CIVITAS 2020
Cleaner and better transport in cities

SUMP-PLUS

D1.6

Space Syntax Simplified Analytical Toolbox Manual

V.02

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Space Syntax

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Introduction

Overview

The Simplified analytical toolbox contains a **set of tools and processes that perform fundamental GIS operations on spatial data**.

As part of SUMP PLUS and through the collaboration on the city-led innovation labs, Space Syntax provided a set of analytical tools and developed a simplified workflow, suitable for most smaller cities who are developing sustainable mobility strategies, based on datasets that are typically available through open sources or through the municipalities.

The toolbox workflow can be **performed with relative ease and with limited availability of data**. It enables smaller cities and stakeholders working on a SUMP, to carry out and test their own spatial analysis. The workflow is structured to create **a simplified version of an Integrated Urban Model.**

The toolbox workflow is open-source and has been adapted for users of all skill levels (basic GIS knowledge required) **without the need to code or script.**

The Space Syntax simplified analytical toolbox workflow is an **iterative process**.

The six steps summarised in the diagram in the following page can be repeated as many times as needed to diagnose the existing conditions and test different scenarios.

The first steps provide guidance on how to collect, process, combine and visualise data, that addresses local SUMP priorities. The final steps focus on the interpretation of the analysis and further scenario testing.

A feedback loop is included in the process, allowing users to review modelling results and inform the optimisation of scenarios in an iterative process.

To implement the toolbox workflow, QGIS (2.14 or above), depthmapXnet and Space Syntax Toolkit for QGIS, are required, all of which are available as **open-source.**

How to use the manual

The manual is structured in chapters that **follow the six key steps of the toolbox workflow**.

Throughout the manual, there are **examples from the Platanias study**, highlighted in grey.

Links and references to supporting documents are provided in some steps, as required.

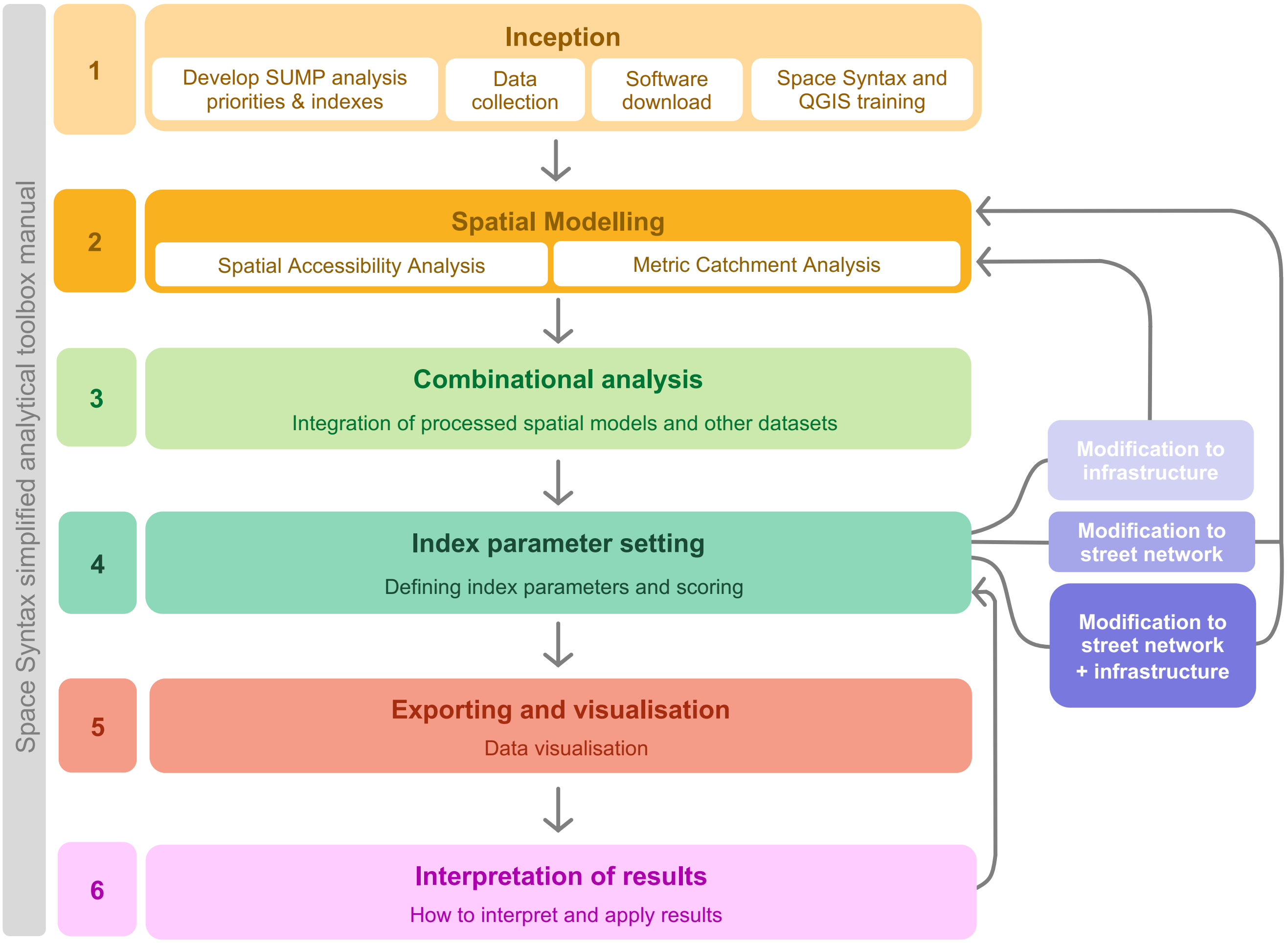
When carrying out the toolbox workflow, it is important to create an **accompanying spreadsheet**. This is to store data sources, index tables, abbreviations, fields names etc. This is useful to reference at any stage of the workflow. This can be done on a spreadsheet software, such as a Microsoft Excel.

Bibliography and references can be found at the end of the manual. This also includes information on where to access support from the Space Syntax research and education communities.

This document

This document provides a step-by-step technical and practical manual on how to build and implement the Space Syntax Simplified Analytical toolbox, described in D1.6.

D1.6 Space Syntax simplified analytical toolbox
Workflow



1. Inception
Development of priorities and indexes for the SUMP PLUS analysis, data collection, downloading required software, additional Space Syntax and QGIS training provision, as required depending on existing team skills.

2. Spatial Modelling
Production of the two key types of analysis, Spatial Accessibility Analysis (SAA) and Metric Catchment Analysis (MCA), using Space Syntax open-source tools.

3. Combinational Analysis
Integration of processed spatial models and other datasets to produce a combinational analysis of user-focused outputs.

4. Index parameter setting
Defining the index parameters and aggregating final scores for each index, based on the priorities set out in Step 1.

5. Exporting and visualisation
Visualisation of indexes in QGIS.

6. Interpretation of results
Evaluation of the results in the context of and to inform the development of SUMP measures. This helps to highlight the priority areas, the easy wins and the areas lacking in facilities or spatial accessibility.

Following the diagnosis of the existing conditions, scenarios can be tested and objectively compared and assessed through the scoring of the indexes (feedback loop in workflow diagram).

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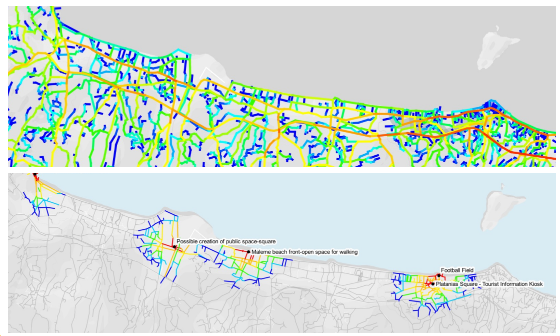
D1.6 Space Syntax simplified analytical toolbox

Workflow

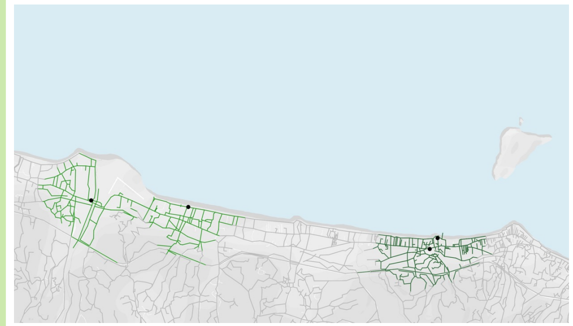
1 Inception

Data			Parameters	Priorities			
Data categories	**Data name**	**Data source**	**Spatial measures / variables**	**Walkability**	**Cyclability**	**Active travel**	**Sustainable tourism**
Road Centre Line model	OpenStreetMap data	Source	Vehicular accessibility				
			Pedestrian accessibility				
			Cycle accessibility				
Important and existing crossings	'Shared map'	Source	No. of important and existing crossings within 5min walk				
Existing car parking locations			No. of existing car parking locations within 15min walk				
Tourist attractions (active travel)			No. of tourist attractions (active travel) within 15min walk				
Other main tourist attractions			No. of other main tourist attractions within 15min walk				
Open space			No. of open space within 15min walk				
Social facilities			No. of social facilities within 15min walk				
Health facilities			No. of health facilities within 15min walk				
Primary schools and kindergartens			No. of primary schools and kindergartens within 15min walk				
High schools			No. of high schools within 15min walk				
Cycle path understudy			Access to cycle path within 5min cycle				
Bus stops	KTEL 'Bus stations/stops'	Source	No. of bus stops within 5min walk				
	KTEL 'BUS STOPS CHANIA-AGIA MARINA - PLATANIAS-KOLIBARI'	Source					
Hotels	OpenStreetMap data	Source	No. of hotels within 15min walk				

2 Spatial Modelling



3 Combinational analysis

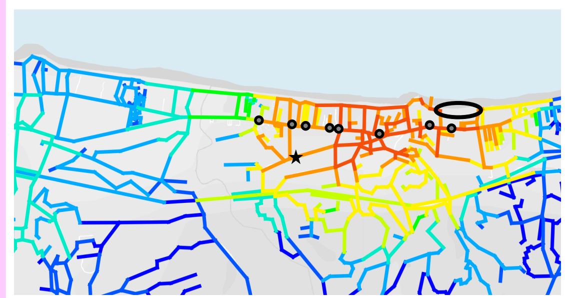


4 Index parameter setting

Segment ID	Vehicular accessibility	Pedestrian accessibility	Cycle accessibility	No. of important and existing crossings within 5 min walk	No. of bus stops within 5min walk	No. of existing car parking locations within 15min walk	No. of hotels within 15min walk	No. of tourist attractions (active travel) within 15min walk	No. of other main tourist attractions within 15min walk	No. of open space within 15min walk	No. of social facilities within 15min walk	No. of health facilities within 15min walk	No. of primary schools and kindergartens within 15min walk	Access to cycle path within 5 min cycle	No. of high schools within 15min walk	Walkability
1	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.172
2	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	0
3	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.357
4	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.403
5	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.421
6	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	5.144
7	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	4.891
8	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	4.924
9	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	4.92
10	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	4.927
11	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.915
12	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.089
13	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.3
14	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.346
15	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.334
16	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	5.513
17	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	0.433
18	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.212
19	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	1.162
20	0	1	0	1	1	0	0	0	0	1	1	1	1	0	1	0.768

5 Exporting and visualisation

6 Interpretation of results



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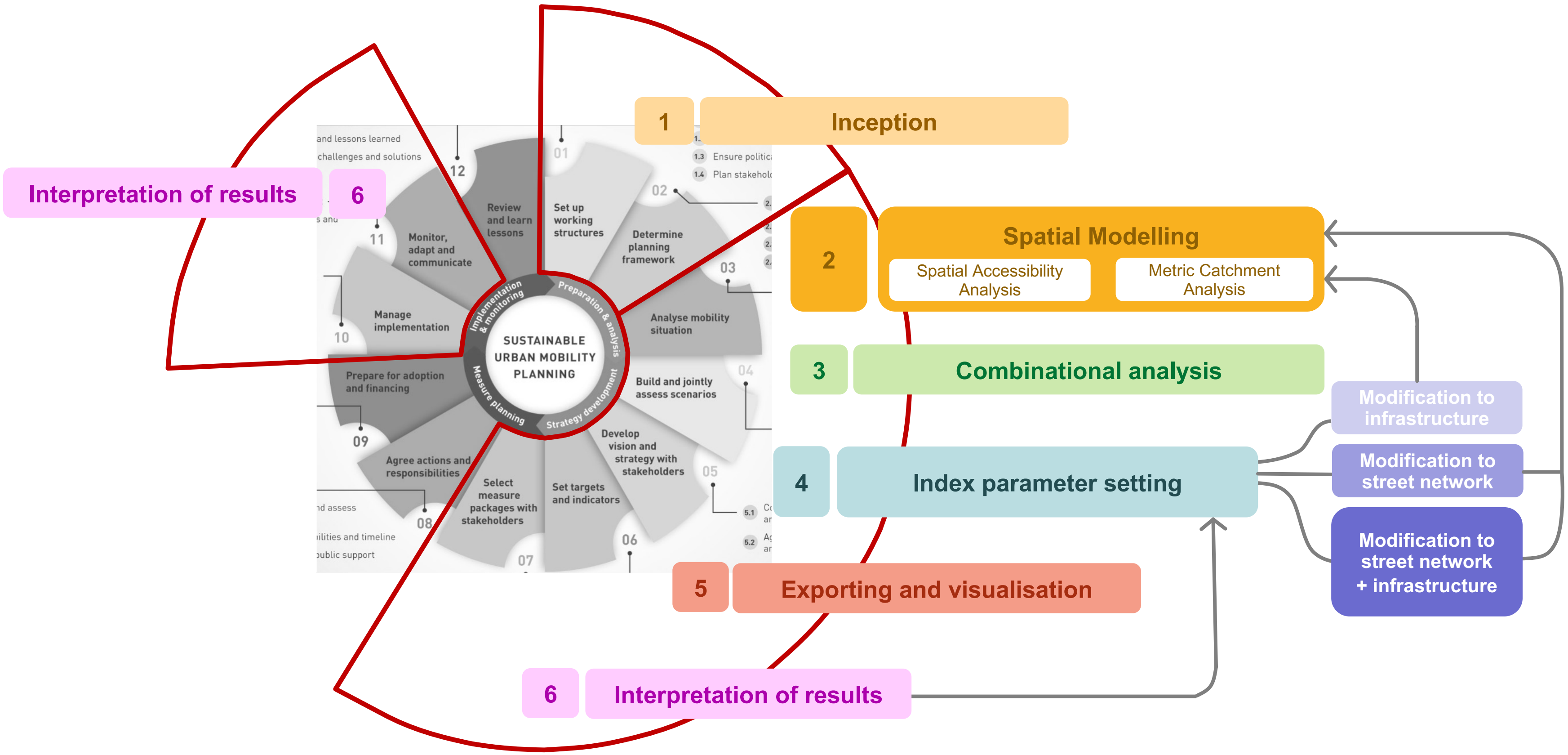
D1.6 Space Syntax simplified analytical toolbox
Alignment with the SUMP cycle



Simplified analytical toolbox

1. Inception

1. Inception

Development of priorities and indexes for the SUMP

The development of the priorities for the SUMP will define the indexes and their key parameters. **Depending on the priorities of the city for the SUMP, the indexes could include walkability, cyclability, active travel, sustainable tourism etc.**

This **will guide the process of the data collection and will define the parameters of each index** i.e. access to public transport, pedestrian infrastructure, amenities and social infrastructure etc. are important parameters for the walkability index.

Data Collection

Based on the priorities defined, the data collection focuses on relevant data availability.

The core data for the spatial analysis is a street network, often referred as a **Road Centre Line (RCL) model.** The **local government or city planning team** might have their own **public data directory** for downloading spatial data. Other open-source data packages can be found on **OpenStreetMap** and **Geofabrik**. Contributions and edits are community-maintained.

Once data and data packages have been identified, it is important to check files contain geographic properties. It is recommended to download data files in **GIS shapefile** format and **CSV (comma-separated values) files that have geographic information such as longitude (x), latitude (y) coordinate columns**.

Alternatively, if data is unavailable a desktop study can be created. Use **Google My Maps** to categorise and pinpoint locations, draw polygons and lines, which can later be imported as a **KML file** in to QGIS.

https://www.google.co.uk/maps/about/mymaps/

Software download

To implement the toolbox, QGIS (2.14 or above), depthmapXnet and Space Syntax Toolkit for QGIS are required. These are **open-source** and available to download:

QGIS (2.14 or above)

QGIS is an open-source software platform to perform a set of geographical information system (GIS) analysis. Download based on your operating system.

https://qgis.org/en/site/

Space Syntax Toolkit for QGIS

The plug-in can be installed from the **QGIS Plugins Manager**. It provides a front-end for the DepthmapX software within QGIS, for seamless spatial network analysis. Installing Space Syntax Toolkit is part of the process in step 2. A detailed explanation on the requirements and how to install it is on **page 15.**

depthmapXnet

This compiled version is used for the Space Syntax Toolkit analysis. Downloading depthmapXnet is part of the process in step 2. A detailed explanation on the requirements and how to download is explained on **page 25**.

An additional spreadsheet software, such as Microsoft Excel, is also recommended.

Space Syntax and GIS training

Whilst this document provides a detailed manual for the toolbox, additional resources are referenced. These cover the fundamentals of Space Syntax theory and techniques. Key resources are listed below:

UCL Space Syntax Online Training Platform (open-source)

Introduces the fundamentals of Space Syntax theory and provides a unified training resource for researchers and practitioners.

https://www.spacesyntax.online

Space Syntax YouTube channel

Introduction, keynotes and training videos on the Space Syntax approach

https://www.youtube.com/user/spacesyntaxdotcom

Space Syntax Training

Training packages for individuals and organisations in the use of the Space Syntax approach: from one-off executive training events to multi-session courses.

https://spacesyntax.com/training/

Documentation for QGIS 3.22

Official documentation of QGIS. Available in various languages and versions. Also available to download for offline reading.

https://docs.qgis.org/3.22/en/docs/index.html

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1. Inception

Development of priorities and indexes

Platanias example study

Data			Parameters	Priorities/ Indexes			
Data categories	**Data name**	**Data source**	**Metrics**	**Walkability**	**Cyclability**	**Active travel**	**Sustainable tourism**
Road Centre Line model	OpenStreetMap data	Source	Vehicular accessibility				
			Pedestrian accessibility				
			Cycle accessibility				
Important and existing crossings	'Shared map'	Source	No. of important and existing crossings within 5min walk				
Existing car parking locations			No. of existing car parking locations within 15min walk				
Tourist attractions (active travel)			No. of tourist attractions (active travel) within 15min walk				
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Bus stops	KTEL 'Bus stations/stops'	Source	No. of bus stops within 5min walk				
	KTEL 'BUS STOPS CHANIA-AGIA MARINA - PLATANIAS-KOLIBARI'	Source					
Hotels	OpenStreetMap data	Source	No. of hotels within 15min walk				

Having established the priorities for the SUMP, the parameters that are important for each index can be selected and relevant data categories, sources and metrics can be identified to quantify these.

The table shows an example of spreadsheet of SUMP priorities/ indexes and relevant data that define key parameters for each index, developed in Step 1. This creates the framework for the analysis and will be further developed in Step 4, to establish a score for each index.

The parameters and metrics used to quantify these can vary, based on the requirements of different cities and data availability. For example, other relevant land uses/ points of interest can be included; the walking distances can be adjusted to reflect different walking catchments i.e. 5-, 10-, 15-minute walk etc; different pedestrian accessibility radii can be used. Detailed description of the Spatial Accessibility and Metric Catchment Analysis is provided in Step 2 Spatial Modelling in this Manual.

At the end of the toolbox process, the relevant index parameters will be aggregated to provide a final score for each segment in a single spatial model (Step 4), will be visualised (Step 5), and will be used to highlight the current performance of the city, priority areas, areas for intervention etc (Step 6).

1. Inception
Data collection
Platanias example study

Data categories	Data name	Source	Format	Geometry type	Link to data source
Road Centre Line model	OpenStreetMap data	Geofabrik	Shapefile	Line	http://download.geofabrik.de/europe/greece.html
Important, existing and proposed crossings Existing, possible and foreseen car parking locations Bus transit centre proposal Tourist attractions (active travel) Other main tourist attractions Open space and possible open space creation Social facilities Health facilities Primary schools and kindergartens High schools Cycle path understudy	'Shared map'	Municipality of Platanias/Technical University of Crete	Keyhole Markup Language (KML)	Point	https://www.google.com/maps/d/u/0/edit?mid=1GKJAOZaJP6uu_KWRDutpcODsQYiQKtxc&ll=35.51841232632995%2C23.924795884530656&z=17
Bus stops	KTEL 'Bus stations/stops'	Municipality of Platanias/Technical University of Crete	Keyhole Markup Language (KML)	Point	https://www.google.com/maps/d/u/0/viewer?mid=1wWdZNUJvMGnznuiAARi2cvEKf-8&ll=35.508180921558605%2C24.00544294708256&z=15
	KTEL 'BUS STOPS CHANIA-AGIA MARINA -PLATANIAS-KOLIBARI'	Municipality of Platanias/Technical University of Crete	Desktop study	Point	https://www.e-ktel.com/en/tourist-guide/tourist-maps
Hotels	OpenStreetMap data	Geofabrik	Shapefile	Point	http://download.geofabrik.de/europe/greece.html
	Hotel accommodations municipality capacity	www.platanias.gr	PDF	N/A	https://www.platanias.gr/xenodochiaka-katalymata-dimou/

Create a project folder.

Create a subfolder called 'data' to save all the downloaded data.

The table shows an example of a list of data collected in the Platanias study.

It is recommended to create and maintain a similar list in an excel spreadsheet as a record for future reference.

Recording the data categories and their data source is useful to evaluate what data is available. This will then be used to help develop SUMP analysis priorities and indexes.

Simplified analytical toolbox

1. Inception

2. Spatial Modelling

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2. Spatial Modelling

Spatial Accessibility and Metric Catchment Analysis

This step produces the two key types of analysis Spatial Accessibility Analysis (SAA) and Metric Catchment Analysis (MCA) using Space Syntax open-source tools.

This will provide an understanding of the role of the spatial network in the mobility patterns at different scales and types of movement - vehicle, cycle, pedestrian - and the metric catchments of specific locations within the network.

This initial analysis highlights potentials and challenges in terms of active travel, purely based on the spatial characteristics of the street network and the location of specific points of interest.

Overview

The **Spatial Accessibility Analysis (SAA)** and **Metric Catchment Analysis (MCA) describe urban form characteristics, linked to the functional performance of a city.**

SAA and MCA are developed using the **Space Syntax Toolkit for QGIS**.

The following five tools from the Space Syntax Toolkit for QGIS are used to process the analysis:

- Road Network Cleaner
- Network Segmenter
- Graph Analysis
- Attributes Explorer
- Catchment Analyser

Spatial Accessibility Analysis

Spatial Accessibility measures key properties of the urban network, which can then be linked to the movement potential of an area for different scales. The Spatial Accessibility Model is based on a unique representation of publicly accessible streets and paths. The street pattern of an area is transformed into a network "graph". This is divided into individual "segments", each one being the street or path between two intersections. Each segment is then evaluated using a mathematical algorithm to calculate the relative spatial accessibility and hierarchy of the different parts of the network for different scales of movement.

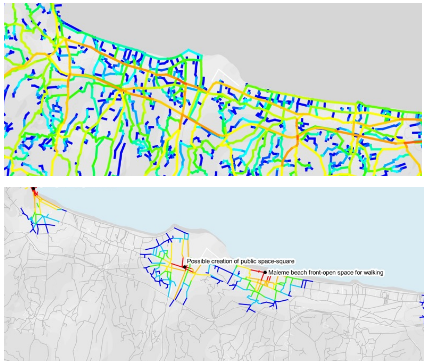
Two measures of spatial accessibility are typically used: **Integration** [1] measures the ease of access and identifies centres of potential activity and **Choice** [1] measures the passing flow potential and highlights which routes are most convenient for most journeys, depending on the scale of journey (as a proxy for transport mode). The two measures **reflect the two fundamental elements in human movement: firstly, the selection of a destination, and secondly, the selection of a route.**

[1] *Space Syntax Online Training Platform, Glossary,* https://www.spacesyntax.online/term/integration/ https://www.spacesyntax.online/term/choice/

Metric Catchment Analysis

The MAA measures the ease of accessibility of specific locations within the network for a specific metric distance. The analysis is used to assess which parts of the city are within a specific distance from key locations and points of interest (land use, infrastructure, transport node etc).

The street network is used to measure walking distances from these key locations/ points of interest. Metric distance is calculated and converted into walking time, where 400m are covered in 5 minutes (based on a conservative walking speed of 1.33m/s).



Examples of SAA (top) and MCA (bottom) visualisations.

2. Spatial Modelling

Installing Space Syntax Toolkit in QGIS

Installing Space Syntax Toolkit plugin in QGIS and relevant tools

Load QGIS

Select **Plugins > Manage and Install Plugins…**

In the 'Plugins' window type **'Space Syntax Toolkit'** in the search bar. Select the toolkit from the list and **Install Plugin**. (Figure 1)

The toolkit icons will appear in the QGIS toolbar. (Figure 2)

The following **five tools from the Space Syntax Toolkit plug-in** will be used:

1. Graph Analysis

Performs Space Syntax analysis by remotely connecting to Depthmap.

2. Attributes Explorer

Visualises results of the analysis and explores basic statistics.

3. Road Network Cleaner

Simplifies OpenStreetMap Road layer to Space Syntax Segment Maps.

4. Network Segmenter

Segments the model.

5. Catchment Analyser

Performs Metric Catchment Analysis. Cost variable can be changed.

