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ATRANS

ASIAN TRANSPORTATION RESEARCH SOCIETY

Walkability Perception around Urban Railway Stations

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Walkability Perception around Urban Railway Stations

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List of Abbreviations and Acronyms

TOD	Transit Oriented Development
SRT	State Railway of Thailand
MRTA	Mass Rapid Transit Authority
OTP	Office for Transport and Traffic Policy and Planning
SP	Stated Preference

CHAPTER I INTRODUCTION

1.1 Background

As the recent social changes, increases in ageing people and millennials leads to changing people's values in a more diverse way. Accordingly, urban infrastructure is increasingly required to meet diverse needs. This is particularly the case of streets in developing countries. In the typical context, road development is focused on for a single issue of traffic efficiency to reduce transport time and cost, i.e., to ease the traffic flow. As a result, street is not originally developed to be used by pedestrians, where sidewalks are neither well provided nor secure the minimum levels of walking spaces as the remaining of road spaces.

Moreover, as the traffic congestion in Bangkok have been at the critical level for long time. Urban railways have been developed with sole hope to alleviate the congestion and solve the problem eventually. However, access to railway stations are not properly developed. Feeder public transport such as shuttle bus is not present, making access to/from area farther away is not convenient and discouraging use of railway. On the other hand, walking environment around station, especially in the 800-m catchment area, are not properly improved and developed in accordance with the railway development. Very often the sidewalks are physically narrow and dirty with broken pavement surface, presence of obstacles and encroachment along the path. Moreover, safety from traffic and security with respect to crime cannot be promised. These conditions discourage people to walk but rather encourage motorcycle-taxi usage as station access mode or discourage railway usage all the way. Therefore, it is an urgent need for Bangkok metropolitan to improve walkability around urban railway stations in order to achieve the anticipated transit-oriented development.

1.2 Objectives

The objectives of this study are as follows:

1) To identify factors that influence walkability of railway station access.
2) To evaluate the perceived walkability in the station catchment area.
3) To suggest policy to enhance station walk accessibility.

1.3 Overview of the Study

Overview of the study is summarized in Figure 1.1 .

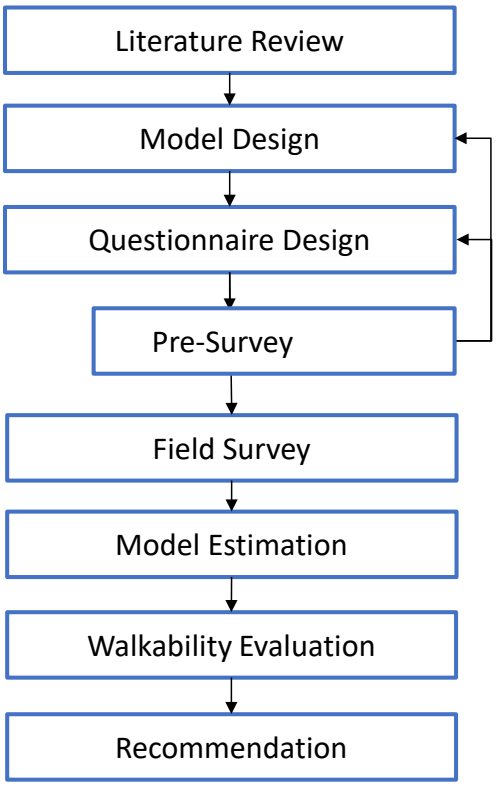
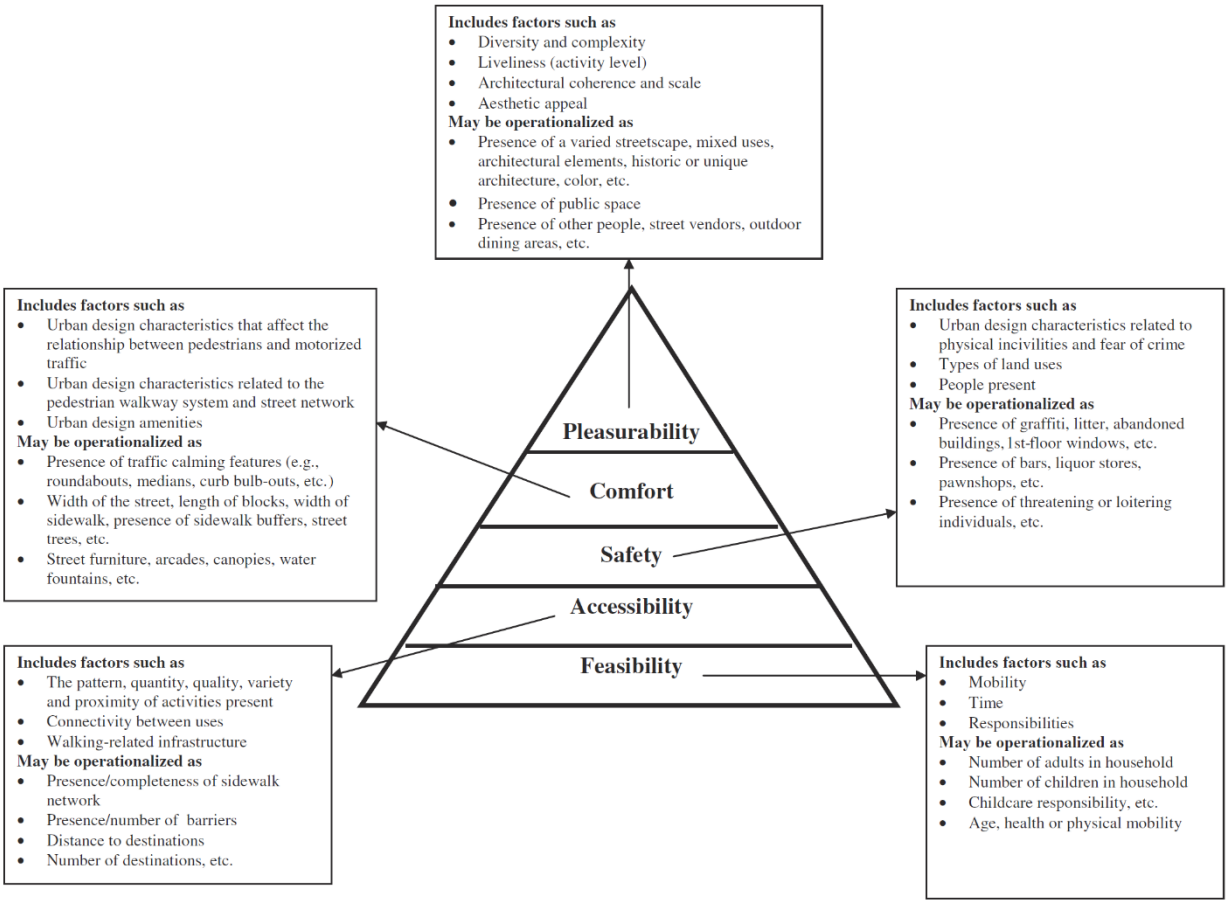


Figure 1.1 Overview of the Study

CHAPTER 2 LITERATURE REVIEW

2.1 Walking

While the term of walkability is not well-defined, the components of walking needs often include convenience, safety, comfort, and attractiveness. (Alfonzo, 2005) suggested that these needs have a hierarchical relationship from the low-level needs of convenience and safety to the high-level needs of comfort and interest as illustrated in Figure 1.1.



Source: (Alfonzo, 2005)

Figure 2.1 Hierarchy of Walking Needs

2.2 Walkability

Walkability Indicators

"Walkability" is a term used to describe and measure the connectivity and quality of walkways, footpaths, or sidewalks in cities. It can be measured through a comprehensive assessment of available infrastructure for pedestrians and studies linking demand and supply.

Some cities have undertaken comprehensive studies and city plans to improve walkability. Transport for London (2004) defines walkability as "the extent to which walking is readily available to the consumer as a safe, connected, accessible and pleasant activity." For New Zealand, it was defined as the extent to which the built environment is walking-friendly (NZ Transport Agency, 2010).Abu Dhabi has developed an Urban Street Design Manual that integrates the concept of the pedestrian realm into overall street composition. Other cities, particularly in Europe, have developed plans and supporting policies specifically to improve the walkability and cyclability of the whole city. A popular website calculates walkability based on the distance from your house to nearby amenities. Walk Score measures the ease of a car-free lifestyle, but it does not include any assessment of the quality of pedestrian facilities, such as street width and block length, street design, safety from crime and crashes, pedestrian-friendly community design, and topography. Many Asian cities can generate high scores in Walk Score because of the traditionally mixed-use character of the cities.

(Krambeck, 2006) defined Global Walkability Index (GWI) for the World Bank, provides a qualitative analysis of walking conditions including the safety, security, and convenience of the pedestrian environment. It was originally applied in Virginia, USA and further developed and applied in Ahmedabad, India. Similarly, (Wibowo et al., 2015) also applied GWI in Bandung, Indonesia with some modification of the evaluation items. (Leather et al., 2011) conducted a pedestrian survey for ADB in 13 Asian cities based on the conflicts between pedestrians and other traffic, availability of walking paths, availability of crossings, grade crossing safety, motorist behavior, amenities, disability infrastructure, obstructions, and security from crime. The evaluations are scored based on the user's subjective evaluation of these factors.

Walkability Components

The walkability components of the GWI (Krambeck, 2006) are summarized in Table 2.1.

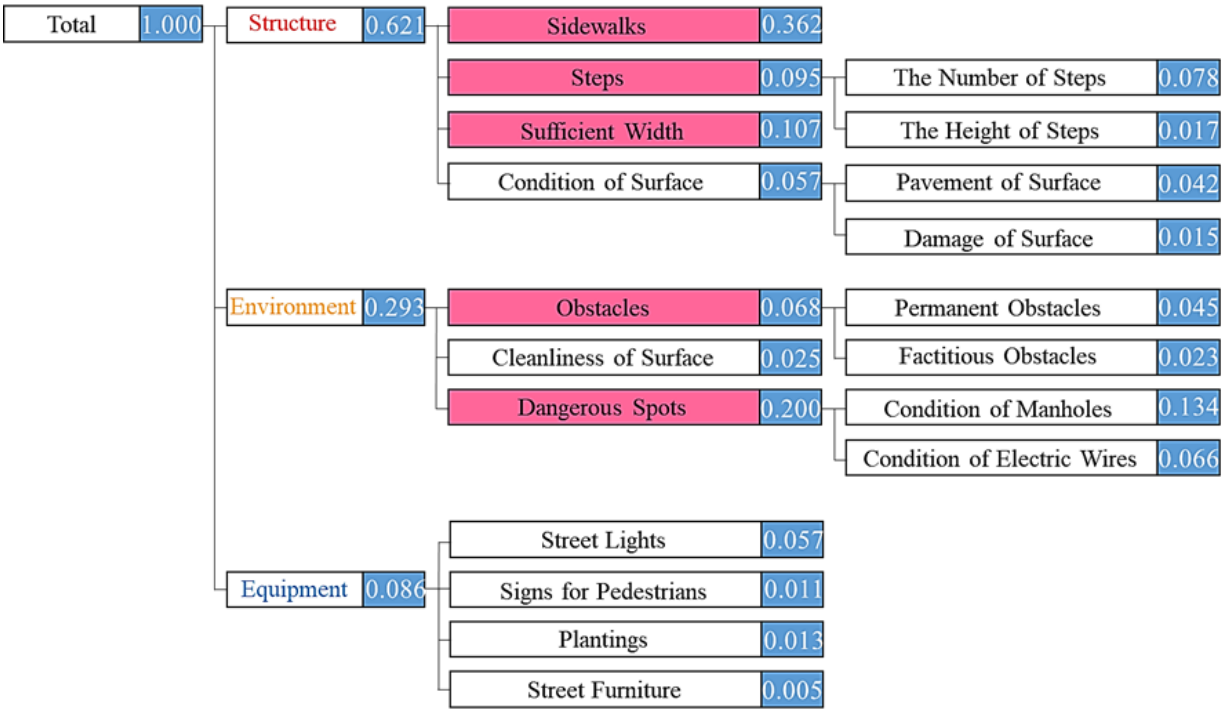
Table 2.1 The Global Walkability Index (GWI) Components

Parameter	Description
Walking Path Modal Conflict	The extent of conflict between pedestrians and other modes, such as bicycles, motorcycles, and cars on the road.
Availability of Walking Paths	This parameter is added to the original Global Walkability Index (combined with the original parameter "Maintenance and Cleanliness"). It reflects the need for, availability, and condition of walking paths.
Availability of Crossings	The availability and distances between crossings to describe whether pedestrians tend to jaywalk when there are no crossings or when the distances between crossings are too long.
Grade Crossing Safety	This refers to the exposure of pedestrians to other modes while crossing, the time spent waiting and crossing the street, and the sufficiency of time given to pedestrians to cross signalized intersections.
Motorist Behavior	The behavior of motorists toward pedestrians, which may well indicate the kind of pedestrian environment there is in that area.
Amenities	The availability of pedestrian amenities such as benches, streetlights, public toilets, and trees. These amenities greatly enhance the attractiveness and convenience of the pedestrian environment, and in turn, the city itself.
Disability Infrastructure	The availability, positioning, and maintenance of infrastructure for the disabled.
Obstructions	The presence of permanent and temporary obstructions on the pedestrian pathways. These ultimately affect the effective width of the pedestrian pathway and may cause inconvenience to the pedestrians.
Security from Crime	The general feeling of security from crime in the street.

Recent studies attempted to identify the influencing factors and components of walkability. Different techniques were employed to determine the relative influence of each component. For example, (Park et al., 2015; Park et al., 2019) identified 42 micro

indicators of walkability such as roadway width, number of lane of roadway, calming elements, pedestrian crossing facility, pedestrian signal, sidewalk, special pavement of sidewalk, steepness of sidewalk, tree, street furniture, luminosity, visual nuisance, sidewalk intermediaries, building height, building façade, building setbacks, commercial, mixed land use, façade transparency, etc. Regression analysis is conducted with these 42 indicators and 13 components for quality walking experience. These factors were grouped into 5 values of walk quality components: safety, security, comfort, convenience, and visual interest. The weight of each component was obtained by asking respondent to give priority rating directly.

(Ozawa et al., 2020) identified items that are used to evaluate the walkability based on Japanese guideline. These include sidewalk structure, geometry of steps, width, surface pavement & conditions, obstacles, cleanliness, manholes, electric wires, street lighting, pedestrian signage, planting, street furniture, pedestrian crosswalk, pedestrian traffic signal, etc. AHP technique was employed to determine the weight of each component and subsequently used to evaluate walkability. The weightings of the evaluation items are shown in Figure 2.2, where the items having large weights are highlighted in red.



Source: Ozawa et.al. (2020)

Figure 2.2 Weighting of Walkability Factors for Walkway or Sidewalk

Example of walkability around MRT Tao Poon station is shown in Figure 2.3.



Tao Poon Station				
Walkability	Catchment Area (min)			The Whole Sections
	0~5	5~10	10~15	
0.9-1.0	0%	0%	0%	0%
0.8-0.9	17.6%	10.8%	10.3%	9.7%
0.7-0.8	39.2%	25.9%	24.8%	22.3%
0.6-0.7	3.4%	4.3%	4.2%	3.9%
0.5-0.6	3.4%	1.3%	1.2%	1.0%
0.4-0.5	24.5%	42.0%	44.2%	48.8%
0.3-0.4	9.8%	14.4%	14.5%	13.2%
0.2-0.3	2.0%	1.1%	0.8%	0.9%
0.1-0.2	0%	0.2%	0.2%	0.1%
0.0-0.1	0%	0%	0%	0%
TOTAL	100%	100%	100%	100%

Source: Ozawa et.al. (2020)

Figure 2.3 Walkability around MRT Tao Poon Station

2.3 Perceived Walkability

(Bivina et al., 2019) identified 20 built environment factors that determine walkability. These include quality of the sidewalk, width of the sidewalk, continuity of the sidewalk, encroachment along sidewalk, infrastructure for people with disabilities, shaded sidewalk, pedestrian amenities, roadside greenery, presence of obstructions, cleanliness, presence of CCTV cameras, police patrols, street lighting, traffic volume, traffic speed, guardrails, presence of a buffer, raised walkway (walkway with a difference in level from the road), presence of crossings, and presence of traffic signals and signs, etc. Exploratory factor analysis (EFA) is employed and found 4 groups of factors that influence walkability satisfaction: mobility & infrastructure, comfort & convenience, safety & security, and traffic. Confirmatory factor analysis (CFA) is conducted. A structural model with 4 latent exogenous variables and 1 latent variable was developed and suggested the weight of each of the four walkability components, as shown in Figure 2.3

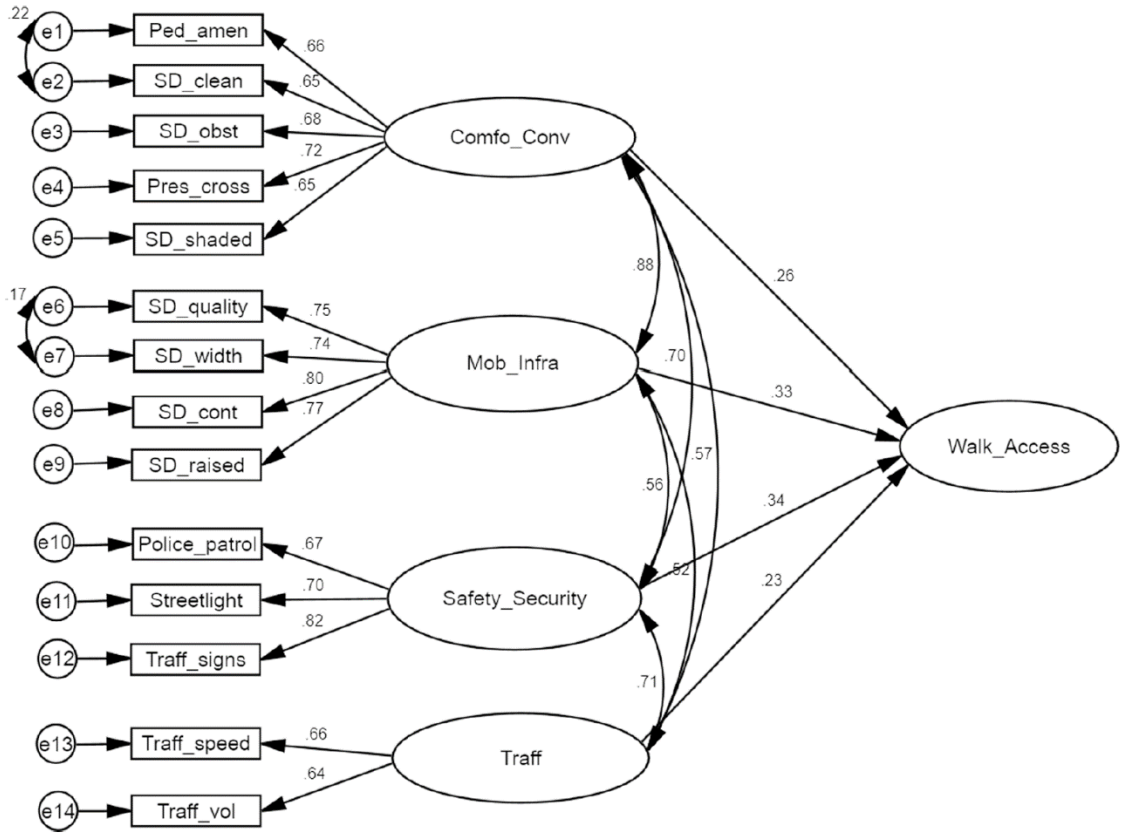


Figure 2.4 Perceived Station Walk-Accessibility

(Coogan et al., 2012) developed a structural equation model to explore the relationship among key factors in the explanation of utilitarian walking. The model examines the relationship between and among unobserved, or "latent," factors that reflect (1) the values and preferences operant at the time of residential selection; (2) the urban form of the neighborhood; (3) the urban form of the residence; (4) the level of auto dependency; and (5) the extent to which the neighborhood is found satisfactory by the participant and those whose opinions he/she respects. The structural equation model that consists of the measurement model and structural model is shown in Figure 2.4.

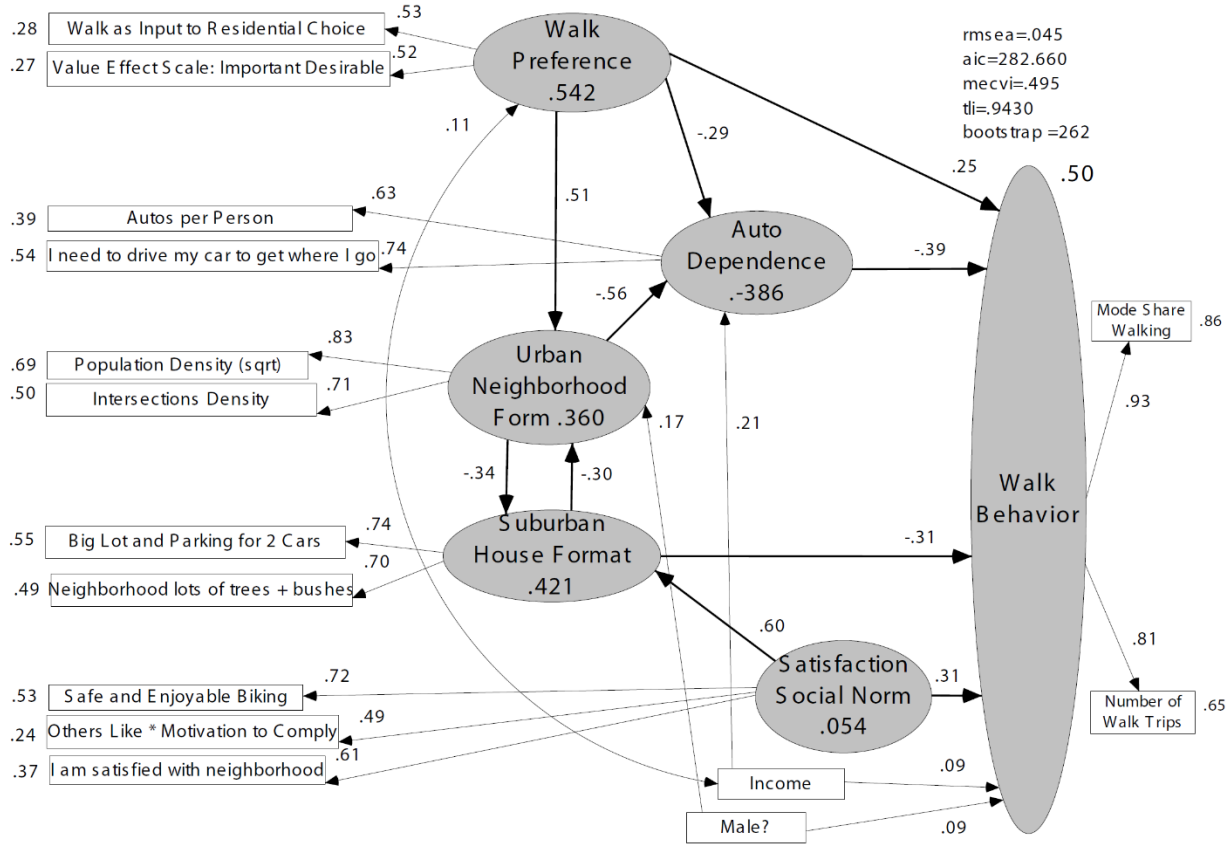


Figure 2.5 SEM Model of Walk Preference and Walk Behavior

CHAPTER 3 WALKABILITY EVALUATION

3.1 Evaluation Items

Based on the framework proposed by Ozawa et.al. (2019), walkability is evaluated in the study area. The field surveyors rated the walkway along each road section by the evaluation items shown in the form in Table 3.1 (to be rated as 1 for the lowest and 4 for the highest).

