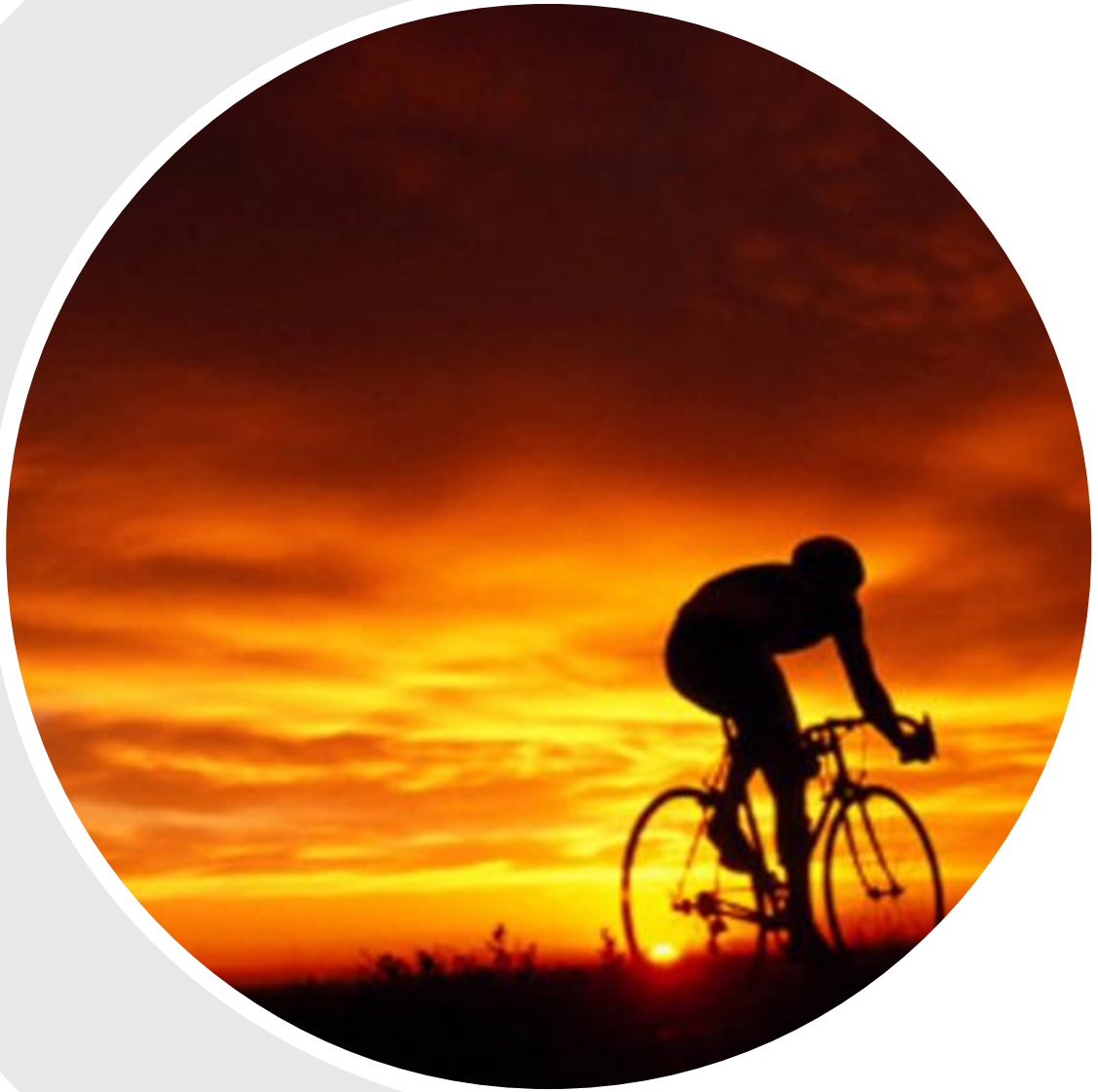


BIKEABILITY
IN THE WEST REGION OF SINGAPORE

GROUP 4: KOHEI YAMAMOTO
TRAN THI MINH PHUONG
WEN JIAZHE
ZHAO MUSHU

OUTLINE

1. Introduction
2. Methodology
3. Results
4. Discussion

INTRODUCTION

Active travel

- Mitigation measure for traffic congestion, air and noise pollution[1].
- Providing health and financial benefits [2].

Built environment

Clear influence on travel behaviour and active travel [3].

"Walkability"

Many studies have focused on walkability: aesthetic attributions of the street corridors, urban greenery and physical features that influence human spatial conception → mainly at street level [4,5,6]

Cycling in Singapore

- Cycling has been highly promoted in Singapore.
- It is necessary to evaluate and visualize the current cycling condition.

"Bikeability"

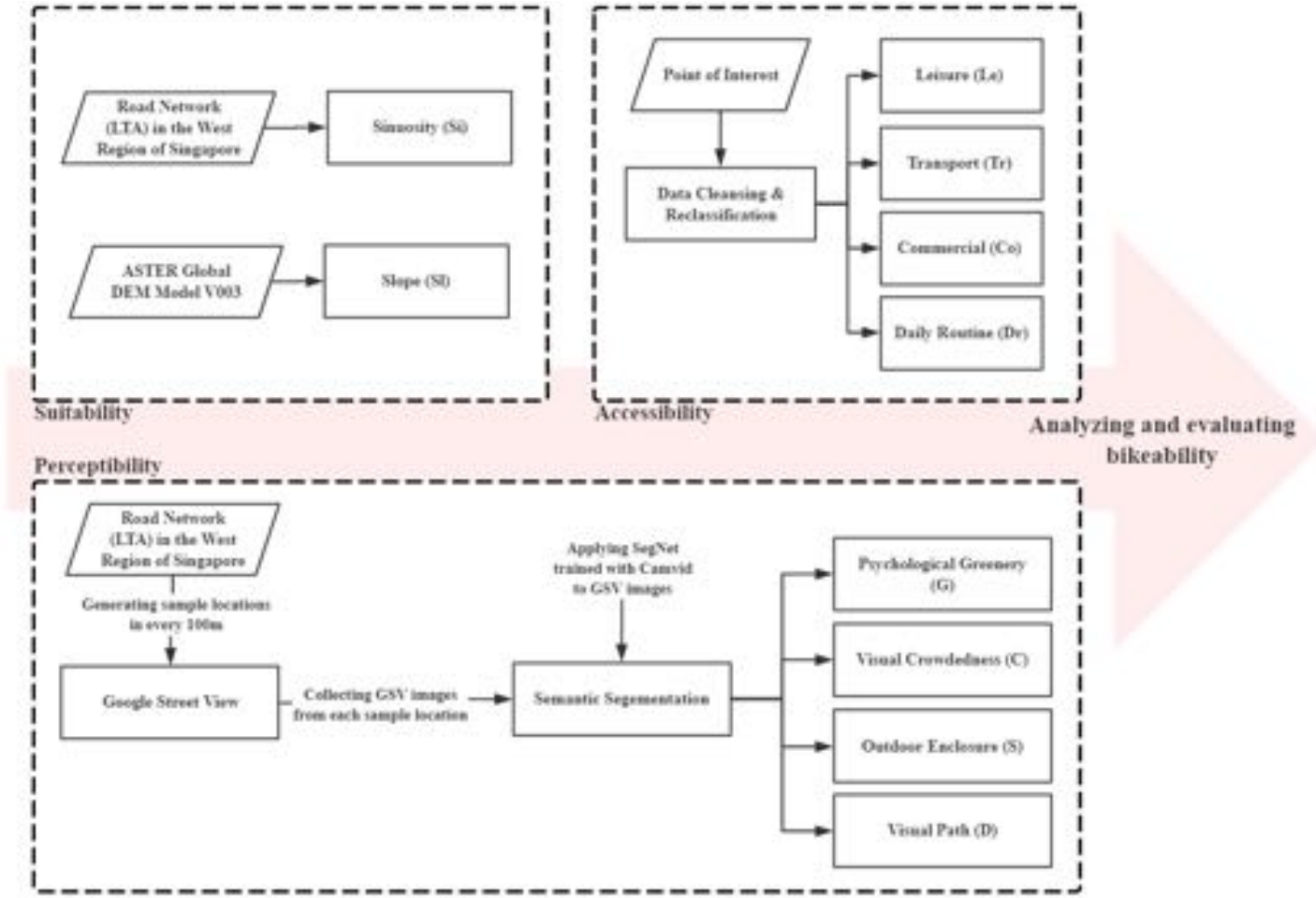
- Few studies has been done to define and map "bikeability" [7].
- Used different criteria, indices and may not suitable for Singapore [8].

Sources: 1. Fraser and Lock, 2011; 2. De Hartog et al., 2010; 3. Handy et al., 2002; 4. Gebel et al., 2011; 5. Van Dyck et al., 2011; 6. Kim et al., 2014; Zhou et al., 2019; 7. Vale et al., 20157. 8. Terh and Cao, 2018

