Preferred citation style for this presentation

Alex ERATH, Michael VAN EGGERMOND, Sergio ORDONEZ, Kay Axhausen (2015) Walkability and pedestrian route choice – key findings, URA Centre, July 2015.

Walkability and pedestrian route choice

Key findings

Alex Erath, Michael van Eggermond, Sergio Ordóñez
The URA Centre
26th June 2015

(FCL) FUTURE CITIES LABORATORY 未来城市实验室

(SEC) SINGAPORE-ETH CENTRE 新加坡–ETH研究中心

Walkability and pedestrian route choice

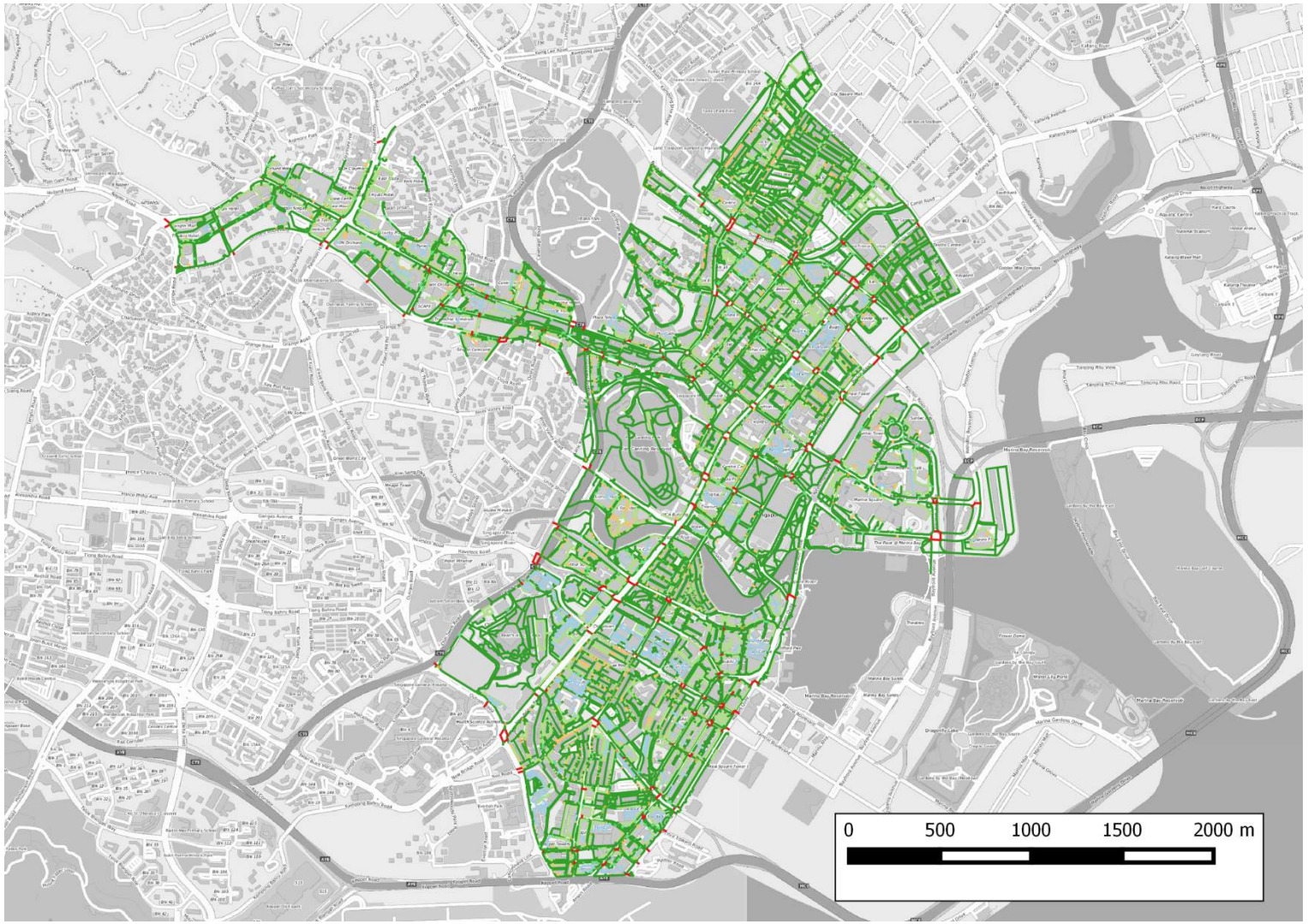
Project overview

WHAT IS WALKABILITY?

Pedestrian network survey

Collecting information for 43km walkways

Extent of the pedestrian network



Network data collected by URA

At grade

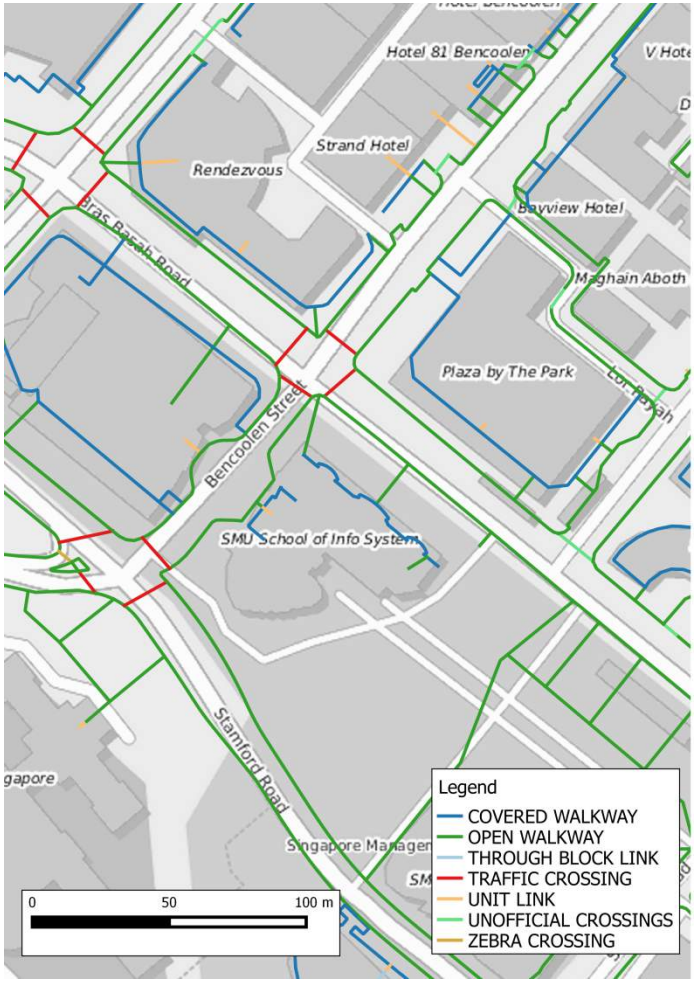
- Open walkway *(14005 features)*
- Covered walkway (*6195 features)*
- Through block link *(829 features)*
- Traffic crossing *(405 features)*
- Unit link *(4538 features)*
- Unofficial crossing *(1175 features)*
- Zebra crossing *(164 features)*

Below grade

Above grade

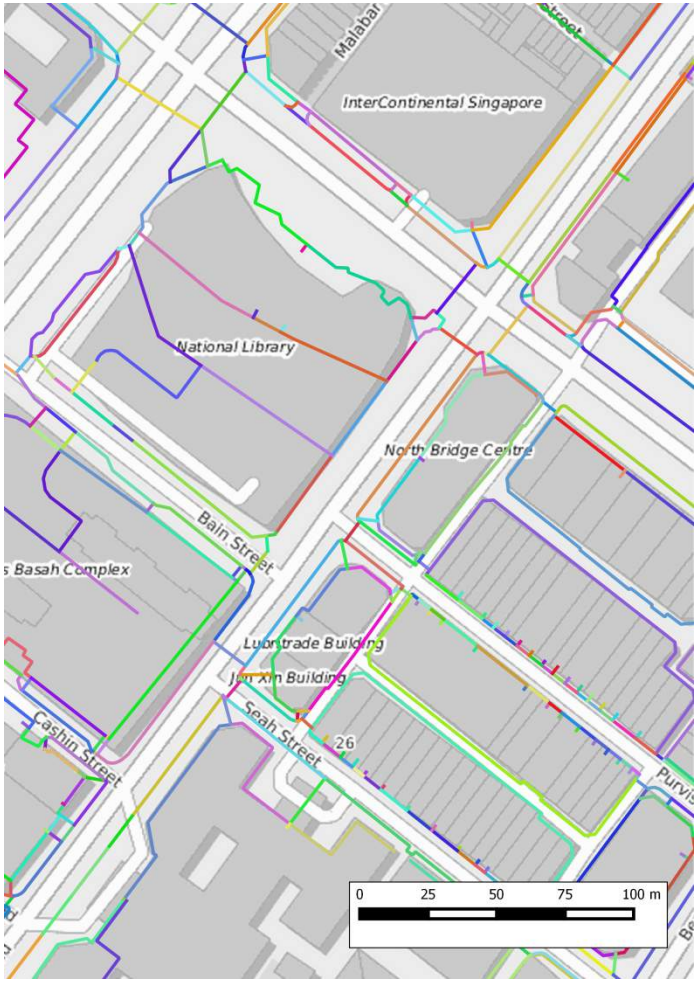
Access points

- Building entrances

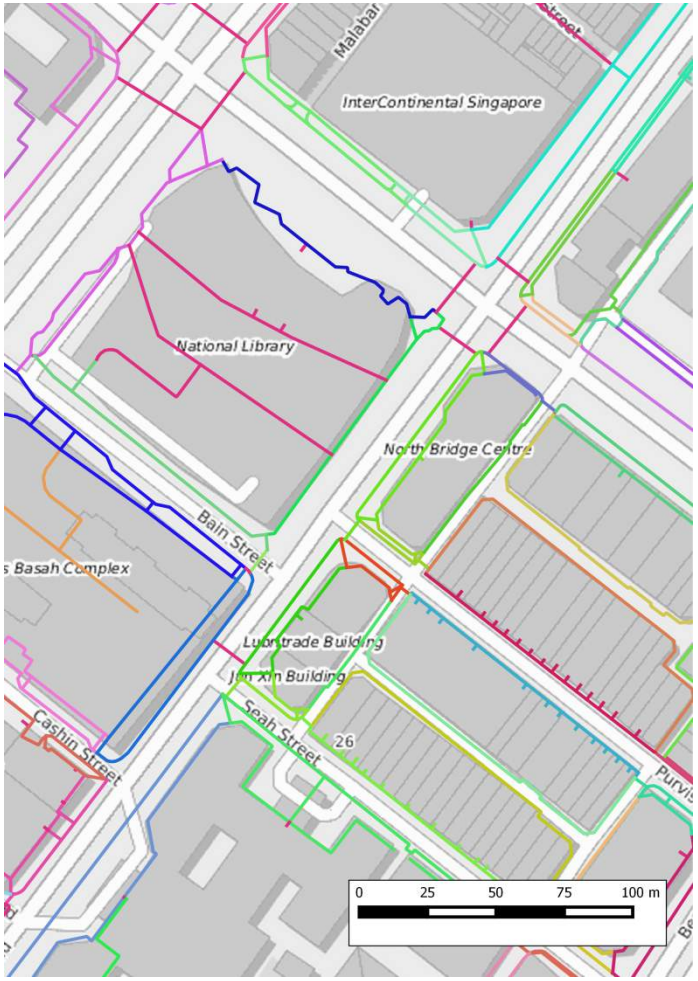


Simplification of network to collect characteristics

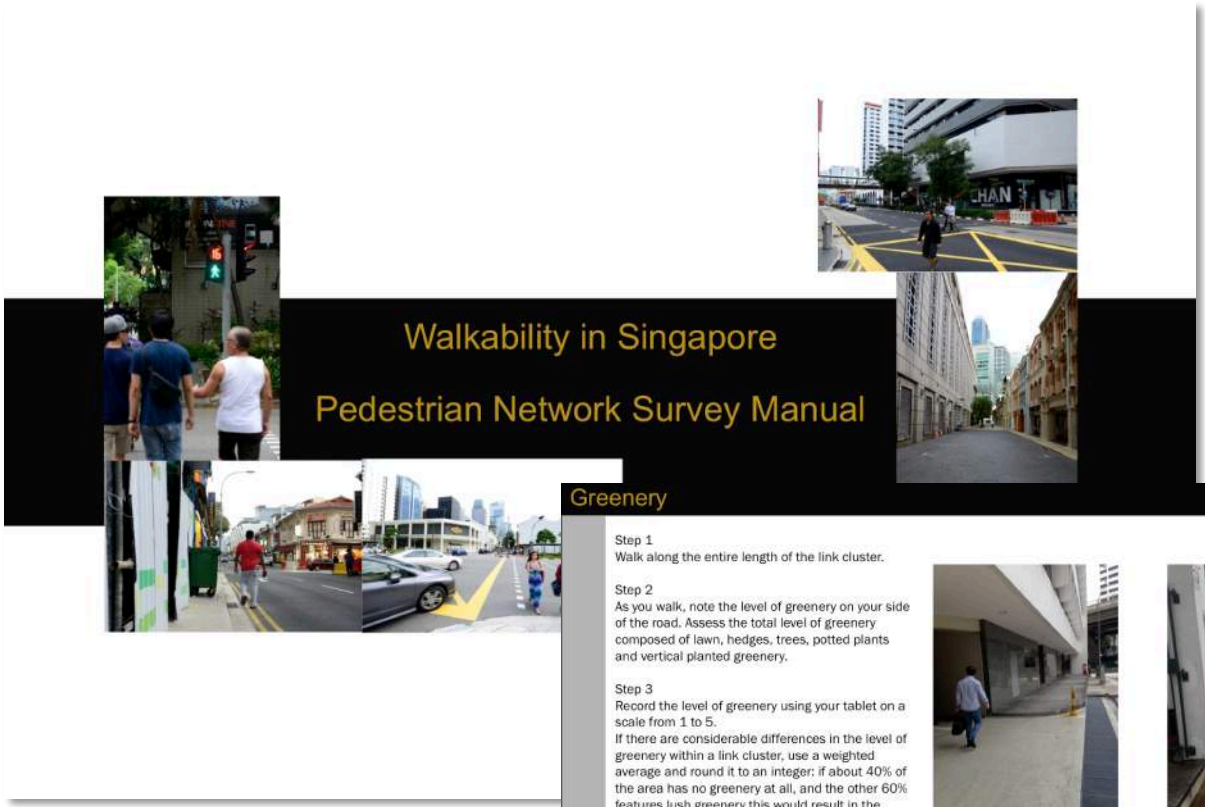
At grade network *(27311 features);*
Each color represents a feature

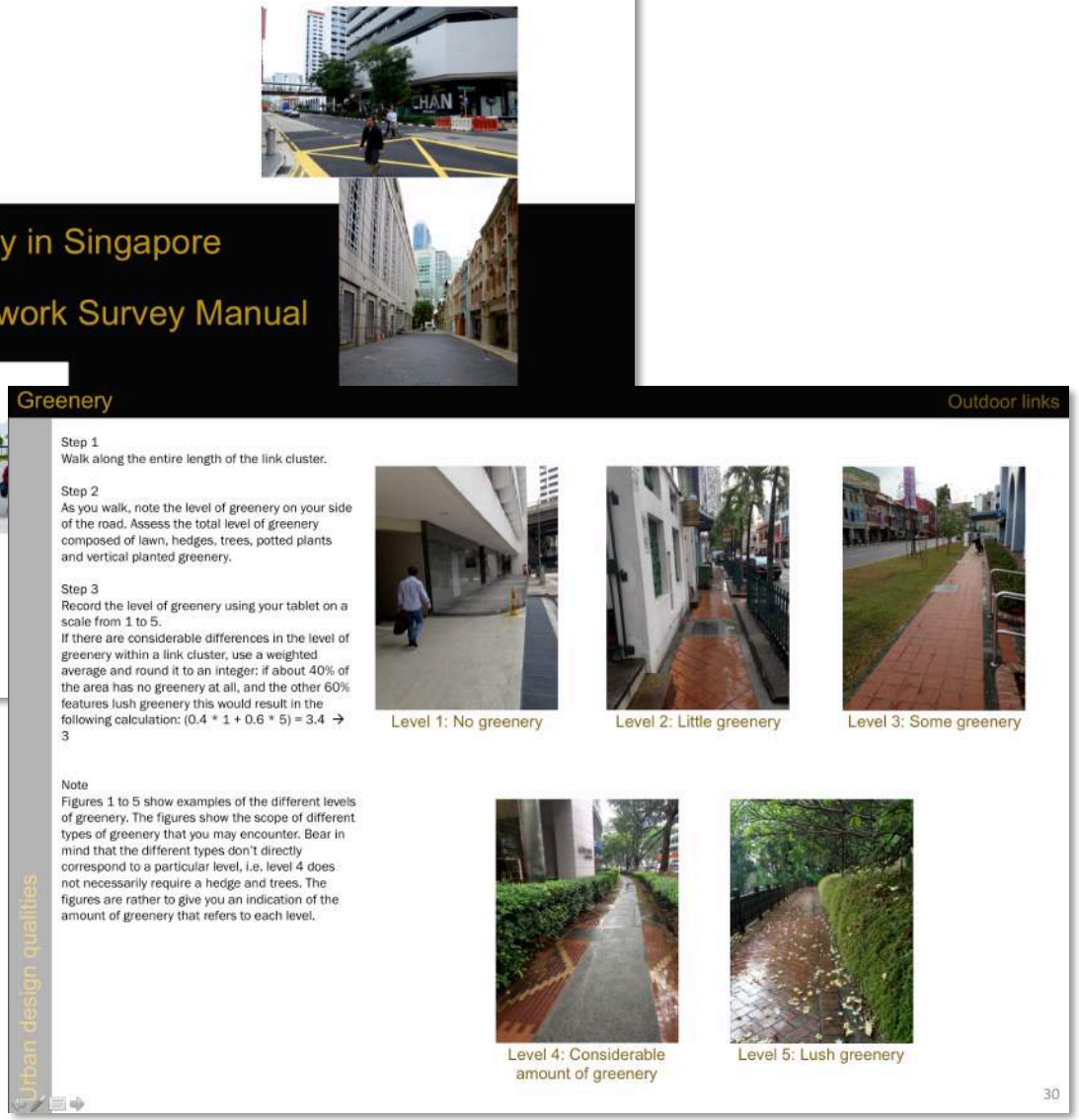


Link clusters *(2833 features);* ;
Each color represents a cluster



Developing a survey manual

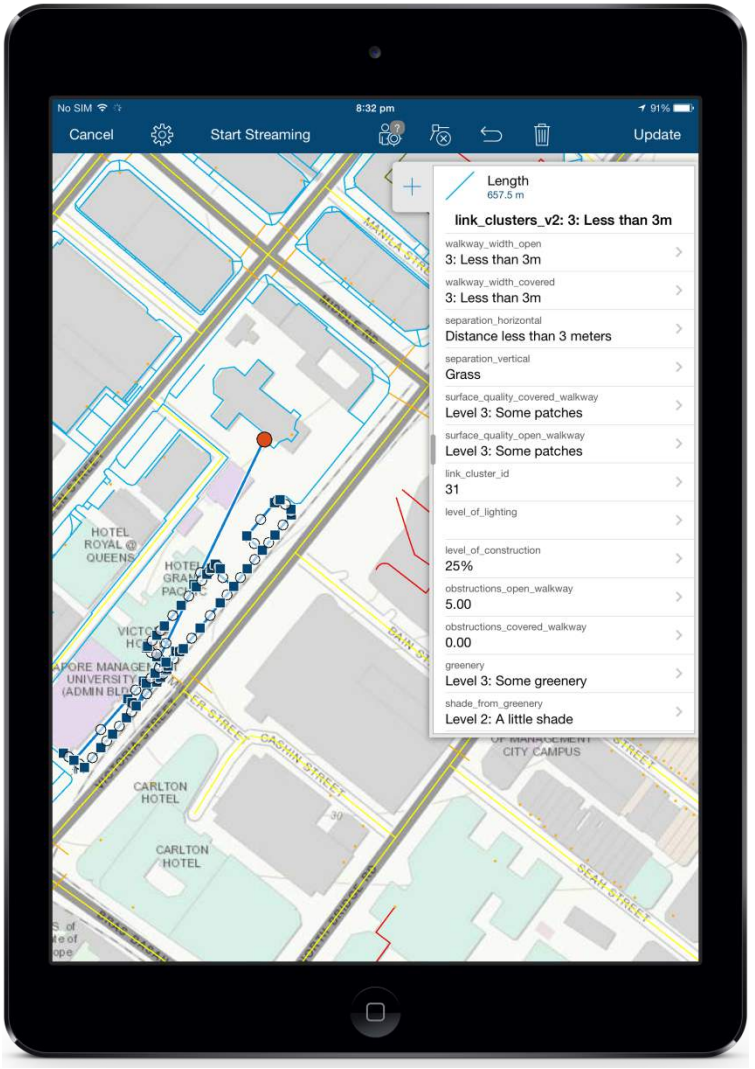




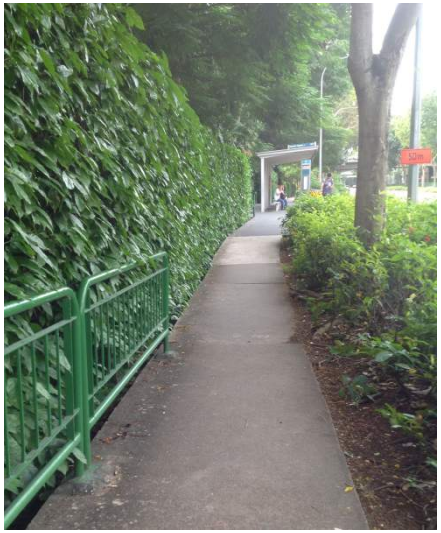
Collector for ArcGIS

Use your smartphone or tablet to collect and update information in the field, whether connected or disconnected.

Your update can include modifying the feature's attributes and location, as well as adding and deleting photos.

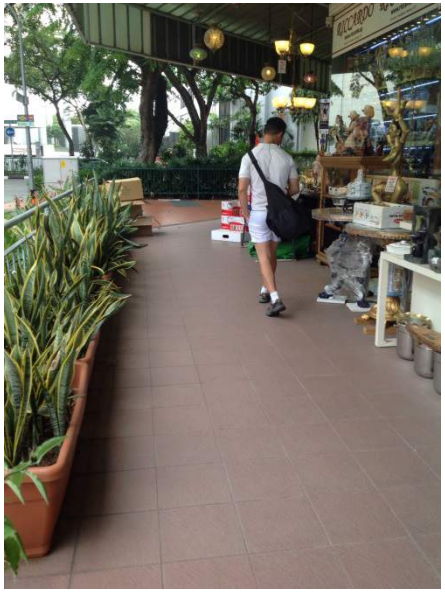


Beach road



Width open walkway	1-2m
Width covered walkway	n.a.
Separation horizontal	1-3m
Separation vertical	medium high hedge
Noise level	69db
Noise source	Mainly from street
Maintenance	5/5 – no rubbish in sight
Slipperiness	No, no tendency to slipperiness
Greenery	5/5 – lush greenery
Shade from greenery	4/5 - clearly shaded
Obstructions	0 – no obstructions in sight
Construction	0%
Imageability	1 feature
Human scale	1 feature
Enclosure	4/5
Transparency	0/100
Level of lighting	2/5 – small amount
Number of persons	5
Wheelchair	fully accessible
Date	6. July 2014

Sultan Gate



Width open walkway	2 – 3 m
Width covered walkway	1 – 2m
Separation horizontal	1-3m
Separation vertical	grass
Noise level	60db
Noise source	Mainly from street
Maintenance	4/5 – a little rubbish in sight
Slipperiness	No, no tendency to slipperiness
Greenery	3/5 – some greenery
Shade from greenery	1/5 - no shade from greenery
Obstructions	0 – no obstructions in sight
Construction	0%
Imageability	2 features
Human scale	13 features
Enclosure	4/5
Transparency	40/100
Level of lighting	2/5 – small amount
Number of persons	4
Wheelchair	fully accessible
Date	8. July 2014

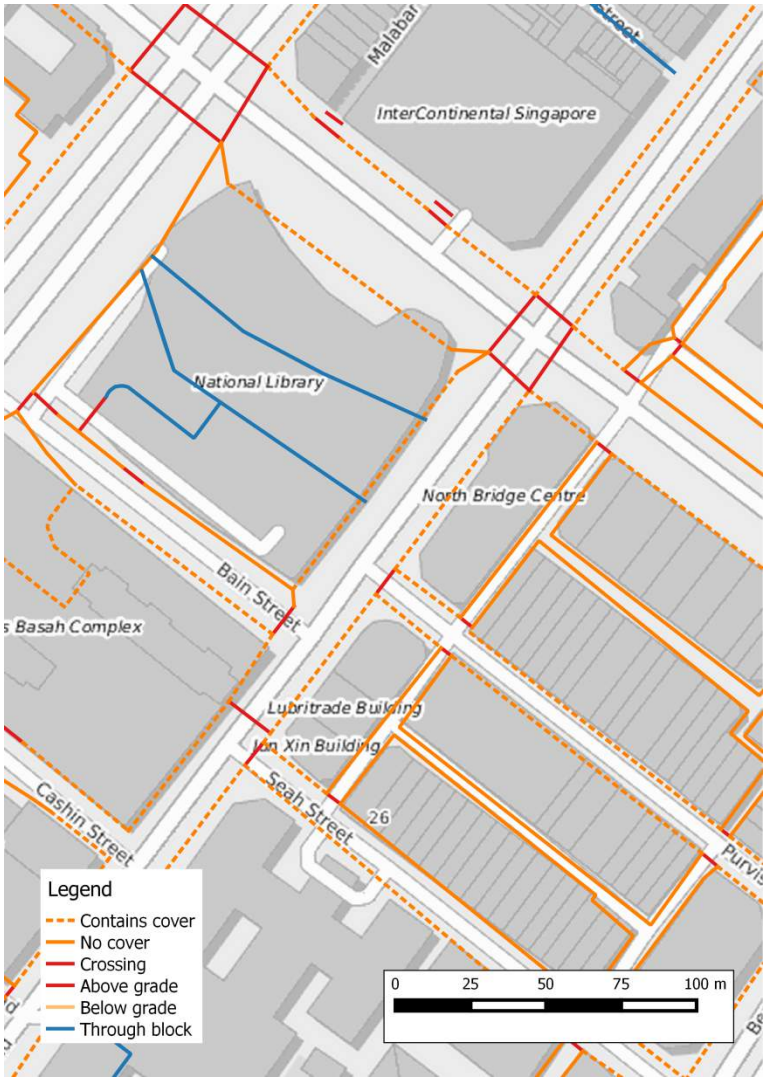
Simplification for analysis

Pedestrians choose their route from a number of distinct routes;

A network containing many links generates many similar route alternatives.

One can envisage this by **enumerating** the **number of routes** possible alongside a row of shophouses, where each covered and open walkway is a separate link.

The initial network is **redrawn** so that it is suitable for network analysis purposes, leading to **faster analysis**, and a network for which it is **easier to collect data** for.

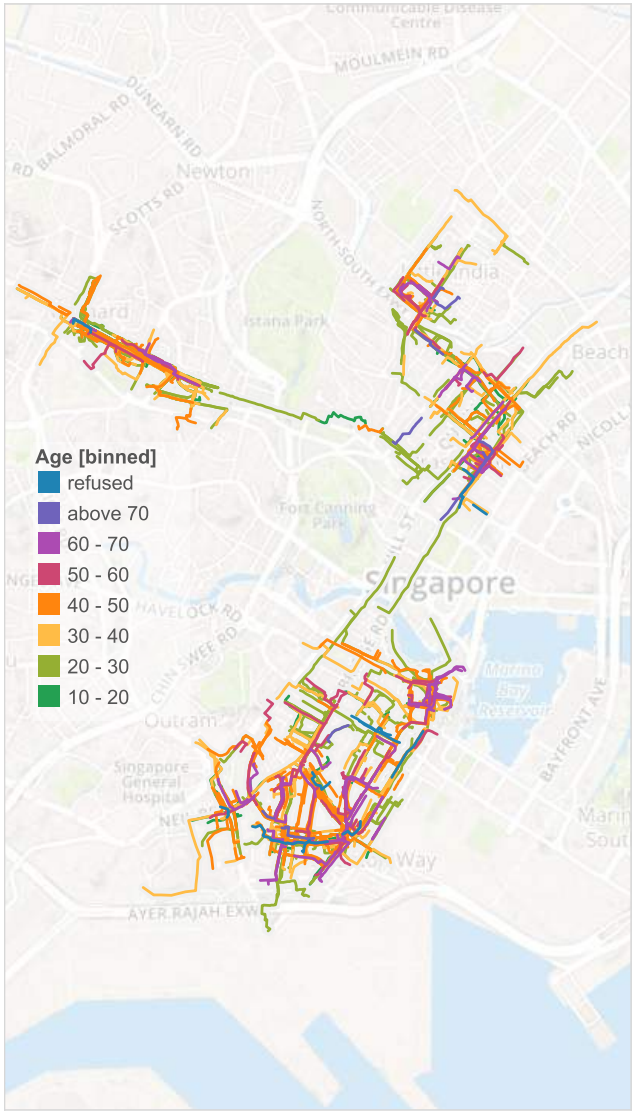


Pedestrian behavior survey

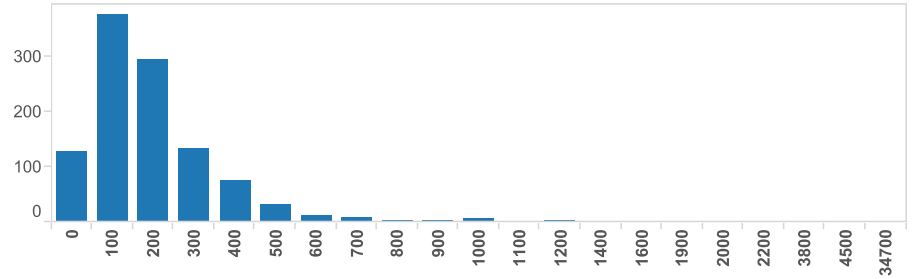
Tracking 1113 pedestrians in Singapore’s city centre

Who walks where?