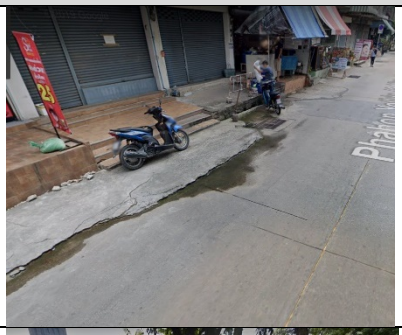
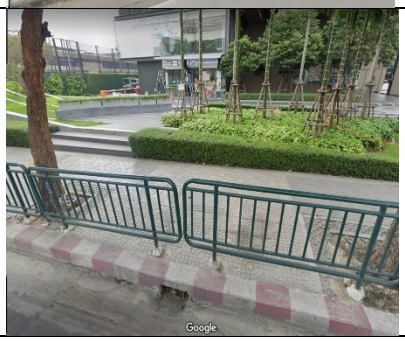
Table 3.1 Objective Evaluation Items

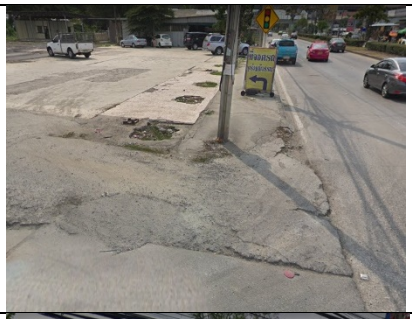
Evaluation items		Section Number				
		1	2	3	4	5
1. Sidewalk						
1.1	Separation of walkway and road					
2. Steps						
2.1	Number of steps in one section					
2.2	Height of the step					
3. Width of the walkway						
3.1	Walkway width					
4. Condition of surface						
4.1	Pavement surface material					
4.2	Damage condition of the pavement					
5. Obstacles						
5.1	Presence of permanent obstacles					
5.2	Presence of movable obstacles					
6. Cleanliness of the surface						
6.1	Cleanliness of walkway					
7. Dangerous spots						
7.1	Evaluate the condition of manhole cover					
7.2	Evaluate the condition of electrical wire above					
8. Street lights						
8.1	Evaluate the condition of street lighting					
9. Sign for pedestrians						
9.1	Evaluate the condition of pedestrian signage					
10. Greenery						
10.1	Evaluate the arrangement of trees/plants					
11. Street furniture						
11.1	Evaluate the condition of street furniture					
12. Attractiveness						
12.1	Evaluate the shopping opportunity					
12.2	Evaluate the liveliness of the environment					

13. Pollution						
13.1	Evaluate the exposure to traffic noise					
13.2	Evaluate the exposure to emission					

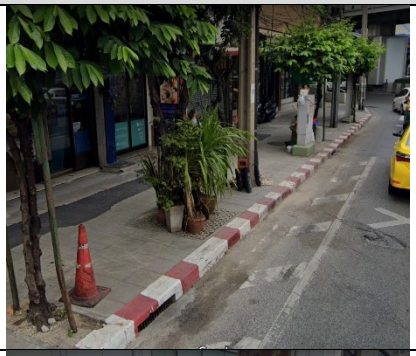
Guideline on how to rate each evaluation item is described in Table 3.2

Table 3.2 Walkway Rating Guideline for Field Surveyors

Item	Rating	Description	Example
1.1 Walkway separation	1	Not separated	
	2	Separated by white line	
	3	Separated by curb or fence	
	4	Sidewalk developed	
2.1 Number of steps	1	Having several steps	
	2	Having only 2 steps	
	3	Having 1 step	
	4	No step	

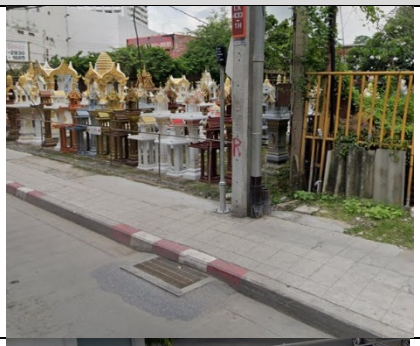
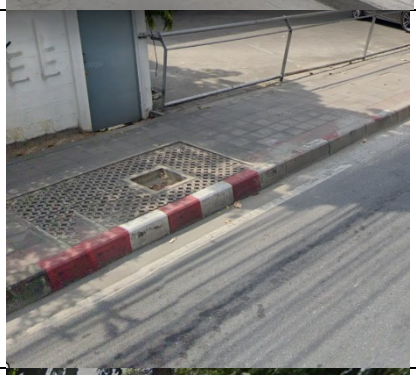
Item	Rating	Description	Example
2.2 Height of steps	1	H >17cm	
	2	5cm ≤ H < 17cm	
	3	H ≤ 5cm	
	4	No step	
3.1 Sufficient width	1	W < 2.0m	
	2	2.0m ≤ W < 2.5m	
	3	2.5m ≤ W < 3.0m	
	4	W ≥ 3.0m	
4.1 Pavement material	1	Sidewalk is unpaved	
	2	A part of sidewalk is paved	
	3	Sidewalk is paved by concrete or asphalt	
	4	Sidewalk is paved by brick or tile	

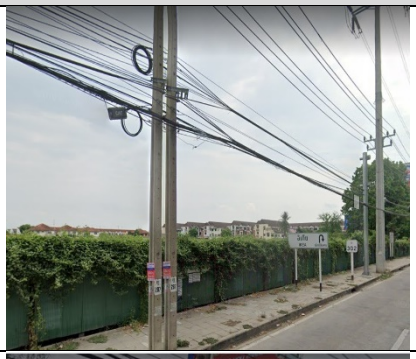
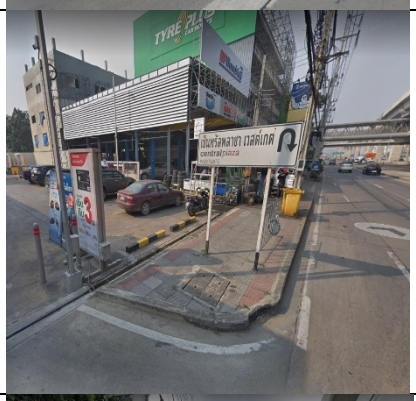
Item	Rating	Description	Example
4.2 Damage of surface	1	Overall sidewalk is severely damaged	
	2	Part of sidewalk is damaged	
	3	Cracks in the pavement on the sidewalk	
	4	There is no damage and crack	

Item	Rating	Description	Example
5.1 Permanent obstacles	1	Having many obstacles that cannot move	
	2	Having over 5 obstacles	
	3	Having 1-5 obstacles	
	4	No obstacle	

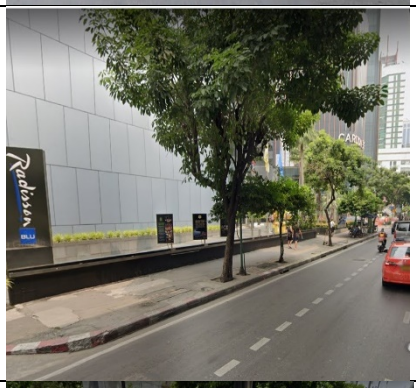
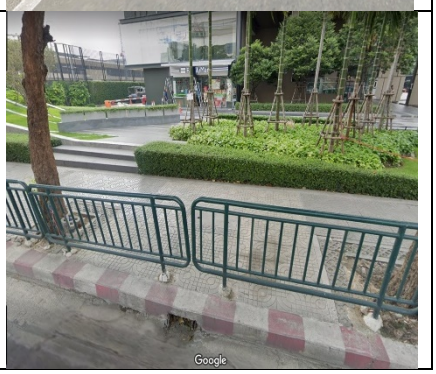
Item	Rating	Description	Example
5.2 Movable obstacles	1	Having many obstacles that cannot move	
	2	Having over 5 obstacles	
	3	Having 1-5 obstacles	
	4	No obstacle	

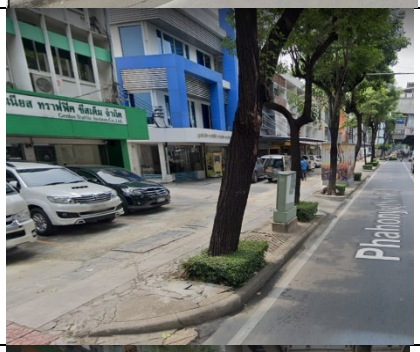
Item	Rating	Description	Example
6.1 Surface cleanliness	1	Having several trash or puddle and sidewalk is dirty	
	2	Having trash or puddle and sidewalk is dirty	
	3	No trash or puddle and sidewalk is still dirty	
	4	No trash or puddle and sidewalk is clean	
7.1 Manhole condition	1	Manhole covers are open	

Item	Rating	Description	Example
	2	Manhole covers are float up	
	3	Manhole is stored	
	4	Manhole is built in	
7.2 Electric wire condition	1	Electric wires are hanging down	
	2	Electric wires are rolled up	

Item	Rating	Description	Example
	3	Electric wires are stored in the cover	
	4	Electric wires are fixed overhead and not existed on the sidewalk	
8.1 Street lights	1	There is no streetlamp	
	2	There is only sign for car	

Item	Rating	Description	Example
	3	There are several streetlamps but arranged disorderly.	
	4	There are several streetlamps but arranged a certain interval.	
9.1 Pedestrian signage or marking	1	There is no sign.	
	2	There is only sign for car.	
	3	There are both signs but more car signs.	

Item	Rating	Description	Example
	4	There are both signs but more pedestrian signs.	
10.1 Greenery	1	Having high trees and do not disturb pedestrian.	
	2	Having a space for pedestrian to walk beside of plants.	
	3	Plants are arranged with fixed space.	

Item	Rating	Description	Example
	4	Type of plants are unified.	
11.1 Street furniture	1	Car can stop, plants as a bench.	
	2	Bus stop, bench, signs are harmony in colors.	
	3	Having characteristics of street furniture.	

Item	Rating	Description	Example
	4	Having facility considered for the elderly or wheelchair, handicapped.	

3.2 Walkability Evaluation Result

This section presents the evaluation of objective walkability at selected 25 stations of 3 railway lines in Bangkok, namely purple, blue and green lines. For each station, at least 5 representative points are selected, of which the walkability is evaluated. The result is shown in Table 3.3 where the maximum, minimum, and average values are calculated. For ease of comparison, these values are compared by graph as shown in Figure 3.1. It is obvious that the walkability values vary considerably at different locations. Although the average values are not very different, the standard deviations are relatively large. This is because the walkability along the small road is usually smaller than that of the main road.

Table 3.3 Walkability at Selected Stations

Line	Station	max	min	avg	s.d.
Purple Line	Khlong Bang Phai	3.05	2.02	2.59	0.41
	Talad Bang Yai	3.28	2.83	3.00	0.16
	Sam Yaek Bang Yai	3.45	2.03	2.76	0.55
	Bang Phlu	3.62	2.83	3.16	0.26
	Bang Rak Yai	3.57	1.99	2.64	0.68
	Bang Rak Noi Tha It	3.50	2.01	2.70	0.56
	Sai Ma	3.09	2.32	2.73	0.32
	Phra Nangklao Bridge	3.36	2.05	2.78	0.58
	Yaek Nonthaburi 1	3.53	2.12	2.74	0.63
	Bang Krasor	3.22	2.01	2.85	0.44
	Nonthaburi Civic Centre	3.22	2.01	2.64	0.49
	Ministry of Public Health	3.37	2.05	2.87	0.53

Line	Station	max	min	avg	s.d.
	Yaek Tiwanon	3.60	1.98	2.76	0.68
	Wong Sawang	3.65	2.13	2.99	0.65
	Bang Son	3.82	1.91	2.69	0.90
	Tao Poon	3.36	2.10	3.02	0.47
Green Line	Sena Nikhom	3.60	2.12	2.76	0.66
	Kasetsart University	3.82	2.01	3.16	0.65
	Ratchayothin	3.65	2.13	2.91	0.63
	Bangbua	3.36	2.10	3.02	0.47
Blue Line	Bang Pho	3.05	2.02	2.59	0.41
	Tha Phra	3.28	2.83	3.00	0.16
	Phasi Chareon	3.45	2.03	2.76	0.55
	Phra Rama 9	3.62	2.83	3.16	0.26
	Yeak Fai Chai	3.57	1.99	2.64	0.68

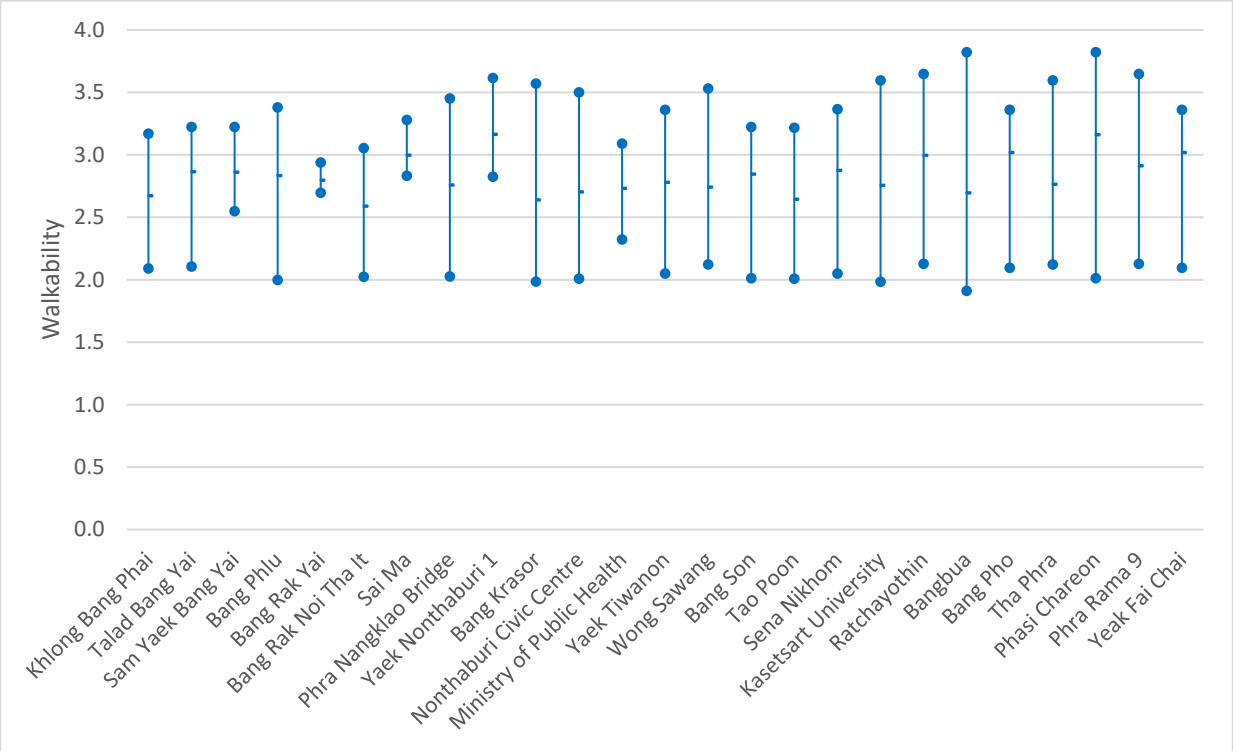


Figure 3.1 Walkability Ranges of Selected Stations

3.3 Walkability at 16 Purple Line Stations

For all 16 stations of the purple line, walkability around the stations is evaluated. For illustration purpose, the average value of walkability at each station is shown in Figure 3.2. More detail of each station will be presented next.

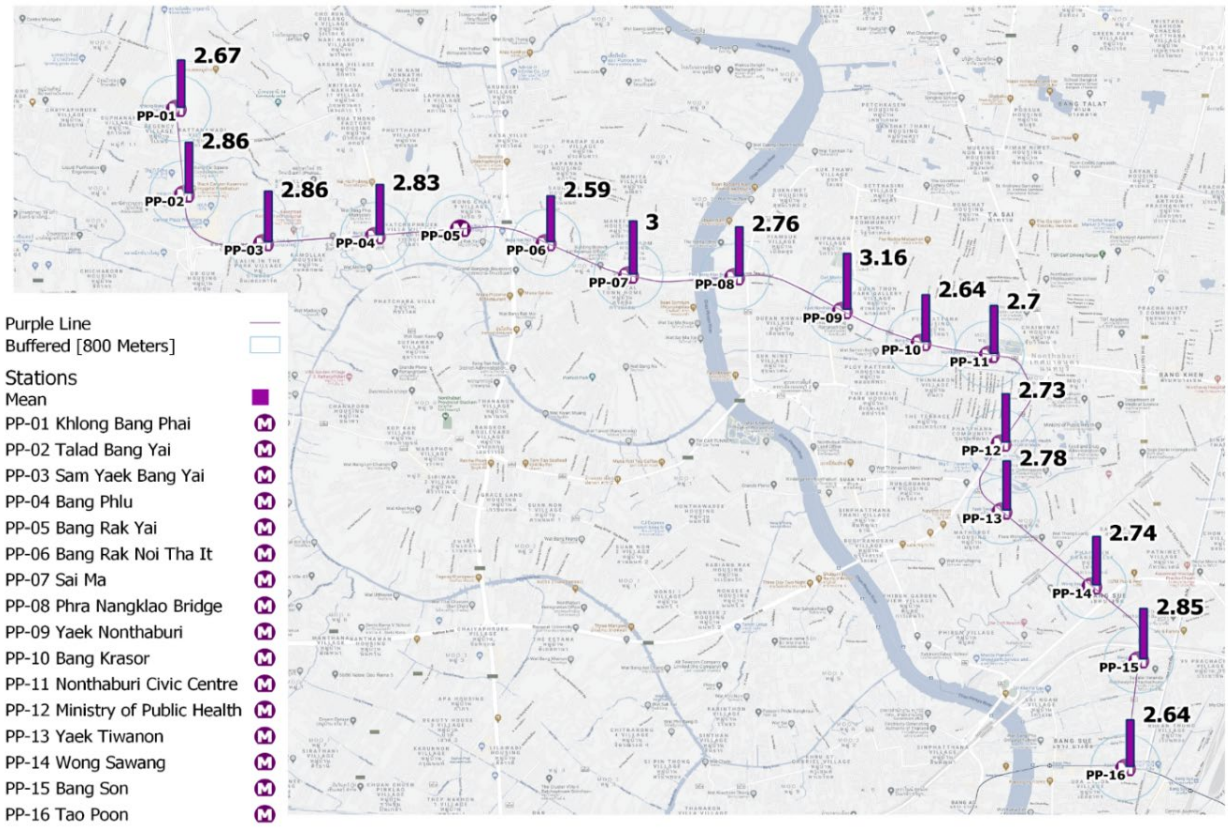
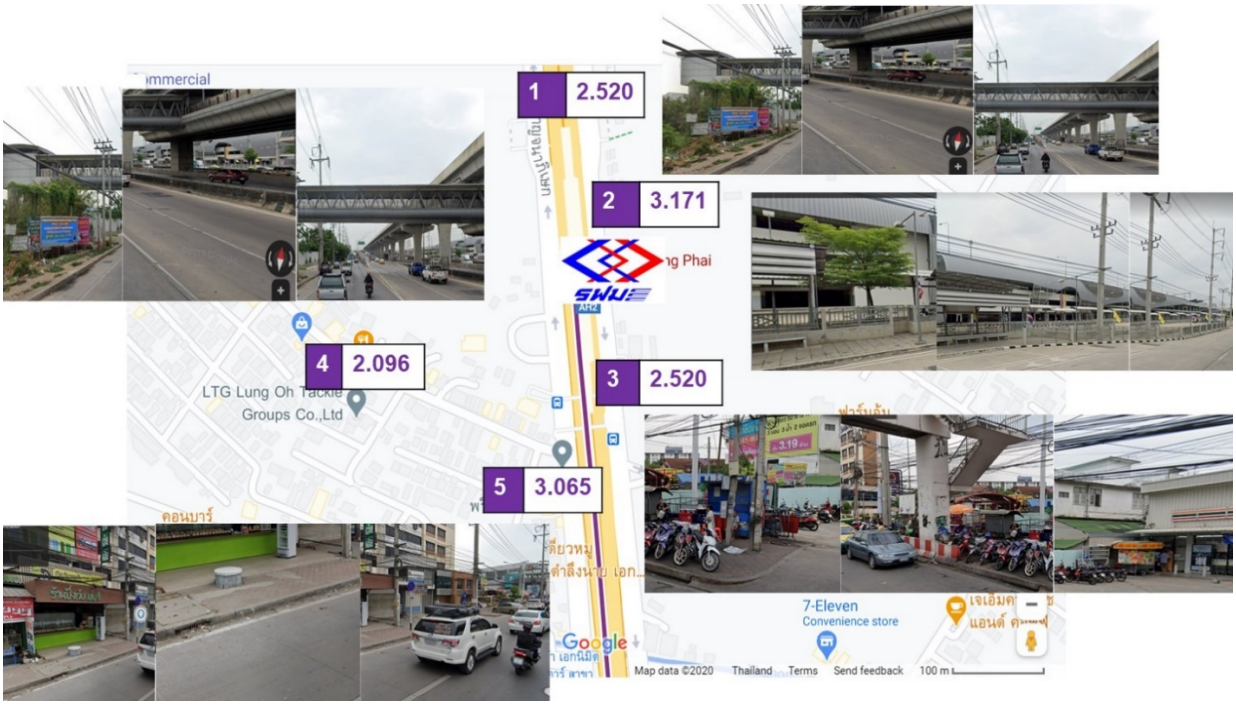