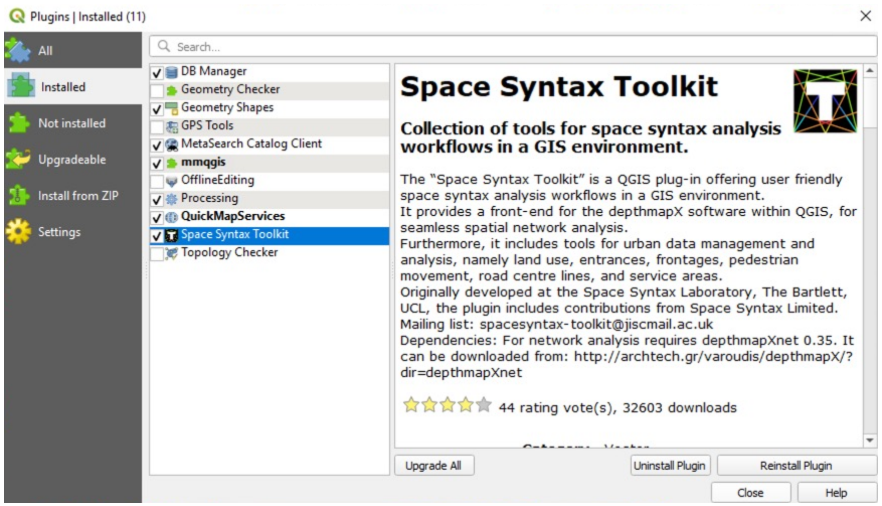


Figure 1. Installing Space Syntax Toolkit in QGIS Plugins

Space Syntax Toolkit in QGIS

Figure 2. Space Syntax Toolkit tool icons in QGIS

2. Spatial Modelling

Importing OpenStreetMap/ Road Centre Line model

Importing OpenStreetMap layer or Road Centre Line layer into QGIS workspace and specifying Coordinate Reference System (CRS).

Load QGIS and create a new project (workspace). **Save the workspace to the main project folder.**

Select the **Current CRS** button, at the bottom right hand side of the workspace (Figure 3).

Specifying the project CRS

Untick No CRS and type in the Filter the area grid name. Always select the correct ESPG from Predefined Coordinate Reference Systems, in **Projected Coordinate Systems under Transverse Mercator** list. Do not select projections from the other lists. Use the preview window as a guide.

If you cannot find the right ESPG, use https://epsg.io or https://spatialreference.org for reference.

Select **Apply** and **OK**.

In the example of Platanias study, the project CRS is GGRS87 / Greek Grid ESPG: 2100

Adding the OpenStreetMap or Road Centre Line data.

Select **Layer > Add Layer > Add Vector Layer…**

Locate the OpenStreetMap or Road Centre Line layer, in Browse from the project data folder. Select **Add**.

All OpenStreetMap datasets are projected in a world CRS (WGS 84) which is a geographic CRS for the whole world. If you look at the map, it may look slightly distorted. This layer needs to be reprojected, in order to use the project CRS defined earlier (GGRS87 / Greek Grid ESPG: 2100 in the Platanias study)

It is recommended that all layers in your workspace are saved with the same CRS. To do that for OpenStreetMap or RCL layer

select **Layer > Save Vector Layer as…**

Select **ESRI Shapefile** format

Browse '…' to select the desired location.

Create a subfolder called 'shapefile' There you will save all the shapefile layers related to the project workspace.

Save as 'osm_roads_georef'

Select the project CRS from the CRS list (GGRS87 / Greek Grid ESPG: 2100 from the Platanias study)

Tick **Add saved file to map.**

Remove the original OpenStreetMap layer.

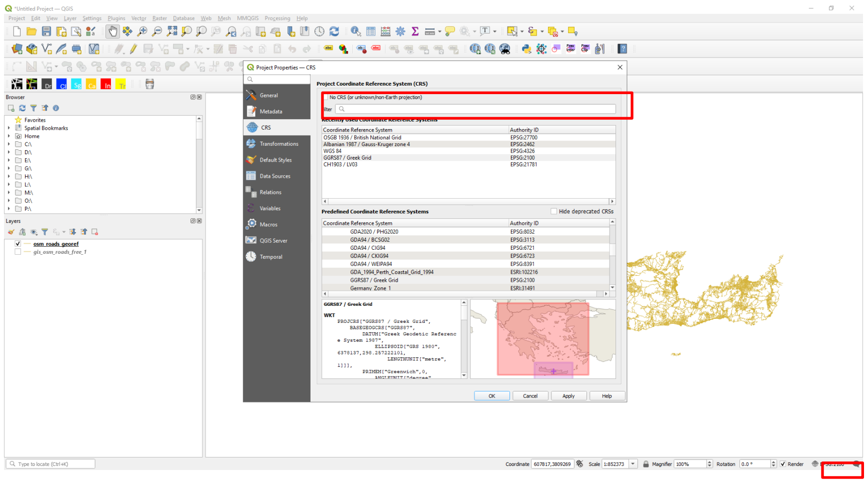


Figure 3. Project Properties – CRS window

2. Spatial Modelling
Simplifying and cleaning the model
Road Network Cleaner

Using the Road Network Cleaner tool to clean topological errors and simplify angular changes in the model.

This generates a cleaned line model layer and an unlinks[1] layer, based on the principles of an axial map[2].

Run the Road Network Cleaner with the appropriate settings (Figure 4).

Specify **input layer.** This the reprojected OpenStreetMap **osm_roads_georef** or Road Centre Line model.

Select **data source** to apply default settings and **edit default** settings if necessary.

Select **output type shapefile** and **browse '…'** to select location. Rename to **spm_ex_cl**

Select to **load unlinks**. Unlinks are automated points. They disconnect two axial lines intersecting on the axial map, that are not directly connected in reality, such as a road bridge crossing the road.

Select to **load errors**. The errors highlight where angular changes were simplified, and where parallel lines have been merged into a single line.

Then select **Run**. The new layers will appear in the Layers panel.

The Road Network Cleaner **outputs** (Figure 5), will have three elements:

1. — A typologically cleaned map, layer name ending **_cl** (polylines angularly simplified and parallel lines merged into a single line towards the principles of an axial map)
2. Unlinks with layer name ending **_cl_u** (blue points)
3. The topological errors that have been fixed layer name ending **_cl_errors** (pink points)

[1] *Space Syntax Online Training Platform, Glossary, https://www.spacesyntax.online/term/axial-unlink/*

[2] *To learn more about axial map and the representations of space, see Space Syntax Online Training Platform. https://www.spacesyntax.online/applying-space-syntax/urban-methods-2/representations-of-space/*

Space Syntax Toolkit in QGIS

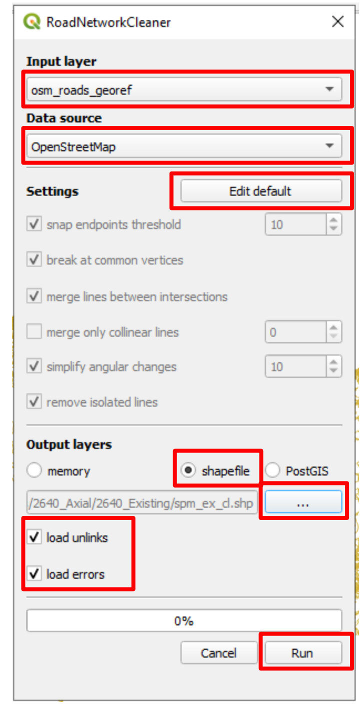


Figure 4. Road Network Cleaner window

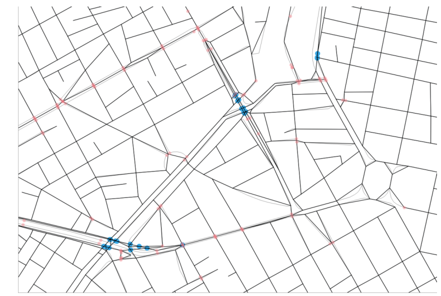


Figure 5. Road Network Cleaner outputs

2. Spatial Modelling

Checking and editing the primary (foreground) network

Checking and editing the primary network and unlinks file in the cleaned spatial model.

This ensures that the key routes/spaces are represented correctly and no key routes are missing.

Modelling axial lines

Axial or road-centre lines must be the **longest and fewest lines necessary to represent spaces in a model**.

The segment map should have:

- The **fewest possible segments** to avoid redundant representation of spaces
- The **smallest angular changes between segments** to minimise angular changes between spaces.

To accomplish that you **MUST model primarily as axial lines**. However, if there is an existing intersection snap the axial line to intersection to avoid creating unnecessary trivial rings.

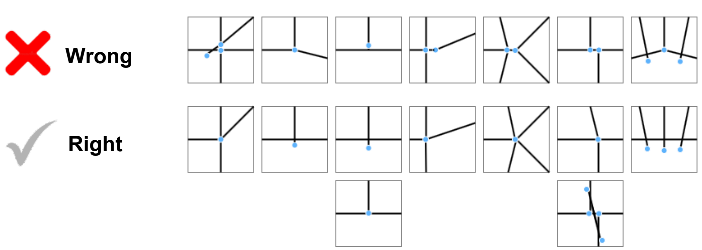


Figure 6. Conventions of modelling axial lines

Key conventions of modelling, using axial lines are shown in Figure 6.

- Lines should be drawn as **straight as possible**.
- **Avoid creating small lines** that add more segments in a graph. Space in the model should not be over-represented. If a route or direction in space can be replaced completely by following other segments, with no important angular cost added, it means that specific segment is not necessary in the model.
- **Simplify angular changes** between segments and prioritise the foreground over the background network. Unnecessary acute angles will increase the cost in calculations based on angular distance.
- **Do not draw polylines.** Lines should have only 2 endpoints.
- **Map needs to be segmented afterwards** (see p.21).

Updating the foreground network (primary spatial network)[1]

The foreground network of the model and the unlinks should be checked and manually updated, as required, following the key principles and conventions of modelling axial lines.

To make edits, **always save a copy of the cleaned model and unlinks layer** created in the previous step. Create a copy called **spm_ex_cl_edited** and **spm_ex_cl_u_edited**

1. Prepare a background map

- Use an OpenStreetMap background in OpenLayers plugin (Web > OpenLayers plugin > OpenStreetMap > OpenStreetMap) and follow the primary network (i.e long routes though the city).
- You can also use QuickMapServices plugin (Settings – Get contributed pack)
- Use road classification information to highlight the primary network (if present)
- Use Google Street View if necessary.

Check how the project CRS changes, as it attempts to adjust between different layers CRS. **You do not need to change the projection of OpenStreetMap raster layer.** If you remove the layer, you can change the project CRS.

Move the OpenStreetMap raster layer to the bottom of your Layer panel.

You can also add any **basemap data layers** that you may have for visualisation. Open-source OpenStreetMap Geofabrik region folder downloads usually contain a zip folder of buildings, railway tracks, water etc. If they are up to date and applicable for the project, make sure when the layers are imported into the workspace they are resaved with the project CRS.

2. Check and edit, as required, the primary spatial network (see key editing tools on p.20)

- Model as axial lines.
- Simplify parallel lines.

3. Check and edit, as required, unlinks (points – snap to intersection – 1m buffer) (see key editing tools on p.20)

- Model as points.
- Snap to intersection.
- Use 1m buffer.

If the foreground has a very big number of representational errors, it is easier to redraw it from scratch.

[1] *To learn more about the **foreground network**, visit the Space Syntax Online Training Platform.*
https://www.spacesyntax.online/term/foreground-network/

2. Spatial Modelling

Checking and editing the secondary (background) network

Checking and editing the secondary network in the cleaned spatial model.

Updating the background network (secondary spatial network)[1]

The checking/ editing of the background network should be focused within a specified distance from the project site/ study area. **This depends on the local radius of the analysis.**

1. **Prepare a background map**

- Use an OpenStreetMap / Google Maps background from OpenLayers / QuickMapServices plugin.
- Use Google Street View if necessary.
- Go for a site visit (if possible).

2. Create a site point layer to set the centre of the site/study area

- Select Layer > Create Layer > New Shapefile Layer
- Click on Browse '…' and locate the project folder. Save as 'site_point'
- Select 'Point' as Geometry type.
- Select the project CRS.
- Select OK.

- In the Maps workspace, find the point of the centre for the analysis. This can be the centre of the site/study area.

- To add a point, select the 'site_point' layer and click on the **Toggle Editing** then **Add Point Feature**.

- Left click the centre of the study area in the workspace, then click 'OK' in the Feature Attributes window.

- Click the Toggle Editing button in the toolbar to save the layer. Click Save button to save the workspace.

3. Buffer the site point by double the radius of your local analysis.

- To create a radius buffer, select
- **Vector > Geoprocessing Tools > Buffer…**
- Select 'site_point' as the **Input layer**. The **Distance** is double the radius of your local analysis. In the example Platanias study,the local analysis radius was (pedestrian accessibility) was 1200m or15min-walk, therefore, the buffer for this was 2,400m.
- **Type the value in metres.**
- Select 'Run'.

The temporary Buffered layer will appear in the Layers panel. To save, select the temporary layer in the Layers panel and select Layer > Save As…

The 'Save Vector Layer As…' window will appear.

Select 'ESRI Shapefile' as the Format.

Select the project CRS.

Click on the Browse '…' button and locate the project folder. Save as 'site_point_*distance*_buffer'.

Move this layer below the network model in the Layer panel.

Delete the temporary Buffered layer.

4. Check and edit spatial network within the buffer (see key editing tools on p.20).

- Start modelling from the site and towards the edge of the buffer
- Model as axial lines.
- Simplify angular changes of existing lines.
- Simplify lines that over-represent spaces.
- Add lines where connections are missing.
- Delete connections if they no longer exist.
- Edit unlinks if necessary.

[1] *To learn more about the* ***background network****, visit the Space Syntax Online Training Platform.* https://www.spacesyntax.online/term/background-network/

2. Spatial Modelling

Model editing tools in QGIS

Editing

Drawing tools

Select the layer and click **toggle editing** to start editing the layer. When in editing mode, you can use the following tools:

Add Feature To add missing connections or redraw lines.

Delete Selected To delete connections that no longer exist and in order to redraw them.

Node Tool To change the alignment of a line.

Save changes frequently.

Make sure you Save Layer Edits as frequently as possible, as QGIS might crash.

Common errors:

Points & NULL geometries

- **Coinciding points**: While using the node tool, if you double click a **node** you will make a coinciding point with no length. You can manually check for these using **select by expressing** running **$Length = 0**

- **NULL geometries**: using the node tool you might also create invalid geometries. You can select them using **select by expression** running **$geometry is NULL** and delete them.

Snapping settings

Snapping settings are extremely important to avoid creating disconnections in your model.

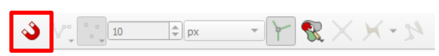
Snapping options can be found in Project > Snapping Options…

Follow the rules below.

Never snap to segment or to segment and vertex as it creates disconnections.

Axial model

Snap to **Off**



Snapping is disabled

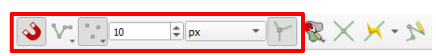
Segment model

Layer selection **Active Layer**

Snap to Vertex

Tolerance 10.00 px

Enable Topological Editing



Use Enable Topological Editing setting to check if all lines are snapped to an intersection

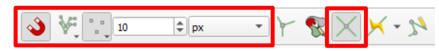
Unlinks

Layer selection **All Layers**

Snap to Vertex

Tolerance 10.00 px

Enable Snapping to Intersection



2. Spatial Modelling
Segmenting
Network Segmenter

Segmenting the model using the Network Segmenter tool.

This tool **breaks the lines of the axial model** (including manual edits from previous step) **into segments** (a line between two intersections). It also performs various other validation procedures in preparation for the analysis.

Run the Network Segmenter and change the settings accordingly (Figure 7):

Input layer, select the updated, simplified and cleaned layer from the previous Modelling step. This is **spm_ex_cl_edited.**

Unlinks layer & **unlinks buffer** (use 1m), select the unlinks layer produced from the simplified and cleaned layer and updated in the previous Modelling stage. This is **spm_ex_cl_u_edited**

Make sure **remove stubs box is ticked**

Select **output type shapefile** and **browse '…'** to select location. Rename to **spm_ex_seg**

Tick to **load break points** (recommended to check invalid unlinks).

After processing, the outputs from the Network Segmenter (Figure 8) will load into the Layers panel:

Segment map layer name ending with **_seg**

Break points layer name ending with **_seg_breakpoints**, containing:

- **Break points**: the points where the lines have been segmented
- **Stubs**: specify in which cases these endpoints are removed (when > 40% of the total length)
- **Invalid unlinks**: specify in which cases they are invalid and how to fix each case

Invalid unlinks must be checked and fixed. Invalid unlinks can be:

- unlinks outside the buffer threshold
- unlinks intersecting more than 2 lines, no line or only 1 line

Resave a copy of the **spm_ex_cl_u_edited** unlinks layer.

Rename the layer **spm_ex_seg_u.** Check and fix invalid unlinks accordingly to the _seg_breakpoints layer.

Space Syntax Toolkit in QGIS

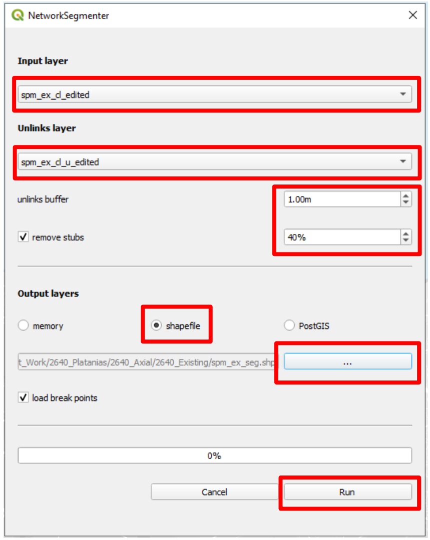


Figure 7. Network Segmenter window

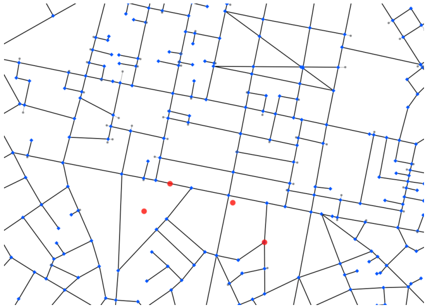


Figure 8. Network Segmenter outputs

2. Spatial Modelling

Verifying the model

Graph Analysis

Verifying the segment model to check for errors using the Verify tab in the Graph Analysis tool before processing the model.

Common errors include: island; orphan; invalid geometry; small line; short line. All errors need to be fixed before processing the model.

Model verification

To run the **verification**(Figure 9):

1. Open the **Graph Analysis** tool in Space Syntax Toolkit, select the **Map** tab and **Verify layer** tab
2. Select the **network layer** (layer name **spm_ex_seg**), **untick** Segment map or road centre line and select **Verify**
3. Go through all errors and fix them one by one. Common errors include: island; orphan; invalid geometry; small line; short line.

Edit or delete islands, orphans and invalid geometries. Manually connect small and short lines. **If there are hundreds of short lines, run the model with Road Network Cleaner with only 'snap endpoints threshold' selected.**

Repeat the verification process, until no errors left.

Space Syntax Toolkit in QGIS

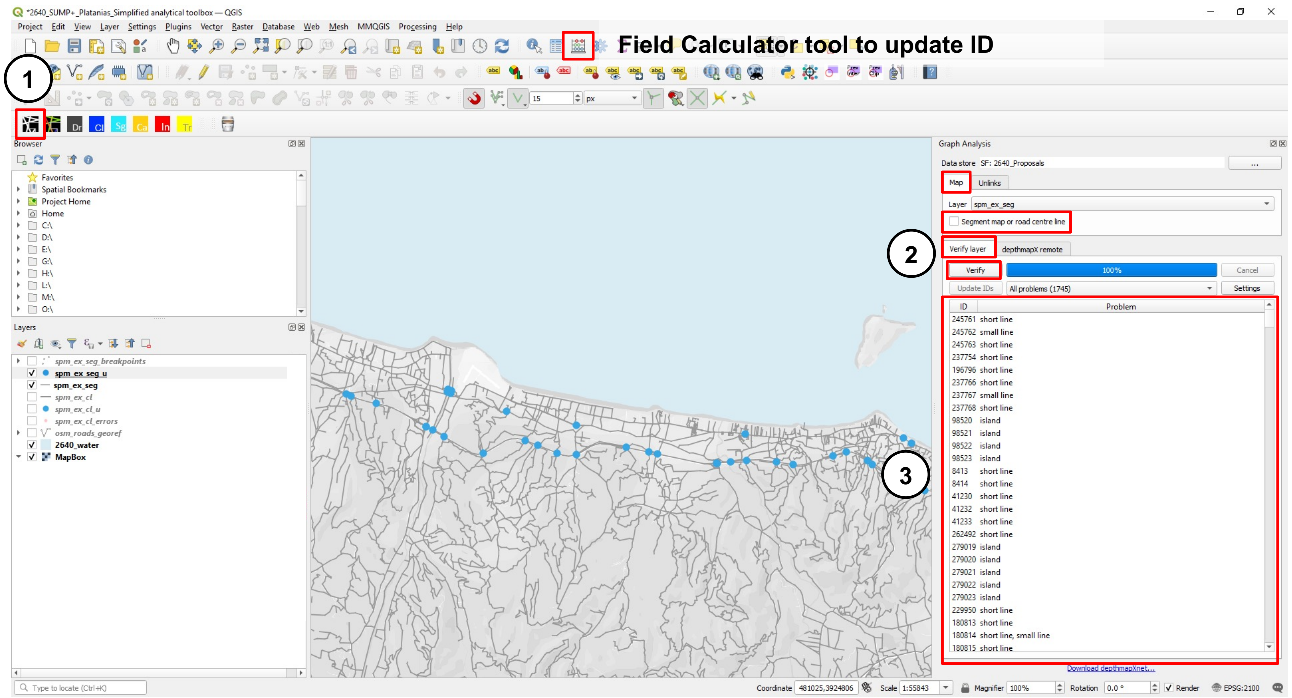


Figure 9. Axial map verification using Graph Analysis tool

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2. Spatial Modelling

Verifying the model

Graph Analysis

Once all the errors have been fixed, update the IDs with the **Field Calculator** tool.

To update IDs (Figure 10):

1. Select the layer in the Layers panel and select **Field Calculator** in the toolbar. The Field Calculator window will appear.
2. Select Create a new field.
3. In the Output field name, type ‘id’
4. Select the Output field type as ‘Whole number (integer)’
5. Double click row_number under Variables in the Functions list, or type **@row_number** into the Expression box.
6. Click OK.
7. Click Toggle Editing in the workspace toolbar to save the layer.

Field Calculator tool

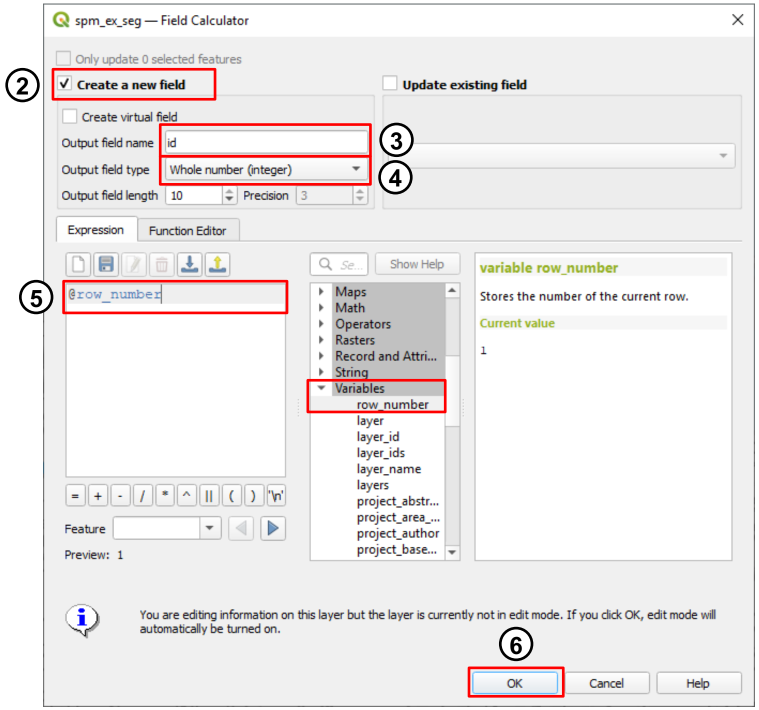


Figure 10. Update segment IDs using the Field Calculator

2. Spatial Modelling
Verifying the unlinks
Graph Analysis

Verifying the unlinks to check for errors using the Verify tab in the Graph Analysis tool before processing the model.

Unlinks verification (Figure 11)

1. Open the Graph Analysis tool in Space Syntax Toolkit, select the **Map** tab and **Verify layer** tab

2. Select the network layer (layer name **spm_ex_seg** with no errors and updated IDs)

3. Select the **Unlinks** tab, and select the corresponding unlinks layer (layer name **spm_ex_seg_u** checked and fixed with manual editing and Network Segmenter)

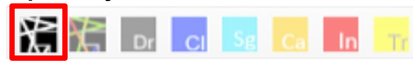
4. Select the **Settings** button to change the verification settings.

Unlink crossing threshold is used to buffer a point on an intersection (recommended 1m). **Use the same unlinks crossing threshold as the unlinks buffer in the Network Segmenter.**

5. Click Update IDs the first time you run the unlink verification. The ids of the unlinked lines are stored in attributes called line1 and line2. The first time unlinks verification runs, it checks if the line1 and line2 attributes are present. If these attributes are missing the user is asked to run Update IDs to assign the id of the lines at the intersection identified by each unlink.