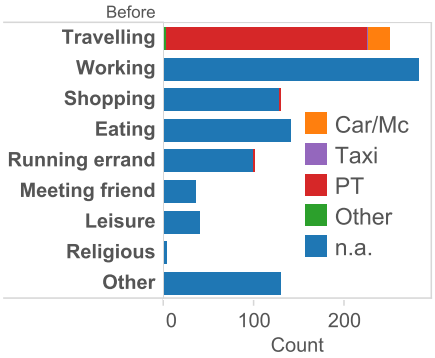
Pedestrian tracks



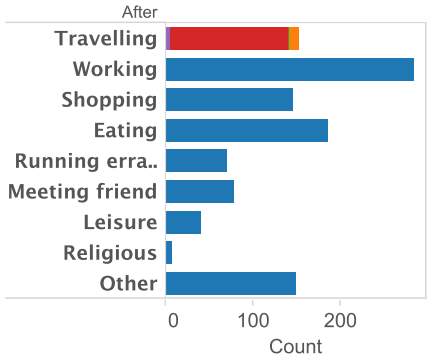
Distance [m]



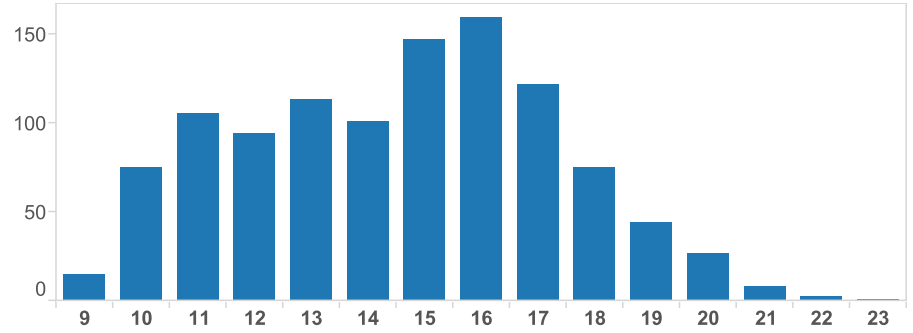
Activity before



Activity after



Time of day



Interactive graph available at:
https://public.tableau.com/profile/alexerath#!/vizhome/Directorsmeeting/Sampling1024

Some basic facts

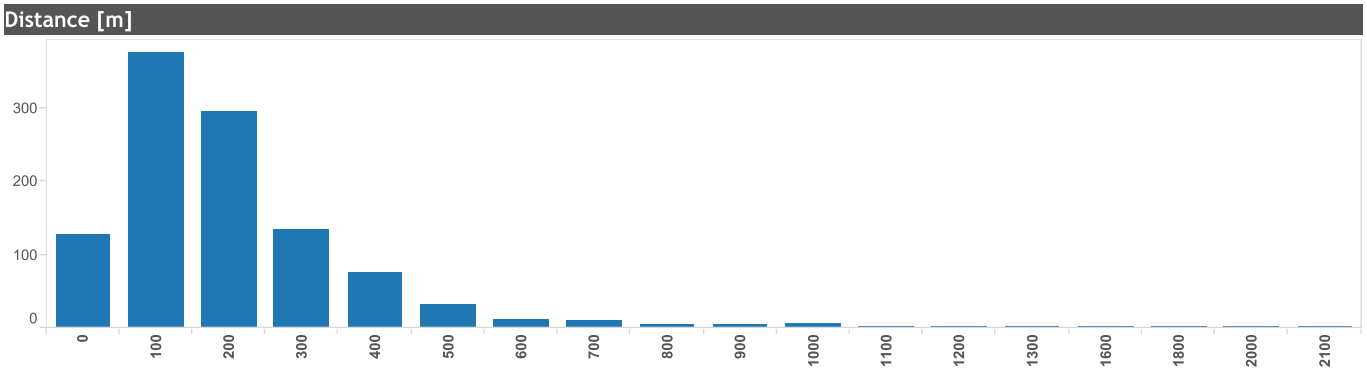
Number of valid tracks:	1077
Average walking distance:	259 m
Median walking distance:	210 m
Lower quartile:	143 m
Upper quartile:	259 m
Average walking duration	3.96 min
Media walking duration	3.23 min
Average walking speed	4.51 km/h
Median walking speed	3.98 km/h

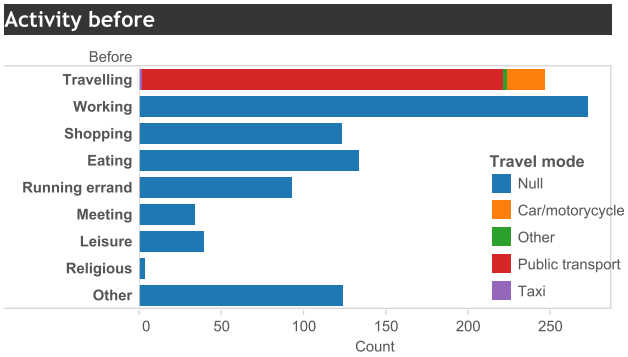
Comparison of average walking distance in other cities:

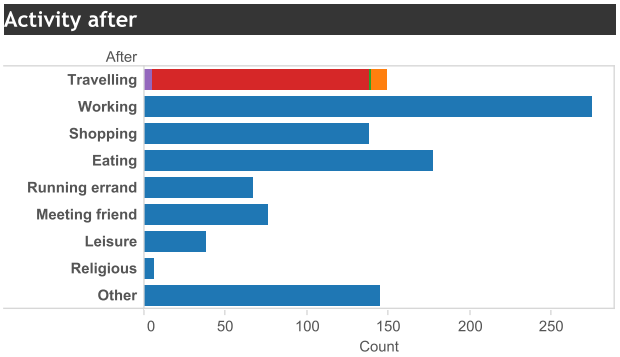
Calgary, city centre (1986):	330m
Portland, whole city (2014):	876m
San Jose / Portland, MRT stops (2012)	832m

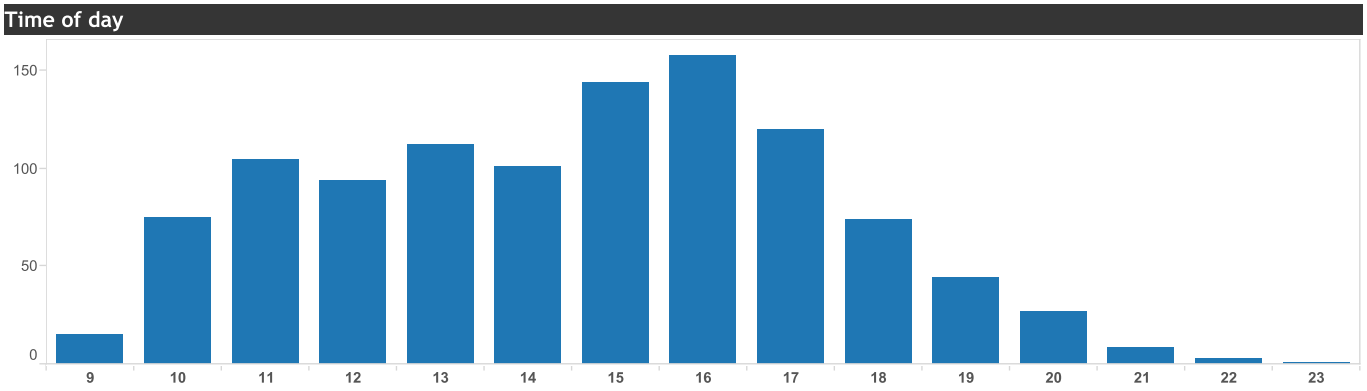
Seneviratne, P. N. and J. F. Morrall (1985). 'Analysis of Factors Affecting the Choice of Route of Pedestrians', Transportation Planning and Technology 10(2): 147–159.
Dill, Jennifer (2015). *Where Do People Prefer to Walk?*, Active Living Research Conference, San Diego.
Agrawal, Asha Weinstein, Marc Schlossberg and Katja Irvin (2008). 'How Far, by Which Route and Why? A Spatial Analysis of Pedestrian Preference', *Journal of Urban Design* 13(1): 81–98.

How long, why, when?

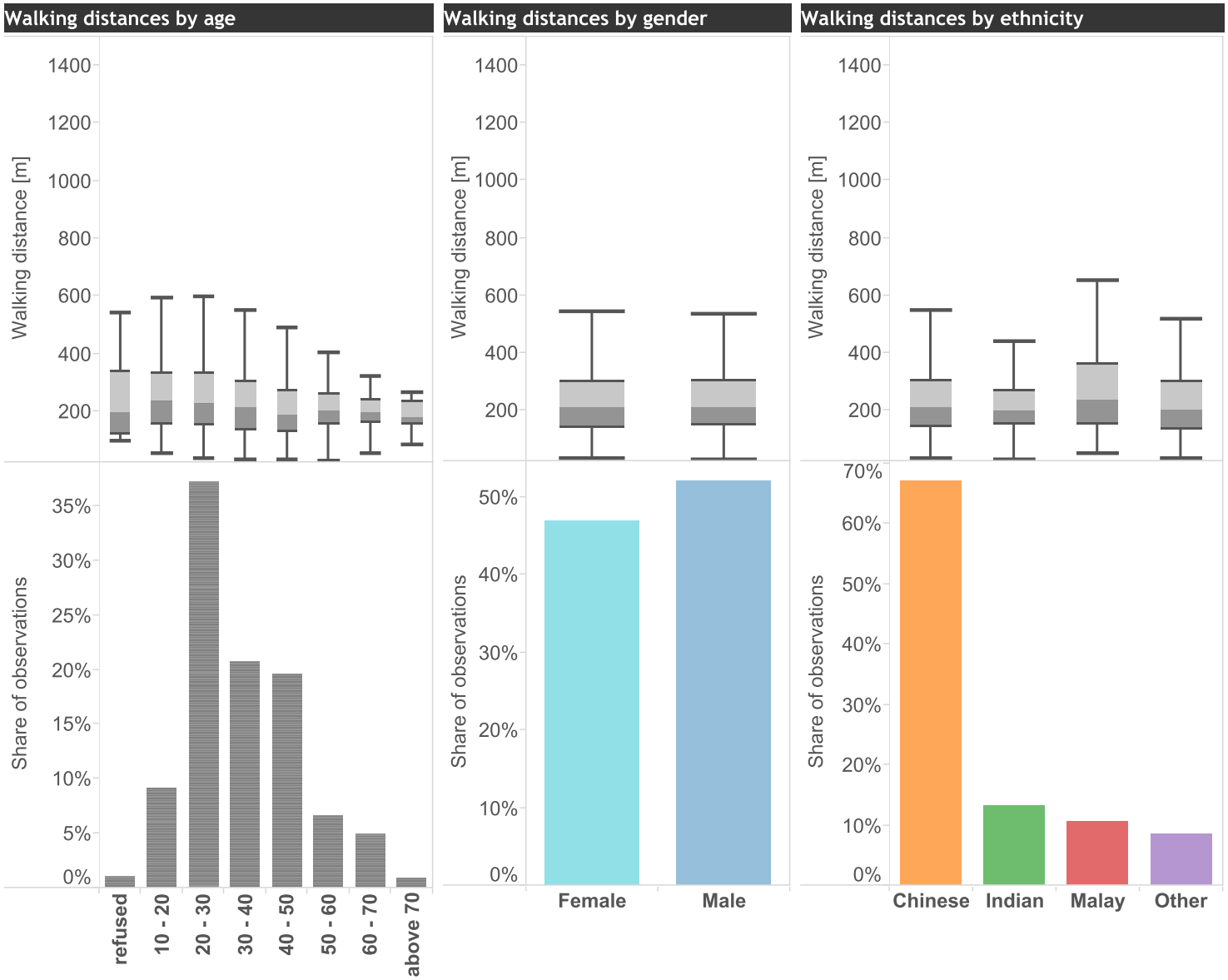




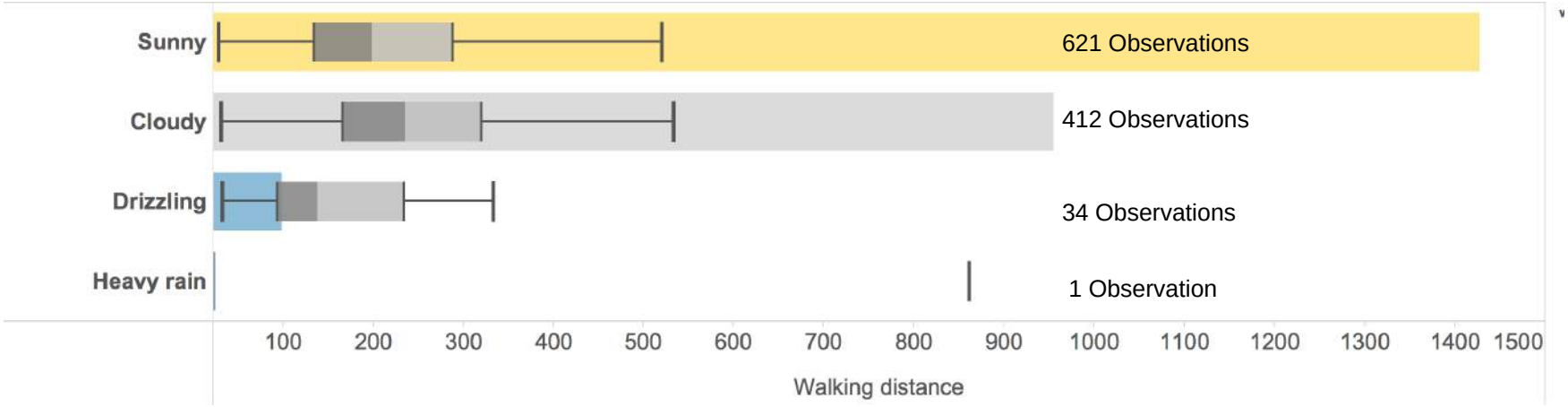




Sampling and walking distance by demography



Walking distance by weather

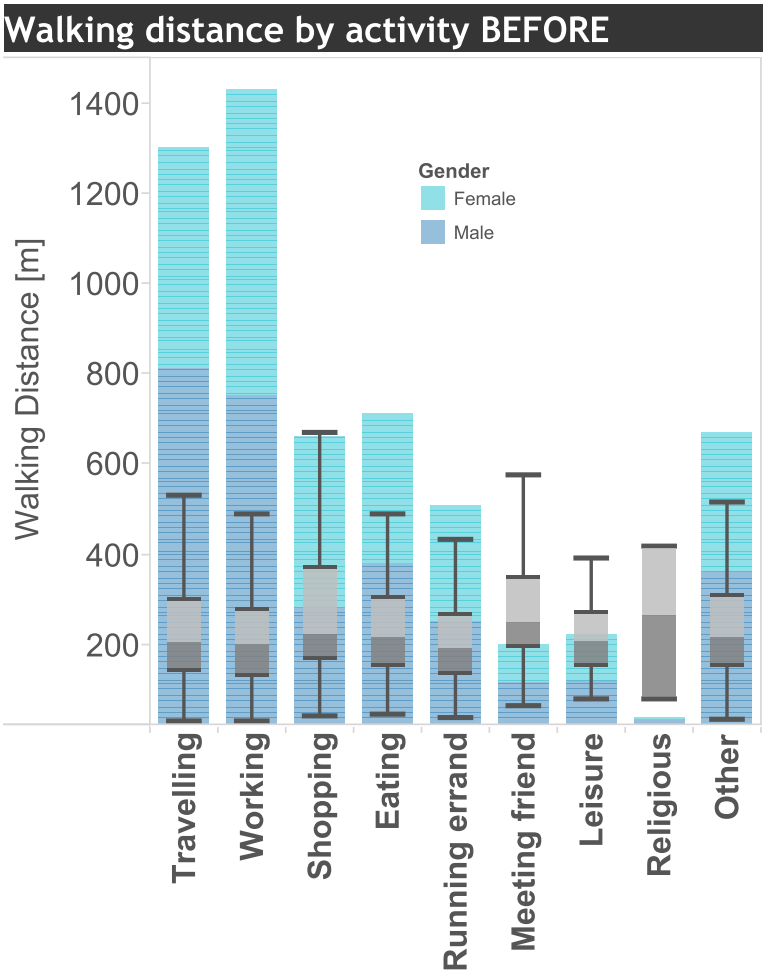


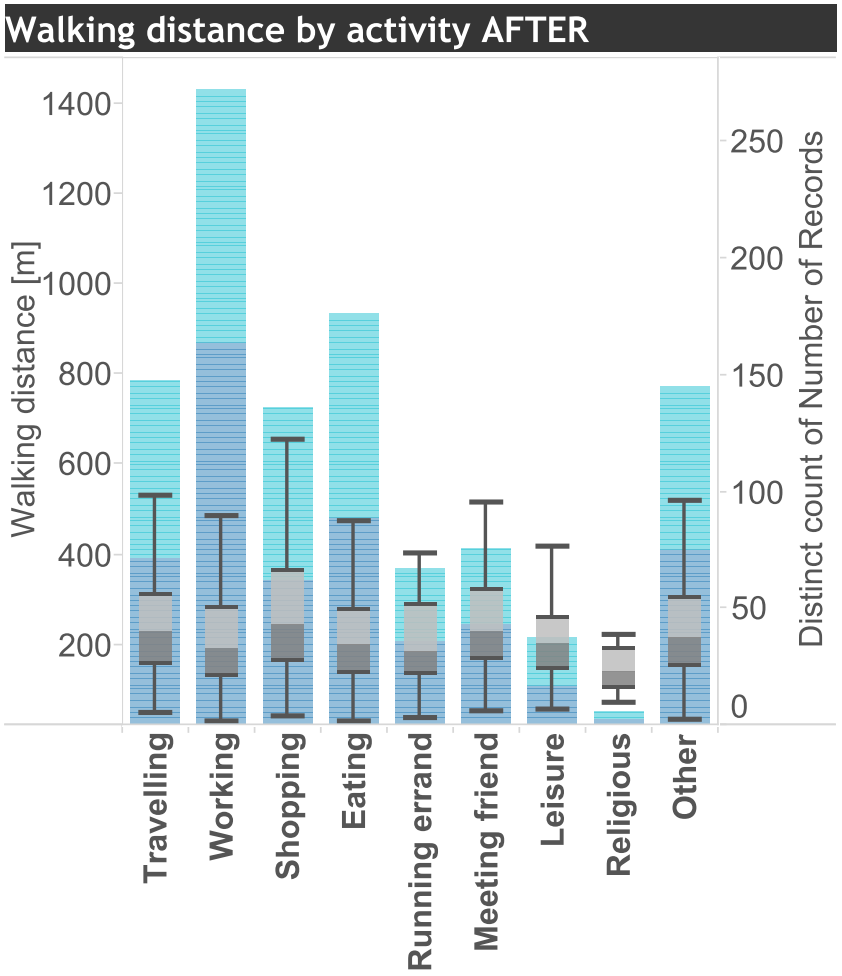
Compared to sunny conditions, people walk:

- 37 meters more, when it is cloudy
- 98 meters less, when it is drizzling

We have too few observation of walks in heavy rain condition to draw a valid conclusion.

Walking distance by activity before and after

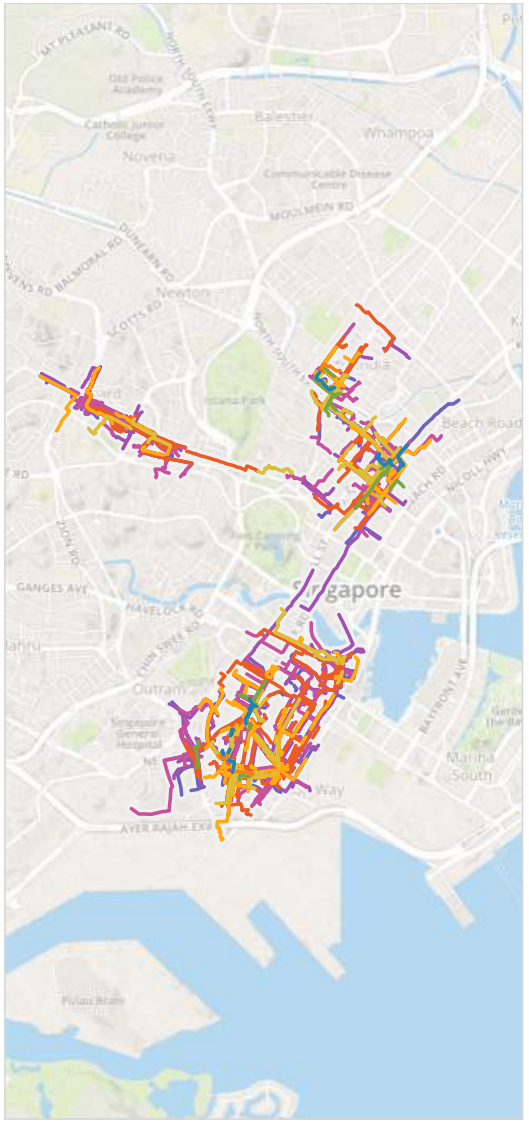




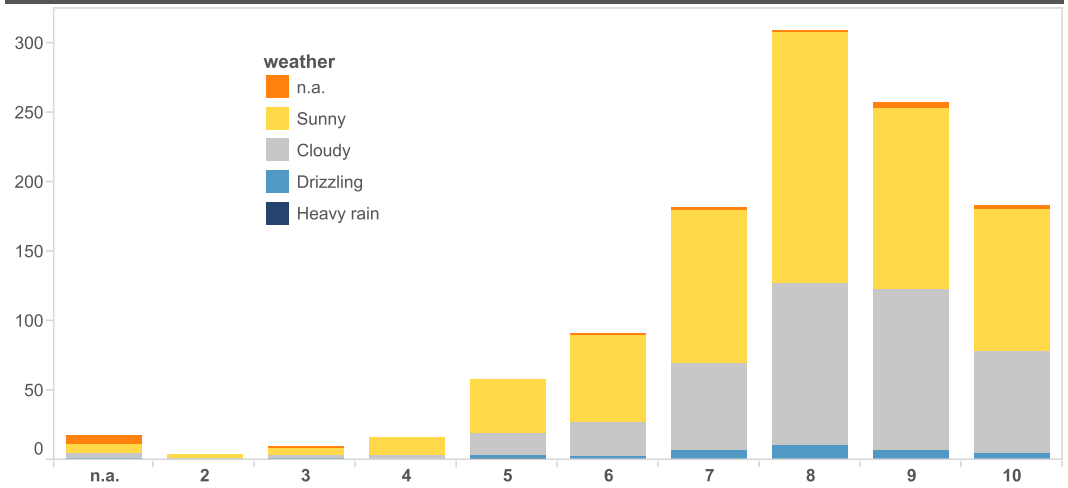
None of the activity types statistically significantly explain walking distance

Pedestrian experience

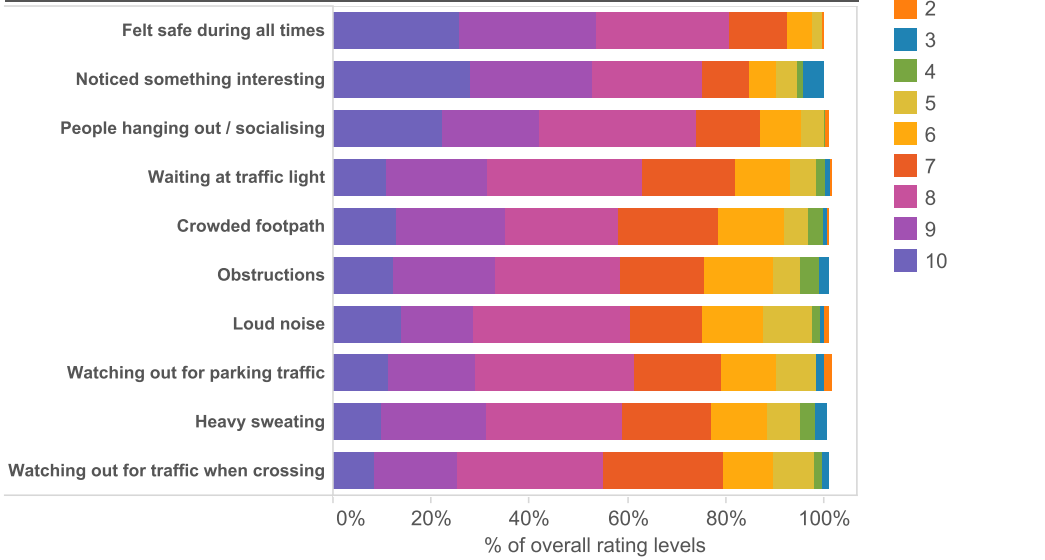
Pedestrian tracks by overall rating of walking experience



Rating of walking experience [0-10]