INTRODUCTION

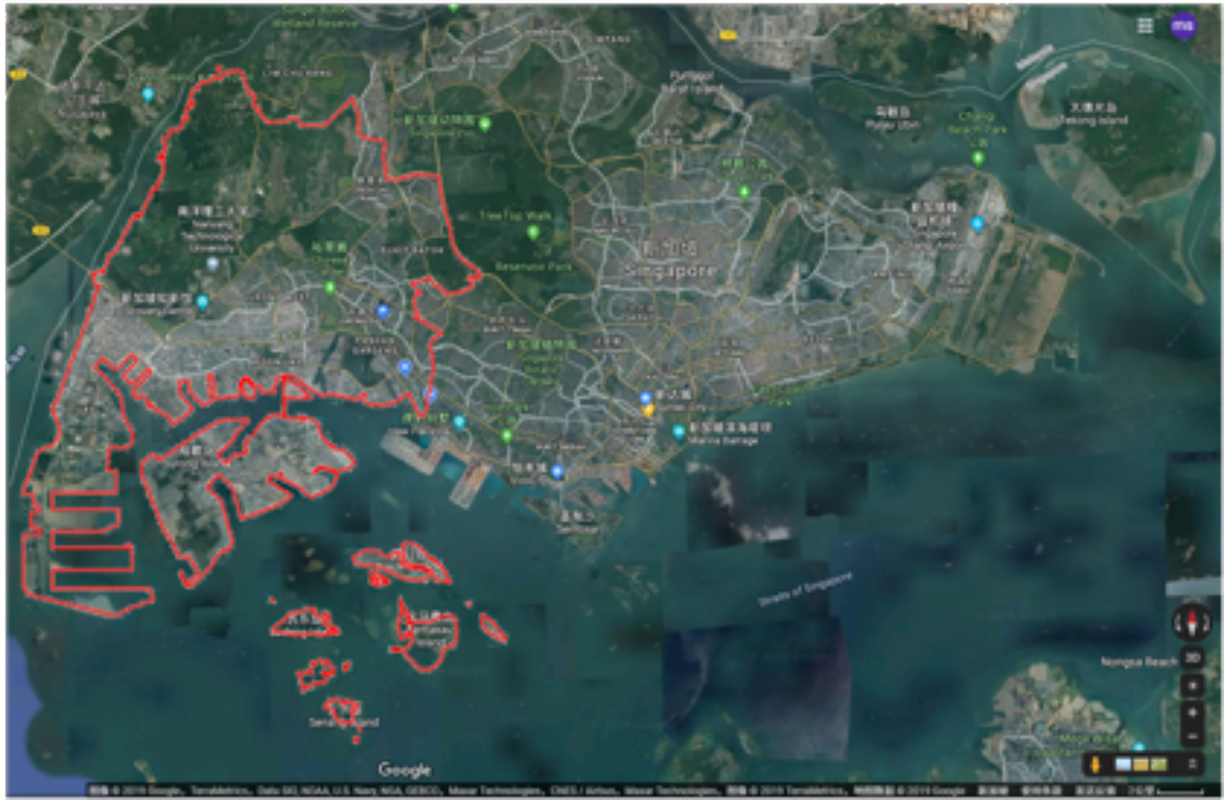
This study built a framework that incorporates **multiple indices** to address and evaluate **"bikeability",** relying on **commonly available data** and **using spatial analysis** as an important tool to solve the problems.

Framework



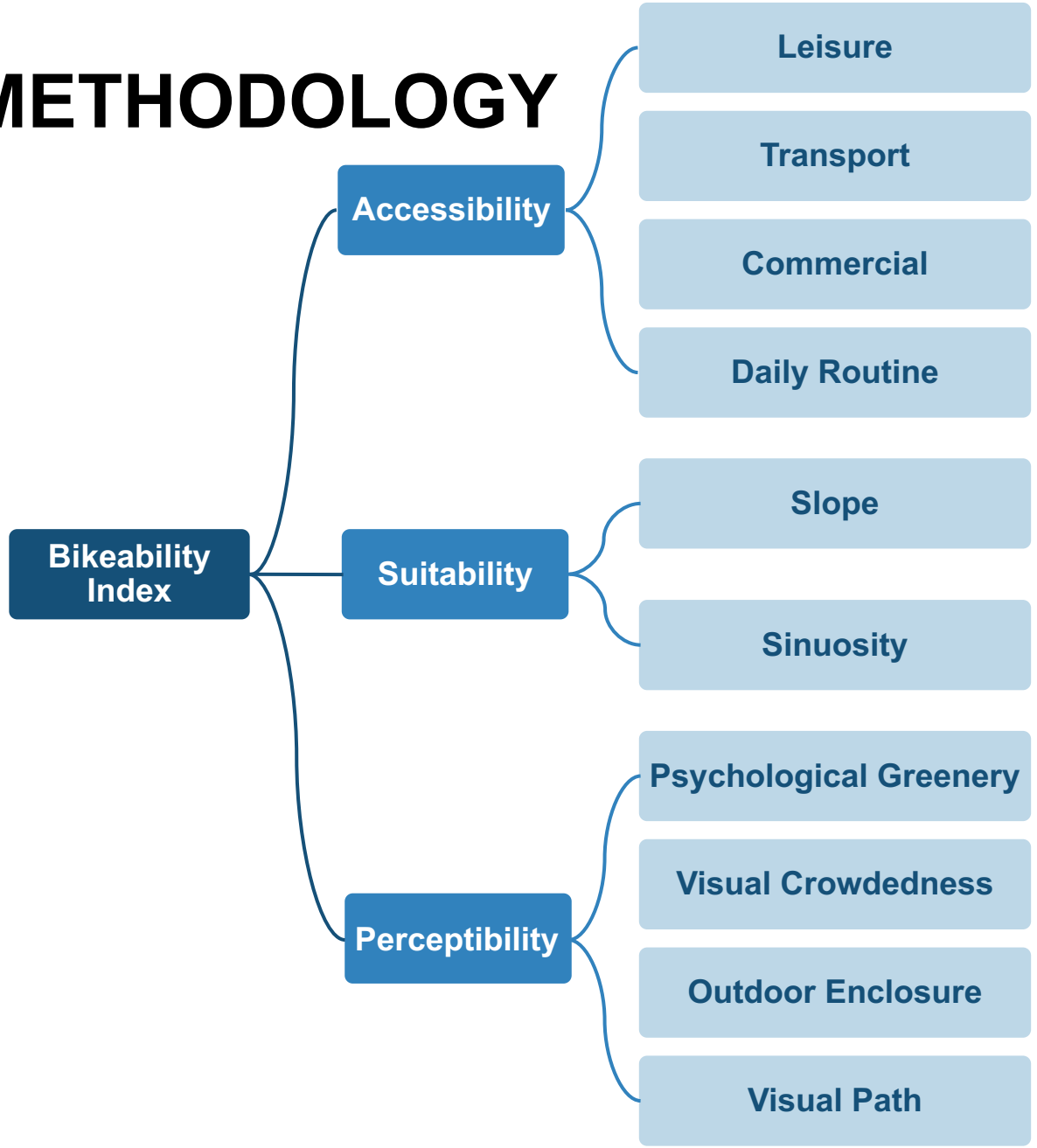
METHODOLOGY

Research Area



Data	Source	Description	Time
Singapore Subzone boundary	URA	the West Region of Singapore	2014
Road Network	LTA	the West Region of Singapore	2017
Google Street View	Google	16,600 images	2018
Point of Interest	Baidu	50,658 records	2019
ASTER Global DEM Model V003	USGS	Spatial Resolution of 1 arc sec	2013