6. Go through the errors and fix them as suggested in the Table 1, on the right.

Space Syntax Toolkit in QGIS



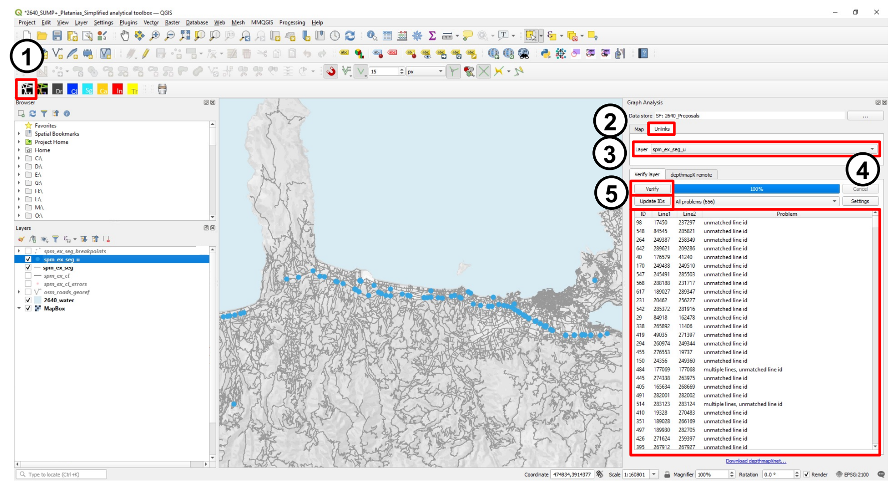


Figure 11. Unlinks verification – verify and update unlinks ID using Graph Analysis tool

Error	Fix
Multiple lines Single lines No lines	Move the unlink to the intersection of two lines. If not relevant delete them
Same id	Click Update IDs
Unmatched id	Click Update IDs

Table 1. Type of ID errors and how to fix the errors

2. Spatial Modelling
Processing
Graph Analysis

CIVITAS
Cleaner and better transport in cities
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Using the Graph Analysis tool to process the model and produce the Spatial Accessibility Analysis (SAA)

The results must be visualised and validated after the analysis is finished.

Downloading and opening depthmapXnet

Download depthmapXnet from the link at the bottom of the Graph Analysis tool (Figure 12).

Unzip the depthmapXnet folder, and open the **depthmapX application**.

This application **needs to be open in the background in order to run** Graph Analysis.

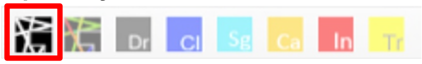
Once opened, you do not need to do anything in depthmapX.

Running the Graph Analysis in QGIS

In QGIS, run Graph Analysis and change the settings accordingly (Figure 12):

- In the map tab, select the segmented layer to be analysed. **The map MUST be already segmented.** This is the verified layer name **spm_ex_seg**
- Tick **segment map or road centre line**.
- In the unlinks tab, select the unlinks layer. This is the verified layer name **spm_ex_seg_u**
- In the **depthmapX remote** tab, type in the analysis radii (typically **1200, 5000, 10000,** see Standard Measures Table 2, on the right) and change the **output table** name (use _p)
- Click **Calculate**.

Space Syntax Toolkit in QGIS



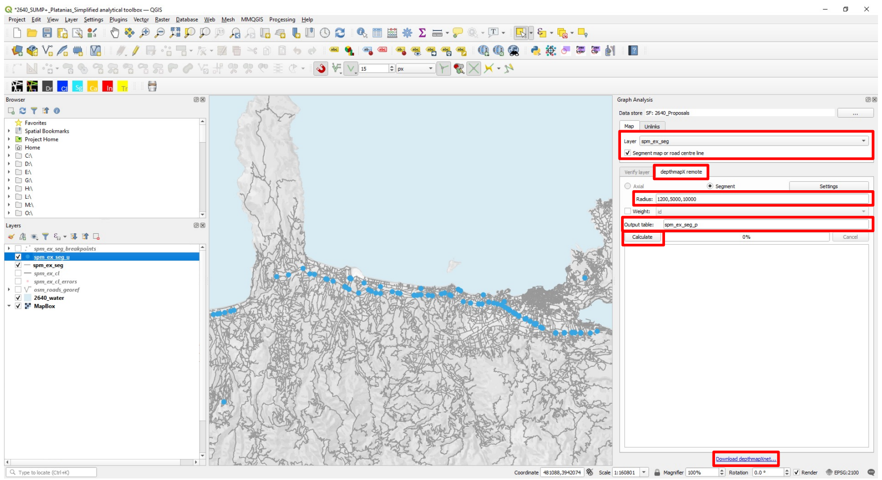


Figure 12. Select layers and change settings to process a model for angular segment analysis using Graph Analysis tool

Radius (m)	Metric
400	Pedestrian Accessibility (5min walk)
800	Pedestrian Accessibility (10min walk)
1,200	Pedestrian Accessibility (15min walk)
2,000	Pedestrian Accessibility (20min walk)
5,000	Cycle Accessibility
10,000	Vehicular Accessibility

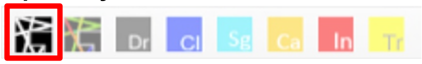
Table 2. Spatial accessibility standard measures

2. Spatial Modelling
Processing
Graph Analysis

A message will appear when processing is completed (Figure 13).

The processed shapefile will automatically be added as a new layer in the workspace.

Space Syntax Toolkit in QGIS



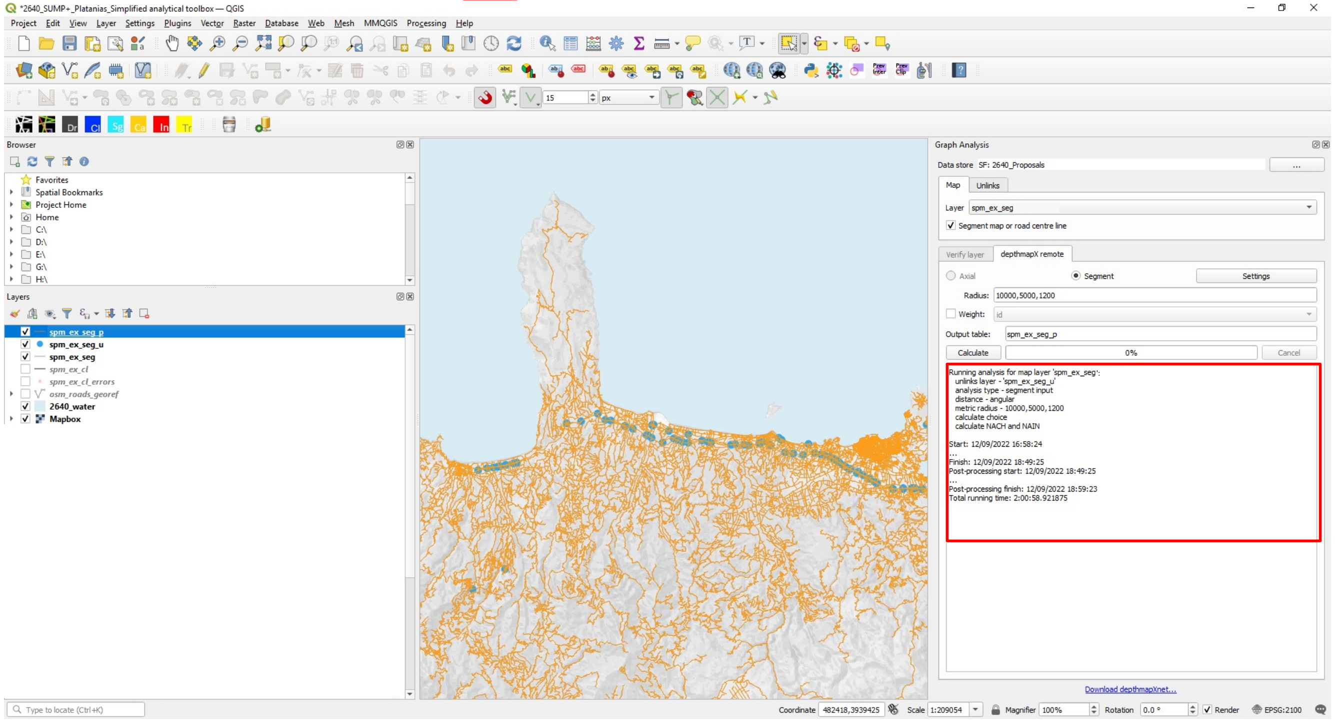


Figure 13. Processed angular segment analysis

2. Spatial Modelling

Spatial Accessibility Analysis visualisation

Attributes Explorer

Using the Attributes Explorer to visualise the Spatial Accessibility Analysis.

Click the Attributes Explorer tool in the Space Syntax Toolkit.

Select the processed layer from the drop down list, and select Refresh.

The processed map will immediately get visualised, using a default style.

In Numeric attributes, scroll down till you reach the NACH measures. (Figure 14) Click on NACHr10000m. The processed map will be visualised to show the result of NACHr10000m.

In the Symbology tab, select **Classic** colour range. Change the Width / Size to **1.00**.

Click on **Apply Symbology** to apply the selected style.

Right click the layer in the Layers panel and select **Properties…**

In the Layers Properties window, change the **Classes from 10 to 16 (Figure 15)**.

Space Syntax Toolkit in QGIS

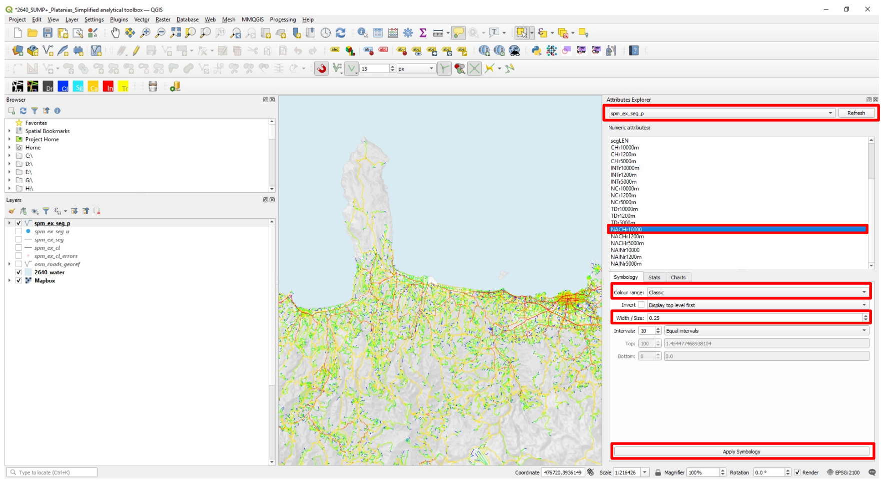


Figure 14. Using Attributes Explorer tool to visualise the processed map

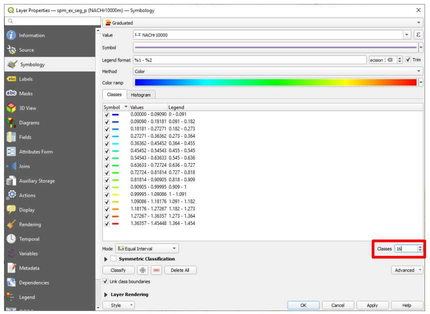


Figure 15. Layers Properties window to adjust Classes

2. Spatial Modelling

Spatial Accessibility Analysis visualisation

Standard ranges

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Applying the Spatial Accessibility Analysis standard ranges for visualisation.

To set up the standard colour ranges (for NACH measures only), double click on Values and change each range to have the specific values shown in Figure 16.

Select **Apply** to apply the standard colour ranges.

Save the style for future use, by selecting **Style > Save Current Style…** to open the Save Layer Style window.

In the Save Layer Style window, click on the **Browse '…'** button and locate the project folder.

The standard colour ranges for Spatial Accessibility Analysis (NACH measures only) is now saved.

The style can be loaded from the file location, by **Style > Load Style…**

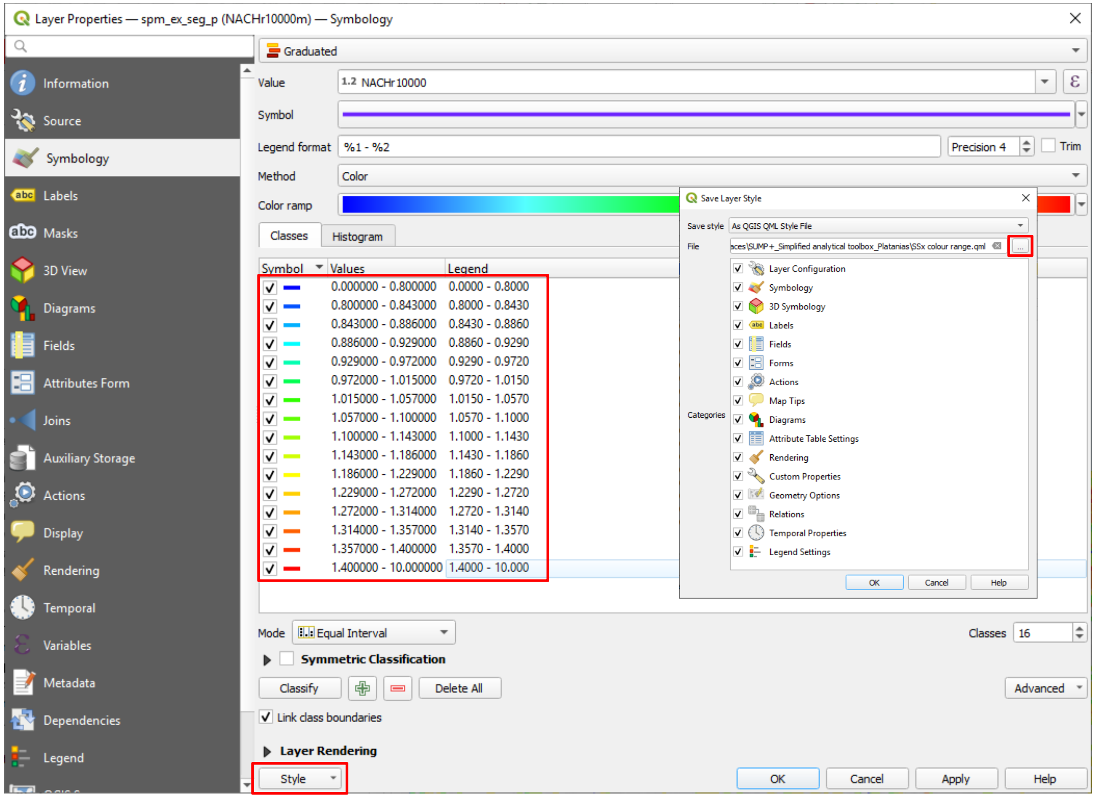


Figure 16. Layer Properties and Save Layer Style window to set up Spatial Accessibility Analysis standard colour range

Attributes Explorer (Optional)

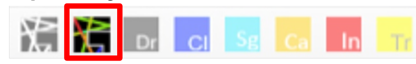
Using the Attributes Explorer to explore statistics for selected measures and to create charts.

There are statistical features in the Attributes Explorer. They can be exported as part of data analysis and documentation in step 5.

Stats

Click the **Stats** tab. A statistical summary for the selected measure are displayed. (Figure 17)

Space Syntax Toolkit in QGIS



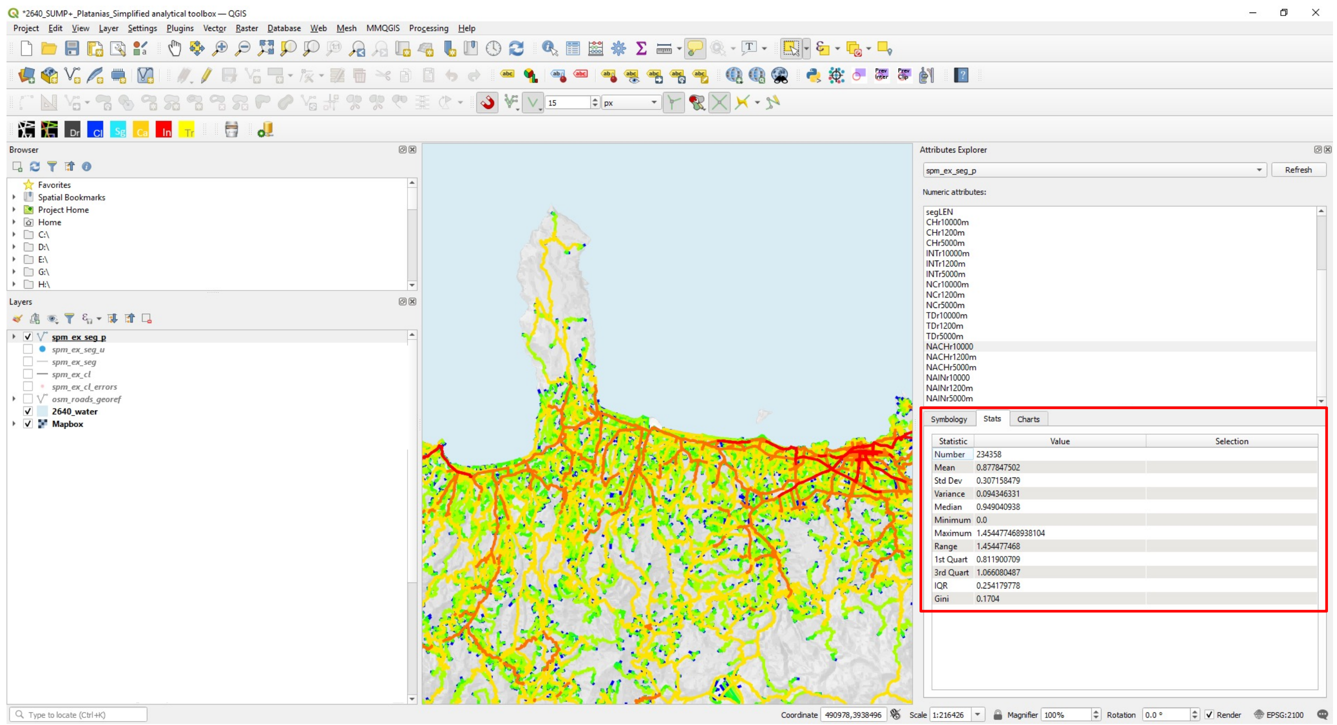
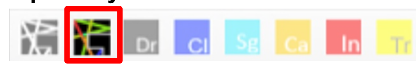


Figure 17. Using Attributes Explorer tool to explore the statistical summary of selected measures

2. Spatial Modelling
Statistics
Attributes Explorer (Optional)

Charts

Space Syntax Toolkit in QGIS



Histogram

Click the **Charts** tab. Select Histogram.

Histogram of the distribution of the values of the selected measures is displayed. Mouse scroll button can be used to zoom in and out. (Figure 18)

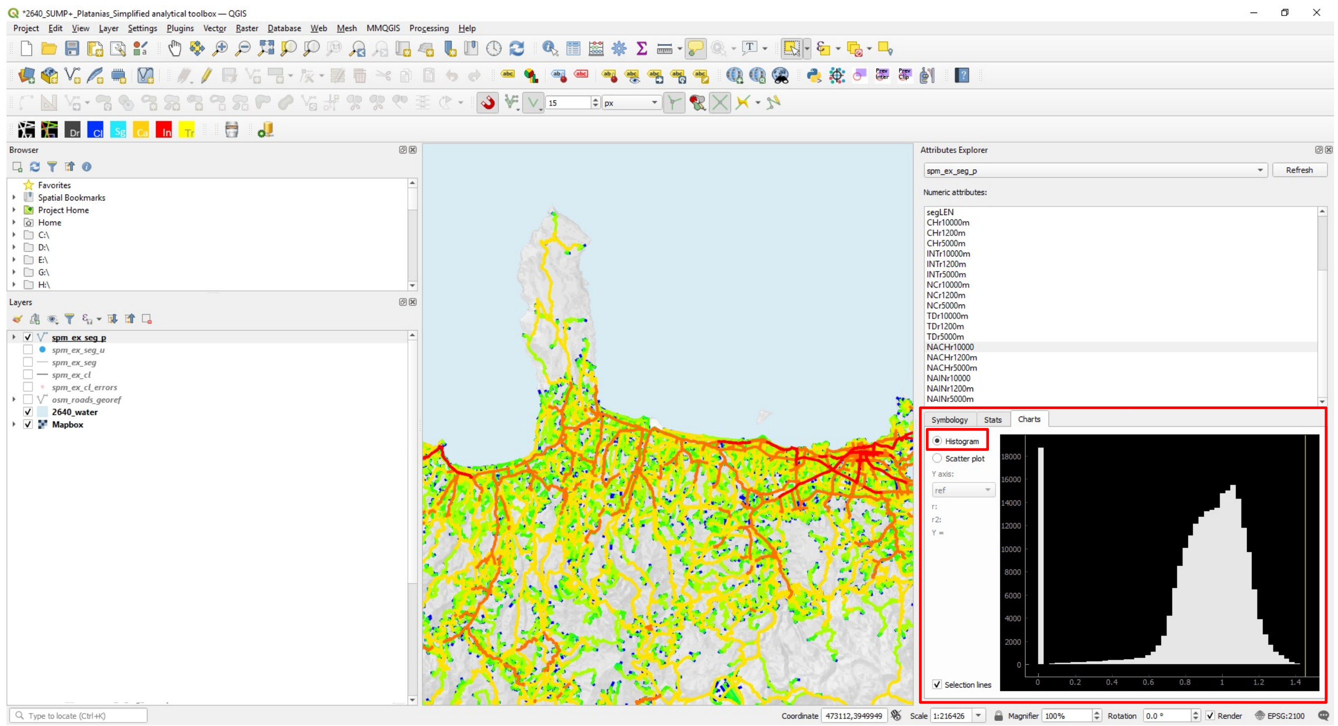


Figure 18. Using Attributes Explorer tool to explore the histogram distribution of selected measures

2. Spatial Modelling

Statistics

Attributes Explorer (Optional)

Scatter plot

Choose first measure (x axis) from the Numeric attributes.

Select Scatter plot in the Charts tab. (Figure 19)

Choose the second measure in Y axis.

The scatter plot will automatically update, with calculated correlations. They are:

r -Pearson's coefficient

r2 - linear regression

Line formula

Select Regression line to display the regression line on the scatter plot.

Use the mouse scroll button to zoom in and out of the scatter plot.

Click the 'A' at the bottom left corner to return to default zoom.

To save the charts, right click the graph area.

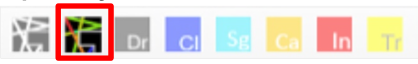
Click on Export…

The Export window will open. Select File format to save image.

Change Export options, such as background colour, according to preference.

Click Export.

Space Syntax Toolkit in QGIS



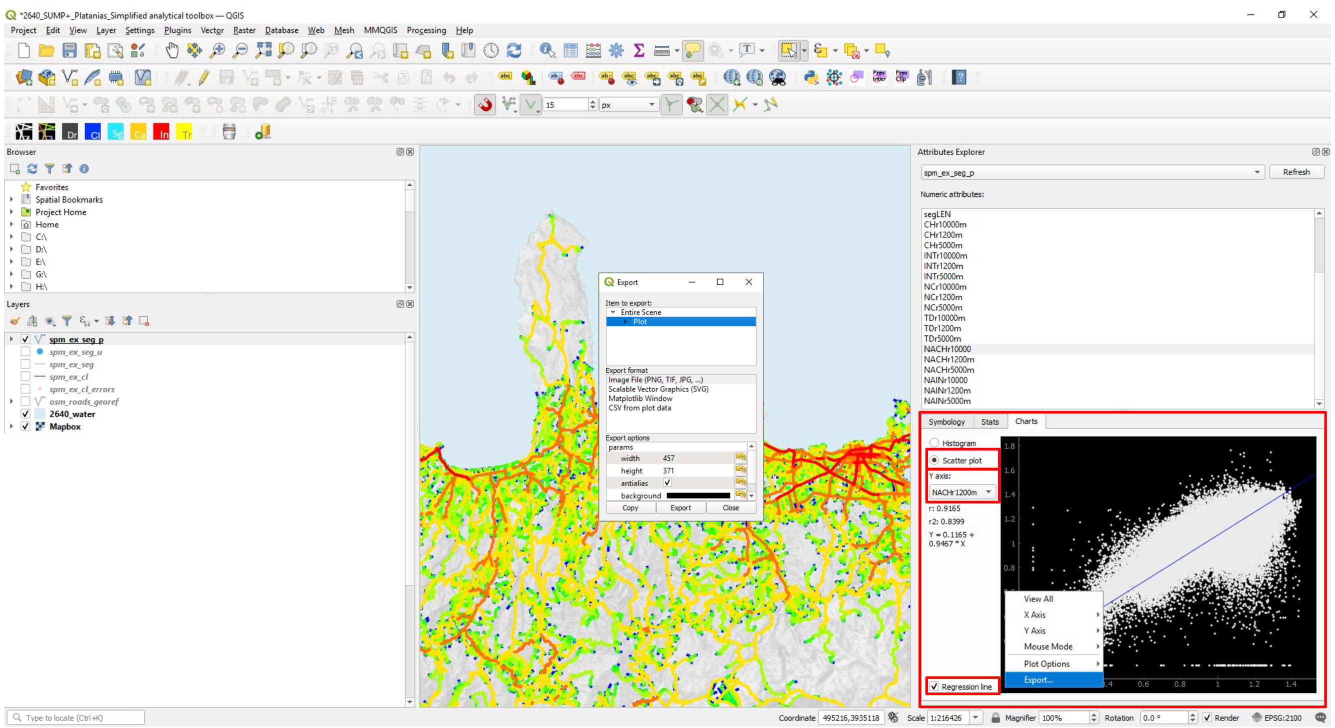


Figure 19. Using Attributes Explorer tool to explore and export scatter plot correlations between two measures

2. Spatial Modelling
Metric Catchment Analysis
Catchment Analyser

Using the Catchment Analyser tool, to produce the Metric Catchment Analysis from various points of interest.