Figure 3.2 Walkability around 16 MRT Purple Line Stations

3.3.1 Khlong Bang Phai Station (PP01)

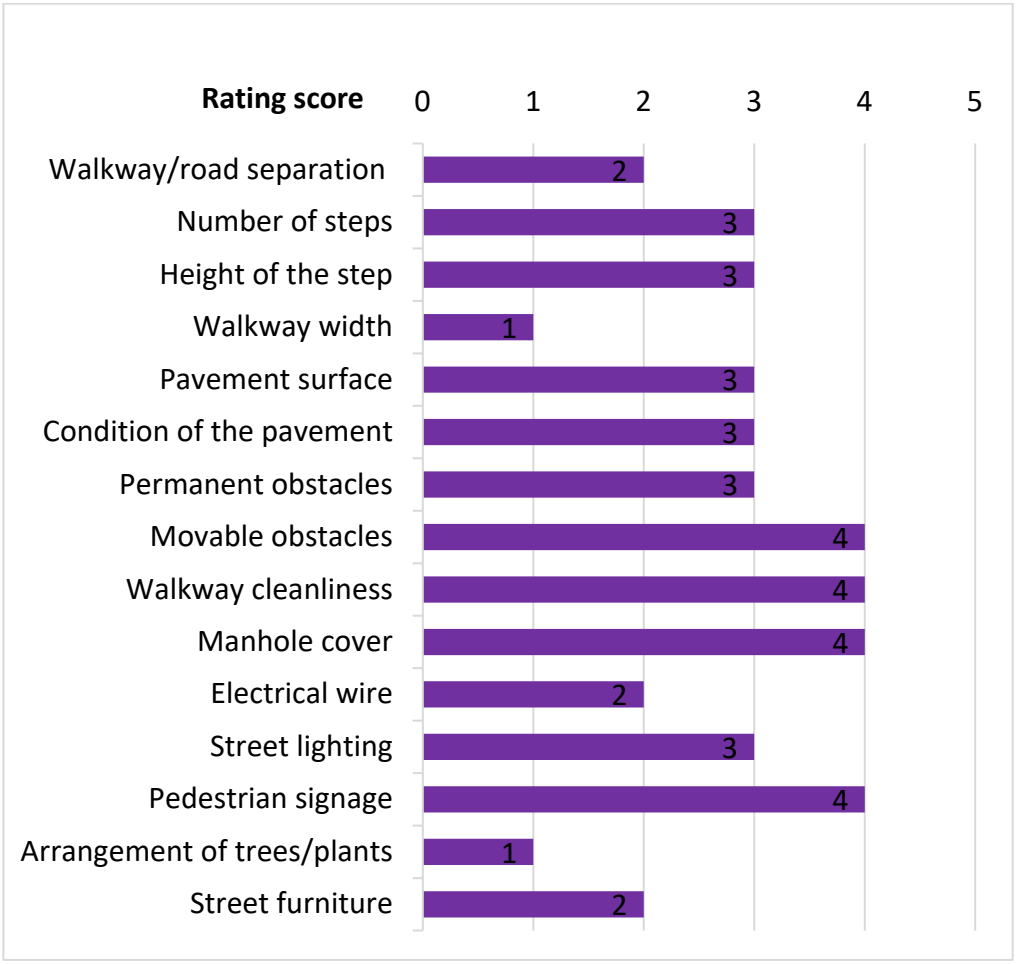


Location PP01-1

Walkability Index	2.520



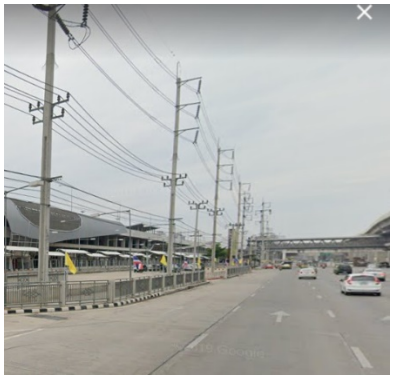


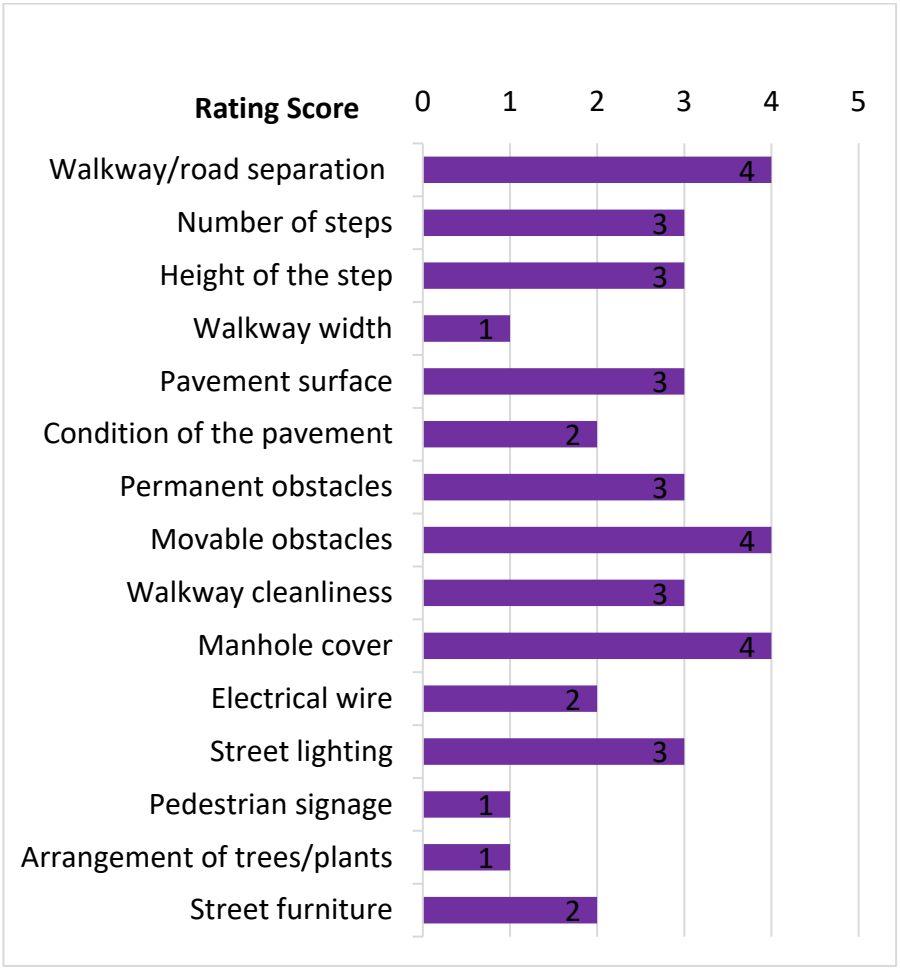


Location PP01-2

Walkability Index	3.171



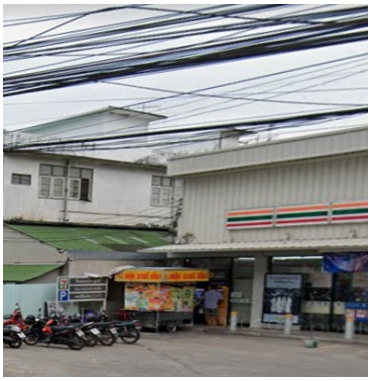


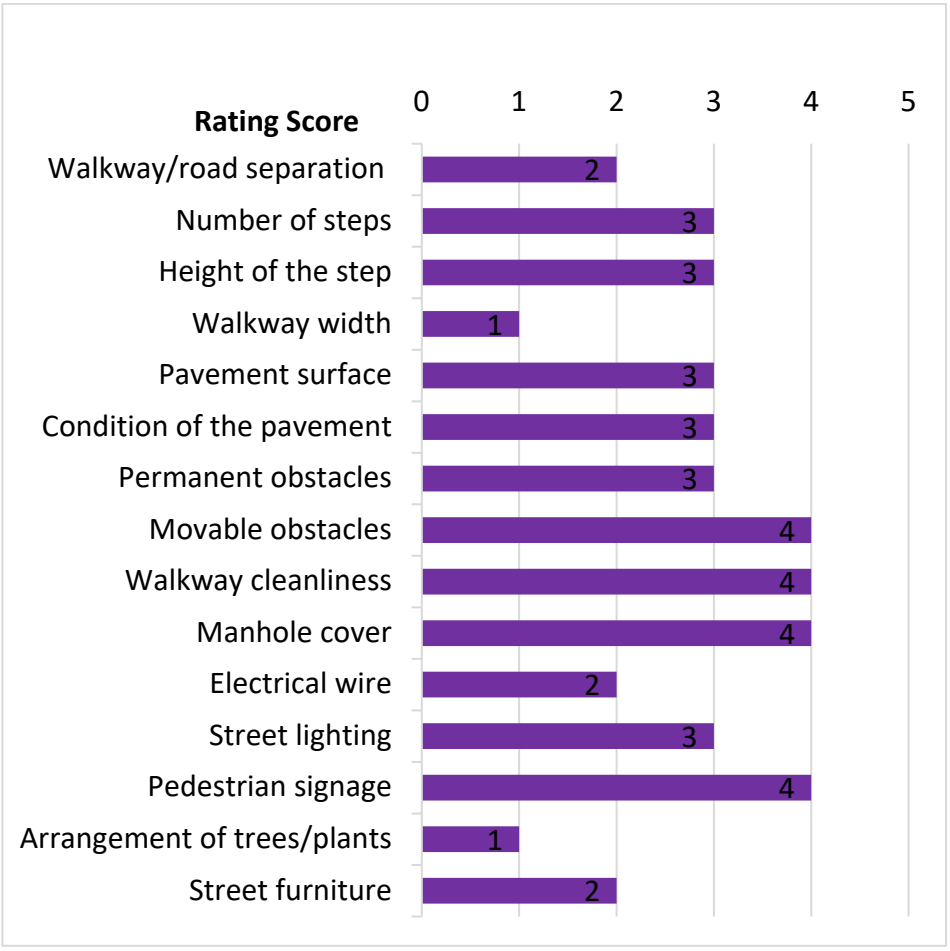


Location PP01-3

Walkability Index	2.520

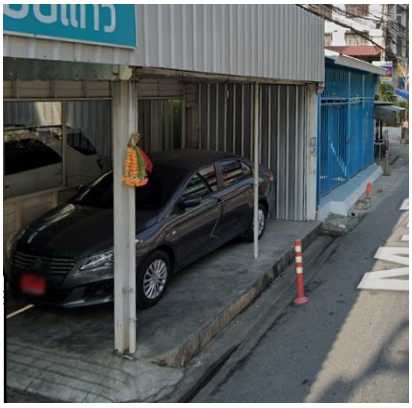


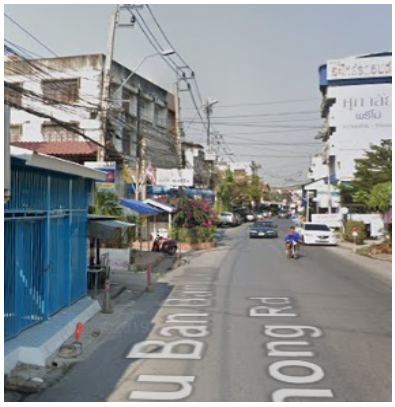




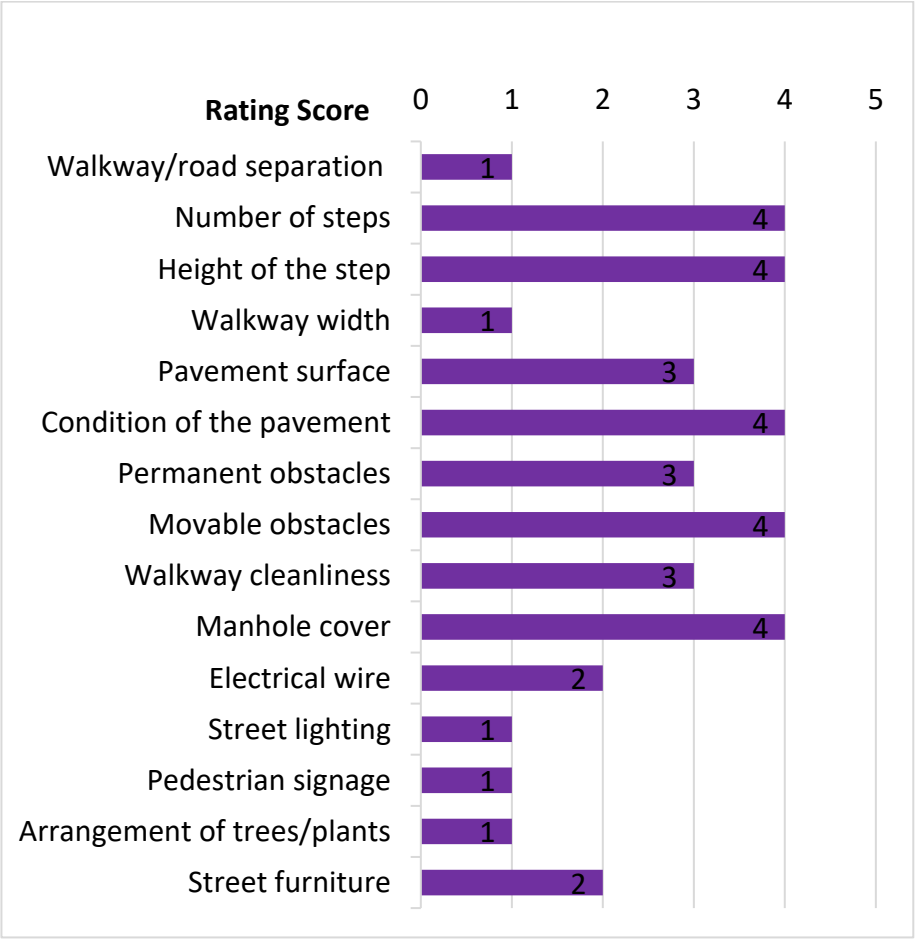
Location PP01-4

Walkability Index	2.096









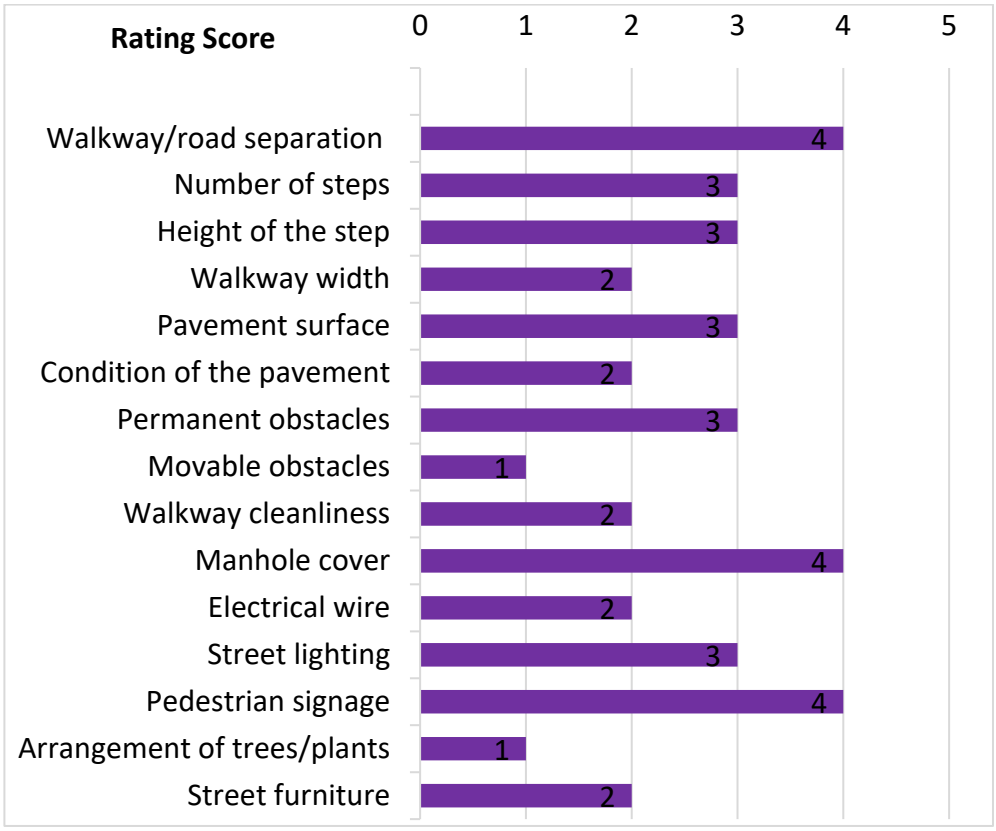
Location PP01-5

Walkability Index	3.065

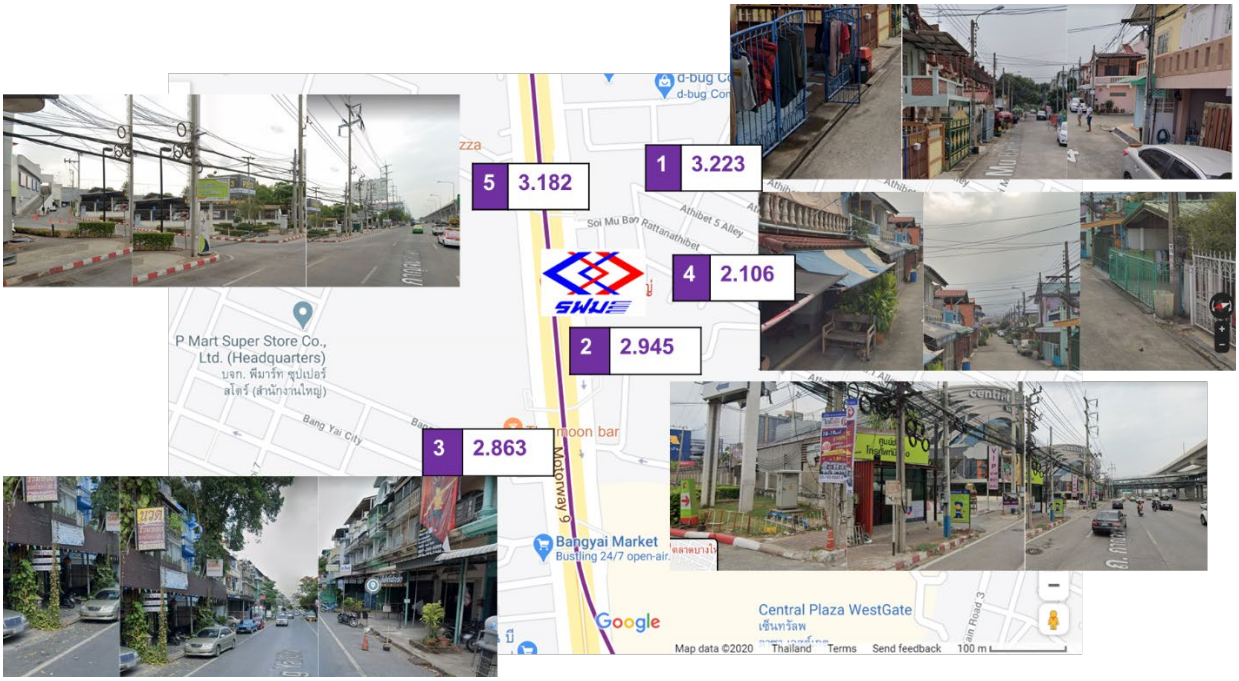






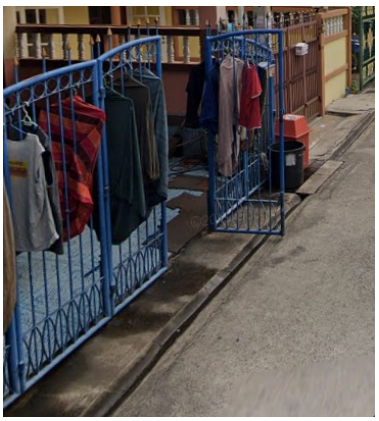


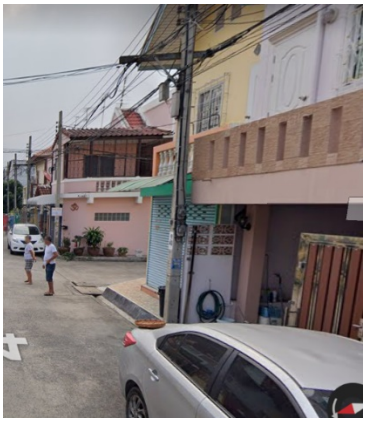
3.3.2 Talad Bang Yai Station (PP02)

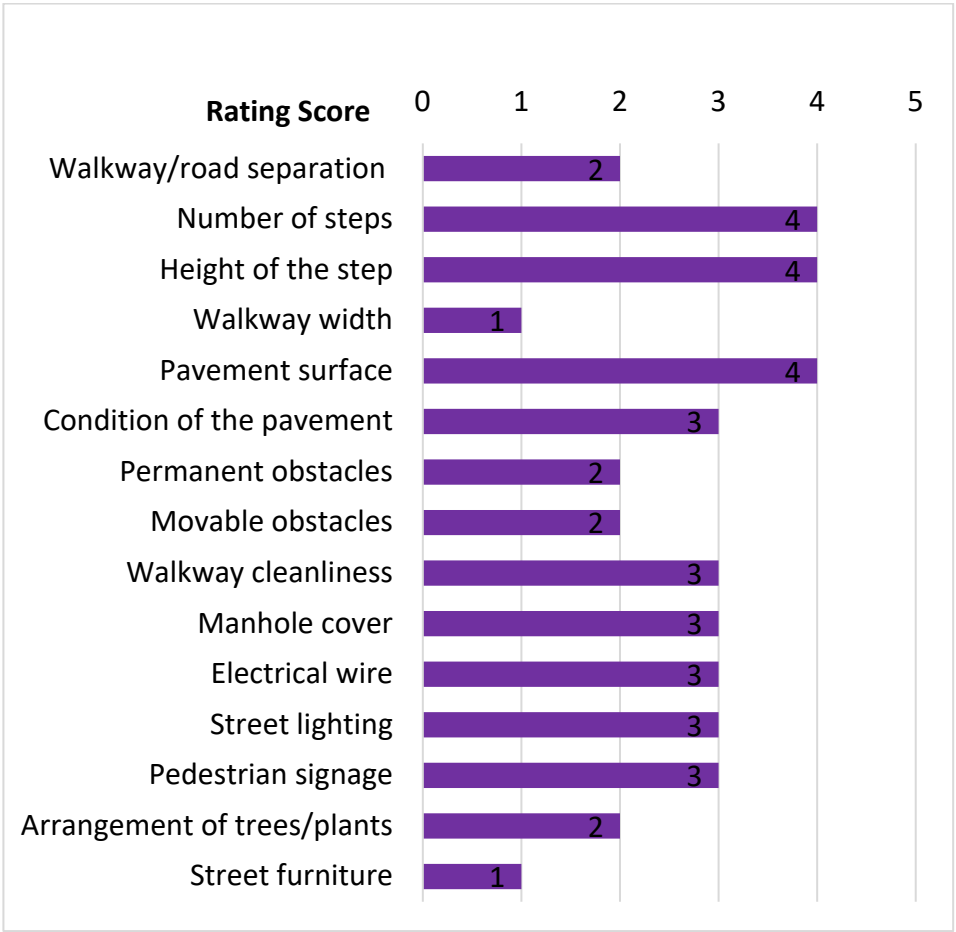


Location PP02-1

Walkability Index	3.223







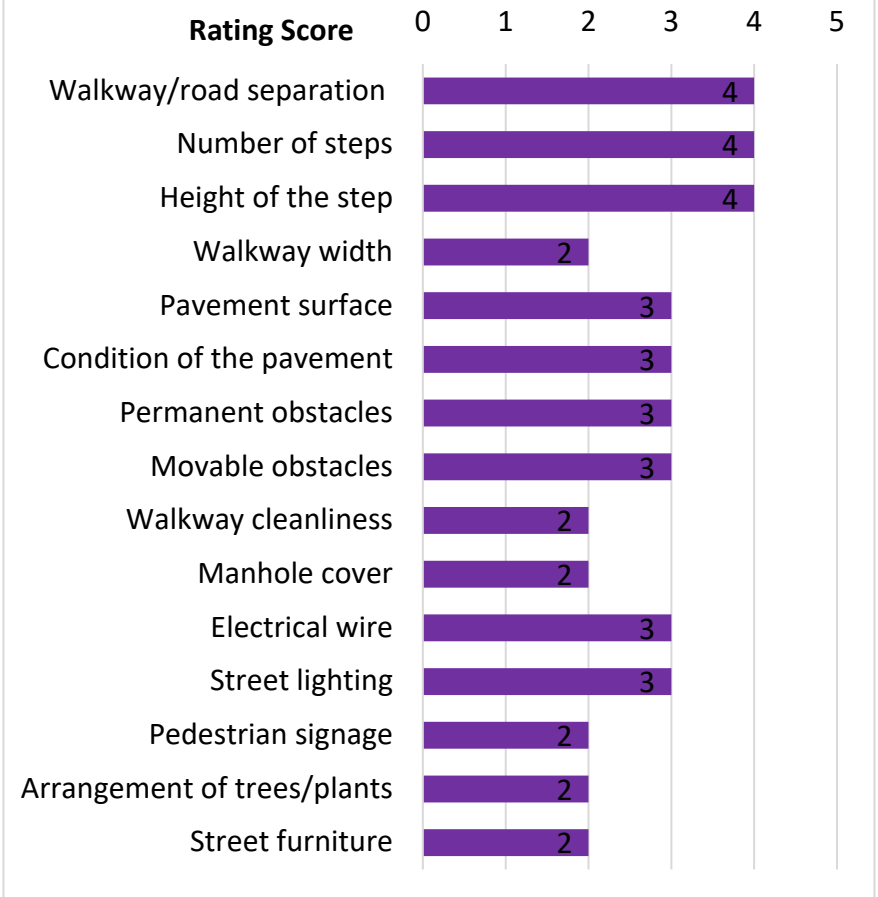
Location PP02-2

Walkability Index	2.945



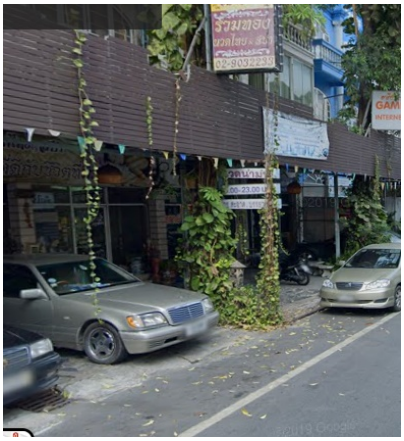
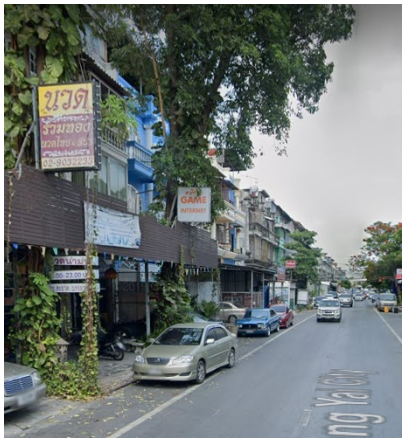