METHODOLOGY



Reclassification

Data cleansing

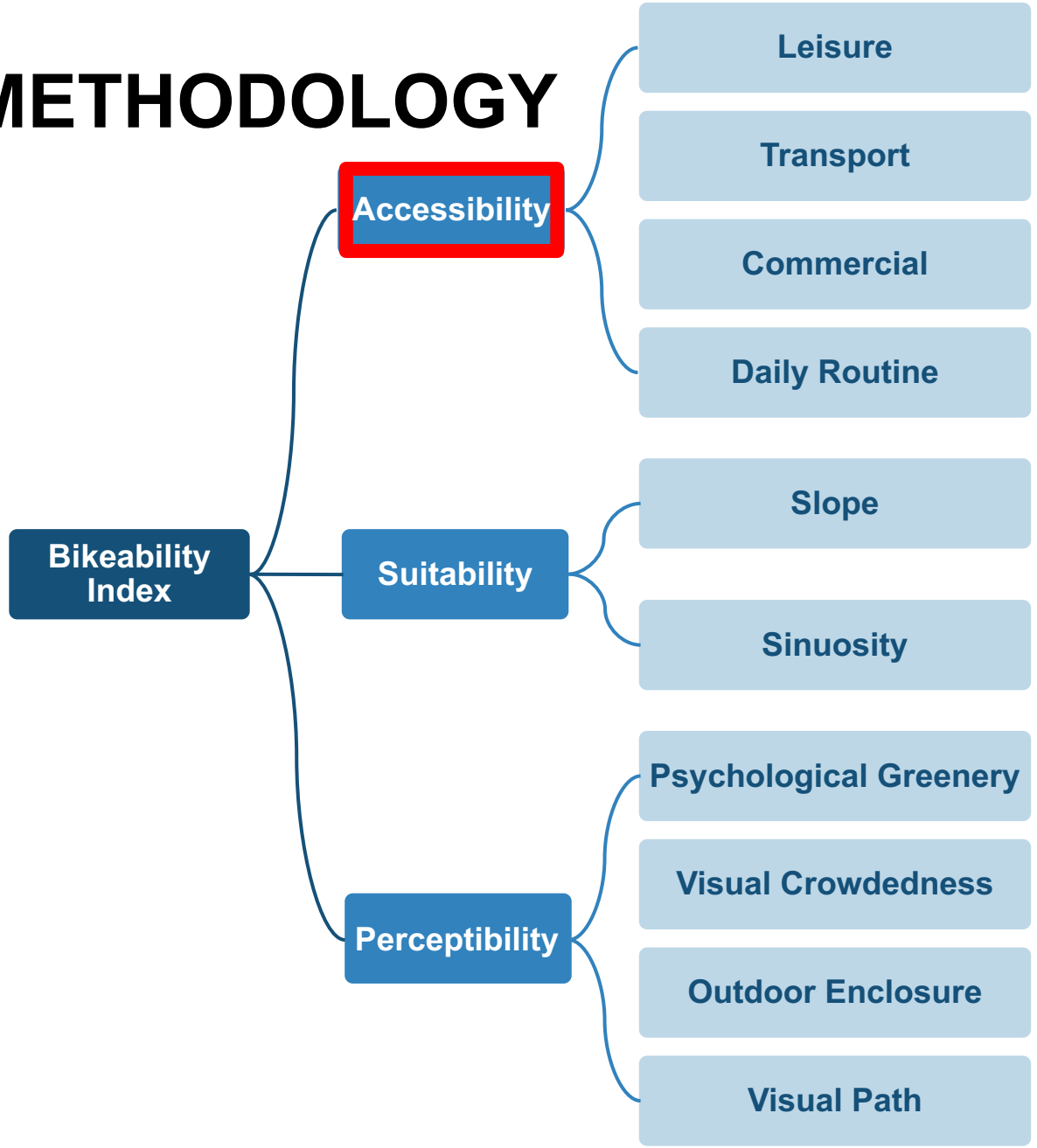
Proportion Parse

Semantic Segmentation

GSV* Curation

*Google Street View

METHODOLOGY



Reclassification

Data cleansing

Proportion Parse

Semantic Segmentation

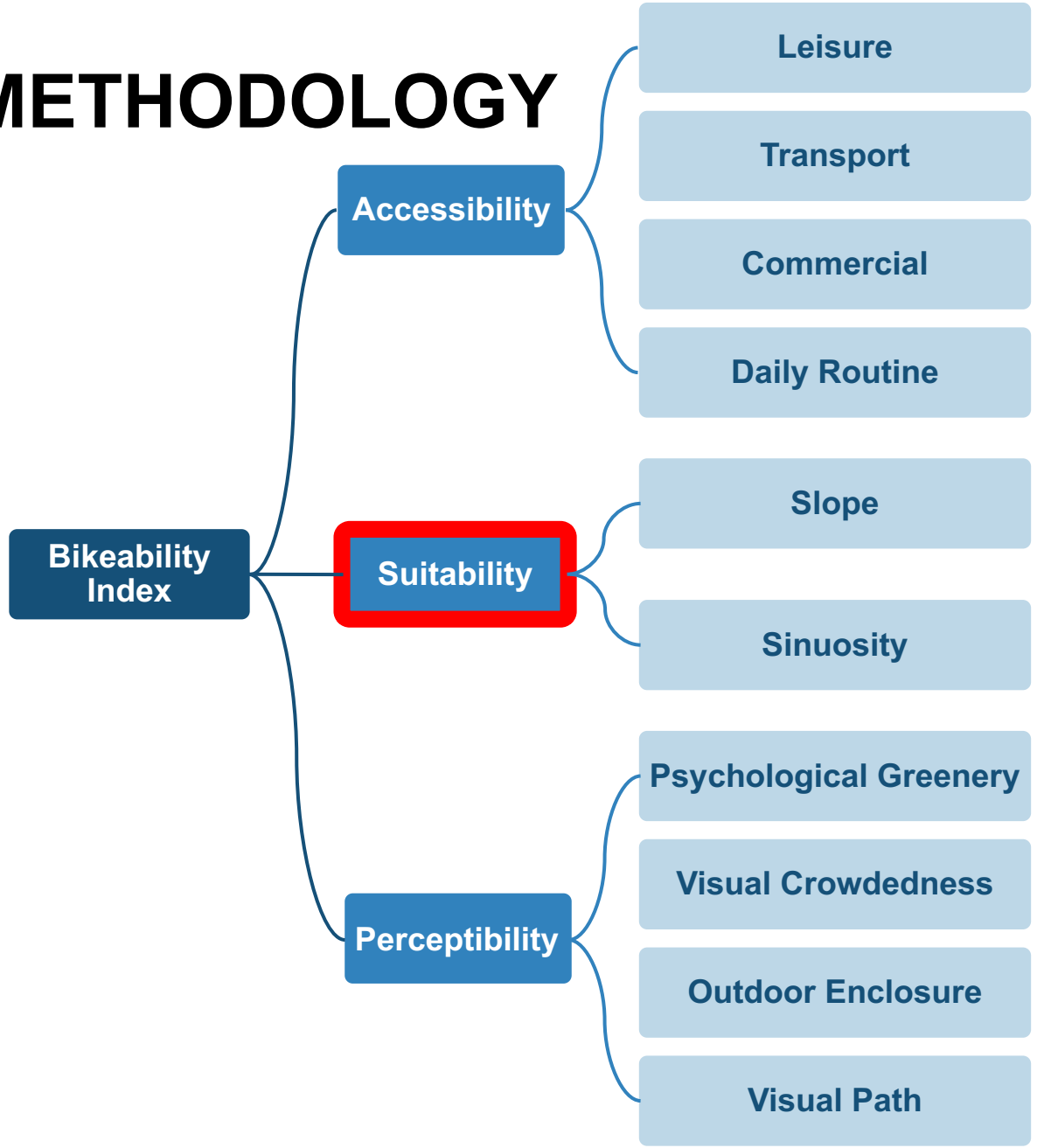
GSV* Curation

*Google Street View

POI RECLASSIFICATION

Reclassification	Class	Sub-class
Leisure	Entertainment	Cinema, theater, KTV, etc.
	Sports	Gym, sport centre, etc.
	Nature	Island, mountain, reservoir, etc.
	Food	Restaurant, bakery, bar, etc.
	Tourist Attraction	Park, zoo, botanical garden, etc.
Transport	Transport	Airport, MRT station, bus station, etc.
Commercial	Enterprise	Company, industry, etc.
	Financial Industry	Bank, ATM, etc.
Daily Routine	Shopping	Shopping centre, department store, supermarket, etc.
	Living Service	Post office, ticket office, laundry, real estate agency, etc.