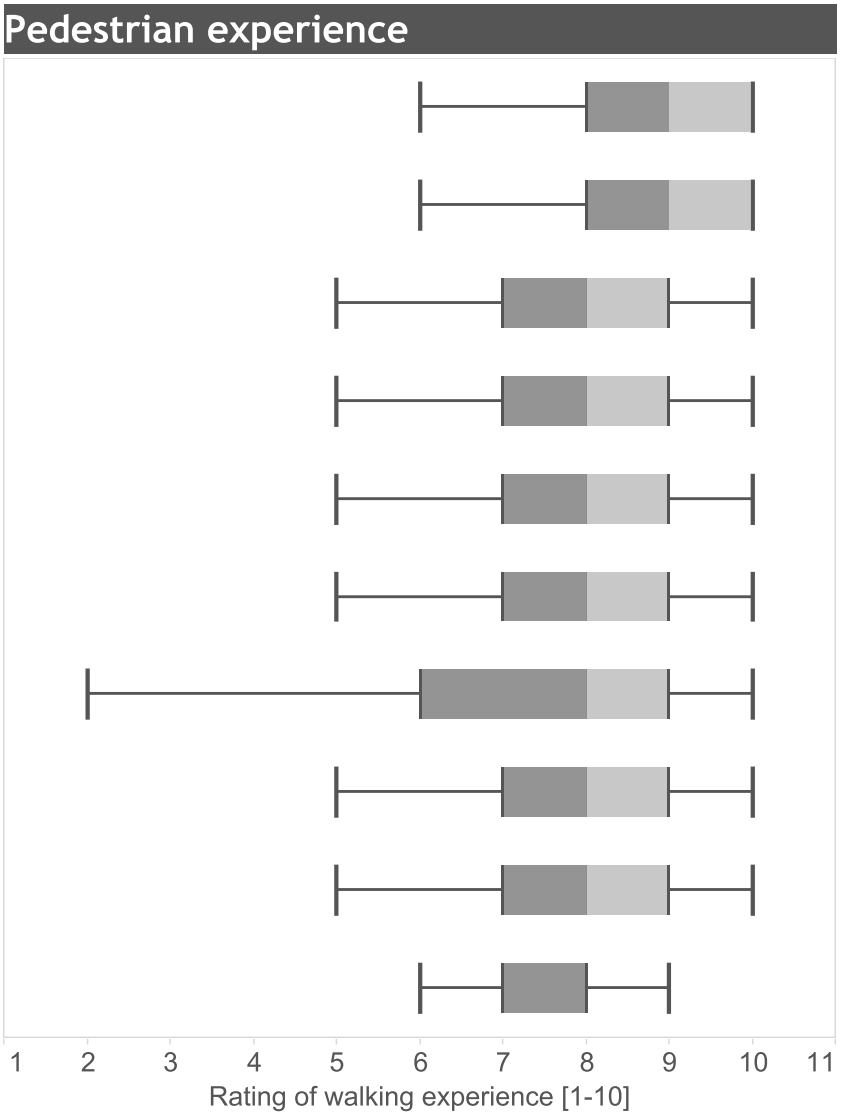


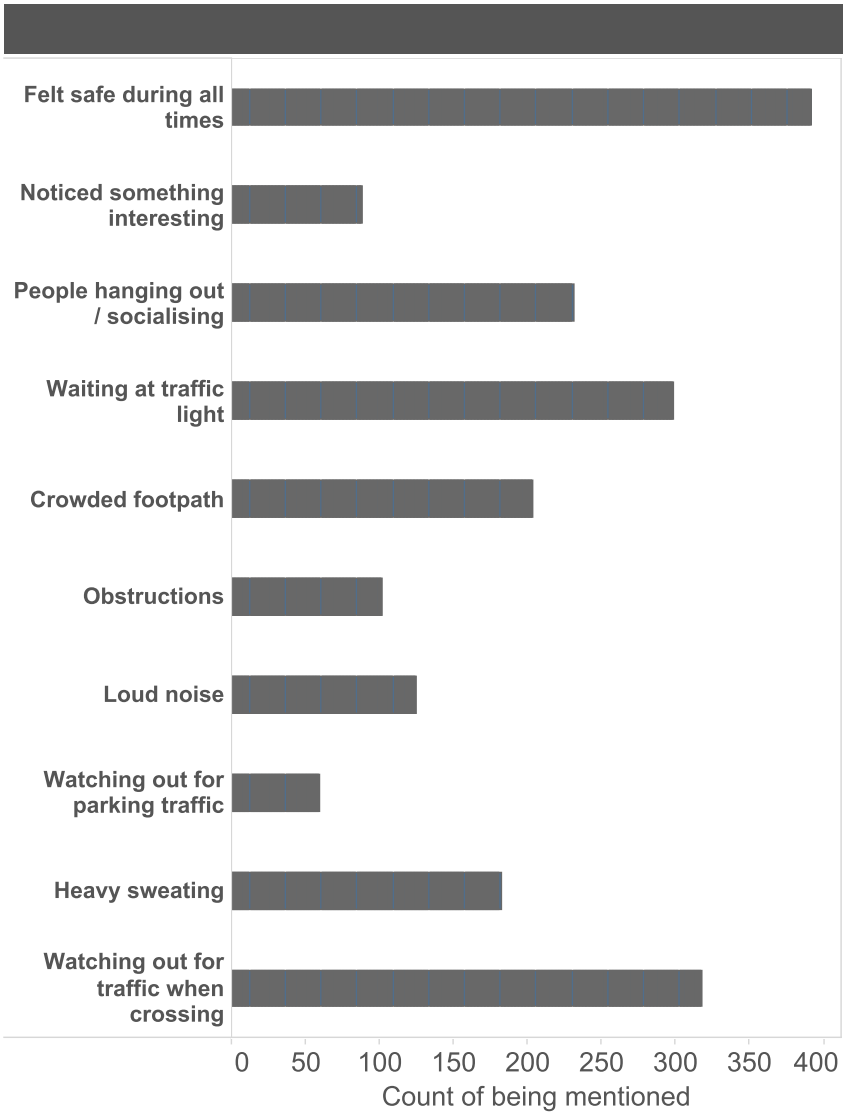
Experiences



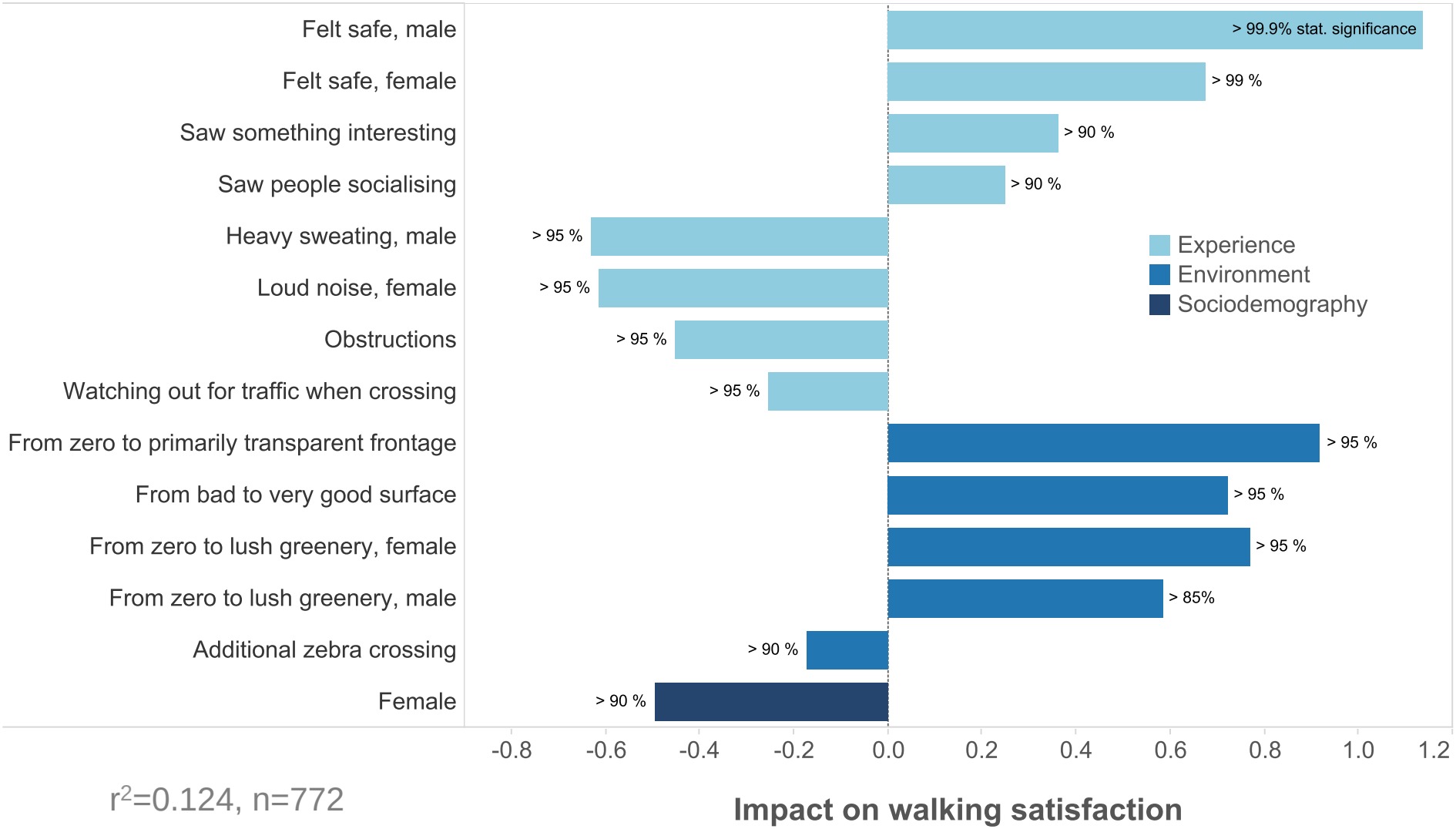
Interactive graph available at:
https://public.tableau.com/views/Directorsmeeting/ExperienceMap_1024

Pedestrian experience





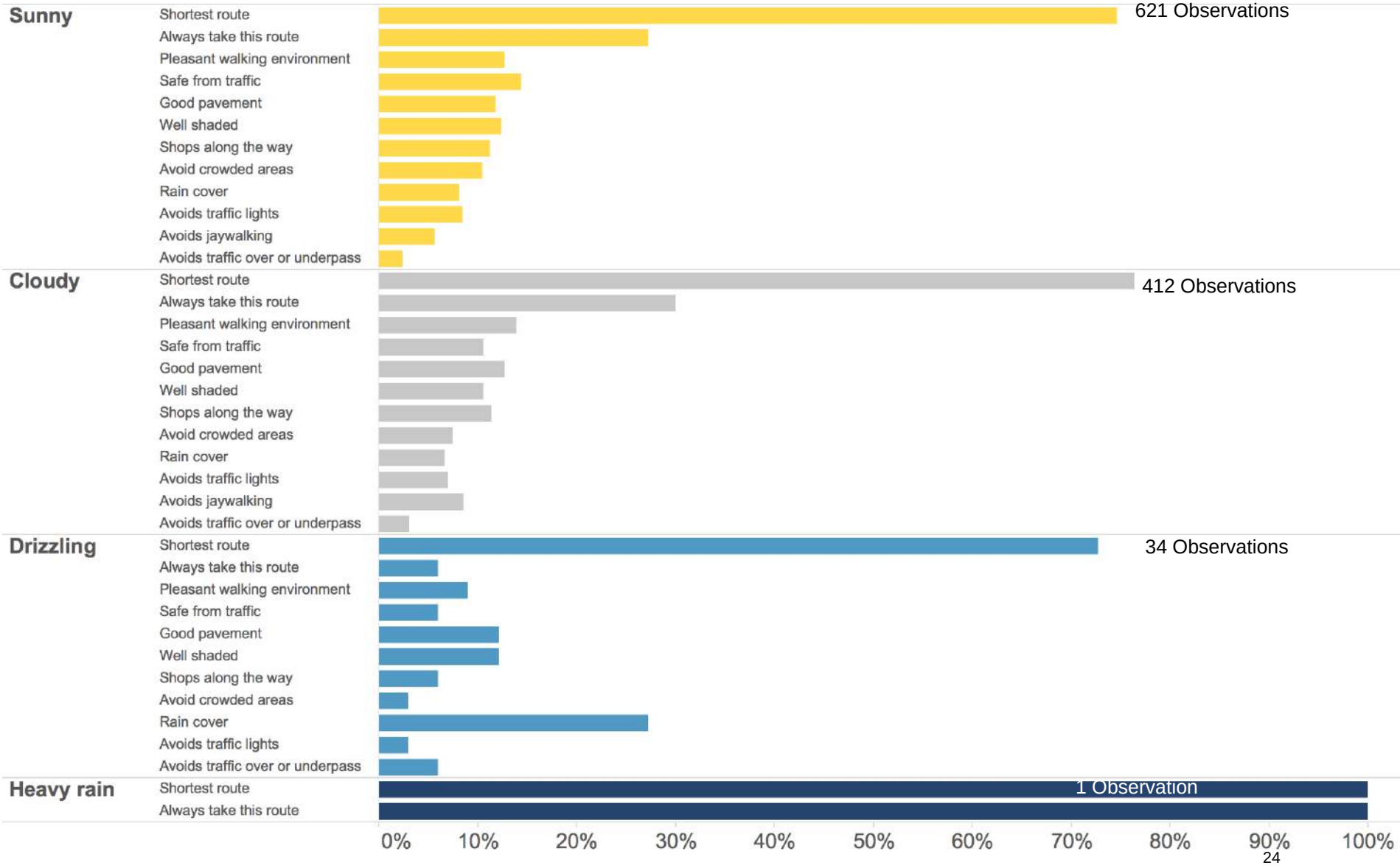
What impacts walking satisfaction?



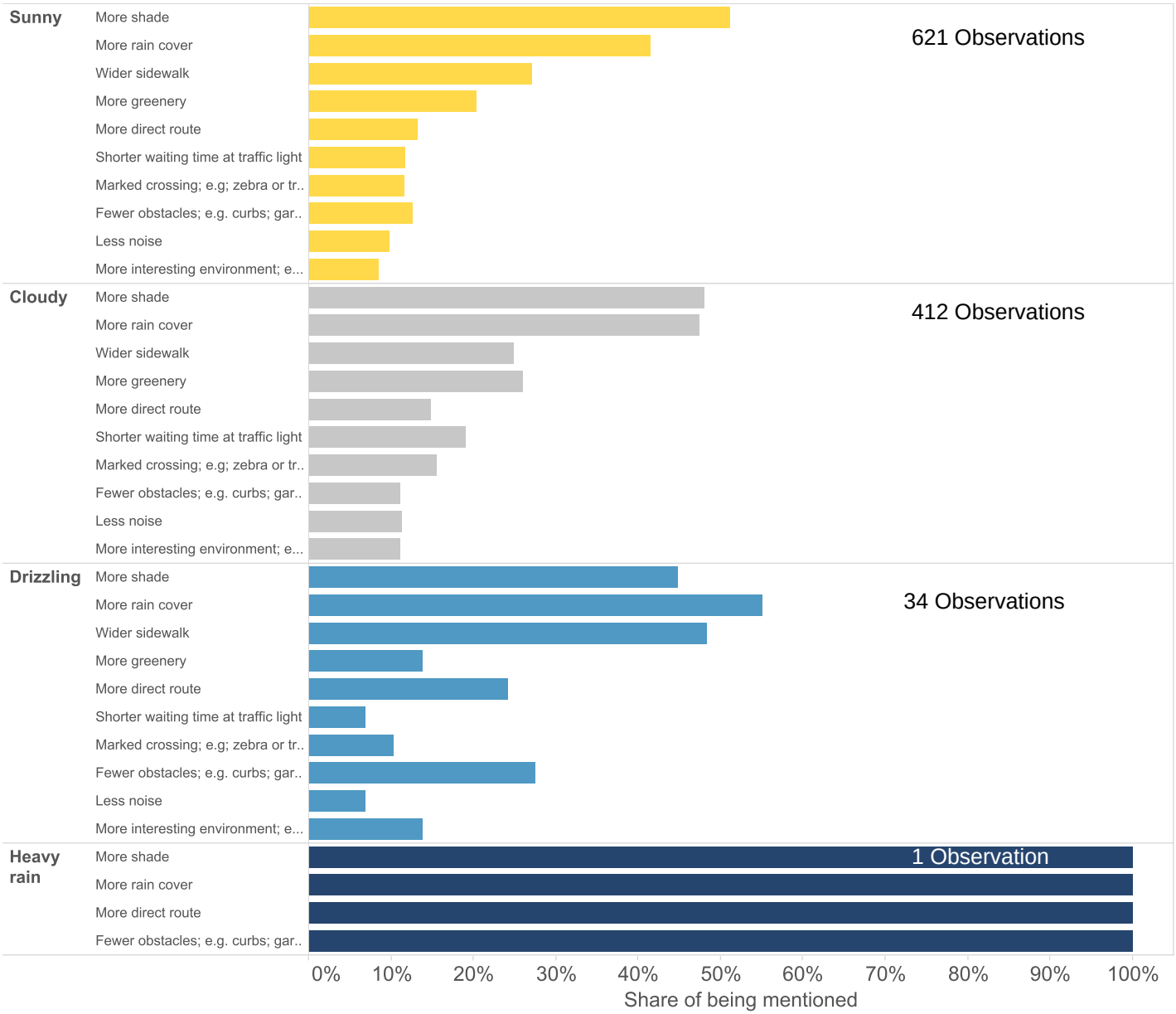
r^2=0.124, n=772

Other variables that have been tested include: walking frequency, ethnicity, age, activity before and after, human scale, imageability, obstruction, , maintenance, width, Enclosure, slipperiness, shade from greenery, availability of cover, horizontal and vertical separation, noise level, constructions site, weather, mode before and after,

Why this route?



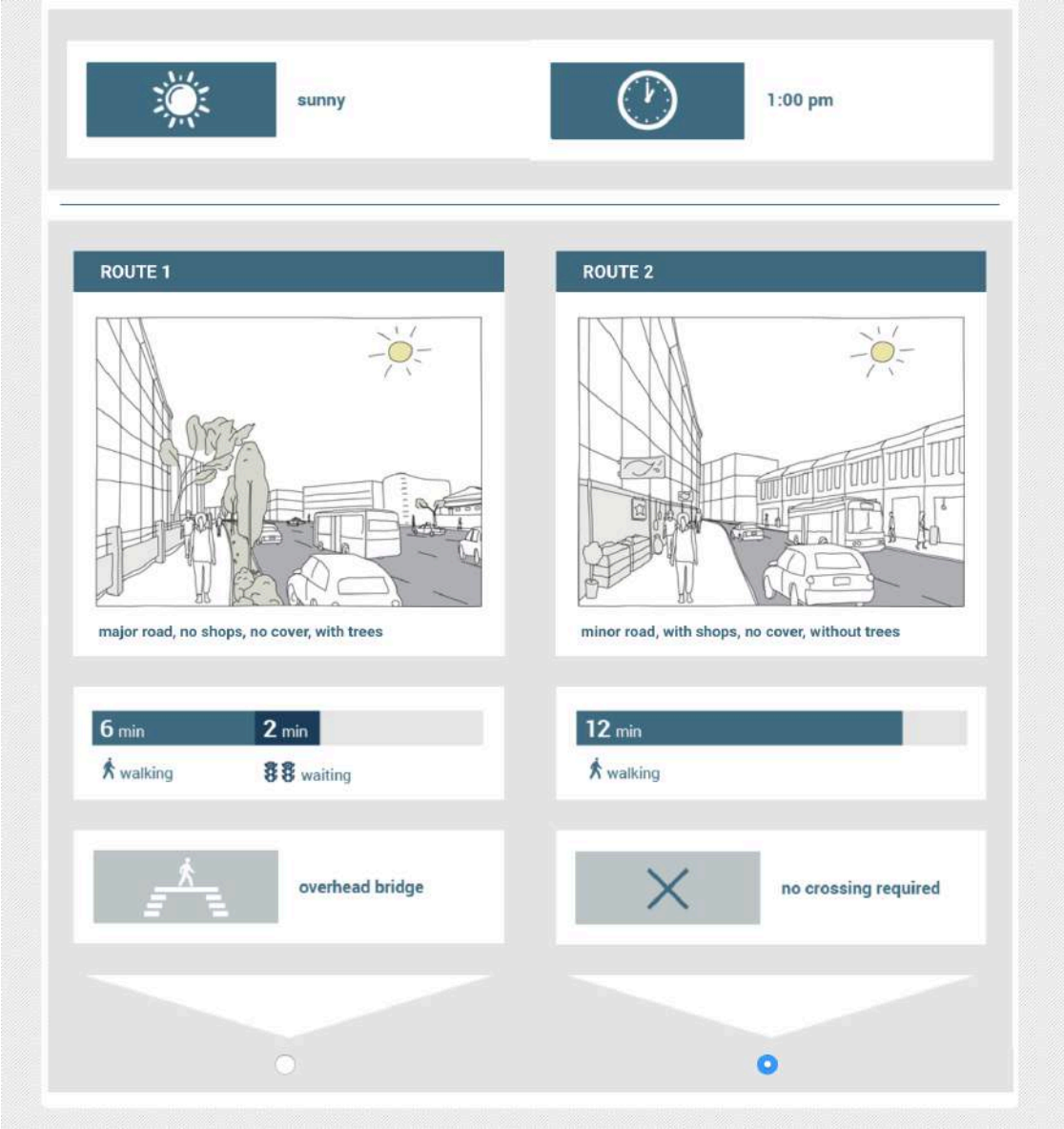
And how to improve the experience?



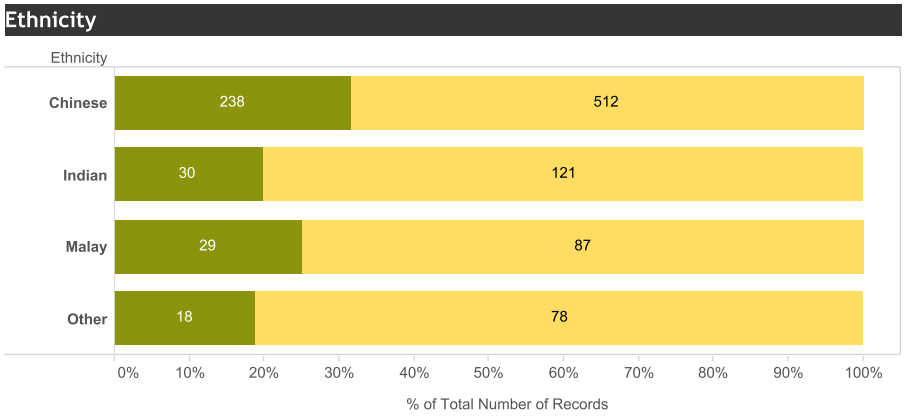
Behavioral models

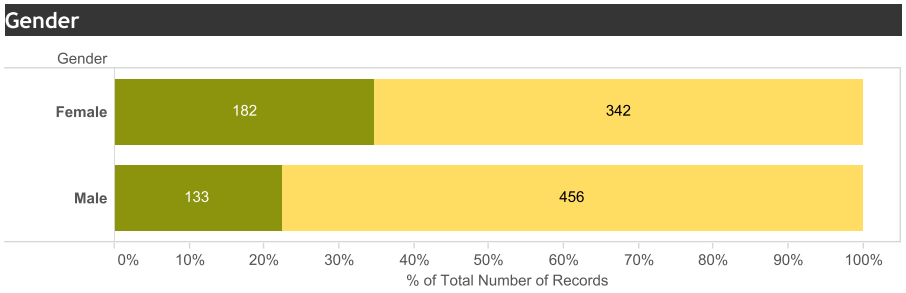
From actual to perceived distance

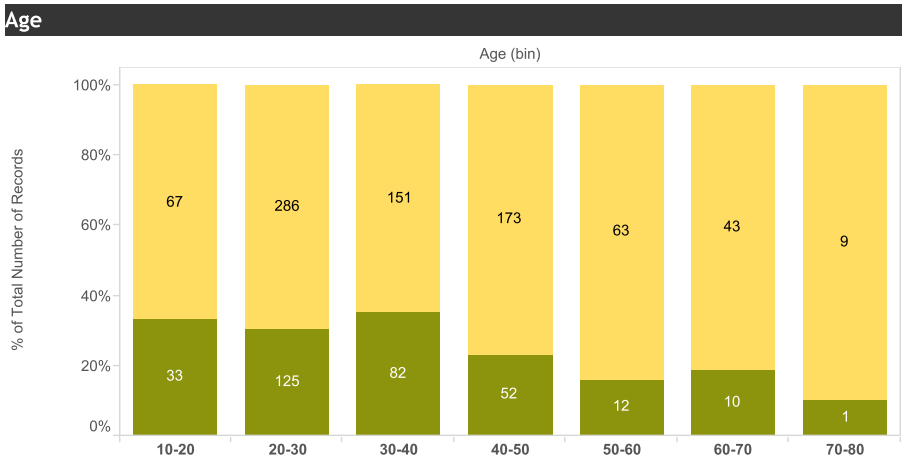
Which route would you prefer?



Response rates







Overall:

315 from 1113 recruited persons

-> 28.3 %

Specification of web-based route choice model

$$
\begin{aligned}
U = {} & \beta_t \cdot time \cdot (\\
& \left(1 + \beta_{min} \cdot minor + \beta_{maj} \cdot major + \beta_u \cdot under \cdot \left(1 + \beta_{u_r} \cdot rainy\right)\right) \cdot \\
& \left(1 + \beta_g \cdot greenery\right) \cdot \\
& \left(1 + \beta_s \cdot shops\right) \cdot \\
& \left(1 + \beta_c \cdot cover \cdot \left(1 + \beta_{c_s} \cdot sunny + \beta_{c_r} \cdot rainy\right)\right) + \\
& \beta_o \cdot overpass + \\
& \beta_{ol} \cdot overpass_{lift} + \\
& \beta_{j_2} \cdot jaywalk_{2lanes} + \\
& \beta_{tl} \cdot trafficlight_{wait}
\end{aligned}
$$

Results of choice model

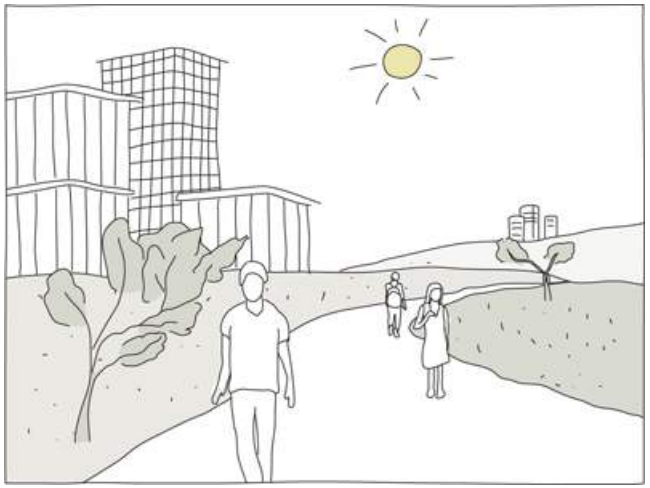
Parameters	Value	Sign.(>95%)
Walking time (through park, cloudy) [min]	-0.019	*
along major road	+59%	*
along minor road	+47%	*
cover	-18%	*
when rainy	-75%	*
when sunny	-51%	*
through block/underpass	-16%	*
when rainy	-66%	*
with greenery	-23%	*
with active frontage	-18%	*
Crossing 2-lane road	-0.015	*
Crossing 4-lane road	-0.094	*
Overpass	-0.082	*
Overpass with lift	-0.043	*
Trafficlight	-0.016	*

n = 2451, $\rho^2 = 0.131$

Numerical example

$$
\begin{aligned}
U = -0.00193 \cdot 10 \cdot (& \\
& \left(1 + \mathbf{0.473} \cdot \mathbf{minor} + \beta_{maj} \cdot 0 + \beta_u \cdot under \cdot \left(1 + \beta_{u_r} \cdot 0\right)\right) \cdot \\
& \left(1 + \mathbf{-0.228} \cdot \mathbf{greenery}\right) \cdot \\
& \left(1 + \mathbf{-0.175} \cdot \mathbf{shops}\right) \cdot \\
& \left(1 + \mathbf{-0.175} \cdot \mathbf{cover} \cdot \left(1 + \mathbf{1.9} \cdot \mathbf{sunny} + \beta_{c_r} \cdot 0\right)\right) + \\
& \beta_o \cdot 0 + \\
& \beta_{ol} \cdot 0 + \\
& \beta_{j_2} \cdot 0 + \\
& \beta_{j_4} \cdot 0 + \\
& \beta_{tl} \cdot 0 \\
= & -0.00193 \cdot 10 \cdot \mathbf{0.62}
\end{aligned}
$$

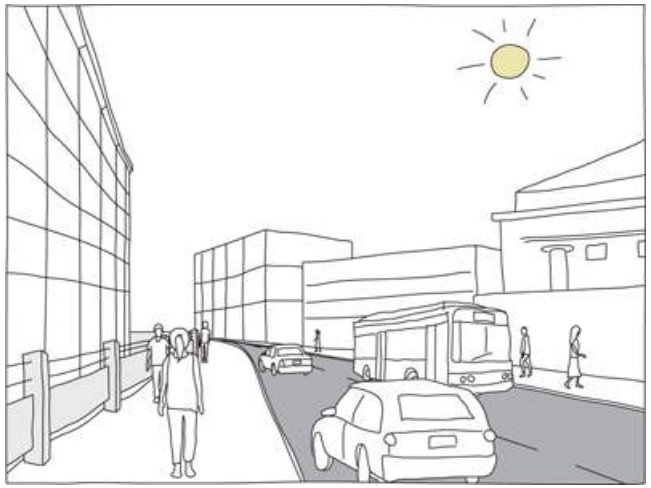
Interpretation of web-survey results



reference

10.0 min

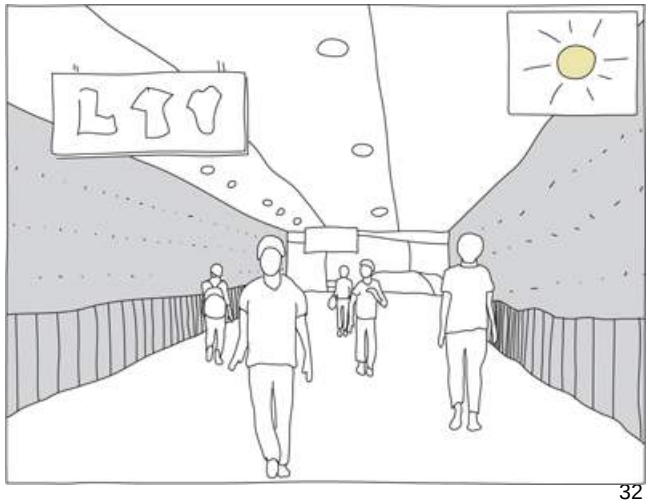
14.7 min



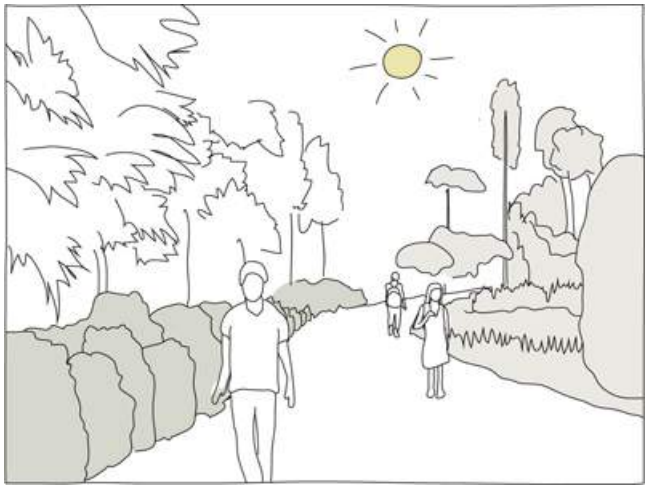
Reference case

15.3 min

8.4 min

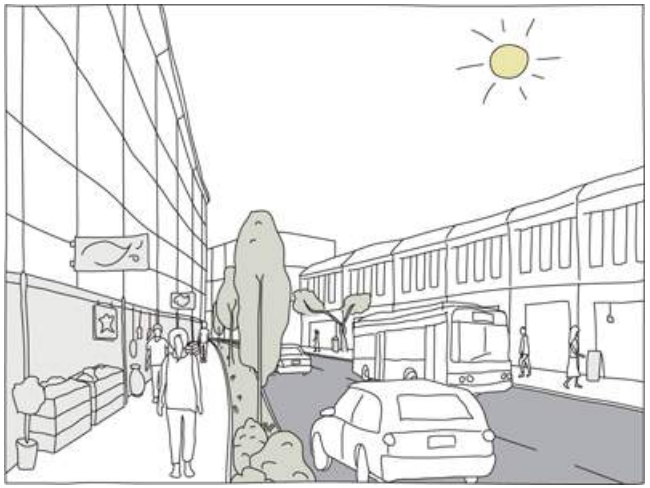


Interpretation of web-survey results

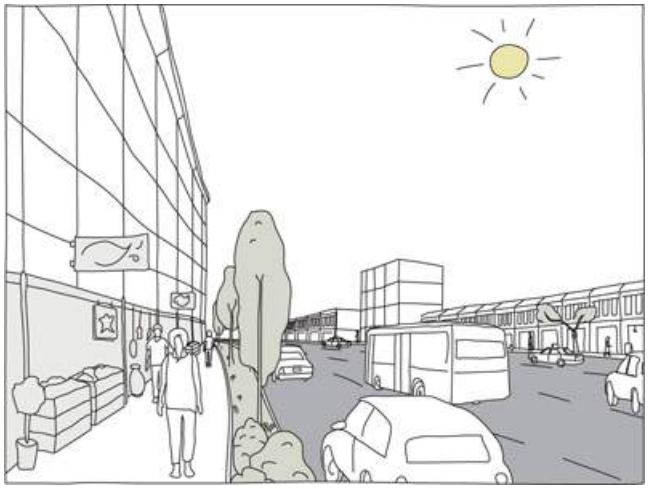


7.7 min

9.3 min



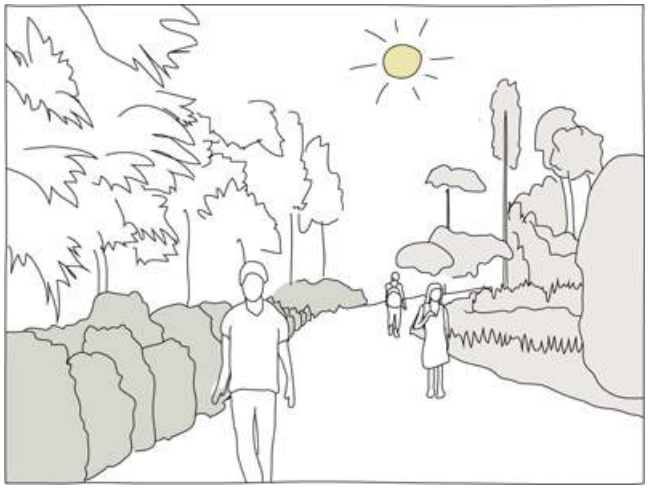
Add greenery (-23%) and shops (-18%)



