	1	3	NULL		
3	7.87456956000	80.6218	569400	56.8903000000	0.6611	6MV2VJFC+RP	ΗМ	2	6	NULL		
4	7.87464604000	80.6224	785400	234.8148999999	0.8386	6MV2VJFC+VX	(5V	1	3	NULL		

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.

🔇 bu	uilding_Layer — Fea	tures Total: 14401,	Filtered: 14401, Sel	ected: 1				-		×	
// 🚀 1.2 lati	Image: Second										
		longitude	area_in_me	confidence	iuii_pius_	FIGOIS	Height		туре		
1	7.87628647000	80.6499751199	191.858100000	0.8852	6MV2VJGX+GX9C	1	3	NULL			
2	0 🛛	0	0	0	NULL	1	3	NULL			
3	7.79692023000	80.6664303999	20.6091000000	0.6518	6MV2QMW8+Q	1	3	NULL			
4	7.79694509000	80.6662508299	90.0948000000	0.8676	6MV2QMW8+Q	1	3	NULL			
5	7.79696759000	80.6667317099	100.7772999999	0.8408	6MV2QMW8+Q	1	3	NULL			
6	7.79746882000	80.6685865000	227.209599999	0.8468	6MV2QMW9+X	1	3	NULL			
7	7.79758341000	80.6664208899	38.9198000000	0.7346	6MV2QMX8+2	1	3	NULL			

Figure 71 - Move the selection to the top

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

🔇 bu	iilding_Layer — Fea	tures Total: 14401,	Filtered: 14401, Sel	ected: 1				-		\times	
/ 🗾	🕞 🗇 i 📆 👼 🍝	e 🖻 🚺 🍋 📒	🔊 😼 🕇 🔳 🔶	P 🖪 🖪 🗷 🖽	= 🗐 🍳						
1.2 lati	1.2 latitude • = 8 1.2 • Up										ed
	latitude 🔺	longitude	area_in_me	confidence	full_plus_	Floors	Height		Type	_	4
1	7.87628647000	80.6499751199	191.858100000	0.8852	6MV2VJGX+GX9C	1		3 Point		⊠	
2	0	0	0	0	NULL	1		3 NUL			
3	7.79692023000	80.6664303999	20.6091000000	0.6518	6MV2QMW8+Q	1		3 NUL	-		
4	7.79694509000	80.6662508299	90.0948000000	0.8676	6MV2QMW8+Q	1		3 NUL	-		

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.

Q bu	🕽 building_Layer — Features Total: 14401, Filtered: 14401, Selected: 7											
/ 1												
	latit ude 🔶	longitude	area in me	confidence	full_plus_	Floors	Height	Туре	-			
1	94970000000 🛚	Toggle ec	liting Mode	0	NULL	1	NULL	Block				
2	7.79692023000	80.6664303999	20.6091000000	0.6518	6MV2QMW8+Q	1	NULL	Point				
3	7.79694509000	80.6662508299	90.0948000000	0.8676	6MV2QMW8+Q	1	NULL	Point				
4	7.79696759000	80.6667317099	100.7772999999	0.8408	6MV2QMW8+Q	1	NULL	Point				

Figure 73 - Toggle editing Mode

Click on "Save"



Figure 74 -Save

Example 1

Point Type

Building layer in QGIS



Strip Type



Block Type



Google Satellite Map

Given the building type for that building in the attribute table

Q b	uilding_Layer — Fea	tures Total: 14401,	Filtered: 14401, Sel	ected: 1				-		×
1	🛛 🕞 😂 i 📆 👼 🖻	¢ 🖻 🚺 😜 🗮	🔊 😼 🕇 🛅 🐥 .	P 🖪 🖪 🗷 🖴	= <u>-</u> Q					
1.2 la	titude 🔻 = E	1.2					•	Update All	Update S	elected
	latitude 🔶	longitude	area_in_me	confidence	full_plus_	Floors	Height		Туре	^
1	7.86821035000	80.6496594000	227.704700000	0.8376	6MV2VJ9X+7VMC	1		3 Point	\mathcal{I}	3
2	0	0	0	0	NULL	1		3 NULL		
3	7.79692023000	80.6664303999	20.6091000000	0.6518	6MV2QMW8+Q	1		3 NULL		