METHODOLOGY



Reclassification

Data cleansing

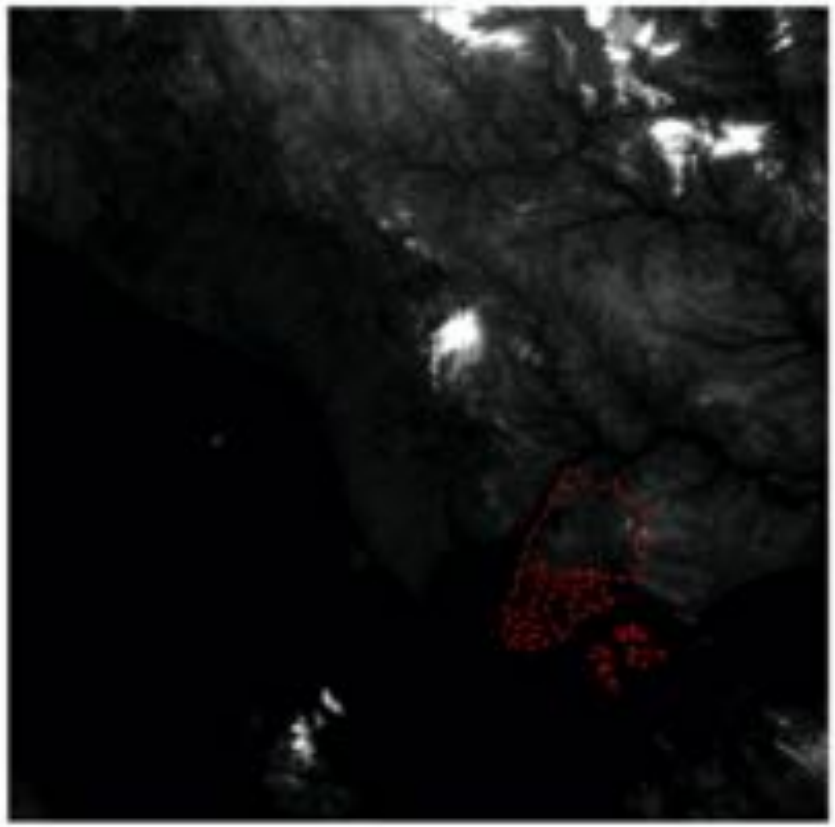
Proportion Parse

Semantic Segmentation

GSV* Curation

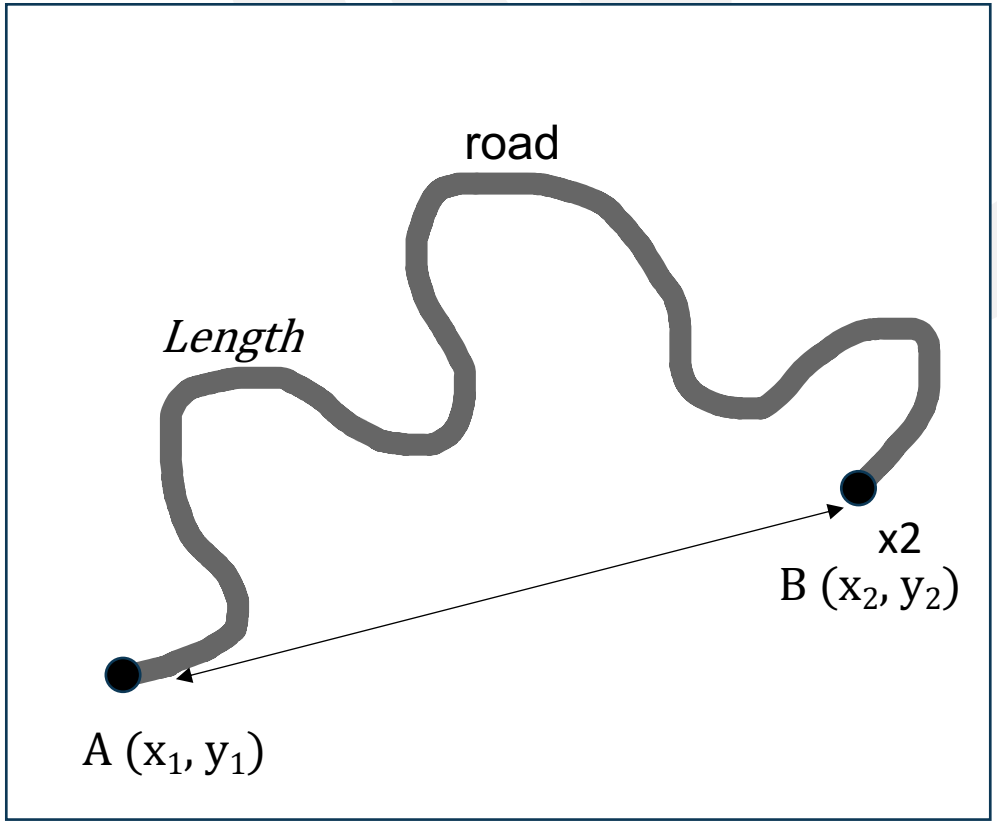
*Google Street View

Slope



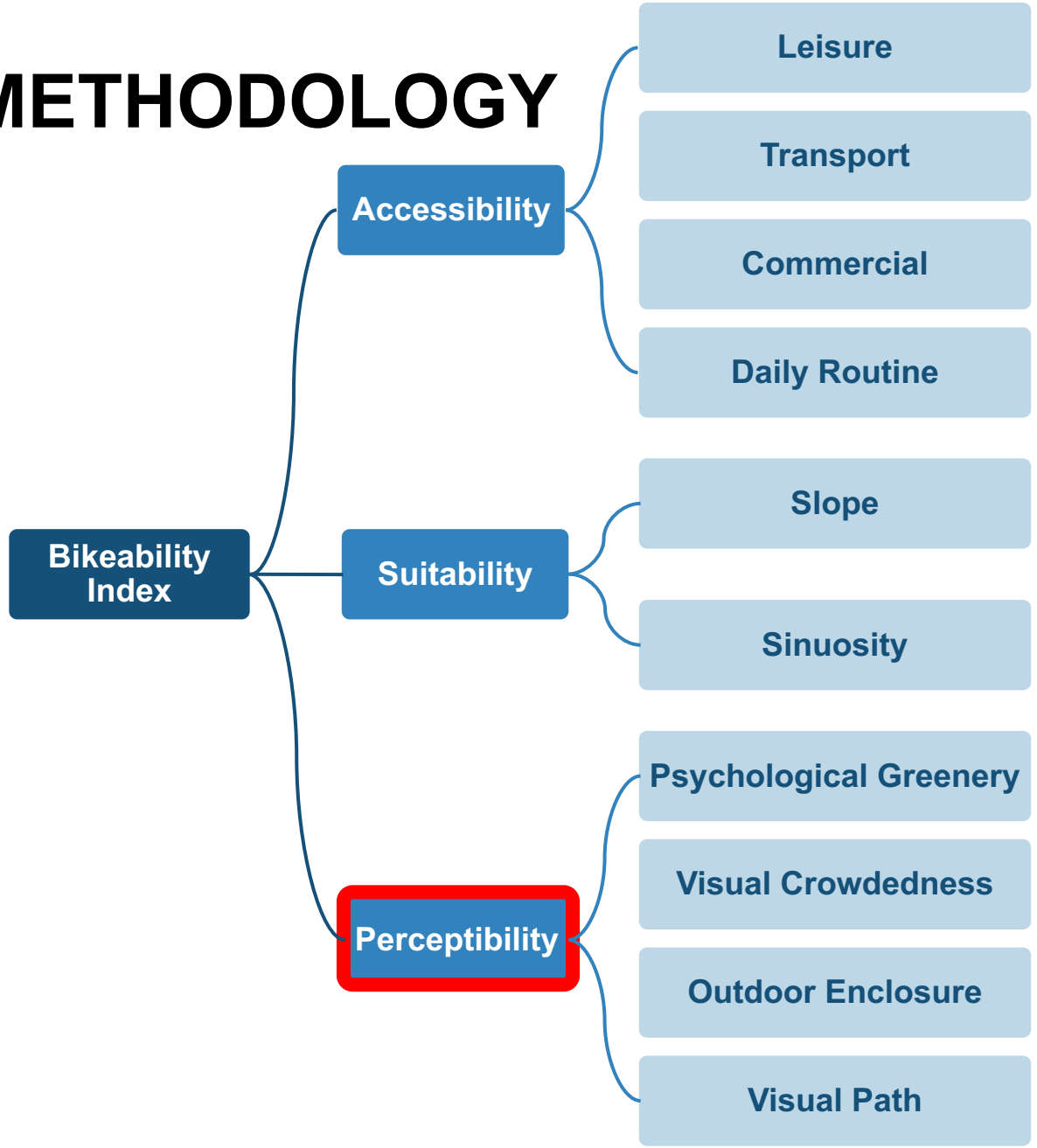
DEM

Sinuosity



$$Sinuosity = \frac{length}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}}$$

METHODOLOGY



Reclassification

Data cleansing

Proportion Parse

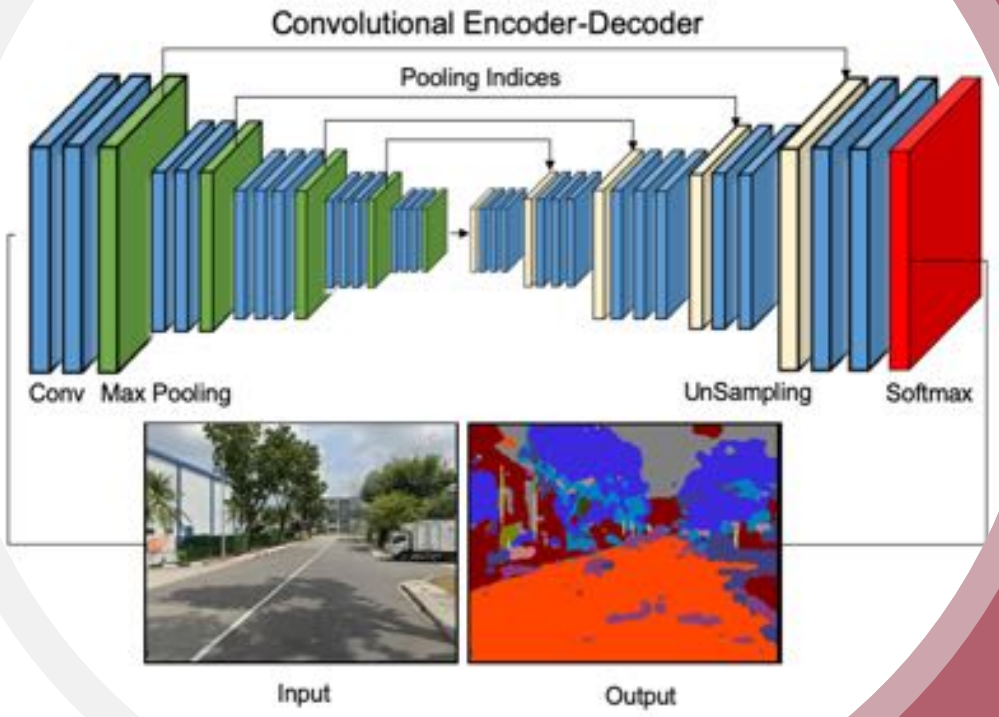
Semantic Segmentation

GSV* Curation

*Google Street View

SEMANTIC SEGMENTATION

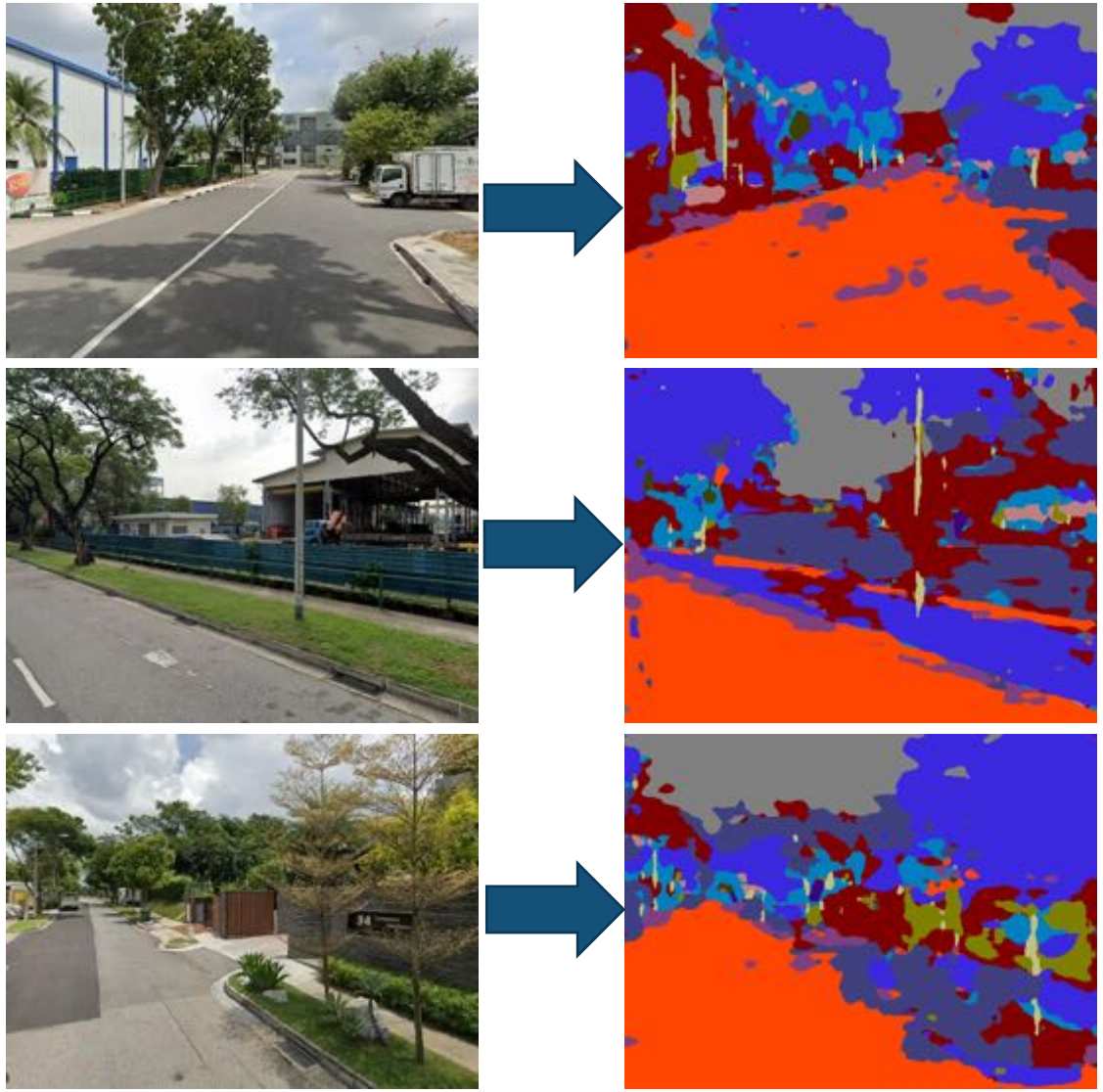
- is the task of assigning a class to every pixel in a given image
  - e.g. tree, pavements, building, etc.
- is to train a Deep Neural Network to achieve fine-grained pixelwise classifications