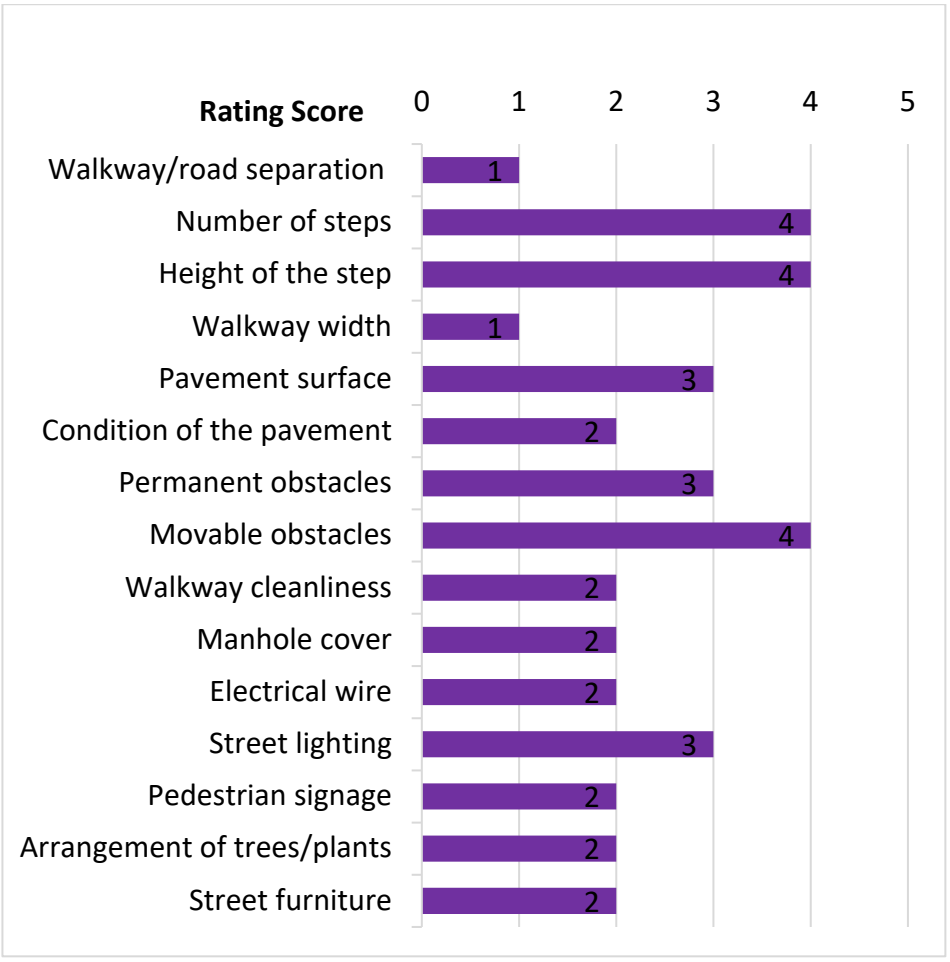




Location PP02-3

Walkability Index	2.863

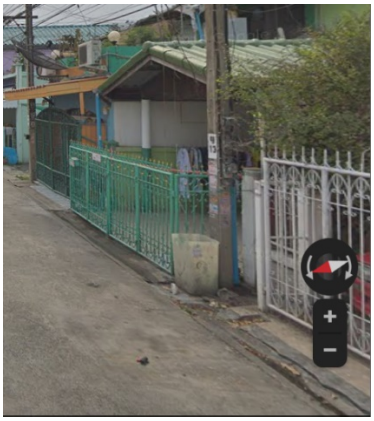



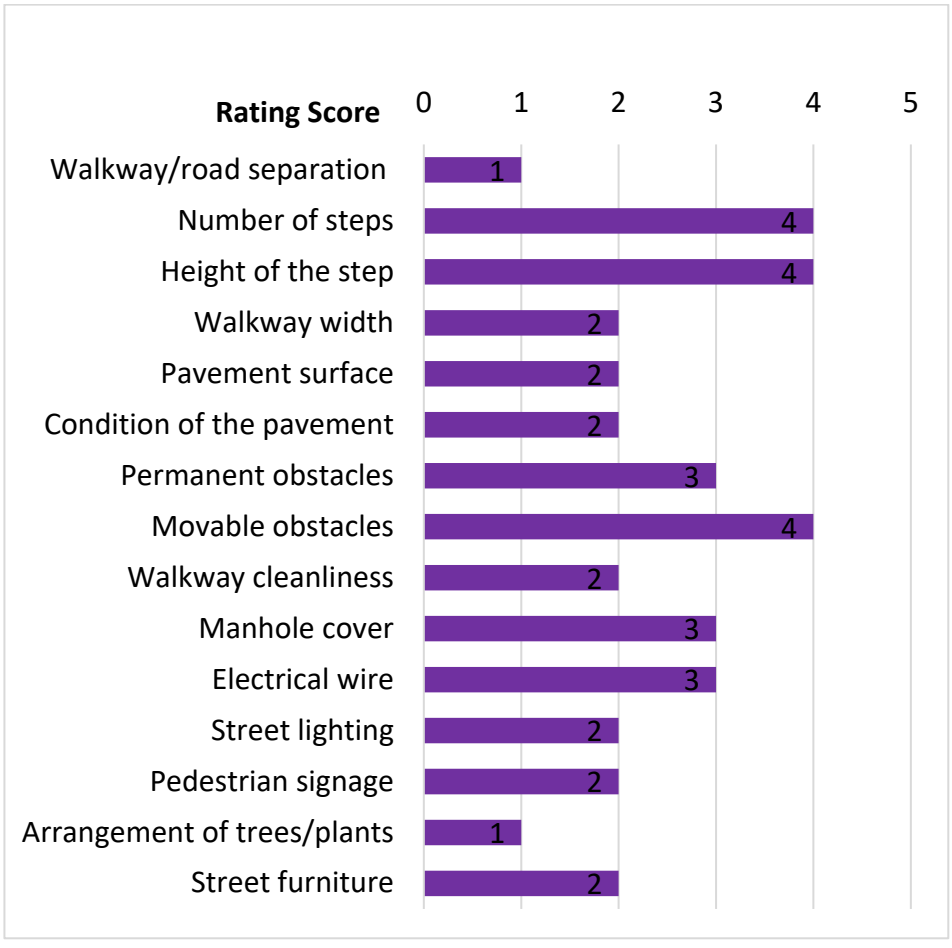



Location PP02-4

Walkability Index	2.106



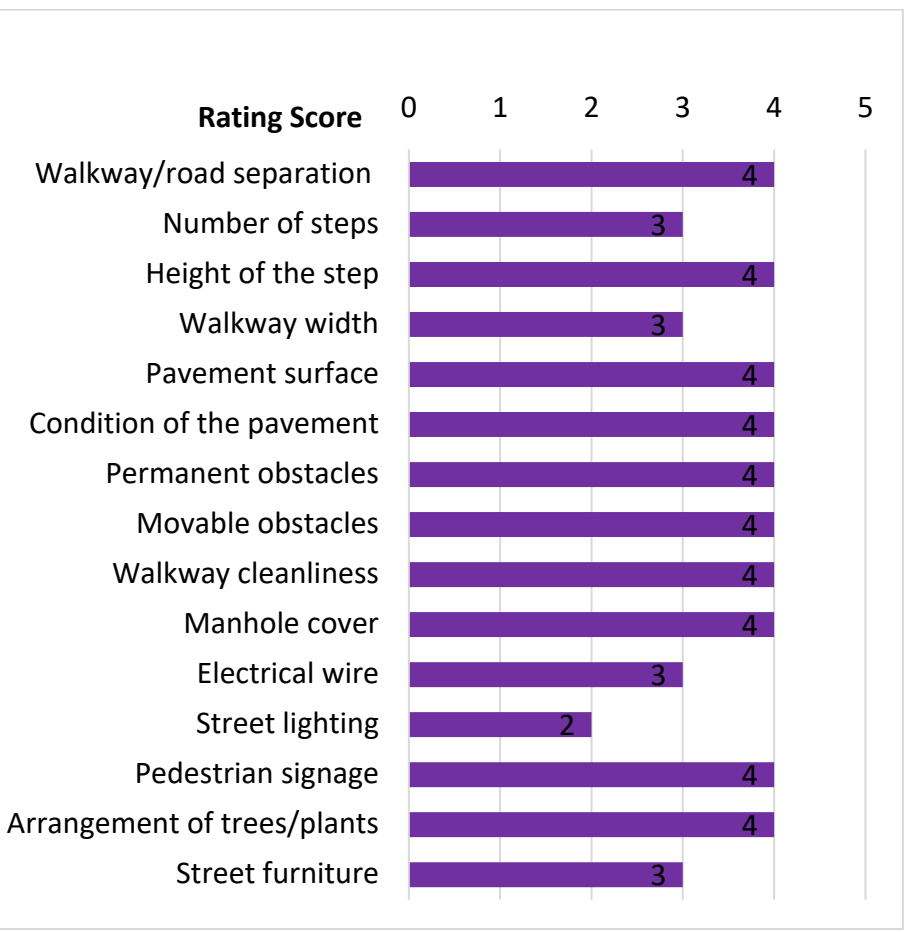




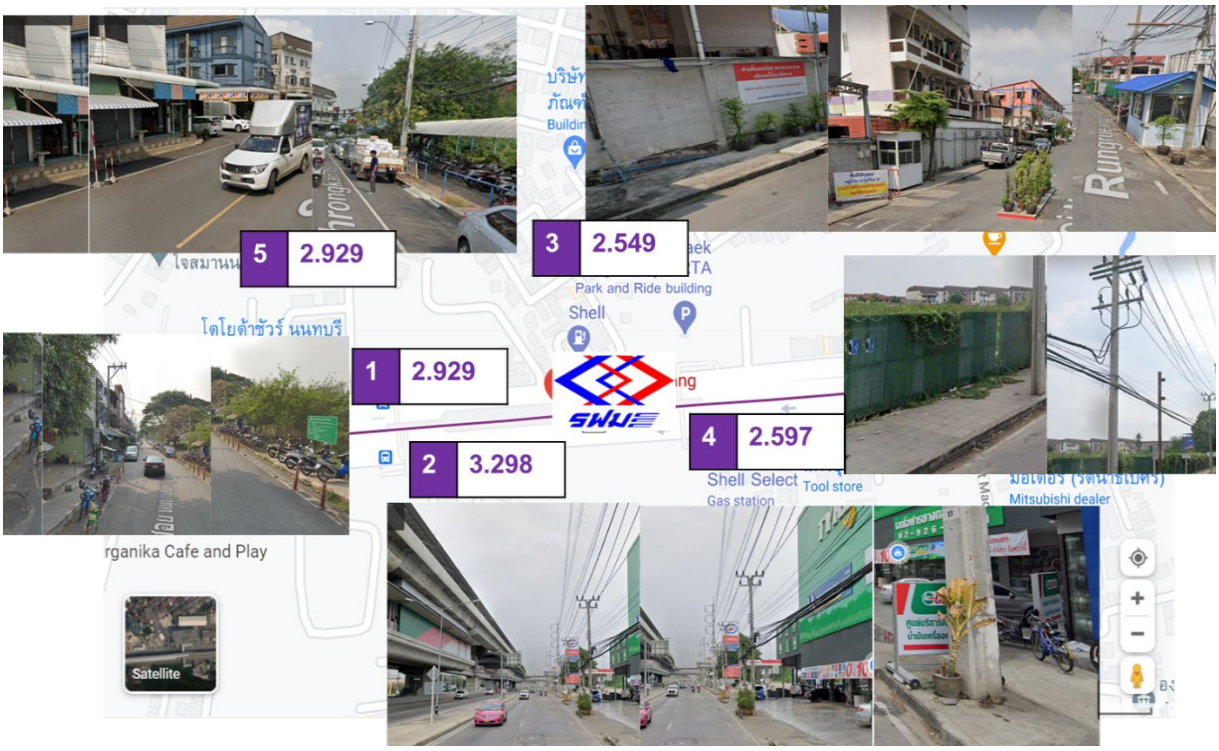
Location PP02-5

Walkability Index	3.182





3.3.3 Sam Yaek Bang Yai Station (PP03)



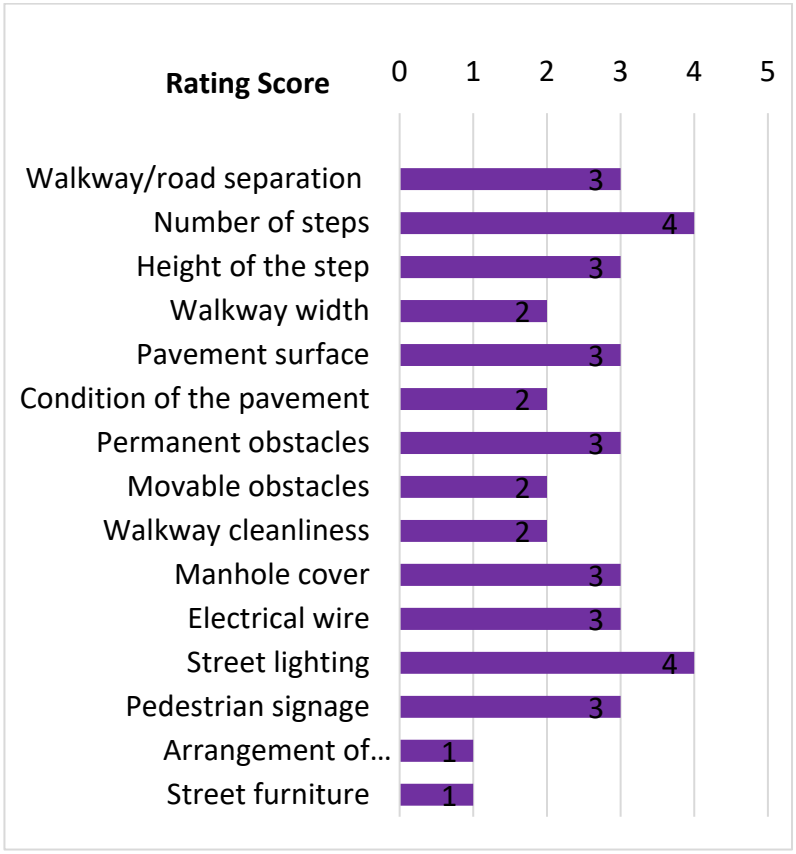
Location PP03-1

Walkability Index	2.929



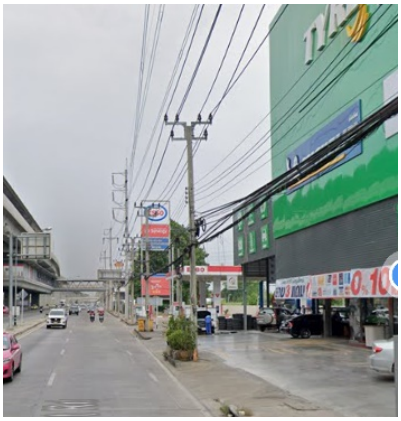


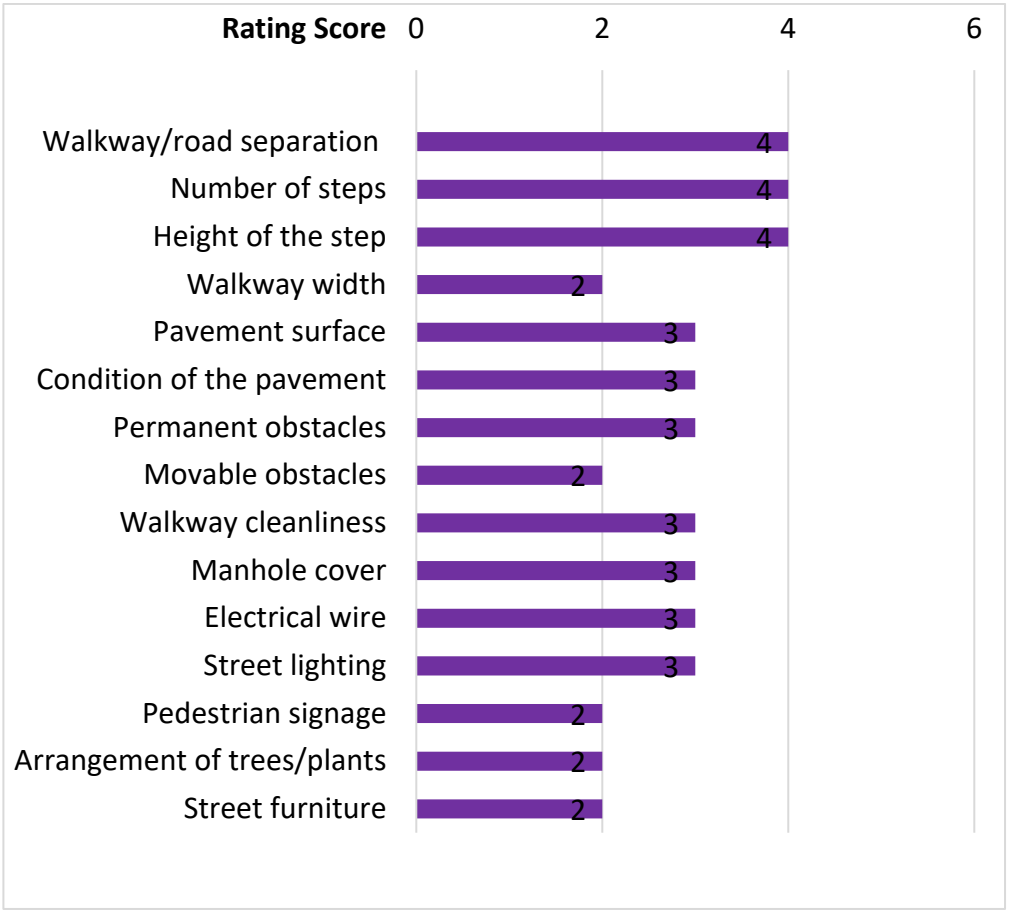




Location PP03-2

Walkability Index	3.298

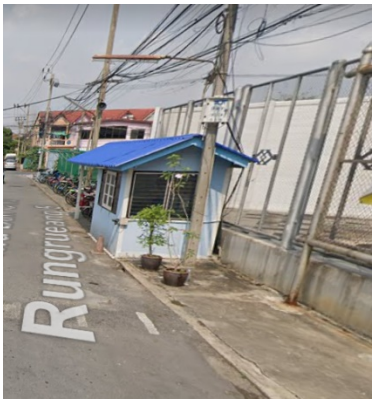



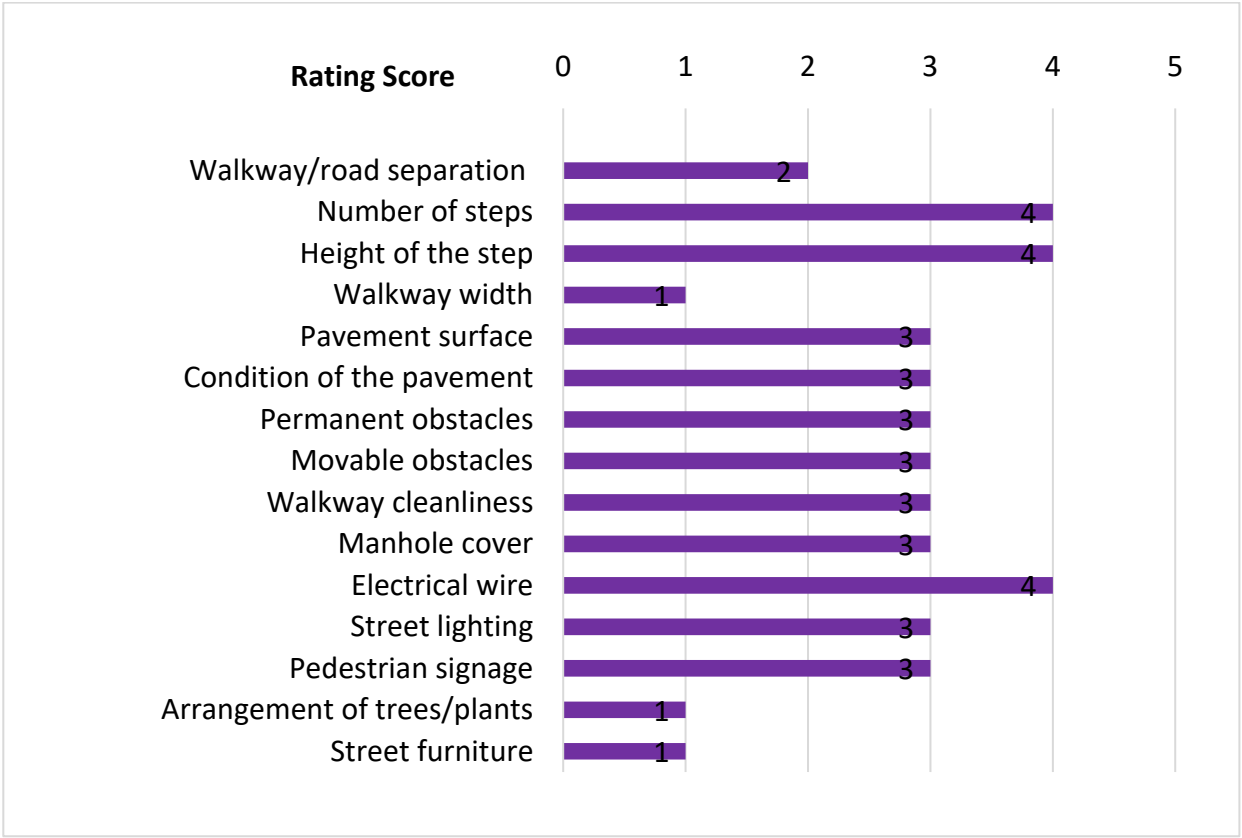



Location PP03-3

Walkability Index	2.549

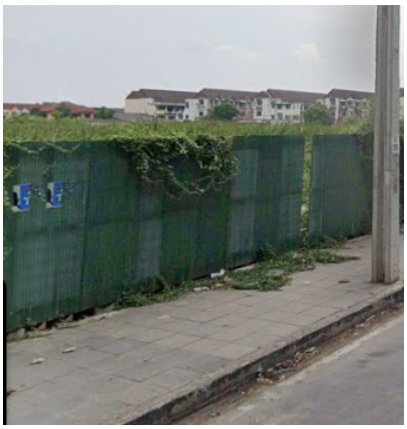




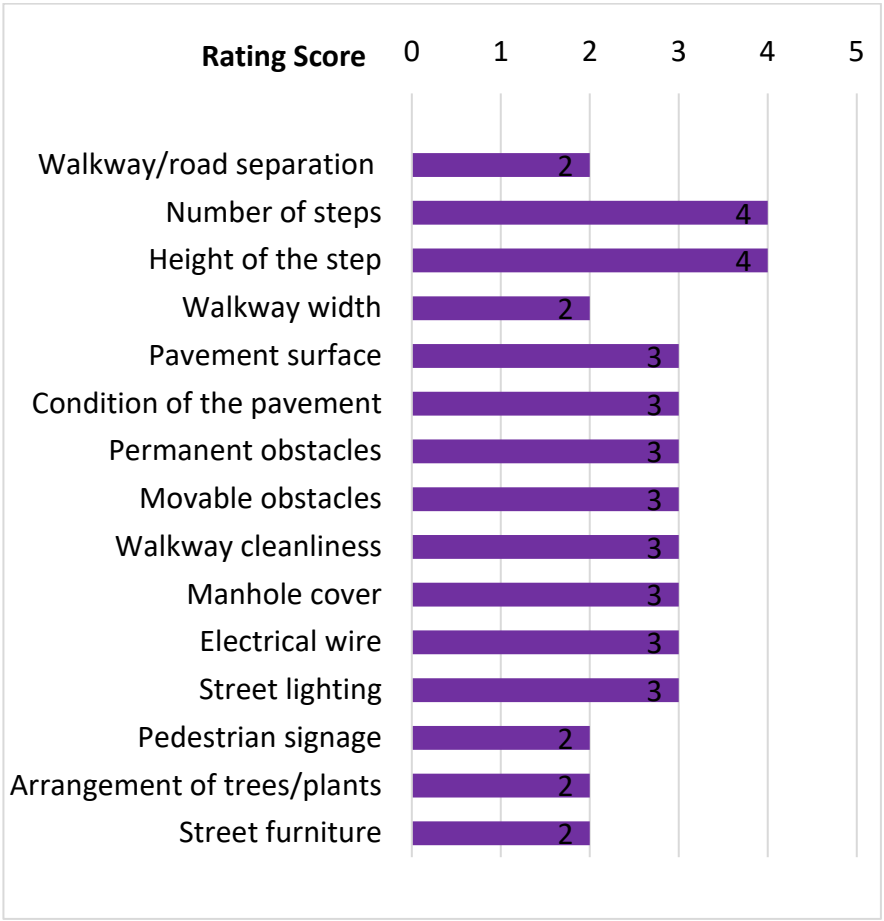


Location PP03-4

Walkability Index	2.597







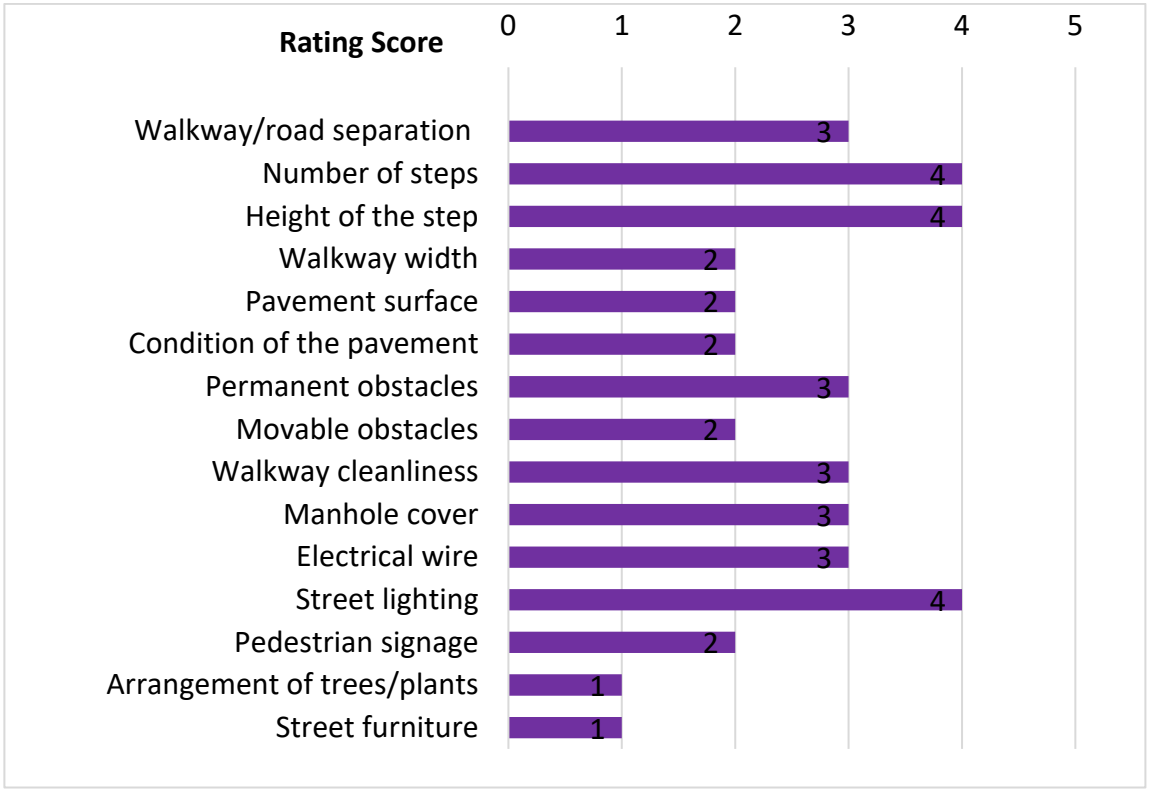
Location PP03-5

Walkability Index	2.929







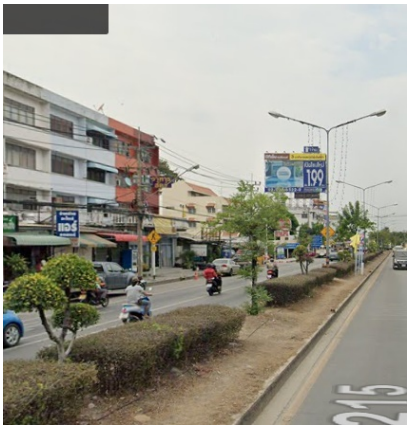


3.3.4 Bang Phlu Station (PP04)

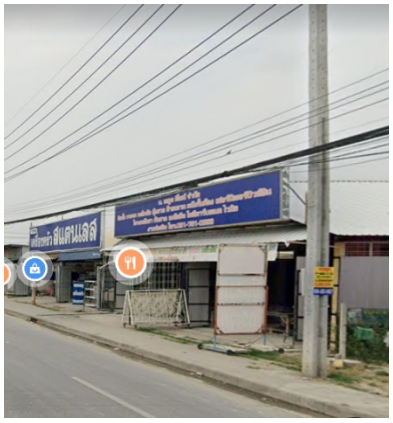


Location PP04-1

Walkability Index	2.855





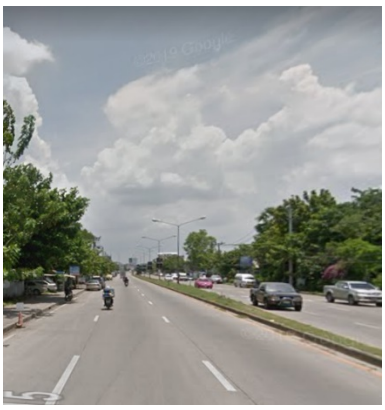


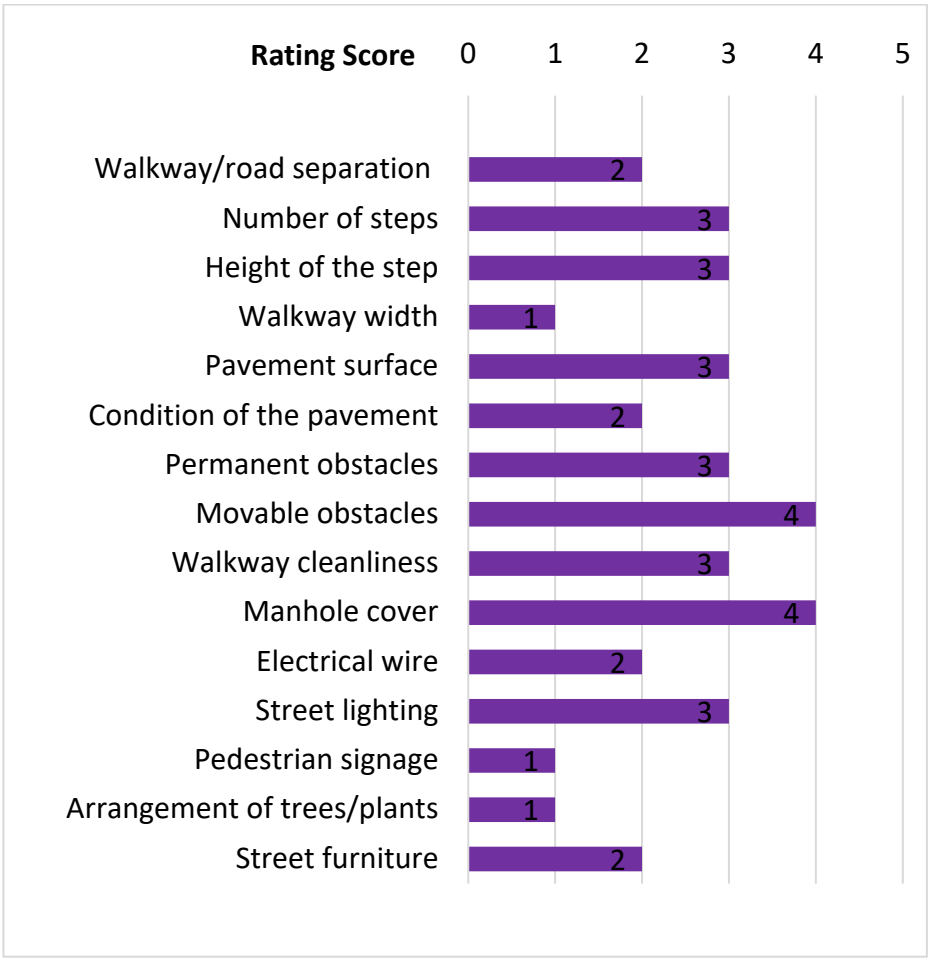