🔇 bu	Q building_Layer — Features Total: 14401, Filtered: 14401, Selected: 1											
/	🕞 C i 📆 👼 🎽	c 🖄 🚺 🗧 🧮	💊 🔩 🝸 🛅 🐥 .	P 🖪 🖪 🖉 🖽	🚍 I 📅 🍳							
1.2 lati	2 latitude 🔻 = E 1.2 V Update All Update Selected											
latitude 🔺 longitude area_in_me confidence full_plus_ Floors Height									Туре			
1	7.87246876000	80.6522303400	1797.97109999	0.9157	6MV2VMC2+XV	2	Ć	Strip	4	2		
2	0	0	0	0	NULL	1	3	NULL				
3	7.79692023000	80.6664303999	20.6091000000	0.6518	6MV2QMW8+Q	1	3	NULL				

🔇 bu	uilding_Layer — Fea	tures Total: 14401,	Filtered: 14401, Sel	ected: 1				-		\times	
// 🐙	🖶 🗇 📑 👼 🍝	: 🖻 🚺 😜 🗮	N 😼 🕇 🛅 🐥 .	P 🖪 🖥 🖉 🔛							
1.2 lati	1.2 latitude 🔻 = 😢 1.2 V Update All Update Selected										
	latitude Iongitude area_in_me confidence full_plus_ Floors H								Туре	4	
1	7.86612658000	80.6516741899	16884.7328000	0.9689	6MV2VM82+FM	1	C	Block		x	
2	0	0	0	0	NULL	1	3	NULL			
3	7.79692023000	80.6664303999	20.6091000000	0.6518	6MV2QMW8+Q	1	3	NULL			
4	7.79694509000	80.6662508299	90.0948000000	0.8676	6MV2QMW8+Q	1	3	NULL			

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)"

🔇 Add Fiel	d	×
N <u>a</u> me	Density	
Comment		
Туре	abc Text (string)	•
Provider type	string	
Length	20	≪ \$
	ОК	Cancel

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^{Preview: 1}

🔇 bu	iilding_Layer — Fea	tures Total: 14401,	Filtered: 14401, Sel	lected: 84	32	_		_	_		×
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1.2 lati	tude 🔻 = 😢	1.2							▼ Update All	Upda	ate Selected
latitude longitude area_in_me onfidenc full_plus_ Floors Height Type									Density	-	
1	0 🛛	0	0	0	NULL	1	3	Block	N	JLL	
2	7.79692023000	80.6664303999	20.6091000000	0.6518	6MV2QMW8+Q	1	3	Point	N	JLL	
3	7.79694509000	80.6662508299	90.0948000000	0.8676	6MV2QMW8+Q	1	3	Point	N	JLL	
4	7.79696759000	80.6667317099	100.7772999999	0.8408	6MV2QMW8+Q	1	3	Point	N	JLL	
5	7.79746882000	80.6685865000	227.209599999	0.8468	6MV2QMW9+X	1	3	Point	N	JLL	
6	7.79758341000	80.6664208899	38.9198000000	0.7346	6MV2QMX8+2	1	3	Point	N	JLL	
7	7.79762837000	80.6683432899	82.6025999999	0.7595	6MV2QMX9+38	1	3	Strip	N	JLL	

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.
| Q building_Layer — Field Calculator | | × |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|---|
| ✓ Only update 8432 selected features Create a new field Create virtual field Output field name Output field type 123 Integer (32 bit) ▼ Output field length 10 ♀ Precision 3 ♀ | ✓ Update existing field 1 abc Density 2 | |
| Expression Function Editor | Q. Search Show Help row_number | |
| Feature 💽 🖉 🕨
Preview: 'Low rise Point' | Fields and Values Files and Paths Fuzzy Matching OK Cancel Help | |
| Figure 70: Assign the selected building | as as "I ow Rise Point" | |

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"



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.

