CLC Network Modelling Project (Inter-agency)

NSCC x Geoworks Enablement Series 2021

5th March 2021

- **How street network spatial modelling and analysis can value-add planning processes and policies within govt agencies**
- **How High Performance Computing (HPC) played a role**

Content produced by the **Complexity Science** team at **CLC**

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Ryan Tan (Research Assistant)

Overall Project Goals Network Modelling Project

- Develop street network modelling analysis to uncover hidden urban structures, missing opportunities
- Designing a robust analytical methodology for scientific modelling and application to agencies’ use cases
- Scientifically testing design options and masterplan proposals
- Providing objective advice, consultancy wherever needed

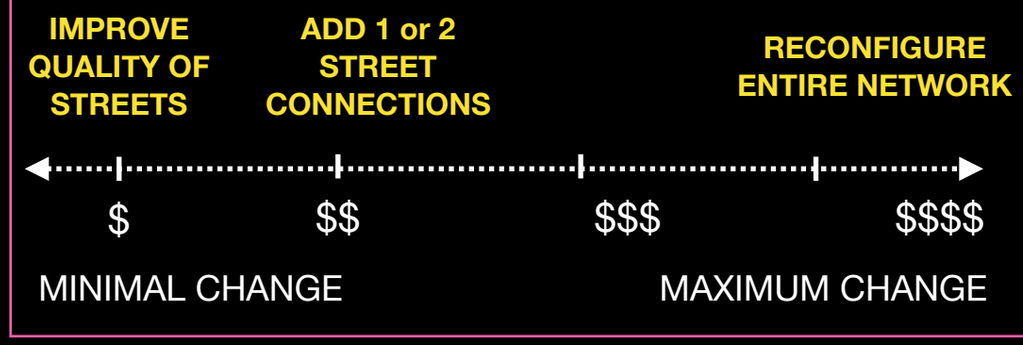
SPACE SYNTAX

Street Network Model

1. Measures accessibility of existing and proposed masterplans

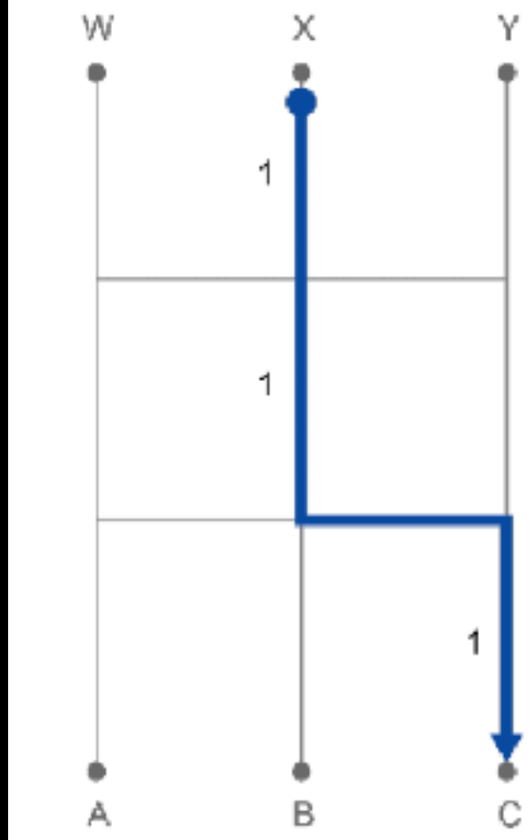
2. Uncovers potential in active mobility routes and identifies missed opportunities

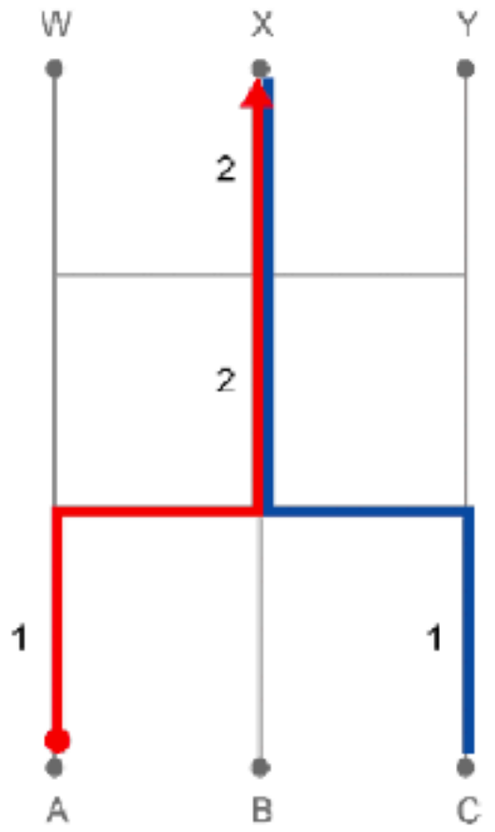
MINIMAL CHANGE TO ATTAIN MAXIMUM EFFECT

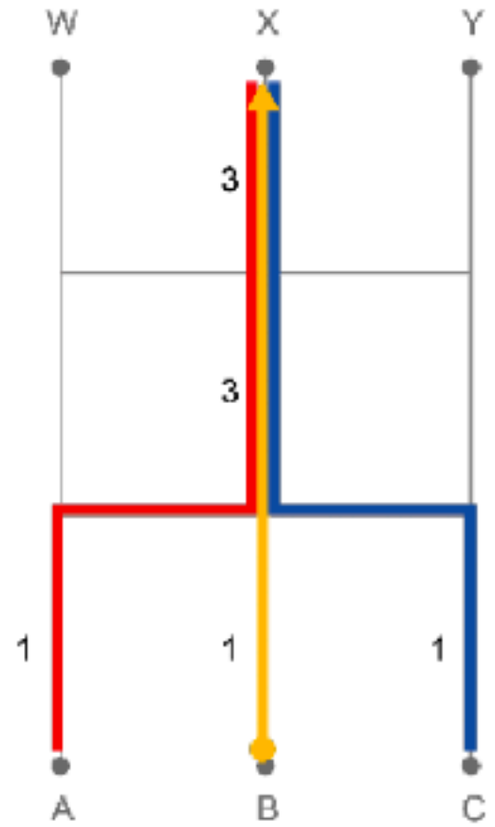


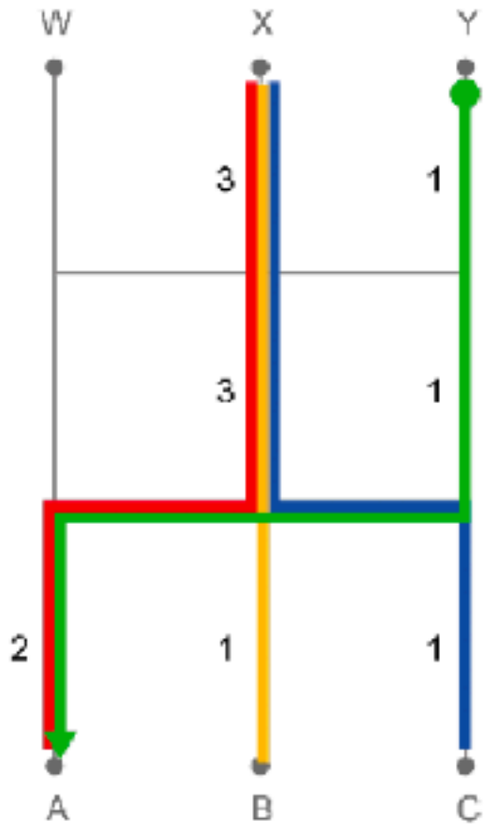
Betweenness Centrality

Choice / Through-Movement









Segment Angular Analysis

Angular Change

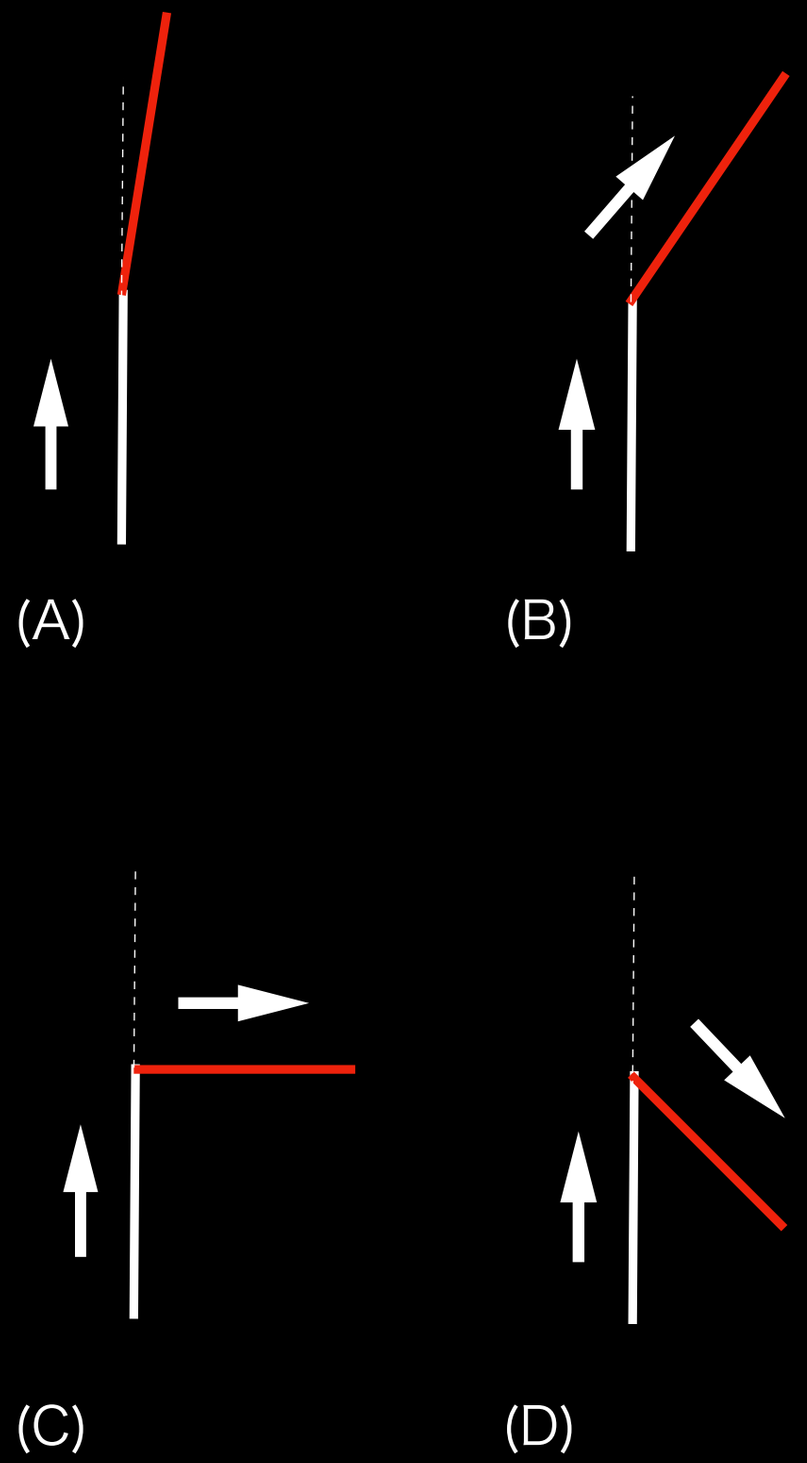
The way angular connectivity is calculated refers also to the way Angular Analysis weights the route choice within the graph.

(A) A turn of less than 22.5 degrees has **0** weighting.