Location PP04-2

Walkability Index	2.447

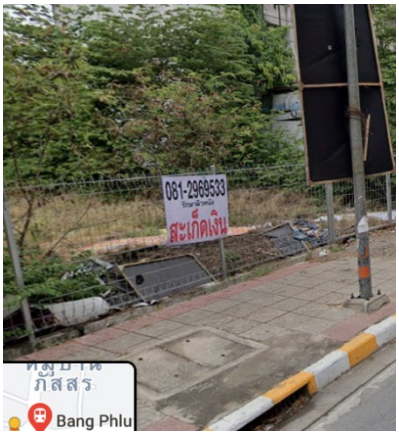


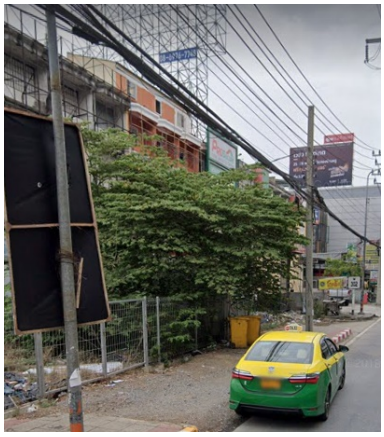




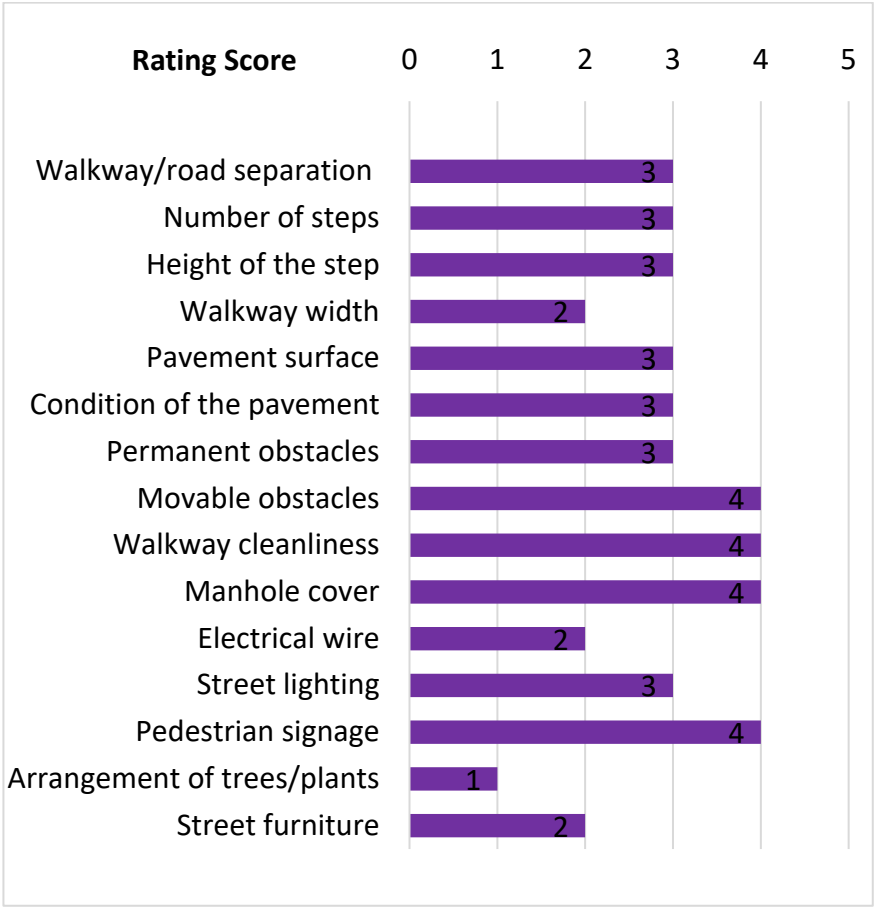
Location PP04-3

Walkability Index	2.989









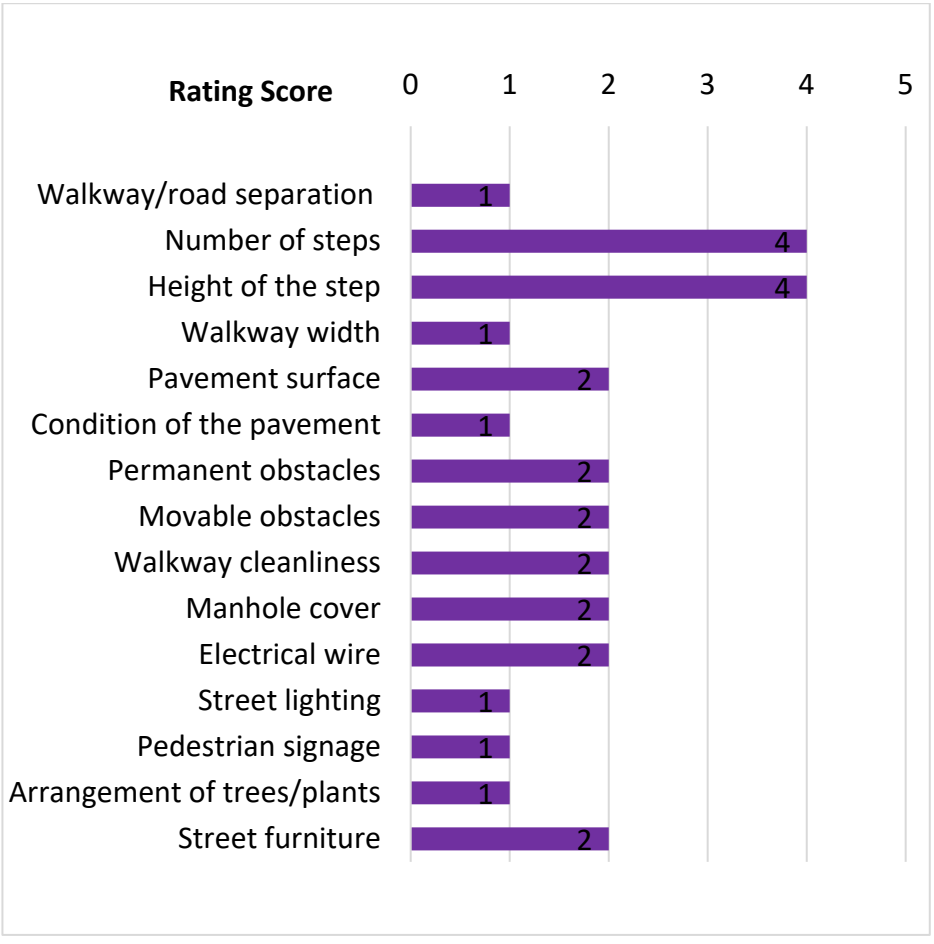
Location PP04-4

Walkability Index	1.998







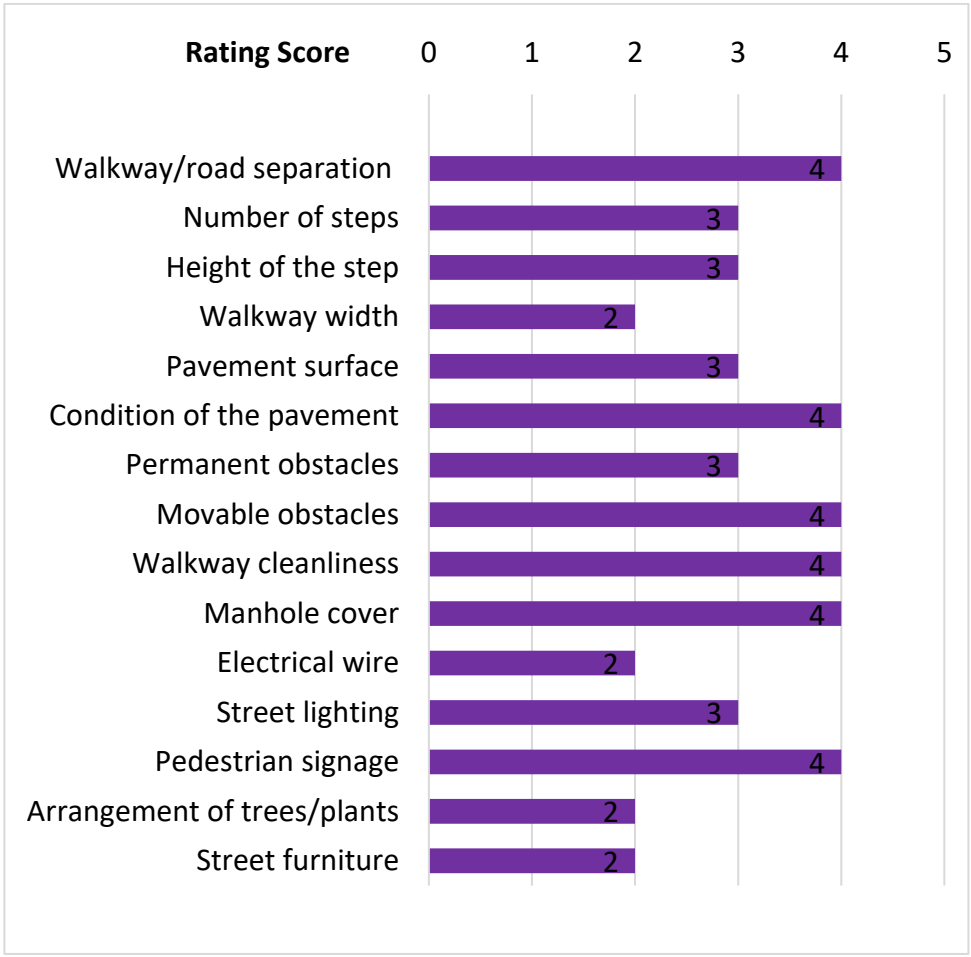


Location PP04-5

Walkability Index	3.378







Location PP04-6

Walkability Index	3.329





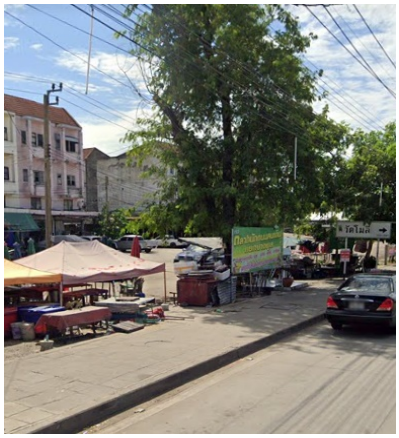


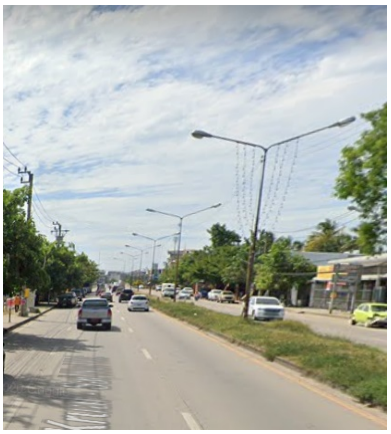


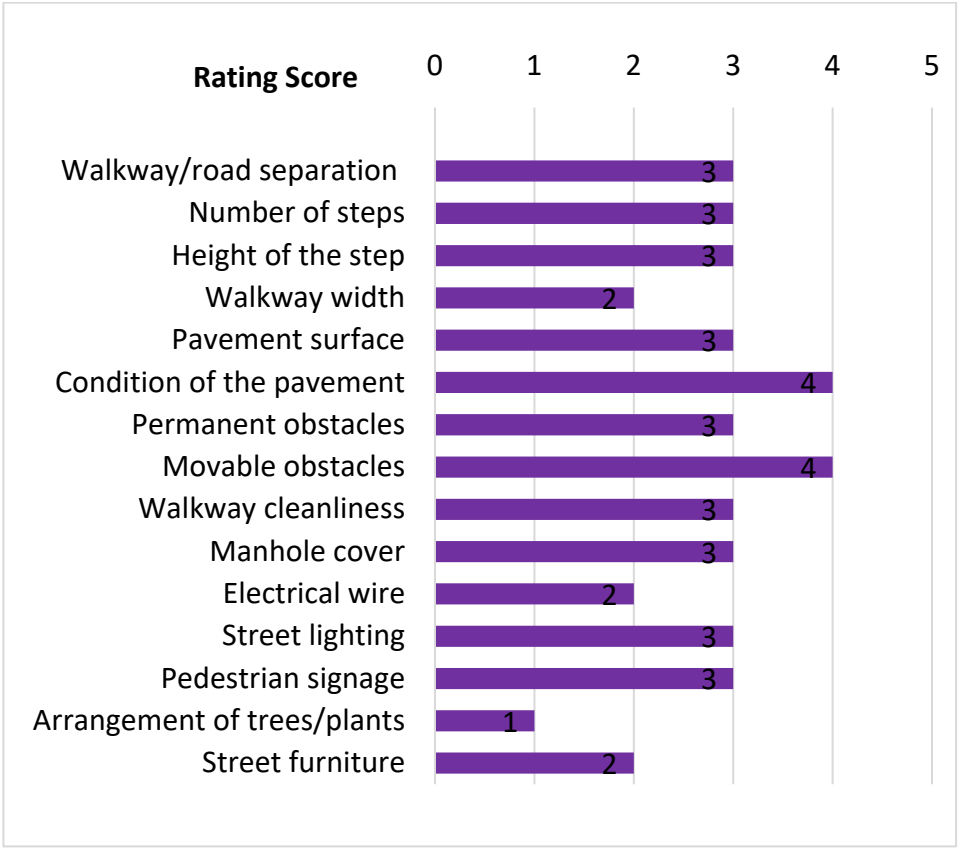
Location PP04-7

Walkability Index	3.834

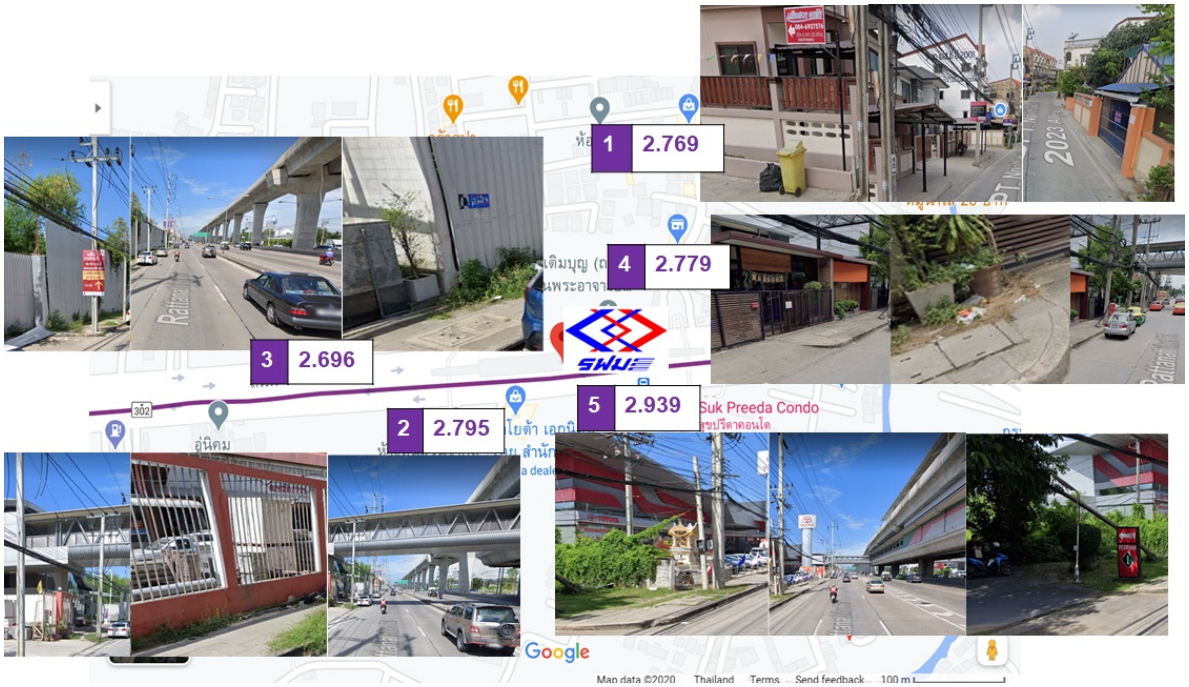








3.3.5 Bang Rak Yai Station (PP05)



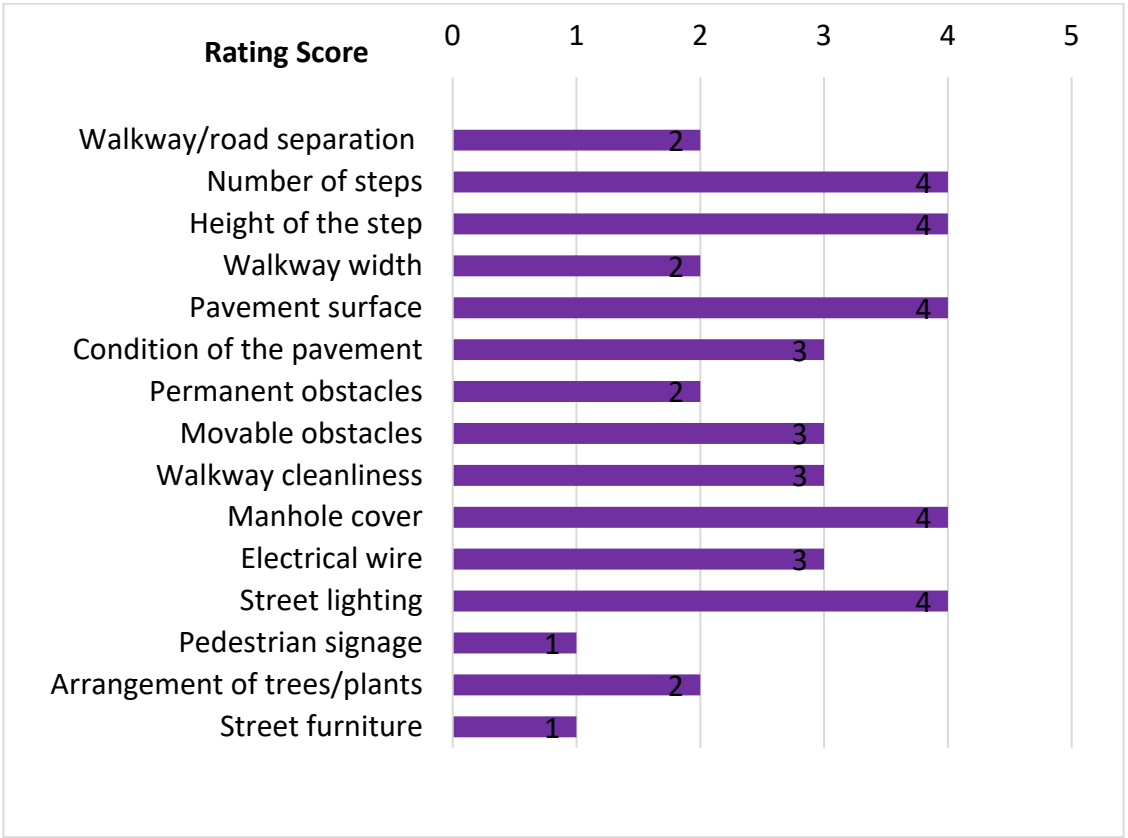
Location PP05-1

Walkability Index	2.769





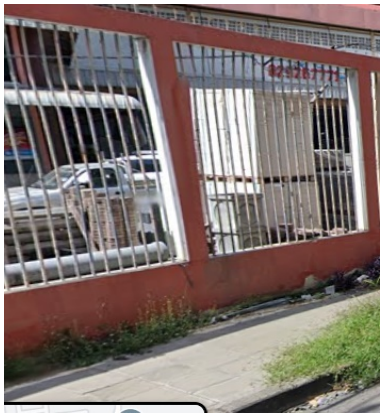




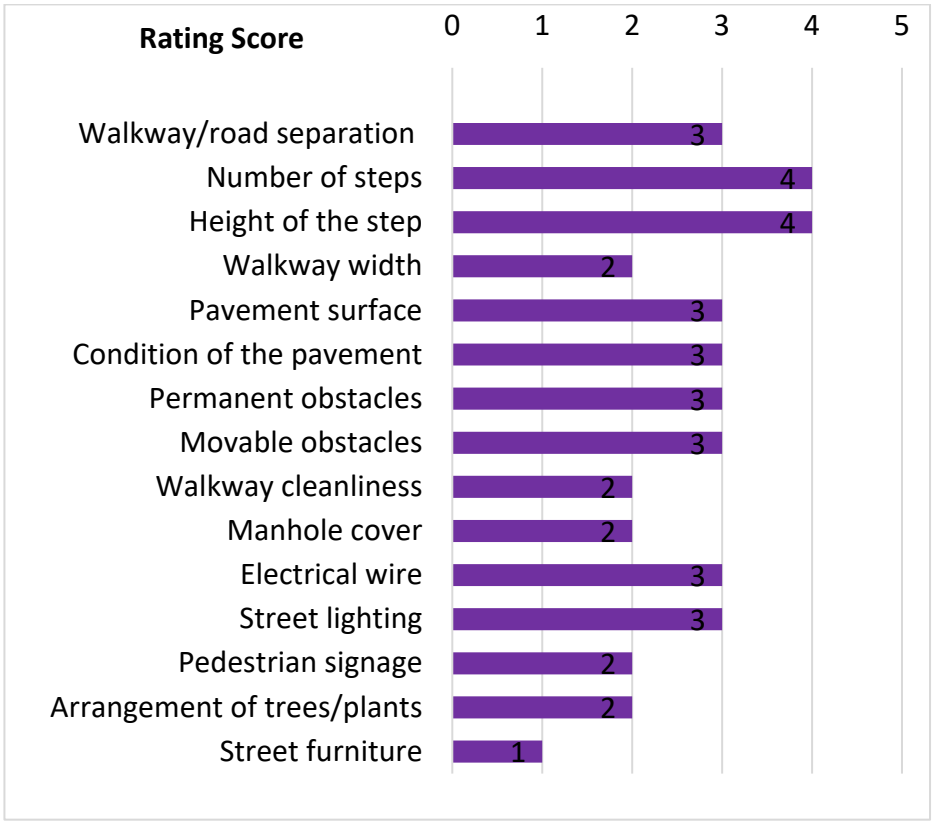
Location PP05-2

Walkability Index	2.795







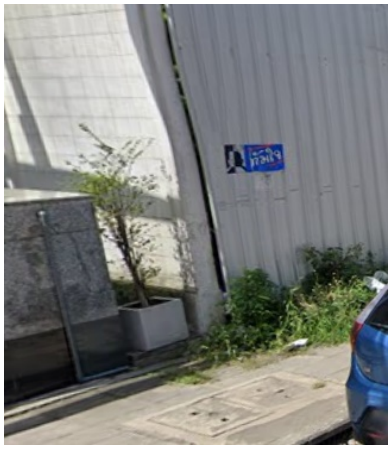


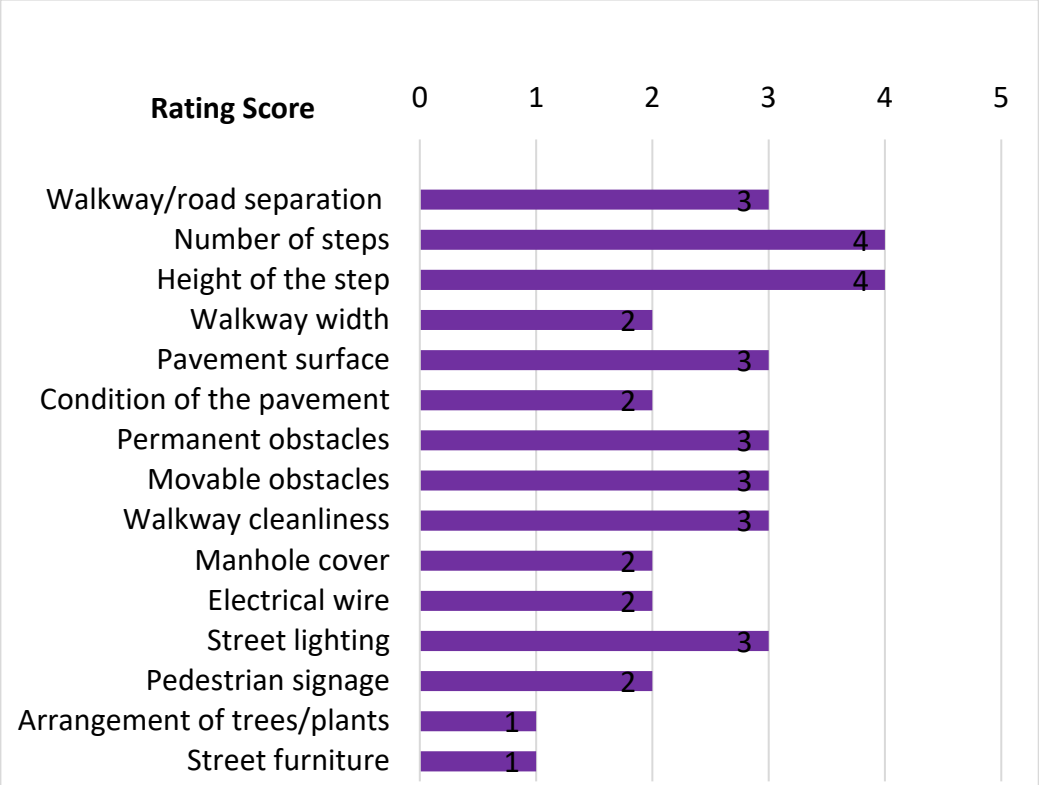
Location PP05-3

Walkability Index	2.696



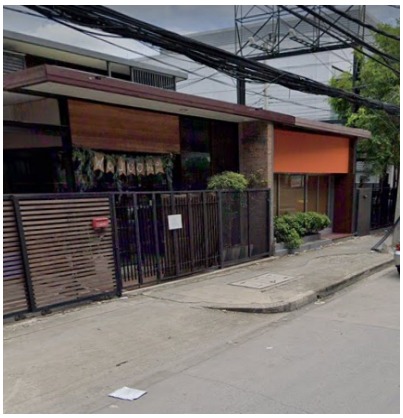






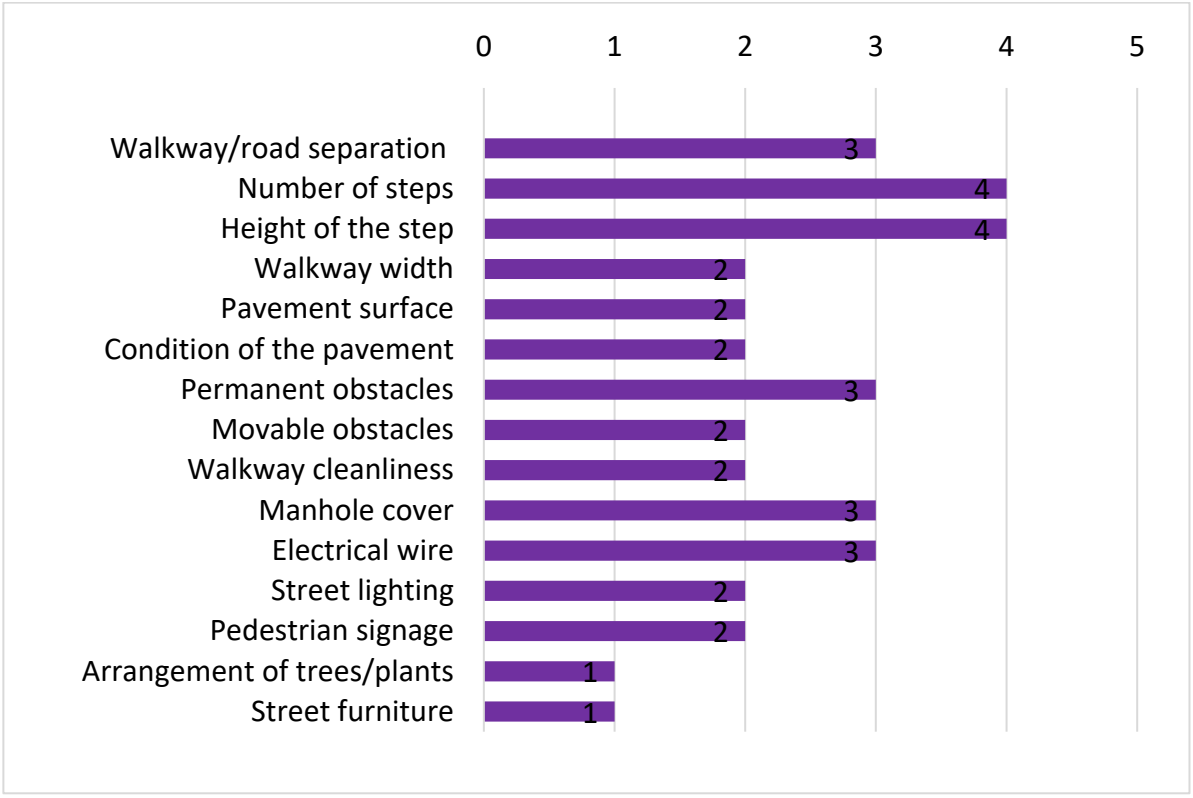
Location PP05-4

Walkability Index	2.779