The analysis uses the street network to assess which parts of the city are within a specific distance from key locations and points of interest (land use, infrastructure, transport node etc).

To run metric catchment analysis, import in the workspace all relevant parameter layers identified in Step 1 Inception, i.e. specific types of land uses, social infrastructure, open spaces, pedestrian and cycling infrastructure, transport etc. These will be the origins for each metric catchment analysis.

The origin layers need to be a point geometry type layer in order to run metric catchment analysis. If any of the variables have geometry type that are polygon or polyline/line, then follow the next steps to **convert to points**.

An example of data with polygon geometry type could be the land use data, often using the building polygons.

Another example of data with polyline/line geometry type could be cycle routes.

Converting polygon to point

This creates a point centroid for each polygon.

Select **Vector > Geometry Tools > Centroids…** (as seen in Figure 19)

Select the polygon layer in Input layer.

Select Create centroid for each part, and click Run.

A temporary layer will appear in the Layers panel. Save the new layer in the project folder.

Converting line to point

This create points at every vertices of the polyline/line.

Select **Vector > Geometry Tools > Extract Vertices…** (as seen in Figure 20)

Select the line layer in Input layer.

A temporary layer will appear in the Layers panel. This creates points for polyline/line vertices. Save the new layer in the project folder.

Space Syntax Toolkit in QGIS

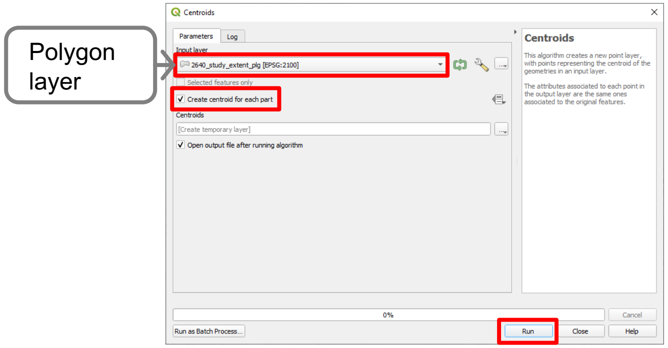


Figure 19. Converting polygon to point using Centroids geometry tool

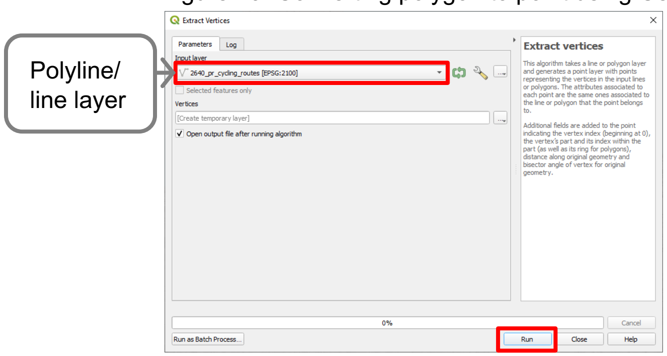


Figure 20. Converting lines to point using Extract Vertices geometry tool

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2. Spatial Modelling
Metric Catchment Analysis
Catchment Analyser

To run the metric catchment analysis, select Catchment Analyser tool in the Space Syntax Toolkit.

The Catchment Analyser window will appear. (Figure 21)

1. **Select network layer** – this is the processed segment model **spm_ex_seg_p**

2. Select network cost as **length**

3. **Select origins as the origin layer.** The origins are the parameter layers identified in Step 1 Inception and converted to point geometry type layer (previous page).

In the Catchment Analyser, **Settings**

4. Enter value for the **cost band** e.g. 400

which represents 400m, 5min walk

Only enter the numeric value in the cost band.

Refer back to the Step 1 Inception, as the measures for each variable have been evaluated when producing SUMP analysis priorities.

Standard measures are shown in Table 3, on the right.

5. Select **shapefile** as the **Output layers**.

6. Select the **Browse button** to save the file. Rename the layer mca_project name_origin name_time_distance

In the example Platanias study, the first metric catchment analysis layer name is;

mca_pl_important and existing crossings_5min walk_400m

where 'mca' is metric catchment analysis

'pl' is Platanias, the project name

'origin name' is important and existing crossings

'time' is 5min walk

'distance' is 400m

7. Tick to **generate lines and polygons**.

8. Select Run.

Space Syntax Toolkit in QGIS

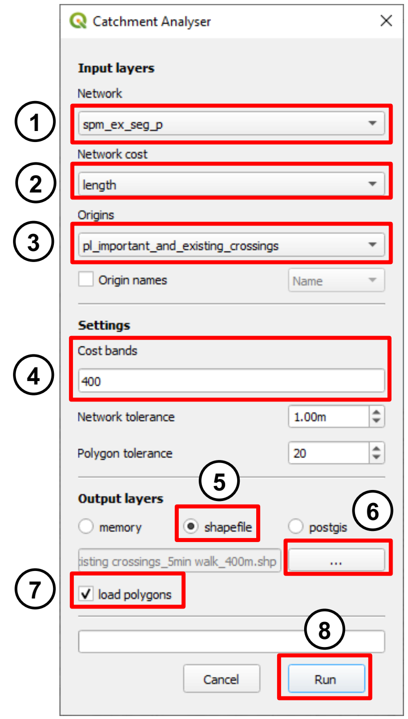

Figure 21. Catchment Analyser window

MCA Standard measures

Metric catchment (m)	Walking time
400	5min walk
800	10min walk
1,200	15min walk
2,000	20min walk
Metric catchment (m)	**Cycling time**
1,200	5min cycle (average speed 12km/h)

Table 3. Metric catchment (m) standard measures

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2. Spatial Modelling
Metric Catchment Analysis
Catchment Analyser

The results of the metric catchment analysis are automatically loaded as lines and polygons.

The standard colour ranges are automatically applied.

The polygon layer will have **_plg** saved at the end of the layer name.

This is the Metric Catchment Analysis. The analysis can be exported using Print Layout. (See Step 5 Exporting and visualisation)

Right click the metric catchment model in the Layers panel. Select **Open Attribute Table**.

The **min_dist column is the data for the minimum distance to the closest origin.** (Figure 22)

Using the Catchment Analyser tool, repeat metric catchment analysis for each parameter/ origin layer.

Make sure to select shapefile as output layers, to save both lines and polygons layer.

Space Syntax Toolkit in QGIS

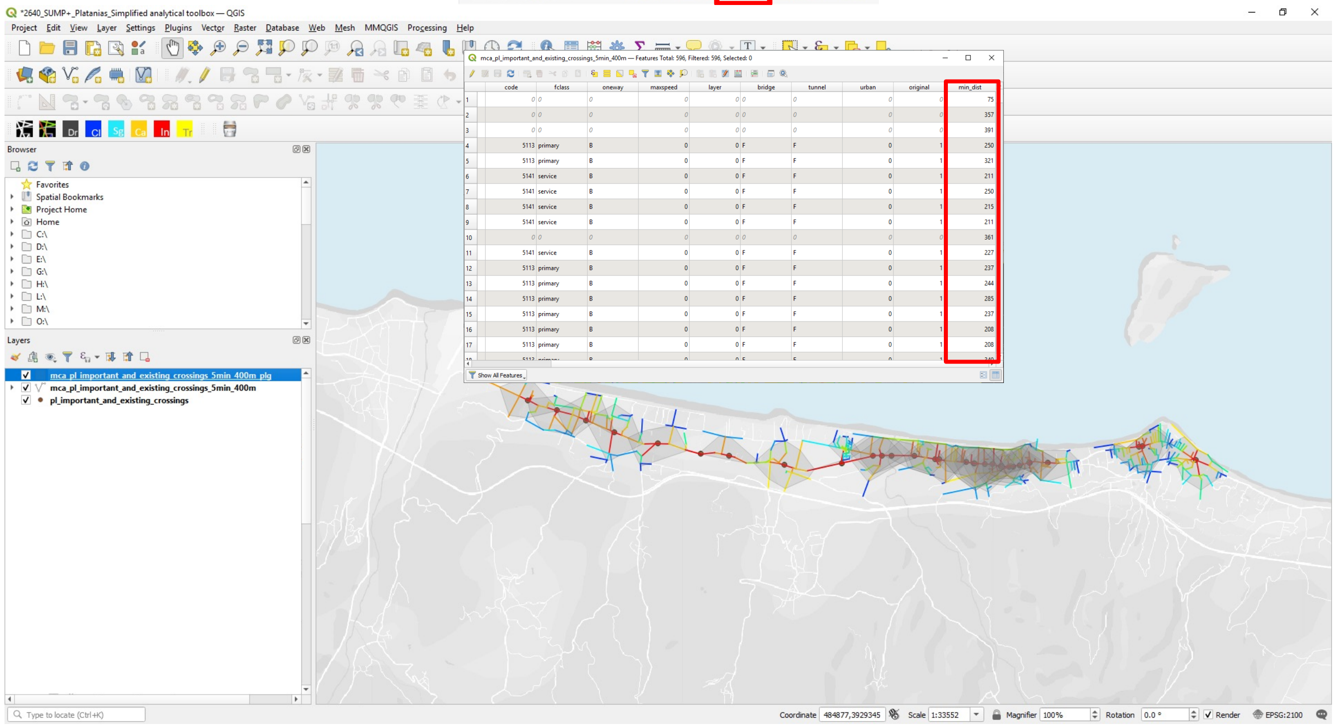

Figure 22. Metric catchment analysis loaded as lines and polygons. Metric catchment analysis model Attribute table showing 'min_dist' column

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Simplified analytical toolbox

1. Inception
2. Spatial Modelling
3. Combinational analysis

3. Combinational analysis

Integration of spatial models & other datasets

This step integrates the processed spatial models and other datasets into a single spatial model. All the parameters of the indexes are aggregated onto each segment of the spatial model to calculate the final scores in Step 4.

This allows to calculate the number of points of interest within specific metric catchment from each segment of the model and to produce a combinational analysis of user focused outputs.

The analysis highlights areas that have access to facilities and areas with few or no facilities that have potential to improve.

How to visualise the analysis is explained on page 42.

Examples of outputs/ index parameters:

- How many schools, health facilities, open spaces and other social infrastructure and amenities can be accessed within a 15-min walk from each segment?
- How many bus stops are there within a 5-min walk from each segment?
- How many pedestrian crossings are there within a 5-min walk from each segment?
- How many tourist attractions and accommodations can be accessed within a 15-min walk from each segment?
- Can a cycle path be reached within a 5-min cycle from a specific segment?

Platanias study example

The diagrams on the right show the 'Primary school and kindergarten' point layer and the Metric Catchment Analysis polygon layer for 1,200m corresponding to a 15-min walk (Step 2 output).

As shown in Figure 24, the street segments that are within the red boundary - defined by the overlapping catchments - have access to two primary school and kindergarten within a 15-min walk. The blue boundary catchment area has access to one primary school and kindergarten within a 15-min walk.

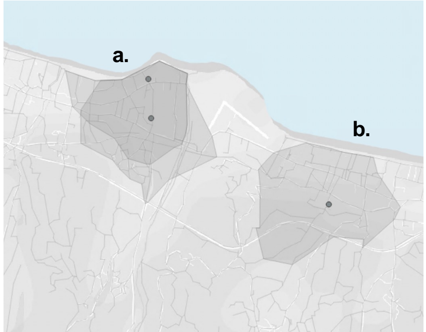

Figure 23. Metric catchment polygons (1,200m) from primary schools and kindergartens

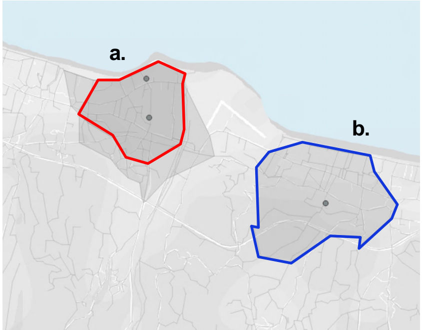

Figure 24. Segments within the red boundary (overlapping catchments) have access to two schools.

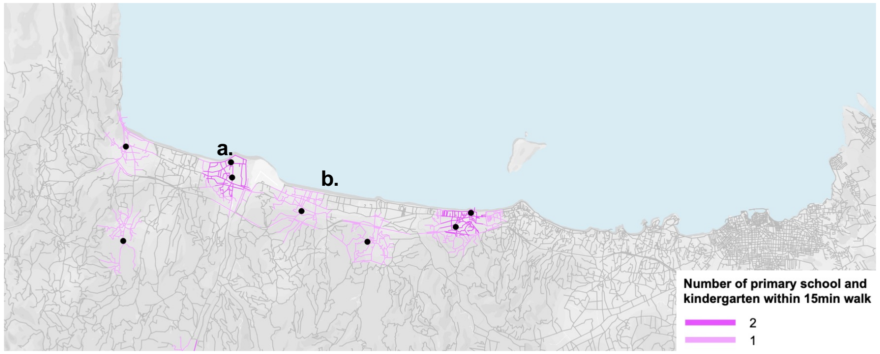

Figure 25. Access to primary school and kindergarten – aggregated per street segment to show the number of primary school and kindergartens that can be accessed from every street segment within 15min walk

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3. Combinational analysis

Integration of spatial models & other datasets

Calculating number of points of interest within a specific metric catchment from each segment of the model

Duplicating the processed Spatial Accessibility model

It is important to **make a copy and resave the processed Spatial Accessibility model**. This is to avoid the possibility of creating errors on this model during the joining process.

To do this, select the processed segment model 'spm_ex_seg_p' and click on **Layer > Save As…**

A 'Save Vector Layer as…' window will appear.

Select **ESRI Shapefile** as the Format.

Select the **project CRS**.

Click on the **Browse '…'** button and locate the project folder.

Save as 'spm_ex_seg_p_copy'

Join Attributes by Location (summary)

To integrate the spatial model and other datasets, select **Processing > Toolbox** in the toolbar. The Processing Toolbox panel will appear in the right panel.

Type **'Join attributes by location (summary)'** in the search bar.

Double click Join Attributes by Location (summary) from the list to open the window.

Select the duplicated processed spatial model **'spm_ex_seg_p_copy'** as the Input layer.

Select a **metric catchment polygon layer** as the Join layer, i.e schools.

In the example Platanias study, the 'mca_polygon_pl_primary schools and kindergartens_15min_1200m' layer was selected.

Select Geometric predicate **intersects**.

Click on the **Fields to summarise (leave empty to use all fields) '…'** button. Select **id** in this window and click on **Go back**. (Figure 27)

Click on the **Summaries to calculate (leave empty to use all available) '…'** button.

Select **count** in this window and click on **Go back**. (Figure 28)

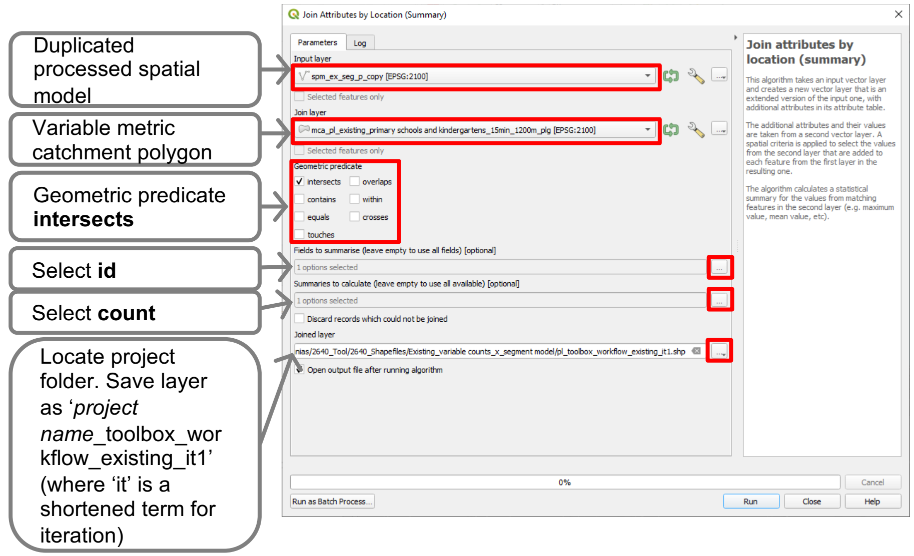


Figure 26. Join Attributes by Location (summary) window

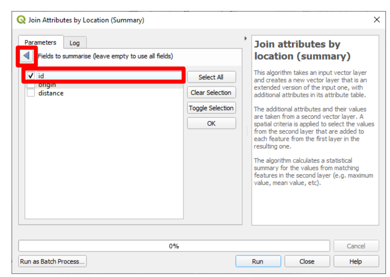


Figure 27. Fields to summarise window

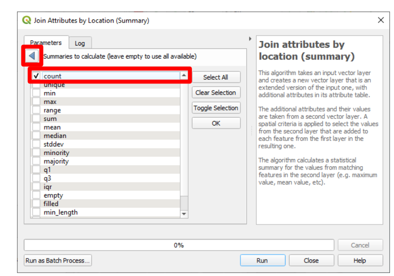


Figure 28. Summaries to calculate window

3. Combinational analysis

Integration of spatial models & other datasets

Click on the **Joined layer '…'** button.

Locate the project folder. Save layer as '*project name*_toolbox_workflow_existing_it1' (where 'it' is a shortened term for iteration)

Select save as type as SHP files ***.shp**

In the example Platanias study this layer was named 'pl_toolbox_workflow_existing_it1'

Select **Run**.

The new layer is automatically added to the Layers panel.

Right click this new layer and select **Properties...**

Select 'Fields' in the left panel. (Figure 29)

Scroll down and select 'id_count' from the list.

The 'id_count' column should be **renamed and unique** to each variable or land use that is joined to the segment model.

In QGIS, a **new field name will only save a maximum of 10 characters**. To maintain consistency in the project, rename it **no_ex_parameter**

where **no** is number of

ex is existing

parameter is the land use type/ point of interest

In the example Platanias study, the field name was renamed **no_ex_prim** for number of existing primary schools and kindergarten.

Select **Toggle editing mode** and type the joined no_ex_parameter field name. To save, select Toggle editing mode again.

Select **Apply** and **OK**.

In order to integrate all the parameter counts onto a single model, this **step needs to be repeated for each metric catchment polygon layer.**

To join more than one variable dataset, repeat the 'Join Attributes by Location (summary)' step. However instead of selecting the 'spm_ex_seg_p_copy' layer as the Input layer, **replace** the **Input Layer** with the latest joined layer.

This is a **cumulative process**. Always save and replace the 'it' number in the new layer name with the number of the latest iteration.

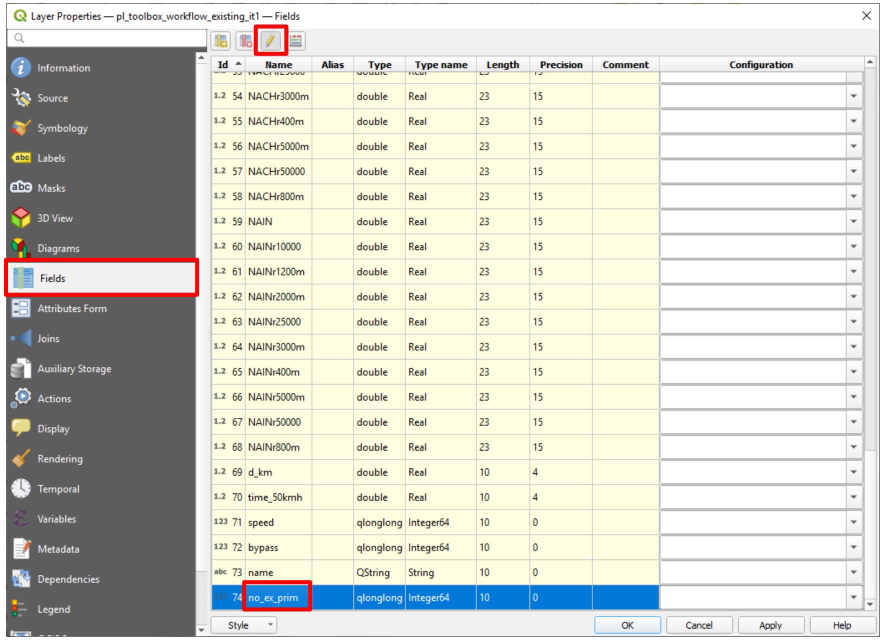


Figure 29. Layer Properties window

3. Combinational analysis

Integration of spatial models & other datasets

Right click the final iteration and select **Properties...**

Select 'Fields' in the left panel.

Check all the joined dataset have been saved and renamed (Figure 30).

After each join, a new iteration model will automatically be saved and added to the Layers panel (Figure 31).

To create the final layer, resave the final iteration, and name the layer *project name*_toolbox_workflow_existing

In the Platanias study, the final layer is called pl_toolbox_workflow_existing

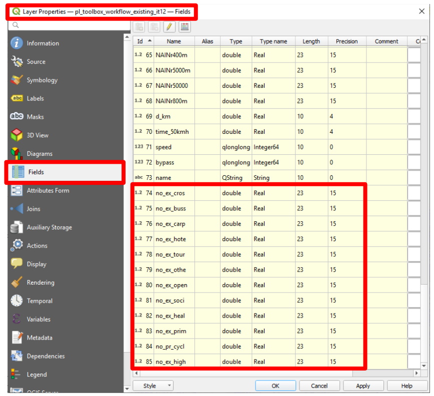


Figure 30. All joined dataset columns in Layers Properties

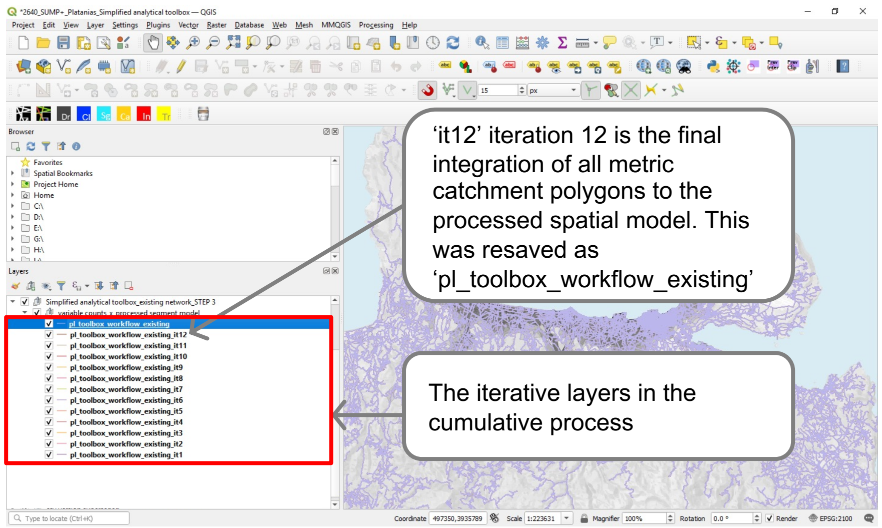


Figure 31. Iterative models in the Layers panel in the workspace, created as a cumulative process

3. Combinational analysis

Setting up the data table for calculations

Once all the data has been combined, NULL values in the data table will need to be replaced with 0.

NULL values are automatically set when there are no data from the join layer to the input layer. This step is **important** as **calculations and index parameter settings will not perform if NULL values are not numerical.**

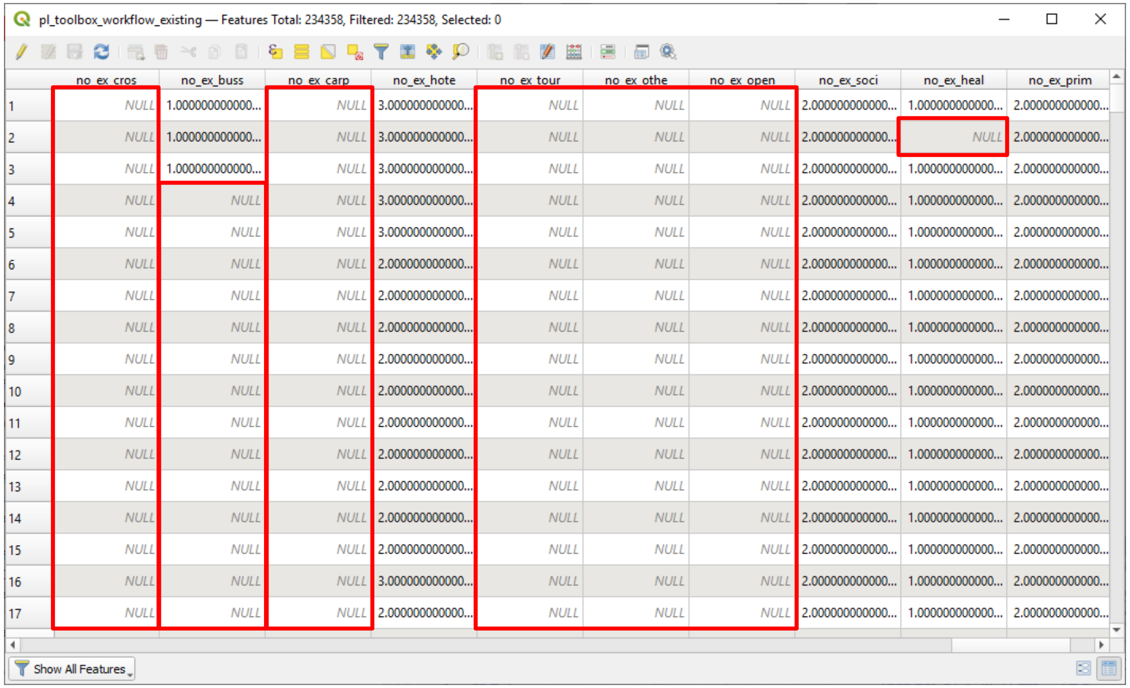
Select the final iteration of the combined model.

In the Platanias study this was, pl_toolbox_workflow_existing

Right click the layer in the Layers panel and select Open Attribute Table. (Figure 32)

Some of the parameter count columns that were recently joined contain NULL values in certain attributes.