(B) A turn at 45 degrees is weighted by **0.5**

(C) A connection at 90 degrees is weighted by **1**

(D) And so forth, the maximum is 180 degrees with a weighting of **2**



Singapore Islandwide

Choice Accessibility

Global

Spatial Accessibility

High

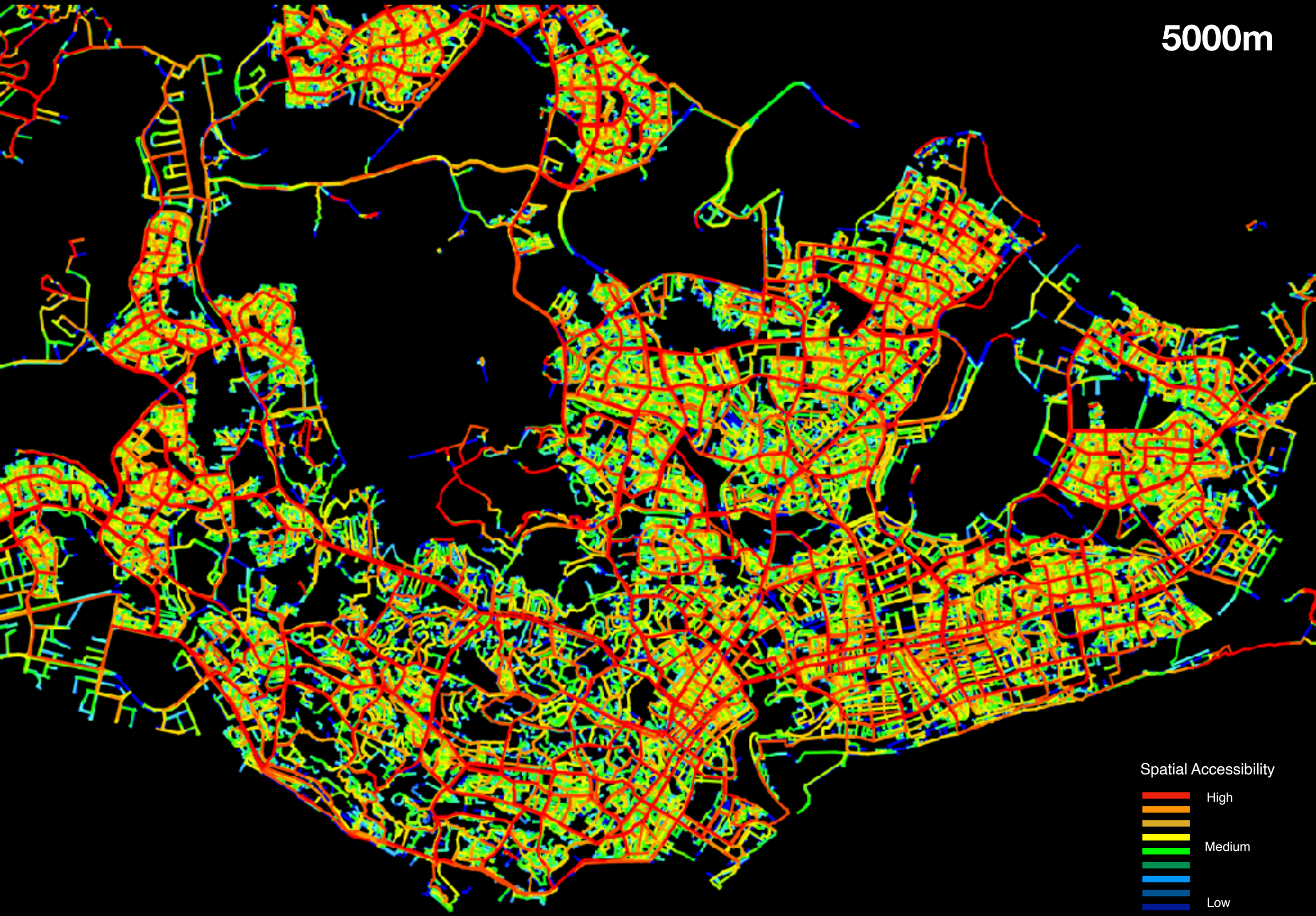
Medium

Low

Singapore Islandwide

Choice Accessibility

5000m



Singapore Islandwide

Choice Accessibility

3000m

Spatial Accessibility

High

Medium

Low

Singapore Islandwide

Choice Accessibility

2000m

Spatial Accessibility

High

Medium

Low

Singapore Islandwide

Choice Accessibility

1200m

Spatial Accessibility

High

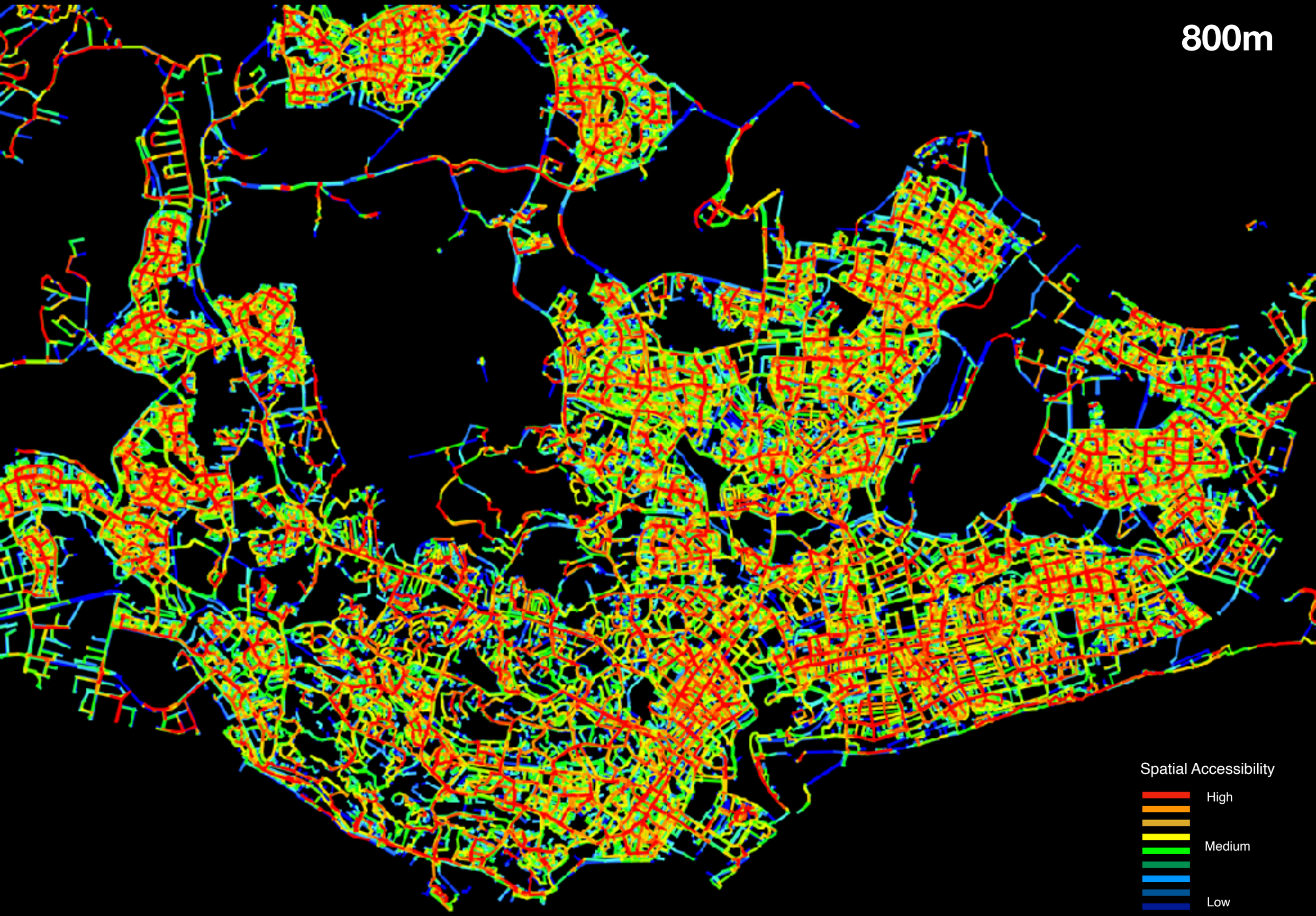
Medium

Low

Singapore Islandwide

Choice Accessibility

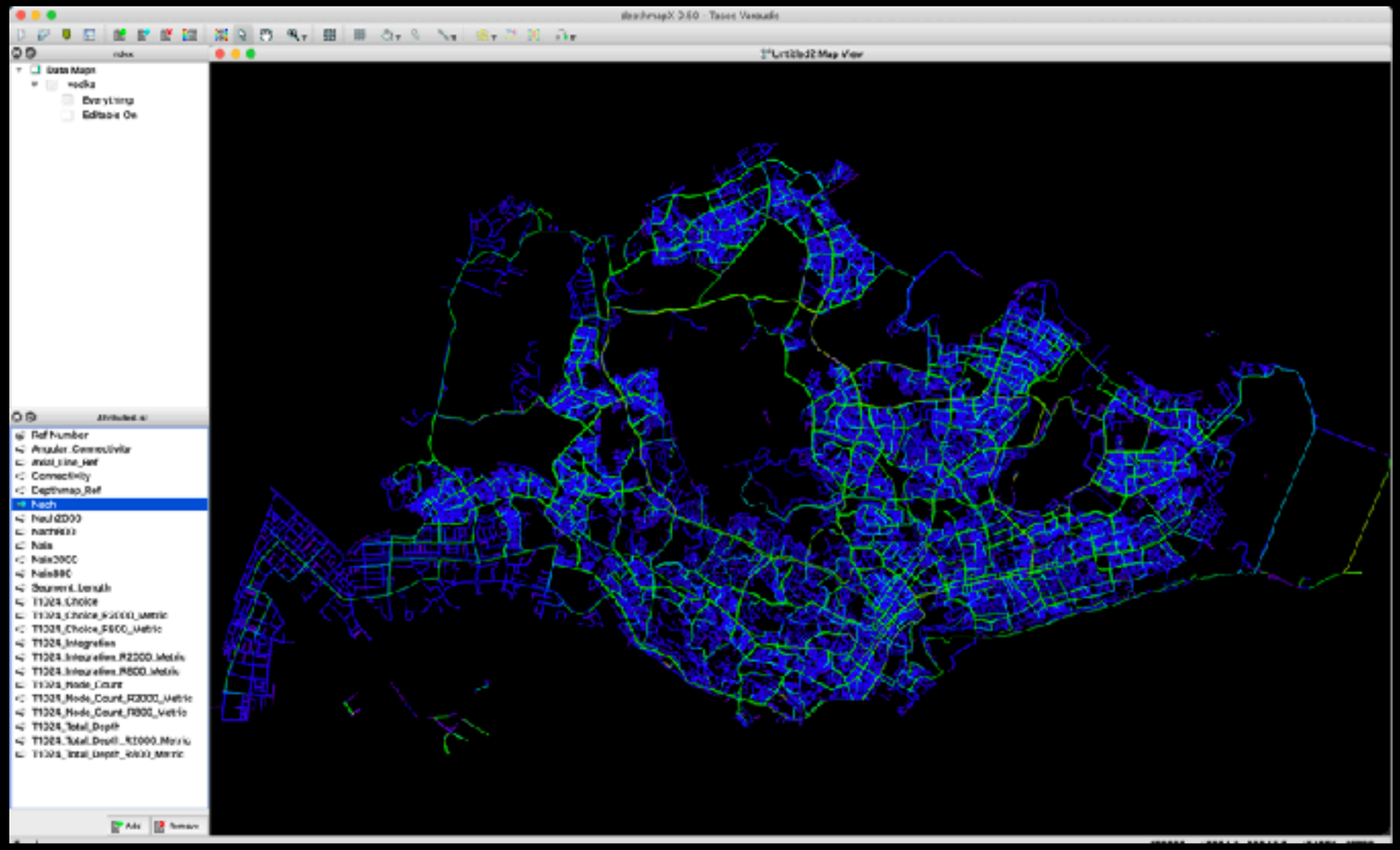
800m



Typical workflow - Without HPC

depthmapX software

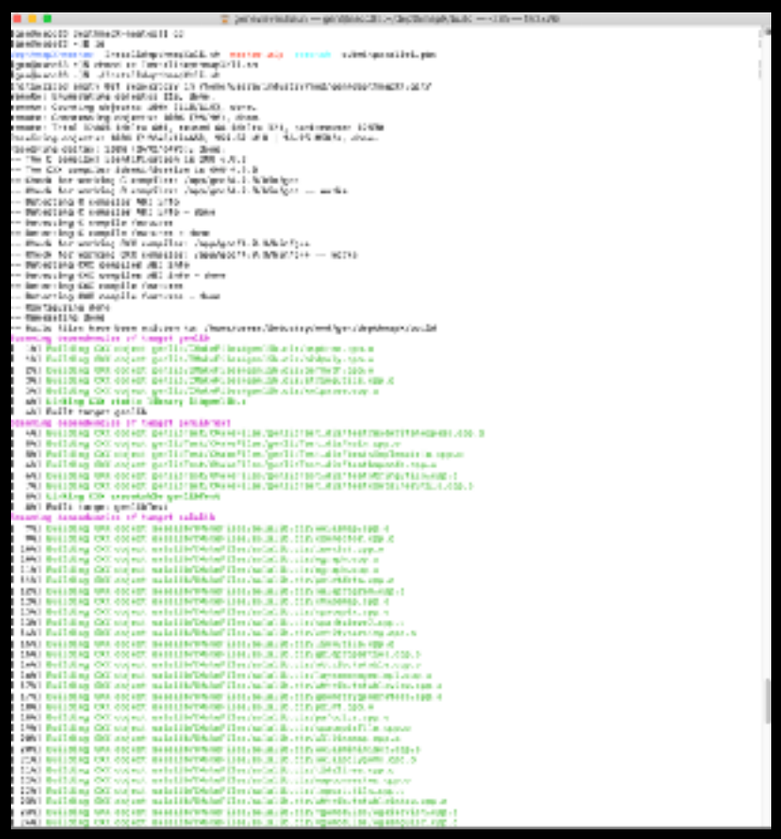
Running analysis using depthmapX software
Processing time: 24-48 hours



Typical workflow - With HPC

depthmapX software

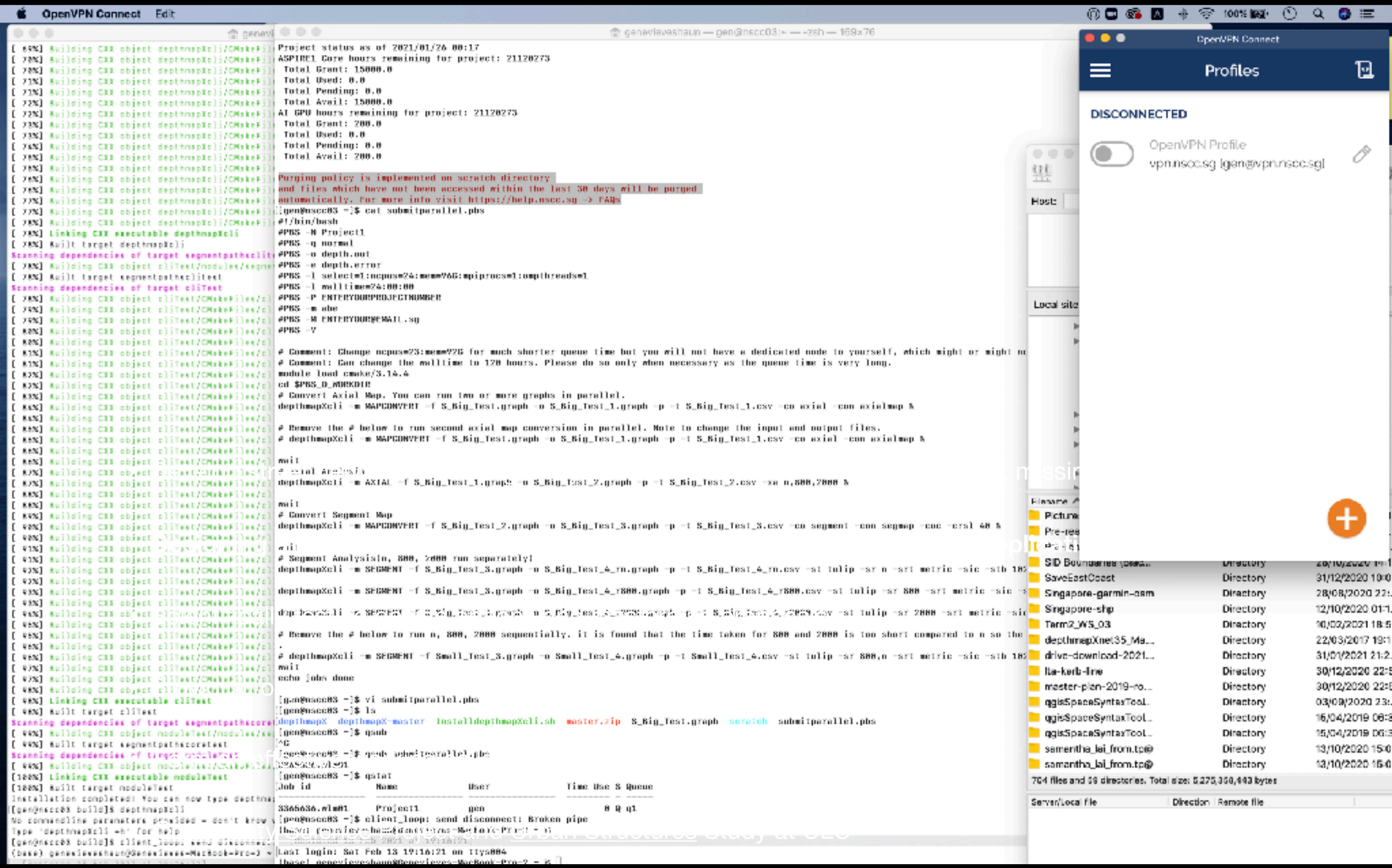
1.
Building depthmapX onto NSCC's server



2.
Running DepthmapX on NSCC's server
Using DepthmapX CLI (Command Line Interface)

3.
Split the different radius analysis as different task to make use of HPC parallel computing

Typical workflow - With HPC



Spatial Accessibility

Global

Choice Accessibility

- Betweenness Centrality
- Potential for Human Movement
- Multi-scale

Dunman Road

Broadrick Road

Spatial Accessibility

High

Medium

Low

Spatial Accessibility

Radius 5000m

Choice Accessibility

- Betweenness Centrality
- Potential for Human Movement
- Multi-scale

Dunman Road

Broadrick Road

Spatial Accessibility

High

Medium

Low

Spatial Accessibility

Radius 3000m

Choice Accessibility

- Betweenness Centrality
- Potential for Human Movement
- Multi-scale

Dunman Road

Broadrick Road

Spatial Accessibility

High

Medium

Low

Spatial Accessibility

Radius 2000m

Choice Accessibility

- Betweenness Centrality
- Potential for Human Movement
- Multi-scale

Dunman Road

Broadrick Road

Spatial Accessibility

High

Medium

Low

Spatial Accessibility

Radius 1200m

Choice Accessibility

- Betweenness Centrality
- Potential for Human Movement
- Multi-scale

Dunman Road

Broadrick Road

Spatial Accessibility

High

Medium

Low

Spatial Accessibility

Radius 800m

Choice Accessibility

- Betweenness Centrality
- Potential for Human Movement
- Multi-scale

Dunman Road

Broadrick Road

Spatial Accessibility

High

Medium

Low

demo
01a

accessibility studies

residential homes to east coast park

- residential catchment from ecp entrances
- 401 bus stop catchment
- spatial accessibility
- cycling routes

network catchment

0m - 2000m

Origin:

Entrances to East Coast Park

network catchment

0m - 2000m

Origin:

Entrances to East Coast Park

residential catchment

0m - 2000m

Origin:

Entrances to East Coast Park

bus stops with 401

0m - 800m

Origin:

Entrances to East Coast Park

bus stops with 401

0m - 800m

Origin:

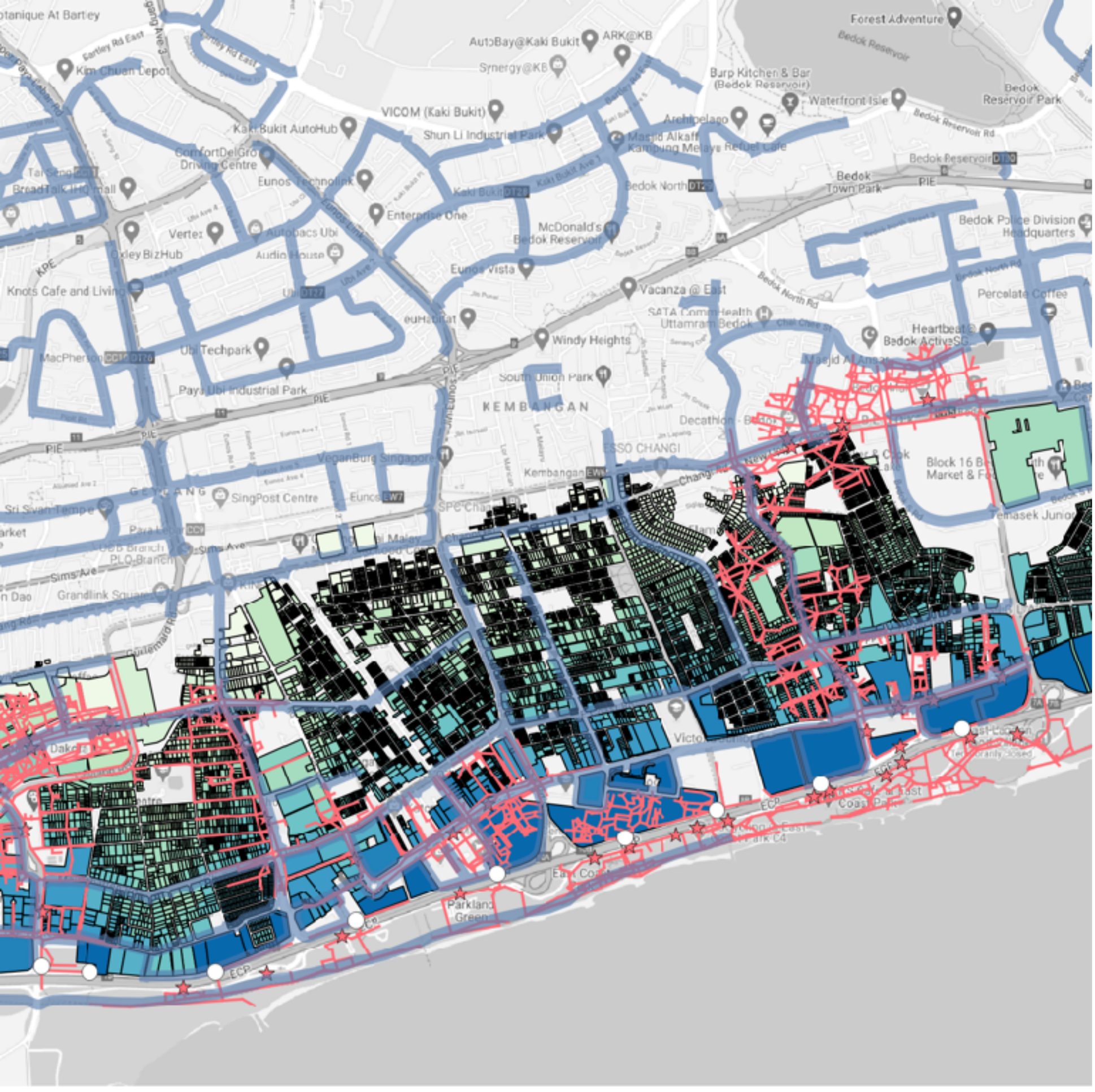
Entrances to East Coast Park

bus stops with 401

0m - 800m

residential catchment

0m - 2000m



bus stops with 401

0m - 800m

residential catchment

0m - 2000m

cycling paths

ura scdp cycling path 2019

residential catchment

0m - 2000m

cycling paths

ura scdp cycling path 2019

accessibility (choice)

5000m

residential catchment

0m - 2000m

cycling paths

ura scdp cycling path 2019

accessibility (choice)

2000m

residential catchment

0m - 2000m

cycling paths

ura scdp cycling path 2019

accessibility (choice)

1200m

demo
01b

accessibility studies

residential homes to commercial activity

- catchment from commercial activity - 20 min walk
- space syntax choice
- How can the cycling routes fill the gap?

Choice 2000m

Origin:

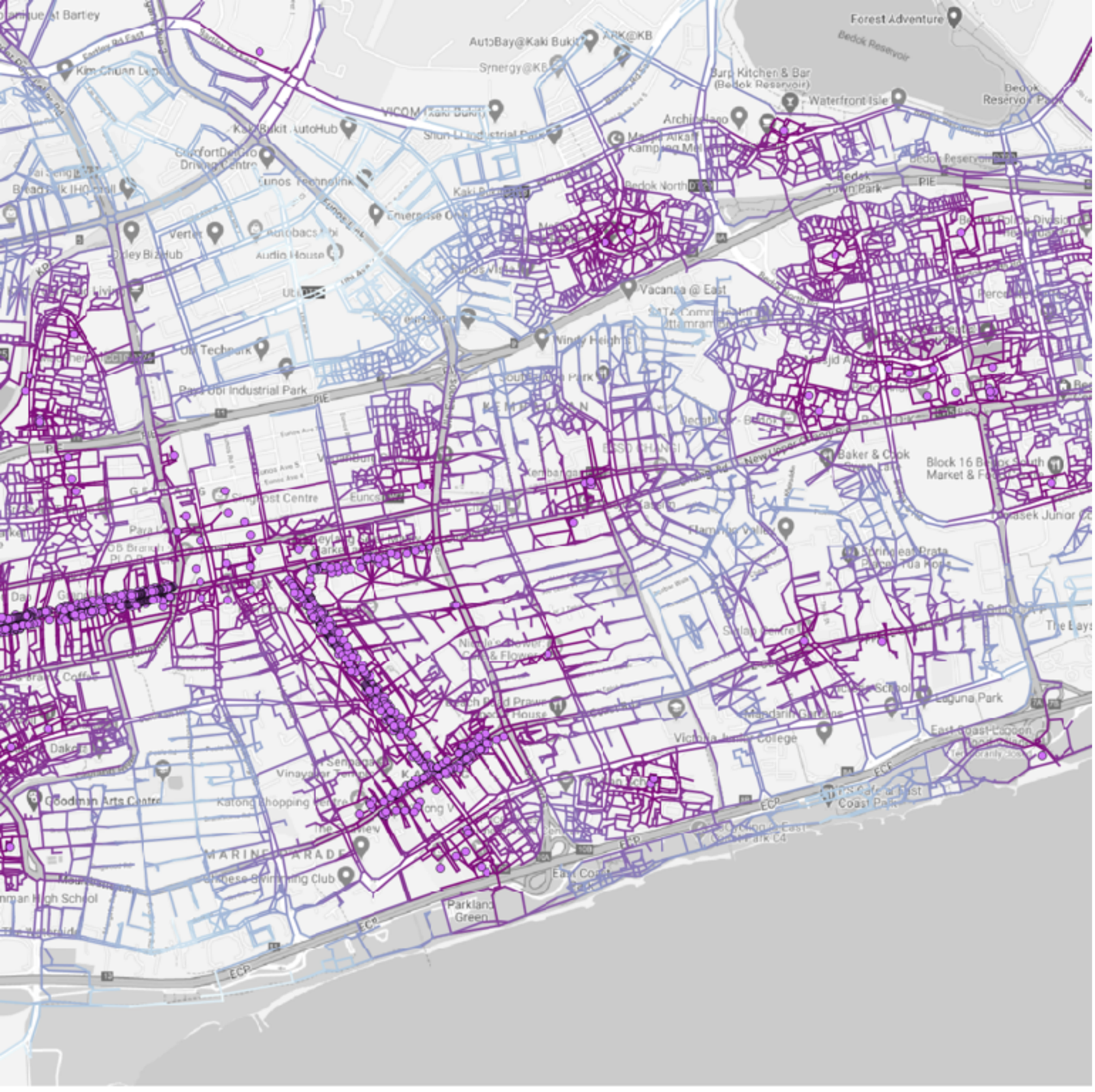
Entrances to East Coast Park

Choice 2000m

Origin:

Entrances to East Coast Park

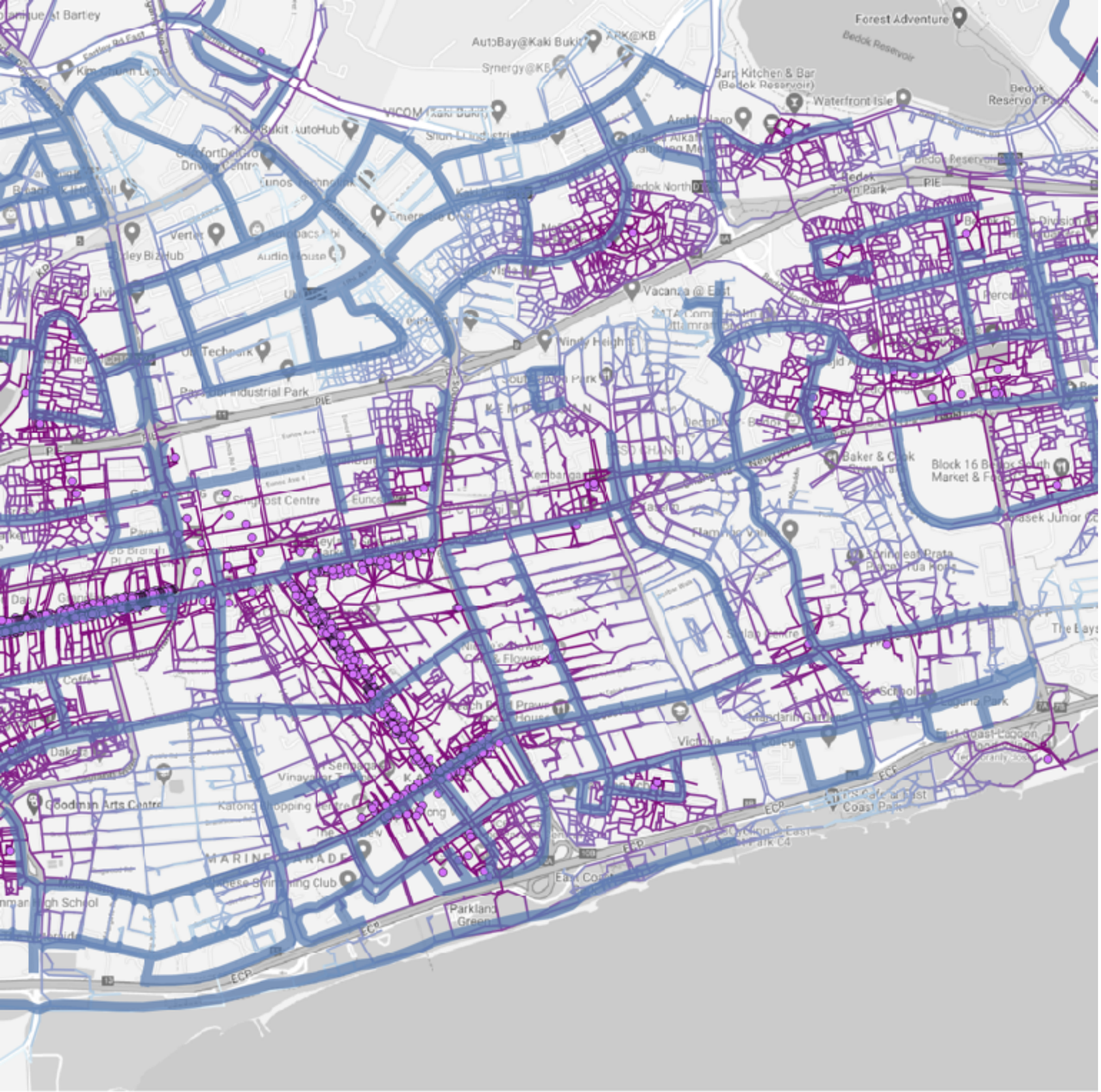
Choice 2000m



Origin:

Entrances to East Coast Park

Choice 2000m



Origin:

Entrances to East Coast Park

Choice 5000m

Origin:

Entrances to East Coast Park

Choice 2000m

Origin:

Entrances to East Coast Park

Choice 1200m

Origin:

Entrances to East Coast Park

Choice 800m

Origin:

Entrances to East Coast Park

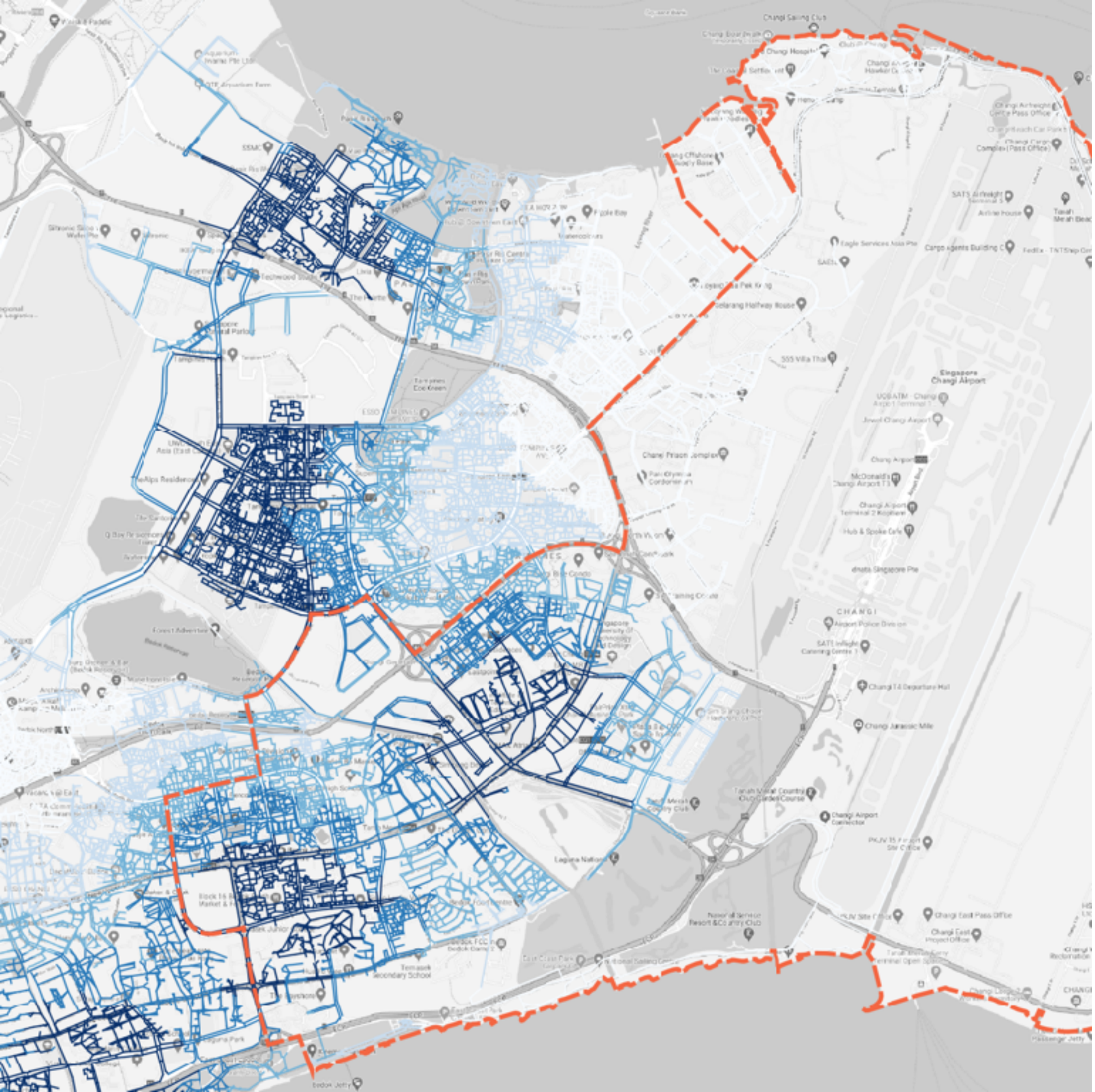
demo
02

accessibility studies

homes to various amenities

baseline data sources for POI:

schools (primary, secondary, tertiary) - OSM & cleaned
polyclinics - OSM & cleaned
hawker centres - data.gov.sg
parks - URA landuse masterplan
retail shops - OSM & cleaned