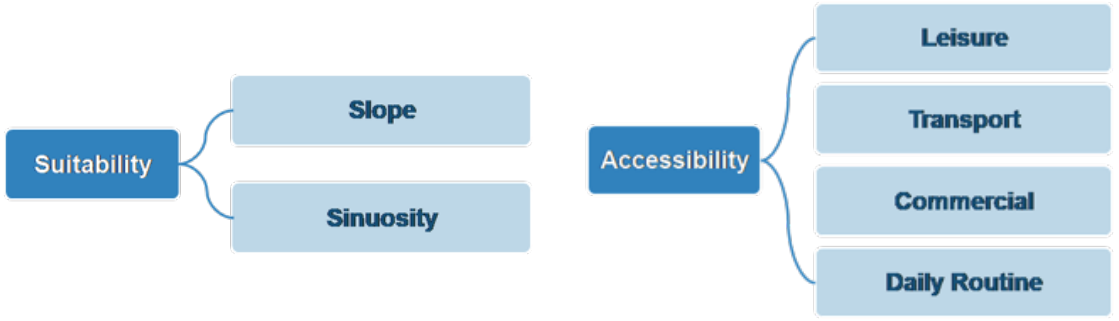
SegNet

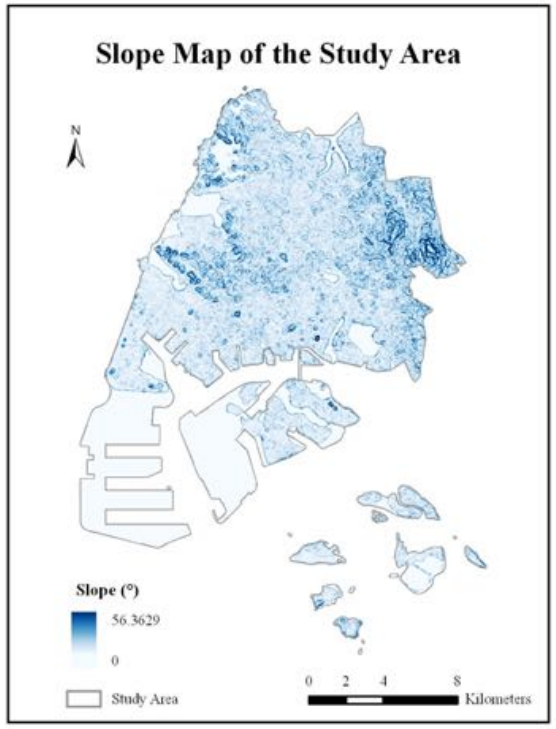
- Lightest model of the said convolutional neural network
- Built with a dataset of 600 street images termed *Camvid*
  - Training acc. 96.7%
  - Validation acc. 79.6%
- Applied to curated 16,660 GSV images
  - to infer each proportion of 12 classes in total

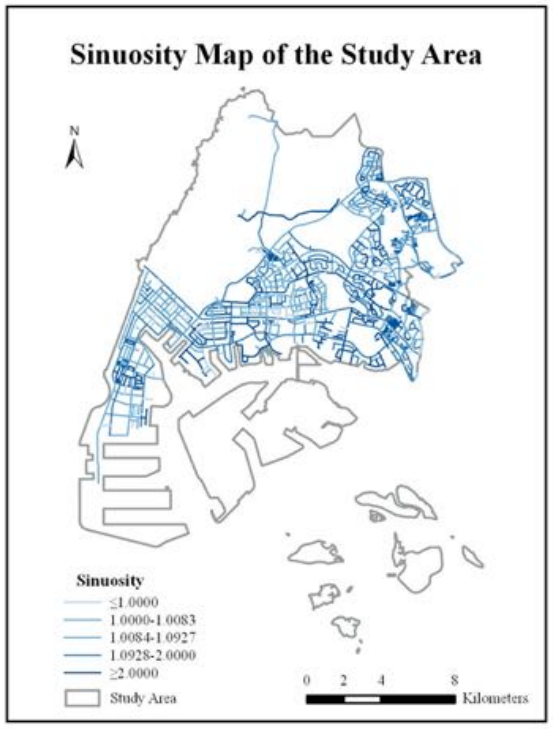
SEMANTIC SEGMENTATION



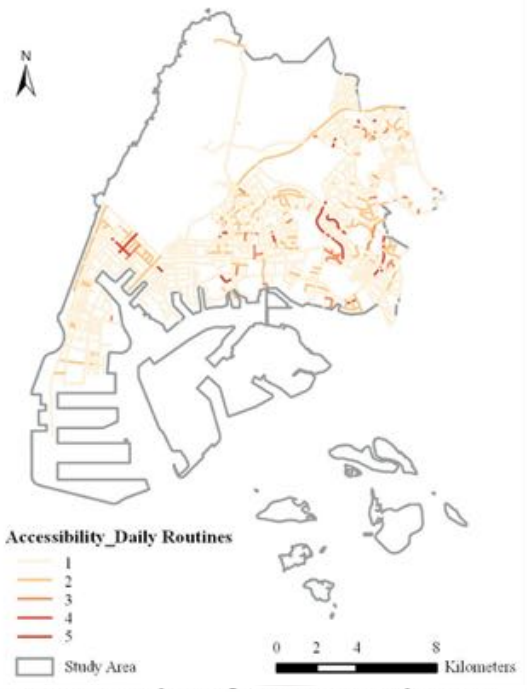
RESULTS (1/6)







Suitability of the Study Area



Accessibility of the Study Area

RESULTS (2/6)

Indicators	Formula	Level
Psychological Greenery (G)	$G_i = \frac{\sum_1^4 T_n}{4 * sum}$	Higher, Better
Visual Crowdedness (C)	$C_i = \frac{\sum_1^4 C_n}{4 * sum}$	Lower, Better
Outdoor Enclosure (S)	$S_i = \frac{\sum_1^4 B_n + \sum_1^4 T_n}{\sum_1^4 P_n + \sum_1^4 R_n + \sum_1^4 F_n}$	Middle, Better
Visual Path (D)	$D_i = \frac{\sum_1^4 P_n + \sum_1^4 F_n}{\sum_1^4 R_n}$	Middle, Better

T_n is the number of tree pixels;
C_n is the number of obstacles pixels;
B_n is the number of building pixels;
P_n refers to the number of cycle lane pixels;
R_n refers to the number of road pixels;
F_n refers to the number of fence pixels;
Sum is the total pixel number.

(G)

(C)

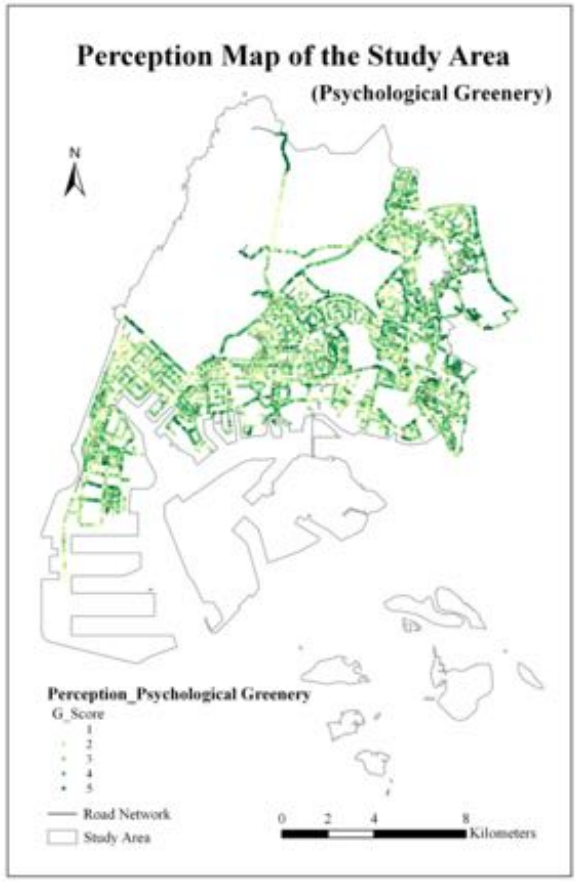
(S)

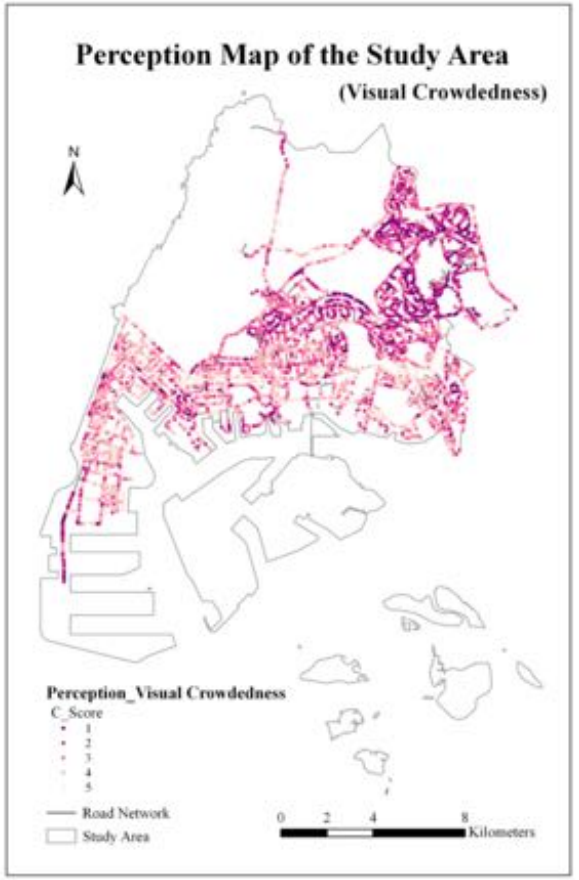
(D)