11.9 min

6.6 min

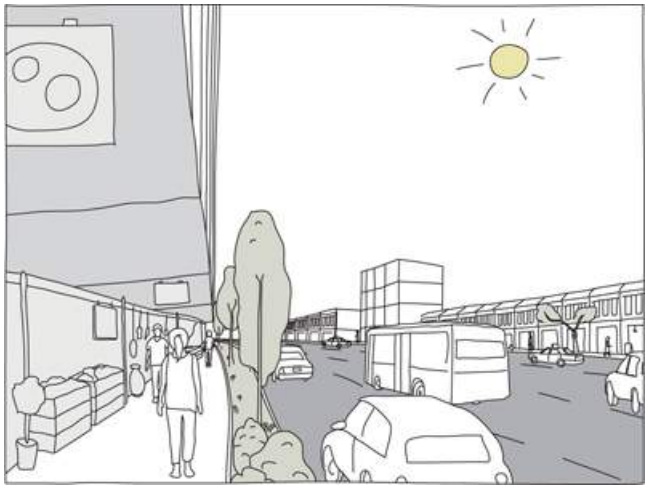
Interpretation of web-survey results



7.7 min

6.2 min

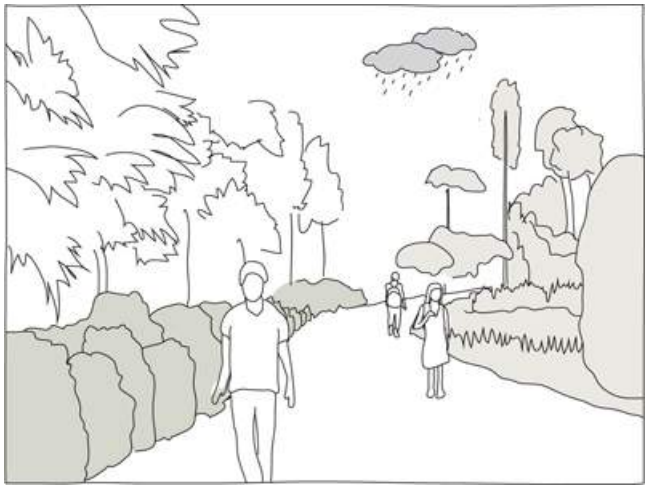
Add cover: -33% perceived walking time



6.8 min

6.6 min

Interpretation of web-survey results



14.8 min

reference

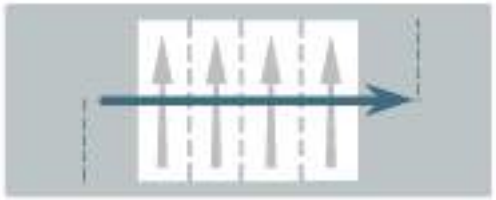
5.6 min

Tropical rain sets in

7.4 min

6.1 min

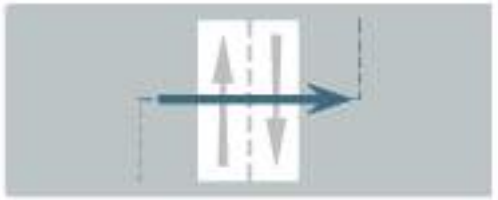
Crossings' equivalent of walking time



Jaywalking, 4 lanes

4.9 min

0.8 min



Jaywalking, 2 lanes

Overpass

4.2 min

2.2 min

Overpass with lift

Traffic light

1 min

2.0 min*

Underpass with stairs

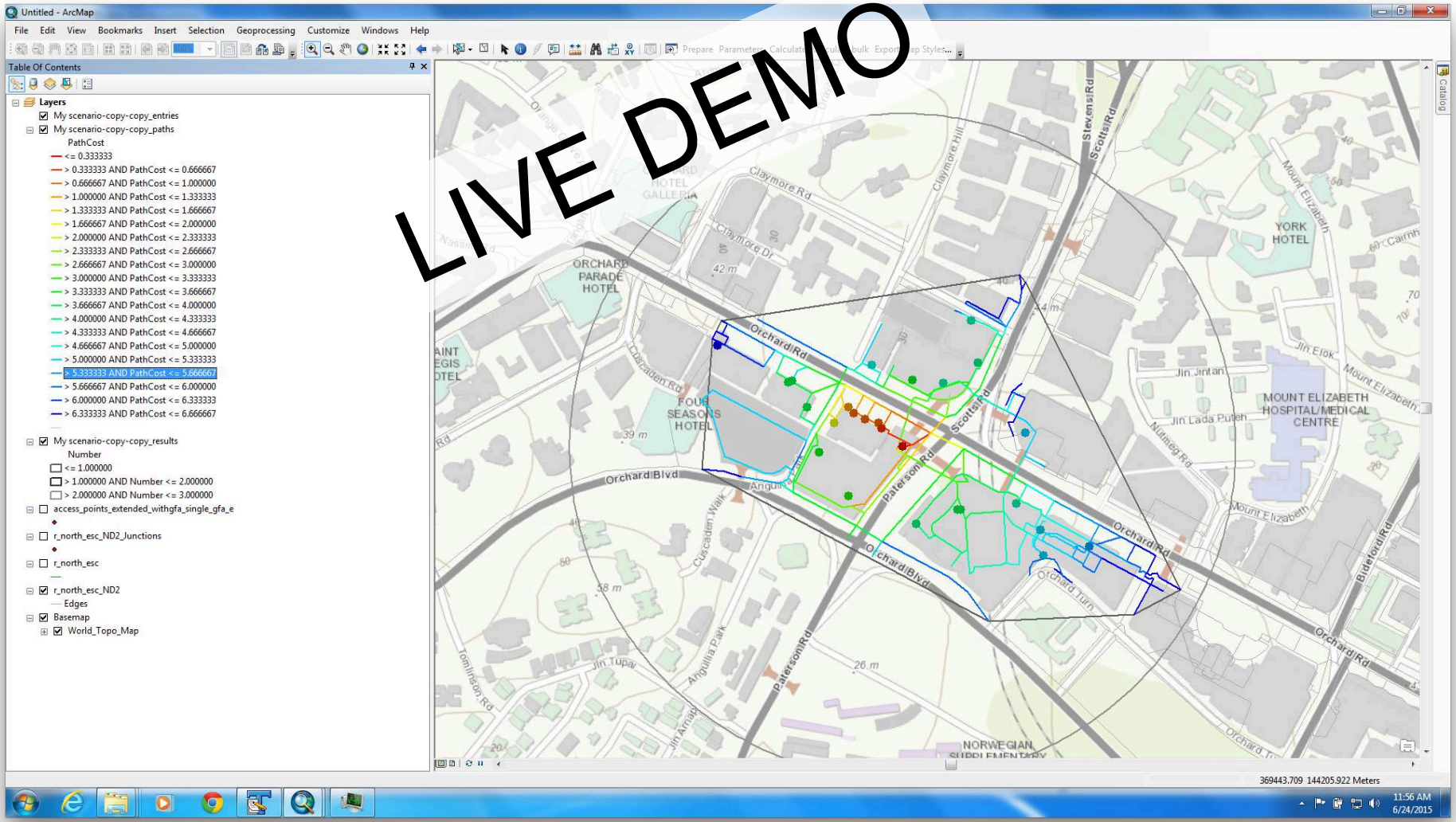
1 min*

Underpass with Escalator

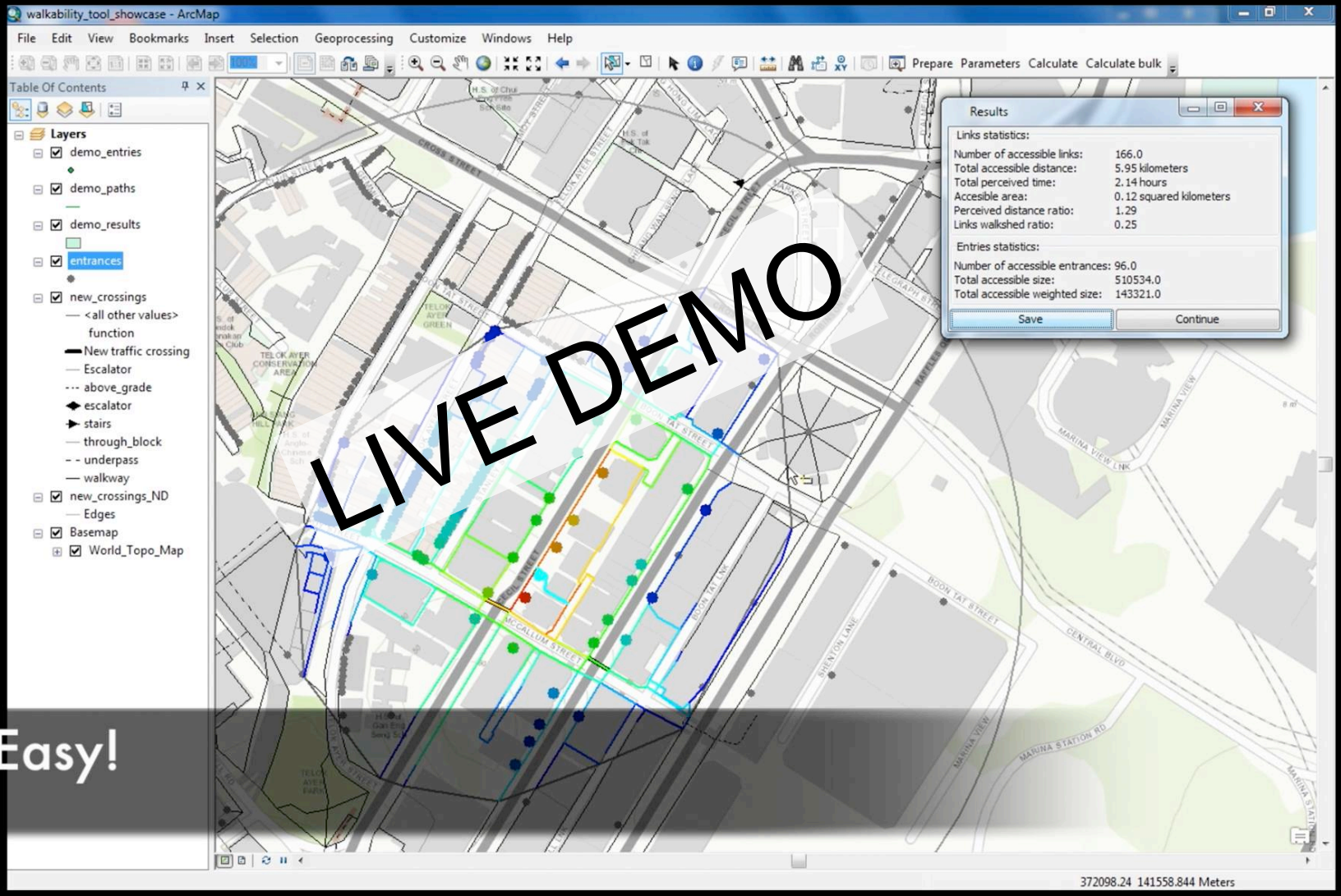
*stat. not significant as variable only available
ein subsample-> assumed values

Walkability Tool

A new ArcGIS add-in to compute walkability

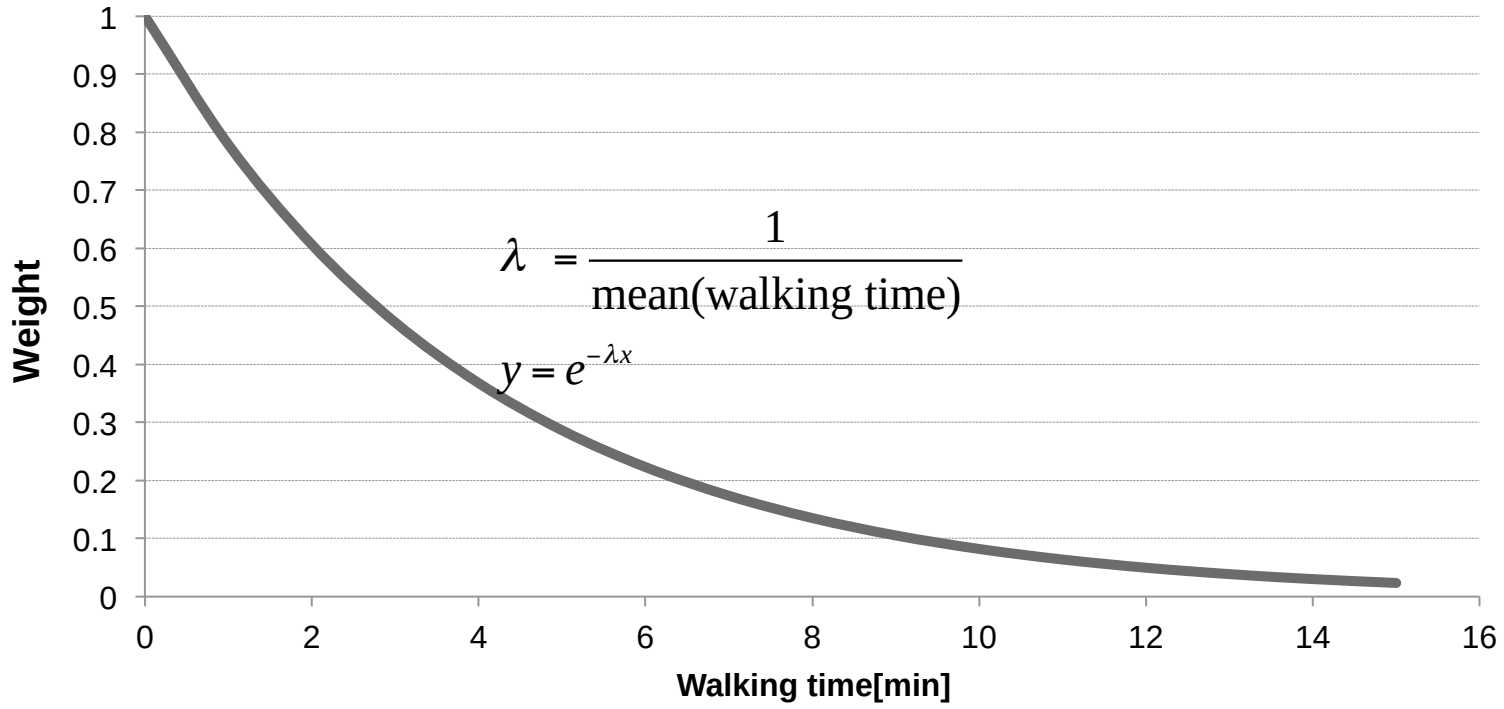

Untitled - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
My scenario-copy-copy_entries
My scenario-copy-copy_paths
PathCost
<= 0.333333
> 0.333333 AND PathCost <= 0.666667
> 0.666667 AND PathCost <= 1.000000
> 1.000000 AND PathCost <= 1.333333
> 1.333333 AND PathCost <= 1.666667
> 1.666667 AND PathCost <= 2.000000
> 2.000000 AND PathCost <= 2.333333
> 2.333333 AND PathCost <= 2.666667
> 2.666667 AND PathCost <= 3.000000
> 3.000000 AND PathCost <= 3.333333
> 3.333333 AND PathCost <= 3.666667
> 3.666667 AND PathCost <= 4.000000
> 4.000000 AND PathCost <= 4.333333
> 4.333333 AND PathCost <= 4.666667
> 4.666667 AND PathCost <= 5.000000
> 5.000000 AND PathCost <= 5.333333
> 5.333333 AND PathCost <= 5.666667
> 5.666667 AND PathCost <= 6.000000
> 6.000000 AND PathCost <= 6.333333
> 6.333333 AND PathCost <= 6.666667
My scenario-copy-copy_results
Number
<= 1.000000
> 1.000000 AND Number <= 2.000000
> 2.000000 AND Number <= 3.000000
access_points_extended_withgfa_single_gfa_e
r_north_esc_ND2_Junctions
r_north_esc
r_north_esc_ND2
Edges
Basemap
World_Topo_Map
LIVE DEMO
ORCHARD PARADE HOTEL
FOUR SEASONS HOTEL
YORK HOTEL
MOUNT ELIZABETH HOSPITAL/MEDICAL CENTRE
NORWEGIAN
Orchard Rd
Orchard Blvd
Scotts Rd
Paterson Rd
Claymore Rd
Mount Elizabeth
369443.709 144205.922 Meters
11:56 AM
6/24/2015

New ArcGIS add-in for planners



https://vimeo.com/132168191

Distance weighted accessibility



Weighted impact

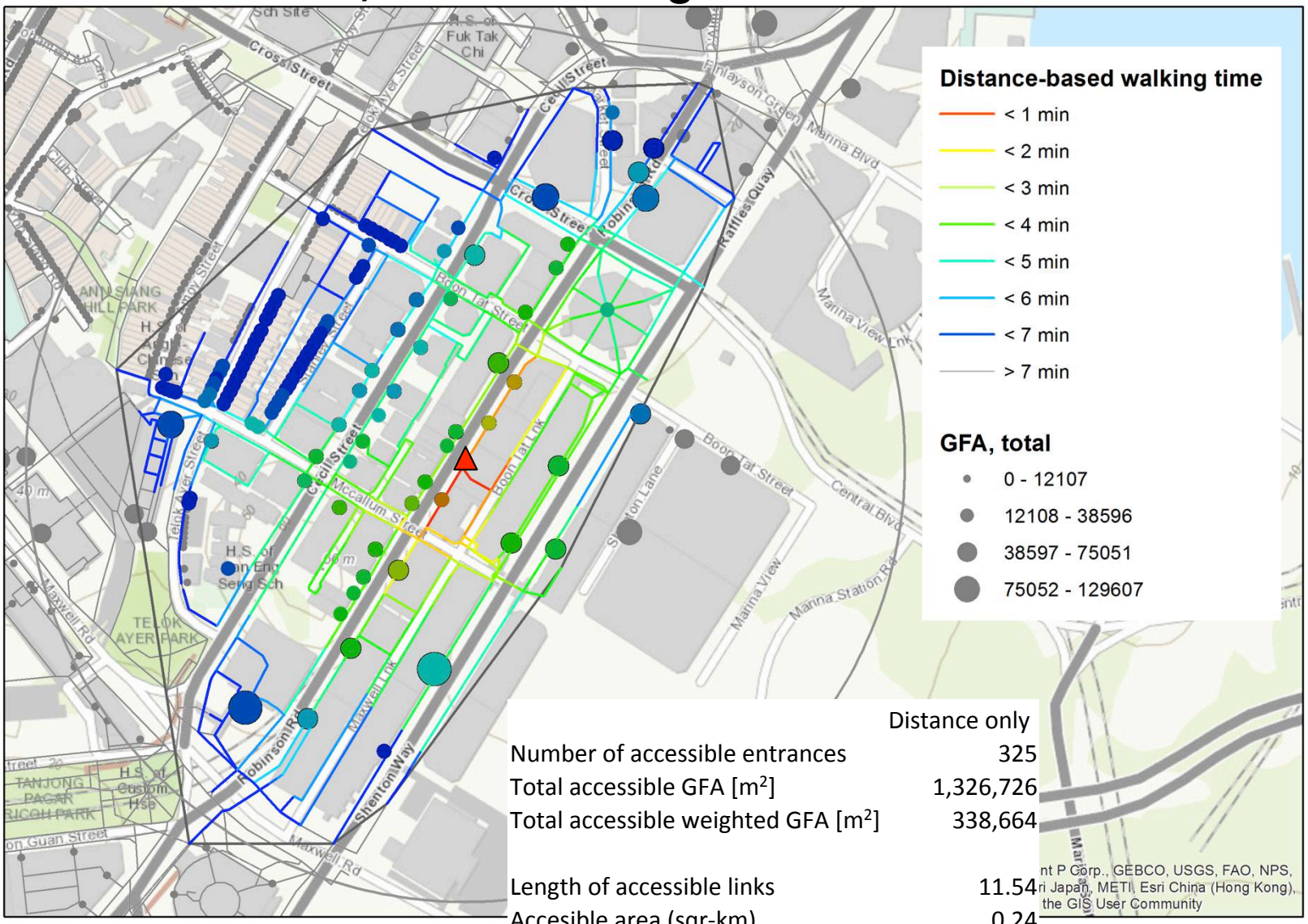
100% 28% 8% 2%

Case study

Adding zebra crossings around Robinson Road

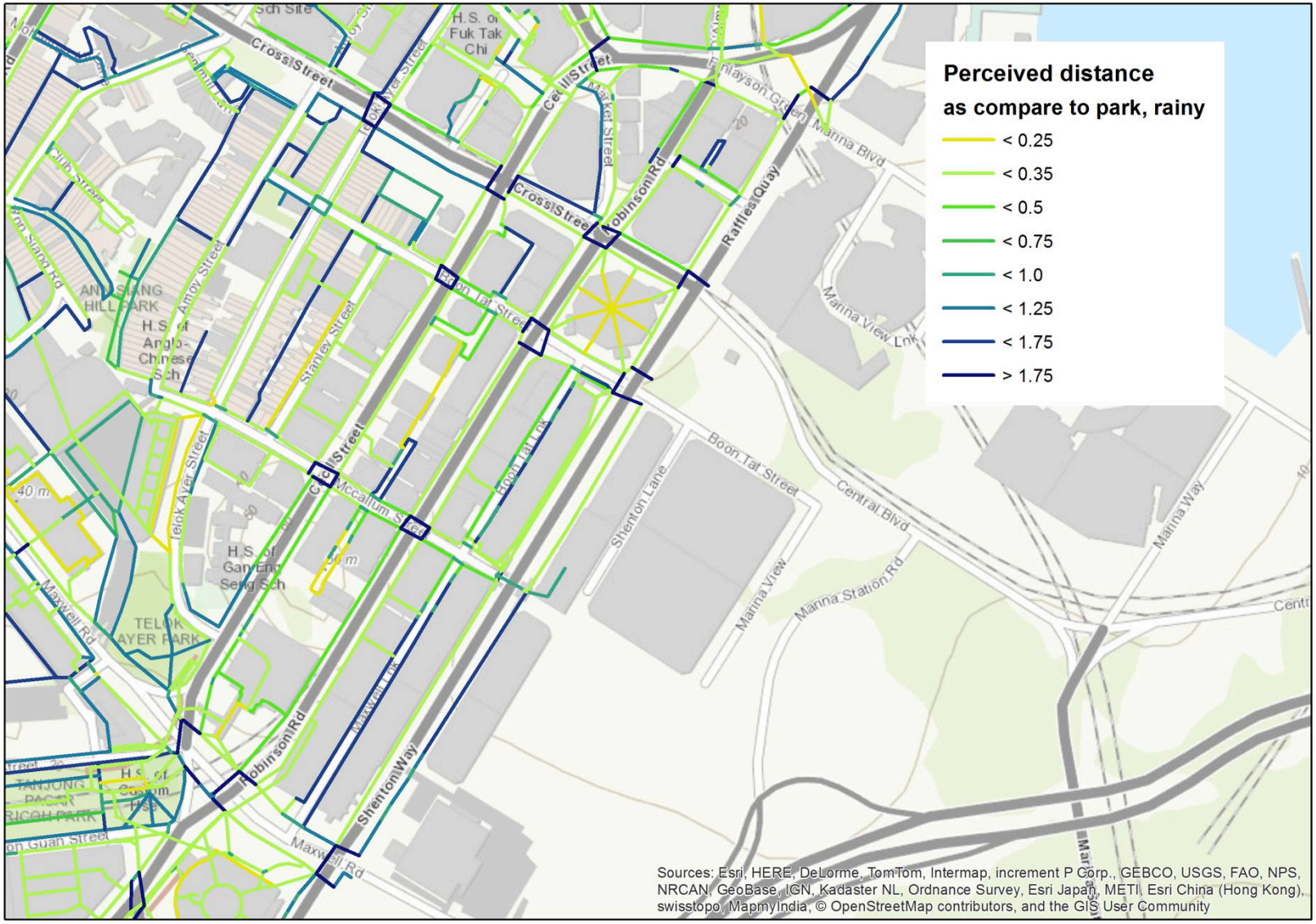
Street view at Robinson Point

Robinson Point, 400m walking distance



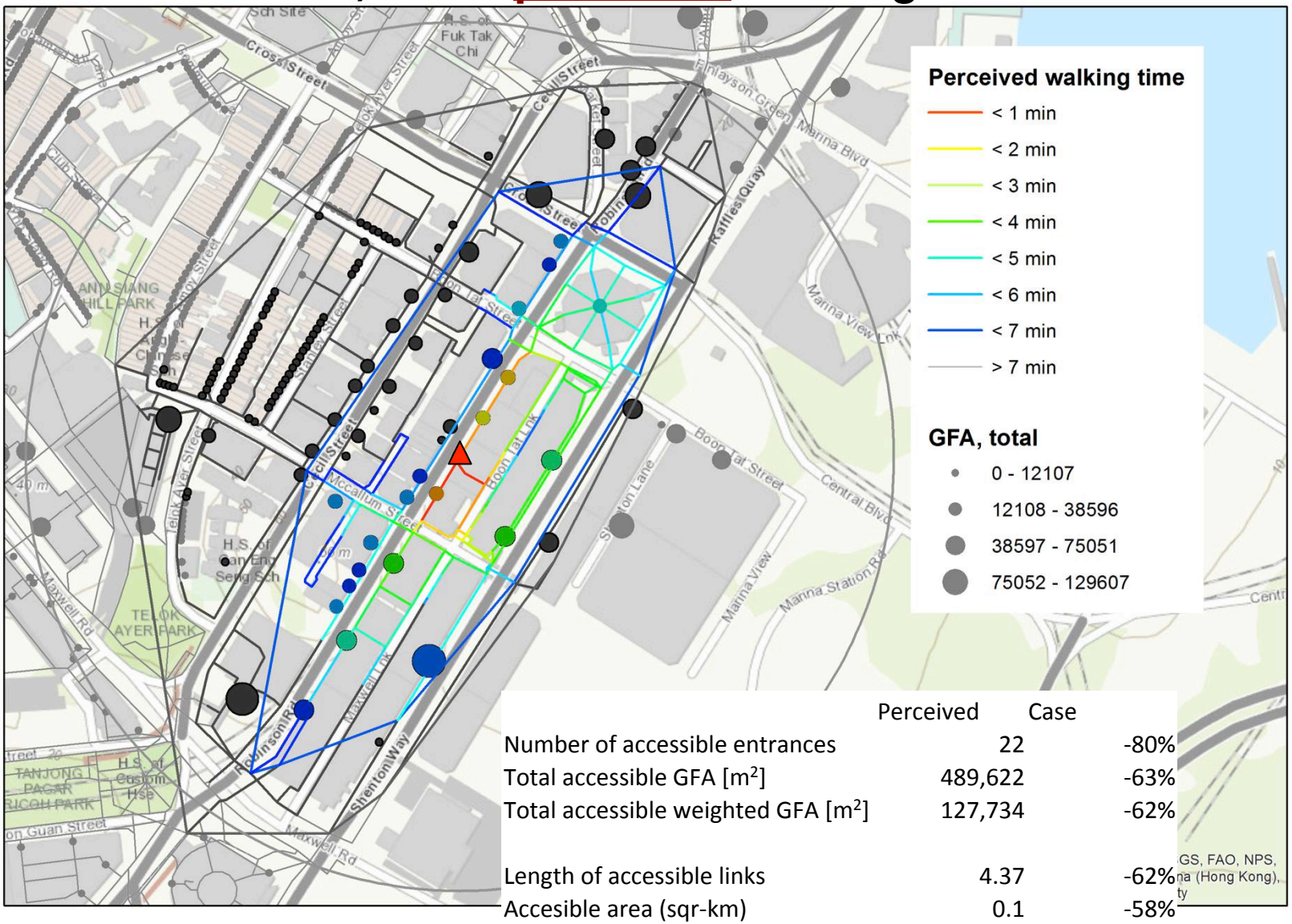
	Distance only
Number of accessible entrances	325
Total accessible GFA [m^2]	1,326,726
Total accessible weighted GFA [m^2]	338,664
Length of accessible links	11.54
Accesible area (sqr-km)	0.24
Perceived distance ratio	1
Links walkshed ratio	0.48