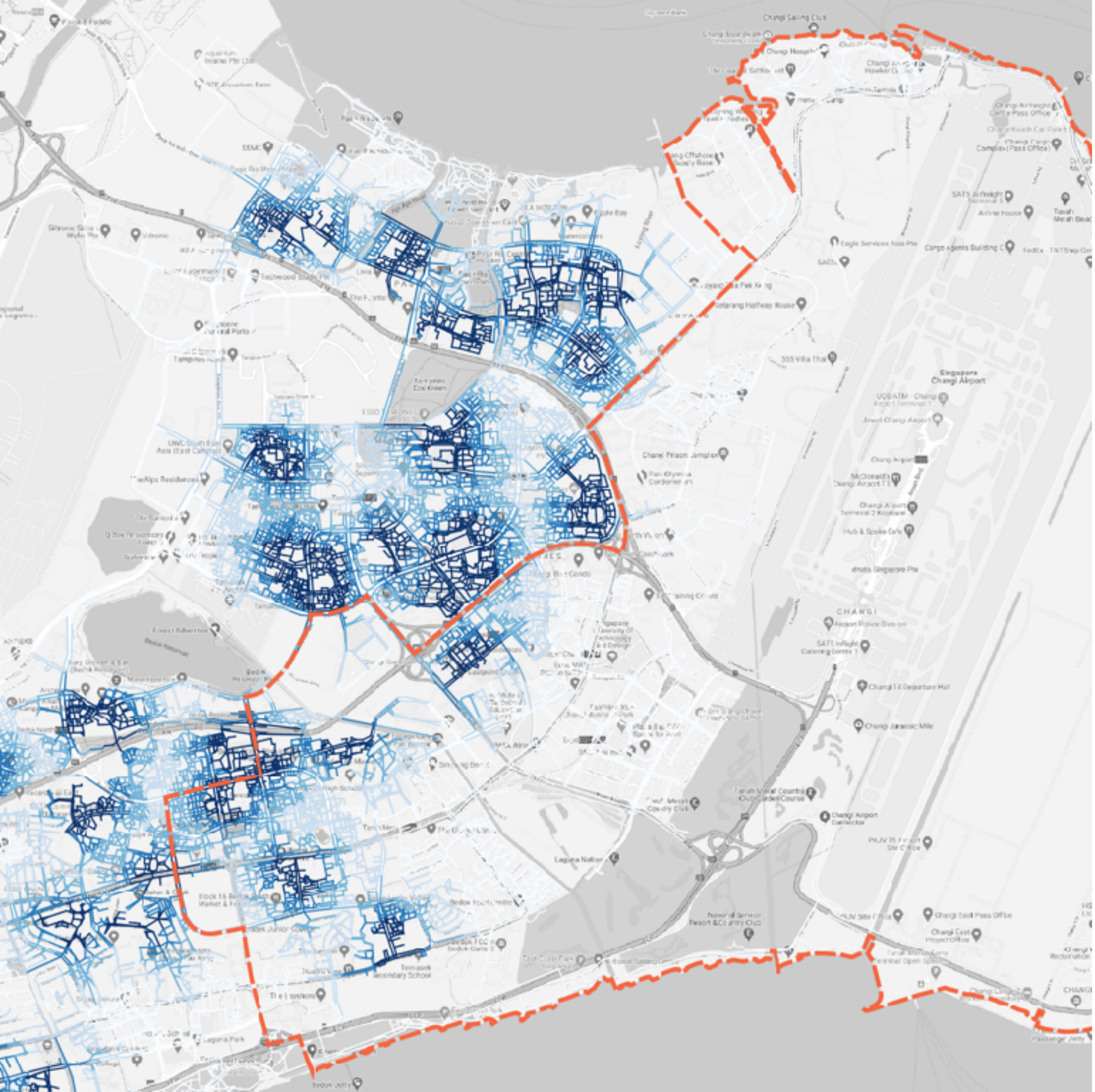


schools tertiary

0-1600m (20 min walk)

baseline data sources for POI:

schools (primary, secondary, tertiary) - OSM & cleaned
polyclinics - OSM & cleaned
hawker centres - data.gov.sg
parks - URA landuse masterplan
retail shops - OSM & cleaned



schools primary

0-1600m (20 min walk)

baseline data sources for POI:

schools (primary, secondary, tertiary) - OSM & cleaned
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parks - URA landuse masterplan
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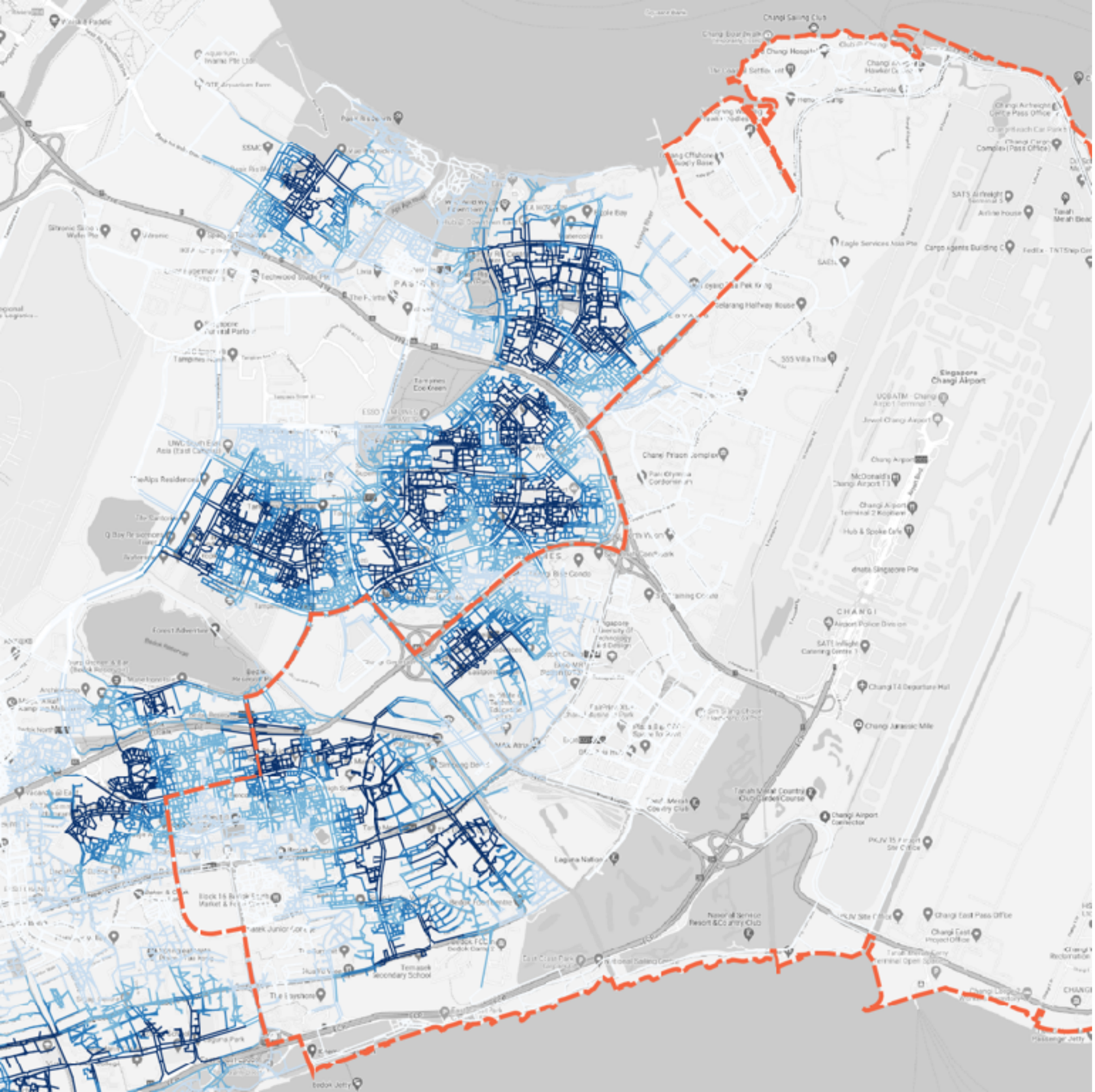

schools secondary

0-1600m (20 min walk)

baseline data sources for POI:

schools (primary, secondary, tertiary) - OSM & cleaned
polyclinics - OSM & cleaned
hawker centres - data.gov.sg
parks - URA landuse masterplan
retail shops - OSM & cleaned

retail shops

0-1600m (20 min walk)

baseline data sources for POI:

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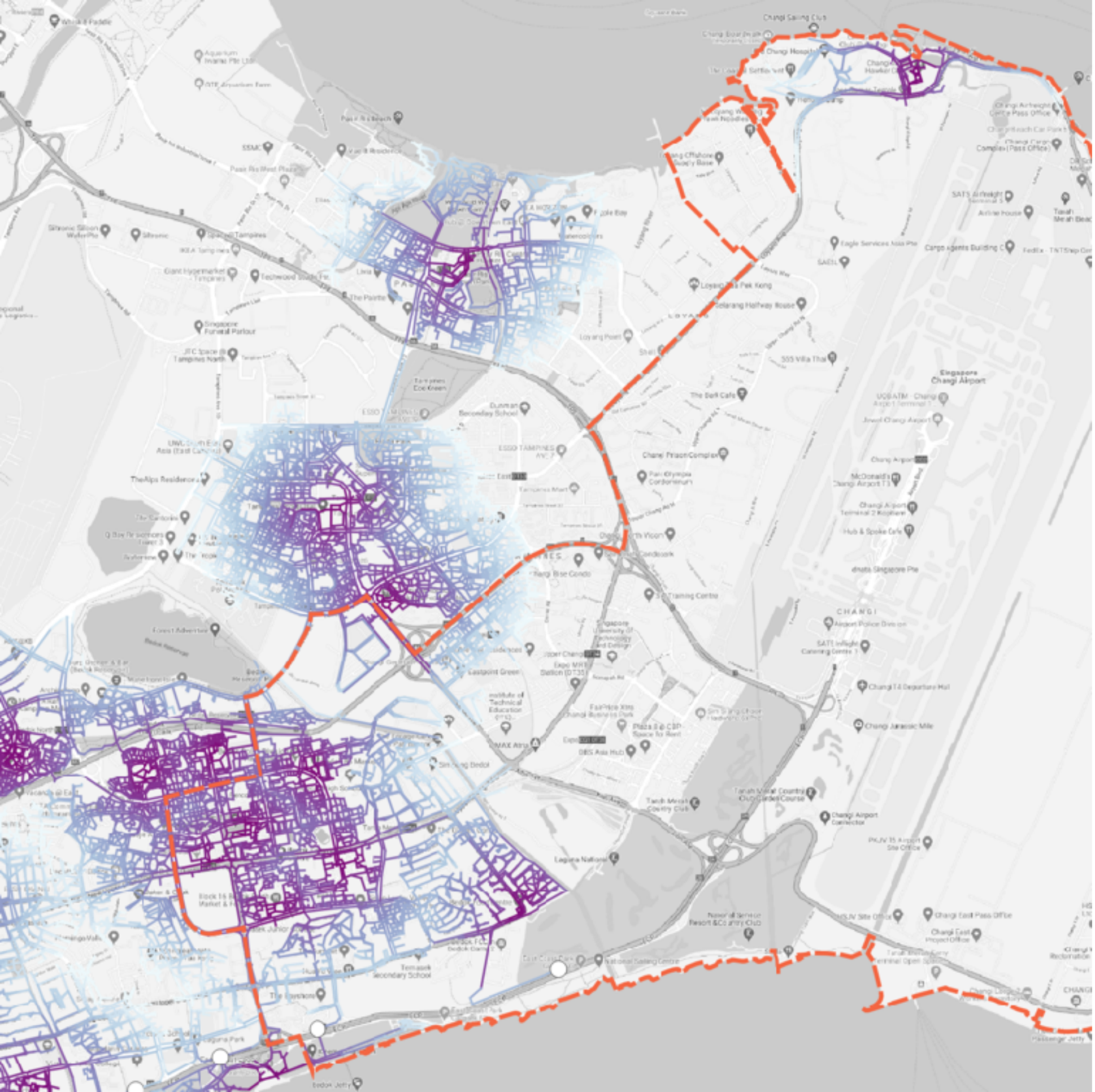

hawker centres

0-1600m (20 min walk)

baseline data sources for POI:

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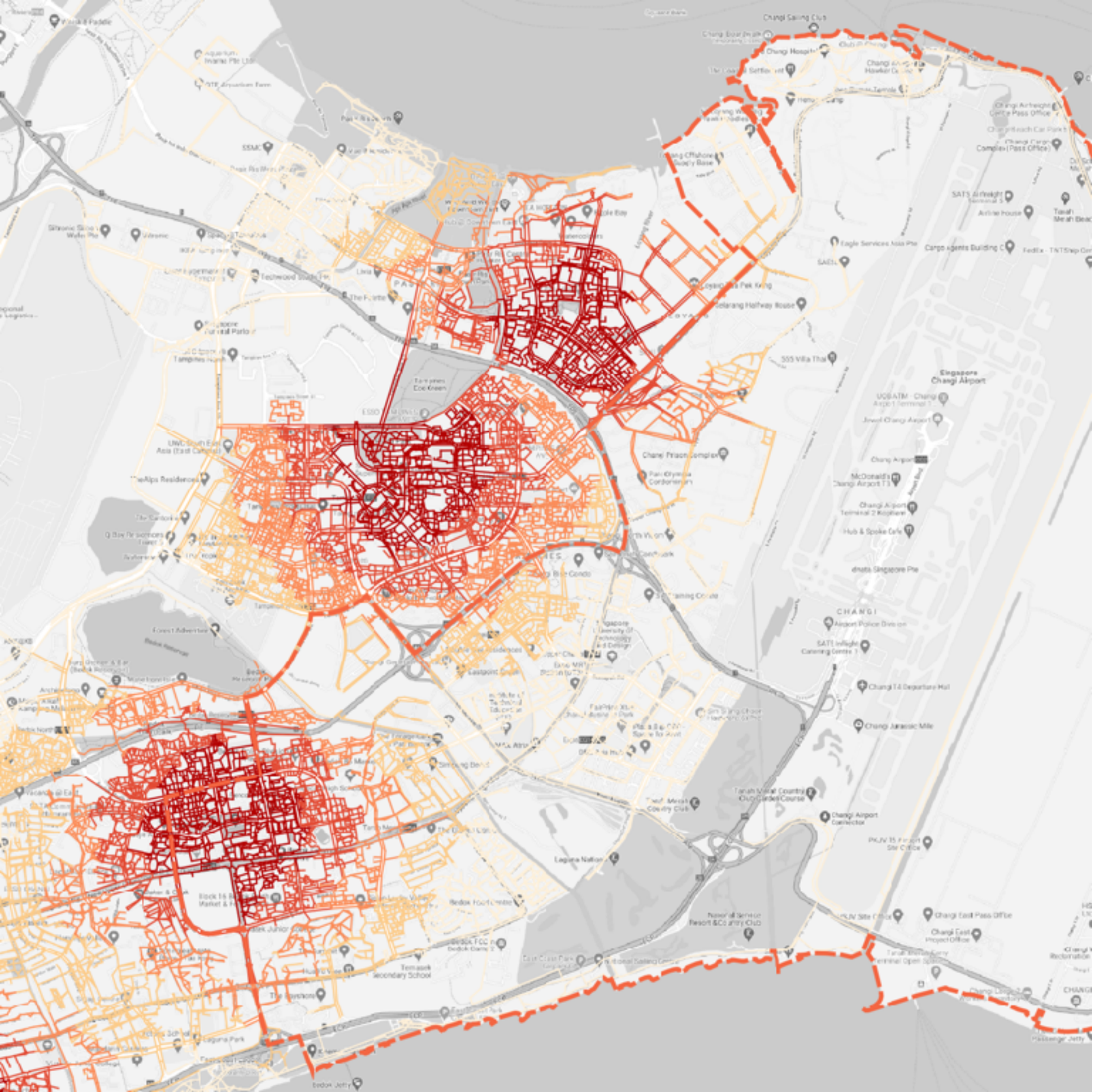

polyclinics

0-1600m (20 min walk)

baseline data sources for POI:

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retail shops - OSM & cleaned

parks

0-1600m (20 min walk)

baseline data sources for POI:

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retail shops - OSM & cleaned

residential plots

east coast grc

Street network **catchment** from all residential plots to the ***nearest*** amenity (by type)

baseline data sources for POI:

schools (primary, secondary, tertiary) - OSM & cleaned
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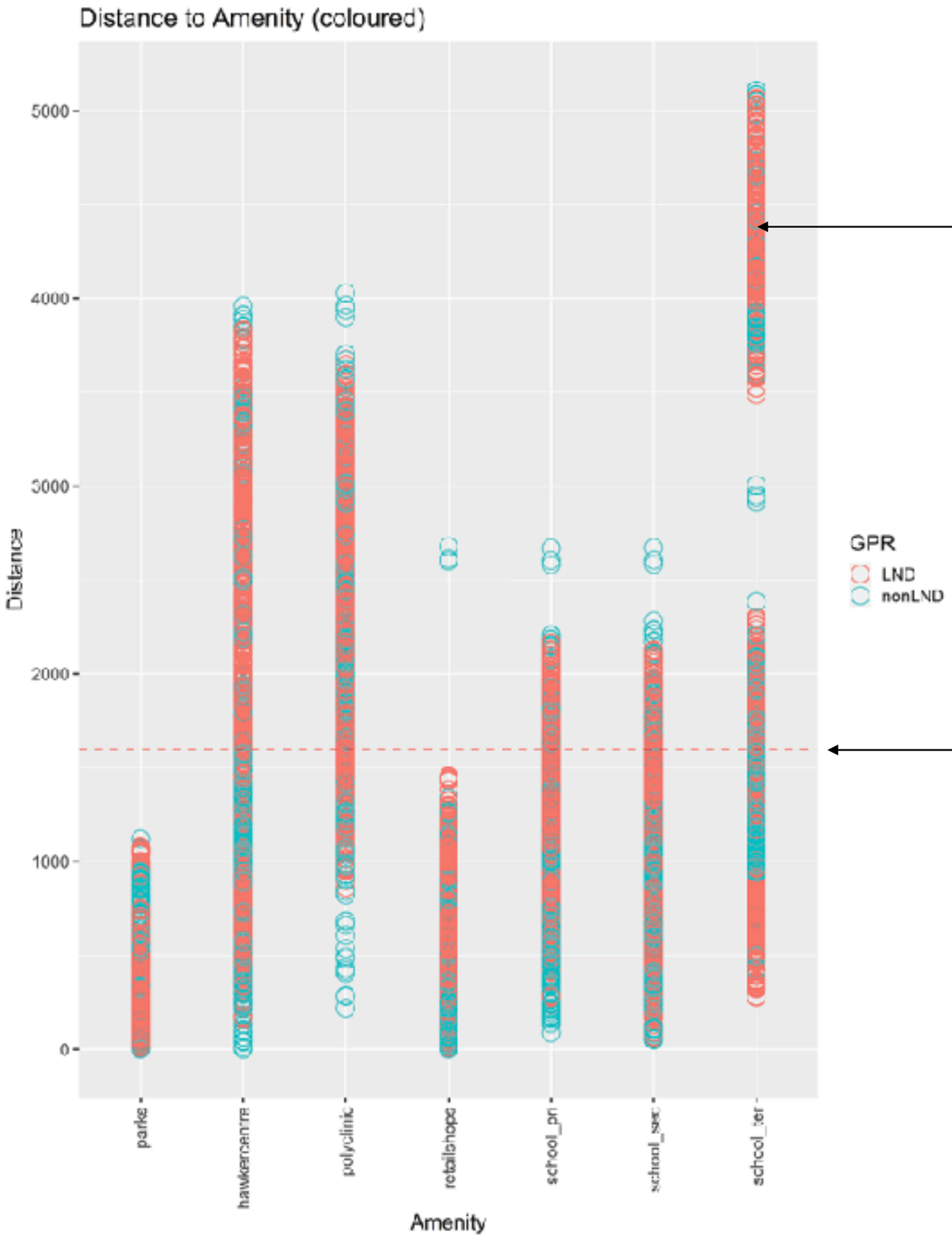
minimum distance from home to amenity

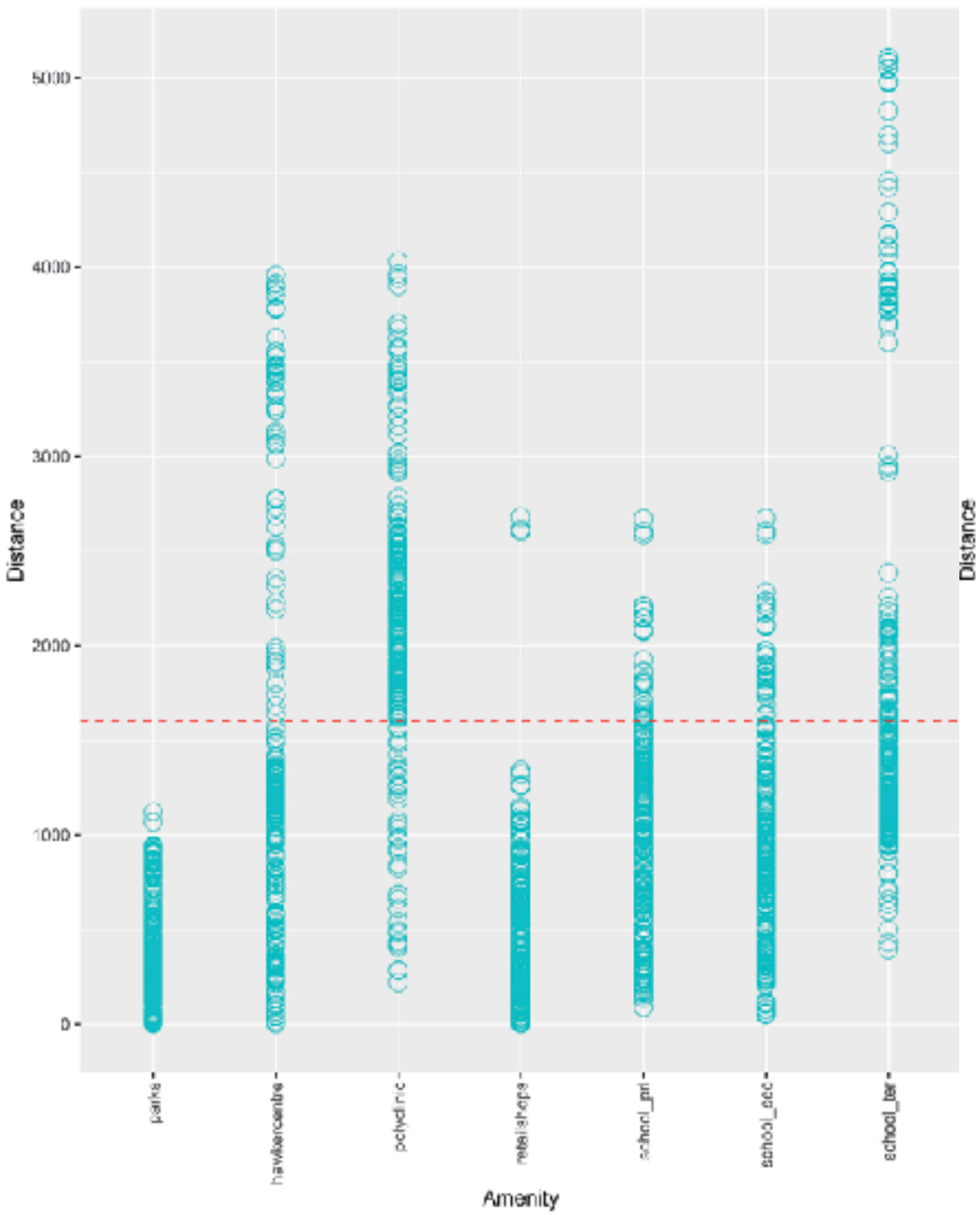


Each point represents a residential plot. Minimum distance away to the closest amenity.

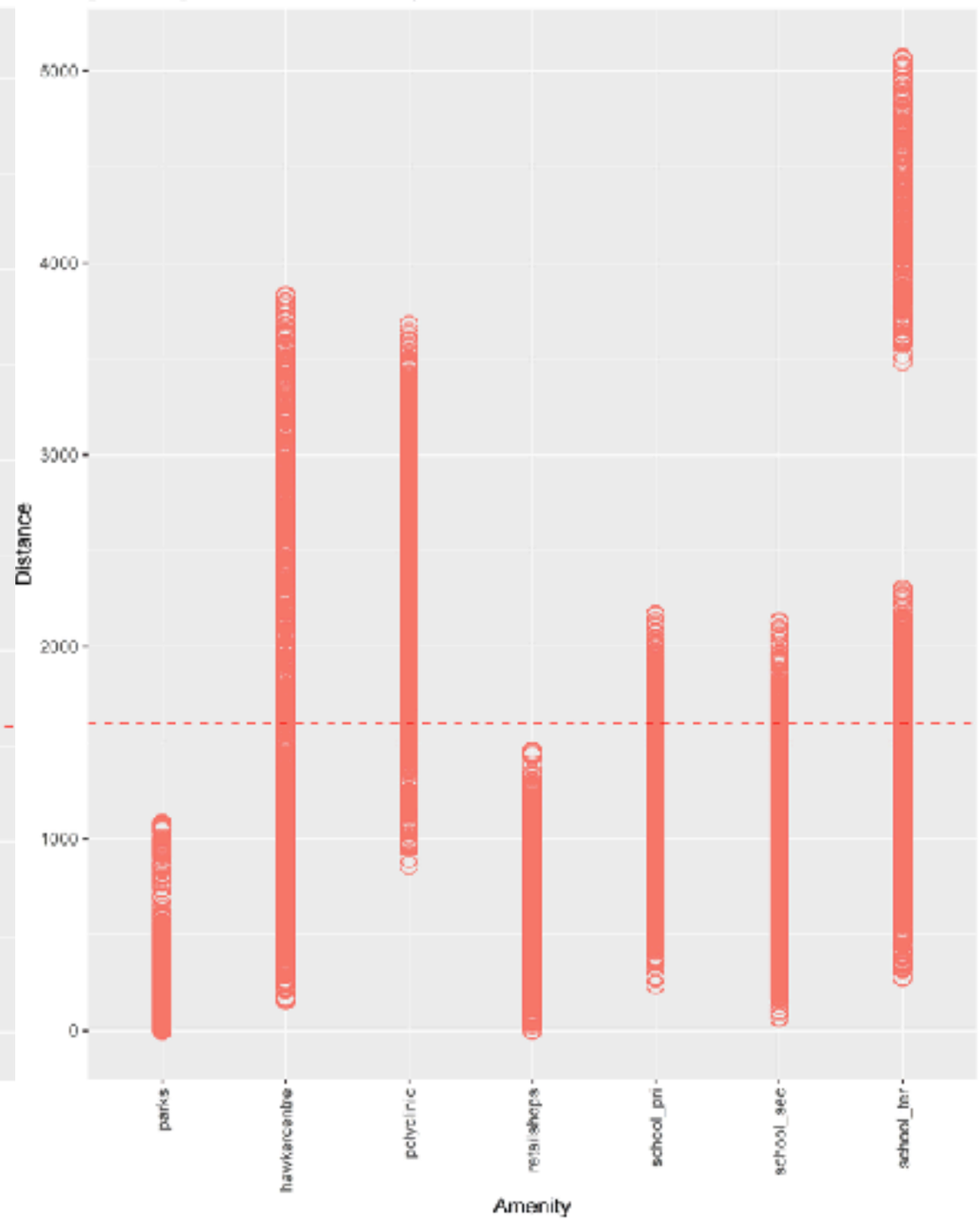
1600m (20 min walk)

minimum distance from home to amenity

Non-landed



Landed



t Park

[note] landed v non-landed could be an indicator for socio-economic background, as well as reliances on car as a main form of commute

For each residential plot that is not a cycling route yet

good proximity from home to amenity

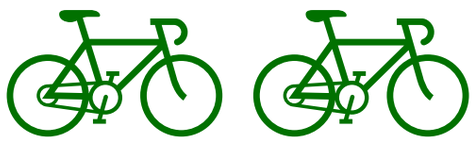
low spatial accessibility

good proximity from home to amenity

high spatial accessibility

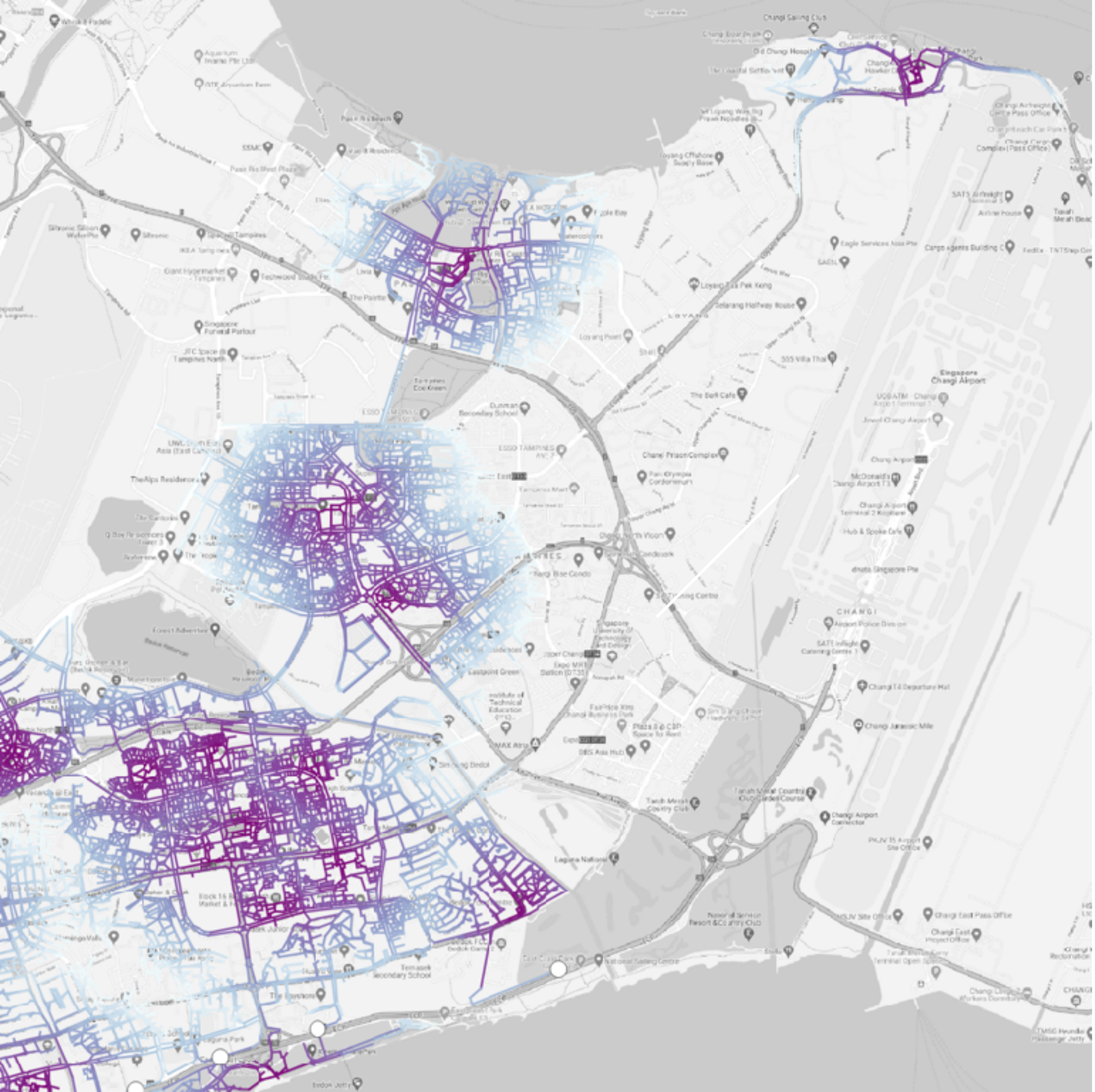
bad proximity from home to amenity

low spatial accessibility



bad proximity from home to amenity

high spatial accessibility



hawker centres

0-1600m (20 min walk)

hawker centre street catchment

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hawker centres

0-1600m (20 min walk)

hawker centre street catchment

URA SDCP Cycling Path 2019

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hawker centres

0-1600m (20 min walk)

hawker centre street catchment

URA SDCP Cycling Path 2019

space syntax recommended cycling routes

(High Choice Accessibility values for 1200, 2000, 3000m radius)