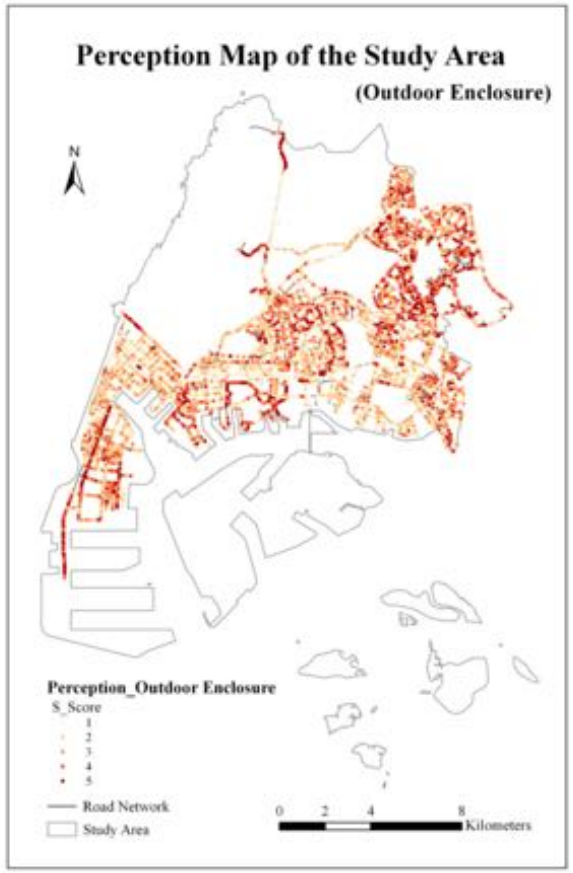
Perceptibility of the Study Area

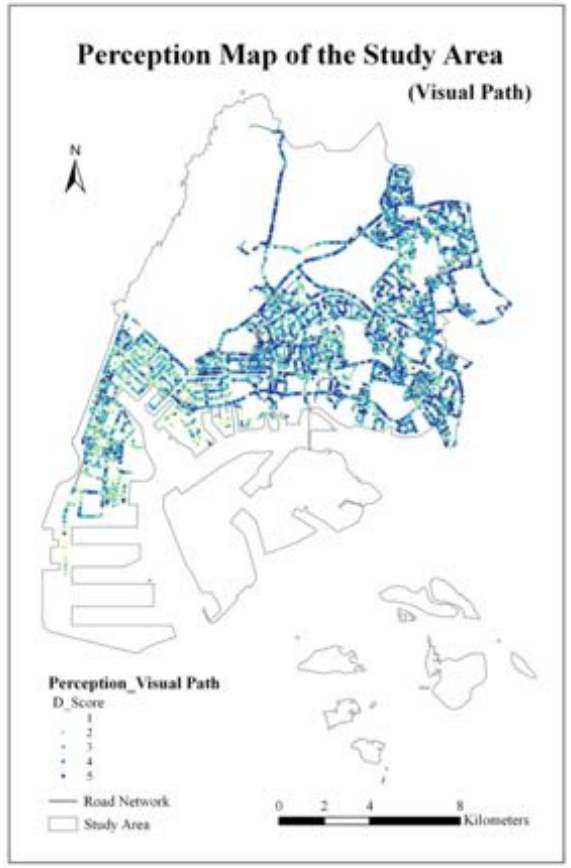
RESULTS (3/6)

Perceptibility of the Study Area

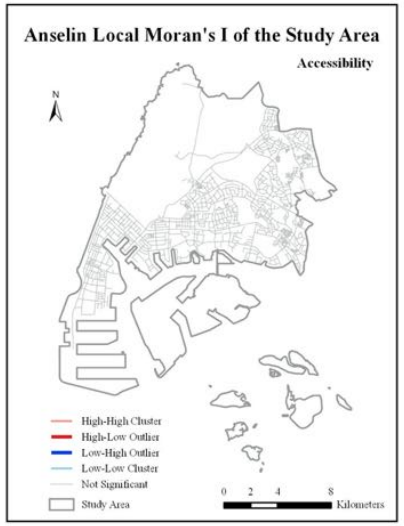


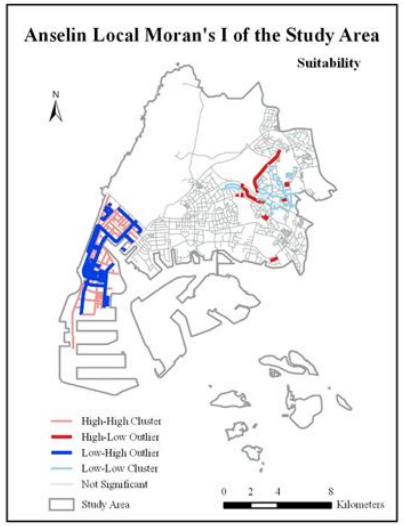


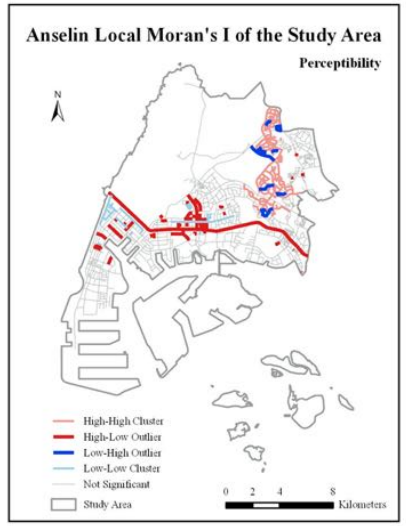


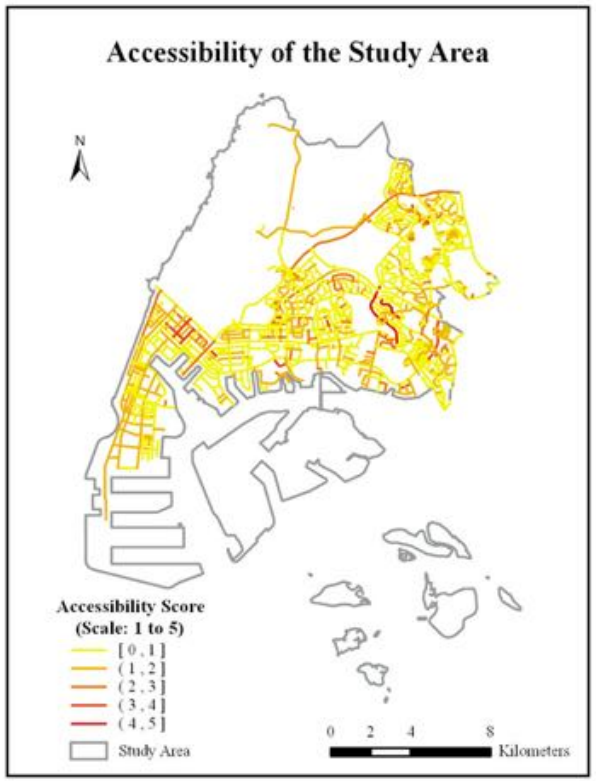


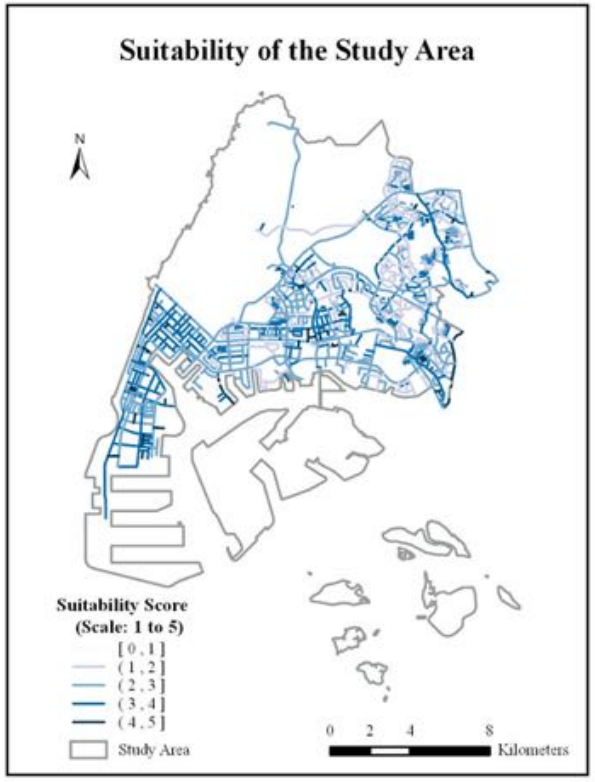
RESULTS (4/6)

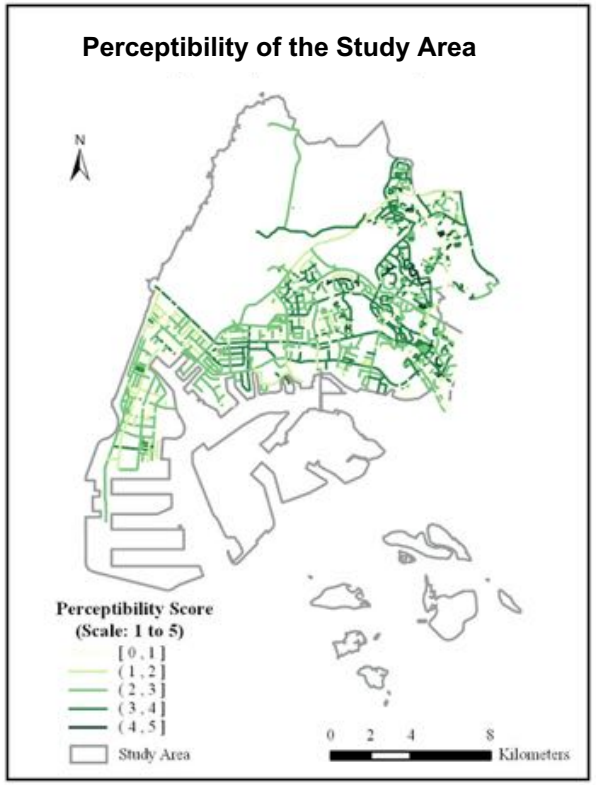

Anselin Local Moran's I of the Study Area
Accessibility
N
High-High Cluster
High-Low Outlier
Low-High Outlier
Low-Low Cluster
Not Significant
Study Area
0 2 4 8
Kilometers


Anselin Local Moran's I of the Study Area
Suitability
N
High-High Cluster
High-Low Outlier
Low-High Outlier
Low-Low Cluster
Not Significant
Study Area
0 2 4 8
Kilometers


Anselin Local Moran's I of the Study Area
Perceptibility
N
High-High Cluster
High-Low Outlier
Low-High Outlier
Low-Low Cluster
Not Significant
Study Area
0 2 4 8
Kilometers