Open the processing toolbox as here. For that,

Go to Processing>>>Toolbox

Q *pro — QGI5	-	0	×
$\label{eq:project_interm} {\tt Project} \ \underline{\tt E} {\tt dit} \ \underline{\tt V} {\tt lew} \ \underline{\tt Layer} \ \underline{\tt Settings} \ \underline{\tt P} {\tt lugins} \ {\tt Vector} \ \underline{\tt R} {\tt aster} \ \underline{\tt D} {\tt atabase} \ \underline{\tt W} {\tt eb}$	Mesh Progessing Help		
i R. R. 역 약 약 🖉 💥 🖾 🖬 🖬 🖬 🔲 🗆	📊 🚚 😤 Toolbox Chil+Altel 🔍 🤮 🌞 Σ 📰 + 🚍 - 💭 🔍 -		
📽 🎕 Vi 🔏 🗮 💹 日 🥂 / 同 🕾 灰 • 副 🖷 🔫 1	(a) (b) (c) (c) <th></th> <th></th>		
MC-9-99998998900000	Provide Besults Viewer Ctrl+Alt+R		
	Edit Features In-Place		
Layers Die			
Search QMS 80%	and the second se		
Filter by extent All *			
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Q. Type to locate (Ctri+K)	Coordinate 80.7865,7.8338 🗞 Scale 1:67484 💌 🔒 Magnifier 101% 💠 Rotation 0.0 ° 💠 🗸 Render 🦿	EPSG:432	6 Q

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.)

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"

Q Centroids		×
Parameters Log Input layer Fixed geometries [EPSG:4326] Selected features only Create centroid for each part Centroids		Centroids This algorithm creates a new point layer, with points representing the centroid of the geometries in an input layer.
[Create temporary layer]		The attributes
V Open output file after running algorithm	Sa	ave to File
	 Sa Sa	ave to GeoPackage ave to Database Table
	 A	ppend to Layer
Run as Batch Process Run	Cł Clos	nange File Encoding (System) se Help

Figure 89 - Run the Centroids

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



Figure 90: The point layer

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.

🔇 Add Field							
N <u>a</u> me	Code						
Comment							
Туре	Whole number (integer 64 bit)	•					
Provider type	integer64						
Length	10	\$					
	OK Cancel						

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.

Q Buildings_point — Features Total: 14401, Filtered: 14401, Selected: 8432 —											\times	
/	🕖 🗶 🖶 C 🛱 👼 🛰 🖄 🖆 I 🖌 🚍 💟 🔩 🌹 🗶 🏘 🔎 I 🏀 🕷 🗶 🗮 I 🗮 I 📾 🍭											
1.2 lati	1.2 latitude 💌 = 🗧 1.2 🔍 Update All Update Selected											
	latitude	longitude	area_in_me	onfidenc	ill_plu:	Floors	Height	Туре	Density	Code		
1	91140000000	⊠ 65505	136.3840	0.8504	6M	1	3	Point	Low Rise Point	NULL		
2	7.8520614	80.65583	36.78249	0.6816	6M	1	3	Block	Low Rise Block	NULL		
3	7.8511093	80.65408	32.87299	0.6997	6M	1	3	Block	Low Rise Block	NULL		
4	7.8508554	80.65508	147.8663	0.861	6M	1	3	Point	Low Rise Point	NULL		

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 follo										culator
Q Buildings_point — Features Total: 14401, Filtered: 14401, Selected: 8432 — — — X											
1.2 lat	Ø Ø Ø Image: Selected 1.2 latitude ✓ = E 1.2										
	latitude	longitude	area_in_me	onfidenc	ill_plu:	Floors	Height	Туре	Density	Code	
1	91140000000	፼ 65505	136.3840	0.8504	6M		3	Point	Low Rise Point	NULL	
2	7.8520614	80.65583	36.78249	0.6816	6M	1	3	Block	Low Rise Block	NULL	
3	7.8511093	80.65408	32.87299	0.6997	6M	1	3	Block	Low Rise Block	NULL	
4	7.8508554	80.65508	147.8663	0.861	6M	1	3	Point	Low Rise Point	NULL	