Close the Attribute Table.



pl_toolbox_workflow_existing — Features Total: 234358, Filtered: 234358, Selected: 0

	no_ex_cros	no_ex_buss	no_ex_carp	no_ex_hote	no_ex_tour	no_ex_othe	no_ex_open	no_ex_soci	no_ex_heal	no_ex_prim
1	NULL	1.000000000000...	NULL	3.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
2	NULL	1.000000000000...	NULL	3.000000000000...	NULL	NULL	NULL	2.000000000000...	NULL	2.000000000000...
3	NULL	1.000000000000...	NULL	3.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
4	NULL	NULL	NULL	3.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
5	NULL	NULL	NULL	3.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
6	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
7	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
8	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
9	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
10	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
11	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
12	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
13	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
14	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
15	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
16	NULL	NULL	NULL	3.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...
17	NULL	NULL	NULL	2.000000000000...	NULL	NULL	NULL	2.000000000000...	1.000000000000...	2.000000000000...

Show All Features

Figure 32. Attribute table showing NULL data in certain joined values

3. Combinational analysis

Setting up the data table for calculations

To replace the NULL values to 0, select the final iteration of the combined model in the Layers panel and select Open Field Calculator in the toolbar. (Figure 33)

In the field calculator window, check the **Update existing field** box.

Select the first variable count field from the drop down menu.

In the Platanias study, the first variable count field was number of existing crossings within 5min walk. The field name is no_ex_cros.

To replace the NULL values, an if statement is applied.

IF statement

A single if statement is:

if(condition, result_when_true, result_when_false)

Enter the following expression in the Expression box:

IF("fieldname" IS NULL, 0, "fieldname")

replacing fieldname with the actual name of the field.

In the Platanias study, this was

IF("no_ex_cros" IS NULL, 0, "no_ex_cros")

The **condition** is that the selection value must equal to NULL. So that, **results when true, will equal to 0**, and when **false the condition will return the existing data value**.

Select OK and select Toggle Editing in the toolbar to save the updates.

In order to replace NULL values to 0 for all other variable count columns, this step of applying the IF statement will need to be **repeated for each variable**.

The IF statement will be revisited and implemented in Step 4 - Index parameter setting.

The final iteration of the combined model with NULL values replaced with 0 **is the Combinational analysis.** The colour ranges for the analysis (as seen on the next page) will need to be applied. This can be exported using Print Layout. (Step 5)

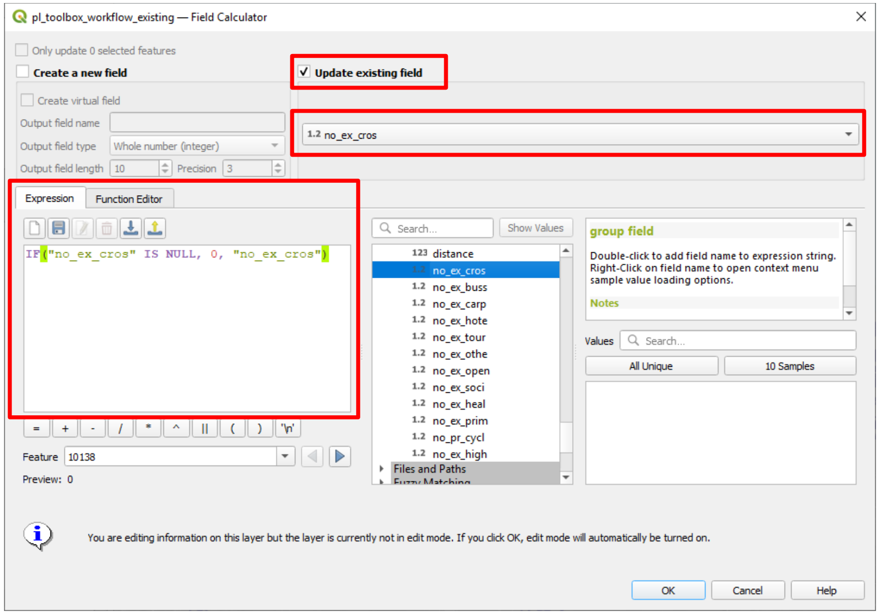


Figure 33. Field Calculator using IF statement to replace NULL value with 0

3. Combinational analysis

Visualising

To visualise the combinational analysis, right click the '*project name*_toolbox_workflow_existing' in the Layers Panel and select 'Properties…'

A new 'Layer Properties' window will appear. Click on 'Symbology' on the left panel. (Figure 34)

In the first drop down menu, select 'Graduated'.

For 'Value' select from the drop down menu the number of land use and variable to be visualised.

Select 'Equal Interval' from the Mode drop down. This method will create classes of the same size.

Depending on the data distribution, you can change the Classes from 5 to a larger number, for example 10. This can be changed later in this step to achieve the desired style.

Now the values are classified, the line weight and colours should be adjusted.

Click on the 'Symbol' (line) button.

The 'Symbol Settings' window will appear.

Increase the 'Width' to 0.86. This can be changed depending on the final visualisation and scale of the exported map.

Click 'OK'.

Click on the arrow beside 'Colour ramp'. Select 'All Colour Ramps'. There will be a default selection of colour ramps to choose from. (Figure 35)

It is possible to create your own colour ramp, by selecting 'Create New Colour ramp…'

You can also edit existing colour ramps by clicking on the ramp colour beside 'Colour ramp'. The 'Select Colour Ramp' window will appear with features on how to edit the colours.

Once you are happy with a selected colour range, in the Layer Properties window, click 'Apply' then click 'OK'.

The model will appear visualised in the workspace. It shows the analysis aggregated per street segment to show the number of land use or other points of interests that can be accessed from every street segment within a specific metric catchment.

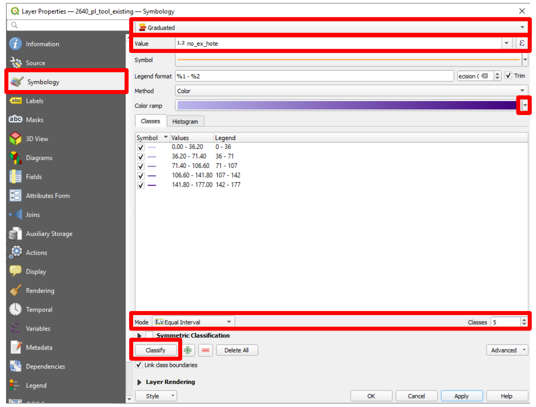


Figure 34. Adjusting value, mode classification and line weight in the Symbology tab

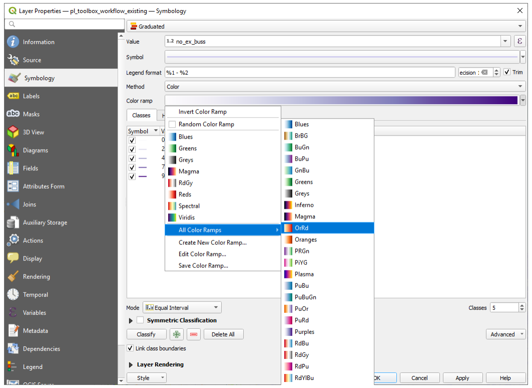


Figure 35. Adjusting and editing colour ramps in the Symbology tab

3. Combinational analysis
Visualising

In the example Platanias study, the number of hotels within 15min walk was visualised on the street network. The number of hotels range from 0 to 177.

Right click the layer in the Layers panel. Go to ‘Styles’ then select ‘Add…’

A ‘New Style’ window will appear. Name the style, then click ‘OK’. (Figure 36)

In the example Platanias study, this is renamed as ‘no. of hotels within 15min walk’

For every field that is visualised, add new styles. This is to avoid repeating the visualisation process when data is already visualised.

When you have added new styles, you can always edit the style. Right click the layer, and under ‘Styles’ tab select the style name. The style will appear in the workspace. Right click the layer again, then select ‘Properties…’

Visualising data might require testing until the desired style, colour ramp and line thickness is achieved.

When visualising other parameters, make sure to **change the field in ‘Values’ and classify the ranges again under the ‘Equal Interval’ mode**. This will recalibrate the data ranges to this field.

In the example Platanias study, a different colour ramp gradient was used for counts of each land use type/ point of interest. This visually differentiates the different counts..

An example of how the data is exported and visualised into a report is shown in the next two pages (Figures 37 and 38). The top images show the Metric Catchment Analysis for touristic attractions and hotels up to 1.2km, a Step 2 Spatial Modelling output). The images below show the number of touristic attractions and hotels within 15min walk from each segment in the model. The analysis shows access to these facilities (Step 3 Combinational analysis output).

The number of touristic attractions are highlighted in a pink gradient, and the number of hotels are highlighted in a purple gradient. This visually differentiates the land use.

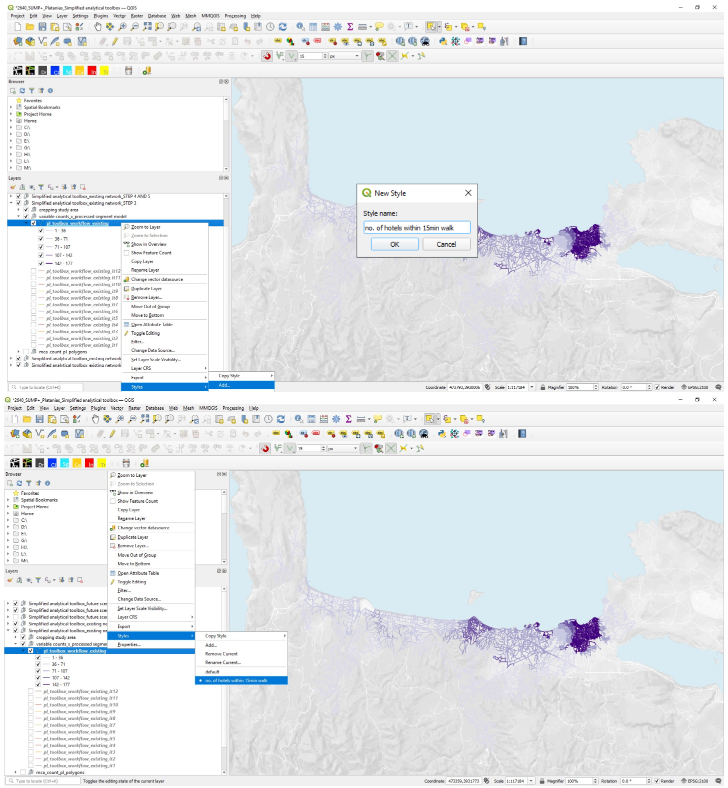


Figure 36. Adding and viewing a visualisation Style in the workspace

3. Combinational analysis
Platanias example study

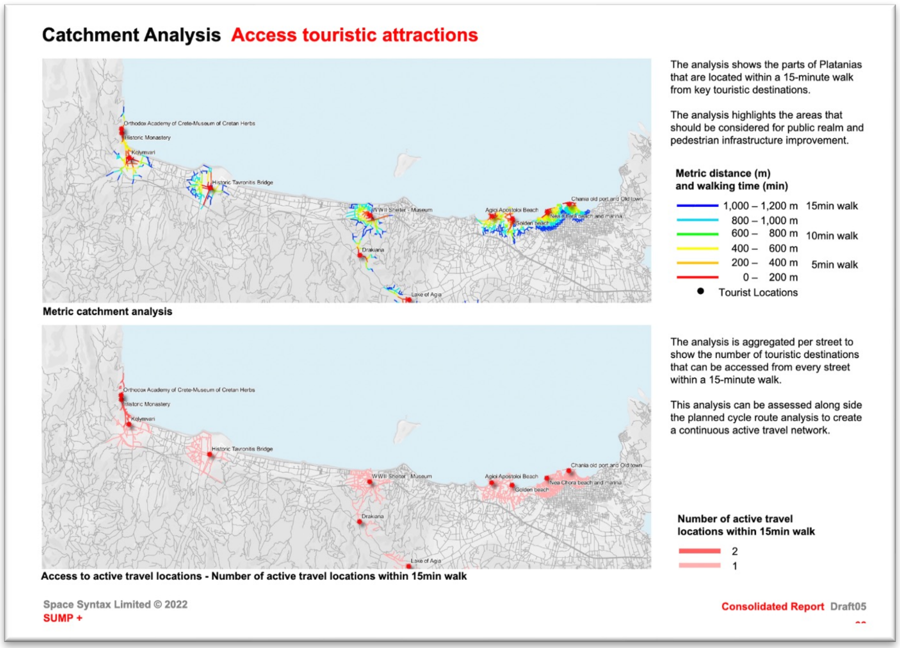


Figure 37. Example Platanias study showing Metric Catchment Analysis and Combinational analysis

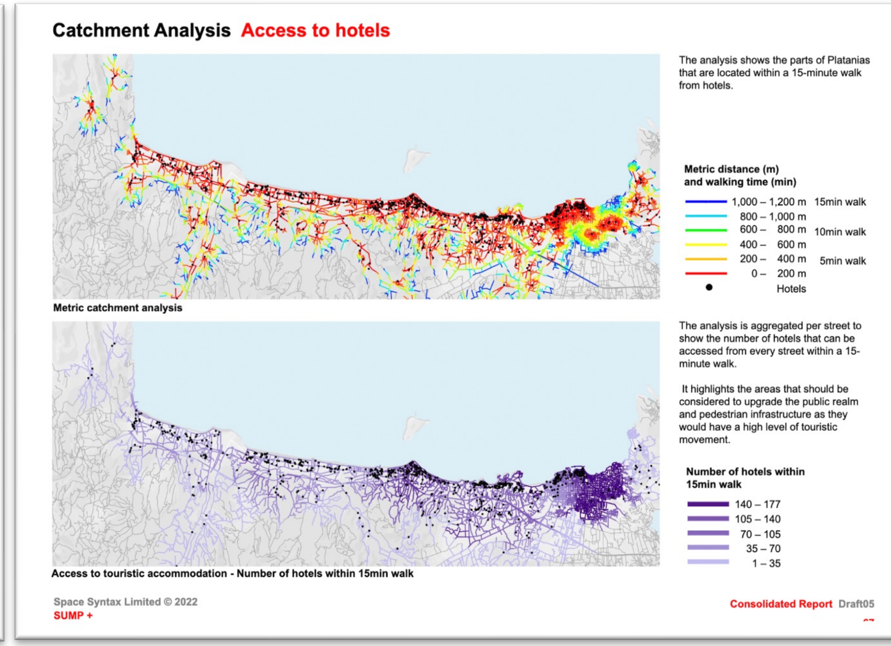


Figure 38. Example Platanias study showing Metric Catchment Analysis and Combinational analysis

3. Combinational analysis

Cropping the study area

Cropping the model to reduce loading time and better manage the data table

Once the final iteration of the combined model named *project name*_toolbox_workflow_existing has been produced with all the data joined and NULL values replaced to 0, it is recommended to crop the model into a smaller area.

There are two methods that the model can be cropped without losing data. This is either by a specific **radius** or by municipality/ city/ administrative **boundary** lines.

Cropping the study area should only be applied when **all the analysis and joins have been processed**. This method does not involve any further processing. It is for data organisation and management.

Study area by radius

Use the previously created **site_point** layer. **This was created in the Step 2 Spatial Modelling, on page 19.**

Use this point layer to create a radius buffer.

To create a radius buffer, select

Vector > Geoprocessing Tools > Buffer… (Figure 39)

Select 'site_point' as the 'Input layer'. The 'Distance' is dependent on the study area. Type the radius value in metres.

Change the 'Segments' to 50.

Select **Run**.

The temporary Buffered layer will appear in the Layers panel.

Select the temporary layer in the Layers panel.

Select **Layer > Save As…**

The 'Save Vector Layer As…' window will appear.

Select **ESRI Shapefile** as the Format.

Select the project CRS.

Click on the **Browse '…'** button and locate the project folder. Save as 'site_point_*distance*_buffer'

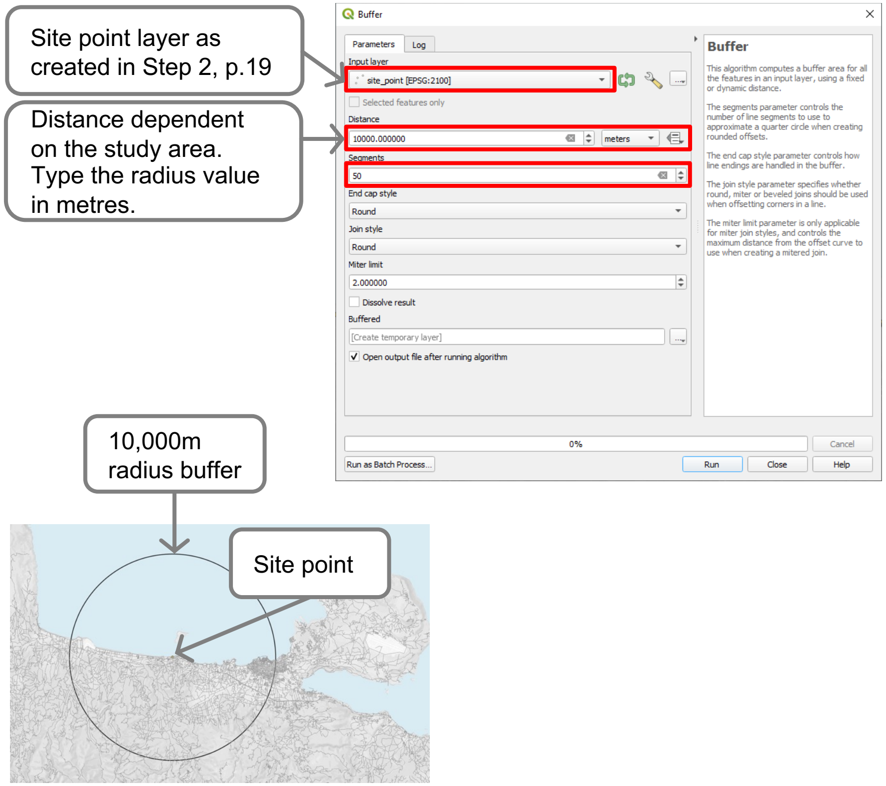


Figure 39. Buffer window and output of a 10,000m radius buffer

3. Combinational analysis

Cropping the study area

Study area by boundary

As part of the data collection stage, municipality or city boundary data might have been collected. This can be used to crop a study area by geographic boundary.

1. Polygon layer

If the boundary shapefile is a **polygon layer**, select the shapefile and select the boundaries in the workspace using **Select Features by Area or Single Click**. Selected polygons will be highlighted in yellow. (Figure 40)

Using **Select Features by Area or Single Click**, select the geographic boundary polygons that you wish to use as a study area boundary.

To select more than one polygon, press the shift button on the keyboard and select.

Select **Layer > Save As…**

The 'Save Vector Layer As…' window will appear.

To resave only the selected boundaries as a new layer, **select 'Save only selected features'** under Encoding. (Figure 41)

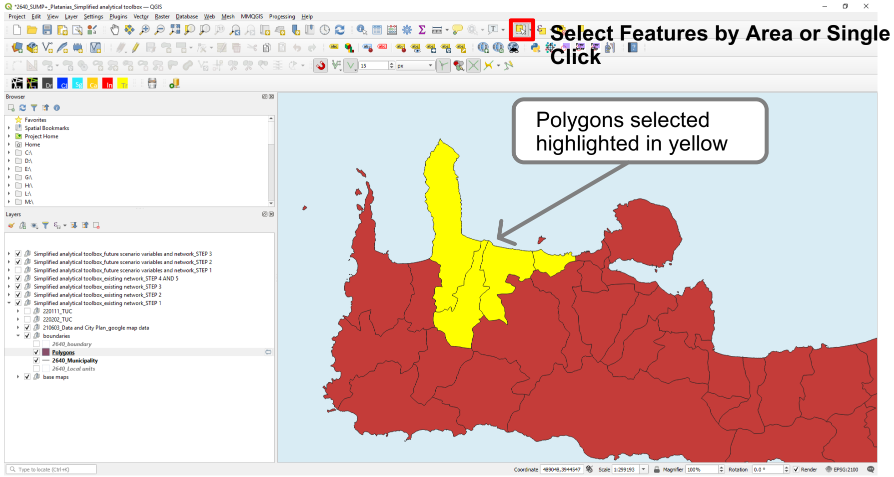


Figure 40. Select Features by Area or Single Click with multiple selected polygons highlighted in yellow

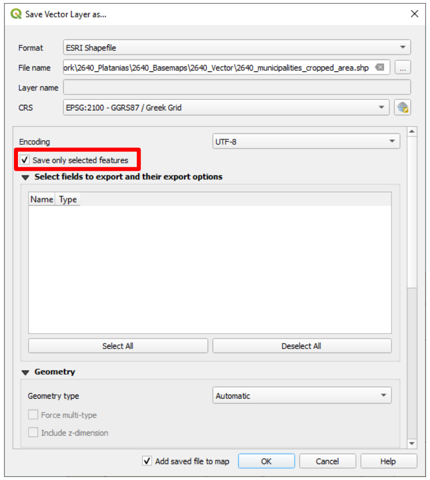


Figure 41. Save Vector Layer as… window– Saving the selected polygon features only

Click on the **Browse '…'** button beside the File name box. Find the project folder in File Explorer. Type 'study_area_boundary' in the File name and select **Save**.

The boundary shapefile will appear in the Layers panel.

3. Combinational analysis
Cropping the study area

2. Line layer

If the boundary shapefile is a **line layer**, then the layer needs to be converted into polygon.

To do this select

Processing > Toolbox

Type in the Processing Toolbox search bar **Polygonize**. Double click on Polygonize under Vector Geometry (Figure 42).

The Polygonize window will appear.

Select the boundary line layer in Input layer and then select **Run**.

A temporary polygonised layer will appear in the Layers panel.

Select the temporary layer in the Layers panel.

Select **Layer > Save As…**

The 'Save Vector Layer As…' window will appear.

Select **ESRI Shapefile** as the Format.

Select the **project CRS**.

Click on the **Browse '…'** button and locate the project folder. Save as 'study_area_boundary_polygons'

The line layer is now converted into a polygon layer. Refer to the previous 'Polygon layer' step to select specific boundaries to clip your model with.

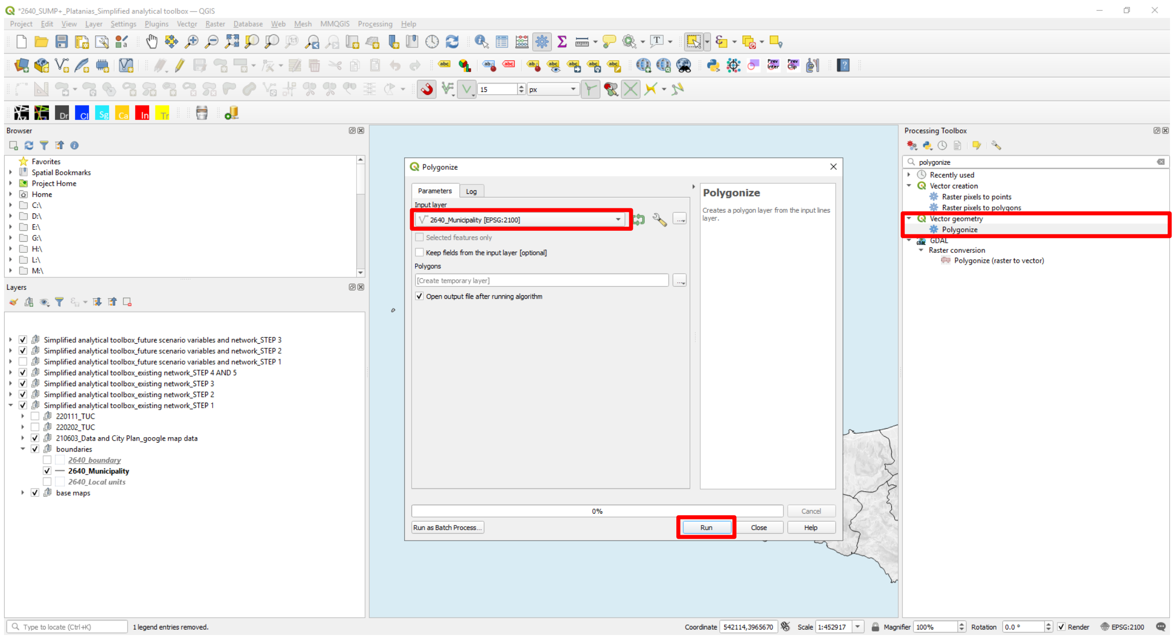


Figure 42.Using Polygonize to convert boundary lines to polygons

Croppping selected study area using the Clip function

To clip the model with all analysis joined by the study area, there is an algorithm function called **Clip**. To do this, select

Vector > Geoprocessing Tools > Clip… (Figure 43)

The **Clip** window will appear, as shown on the right.

Select the model with all joined analysis as the 'Input Layer'.

Select either the **study area by radius** (circle polygon) **or study area by boundary** (boundary polygon) created in the previous step as the 'Overlay layer'.

Select **Run**.

The temporary shapefile will appear in the Layers panel.

Select the temporary shapefile.

Select **Layer > Save As…**

The 'Save Vector Layer As…' window will appear.

Select **ESRI Shapefile** as the Format.

Select the **project CRS**.

Click on the **Browse '…'** button and locate the project folder. Save as '*project name*_toolbox_workflow_existing_cr'

The shapefile will now appear in the Layers panel.

Remove the temporary layer from the Layers panel.