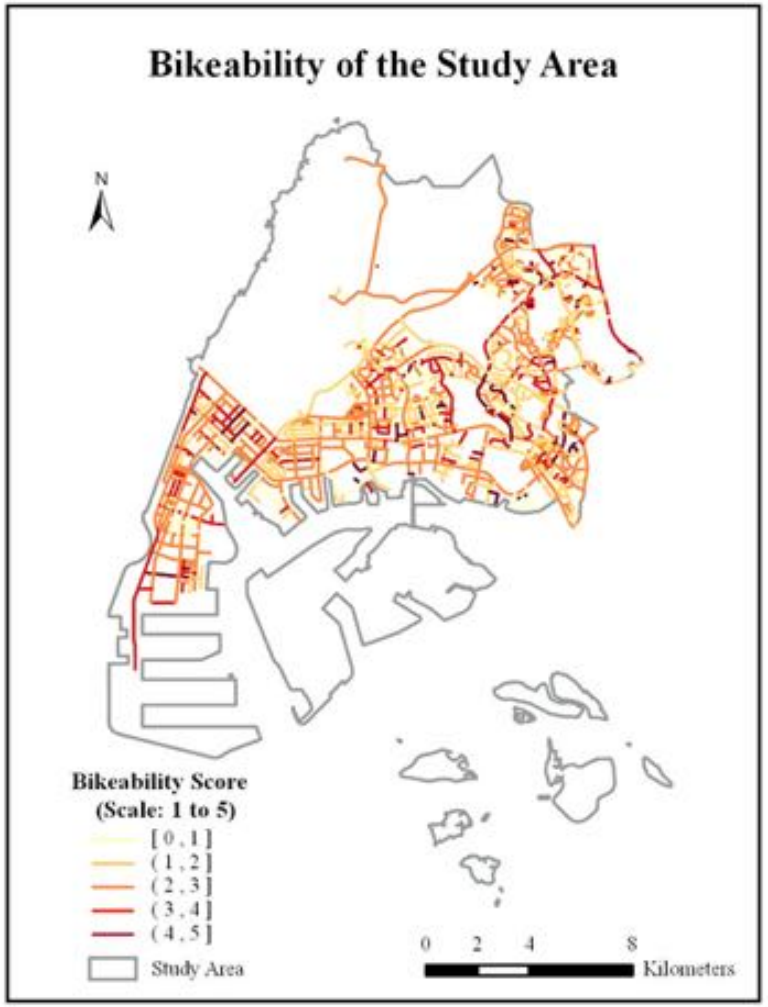

Accessibility of the Study Area
N
Accessibility Score
(Scale: 1 to 5)
[0,1]
(1,2]
(2,3]
(3,4]
(4,5]
Study Area
0 2 4 8
Kilometers

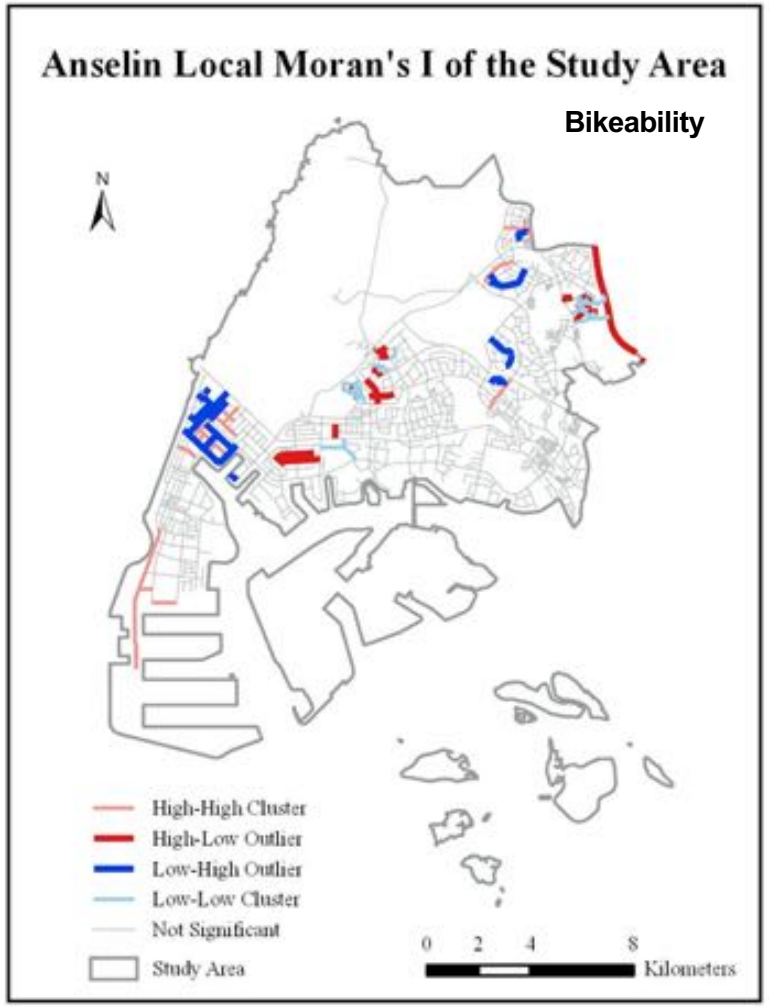

Suitability of the Study Area
N
Suitability Score
(Scale: 1 to 5)
[0,1]
(1,2]
(2,3]
(3,4]
(4,5]
Study Area
0 2 4 8
Kilometers


Perceptibility of the Study Area
N
Perceptibility Score
(Scale: 1 to 5)
[0,1]
(1,2]
(2,3]
(3,4]
(4,5]
Study Area
0 2 4 8
Kilometers

RESULTS (5/6)

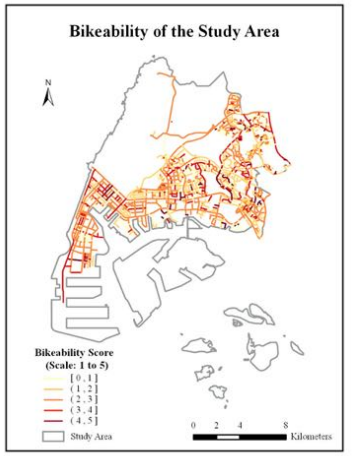
Class	Weight
Accessibility	1/3
Suitability	1/3
Perceptibility	1/3

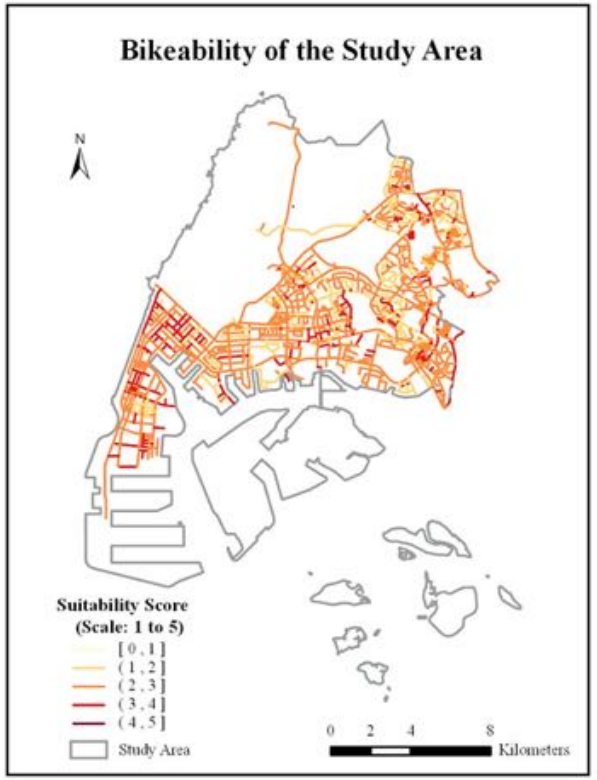




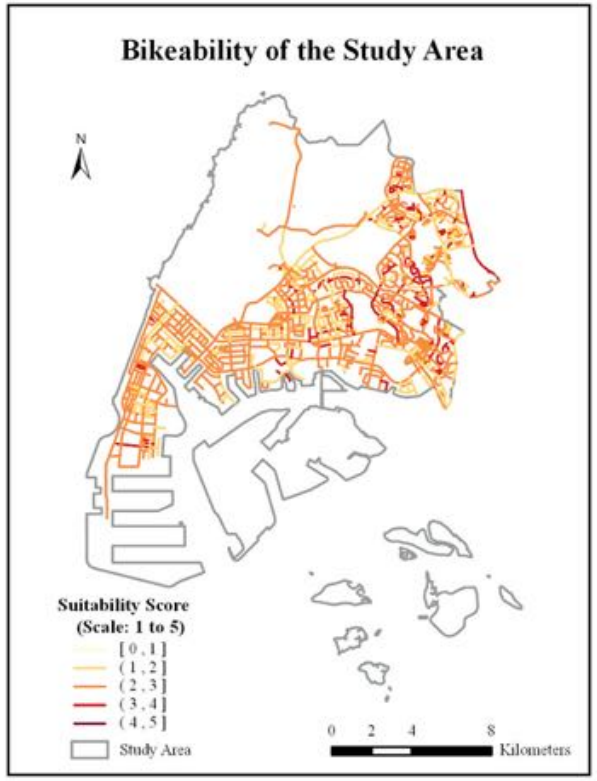
RESULTS (6/6)

Class	Weight	Weight	Weight
Accessibility	0.6	0.2	0.2
Suitability	0.2	0.6	0.2
Perceptibility	0.2	0.2	0.6