Robinson Point: perceived distance on a sunny day



0 100 200 400 Meters

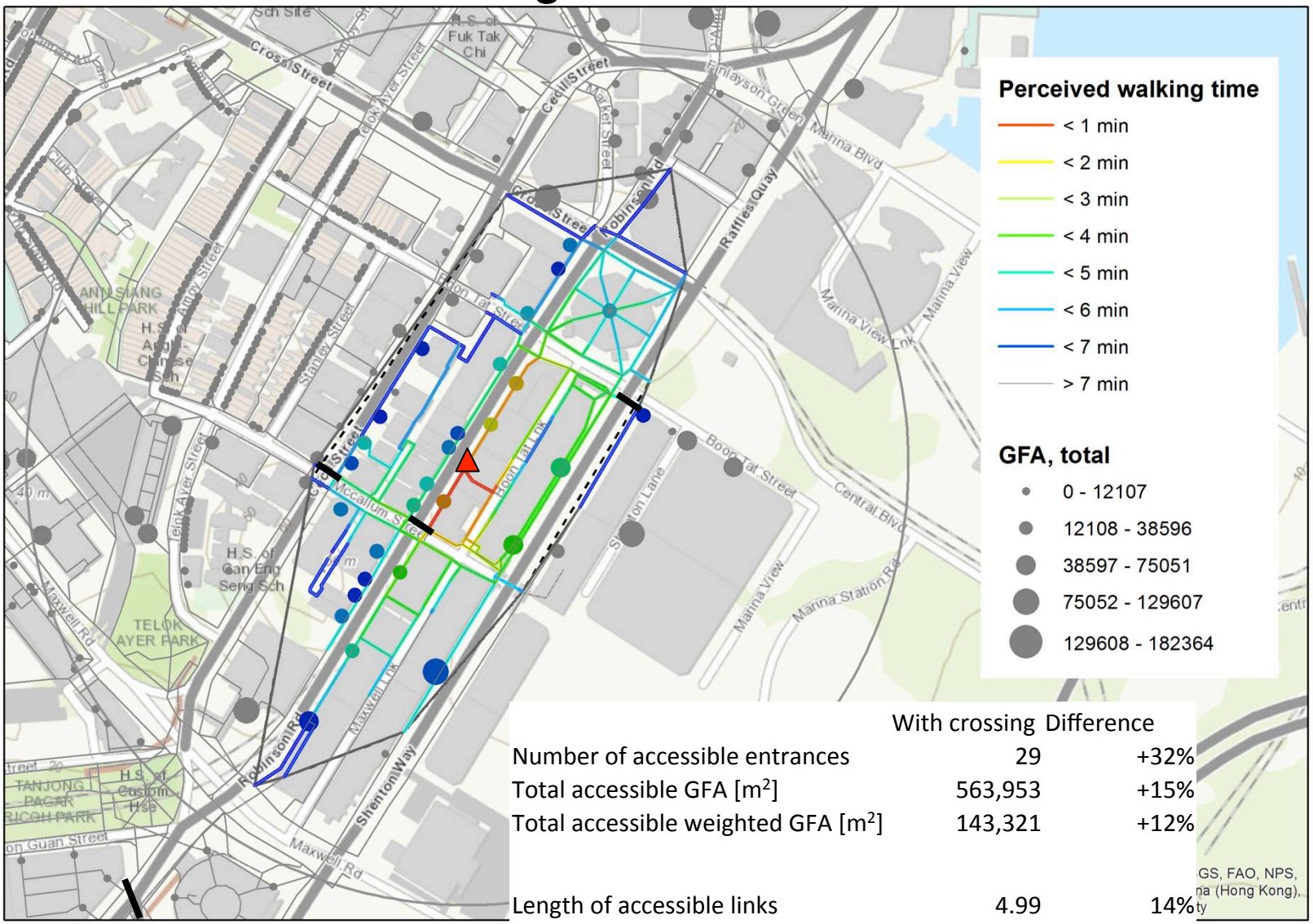
Robinson Point, 400m perceived walking distance



	Perceived	Case	
Number of accessible entrances	22		-80%
Total accessible GFA [m^2]	489,622		-63%
Total accessible weighted GFA [m^2]	127,734		-62%
Length of accessible links	4.37		-62%
Accesible area (sqr-km)	0.1		-58%
Perceived distance ratio	1.48		+48%
Links walkshed ratio	0.21		-56%

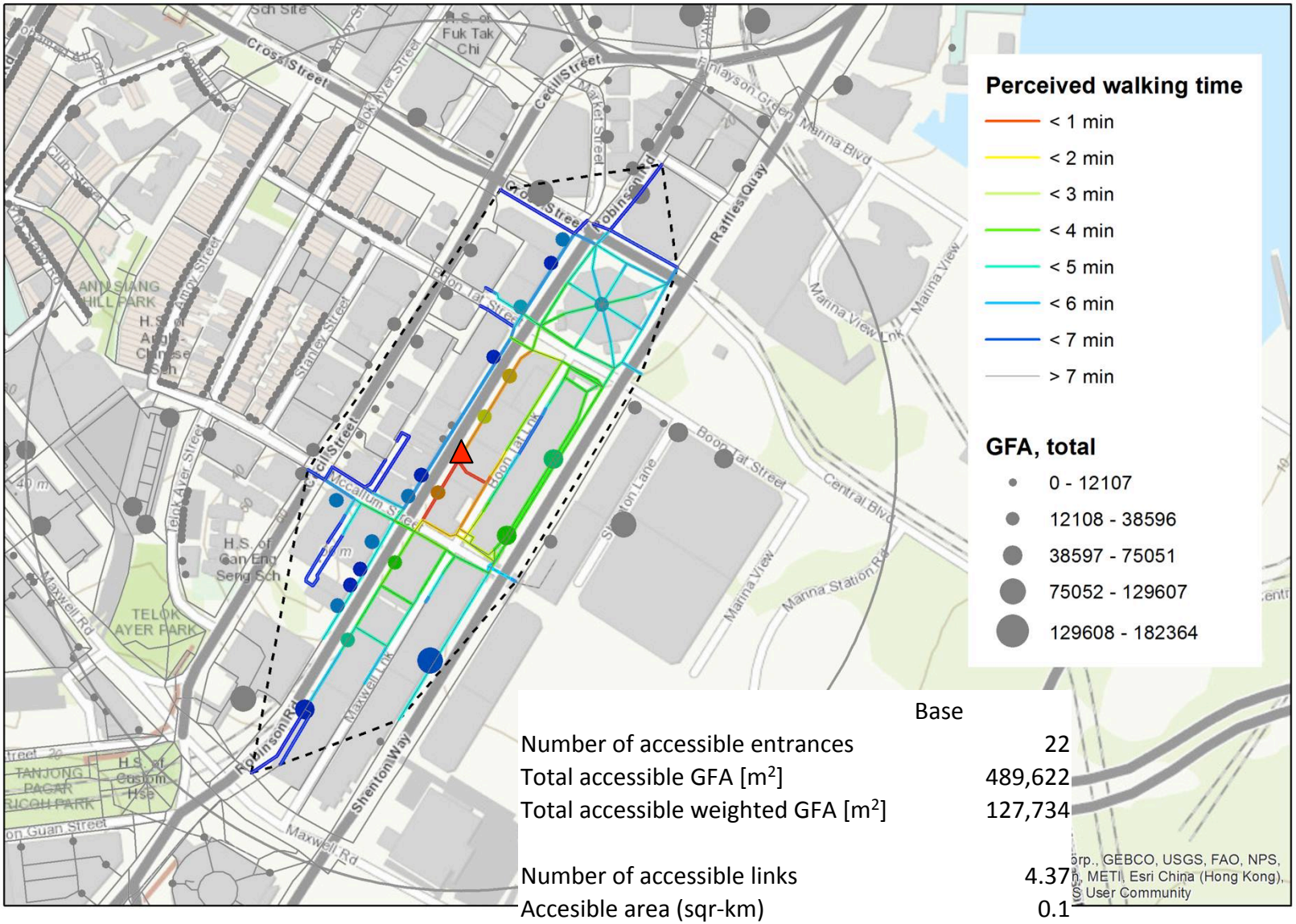
Case study – New Crossing at McCallum and Robinson Street

Add new street crossings



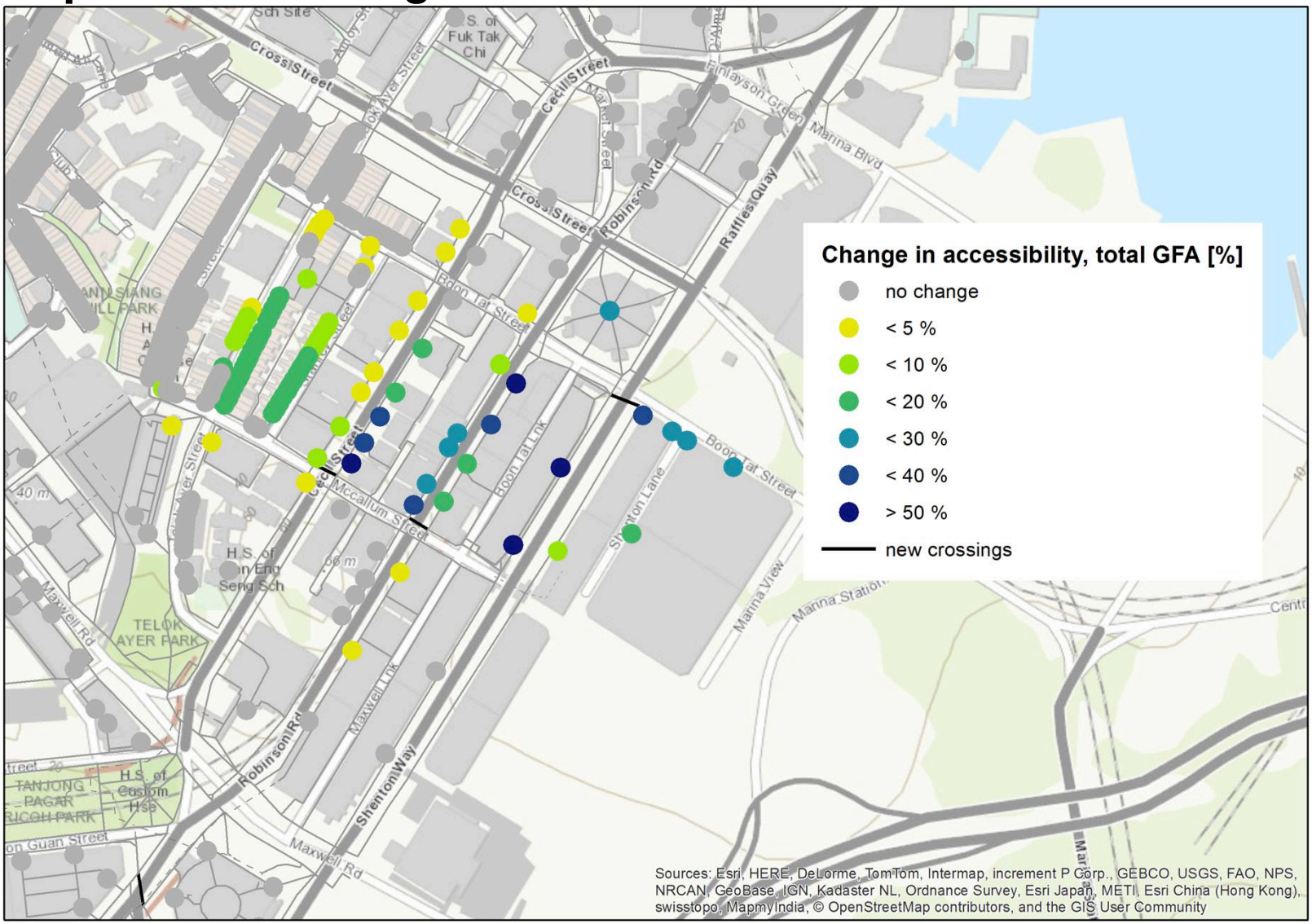
	With crossing	Difference
Number of accessible entrances	29	+32%
Total accessible GFA [m^2]	563,953	+15%
Total accessible weighted GFA [m^2]	143,321	+12%
Length of accessible links	4.99	14%
Accesible area (sqr-km)	0.1	0%
Perceived distance ratio	1.45	-2%
Links walkshed ratio	0.21	0%

Base scenario, start at Robinson Point



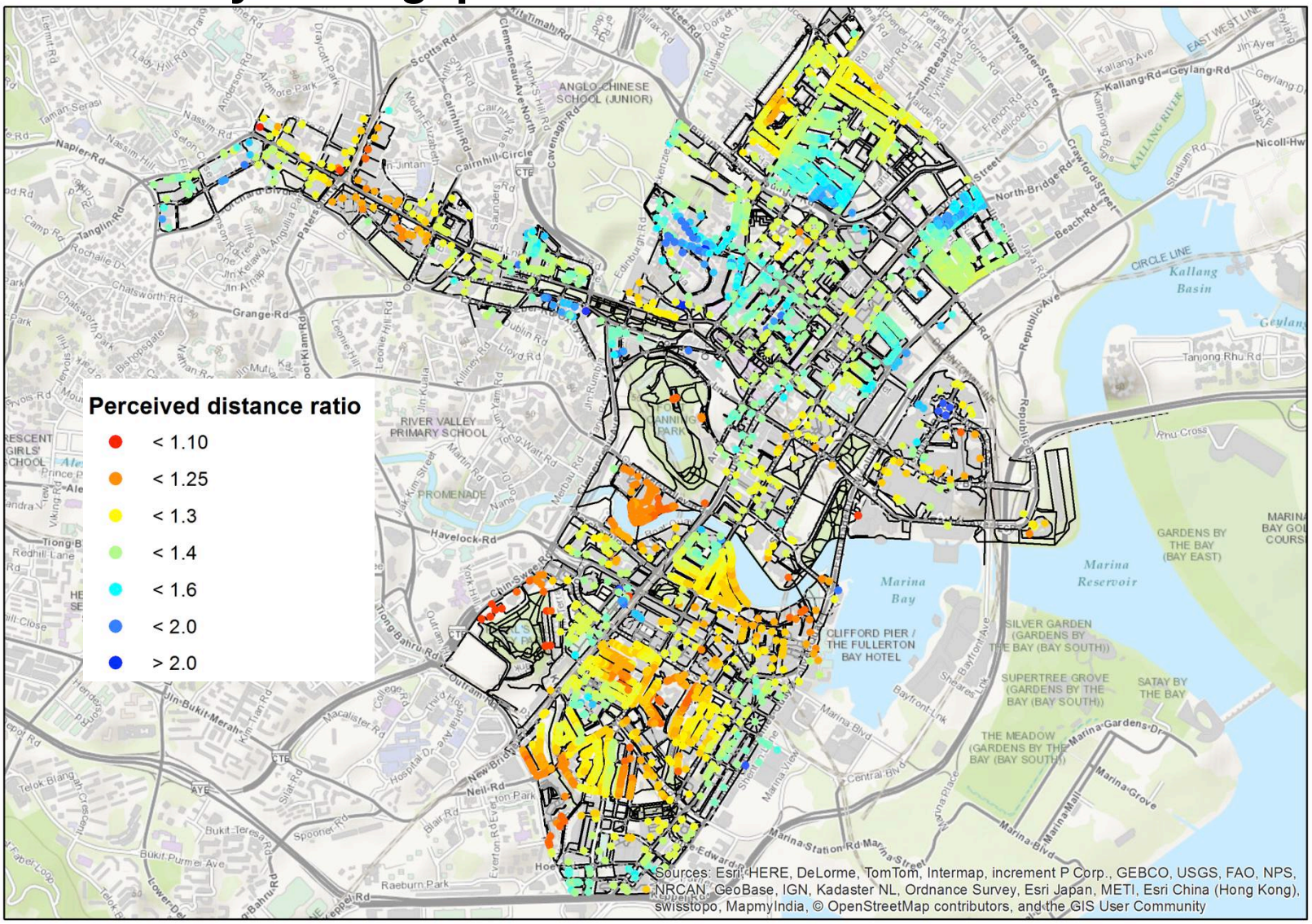
	Base
Number of accessible entrances	22
Total accessible GFA [m^2]	489,622
Total accessible weighted GFA [m^2]	127,734
Number of accessible links	4.37
Accesible area (sqr-km)	0.1
Perceived distance ratio	1.48
Links walkshed ratio	0.21

Impact on building level



0 100 200 400 Meters

Walkability in Singapore



Conclusion and policy recommendations

Key findings

Key findings

Who walks?

- Primarily public transport users
- No real segmentation by age, sex or ethnicity
- To get to various types of activities

How to plan for a good walking experience?

- Safe walking environment
- Create social, interesting environments
- Provide shelter from sun and rain

Key findings

Most frequently mentioned suggestions for improvement:

- More shade / cover
- Wider sidewalk
- Shorter waiting time at traffic lights
- More direct route

How to make a walk shorter?

Greenery: -23%

Covered walkway: - 17% / - 33 % / -75% (cloudy / sunny / rainy)

Underground: - 17 % (as compared to park)

Active frontage: -18%

Remaining tasks and future research

Model pedestrian route choice to better understand influence of:

- Influence of turns, wayfinding
- Traffic lights
- Distance vs built environment based on actual behavior

Open questions:

- Influence of crowding and width of walkway
- Heterogeneity of built up environment
- Perceived cost of vertical movement
- Wind as a comfort factor

Next steps

Role out of Walkability Tool

- Workshop in August 2015
- Preparation of ArcGIS geodatabase
- Archiving of survey data and models

Topics for potential next phase

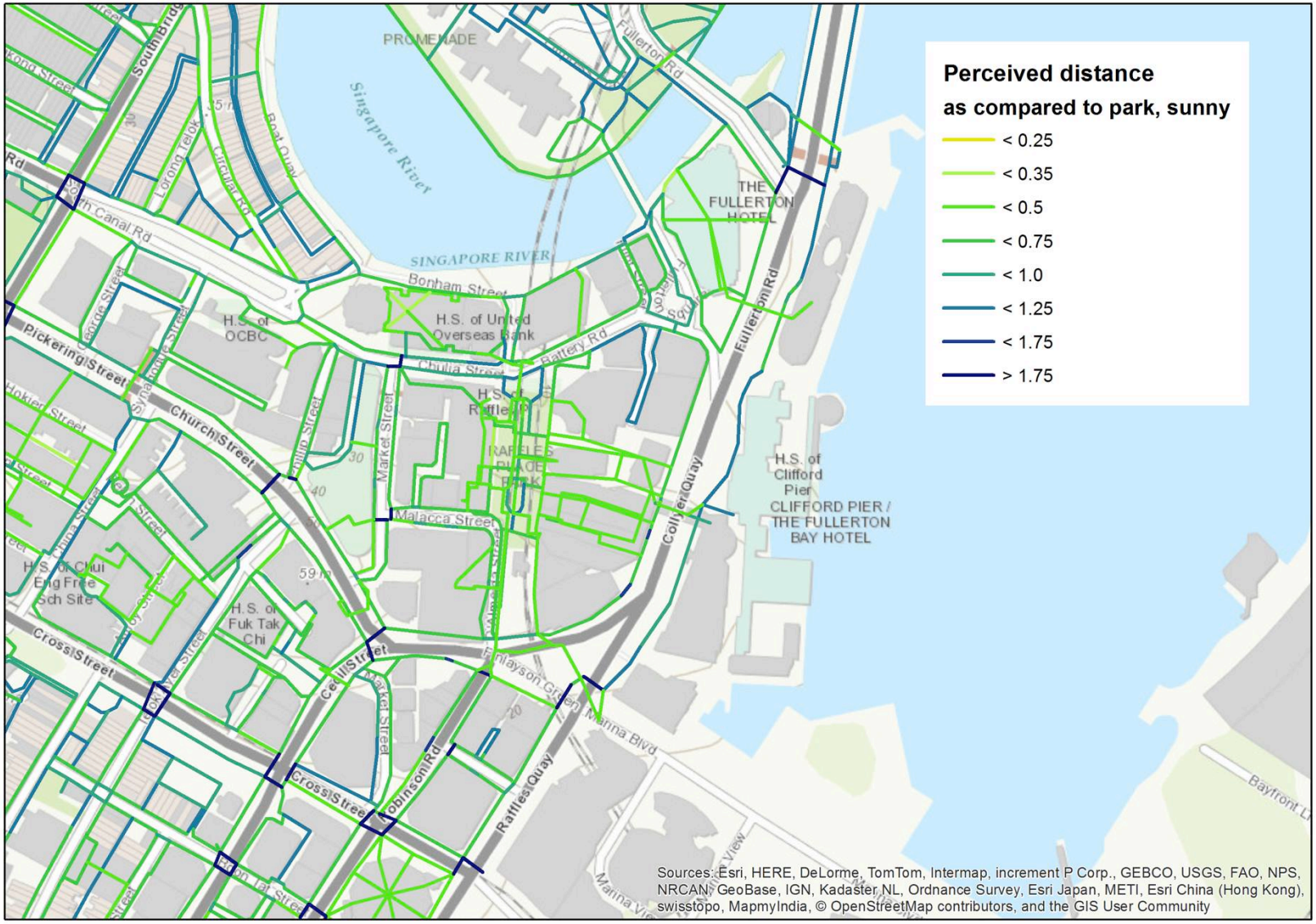
- Walkability in new towns
- Understanding of destination choice
- Enhance Walkability tool
  - Link it to spatial databases, e.g. building inventory, MATSim
  - Map pedestrian potential
  - Model pedestrian flows