Select *project name*_toolbox_workflow_ existing

Select the study area **crop by radius** or **crop by boundary** layer

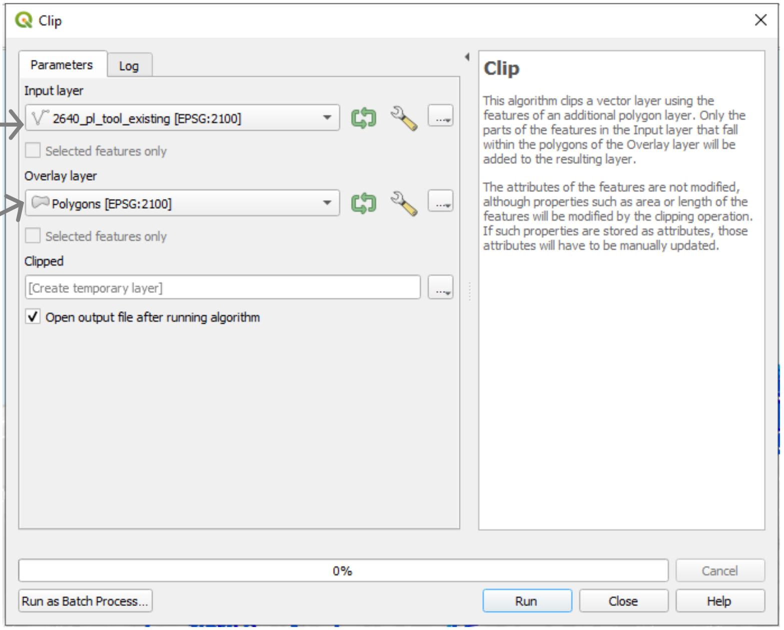


Figure 43. Clip window

3. Combinational analysis

Cropping the study area

Examples of models with all data integrated and cropped by radius (Figure 44) or by boundaries (Figure 45).

The cropped model will aid in data management and organisation, specifically in the next step of setting up index parameters.

In the Platanias study, Figure 45, the boundary highlighted in black was used.

The four boundary polygons selected are municipality boundaries covering Platanias and its surrounding area.

The segment model in dark red is the Platanias model with all analysis joined. This is the ‘pl_toolbox_workflow_existing’ layer.

By using the ‘Clip’ function, the model was cropped by the boundary of polygons. This cropped the model into a smaller study area, to manage and clean the Attributes data table.

The cropped model was saved with the layer name ‘pl_toolbox_workflow_existing_cr’

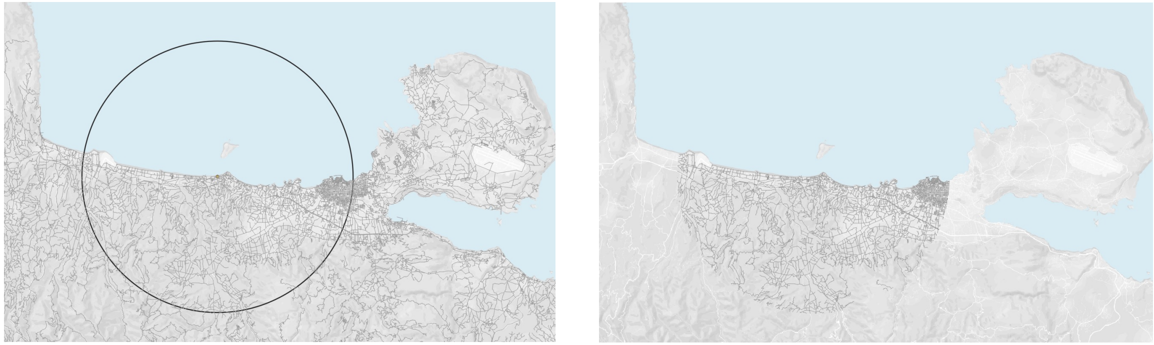


Figure 44. Radius buffer from site_point (left) and clipped model by radius buffer (right)

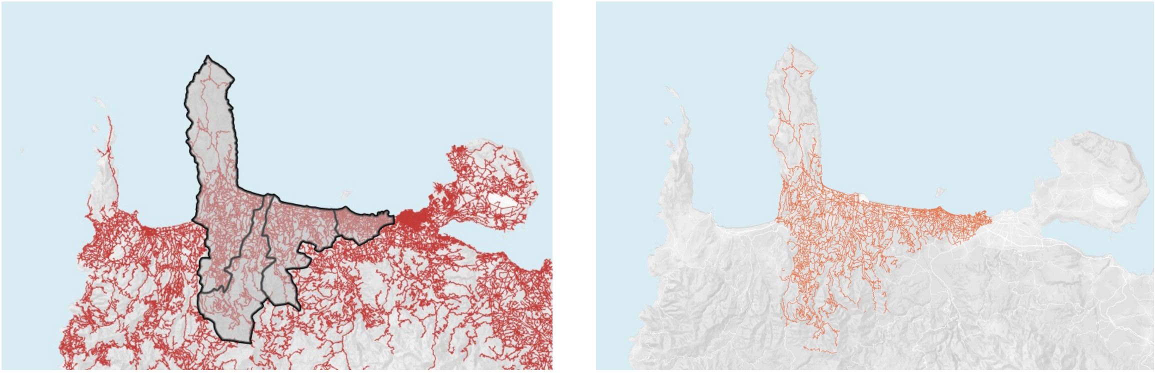


Figure 45. Selected boundaries (left) and clipped model by selected boundaries (right)

Simplified analytical toolbox

1. Inception
2. Spatial Modelling
3. Combinational analysis
4. **Index parameter setting**

4. Index parameter setting

This step defines the parameters and aggregates final scores for each index, based on the priorities set out in Step 1.

Following the aggregation of all data/ index parameters onto each segment of a single spatial model in Step 3, in Step 4 the parameters are:

- **normalised and scaled from 0 to 1, to ensure that all parameters have the same range of values**
- **weighted, with either 0 or 1 based on the importance of each parameter for the specific index**
- **aggregated to provide a final index score for each segment within the model.**

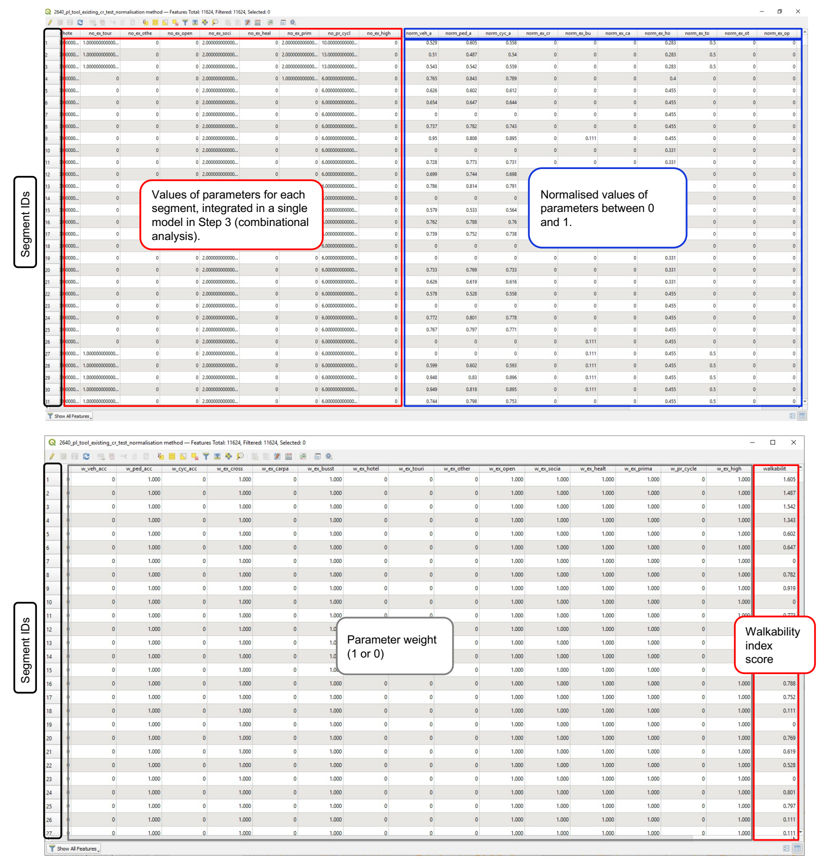


Figure 46. Attribute tables from QGIS showing the parameter values for each segment, the normalised values, the parameter weights and the aggregated walkability index score for each segment in the spatial model.

4. Index parameter setting

Normalising index parameters

Normalising index parameters to ensure they have the same range of values.

Before calculating the final index score as a sum of all parameters, each parameter needs to have the same range. This prevents one parameter from being overly influential, especially if it is measured in different units.

Click the '*project name*_toolbox_workflow_existing_cr' shapefile in the Layers Panel and select Open field calculator in the toolbar. The Field Calculator window will appear (Figure 47).

Select **'Create a new field'**.

In 'Output field name', type "norm_*parameter_name*" where 'norm' indicates this is a normalised data column.

In the example Platanias study, each parameter field starts with 'no'. This indicates 'number of'. However, as the field name character has a maximum of 10 characters, it might be better to omit this information, so that the new fields are easier to distinguish.

Select 'Create a new field'

Type 'norm' then the spatial measure or variable name in the Output field name. The 'norm' indicates this is a normalised data column.

Select 'Decimal number (real)'.
Type '10' in the Output field length.
Type '3' in Precision.

When creating new fields, always update the list of shortened field names with their longer description in the spreadsheet reference document.

Select 'Decimal number (real)' in the 'Output field type' drop down menu.

Type '10' in the 'Output field length' criteria box and the '3' in the 'Precision'. This controls the number of decimal places to three decimal places.

The Expression box is where the normalisation formula will be applied.

As this is a new column, none of the data columns generated from the analysis will be overruled.

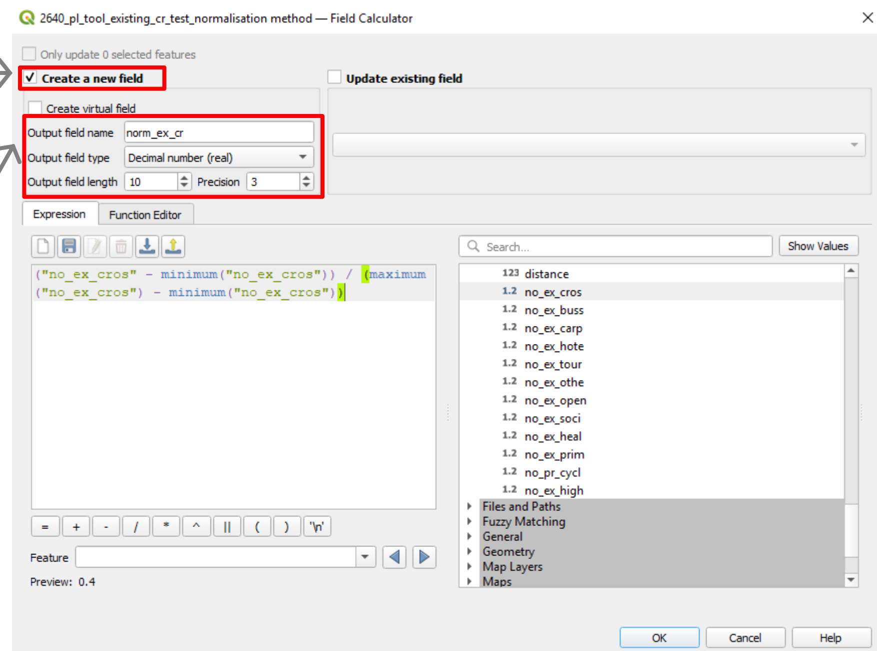


Figure 47. Field Calculator to create new normalised spatial measure and data variable fields

4. Index parameter setting
Normalising index parameters

Copy the normalisation formula in the Expression box

(“field_name” - minimum(“field_name”)) / (maximum(“field_name”)- minimum(“field_name”))

Replace “field_name” with the appropriate parameter field name. Check the “field_name” is the same name throughout in the formula.

The parameters in the data table can be found in the middle list of drop down values, under ‘Fields and Values’.

Double click the field name to be normalised in the field list. This will appear in the Expression box.

Alternatively, typing the field names directly in the Expression box will also work. When typing the field name, a drop menu will appear as a prompt. However if there is a typo or incorrect spelling, the formula will not work.

In the example of Platanias study, Figure 48, the new field is the normalisation of the number of crossings parameter, named ‘no_ex_cros’.

After the formula is updated into the Expression box, check there is a Preview value in the bottom left corner.

If the Preview displays ‘NULL’ or ‘Expression is not valid’, there could be a mistake in the normalisation formula. Check before proceeding to save the new field.

Click ‘OK’ and then click on ‘Toggle Editing’ in the toolbar to save the new field.

Check the new column is saved in the Attribute Table, and the values are between 0 to 1.

This step of creating a new column and applying the normalisation formula will need to be repeated for each parameter.

Once this is completed, right click the layer and open the Attribute Table. Check that all the raw values processed from the analysis have their corresponding normalised columns.

Make sure ‘Toggle editing’ is off and the layer is saved.

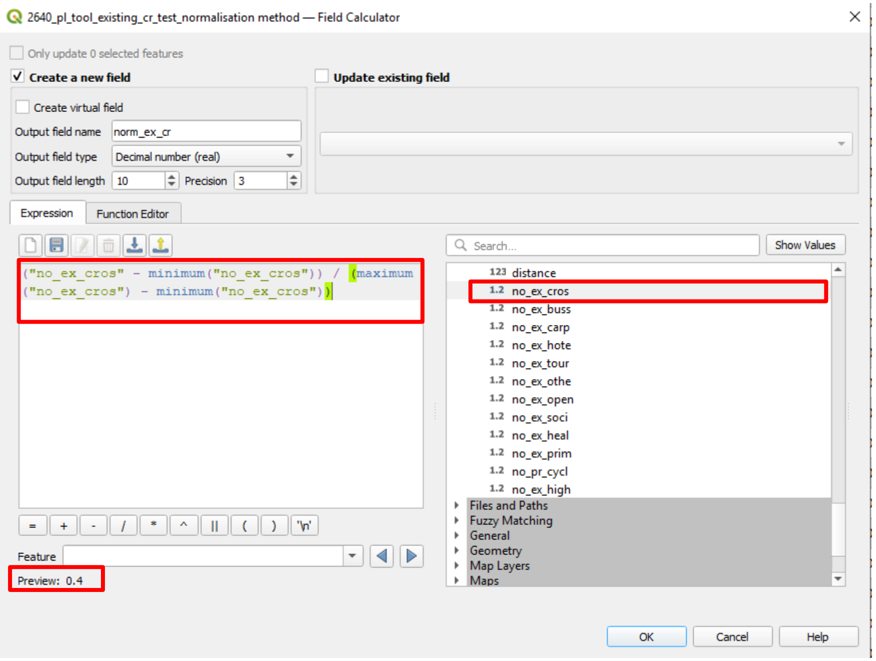


Figure 48. Field Calculator to normalise parameters from 0 to 1, in the newly created normalised fields

4. Index parameter setting

Normalising index parameters

Figure 49 shows the parameter fields and normalised values in the example of the Platanias study Attribute table.

The field names starting with ‘norm’ are the normalised fields.

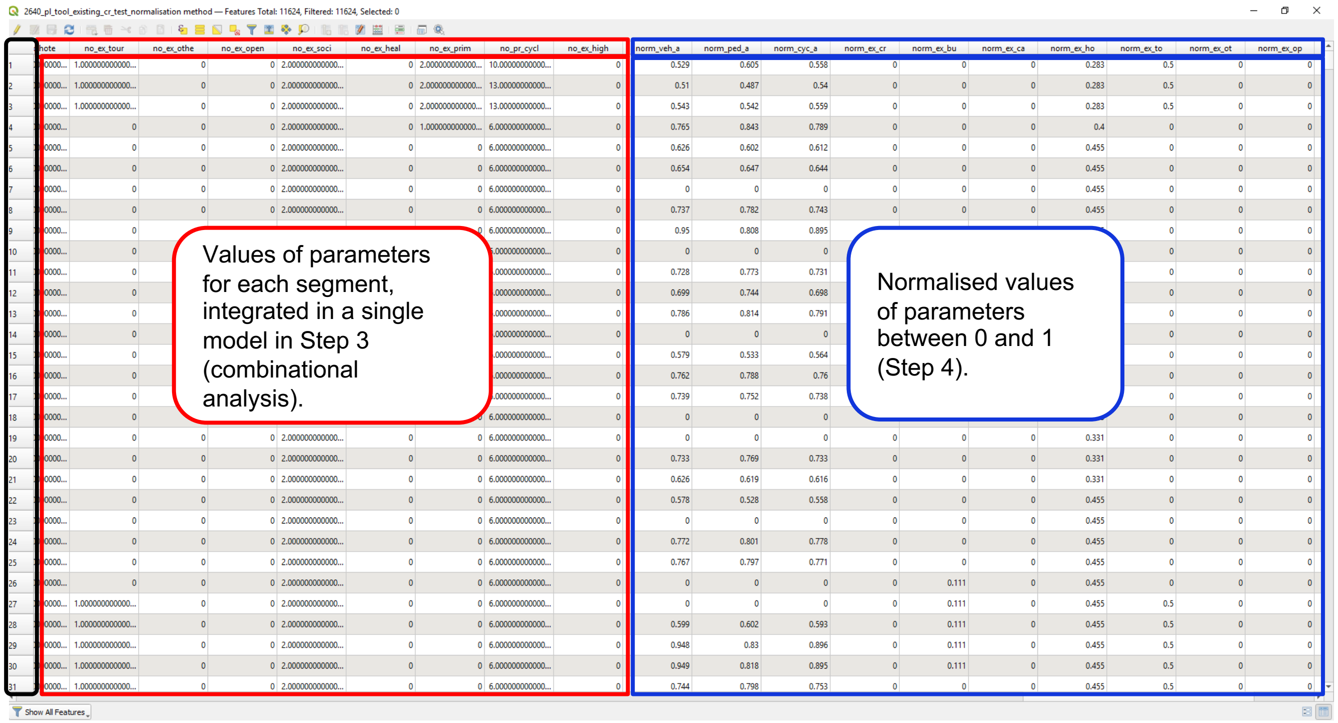


Figure 49. Columns in the Attribute table showing actual values of parameters (highlighted in red), and normalised values of parameters from 0 to 1 (highlighted in blue) for each segment in the model.

4. Index parameter setting

Weighting the index parameters

Weighting parameters based on their importance for a specific index.

A weight of 0 for not important and 1 for important is applied (Refer to SUMP priorities and key parameters set up in Step 1 Inception to define this).

In the example Platanias study, the indexes developed from SUMP priorities were walkability, cyclability, active travel and sustainable tourism.

The walkability index in the Platanias study the important parameters include pedestrian accessibility, no of pedestrian crossings, no of social infrastructure (schools, health institutions) and access to public transport (i.e. no of bus stops) etc. and, therefore they have a weight (1). Cycle accessibility and access to cycle paths parameters had a weight of (0) for the walkability index, however, they had a weight of (1) for the cyclability index.

To create the index fields, click on the '*project name*_toolbox_workflow_existing_cr' in the Layers Panel.

Click **Open Field Calculator** in the toolbar. (Figure 50)

Select **Create a new field**.

In the Output field name, type 'index initial_parameter'

In the example Platanias study, this was

w_veh_acc

where the first character symbolises the index and the spatial measure comes after.

For instance, the

w represents **walkability** and

veh_acc represents **vehicular accessibility**.

When creating new fields, always update the list of shortened field names with their longer description in the spreadsheet reference document.

In Output field type select **Decimal number (real)** from the drop down menu.

In Output field length, type '10', and in Precision type '3'.

In order to set up the index table, you will need to refer back to the SUMP analysis priorities in Step 1.

Type either '0' or '1' for the importance.

Click **OK** and save the layer by clicking the **Toggle editing** button.

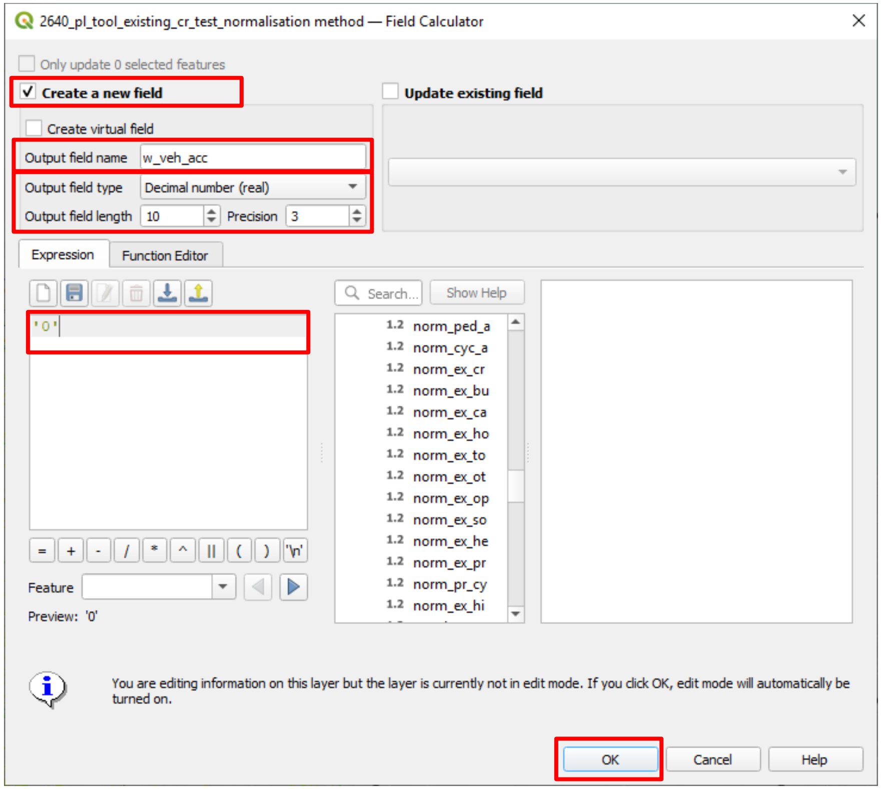


Figure 50. Field Calculator to create index parameter fields

4. Index parameter setting

Weighting the index parameters

In the example Platanias study, it was evaluated in Step 1 that vehicular accessibility is not important to Walkability. It has an importance value of 0. Therefore, in the Expression box, the value entered was '0' for this field.

This will need to be repeated for each spatial measure and variable.

If your project assesses more than one index, then this step needs to be repeated for each spatial measure and variable, for each index.

Save the layer every time a new field is created.

Referring back to Step 1 for the Platanias study, the next spatial measure field in the Walkability index is pedestrian accessibility. This new field name is labelled **w_ped_acc**. As agreed in the SUMP analysis priorities this measure is regarded as important for Walkability, therefore the selection value for this field is 1. The complete Walkability index has been added to the model and can be viewed in the Attribute Table, as seen in Figure 46. The following field names for Walkability are w_cyc_acc, w_ex_cross, w_ex_carpa etc.

If you are assessing more than one index, assign a unique initial or abbreviation for each index.

In the example Platanias study there are four indexes. They are;

w_*parameter_name*

c_*parameter_name*

at_*parameter_name*

st_*parameter_name*

where **w** represents **walkability**

c represents **cyclability**

at represents **active travel**, and

st represents **sustainable tourism**.

The index table that was developed in step two is now integrated into the model layer in QGIS.

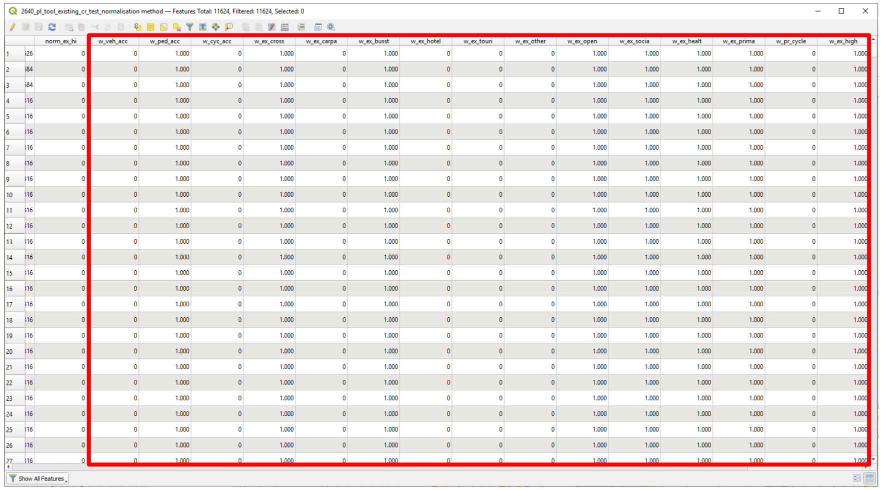


Figure 51. Example Platanias study Attribute table view showing Walkability index parameters added to the model

Field names starting with 'w' indicate the fields are the index values for Walkability.

The values should be 1 for important Walkability parameters, and 0 for not important Walkability parameters.

The importance of each parameter, for a specific index/priority was evaluated and developed in Step 1 Inception.

4. Index parameter setting

Weighting the index parameters

Once all the index parameters have been added and saved to the model, they can be viewed in the **Attribute Table**.

In Figure 52, it shows the Platanias study example Sustainable tourism index parameters.

For ease of viewing and to check if there are errors in the parameter values, click on **Switch to form view** in the bottom right of the Attribute table window.