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hawker centres

0-1600m (20 min walk)

hawker centre street catchment

URA SDCP Cycling Path 2019

space syntax recommended cycling routes

residential plots within East Coast GRC

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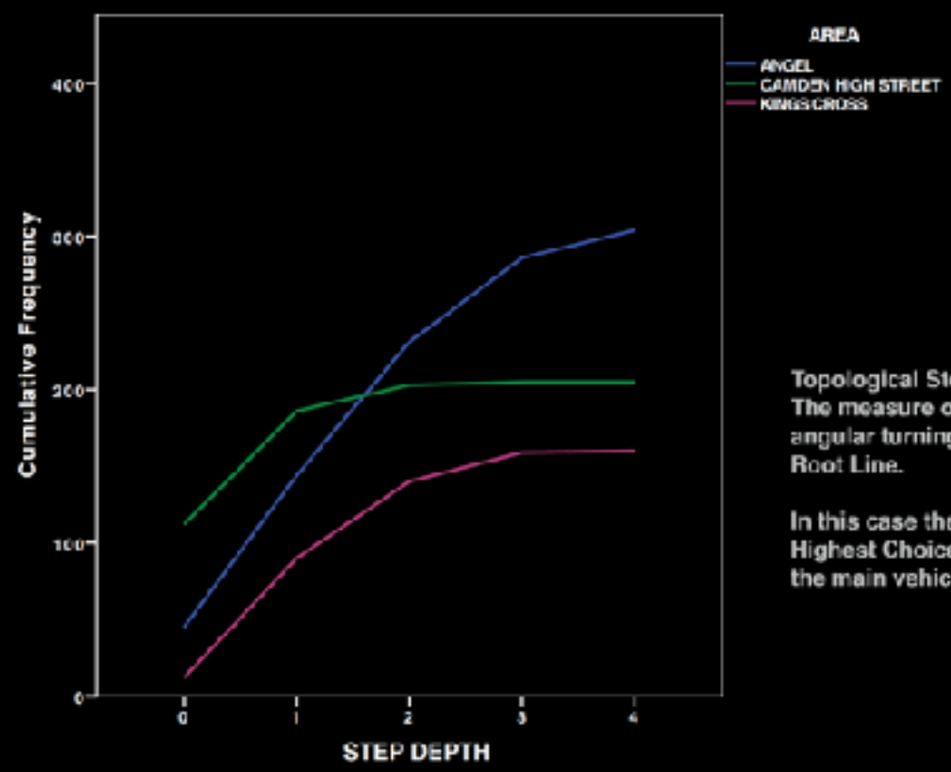
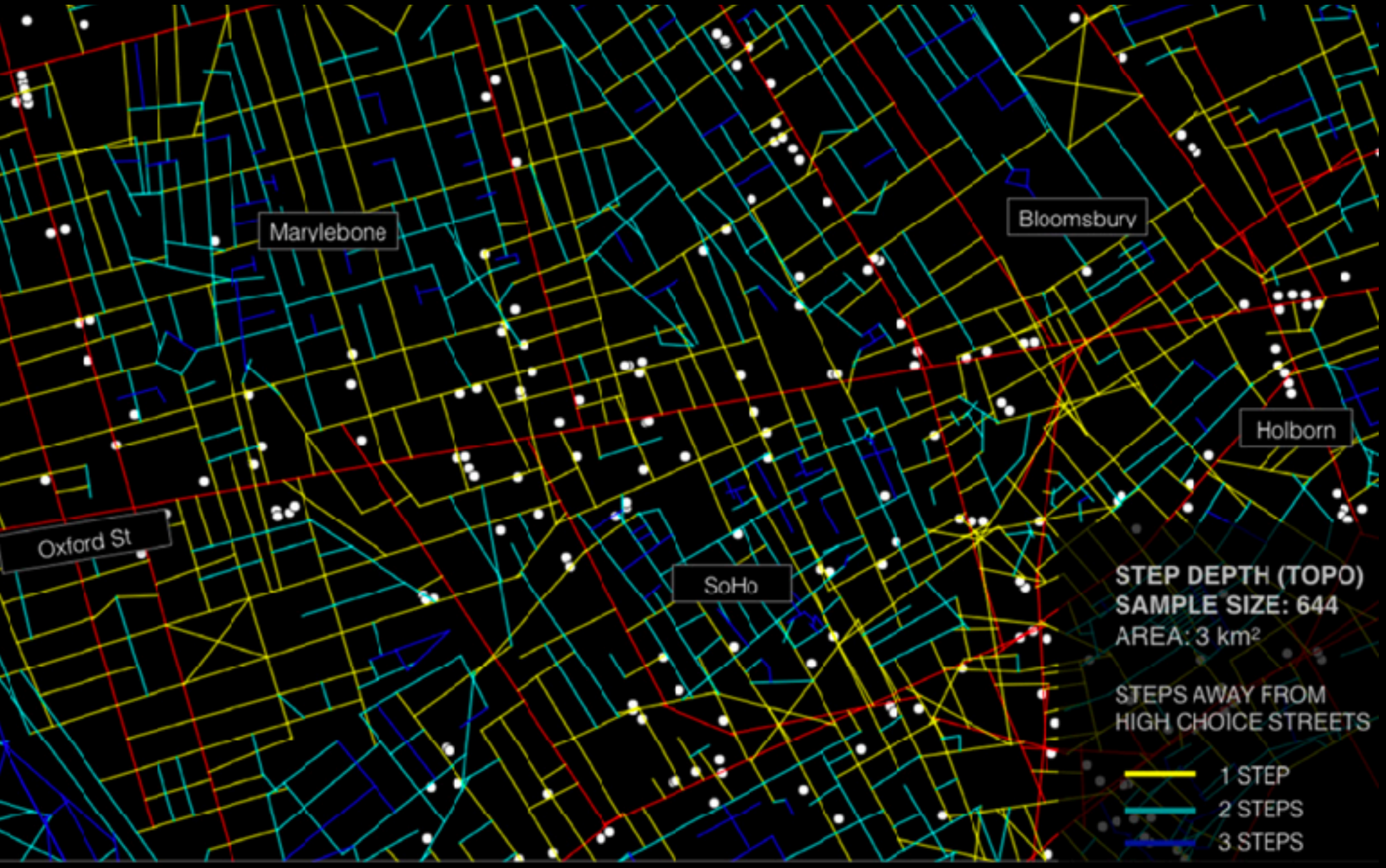
Topological Step Depth

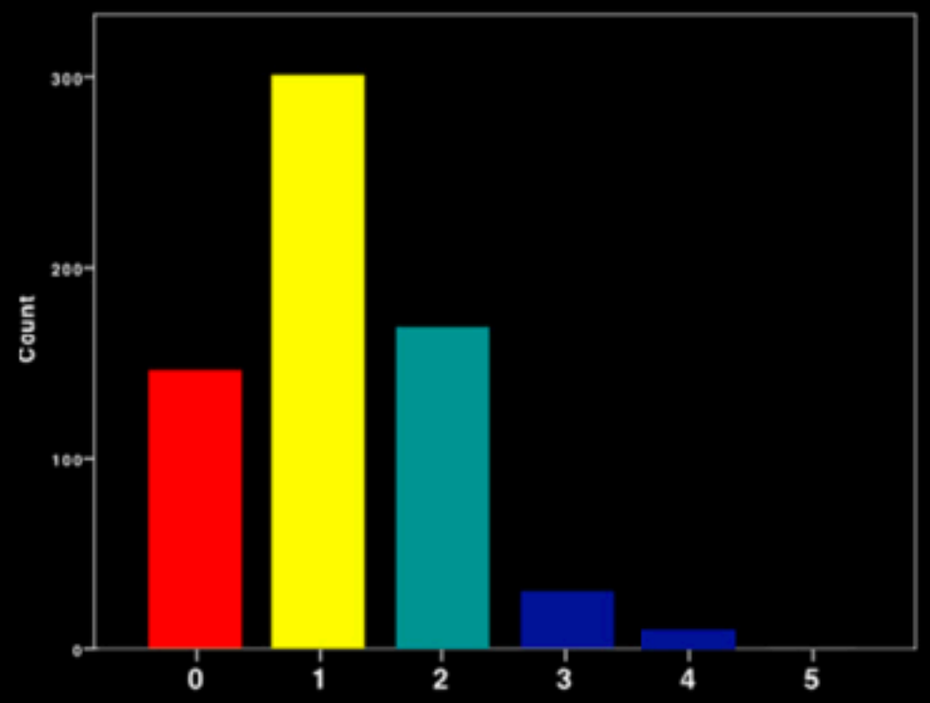


Topological Step Depth:
The measure of the number of the angular turnings away from the Root Line.

In this case the Root Line is the Highest Choice Lines, which are the main vehicular streets.

Topological Step Depth





TOPOLOGICAL STEP DEPTH

Area Size: 3km²
Sample Size: 644 Outlets

STEPS AWAY FROM HIGHEST CHOICE STREETS:

- 1 STEP
- 2 STEPS
- 3 STEPS

SPACE SYNTAX

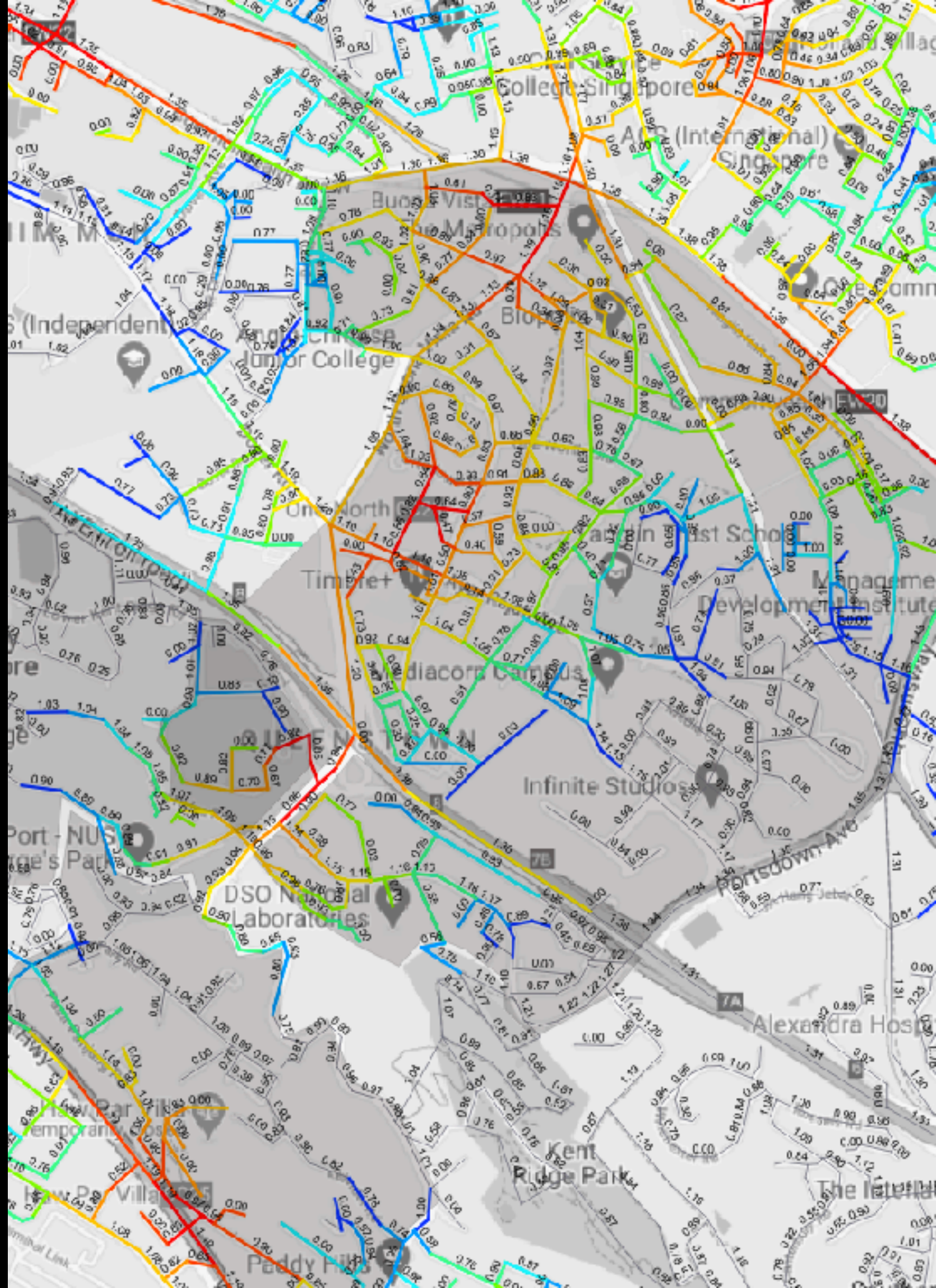
Benefits of a street network model as a baseline analysis

- Conducting preliminary studies before making a case to stakeholders

- Simple analysis can help in engaging stakeholders and develop deeper ideas

- Avoid guesswork between various stakeholders and govt agencies

- These ideas can be tested through the model, to examine its effectiveness



Demo 01

Measures accessibility of existing and proposed masterplans

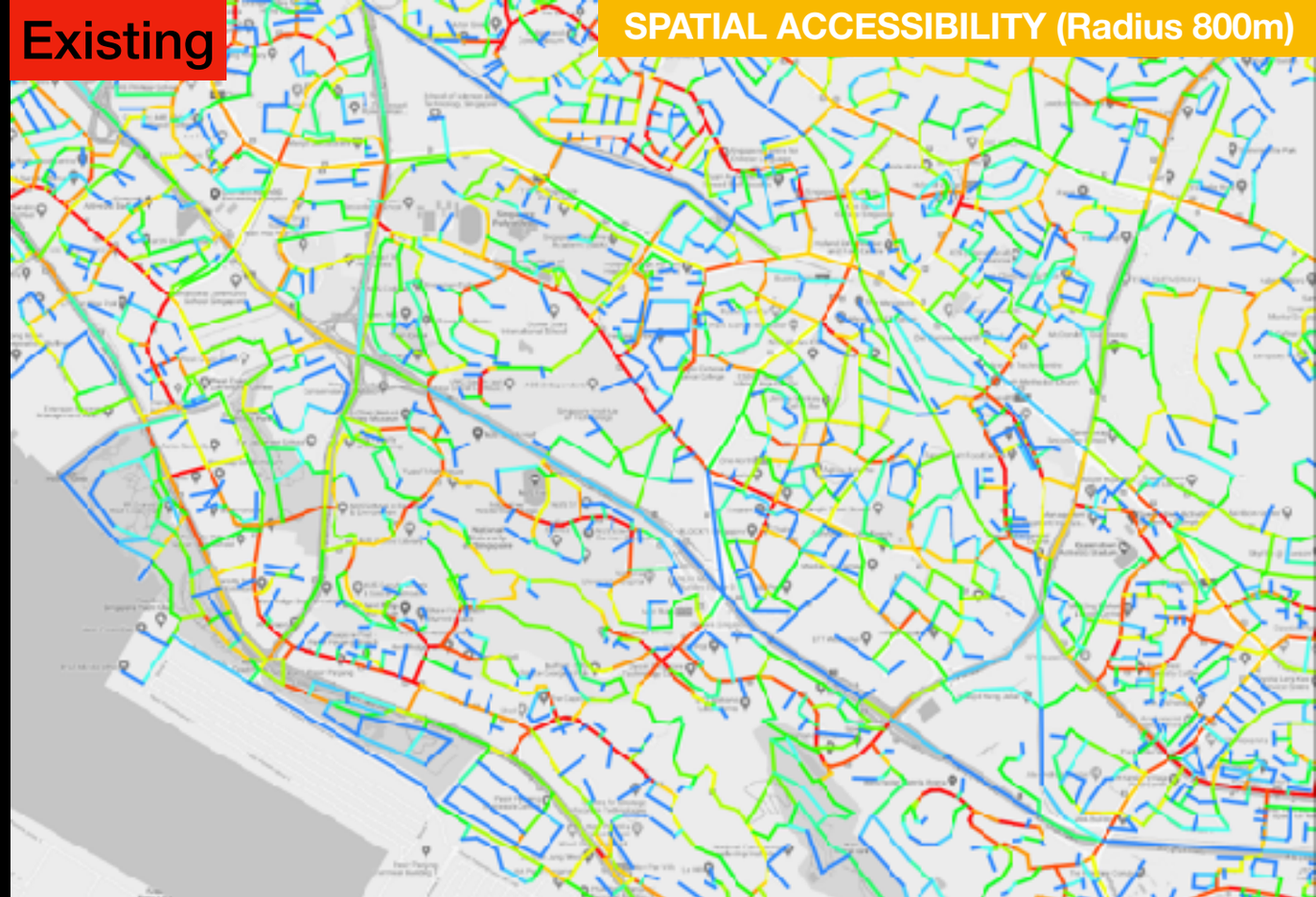
What it can do for SID:

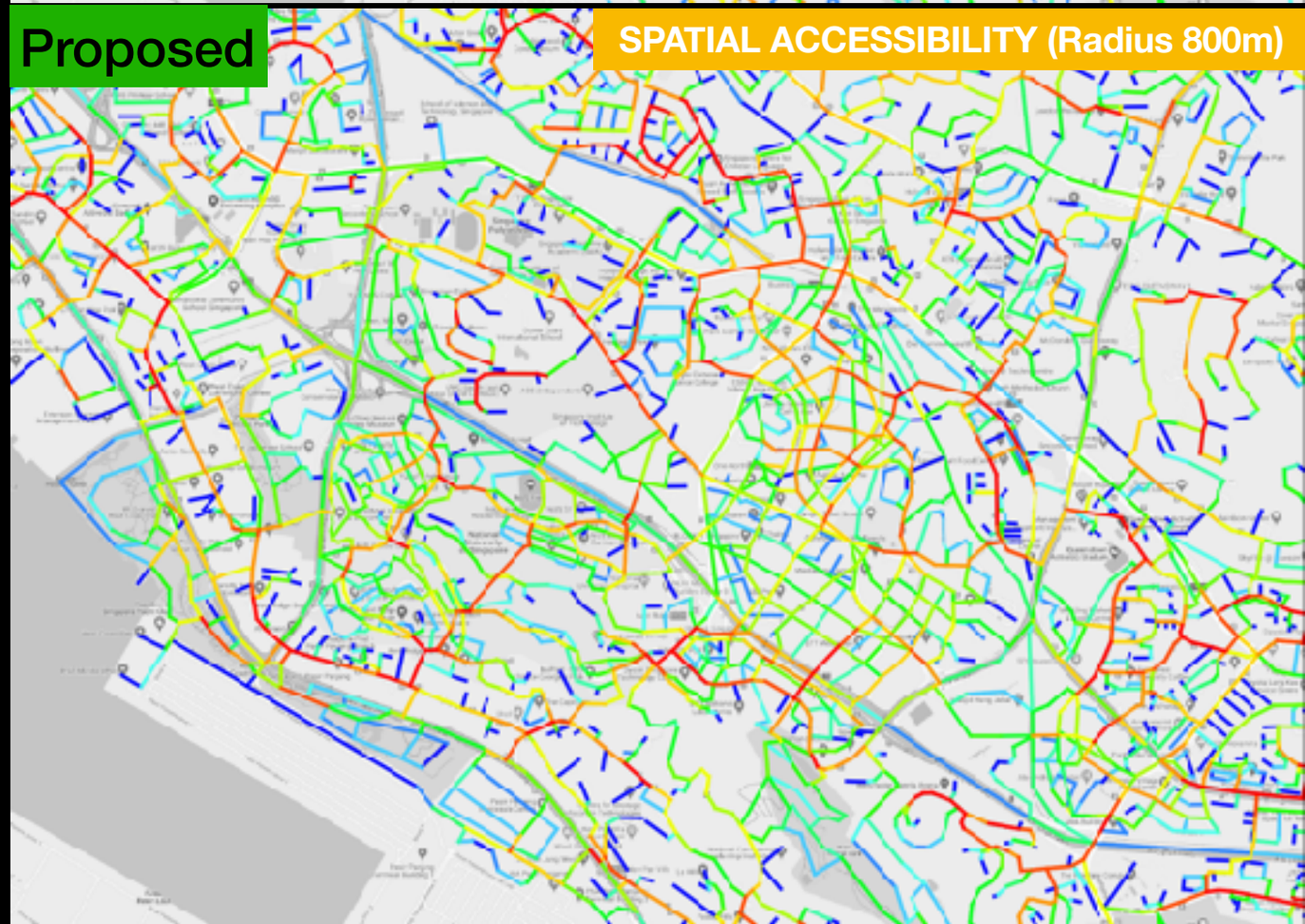
A. Analysing connections *between* the various plots of land

B. Analysing connections within the various plots of land

Methodology:

1. Process and evaluate existing street network model, calculate global, local & multi-scale accessibility
2. Geo-reference masterplans. Digitise proposed network to stitch it into the street network model.
3. Run analysis on the proposed network. Evaluate the differences in accessibility between existing and proposed.
4. Identify missed opportunities in connections, or better placement of connects. Run tests.