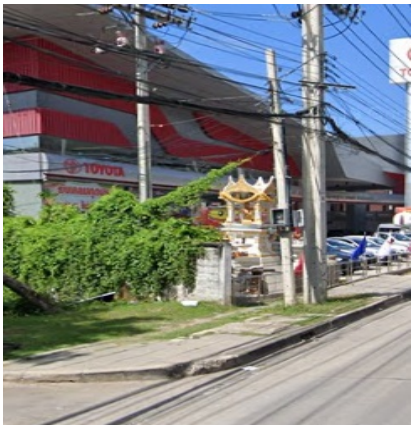




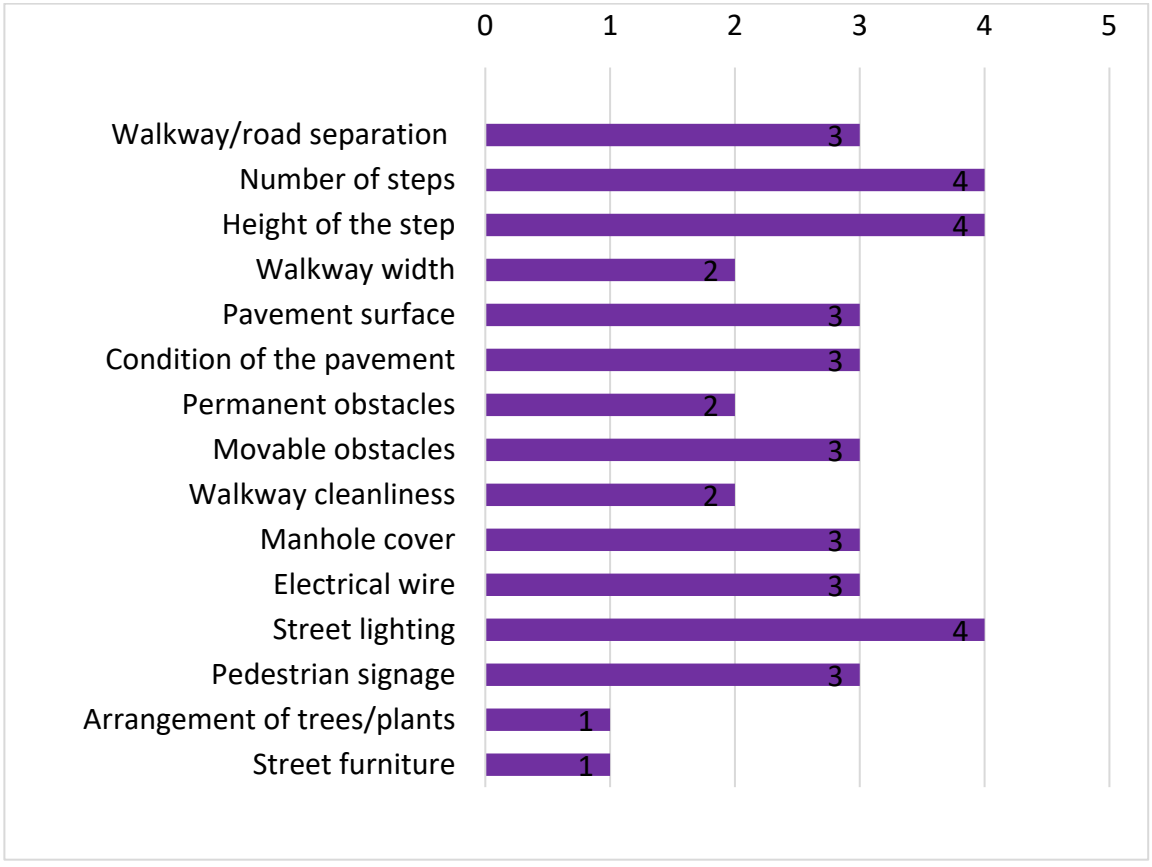


Location PP05-5

Walkability Index	2.939







3.3.6 Bang Rak Noi Tha It Station (PP06)



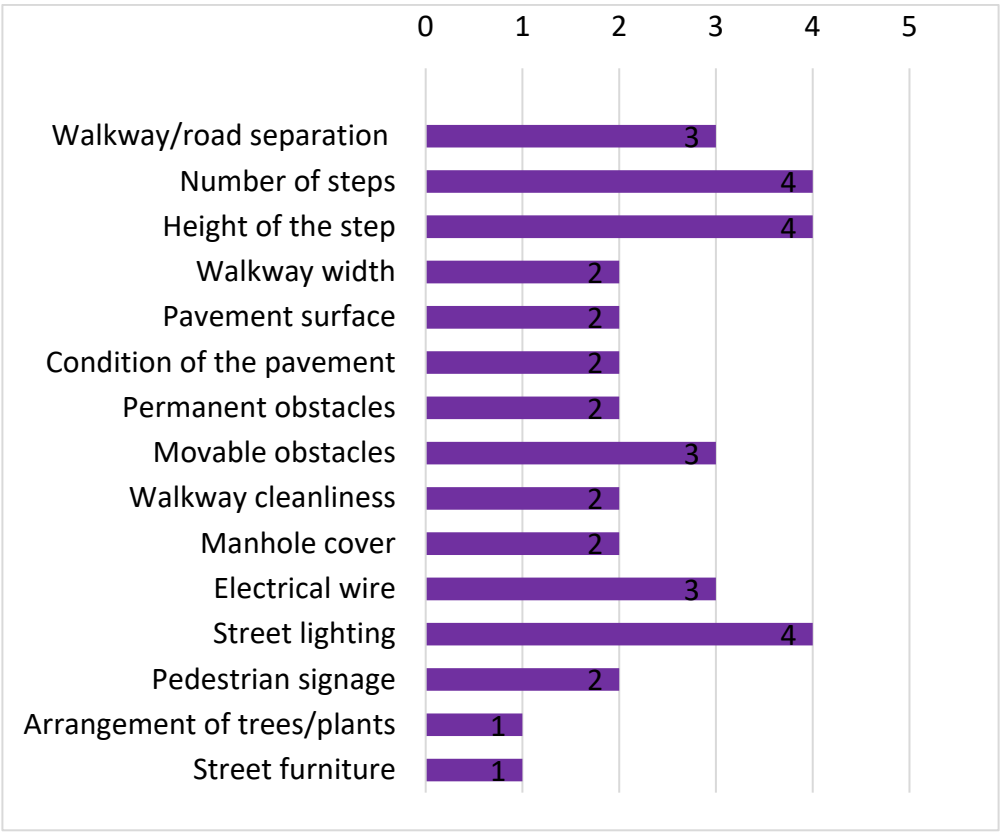
Location PP06-1

Walkability Index	2.782



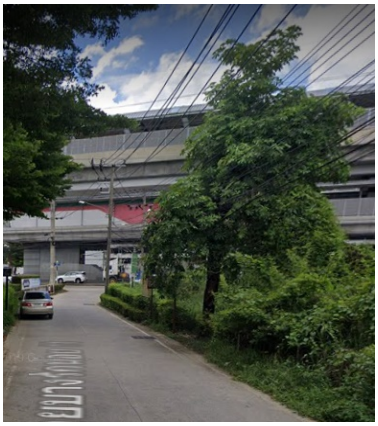


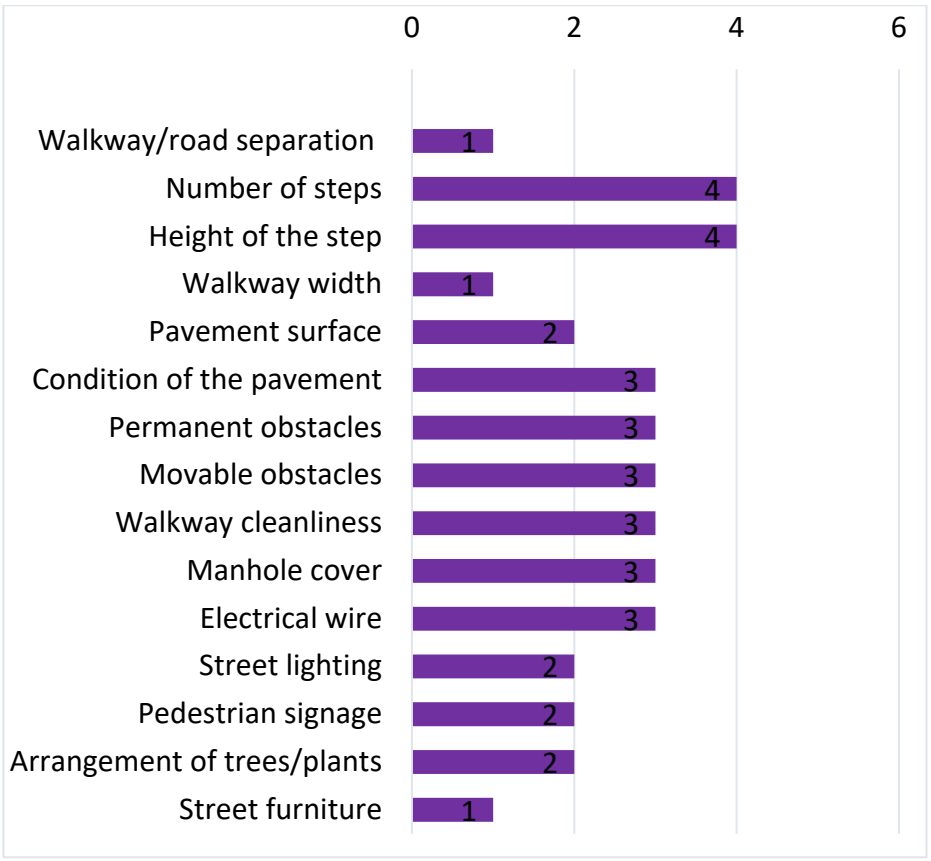




Location PP06-2

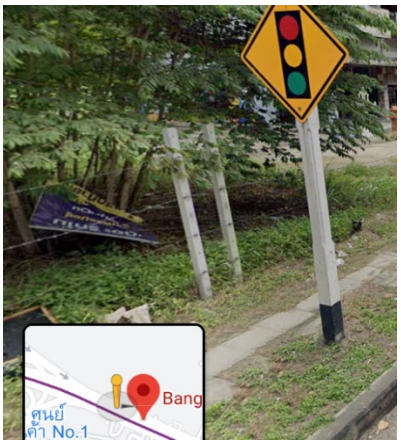
Walkability Index	2.024

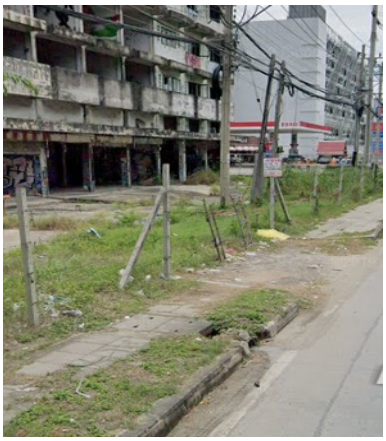



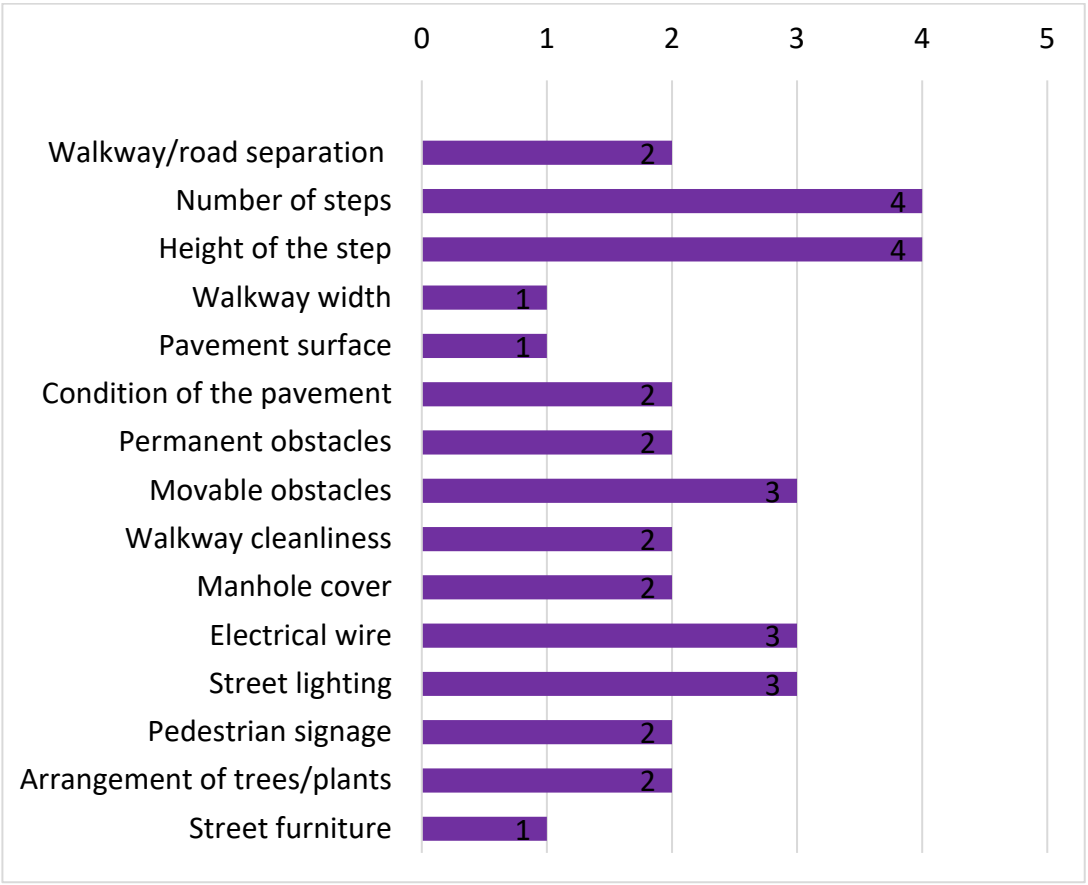
Location PP06-3

Walkability Index	2.182









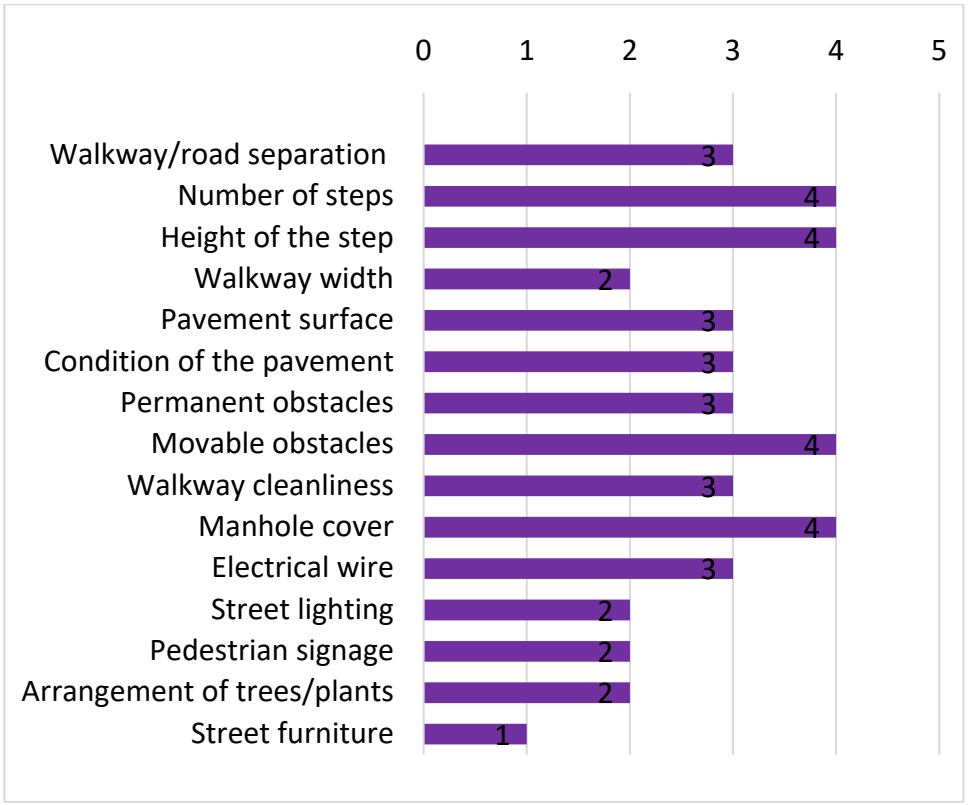
Location PP06-4

Walkability Index	3.054



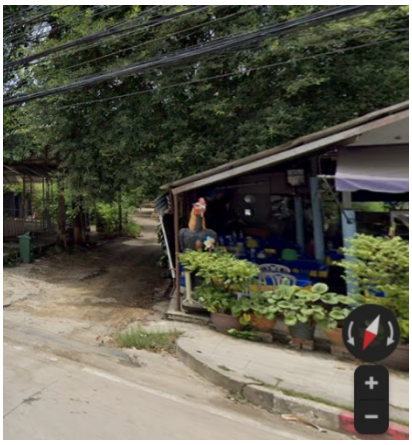




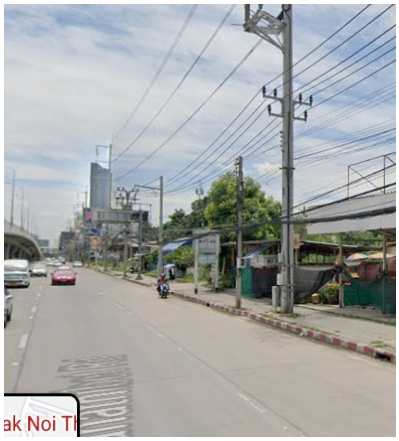


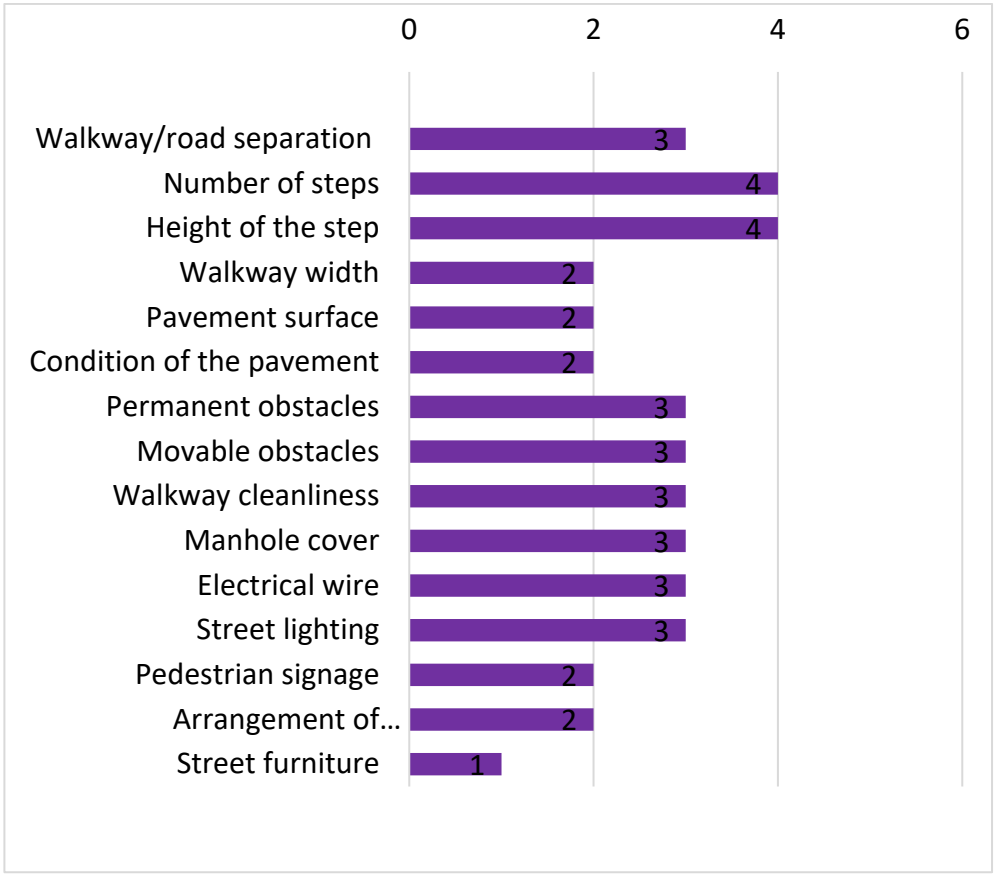
Location PP06-5

Walkability Index	2.897








0
2
4
6
Walkway/road separation
3
Number of steps
4
Height of the step
4
Walkway width
2
Pavement surface
2
Condition of the pavement
2
Permanent obstacles
3
Movable obstacles
3
Walkway cleanliness
3
Manhole cover
3
Electrical wire
3
Street lighting
3
Pedestrian signage
2
Arrangement of...
2
Street furniture
1

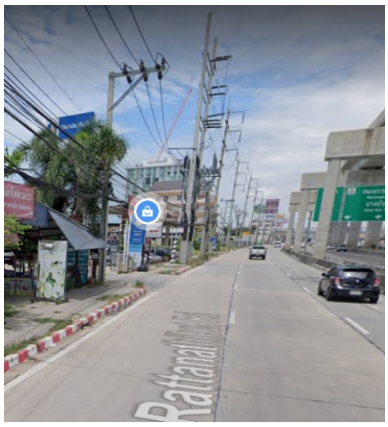
3.3.7 Sai Ma Station (PP07)