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".
- Type 1
 Click "OK"

Q Buildings_point — Field Calculator	×
 ✓ Only update 8432 selected features Create a new field 	✓ Update existing field
Create virtual field Output field name Output field type Whole number (integer) Output field length 10 Precision Supression Evention Editor	123 Code 2
Image: Second Function Image: Second Function 1 3 1 3 Image: Second Function Age Age Age Age Age Image: Second Function Age	Show Help y_number gregates ays lor nditionals nversions te and Ti Ids and V es and Pat
	4 OK Cancel Help

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.

R Bu	Q Buildings_point — Features Total: 14401, Filtered: 14401, Selected: 0											×
🖊 🐹 🖶 😂 🖷 🖮 🖄 🖄 🖕 🦉 📓 🗞 🖓 🍸 📓 🗞 🗭 🛯 📓 🕷												
	latitude	longitudo	araa in ma	onfidonc	ill_plu:	Floors	Height	Туре	Density		Code	4
1	91140000000	Toggle	editing mo	de	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

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"



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.

Figure 101: The IDW Interpolation

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

7. Click on Run

🔇 IDW Inter	polation					×
Parameters	Log				J	IDW
Input layer(s)						interpolati
Vector layer		° Buildings	s_point		-	on
Interpolation	n attribute	123 Code			•	Inverse Distance
Use Z-co	oordinate	for interpolatio	n			interpolation of a
					#	Sample points are
Vector lay	er	Attribute	Туре	9		weighted during interpolation such
Buildi	ngs_p	Code	Point	ts	•	that the influence of one point
						declines with
Distance coeff	icient P					unknown point you
2.000000					\$	want to create.
Extent						
80.620946935	5,80.6854	12415,7.79658	1086,7.91543	37296 [EPSG:4326]		
Output raster	size					
Rows	462	\$	Columns	251		
Pixel size X	0.000258	3 \$	Pixel size Y	0.000258		
Interpolated						
[Save to temp	orary file]				
V Open outp	ut file afte	er running algo	rithm	(6		ave to a Temporary File
						ave to File
			0%		_	Cancel
Run as Batch F	rocess					Help

The Output Layer is given below.

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NC+4-336383388806	- のまのかい	
Lavers 232	and the second	Processing Toolbox III a
✓ P Density Interpolated		Q, idw interpolation
Buildings. Updated. MC_NEW Boundary_MC_84		Secently used Q Interpolation IDW interpolation
Search QMS 2015 Search drug This by estant A4 * Last used: Socyle Satellike mybrid TMS details: report a problem M Google Maps Coogle Maps Coogle Maps Coogle Maps		valu care add more algorithms to the twikkey, anality white care previous. Toke of
Q, Type to locate (Otri+K)	Coardinate #0.7423.7.8415 🏶 Scale 1:67500 💌 🔒 Magnifi	er 180% \$ Relation 0.8 ° \$ √ Render @1950.4326 @



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.

Q Layer Properties	— interpolaed_density1 — Symbology	\times
Q	Band Rendering	
🧿 Information	Render type Singleband gray	
Source	Gray band Band 1 (Gray)	
	Color gradient Black to White	
Symbology	Min 1.00005 Max 8.75454	
ITransparency	Contrast enhancement Stretch to MinMax	
📐 Histogram	Min / Max Value Settings	
🞸 Rendering	Legend Settings	
🕓 Temporal	▼ Layer Rendering	
🖄 Pyramids	Blending mode Normal	
📝 Metadata	Brightness 0 🗢 Contrast 0 🗢	
E Legend	Gamma	
	Invert colors Grayscale Off	
	Luna Coloriza Strangth 10.04	1 -
	Style Style K Cancel Apply Hel	р

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.