Appendices

Appendix I - Walkability index

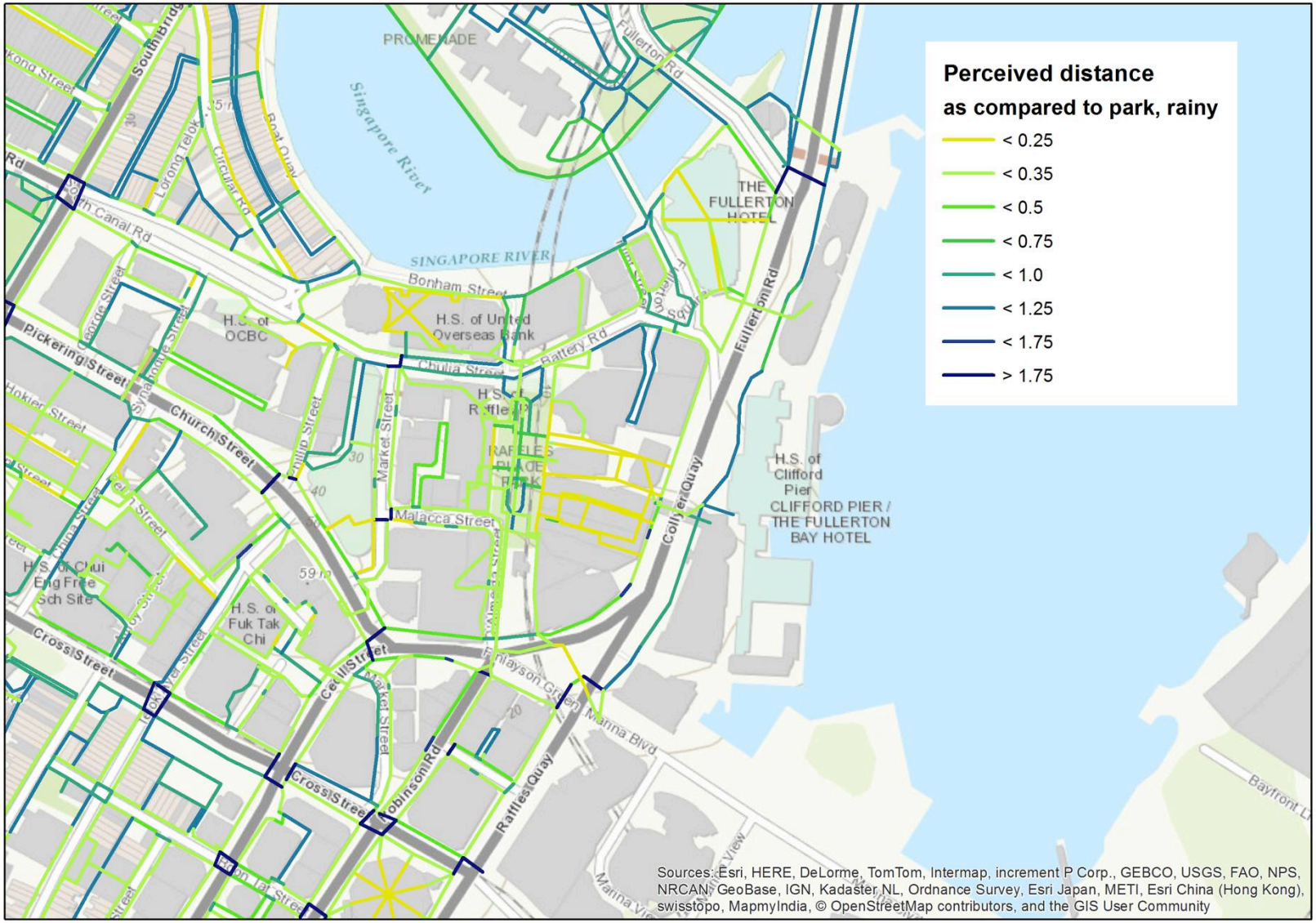
Actual vs. perceived distance

Raffles place: perceived distance on a sunny day



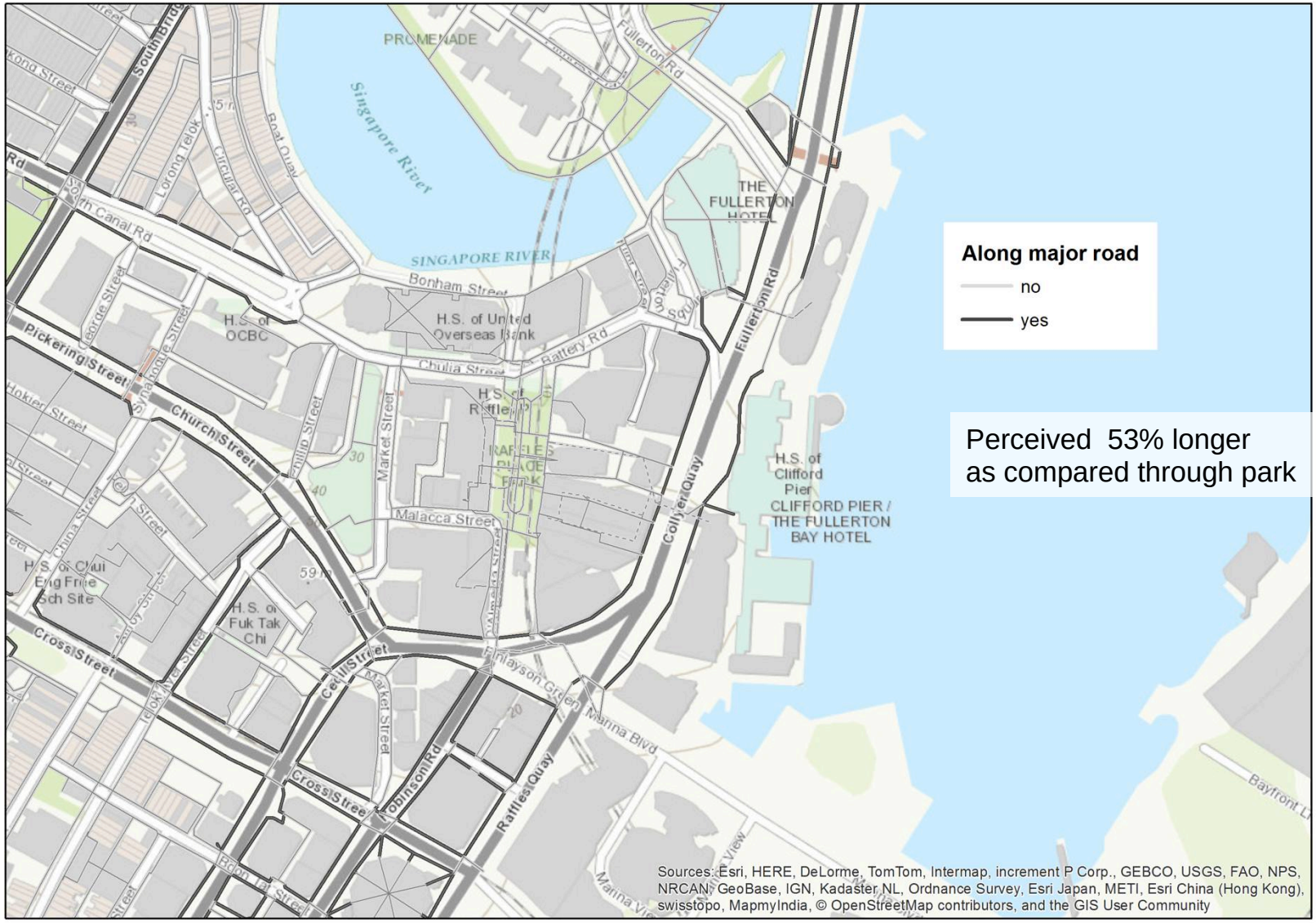
0 100 200 400 Meters

Raffles place: perceived distance on a rainy day



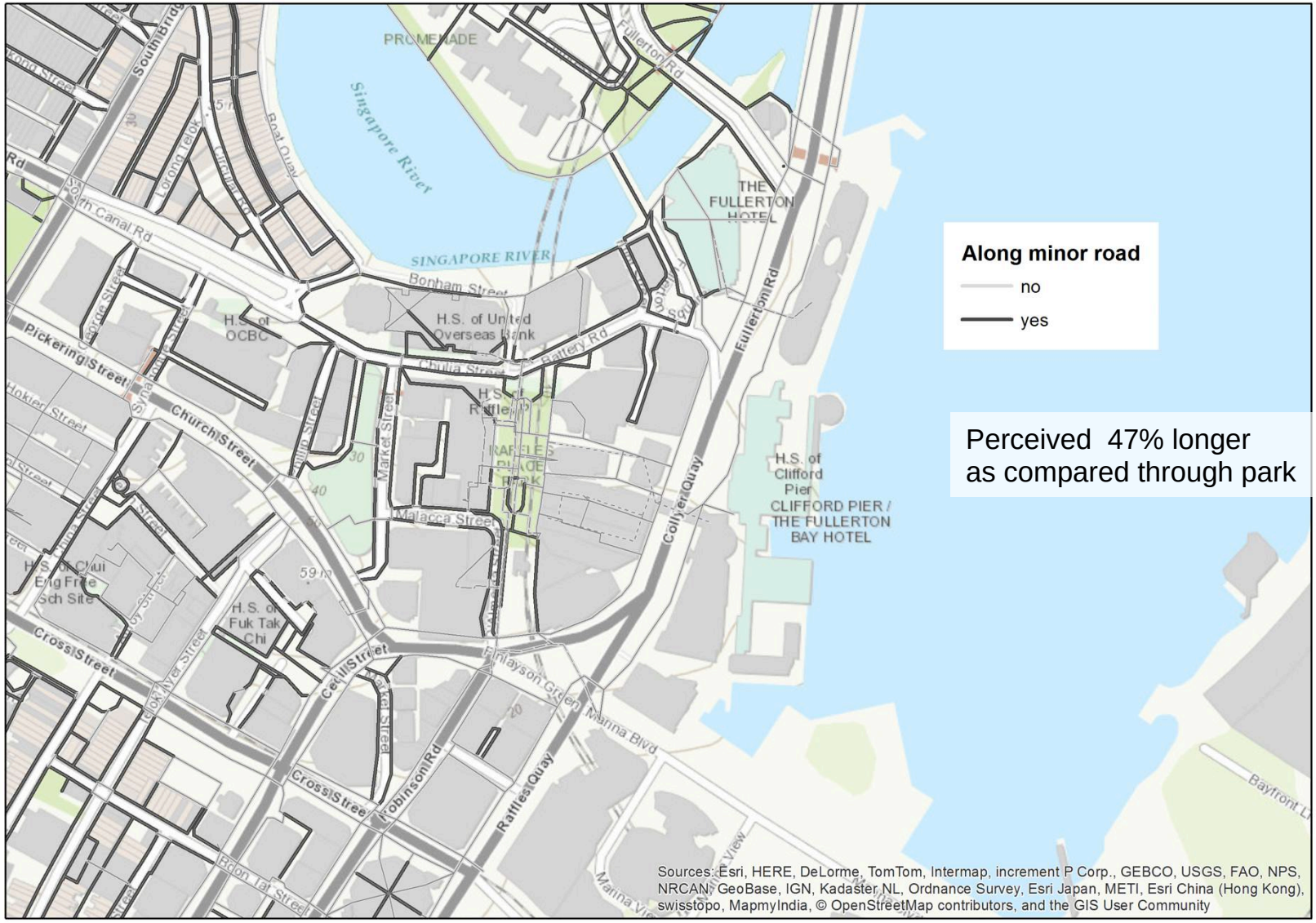
0 100 200 400 Meters

Raffles place: along major road



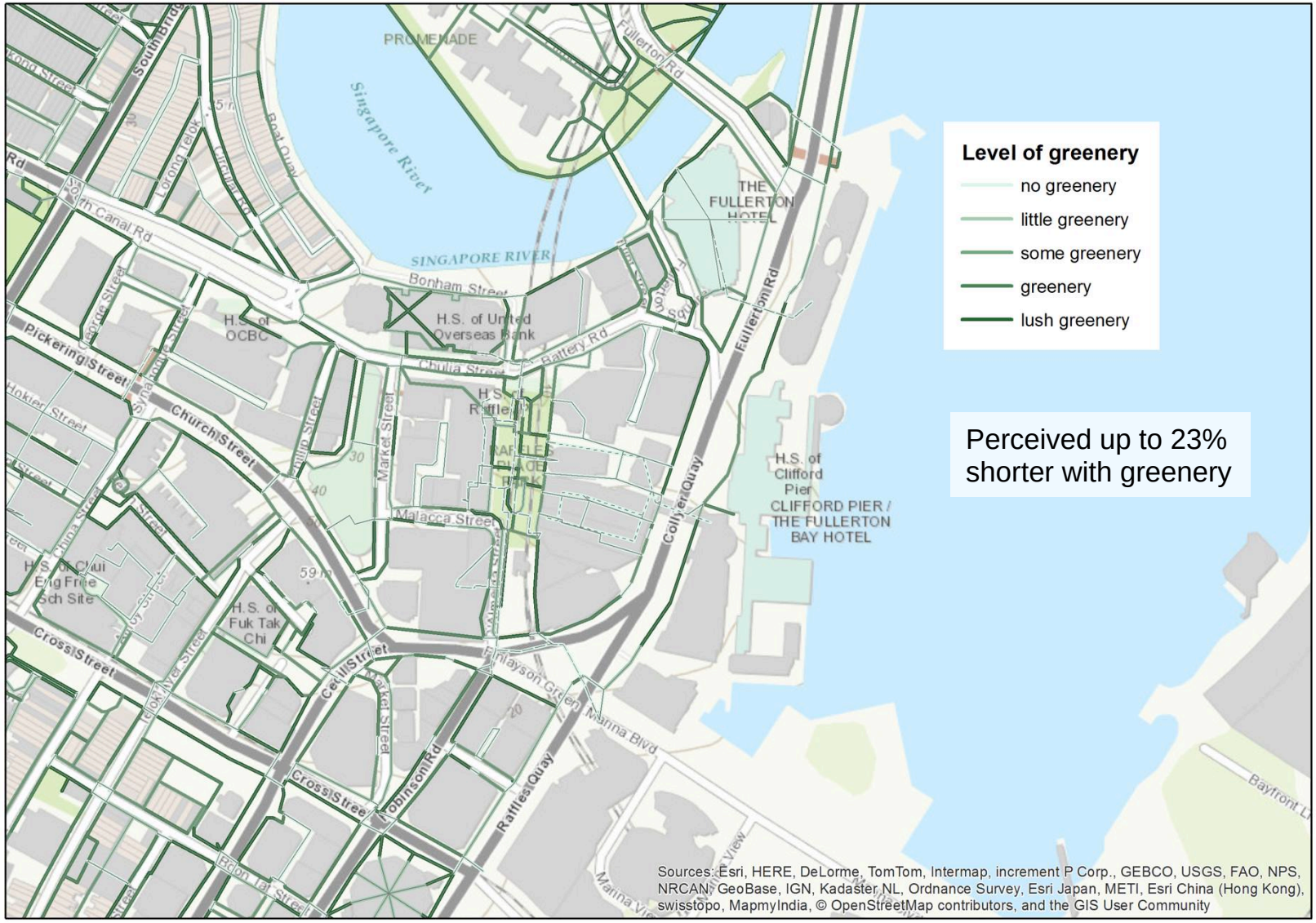
0 100 200 400 Meters

Raffles place: along minor road

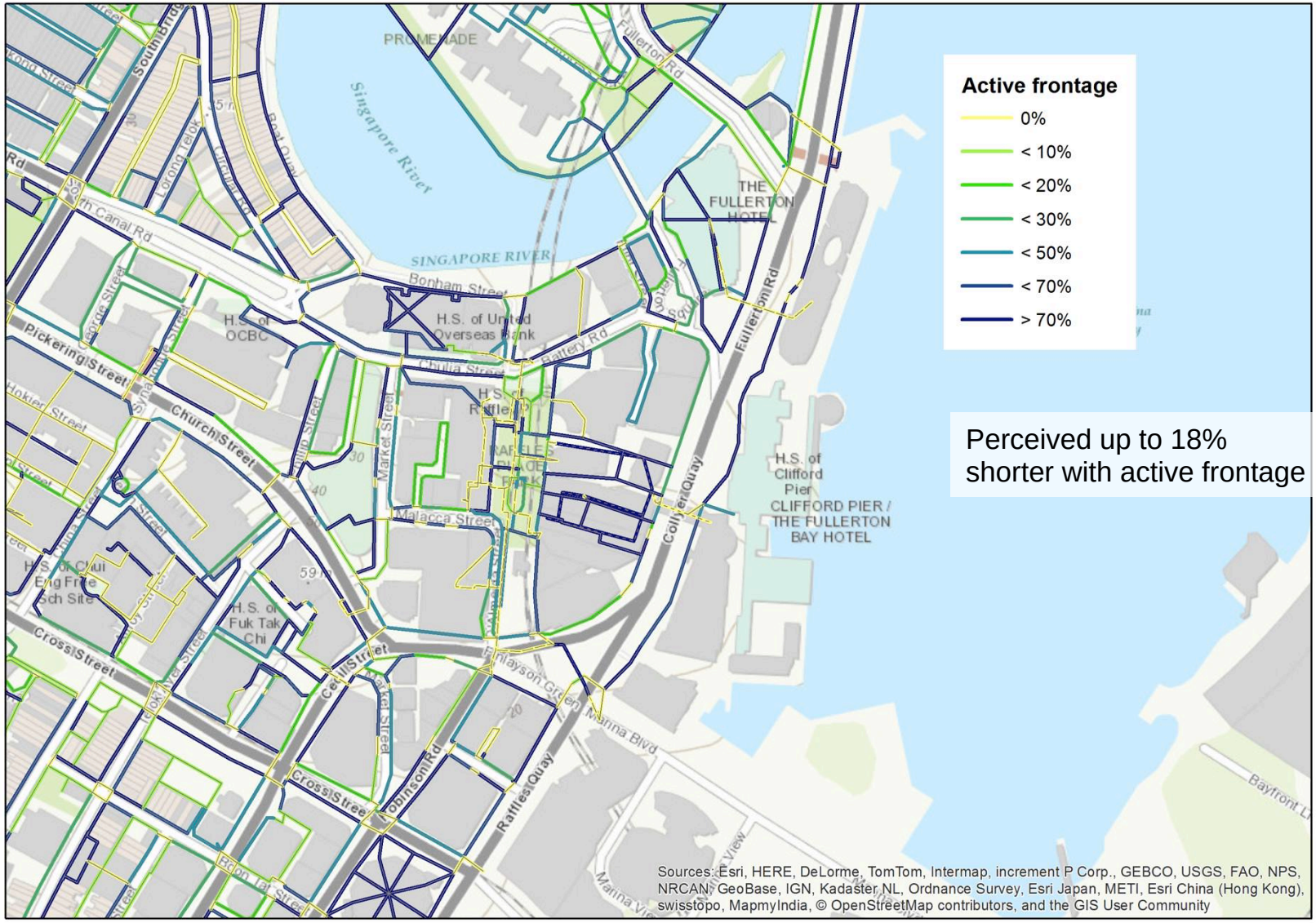


0 100 200 400 Meters

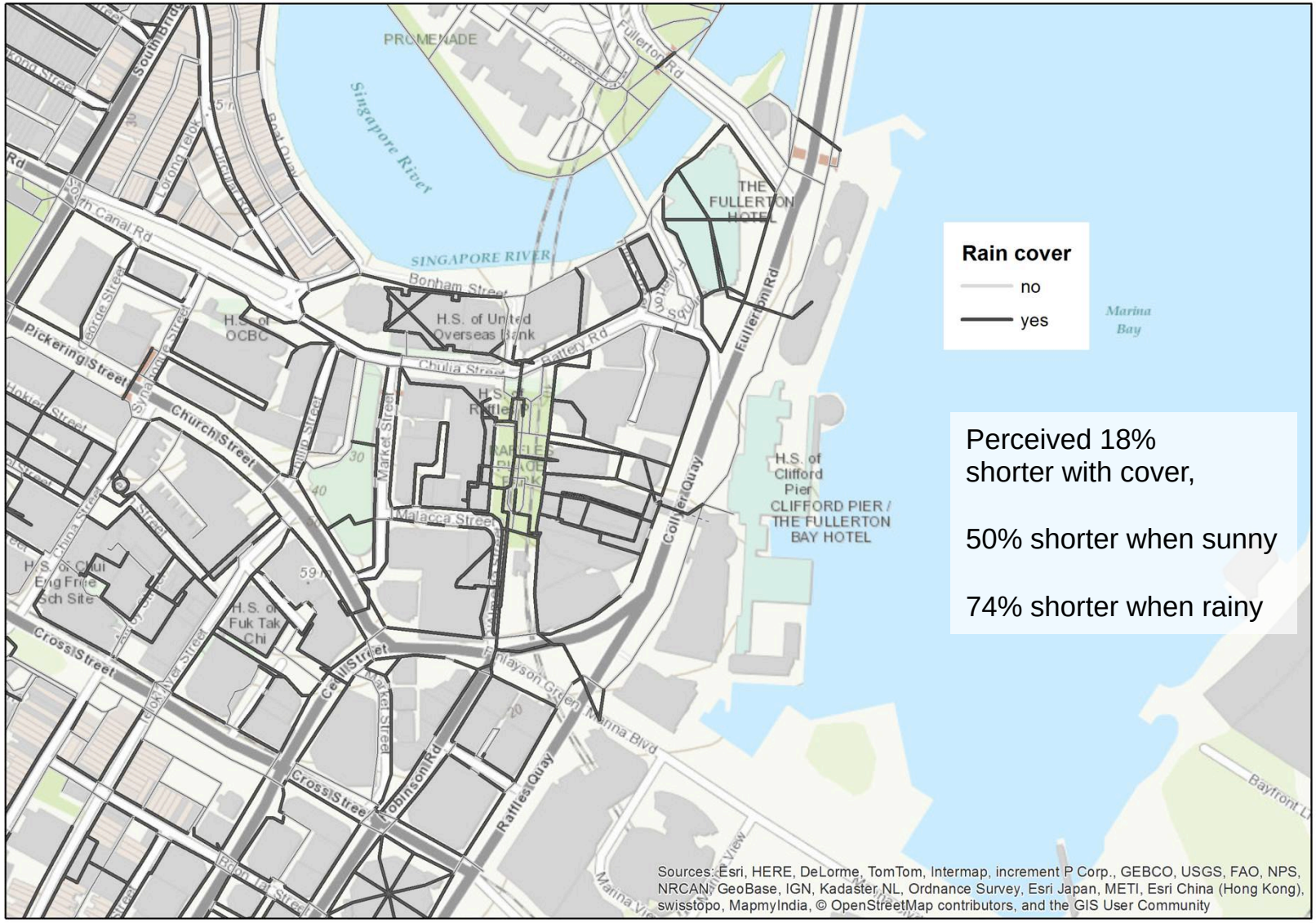
Raffles place: levels of greenery



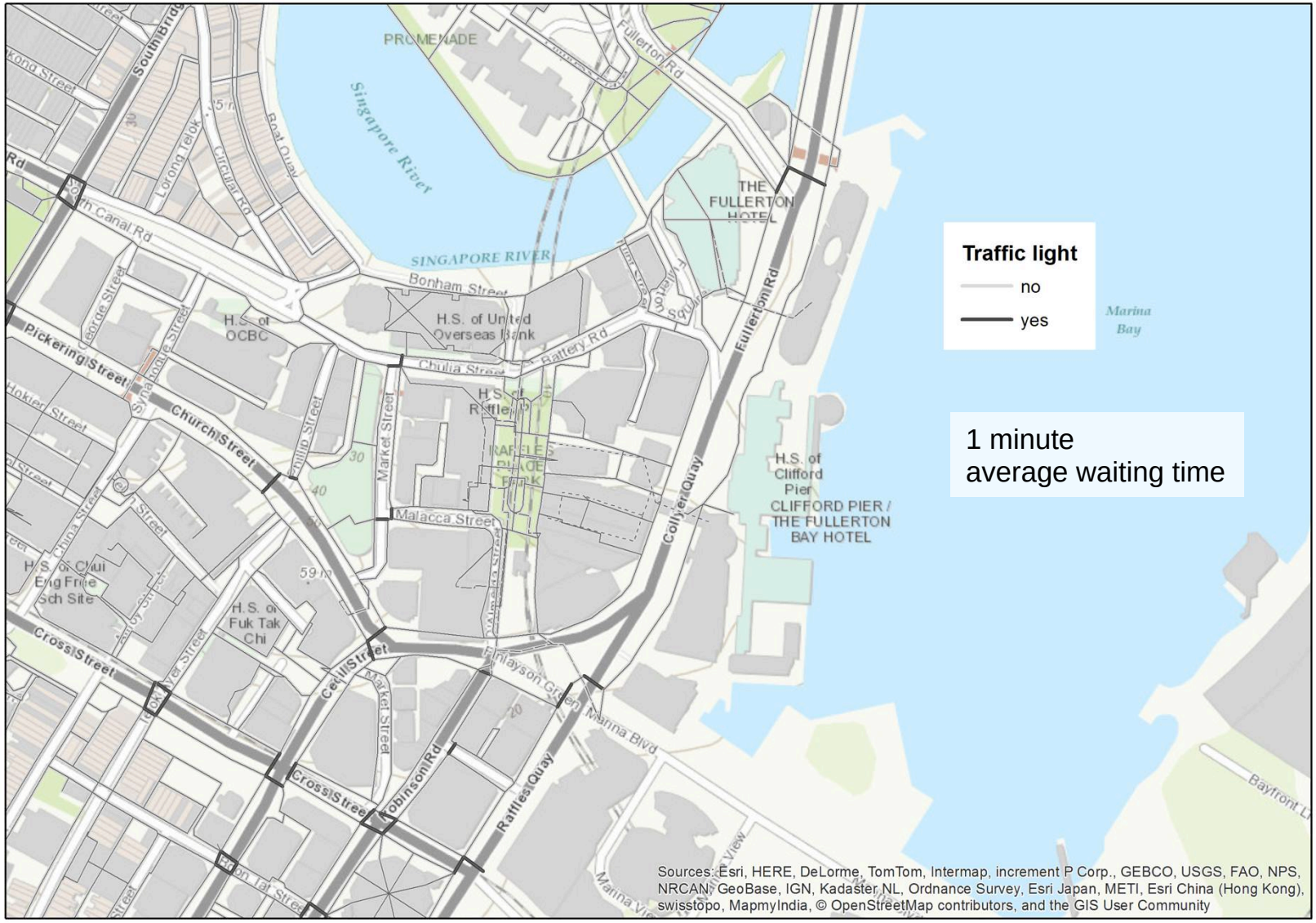
Raffles place: active frontage



Raffles place: covered walkway

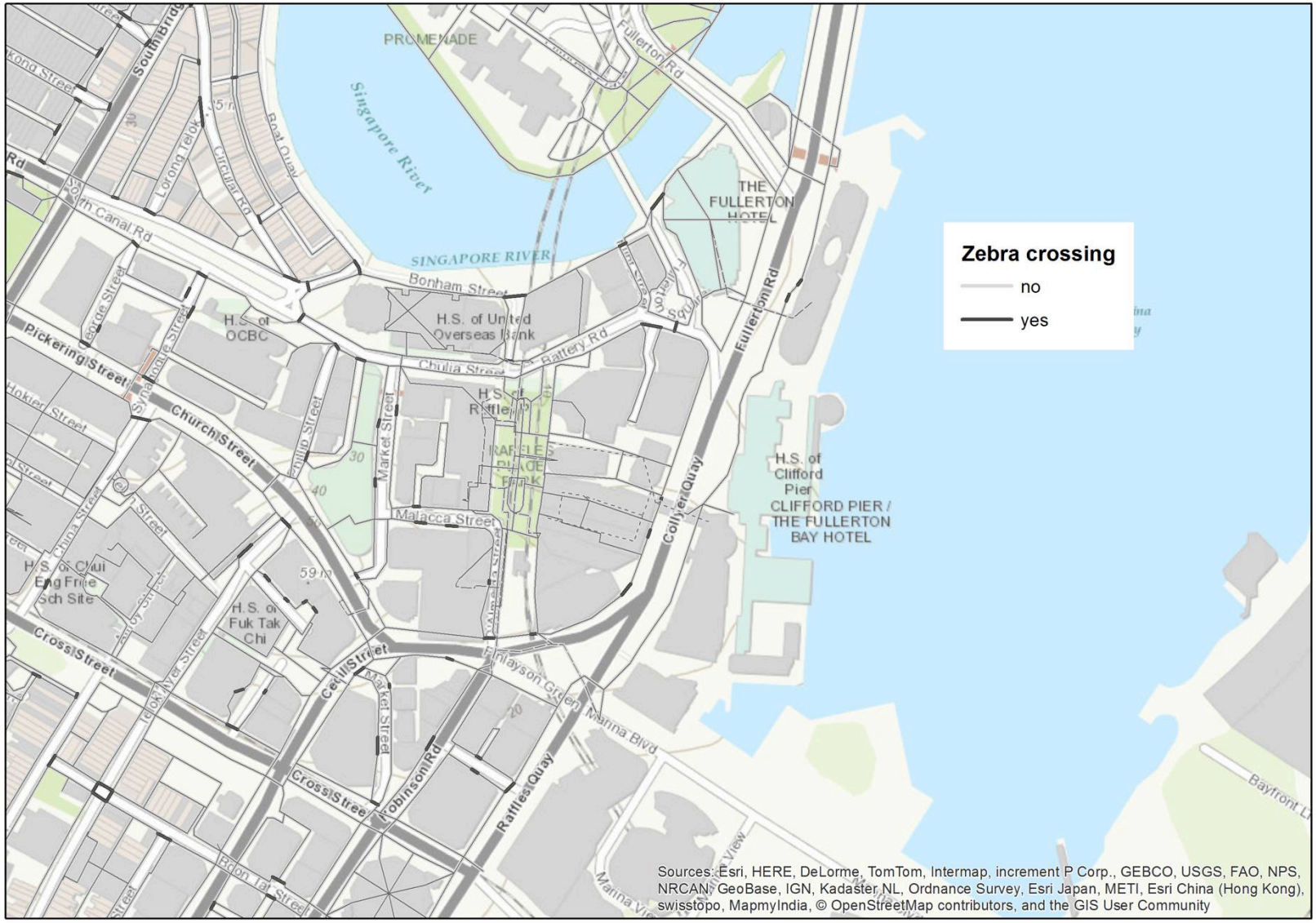


Raffles place: traffic light



0 100 200 400 Meters

Raffles place: minor crossings



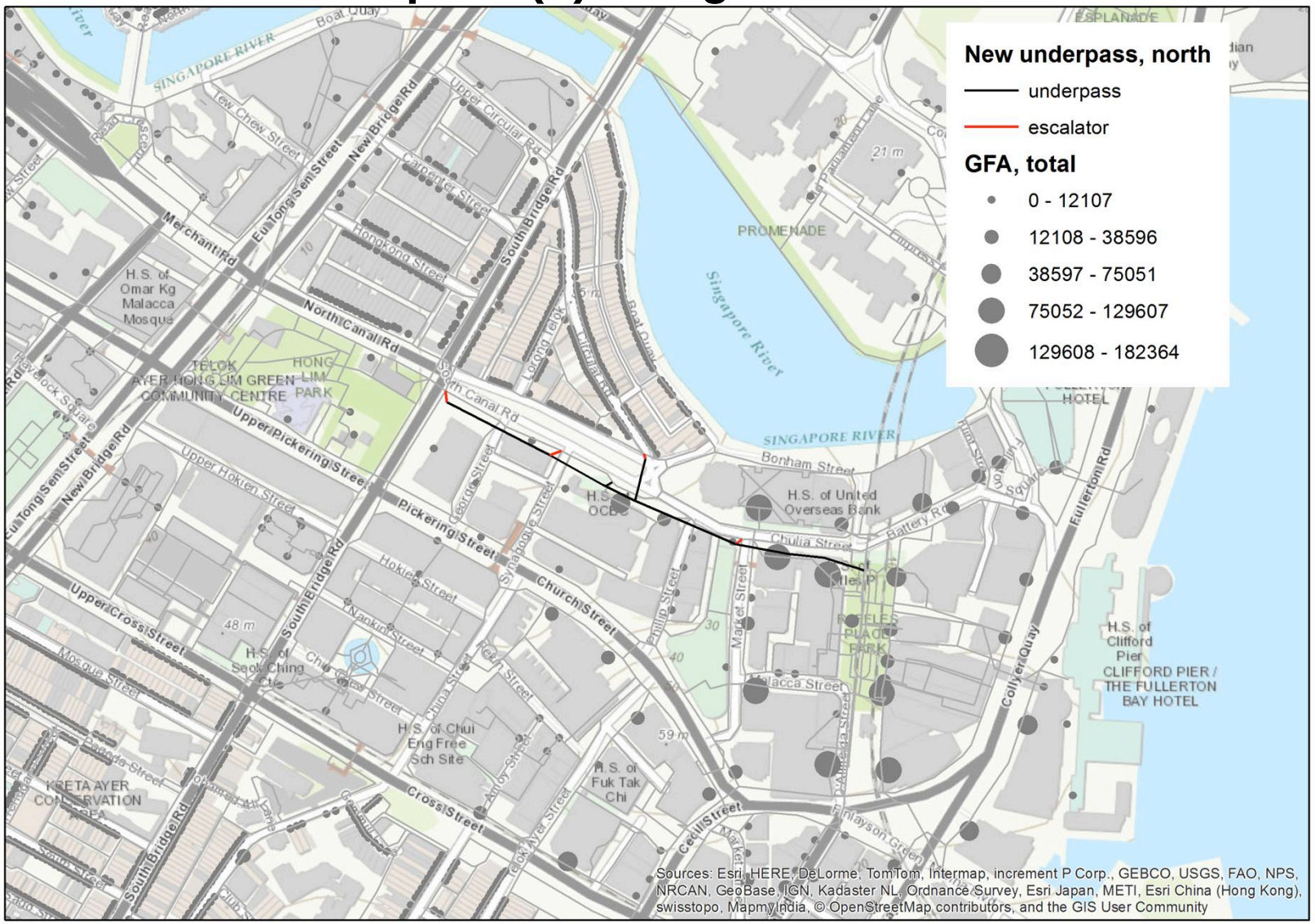
0 100 200 400 Meters

Appendix II - Case study Raffles Place

Extension of underground walkways

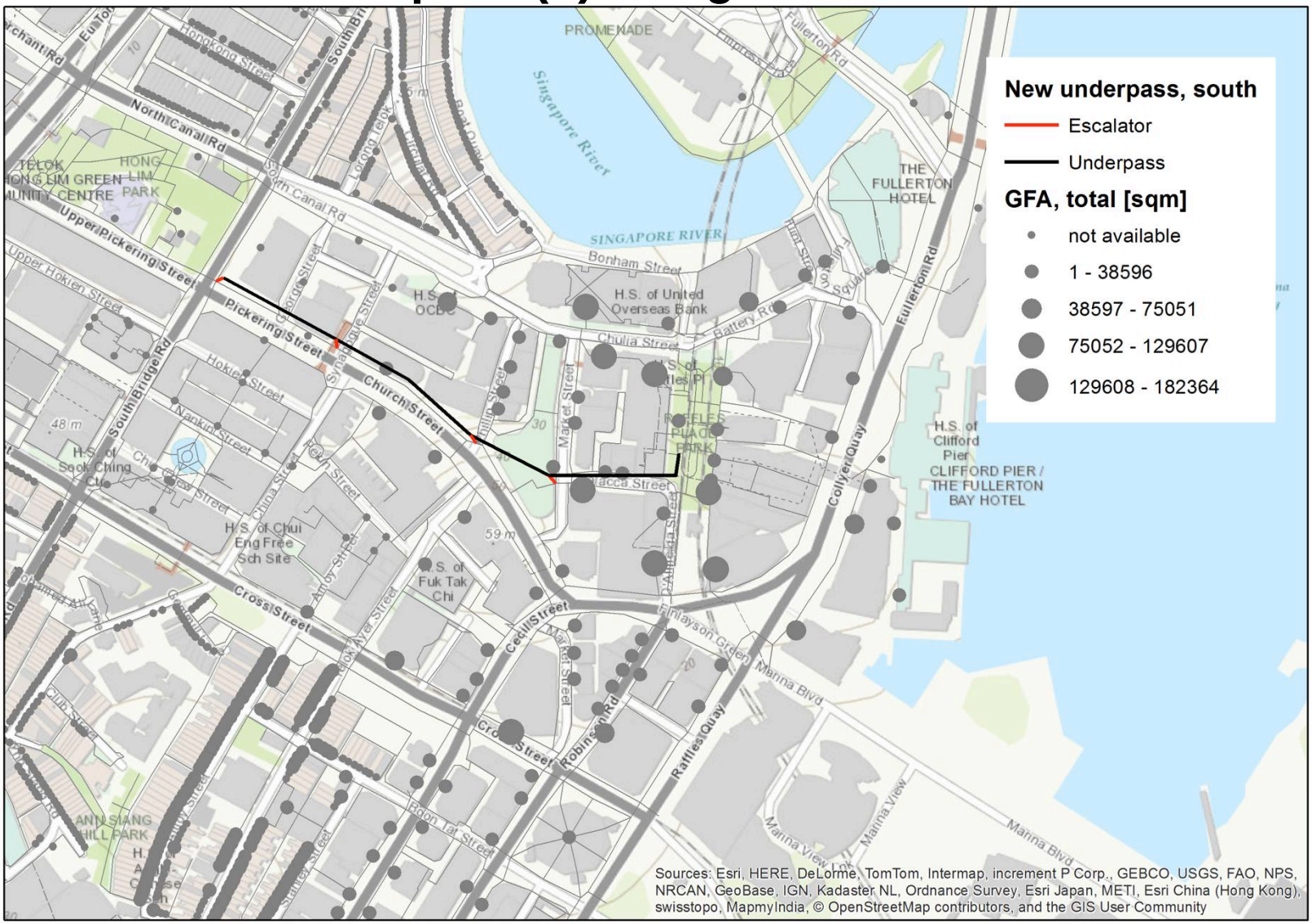
Along Chulia Street

Scenario 1: underpass (n) along Chulia Street



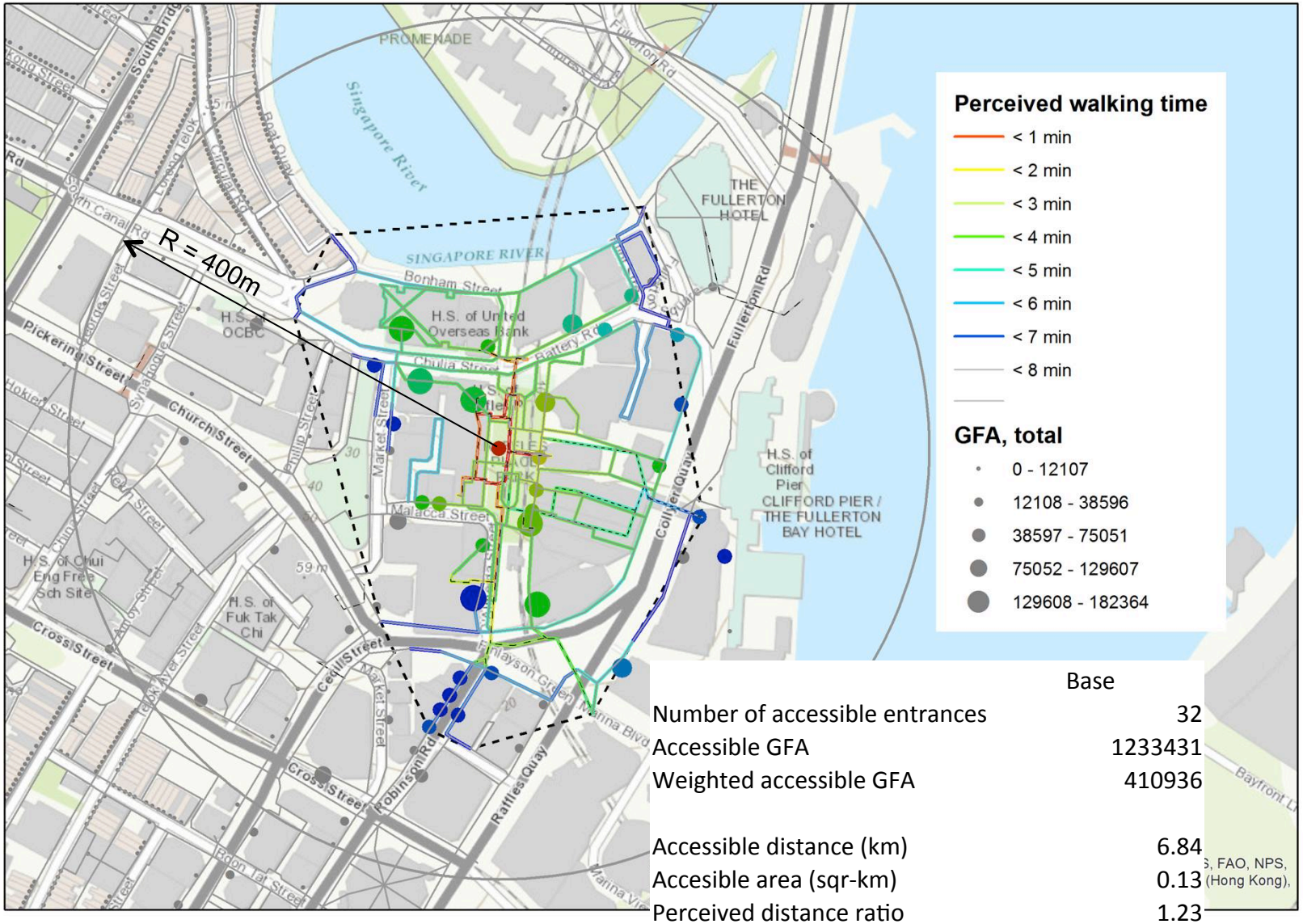
… or along Church Street?

Scenario 2: underpass (n) along Chruch Street



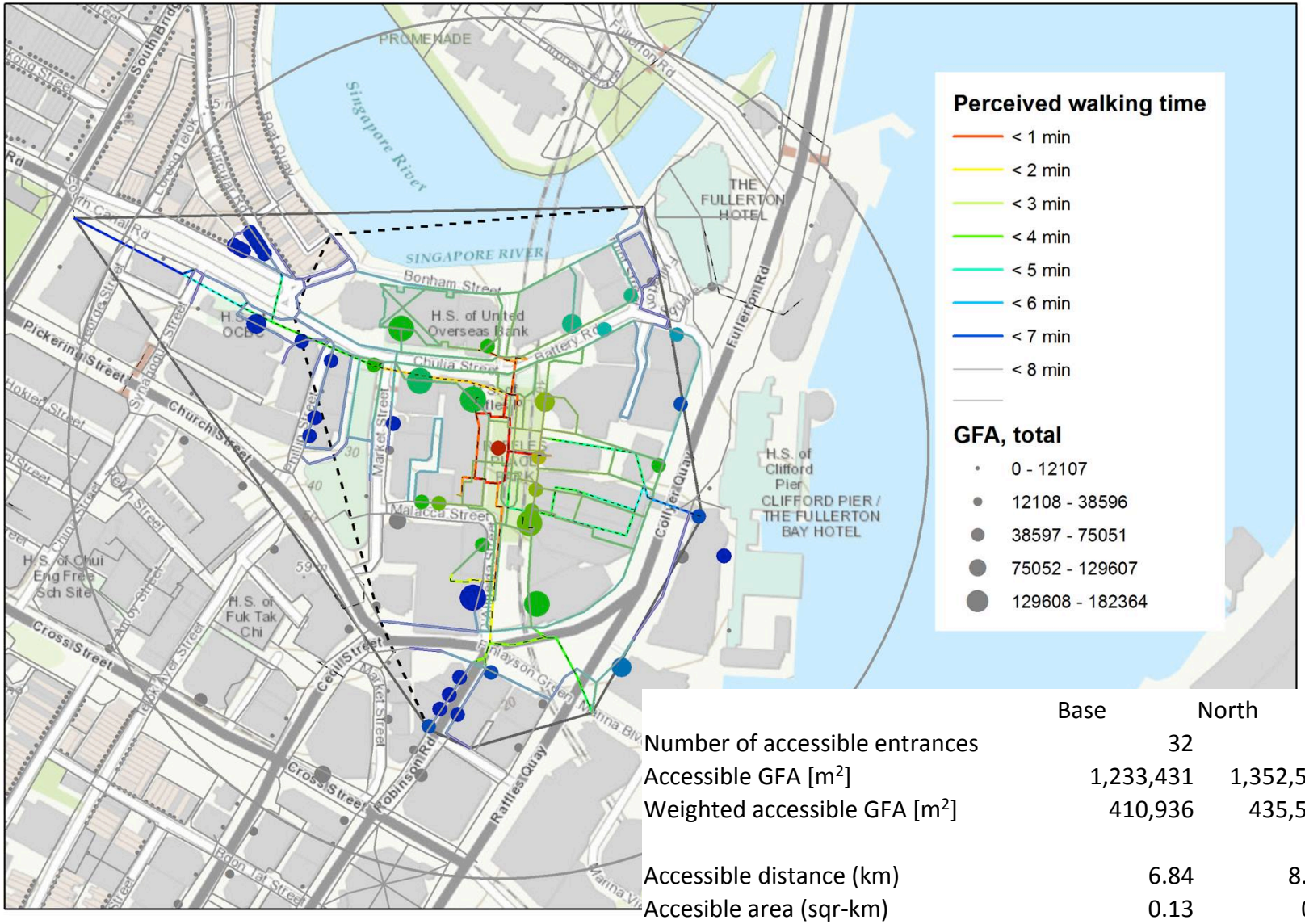
0 100 200 400 Meters

Base scenario: start at Raffles Place MRT



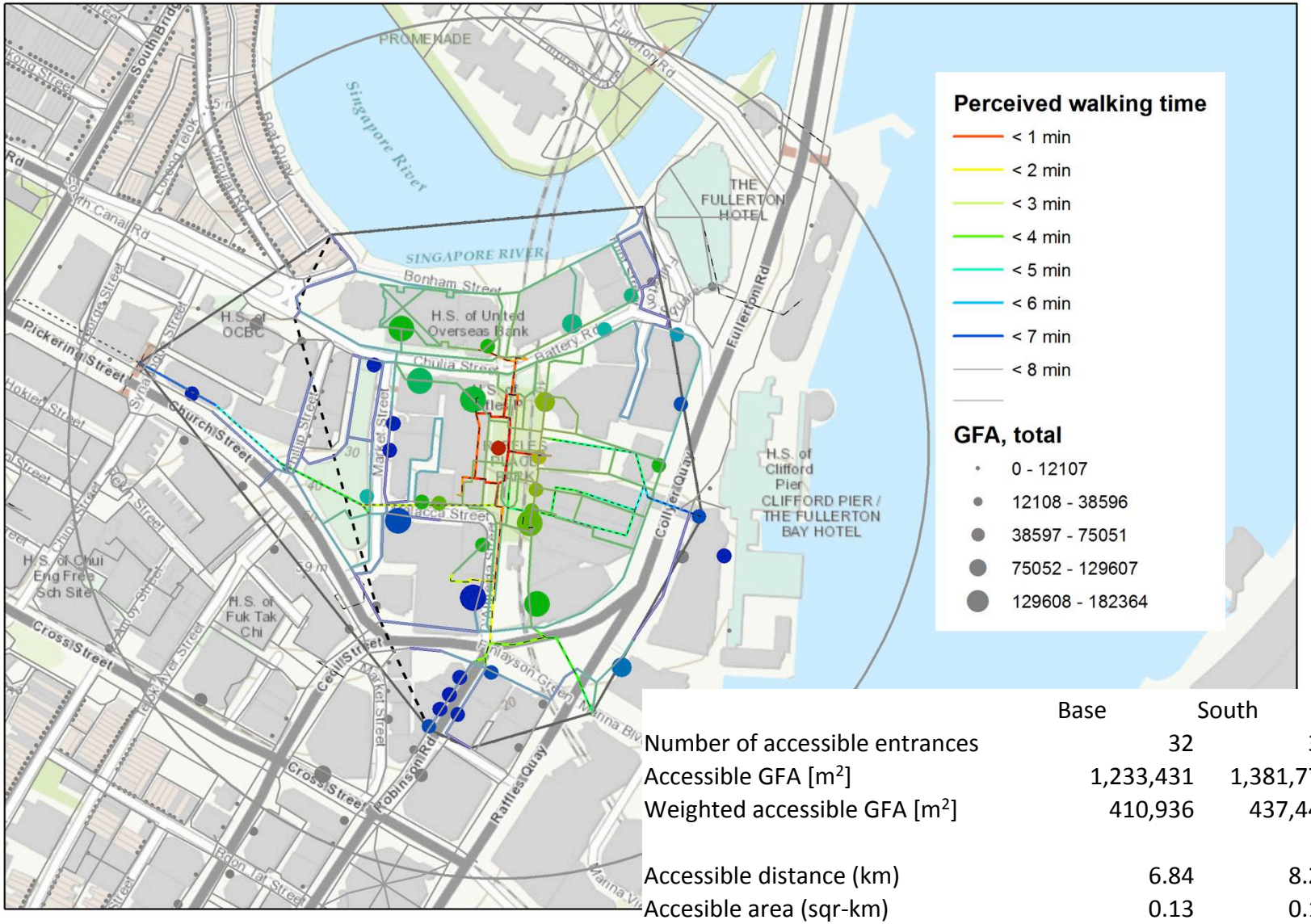
	Base
Number of accessible entrances	32