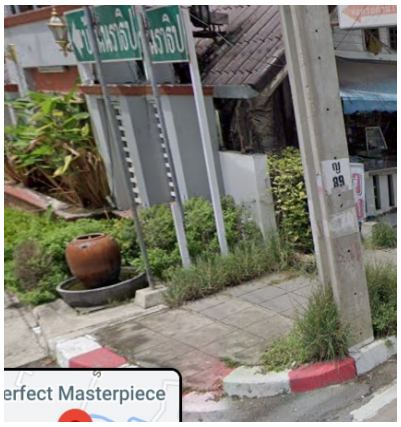


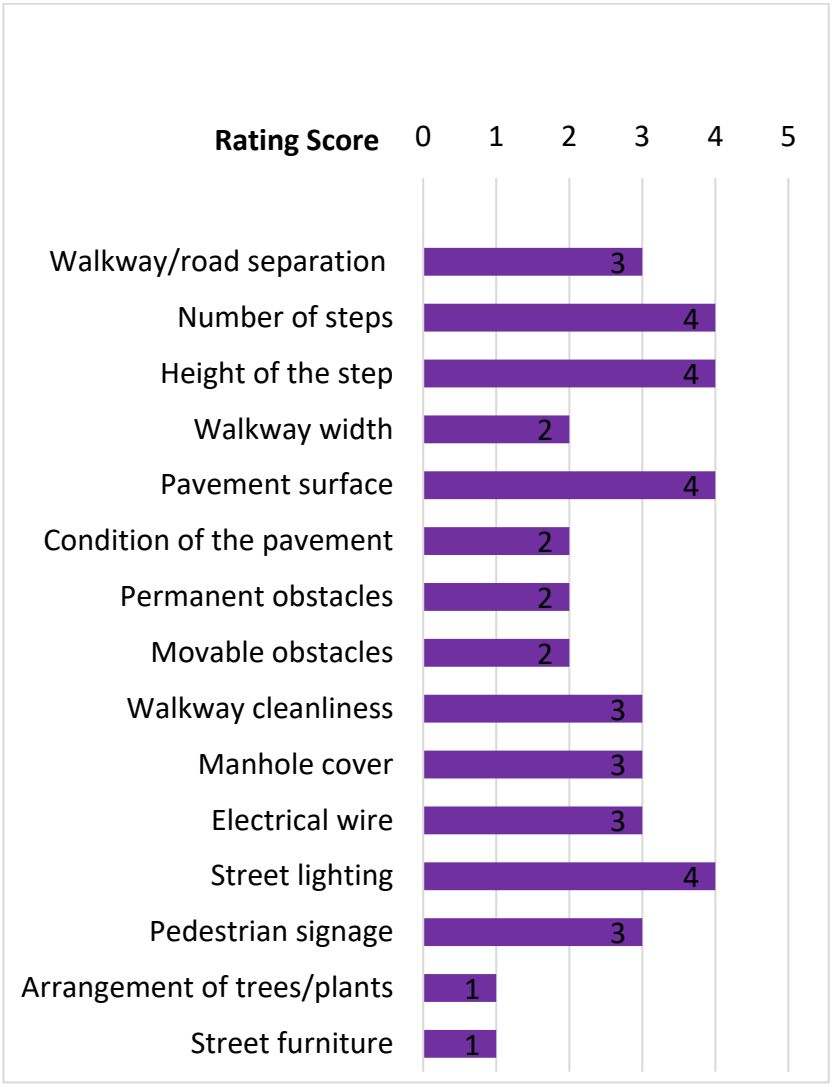
Location PP07-1

Walkability Index	2.968



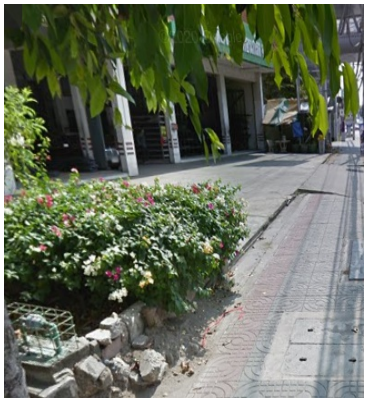


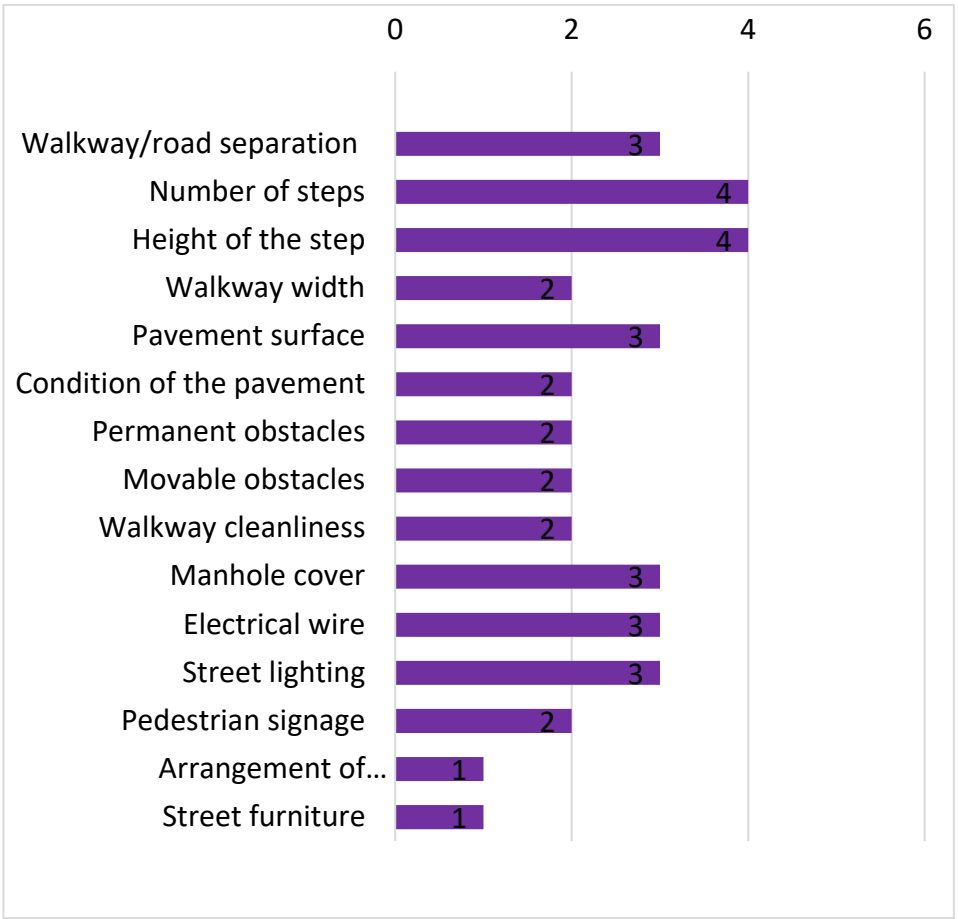




Location PP07-2

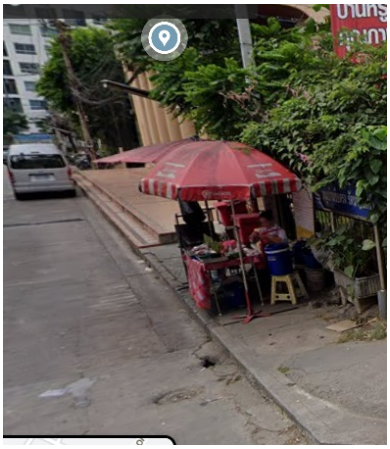
Walkability Index	2.833

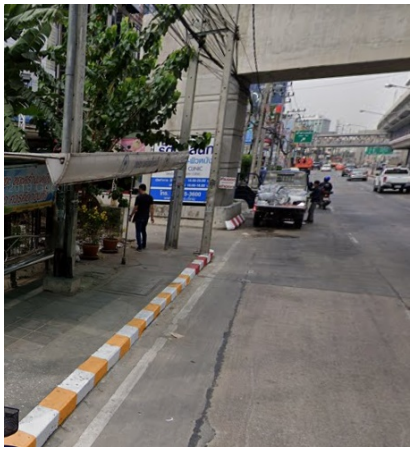



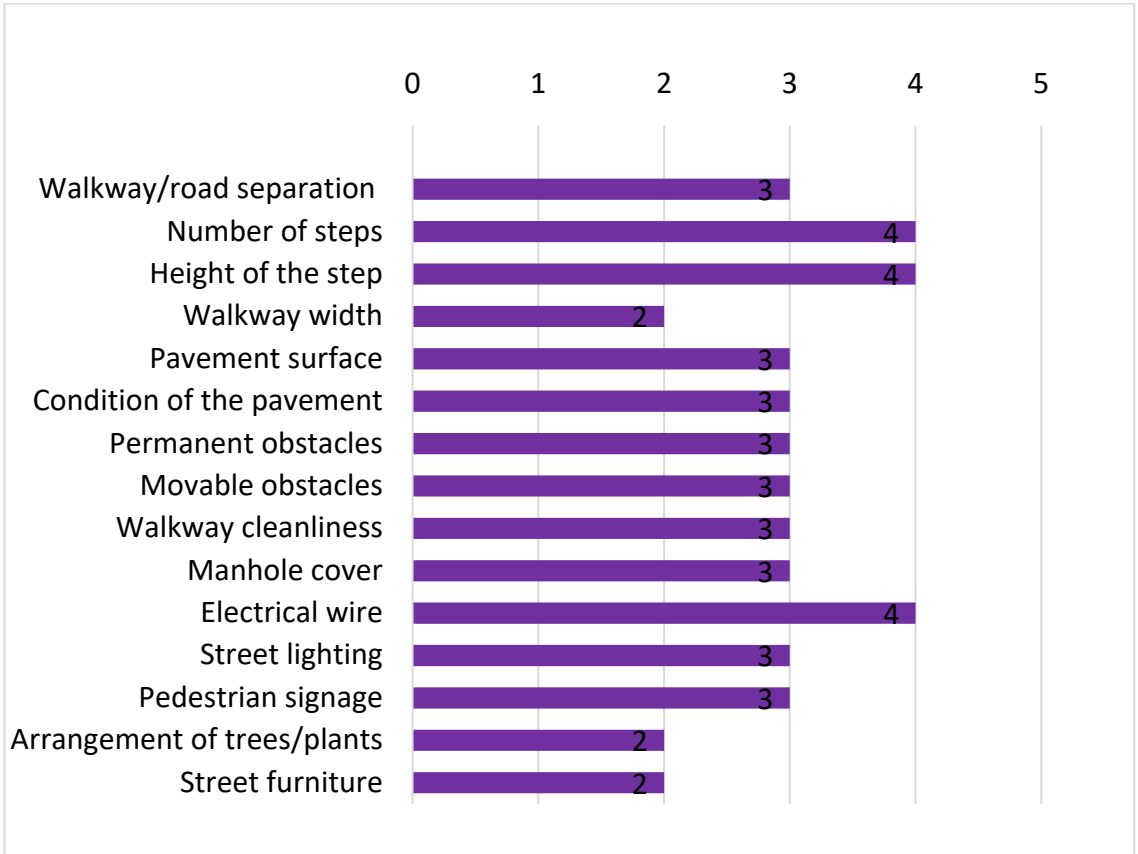



Location PP07-3

Walkability Index	3.036

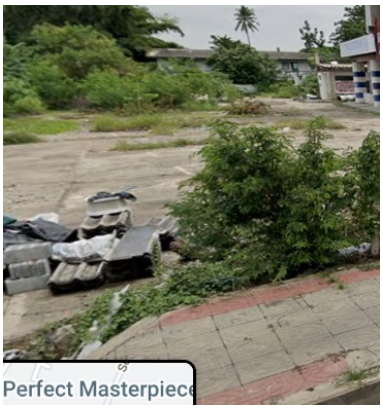




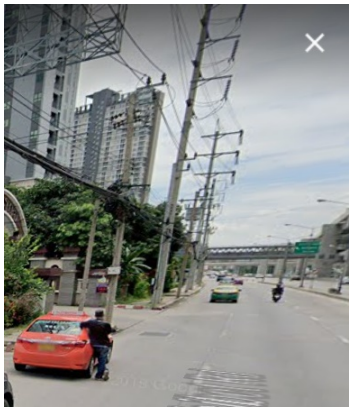


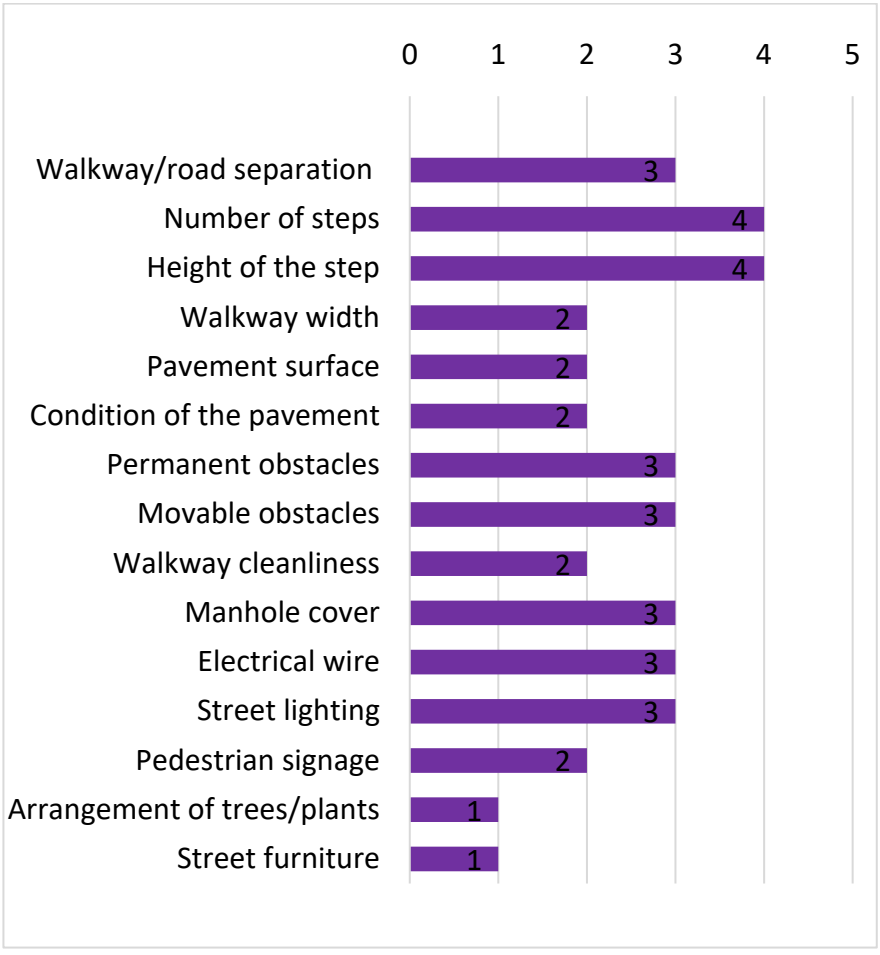
Location PP07-4

Walkability Index	2.859



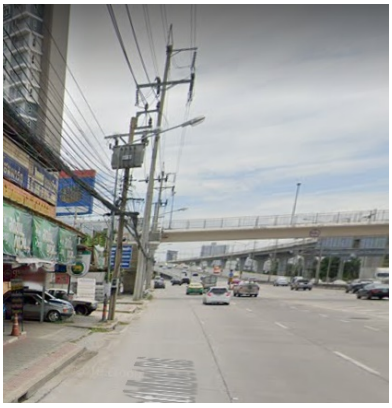


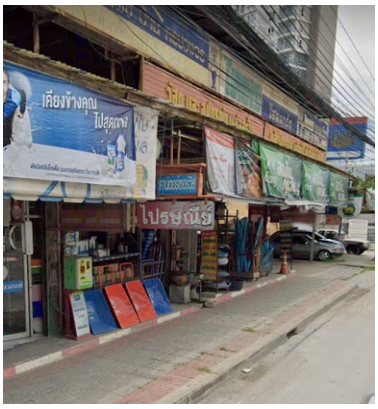


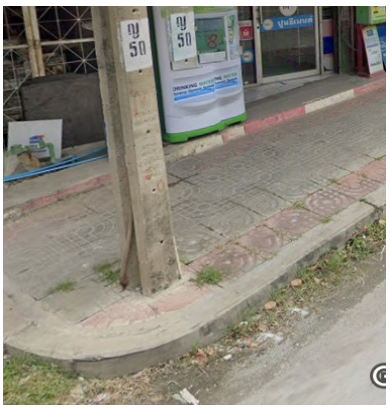


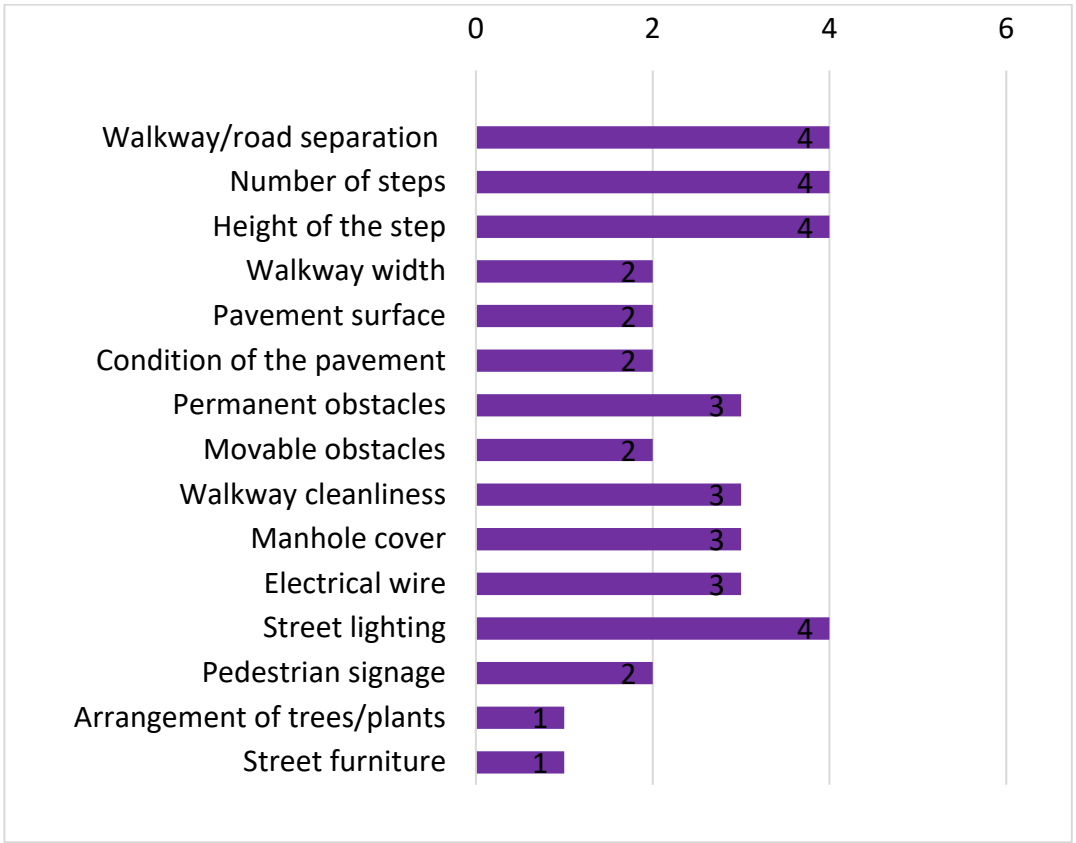
Location PP07-5