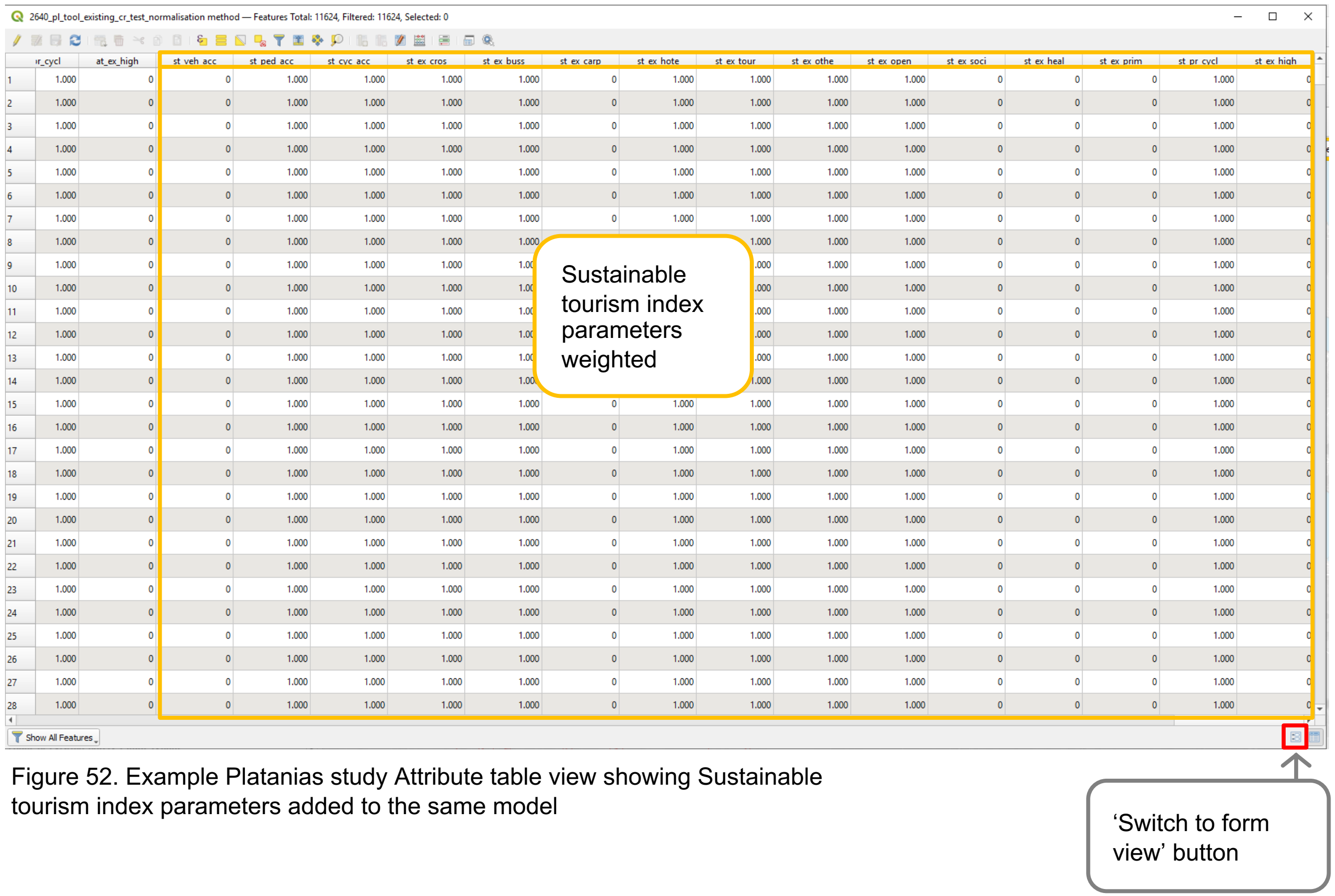


Figure 52. Example Platanias study Attribute table view showing Sustainable tourism index parameters added to the same model

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4. Index parameter setting
Weighting the index parameters

Display the Attribute table in a form view to check the parameter weights are correct and in line with the SUMP priorities and indexes developed in Step 1 (Figure 53).

If there is an input error, click on **Toggle editing mode**. Select the parameter field name that needs to be corrected from the drop down menu.

Type ‘0’ or ’1’ in the input box to correct the selection value. **Select Update All**. You will see the parameter value number change.

To save, select **Toggle editing mode**.

To go back to the main Attributes table viewing mode, select **Switch to table view**.

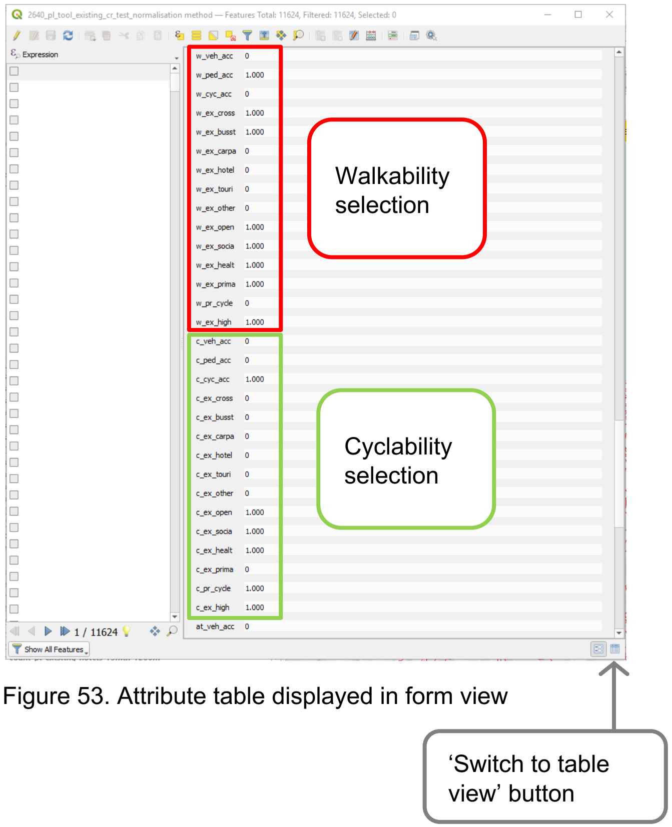


Figure 53. Attribute table displayed in form view

4. Index parameter setting

Calculating the index score

Calculating final index score for each segment by aggregating the normalised values of the weighted/ important parameters.

In the example of Platanias study, for the Walkability index, pedestrian accessibility is important and has a selection value 1. Therefore, the normalised spatial measure for pedestrian accessibility will be aggregated into the total Walkability score.

When there is a variable that is not important to the Walkability index, such as vehicular accessibility, the normalised spatial measure will not be included in the aggregated score. Instead it will return 0 value.

To calculate the aggregated score, multiple 'if statement' is applied.

IF statement

A single if statement is:

if(condition, result_when_true, result_when_false)

The **condition** is that the selection value must equal to 1. So that, **results when true, will equal the normalised spatial measure**, and when **false will equal to 0**.

In order to calculate the score, the if statement will need to be **applied to all spatial measures and** form an aggregation that makes up the index.

Select the '*project name*_toolbox_workflow_existing_cr' layer.

Click 'Open Field Calculator' in the toolbar. (Figure 54)

Select 'Create a new field'.

In the Output field name, type the index name. In the Platanias study, this was **'walkabilit'**. (Cannot name it 'walkability' as field names have a maximum of 10 characters)

In Output field type select 'Decimal number (real)' from the drop-down menu.

In Output field length, type '10', and in Precision type '3'.

The index selection values and normalised parameters in the data table (created in the previous steps) can be found in the middle list of drop-down values, under 'Fields and Values'.

Double click the field name in the field list. The field name will appear in the Expression box.

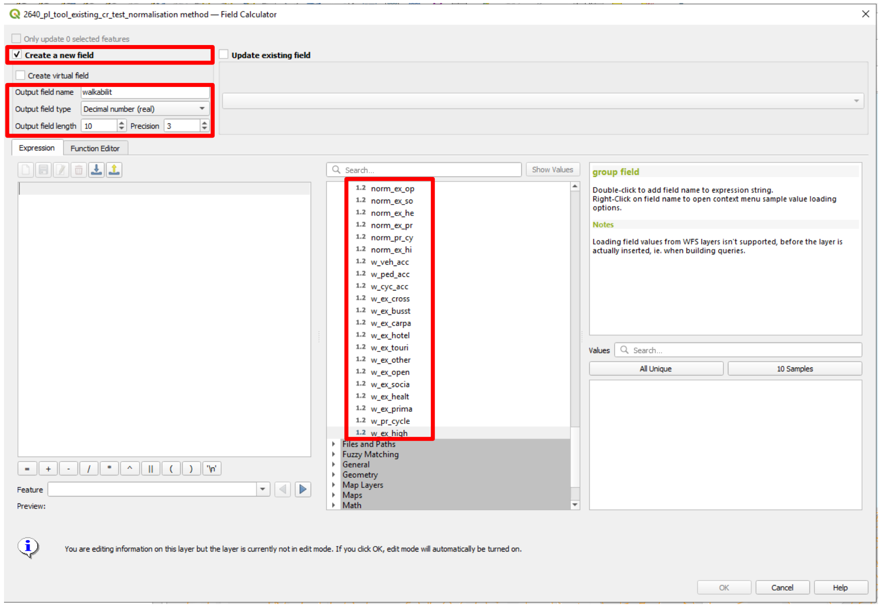


Figure 54. Field Calculator to set up index fields

4. Index parameter setting

Calculating the index score

The multiple if statement in the Expression box is

if(“*index_parameter_name_A*” IS 1, ”*norm_parameter_name_A*”, 0) + if(“*index_parameter_name_B*” IS 1, ”*norm_parameter_name _B*”, 0) + if(“*index_parameter_name_C*” IS 1, ”*norm_parameter_name_C*”, 0) + …

where the sum (+) between each if statement is the **aggregation process**. (Figure 55)

Check there are no mistakes in the syntax. Check spelling, punctuation, each index selection and normalised field in the if statements are corresponding in variables.

Highlight the statement in the Expression box, Copy and Paste into a word processing document or notepad. This is to reference, copy and manipulate other aggregating score of indexes in the project.

Click on ‘OK’ and click the ‘Toggle editing’ button to save.

This step will need to be repeated for each index. Save the layer every time a new field is created.

Multiple if statements to aggregate a final score of index

To calculate walkability in the example Platanias study, all the fields starting with ‘w’ are selected. If the field is important to walkability, the normalised value will be aggregated into the index.

If the field is not important to walkability, no value from that field will be aggregated into the index.

If the Preview displays ‘NULL’ or ‘Expression is not valid’, there could be a mistake in the if statement formula. Check before proceeding to save the new field.

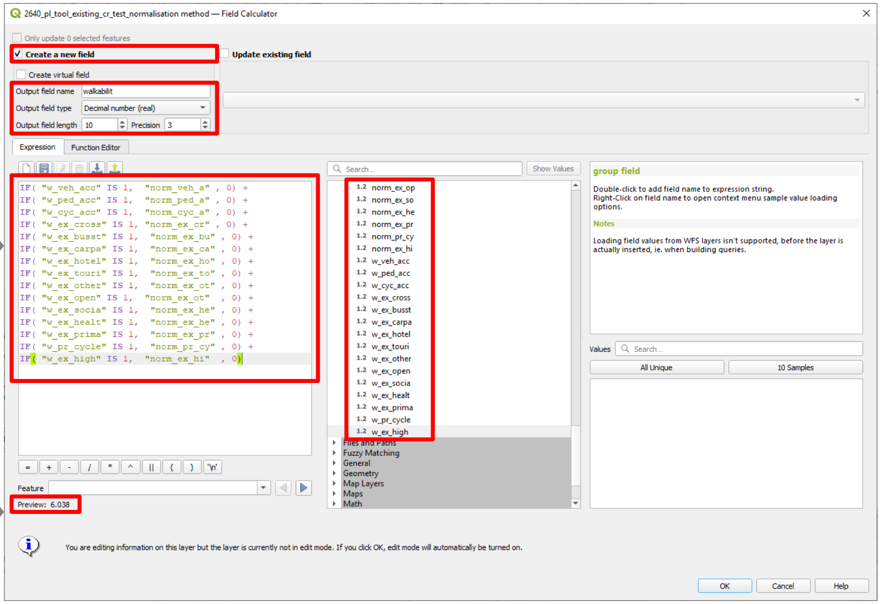


Figure 55. Field Calculator to calculate multiple IF statements to aggregate a final score of index

4. Index parameter setting
Calculating the index score
Example study

What is the formula calculating?

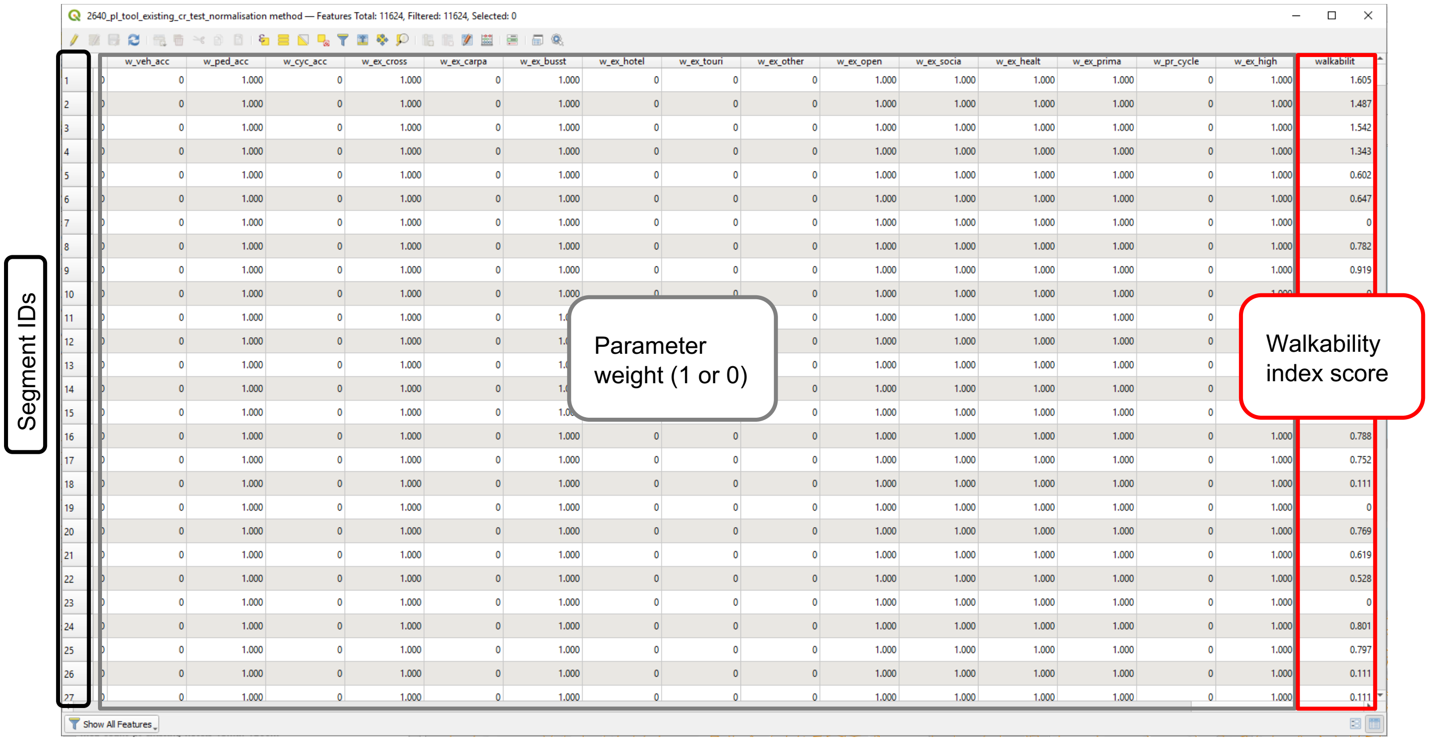
Metrics	Walkability	
Vehicular accessibility	0	If importance is 0, then return 0
Pedestrian accessibility	1	If importance is 1, then return normalised 0 to 1 NACHr1200m values
Cycle accessibility	0	If importance is 0, then return 0
No. of important and existing crossings within 5min walk	1	If importance is 1, then return normalised 0 to 1 number of important and existing crossings within 5min walk
No. of existing car parking locations within 15min walk	0	If importance is 0, then return 0
No. of tourist attractions (active travel) within 15min walk	0	If importance is 0, then return 0
No. of other main tourist attractions within 15min walk	0	If importance is 0, then return 0
No. of open space within 15min walk	1	If importance is 1, then return normalised 0 to 1 number of open space within 15min walk
No. of social facilities within 15min walk	1	If importance is 1, then return normalised 0 to 1 number of social facilities within 15min walk
No. of health facilities within 15min walk	1	If importance is 1, then return normalised 0 to 1 number of health facilities within 15min walk
No. of primary schools and kindergartens within 15min walk	1	If importance is 1, then return normalised 0 to 1 number of primary schools and kindergartens within 15min walk
No. of high schools within 15min walk	1	If importance is 1, then return normalised 0 to 1 number of high schools within 15min walk
Access to cycle path within 5min cycle	0	If importance is 0, then return 0
No. of bus stops within 5min walk	1	If importance is 1, then return normalised 0 to 1 number of bus stops within 5min walk
No. of hotels within 15min walk	0	If importance is 0, then return 0

Important to walkability
- Pedestrian accessibility
- No. of important and existing crossings within 5min walk
- No. of open space within 15min walk
- No. of social facilities within 15min walk
- No. of health facilities within 15min walk
- No. of primary schools and kindergartens within 15min walk
- No. of high schools within 15min walk, and
- No. of bus stops within 5min walk

4. Index parameter setting

Calculating the index score

Open the Attribute table. The index field is now saved into the layer.



	w_veh_acc	w_ped_acc	w_cyc_acc	w_ex_cross	w_ex_carpa	w_ex_busst	w_ex_hotel	w_ex_touri	w_ex_other	w_ex_open	w_ex_socia	w_ex_healt	w_ex_prima	w_pr_cycle	w_ex_high	walkabilit
1	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	1.605
2	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	1.487
3	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	1.542
4	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	1.343
5	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.602
6	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.647
7	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0
8	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.782
9	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.919
10	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0
11	0	1.000	0	1.000	0	[illegible]	[illegible]	[illegible]	0	1.000	1.000	1.000	1.000	0	[illegible]	[illegible]
12	0	1.000	0	1.000	0	[illegible]	[illegible]	[illegible]	0	1.000	1.000	1.000	1.000	0	[illegible]	[illegible]
13	0	1.000	0	1.000	0	[illegible]	[illegible]	[illegible]	0	1.000	1.000	1.000	1.000	0	[illegible]	[illegible]
14	0	1.000	0	1.000	0	[illegible]	[illegible]	[illegible]	0	1.000	1.000	1.000	1.000	0	[illegible]	[illegible]
15	0	1.000	0	1.000	0	[illegible]	[illegible]	[illegible]	0	1.000	1.000	1.000	1.000	0	[illegible]	[illegible]
16	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.788
17	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.752
18	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.111
19	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0
20	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.769
21	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.619
22	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.528
23	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0
24	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.801
25	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.797
26	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.111
27	0	1.000	0	1.000	0	1.000	0	0	0	1.000	1.000	1.000	1.000	0	1.000	0.111

Figure 56. Example Platanias study Attribute table view showing final score of index for Walkability (highlighted in red)

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4. Index parameter setting

Calculating the index score

As mentioned before, it is useful to save the if statement Expression into a word processing or notepad software. The expression can be applied to build other indexes.

When creating other score of indexes, the **normalised field names in the if statement will not change**. Only the condition will change, as **the spatial measures importance change based on the index.**

In the example Platanias study, the expression for Cyclability is similar to Walkability. The only difference is the 'w' in the condition field was replaced with 'c'. This indicates the Walkability selection fields are replaced with Cyclability selection fields.

A useful tip is to have the list of 'Fields and Values' opened. This makes it easier to reference and check the field names are correct in the Expression. This is important if you are assessing more than one index, as the index selection field names might differ.

The result when true and result when false fields do not change. Only the condition will change, as **the spatial measures importance change based on the index.**

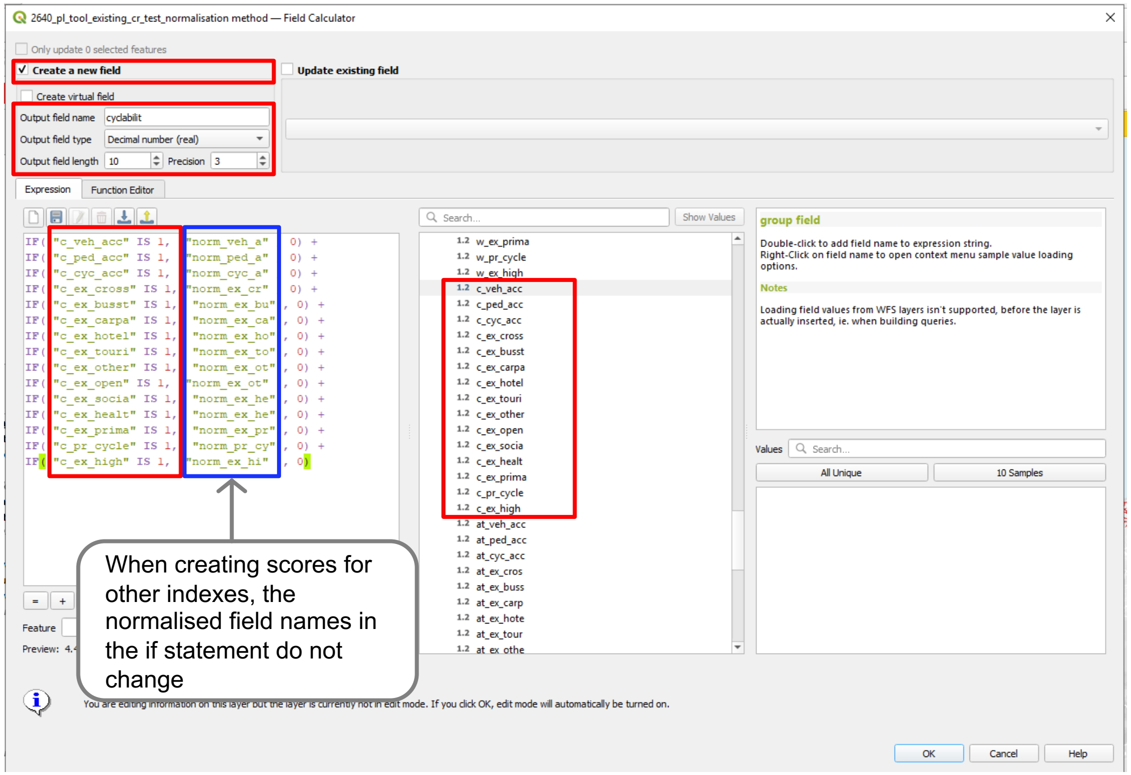

Figure 57. Field Calculator to create other score of indexes

4. Index parameter setting

Calculating the index score

Once all the indexes have been aggregated, open the Attribute table to check if the fields have been saved properly. (Figure 58)

In the example Platanias study, walkability, cyclability, active travel and sustainable tourism were assessed.

Now that the final score of indexes have been calculated, they should be visualised for analysis.

This is the indexes for the SUMP PLUS analysis. The colour ranges will need to be applied before the analysis is exported using Print Layout. (Step 5)

2640_pl_tool_existing_cr_test_normalisation method — Features Total: 11624, Filtered: 11624, Selected: 0

	ed_acc	st_cyc_acc	st_ex_cros	st_ex_buss	st_ex_carp	st_ex_hote	st_ex_tour	st_ex_othe	st_ex_open	st_ex_soci	st_ex_heal	st_ex_prim	st_pr_cycl	st_ex_high	cyclabilit	active_tra	sust_tour
1	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.582	5.119	3.457
2	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.313	4.865	3.203
3	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.581	5.086	3.424
4	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.221	4.411	2.749
5	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	3.798	3.567	1.905
6	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.058	4.036	2.374
7	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.579	5.306	3.644
8	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	3.632	3.854	2.733
9	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	3.632	3.854	2.733
10	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	3.632	3.854	2.733
11	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.238	5.071	3.950
12	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.525	5.648	4.527
13	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.443	5.481	4.360
14	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.299	5.181	4.060
15	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.248	5.102	3.981
16	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.359	5.049	3.928
17	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.467	4.195	3.074
18	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.159	4.860	3.739
19	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	3.925	4.484	3.363
20	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.018	4.716	3.595
21	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.615	5.812	4.691
22	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.252	5.148	4.027
23	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	3.632	3.854	2.733
24	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.493	5.556	4.408
25	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.346	5.307	4.159
26	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.563	5.689	4.541
27	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.527	5.594	4.446
28	1.000	1.000	1.000	1.000	0	1.000	1.000	1.000	1.000	0	0	0	1.000	0	4.301	5.258	4.089

Show All Features

Figure 58. Example Platanias study Attribute table view showing final score of index for Cyclability (highlighted in green), Active travel (highlighted in blue) and Sustainable tourism (highlighted in orange)

Simplified analytical toolbox

1. Inception
2. Spatial Modelling
3. Combinational analysis
4. Index parameter setting
5. Exporting and visualisation

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5. Exporting and visualisation
Visualising the indexes

This step produces the visualisation of the final scores of the indexes.

To visualise the indexes, the cropped model where the index parameters were defined should be selected.

Right click the '*project name*_existing_toolbox_cr' in the Layers Panel and select Properties… The **Layer Properties** window will appear. Select **Symbology**.

For 'Value' select from the drop down menu the index to be visualised.

Once selected, make sure to classify the ranges again with 'Equal Interval' mode and the number of Classes. This will recalibrate the data ranges to this field, and will appear updated in the workspace. (Figure 59)

In the example Platanias study, the index selected is 'walkabilit'. This field represents the walkability.

Visualising data might require testing until the desired style, colour ramp and line thickness is achieved.

In your study, you may want to maintain a colour range to be applied across all indexes. However, it is important to classify the ranges every time a new field is visualised.

Once a style is set, make sure to save the style under the 'Styles' tab.

Alternatively, you can use the Attributes Explorer tool to visualise the indexes. (Figure 60) The Classic colour range can be applied in the same style across all indexes.

Using the **Attributes Explorer also provides an interface to quickly assess the differences between the indexes**.

It is important to remember the threshold and data distribution are not the same across the indexes. You will see the top values change in the Attributes Explorer when you change from one index to another.