Accessible GFA	1233431
Weighted accessible GFA	410936
Accessible distance (km)	6.84
Accesible area (sqr-km)	0.13
Perceived distance ratio	1.23
Links walkshed ratio	0.27

Scenerio 1: from Raffles Place MRT



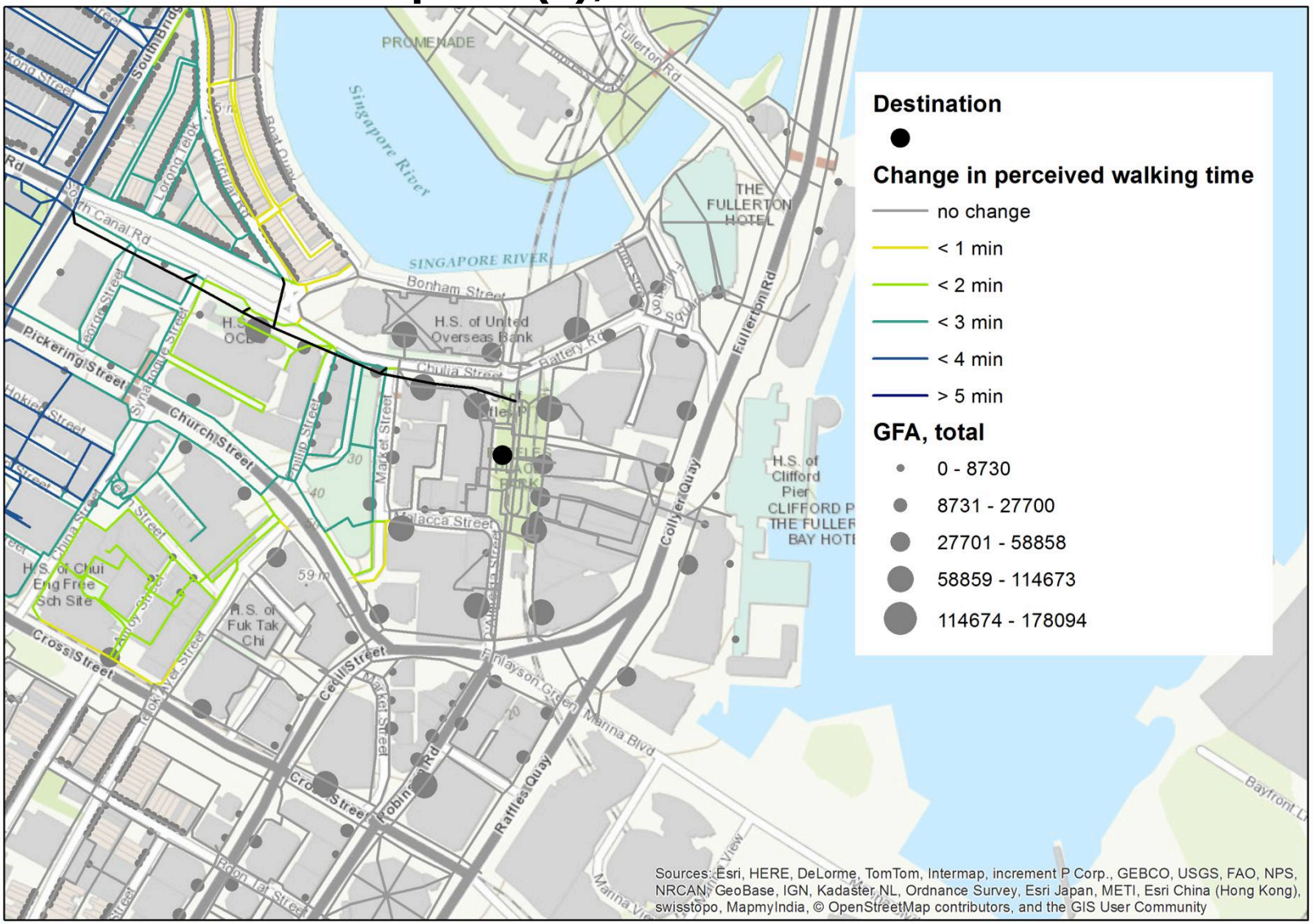
	Base	North
Number of accessible entrances	32	70
Accessible GFA [m^2]	1,233,431	1,352,554
Weighted accessible GFA [m^2]	410,936	435,520
Accessible distance (km)	6.84	8.76
Accesible area (sqr-km)	0.13	0.2
Perceived distance ratio	1.23	1.23
Links walkshed ratio	0.27	0.41

Scenario 2: from Raffles Place MRT

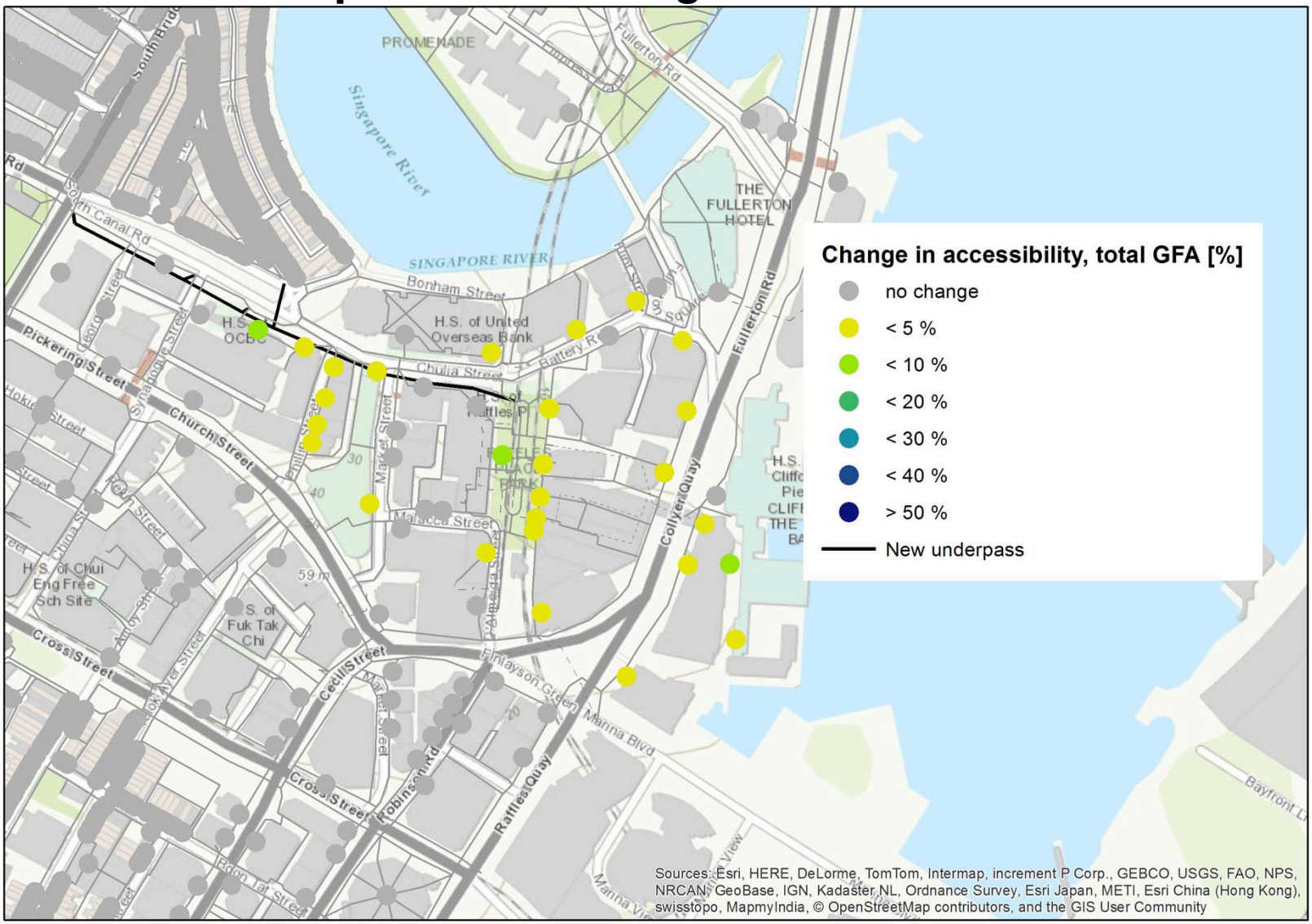


	Base	South
Number of accessible entrances	32	36
Accessible GFA [m^2]	1,233,431	1,381,773
Weighted accessible GFA [m^2]	410,936	437,442
Accessible distance (km)	6.84	8.24
Accesible area (sqr-km)	0.13	0.17
Perceived distance ratio	1.23	1.25
Links walkshed ratio	0.27	0.34

Scenario 1: underpass (s), from Raffles Place MRT

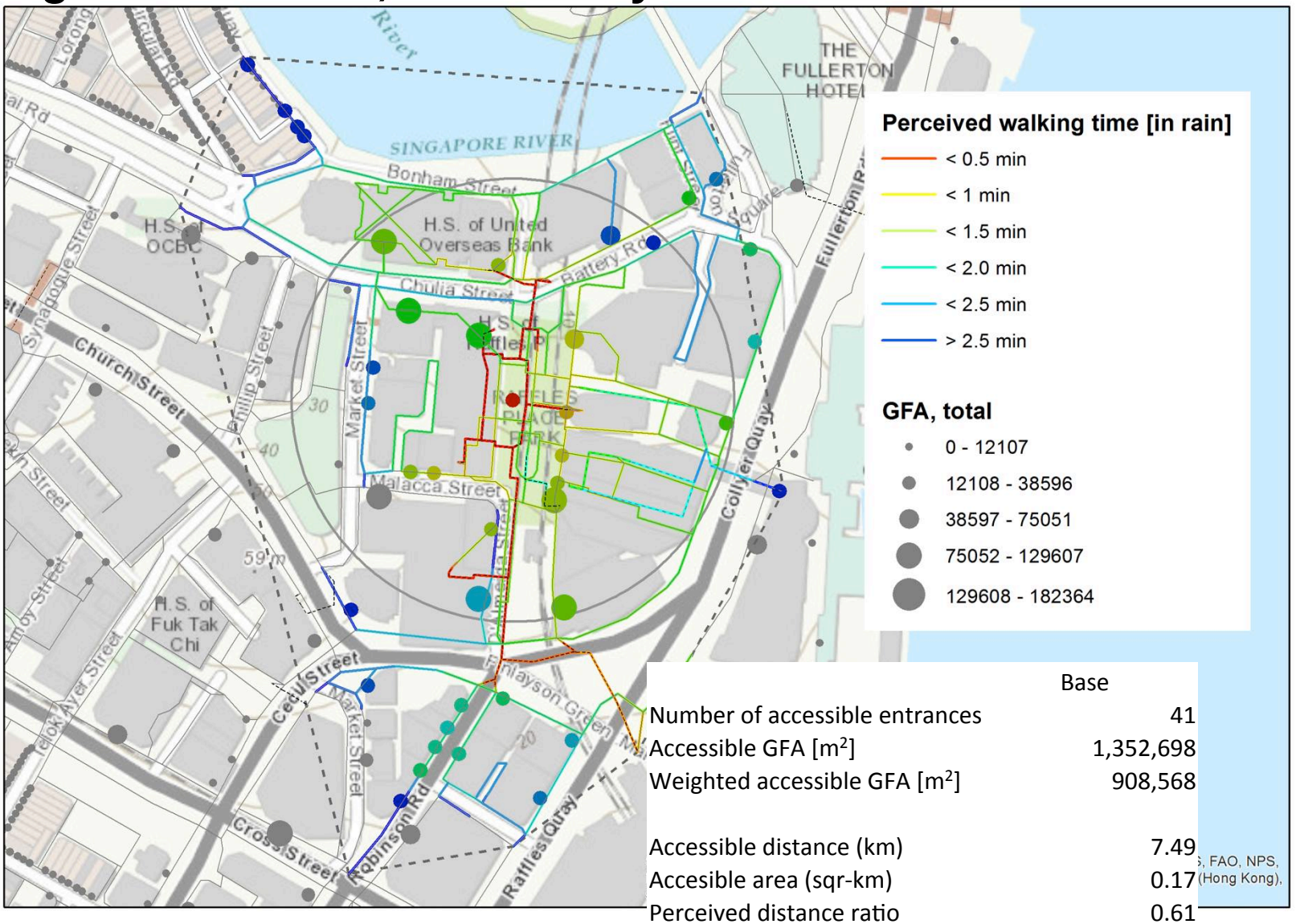


Scenario 1: impact on building level



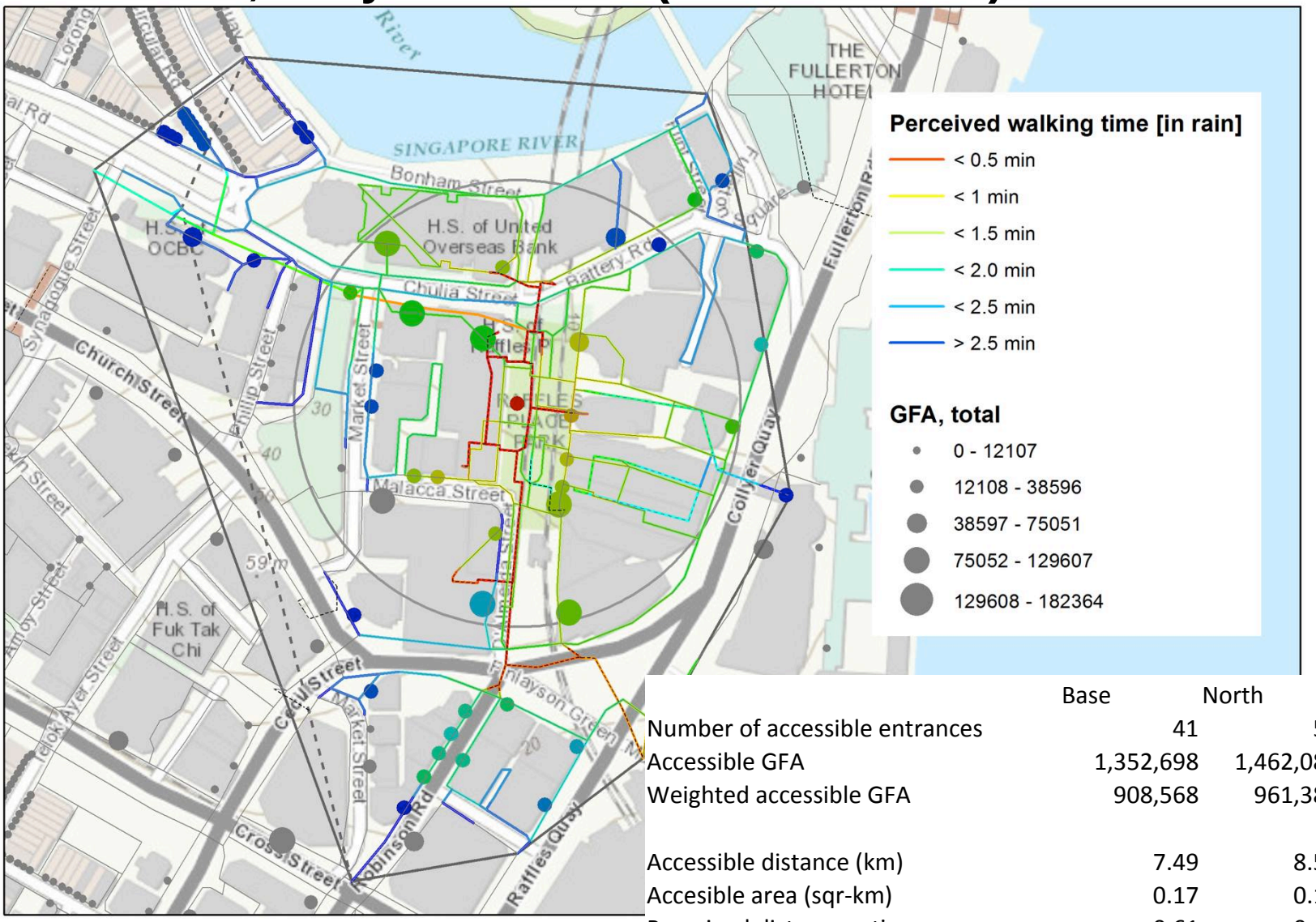
0 100 200 400 Meters

Again base case, but in rainy conditions -> 150m radius



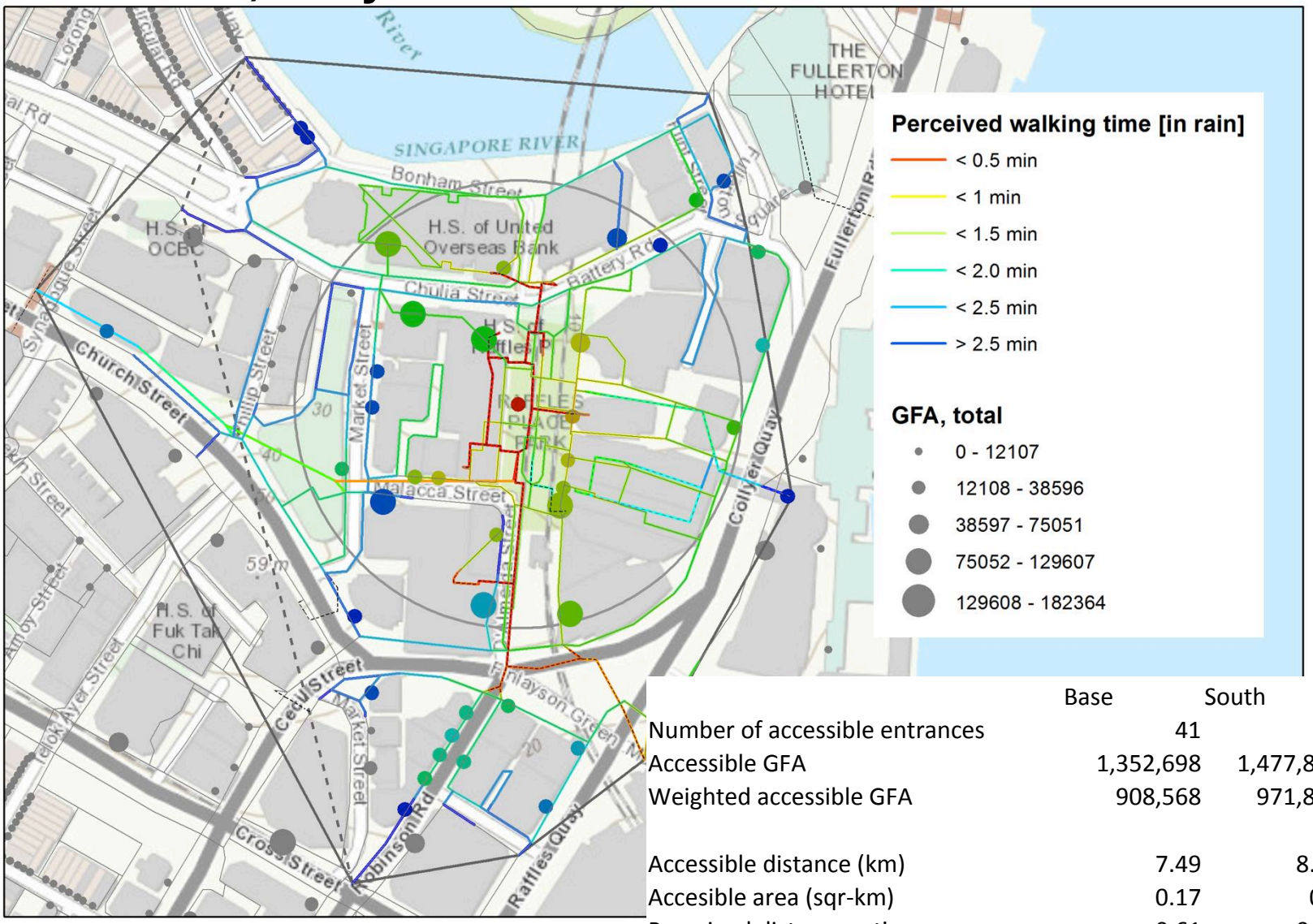
	Base
Number of accessible entrances	41
Accessible GFA [m²]	1,352,698
Weighted accessible GFA [m²]	908,568
Accessible distance (km)	7.49
Accesible area (sqr-km)	0.17
Perceived distance ratio	0.61
Links walkshed ratio	2.32