Q Layer Properties –	- Density_interpolat	ed — Symbo	logy						×
٩	▼ Band Rendering								-
information	Render type Single	aband pseudoo	olor 🔻						
Source	Band		Band 1						-
Symbology	Min		1		Max		9		
Symbology	▶ Min / Max Va	ue Settings							
Transparency	Interpolation			Linear					-
🔛 Histogram	Color ramp								
🎸 Rendering	Label unit suffix								
🕓 Temporal	Label precision			4				$\langle \times \rangle$	\$
Pyramids	Value	Color	Label						^
Metadata	1								
E Legend	2		2						
말로 QGIS Server	3		3						
	4		4						Ŧ
	Mode Equal Interv	al 🔻						Classes 9 🐼	\$
	Classify							Legend Setting	s
	Style 💌					ОК	Cancel	Apply	Help

Figure 107 - Legend settings

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

Q Legend Settings					
Jse continuous	legend				
Labels					
Prefix					
Suffix					
Minimum	Default				
Maximum	Default				
Number format	Customize				
Text format	Font				
	(Applies to print layout legends only)				
Layout					
Orientation	Vertical				
Direction	Maximum on Top 💌				
	OK Cancel Help				

The Output layer is given below.



Figure 109: The Categorized Density layer

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".

Parameters Log	Reclas	sifv
Raster layer	by tab	le (
Density_interpolated [EPSG:4326]	This algorit	thm
Band number	raster ban	:a d by
Band 1	 assigning r class value 	iew s based
Reclassification table	on the range	jes
Fixed table (0x3)	specified in table.	атіхео
Advanced Parameters		
Reclassified raster		
[Save to temporary file]		
✔ Open output file after running algorithm		
0%	C	ancel

Figure 111 -Reclassify by table

Step 7.4 - Fill the reclassification table as given below.

Click on the following icon to open it.

Reclassify by Table		×		
Parameters Log	1	Reclassify		
Raster layer		by table		
Density_interpolated [EPSG:4326]	•	This algorithm		
Band number		reclassifies a raster band by		
Band 1	¥	assigning new		
Reclassification table		on the ranges		
Fixed table (0x3)		table.		
Advanced Parameters				
Reclassified raster				
[Save to temporary file]				
✔ Open output file after running algorithm				
0%		Cancel		
Run as Batch Process	Run	ose Help	Figure 112 - Fill th	e 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.)

🔇 Reclassify by Table						×
Parameters Log Reclassification tab	le			•	Rec by t	lassify able
Minimum	Maximum	Value	Add Row Remove Row(s) Remove All OK Cancel		This al reclass raster assigni class v on the specifi table.	gorithm sifies a band by ing new alues based ranges ed in a fixed
Run as Batch Process	0	%	Run	Clos	e (Cancel Help

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.

Parameters	Log			Reclassify
Reclassifica	ition table			by table
Minimu	m Maxim	Add Row	This algorithm reclassifies a	
1.0	1.9	1	Remove Row(s)	raster band by assigning new
2.0	2.9	2	Remove All	class values base on the ranges
3.0	3.9	3	ОК	table.
4.0	4.9	4	Cancel	
5.0	5.9	5		
6.0	6.9	6		
7.0	7.9	7		
8.0	8.9	8		
9.0	9.9	9		
		0%		Cancel
in ac Datch Drov	1000			

Figure 114: Reclassification table

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

Reclassify by Table		×
Parameters Log Raster layer	F	Reclassify by table
Density_interpolated [EPSG:4326] Band number Band 1 Reclassification table Fixed table (9x3) Advanced Parameters	• • • • • • • • • • • • • • • • • • •	his algorithm calcastifies a aster band by ssigning new ass values based n the ranges pecified in a fixed bble.
Reclassified raster		
✓ Open output file after running algorithm	Save	to a Temporary
0%		Cancel
Run as Batch Process	Run Close	Help

Figure 115 - Save to File

The output layer is given below.



Figure 116: The Reclassified density layer

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.



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



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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