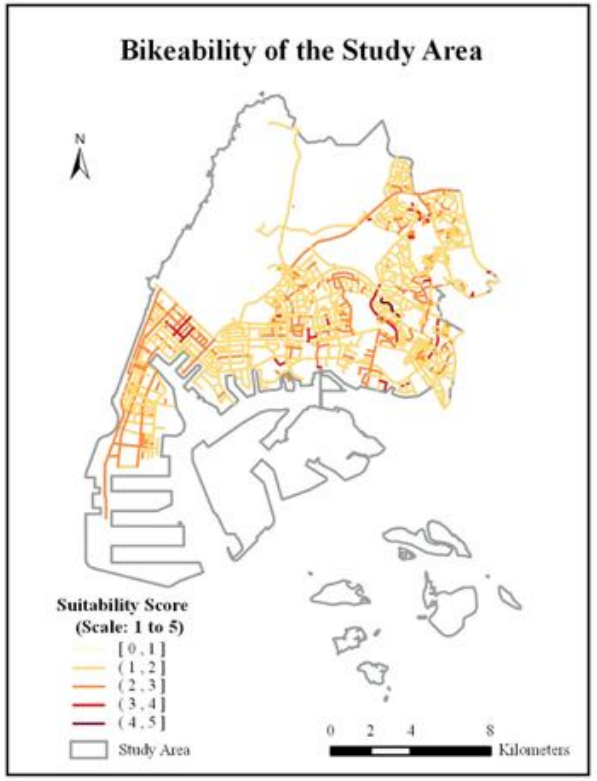




Fitting overall citizens



Fitting exercise purpose



Fitting scenery purpose

DISCUSSION

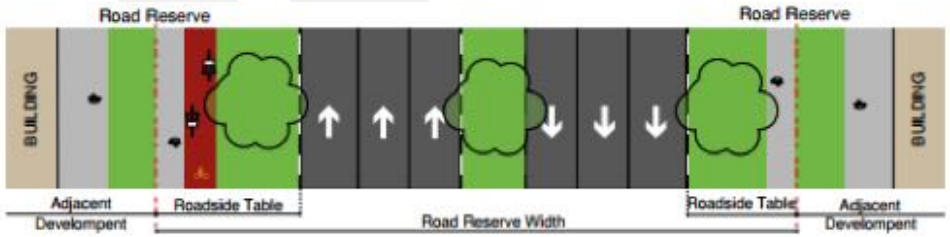
Limitation

- Further works in validations of scale range

  Survey: Questionnaire

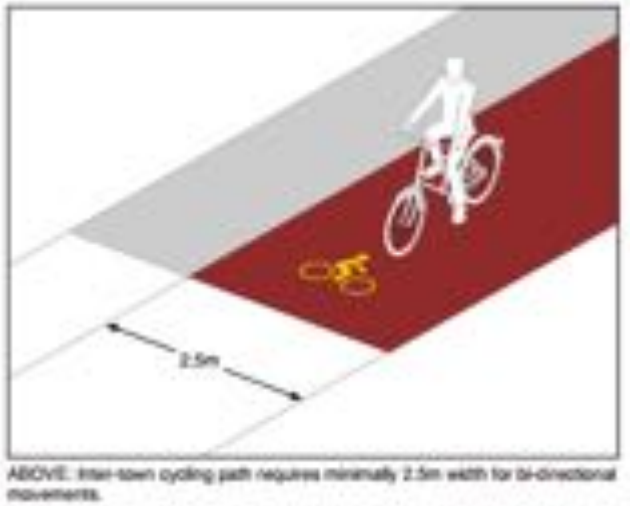
  Field research

- GSV



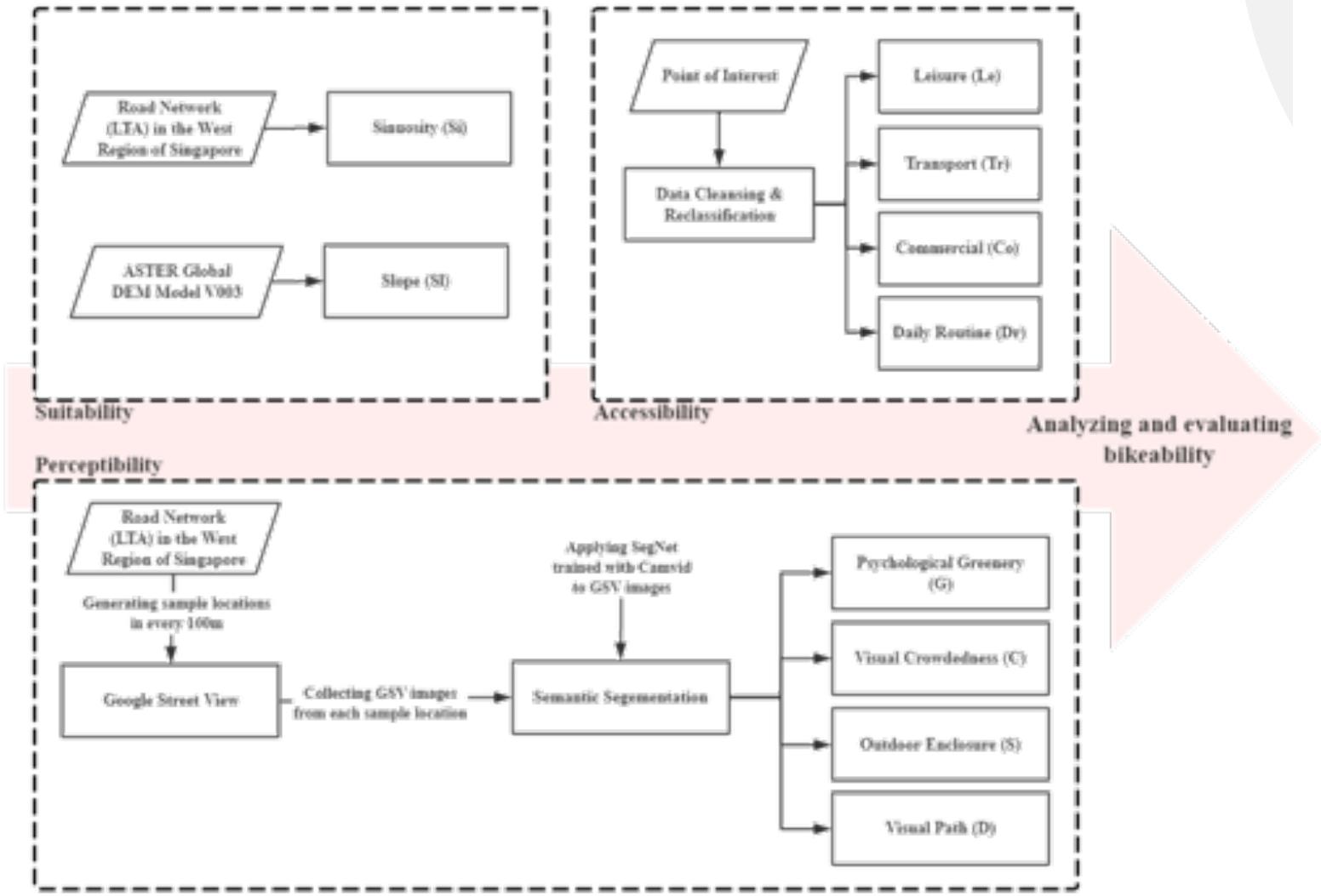
Outlook

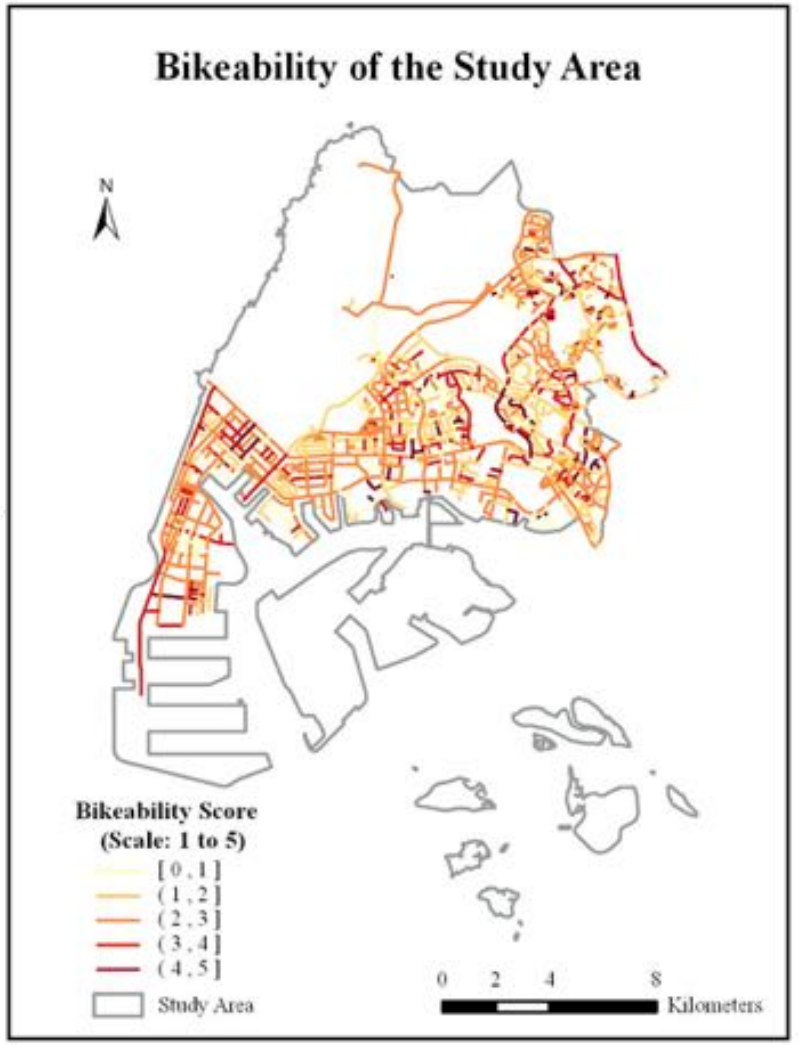
- Buffer distance
- Analysis according to different types of cycling paths



Source: Walking and Cycling Design Guide,2018

SUMMARY


Road Network (LTA) in the West Region of Singapore
Sinuosity (Si)
ASTER Global DEM Model V003
Slope (Sl)
Suitability
Point of Interest
Data Cleansing & Reclassification
Leisure (Le)
Transport (Tr)
Commercial (Co)
Daily Routine (Dr)
Accessibility
Perceptibility
Road Network (LTA) in the West Region of Singapore
Generating sample locations in every 100m
Google Street View
Collecting GSV images from each sample location
Applying SegNet trained with Camvid to GSV images
Semantic Segementation
Psychological Greenery (G)
Visual Crowdedness (C)
Outdoor Enclosure (S)
Visual Path (D)
Analyzing and evaluating bikeability


Bikeability of the Study Area
N
Bikeability Score
(Scale: 1 to 5)
[0, 1]
(1, 2]
(2, 3]
(3, 4]
(4, 5]
Study Area
0 2 4 8
Kilometers

APPENDIX

APPENDIX

(a). Segmentation sample of Segnet

(b). Segmentation sample after reclassed