Scenario 1, rainy conditions (radius = 150m)



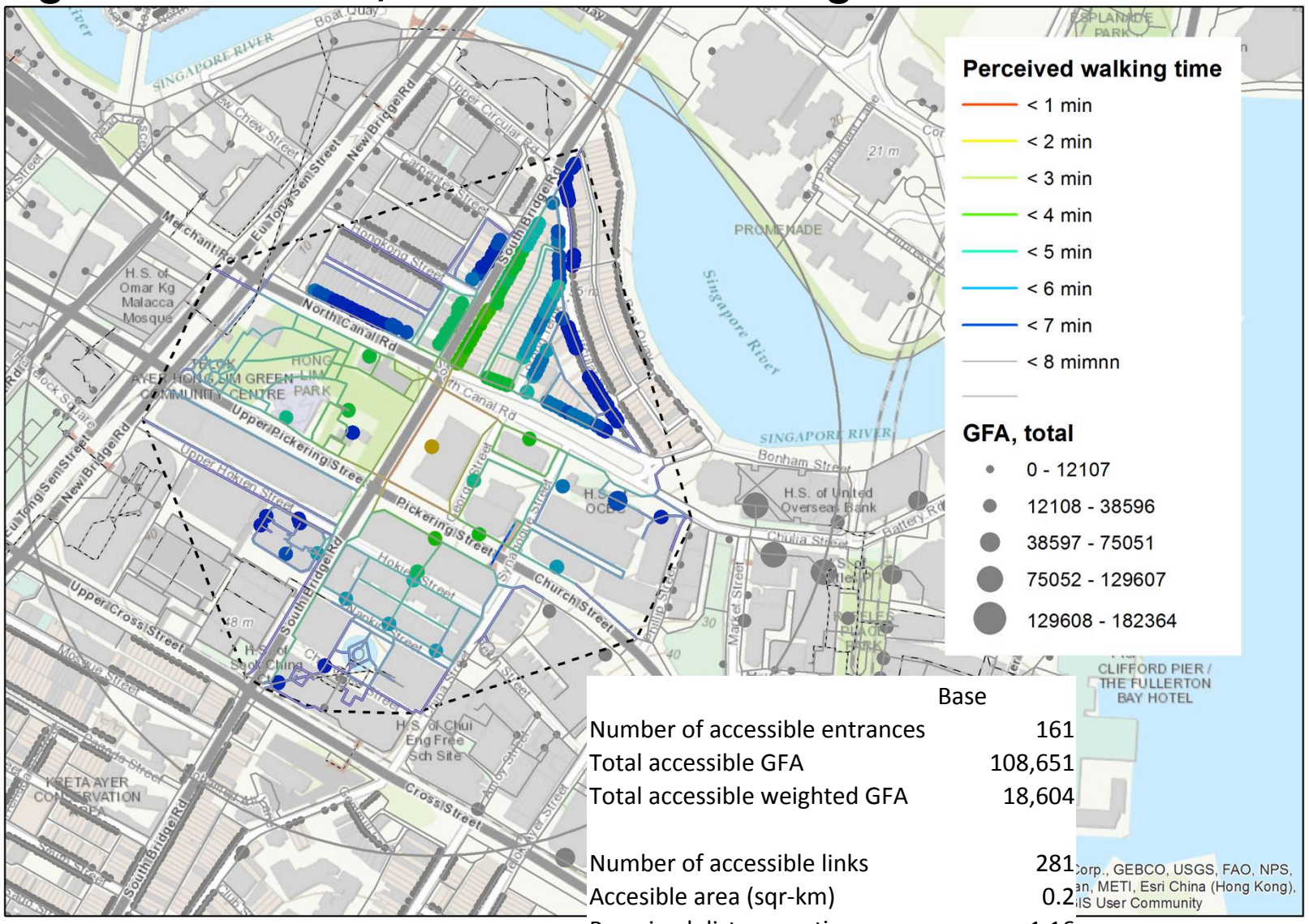
	Base	North
Number of accessible entrances	41	51
Accessible GFA	1,352,698	1,462,089
Weighted accessible GFA	908,568	961,389
Accessible distance (km)	7.49	8.53
Accesible area (sqr-km)	0.17	0.19
Perceived distance ratio	0.61	0.61
Links walkshed ratio	2.32	2.54

Scenario 2, rainy conditions



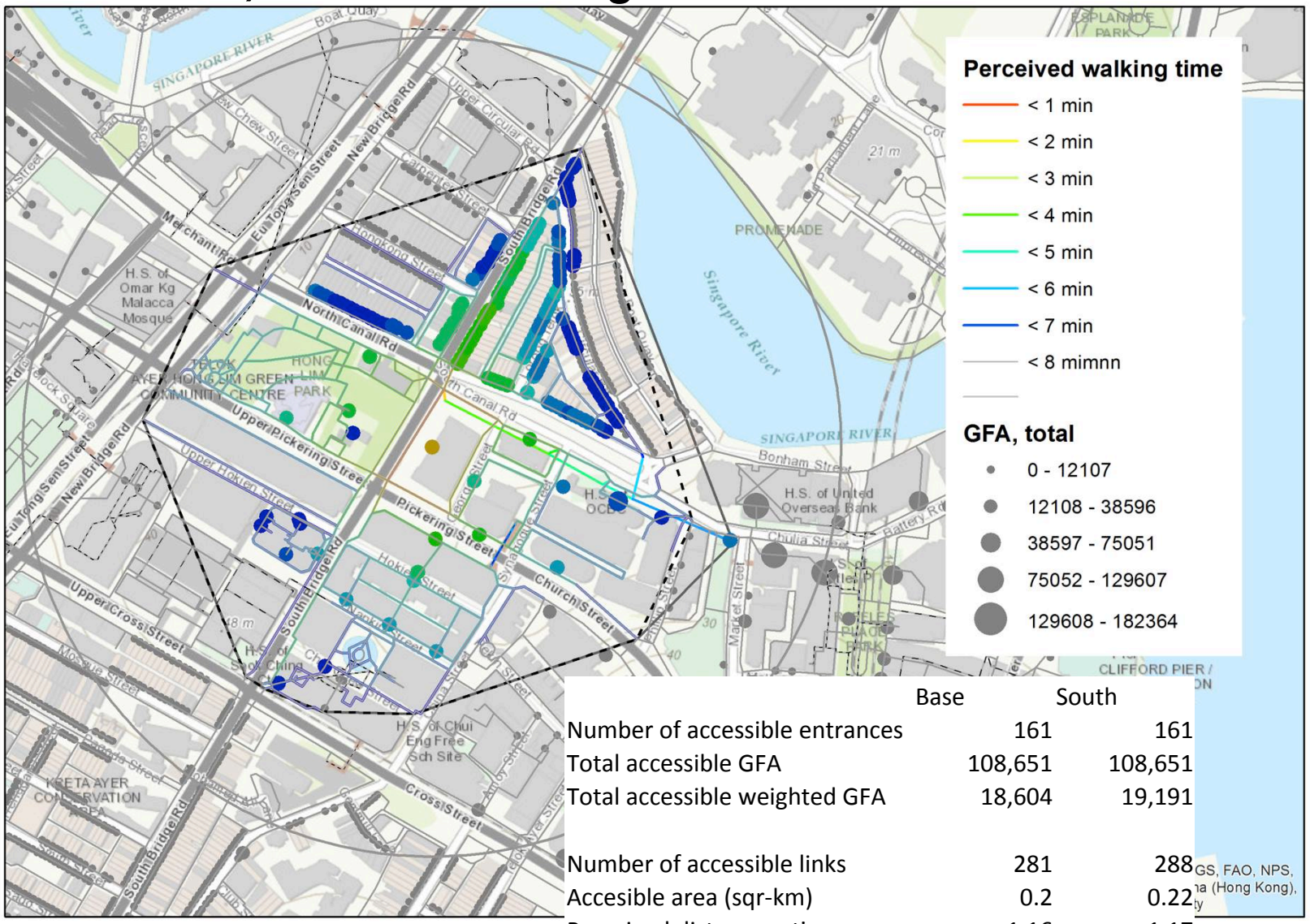
	Base	South
Number of accessible entrances	41	42
Accessible GFA	1,352,698	1,477,887
Weighted accessible GFA	908,568	971,856
Accessible distance (km)	7.49	8.78
Accesible area (sqr-km)	0.17	0.2
Perceived distance ratio	0.61	0.61
Links walkshed ratio	2.32	2.73

Again base case, but from One George Street



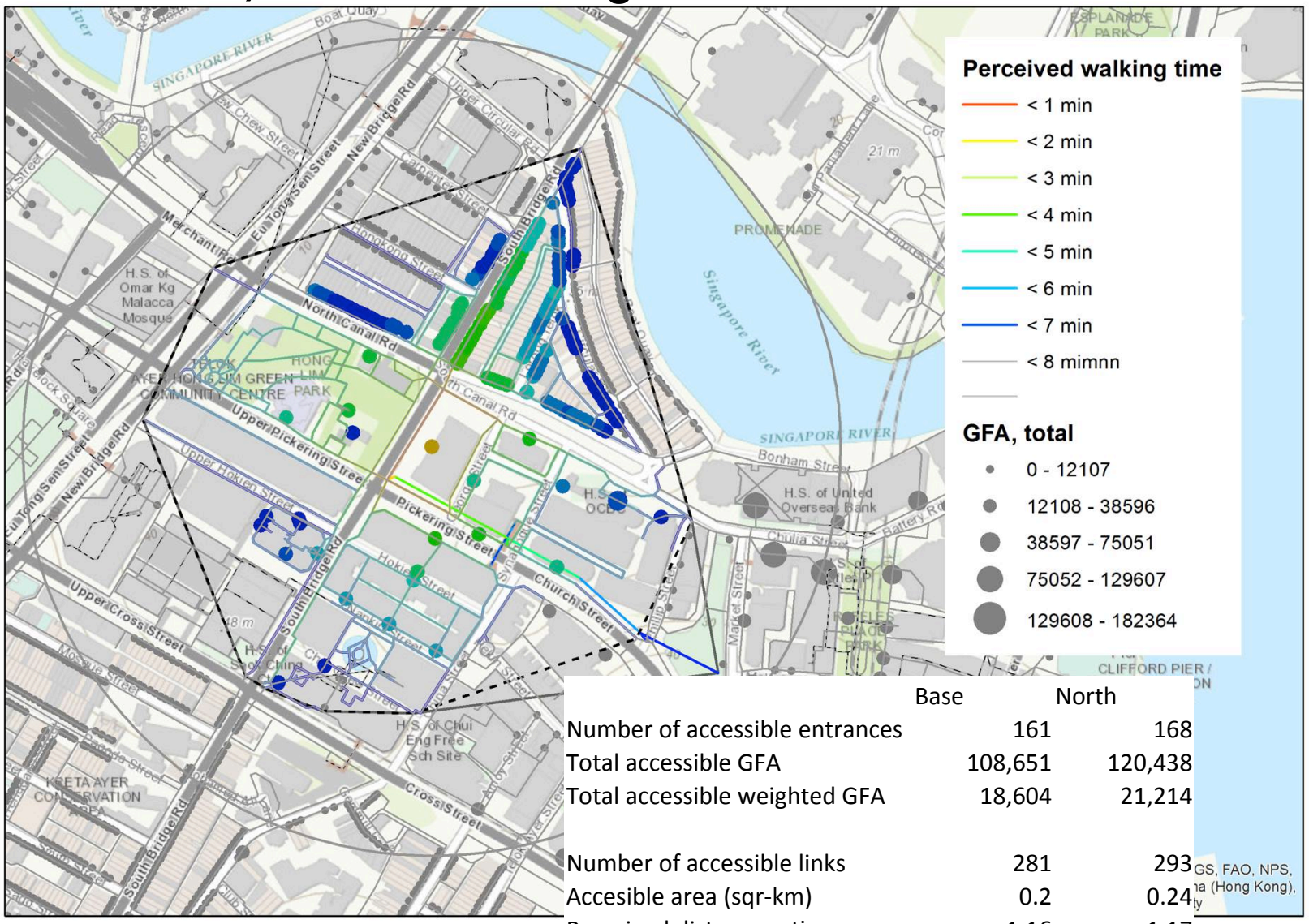
	Base
Number of accessible entrances	161
Total accessible GFA	108,651
Total accessible weighted GFA	18,604
Number of accessible links	281
Accesible area (sqr-km)	0.2
Perceived distance ratio	1.16
Links walkshed ratio	0.41

Scenario 1, from One George Street



	Base	South
Number of accessible entrances	161	161
Total accessible GFA	108,651	108,651
Total accessible weighted GFA	18,604	19,191
Number of accessible links	281	288
Accesible area (sqr-km)	0.2	0.22
Perceived distance ratio	1.16	1.17
Links walkshed ratio	0.41	0.44

Scenario 2, from One George Street



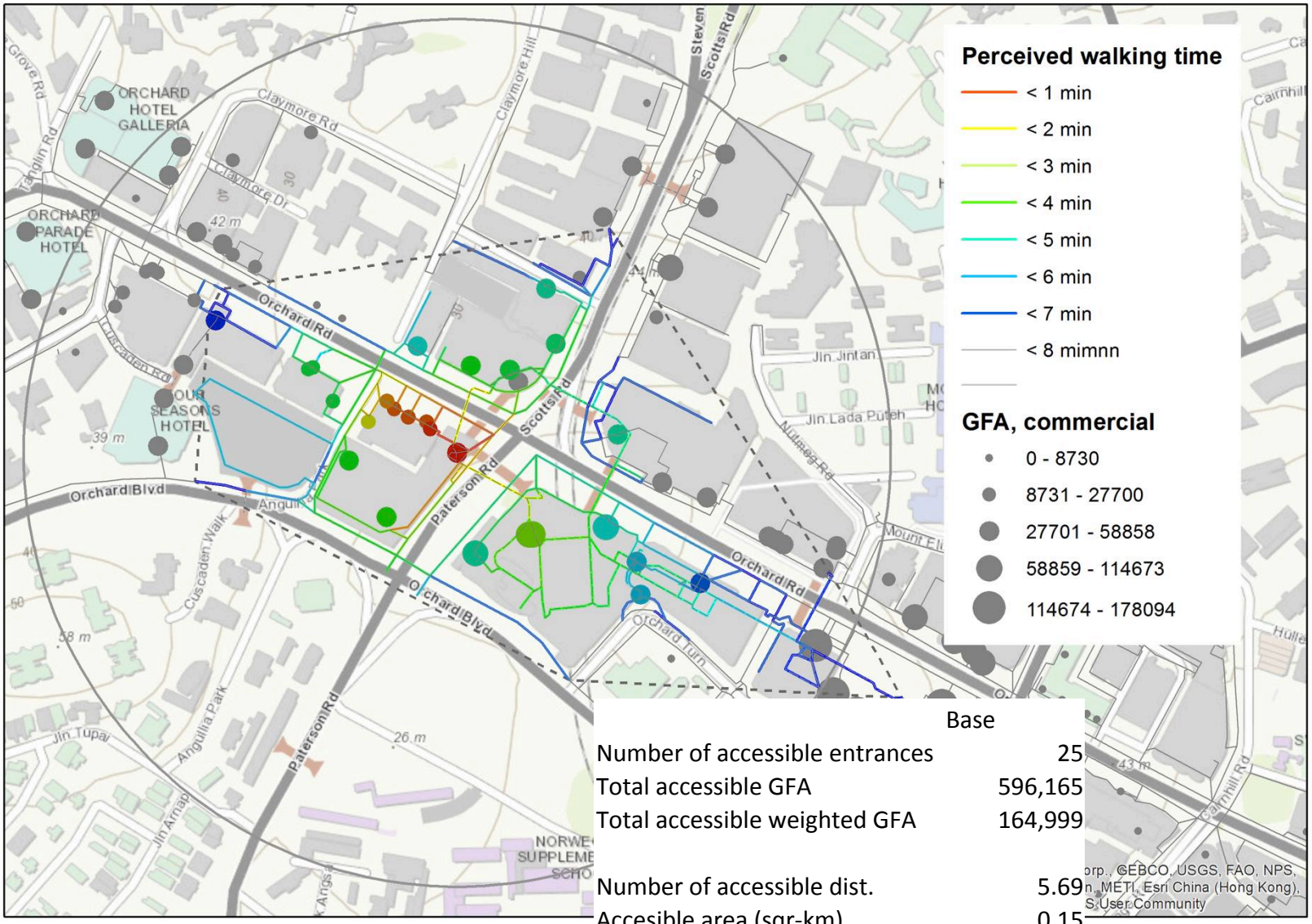
	Base	North
Number of accessible entrances	161	168
Total accessible GFA	108,651	120,438
Total accessible weighted GFA	18,604	21,214
Number of accessible links	281	293
Accesible area (sqr-km)	0.2	0.24
Perceived distance ratio	1.16	1.17
Links walkshed ratio	0.41	0.49

Appendix III - Case study: Patterson Road

(Re-)Introducing zebra crossing between ION Orchard and Wheelock Plaza

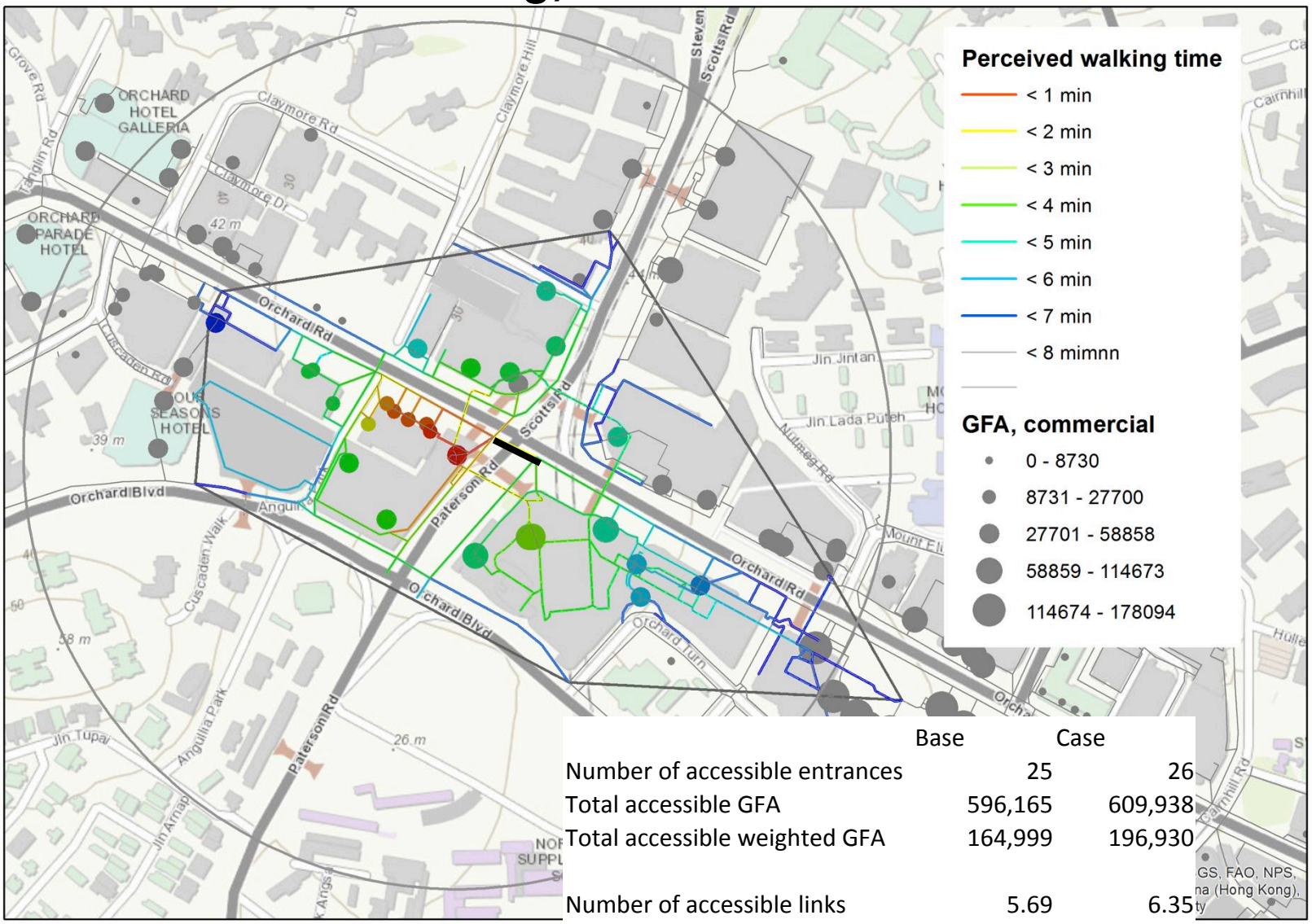
Base scenario, from Wheelock Plaza

Base scenario, from Wheelock Plaza



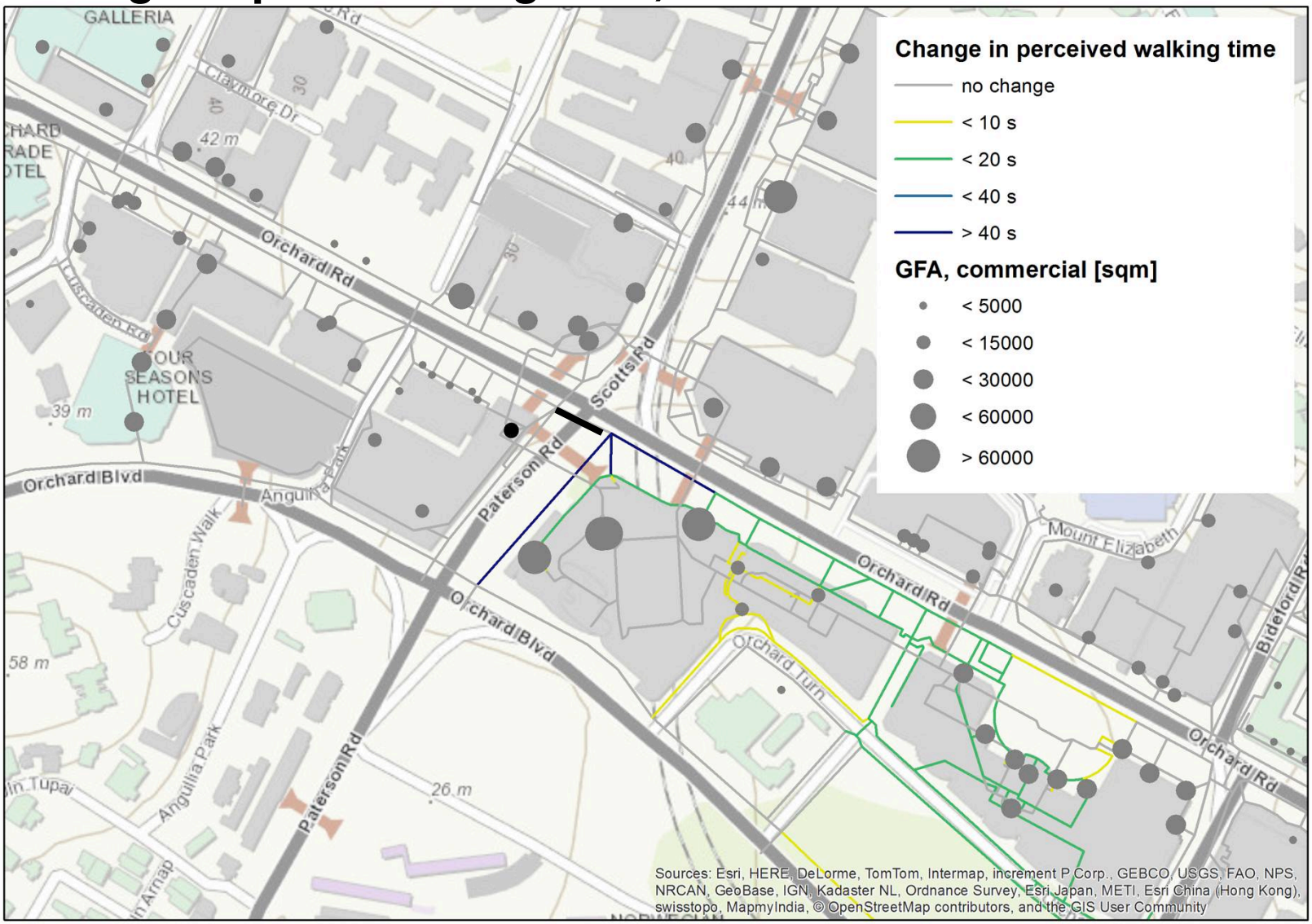
	Base
Number of accessible entrances	25
Total accessible GFA	596,165
Total accessible weighted GFA	164,999
Number of accessible dist.	5.69
Accesible area (sqr-km)	0.15
Perceived distance ratio	1.25
Links walkshed ratio	0.29

New Patterson crossing, from Wheelock Plaza



	Base	Case
Number of accessible entrances	25	26
Total accessible GFA	596,165	609,938
Total accessible weighted GFA	164,999	196,930
Number of accessible links	5.69	6.35
Accesible area (sqr-km)	0.15	0.15
Perceived distance ratio	1.25	1.24
Links walkshed ratio	0.29	0.31

Change in perc walking time, from Wheelock Plaza



0 100 200 400 Meters

New Patterson crossing: impact on building level