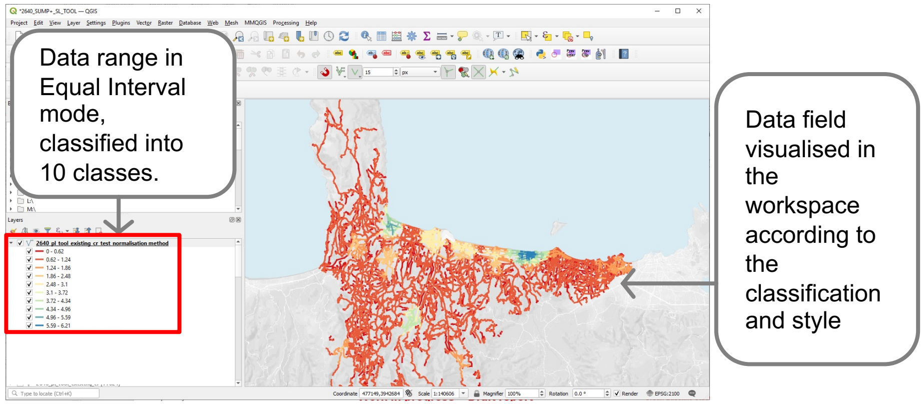

Figure 59. Data ranges classified and visualised in the workspace using the Symbology tab in Layer Properties window

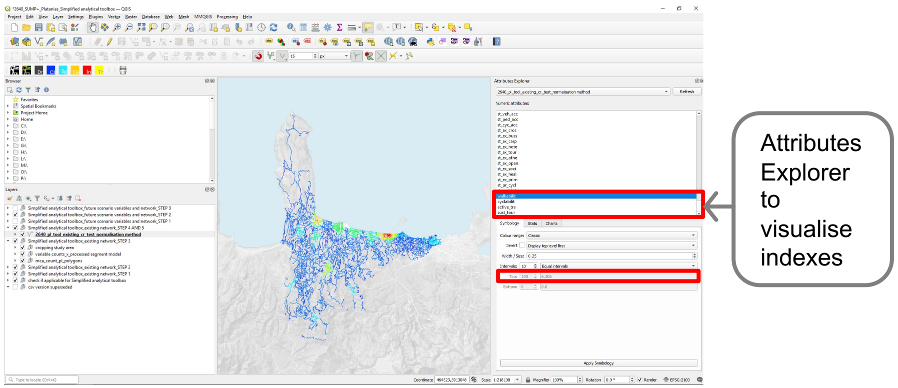

Figure 60. Attributes Explorer tool to visualise the indexes

5. Exporting and visualisation

Exporting visualised indexes Print layout

Exporting visualised data using the Print Layout

The next step is to create a Print Layout template to export the visualised data.

There are many features in Print Layout. One main feature is to set a paper size and export a scaled map. Additional features, such as adding a legend, scale bar and north point are optional. This depends on the Print Layout design and the style developed for reporting and analysis.

Print Layout - Set paper size and add a scaled map

In the workspace, click on 'Project' then 'Layout Manager…'

The 'Layout Manager' window will appear.

Under 'New from Template' select 'Empty Layout', and then click on 'Create…'

The 'Create Print Layout' window will appear.

Type the name of the print layout. Example print layout names could be 'zoom-out', 'zoom-mid' and 'zoom-in' indicating the zoom extent and scale of the map.

Once the title is set (you can always go back and edit the title), click 'OK'. The new print layout window will appear (Figure 61).

To change the paper size, right click the centre of the board and select 'Page Properties…'

The 'Page Size' properties will appear in the right hand panel. The page is defaulted to A4 landscape. Click on the 'Size' and 'Orientation' drop down menu to adjust based on your project.

To add the map from the workspace, click on 'Add Map' button on the left panel.

Left click and drag the cursor from the top left corner to the bottom right corner to create a bounding box. The workspace will appear on the page. This is 'Map 1'. **What is currently displayed in the workspace, will appear in 'Map 1'**. The map in the Print Layout will update itself, when the workspace view is updated.

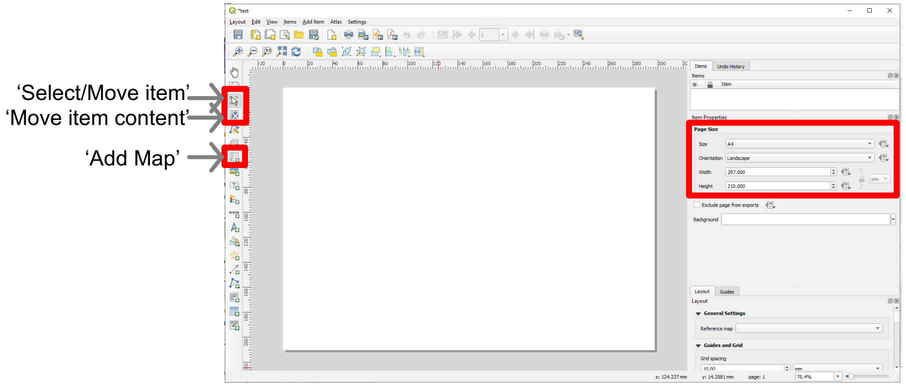

Figure 61. Print layout window

To move the map and its bounding box, click on 'Select/Move item' and move bounding box. This allows the box to be moved around the page.

To edit the map zoom, select 'Select/Move item' and click on the map. Select 'Move item content'. This allows the map to be dragged and moved within the bounding box.

When 'Move item content' is selected, the 'Main Properties' for 'Map 1' is displayed on the right panel. Here you can edit the scale of the map.

Once the scale is confirmed, click once outside the page to deselect 'Move item content'. This locks the scale and ensures there are no accidental changes to the scale and zoom.

Click the 'Save' button to save the Print Layout template.

To learn more on Print Layout features, such as adding legend, scale bar and north point, visit the Documentation for QGIS here: https://docs.qgis.org/3.22/en/docs/user_manual/print_composer/composer_items/index.html

Simplified analytical toolbox

1. Inception
2. Spatial Modelling
3. Combinational analysis
4. Index parameter setting
5. Exporting and visualisation
6. Interpretation of results

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6. Interpretation of results

This step produces and evaluation of the results in the context of and to inform the development of SUMP measures.

This is based on the visualisation of the indexes, which helps to highlight the priority areas, the easy wins and the areas lacking in the facilities, active travel infrastructure or spatial accessibility and inform the decision-making process and policy planning.

Following the diagnosis of the existing conditions, a number of scenarios can be tested and objectively compared and assessed through the scoring of the indexes of the combinational analysis (feedback loop in workflow diagram).

Examples of how the results of the analysis can inform the SUMP development

The walkability index analysis can highlight an area with a high number of social facilities or tourist attractions that lacks public transport and pedestrian infrastructure, and, therefore, has a relatively low walkability score. This could help to establish this as a priority area for improvements, compared to other areas with a similar walkability score.

An area with relatively high walkability levels, can be suitable for locating a tourist attraction, a school, a new open space etc. or it can be further strengthened by adding a missing connection or a pedestrian crossing, or by improving the public realm conditions. This can be used as a basis to plan a network of tourist destinations that can be accessed via public and active travel modes.

Existing_Platanias	Importance*
Vehicular accessibility	0
Pedestrian accessibility	1
Cycle accessibility	0
No. of important and existing crossings within 5min walk	1
No. of bus stops within 5min walk	1
No. of existing car parking locations within 15min walk	0
No. of hotels within 15min walk	0
No. of tourist attractions (active travel) within 15min walk	0
No. of other main attractions within 15min walk	0
No. of open space within 15min walk	1
No. of social facilities within 15min walk	1
No. of health facilities within 15min walk	1
No. of primary schools and kindergartens within 15min walk	1
Access to cycle path within 5min cycle	0
No. of high schools within 15min walk	0

*where 0 is not important and 1 is important

Example of Walkability index analysis for the diagnosis of the existing conditions in Platanias.

The figure shows the Platanias walkability output created with the Simplified analytical toolbox. The table below outlines the spatial measures and their importance to walkability.

Reporting the score in a table with the visualisation clearly outlines the measures that are aggregated into the index.

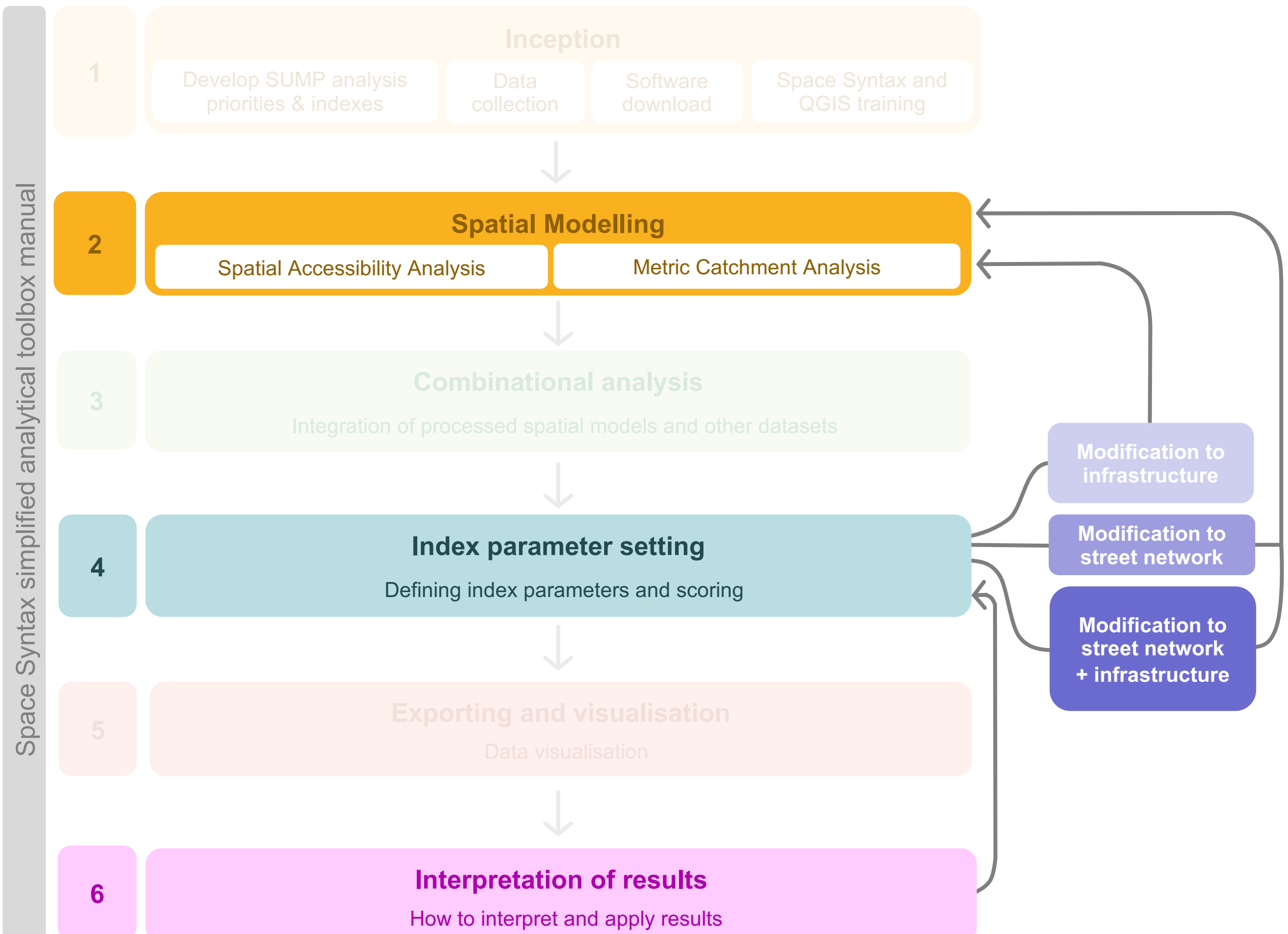
When interpreting the data, you may notice outliers or error in the data. This is common in data analytics, and reiterates the toolbox iterative process.

Following the diagnosis of the existing conditions, a number of scenarios can be tested and objectively compared and assessed (feedback loop in workflow diagram).

The next step explains the process.

6. Interpretation of results

Scenario development and testing



Depending on the type of the modification that needs to be tested, different parts of the workflow need to be repeated.

For modifications to infrastructure

(i.e. land use, public transport, new pedestrian crossings etc.) Step 2 Metric Catchment Analysis will need to be updated.

This applies if there are:

- No changes to the street network
- Additional parameters.
- Proposed new infrastructure

For modification to street network

(i.e. a new connection or realignment of an existing route) both the Step 2 Spatial Accessibility Analysis and Metric Catchment Analysis will need to be updated.

For modification to street network and infrastructure

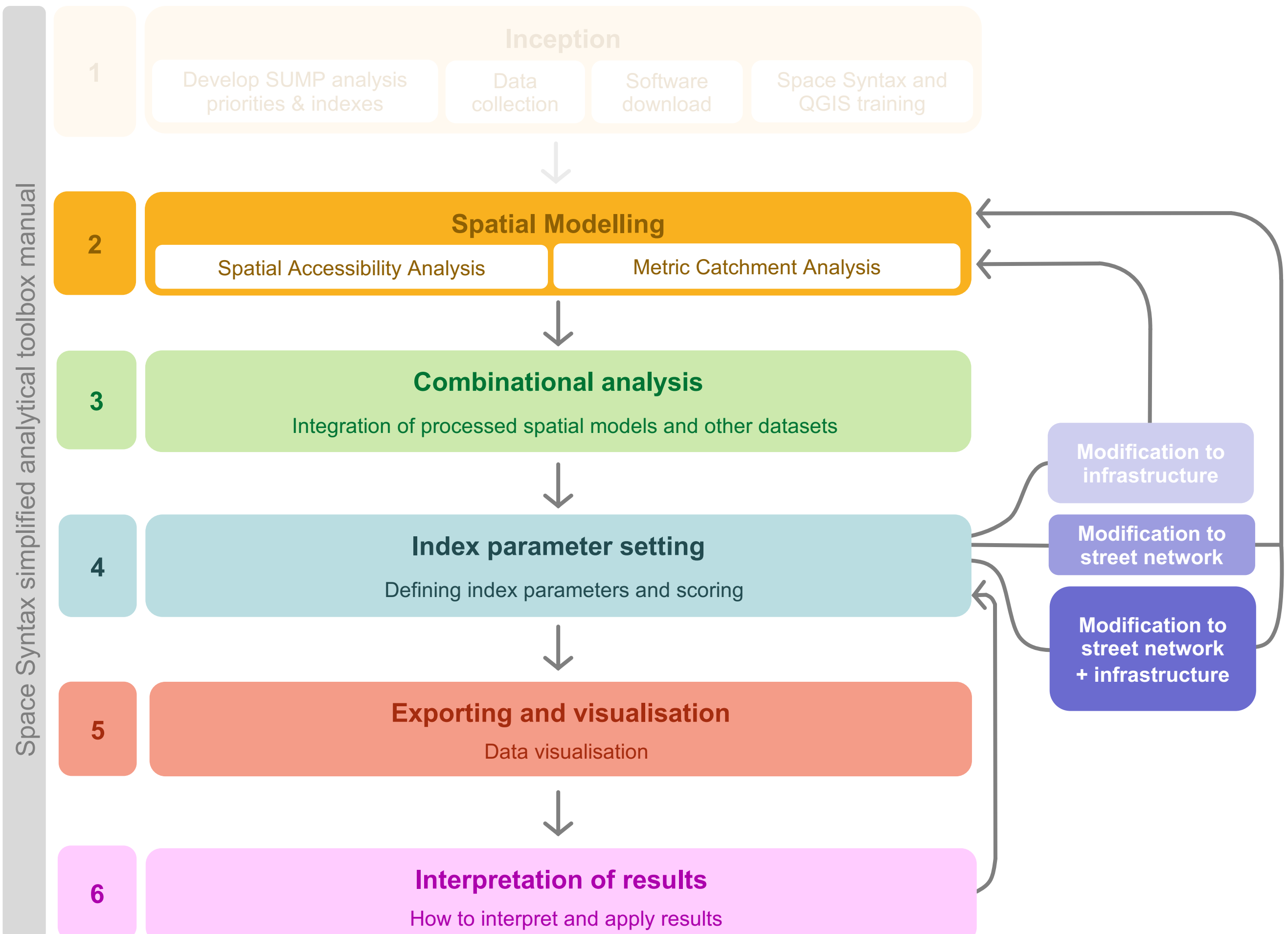
both the Step 2 Spatial Accessibility Analysis and Metric Catchment Analysis will need to be updated.

Further **scenario testing will generate new data.**

It is important to create a copy of the original unprocessed segment model and original parameters points, before making modifications

6. Interpretation of results
Scenario development and testing

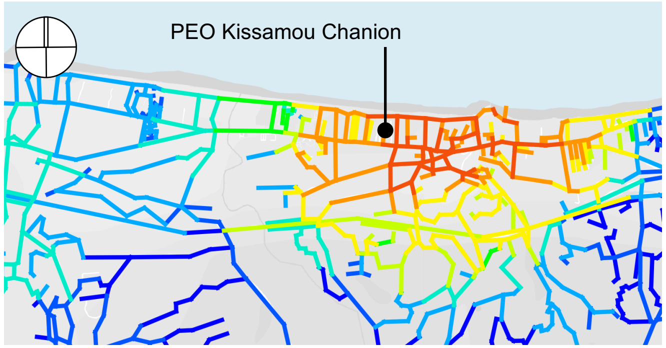
Further scenario testing will generate new data in Step 2, and, therefore, **the following steps (3-6) in the workflow should be repeated.**



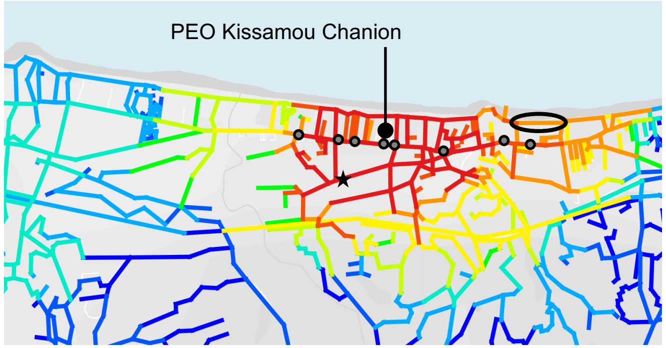
6. Interpretation of results

Platanias example study

Future scenario testing



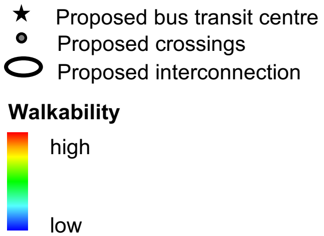
Existing scenario



Future scenario

Platanias	Importance*	Future scenario changes
Vehicular accessibility	0	Proposed interconnection
Pedestrian accessibility	1	Proposed interconnection
Cycle accessibility	0	Proposed interconnection
No. of important and existing crossings within 5min walk	1	Proposed crossings
No. of bus stops within 5min walk	1	Proposed bus transit centre
No. of existing car parking locations within 15min walk	0	
No. of hotels within 15min walk	0	
No. of tourist attractions (active travel) within 15min walk	0	
No. of other main attractions within 15min walk	0	
No. of open space within 15min walk	1	Possible creation
No. of social facilities within 15min walk	1	
No. of health facilities within 15min walk	1	
No. of primary schools and kindergartens within 15min walk	1	
Access to cycle path within 5min cycle	0	Proposed interconnection
No. of high schools within 15min walk	0	

*where 0 is not important and 1 is important



The future scenario testing shows that by implementing future scenario changes, such as the proposed interconnection, proposed crossings and bus transit centre in Platanias, the walkability index increases around the main route, PEO Kissamou Chanion.

Based on the findings from the existing analysis, recommendations for a proposed interconnection was highlighted in the Platanias study.

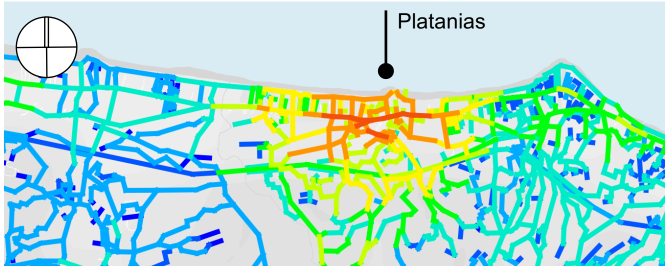
The image on the left shows the walkability index for the existing conditions. The model on the right shows the walkability index in the future scenario, with modifications to both the street network and infrastructure.

This considers possible and proposed infrastructure such as crossings, and a new bust transit centre (provided by MU/TUC) and the proposed interconnection.

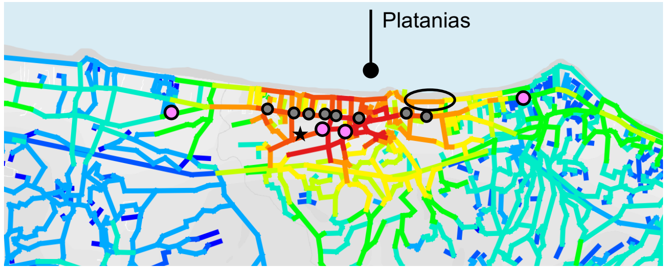
The values and colour ranges have been recalibrated based on the future scenario model, as the future scenario model has higher ranges. By applying the same data and colour ranges, the two outputs can be comparable.

The future scenario shows the impact of the proposals on the walkability of Platanias.

6. Interpretation of results
Platanias example study
Future scenario testing



Existing scenario



Future scenario

Platanias	Importance*	Future scenario changes
Vehicular accessibility	0	Proposed interconnection
Pedestrian accessibility	1	Proposed interconnection
Cycle accessibility	1	Proposed interconnection
No. of important and existing crossings within 5min walk	1	Proposed crossings
No. of bus stops within 5min walk	1	Proposed bus transit centre
No. of existing car parking locations within 15min walk	0	Possible and foreseen
No. of hotels within 15min walk	1	
No. of tourist attractions (active travel) within 15min walk	1	
No. of other main attractions within 15min walk	1	
No. of open space within 15min walk	1	Possible creation
No. of social facilities within 15min walk	0	
No. of health facilities within 15min walk	0	
No. of primary schools and kindergartens within 15min walk	0	
Access to cycle path within 5min cycle	1	Proposed interconnection
No. of high schools within 15min walk	0	

*where 0 is not important and 1 is important

★ Proposed bus transit centre
- Proposed crossings
- Possible creation of open space
- Possible and foreseen parking locations
- Proposed interconnection

Sustainable tourism

high

low

The future scenario testing shows that by implementing future scenario changes, such as; the proposed interconnection, proposed crossings, bus transit centre, possible and foreseen parking locations and possible creation of open space in Platanias, the sustainable tourism index increases in the Kolymvari, Tavronitis and Platanias areas.

Another example use of further scenario testing for the Platanias study is shown on this page.

The model on the left shows sustainable tourism index for the existing conditions. The model on the right shows the sustainable tourism index in the future scenario, with modification to the street network and infrastructure. This considers possible and proposed additional infrastructure provided by MU/TUC and the proposed interconnection.

The values and colour ranges have been recalibrated based on the future scenario model, as the future scenario model has higher ranges. By applying the same data and colour ranges, the two outputs can be comparable.

The future scenario shows the impact of the proposals on sustainable tourism.

Bibliography and references

Bibliography and references

Bibliography

Hillier, B. and Hanson, J. (1984). The social logic of space. Cambridge, MA: Cambridge University Press.

Hillier, B. (2006). Space is the machine. Cambridge, MA: Cambridge University Press.

Hillier, B., Penn, A., Hanson, J., Grajewski, T., Xu, J. (1993). Natural movement: or, Configuration and attraction in urban pedestrian movement. Environment and Planning B: Planning and Design

Hillier, B. (1996). Cities as movement economies. in: Urban Design International 1

Hillier, B. (2009), Spatial sustainability in cities: organic patterns and sustainable forms. In: Koch, D. and Marcus, L. and Steen, J., (eds.) Proceedings of the 7th International Space Syntax Symposium. (pp. p. 1). Royal Institute of Technology (KTH): Stockholm, Sweden.

References

Space Syntax JiscMail

An email discussion lists for the UK Education and Research communities, specifically for sharing Space Syntax discussions and information.

Link to subscribe to the mailing list: https://www.jiscmail.ac.uk/cgi-bin/webadmin?A0=spacesyntax

Space Syntax Toolkit JiscMail

An email discussion lists for the UK Education and Research communities, specifically for sharing Space Syntax Toolkit discussions and information

Link to subscribe to the mailing list: https://www.jiscmail.ac.uk/cgi-bin/webadmin?A0=SPACESYNTAX-TOOLKIT

UCL Space Syntax Online Training Platform (open-source)

Introduces the fundamentals of Space Syntax theory and provides a unified training resource for researchers and practitioners.

https://www.spacesyntax.online

Documentation for QGIS 3.22

Official documentation of QGIS. Available in various languages and versions. Also available to download for offline reading.

https://docs.qgis.org/3.22/en/docs/index.html

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Bibliography and references

Download links

QGIS (2.14 or above)
https://qgis.org/en/site/

depthmapXnet 0.35 – compiled version used for the Space Syntax Toolkit analysis
http://archtech.gr/varoudis/depthmapX/?dir=depthmapXnet

depthmapX v.0.8.0 (latest release 2020) – multi-platform software platform to perform a set of spatial network analyses designed to understand social processes within the built environment
https://github.com/SpaceGroupUCL/depthmapX/releases/tag/v0.8.0

Space Syntax

Website: https://spacesyntax.com/

Training: https://spacesyntax.com/training/

YouTube channel: https://www.youtube.com/user/spacesyntaxdotcom

GitHub: https://github.com/spacesyntax

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