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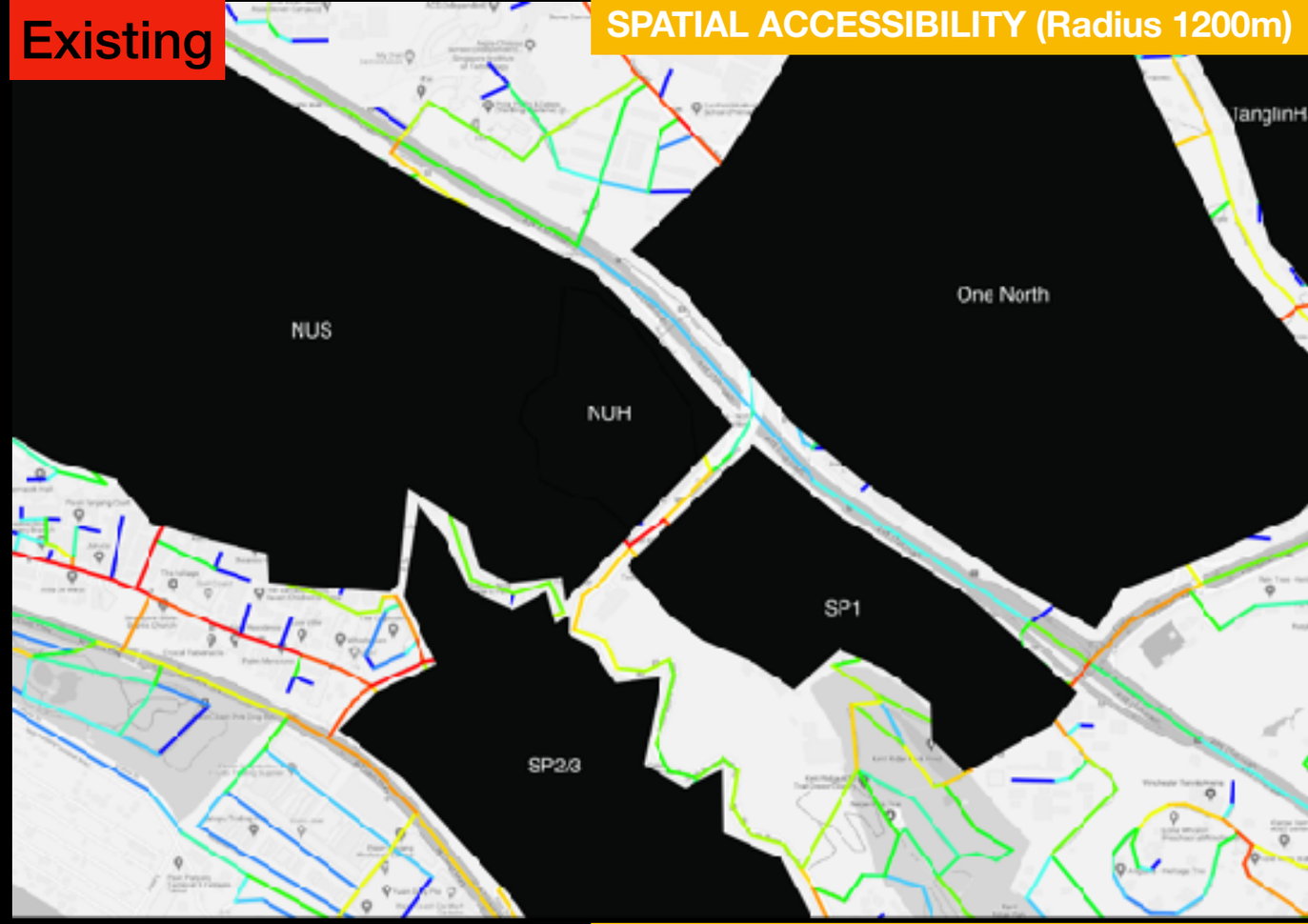

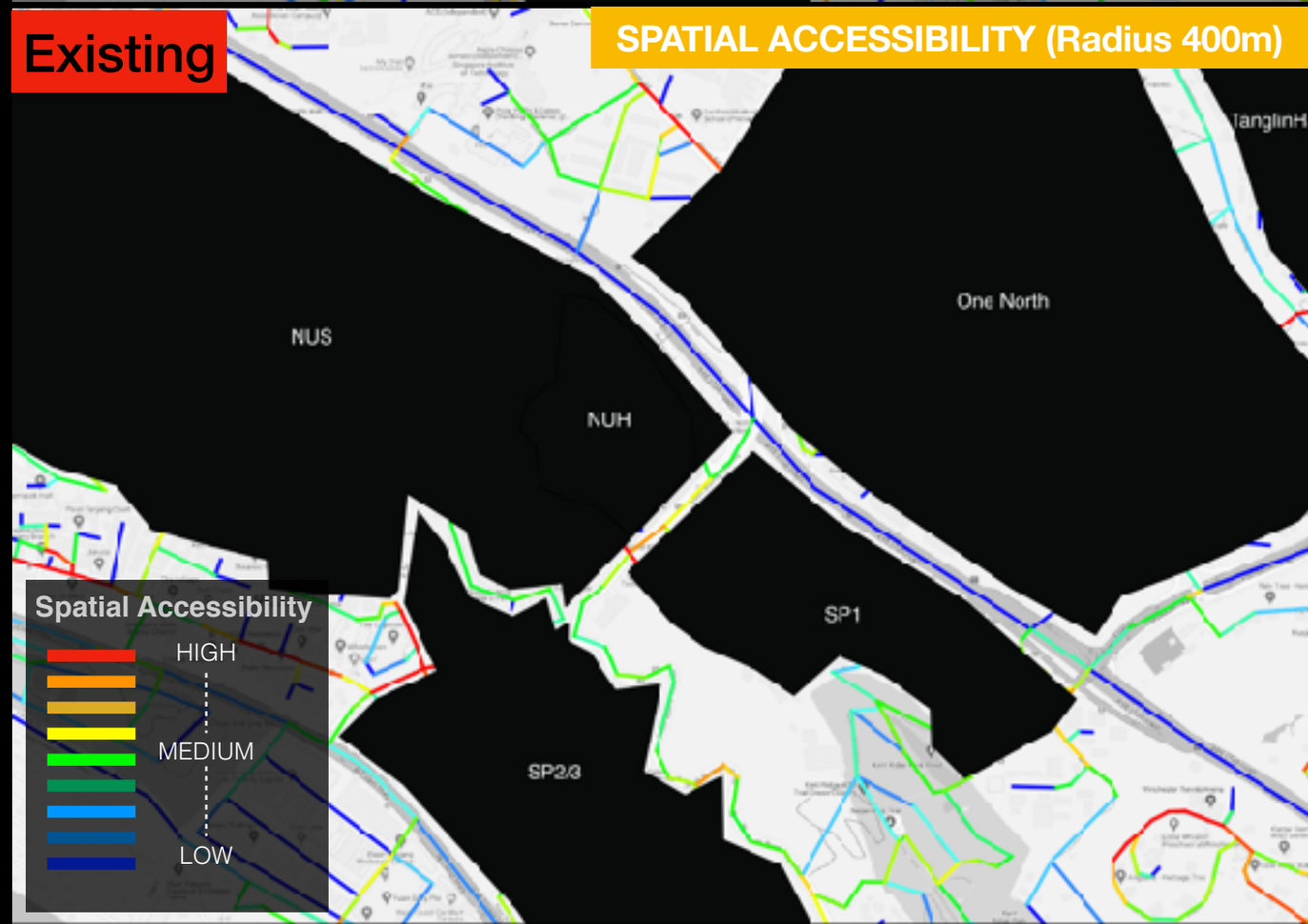

Demo 01

Measures accessibility of existing and proposed masterplans

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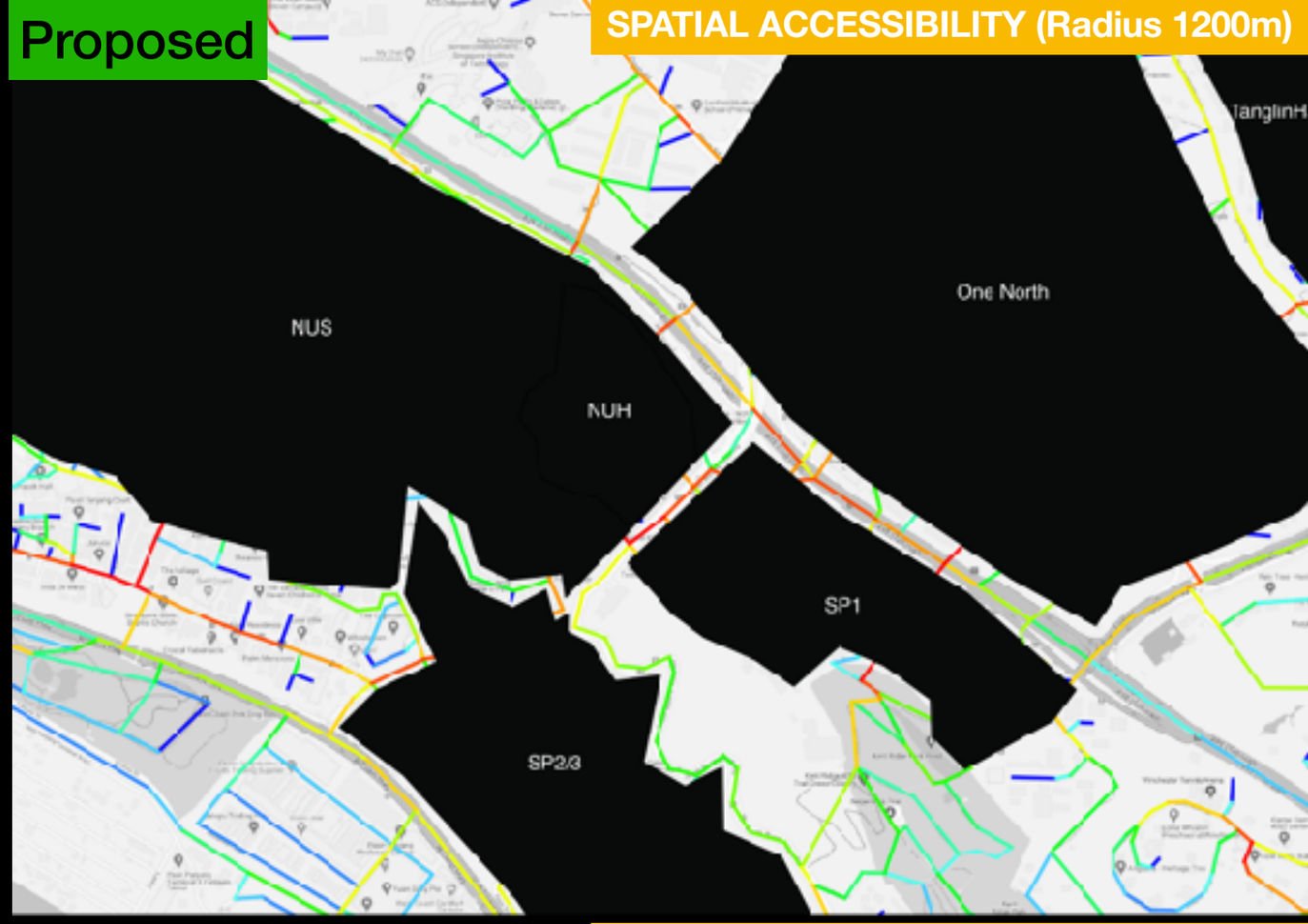
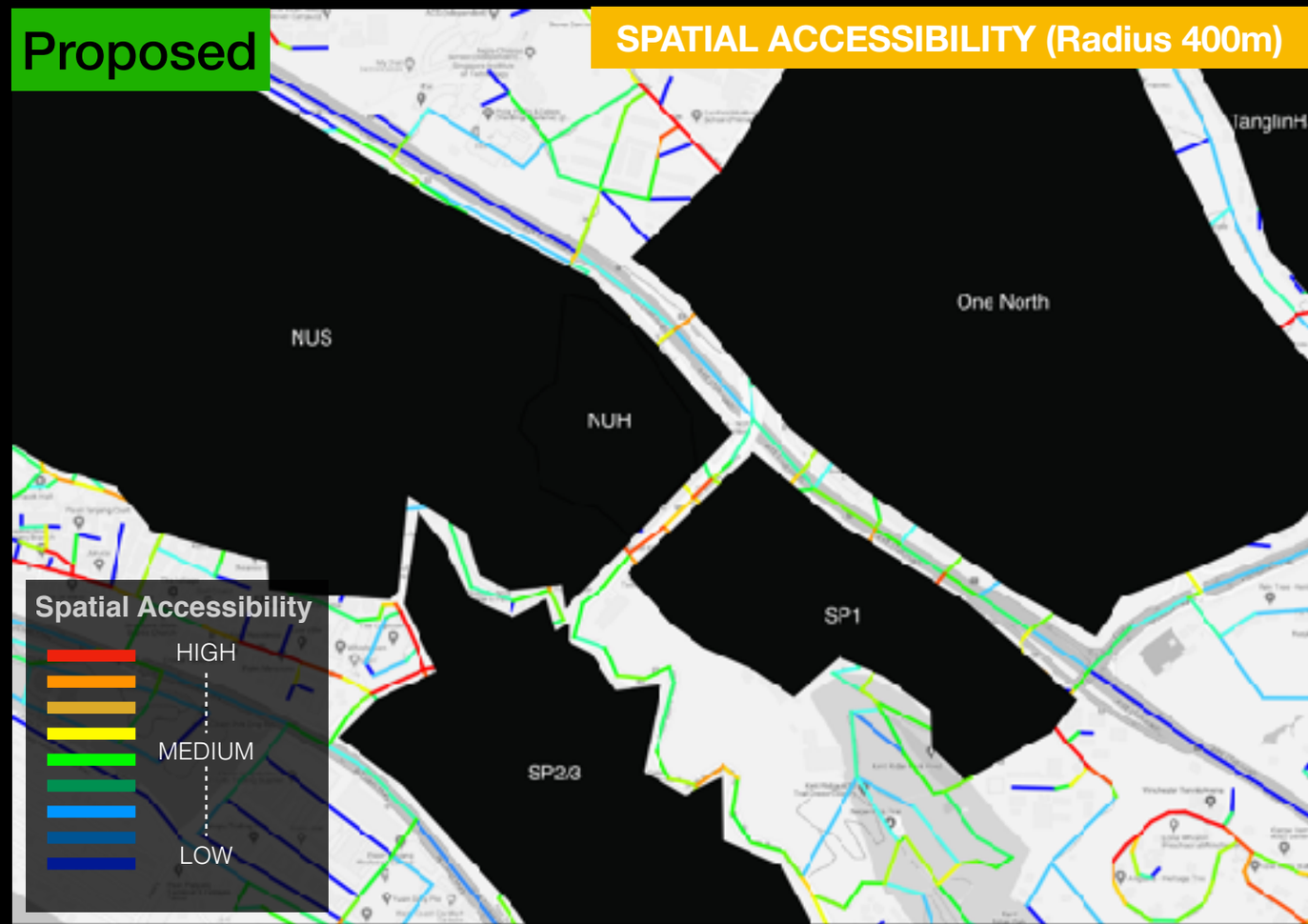




Demo 02

Uncovers potential in active mobility routes and identifies missed opportunities

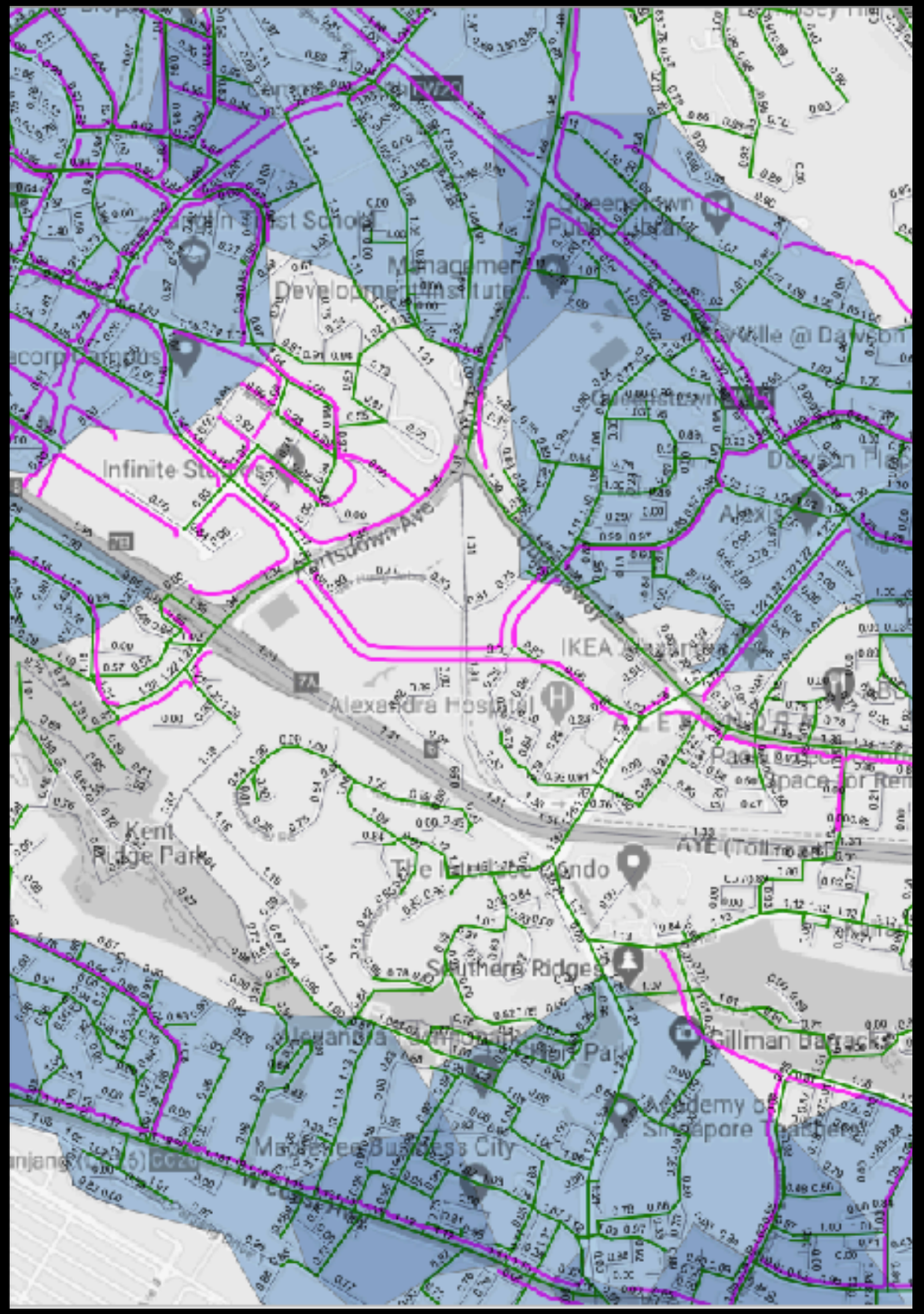
What it can do:

A. Evaluates how well the proposed active mobility routes compliments the MRT catchment of a 10-mins walk

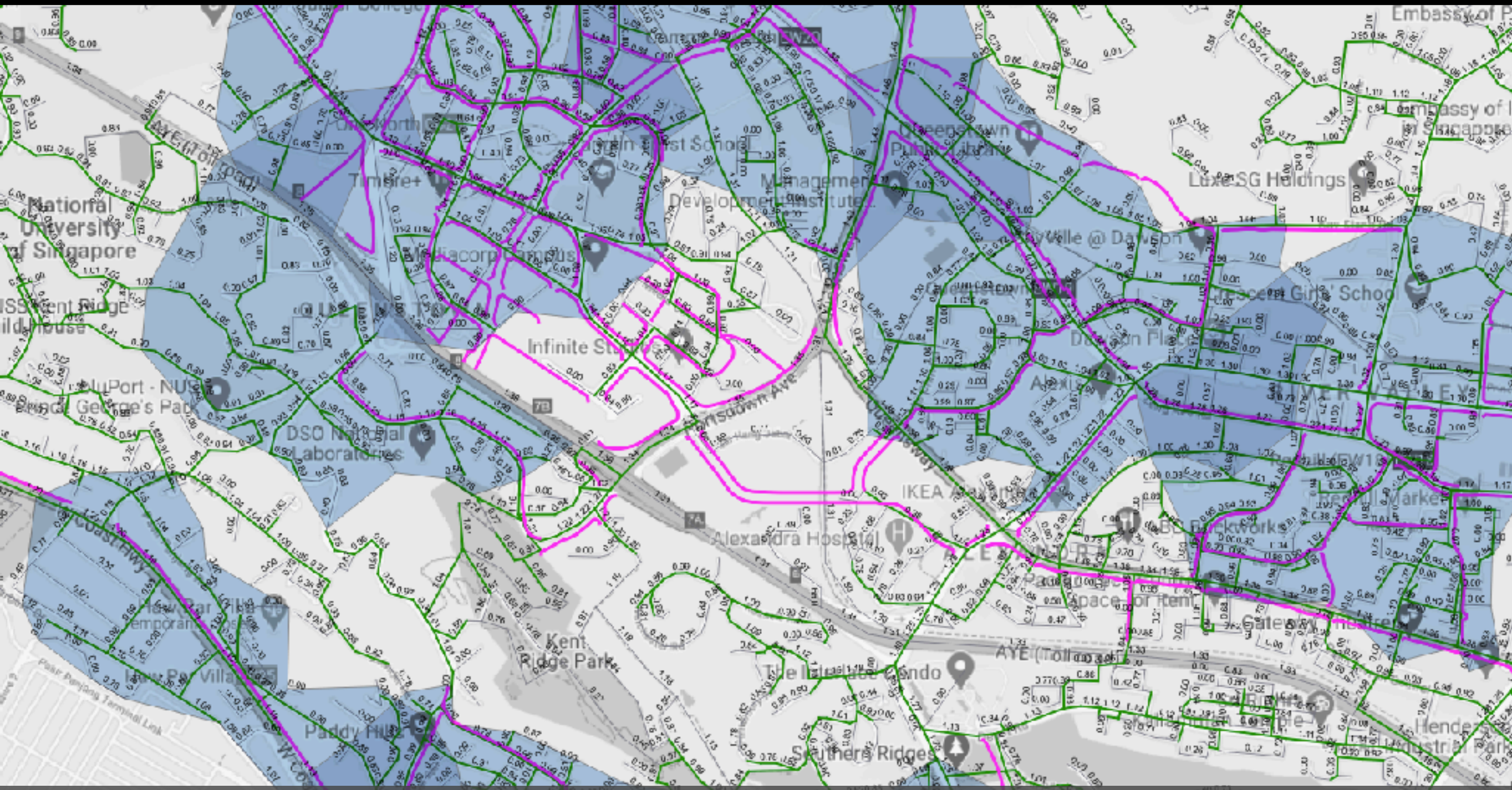
B. Identifies which streets are suitable for active mobility and any new connections are necessary

Methodology:

1. Process and evaluate street network model, calculate local accessibility
2. Perform network catchments for all MRT stations (800m radius or 10 min walk) - Actual AM routes and Space Syntax pedestrian-recommended
3. Calculate what percentage of those MRT catchments are active mobility / pedestrian-recommended
4. Evaluate the connection of the proposed active mobility paths outside the catchments - do they connect well to the catchments?
5. In areas NOT within the catchments, is there a need for more active mobility routes? - Analyse Telco data to determine density and movement of people



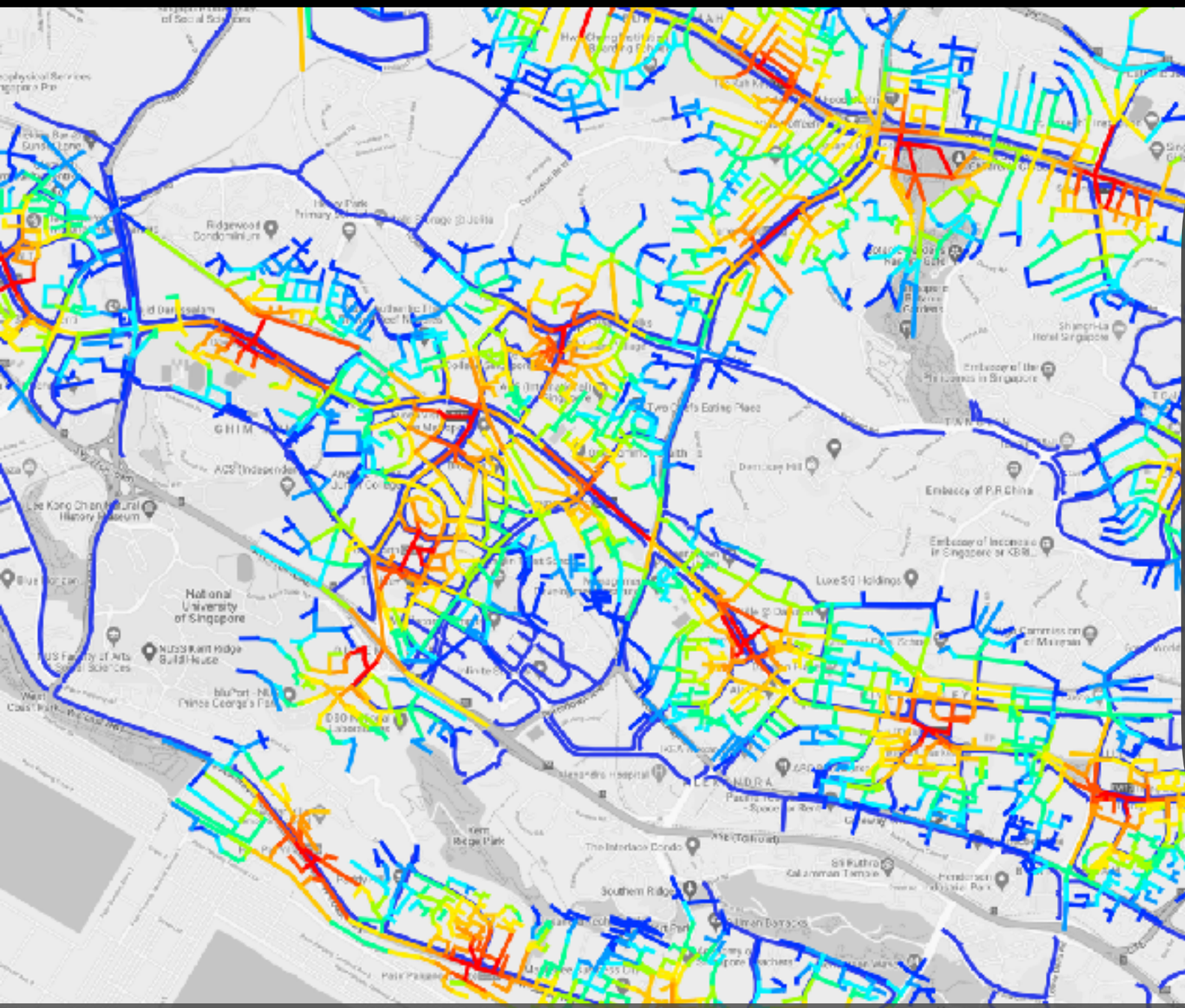
Effectiveness: Sum of length of streets within the MRT Catchment

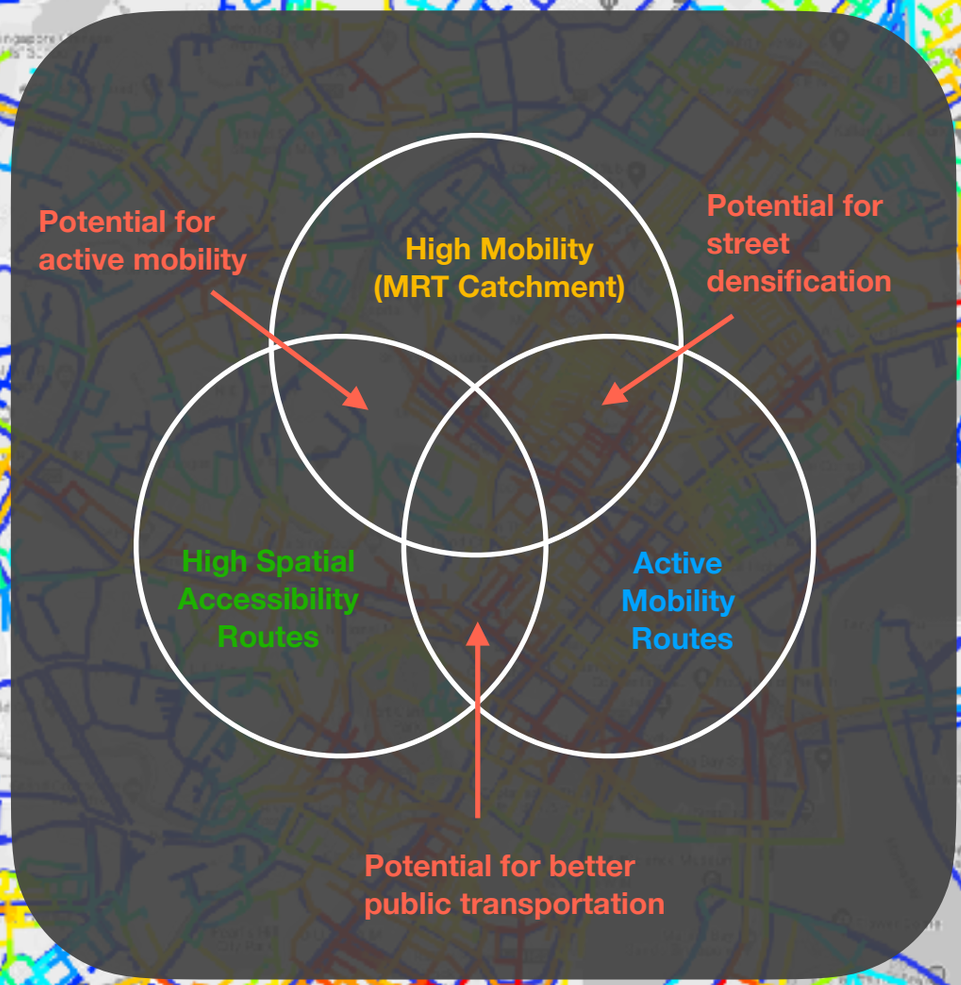


% of LTA proposed cycling routes (sum of length) / Total street length within MRT catchment

% of pedestrian recommended routes (based on network model) / Total street length within MRT catchment

Outreach: MRT Catchment + Proposed Cycling Paths





Street catchment from any MRT station origin (10-mins walk)

LTA Proposed Cycling Masterplan

CLC Network Modelling Project (Inter-agency)

NSCC x Geoworks Enablement Series 2021

Special Thanks

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