Walkability Index	3.280

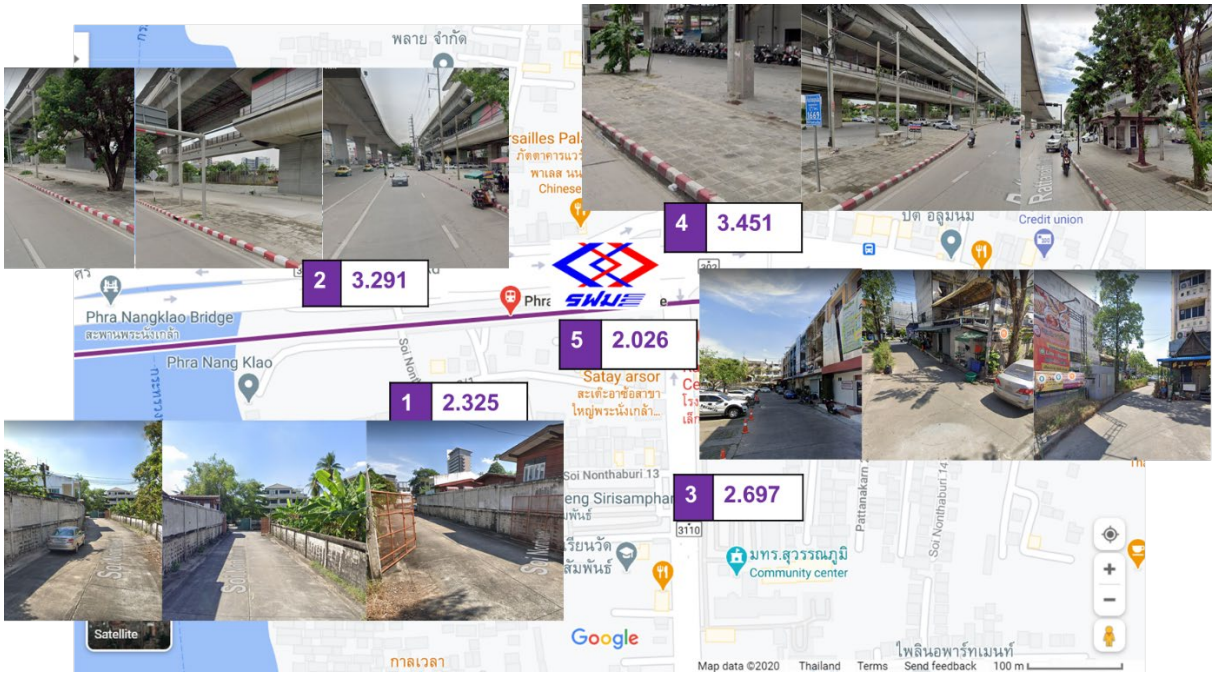








3.3.8 Phra Nang Klao Bridge Station (PP08)



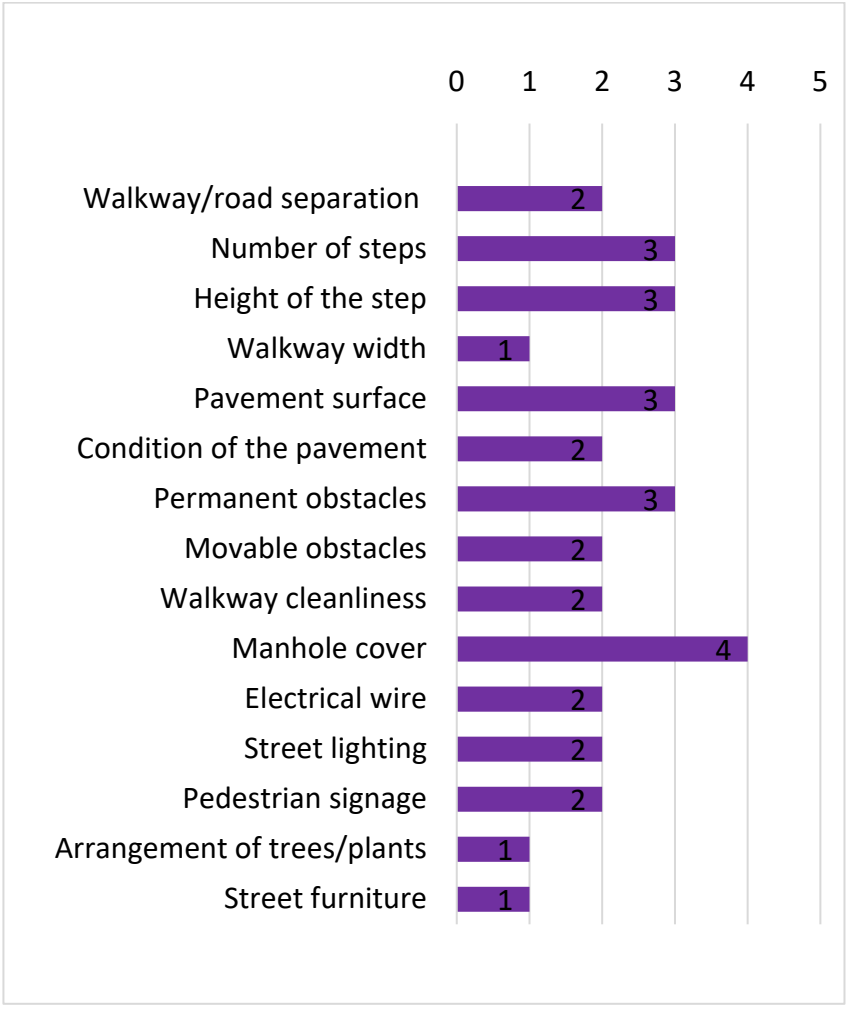
Location PP08-1

Walkability Index	2.325







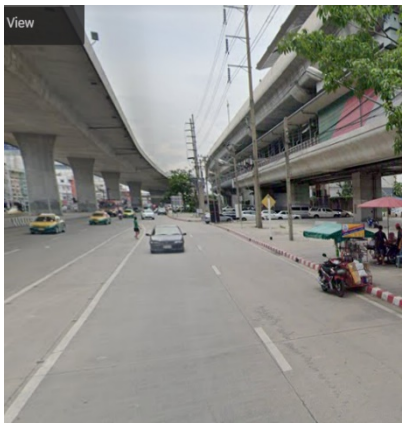


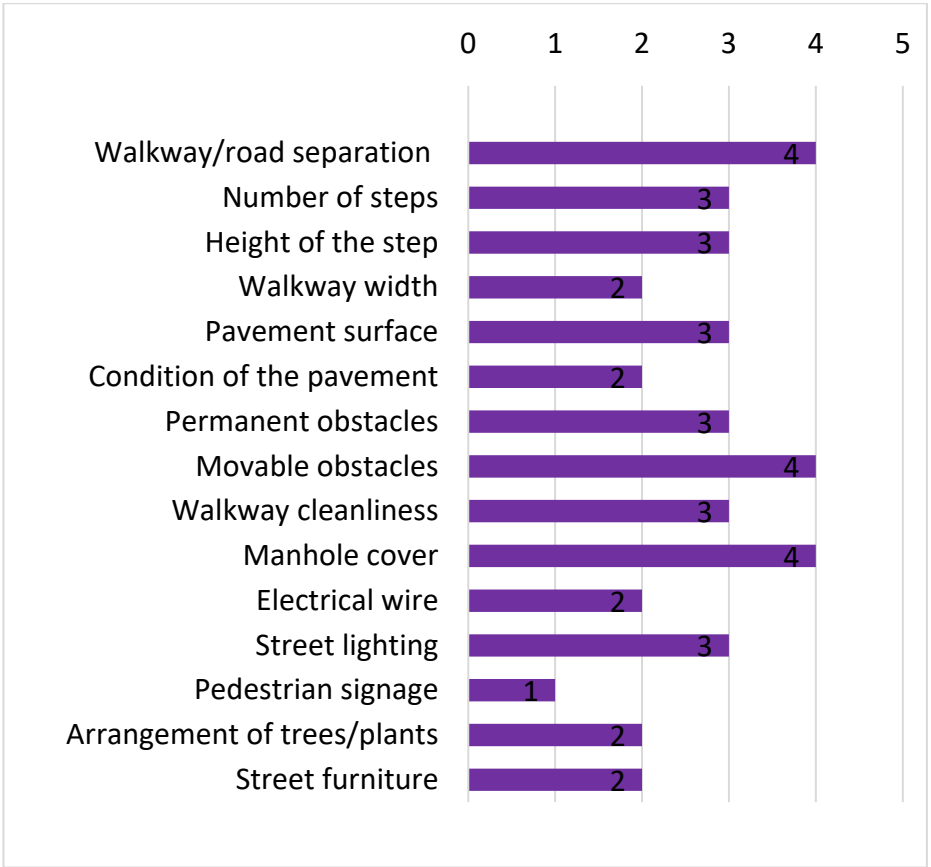
Location PP08-2

Walkability Index	3.291



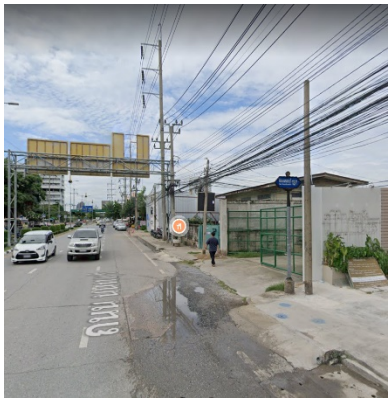


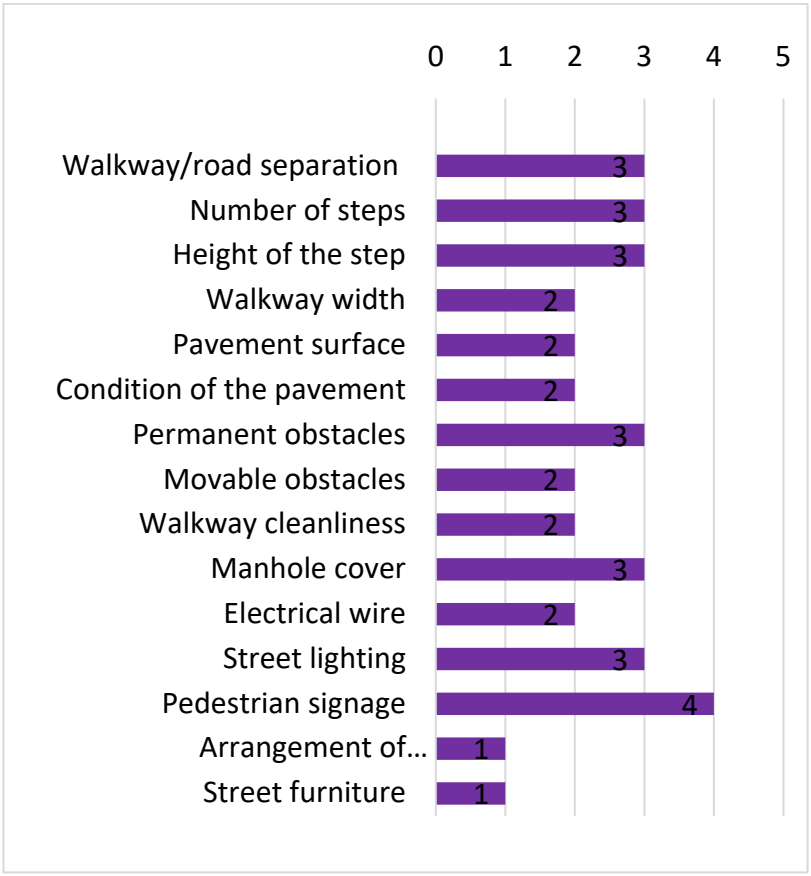




Location PP08-3

Walkability Index	2.697

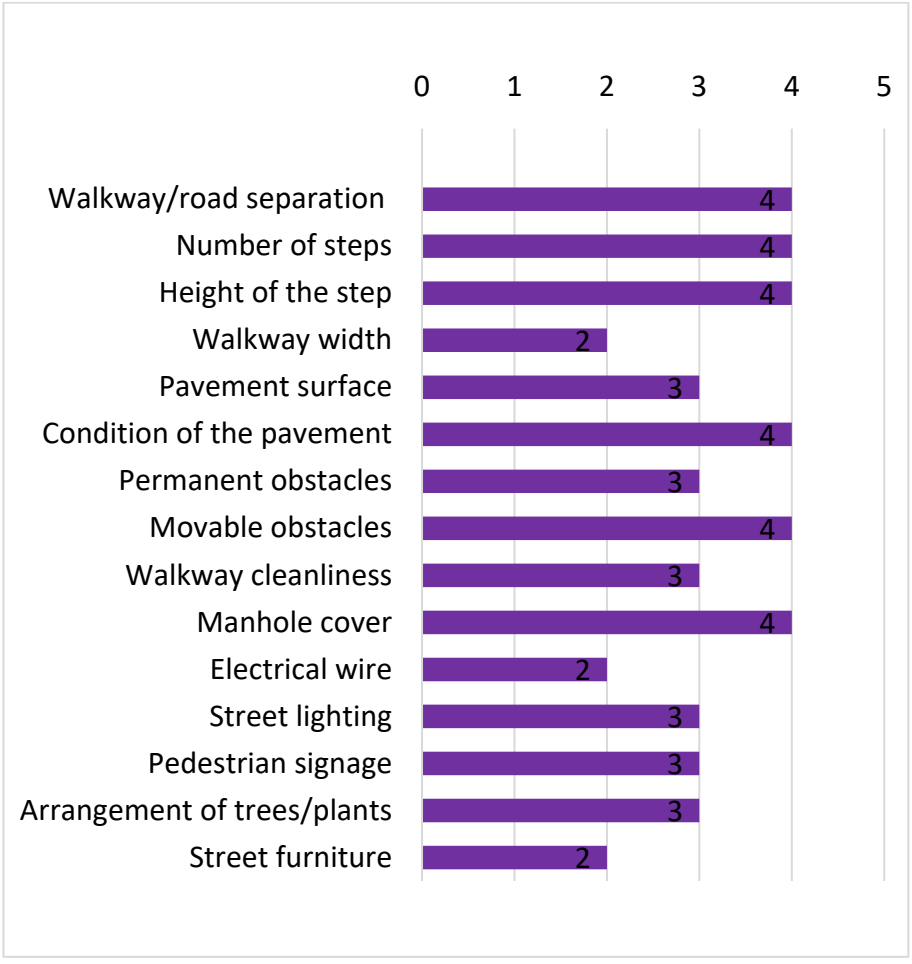



Location PP08-4

Walkability Index	3.451

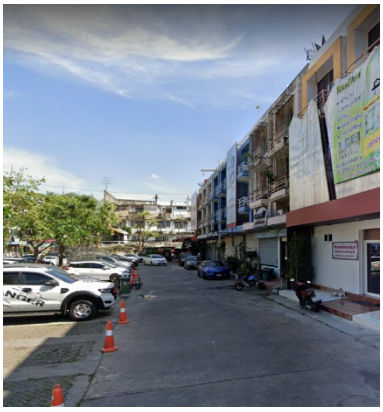




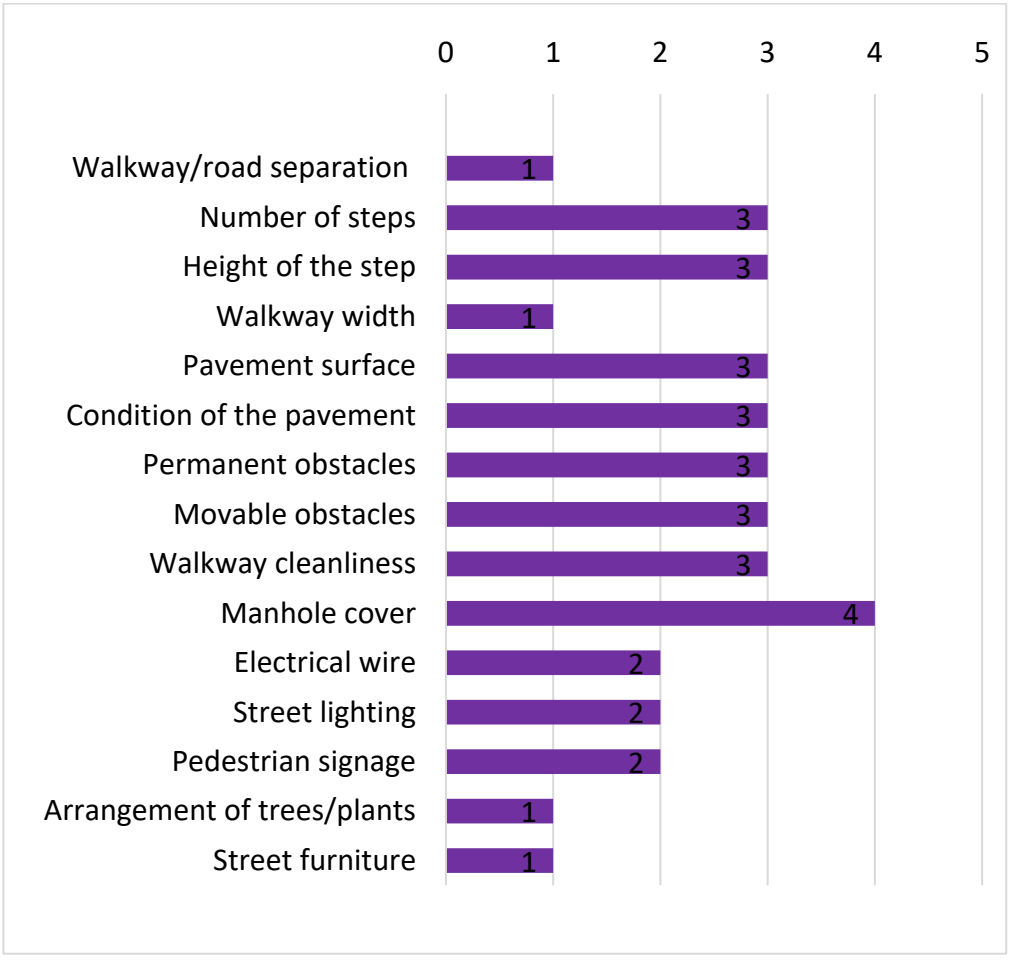


Location PP08-5

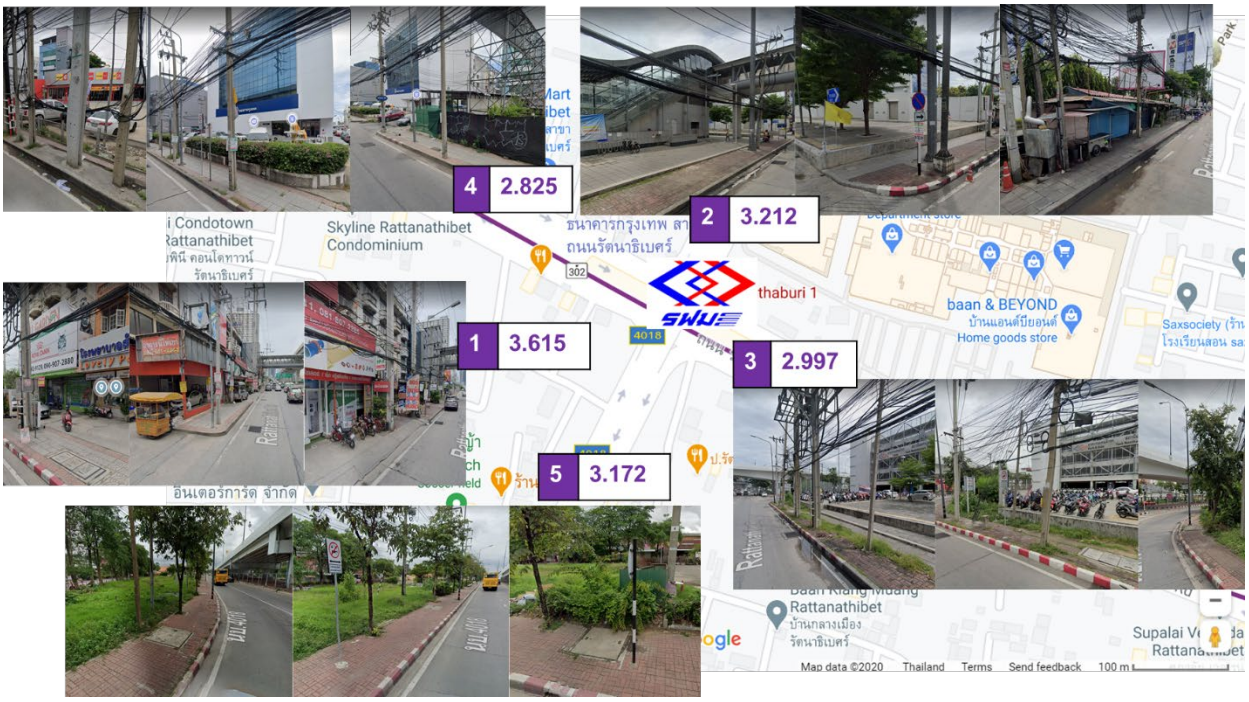
Walkability Index	2.026





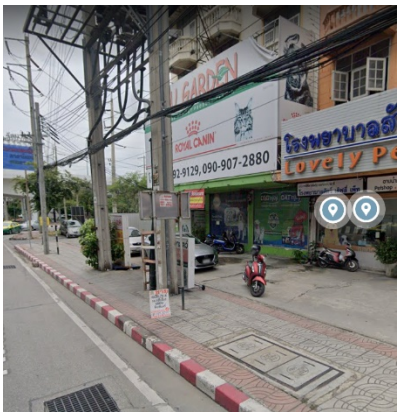


3.3.9 Yaek Nonthaburi 1 Station (PP09)



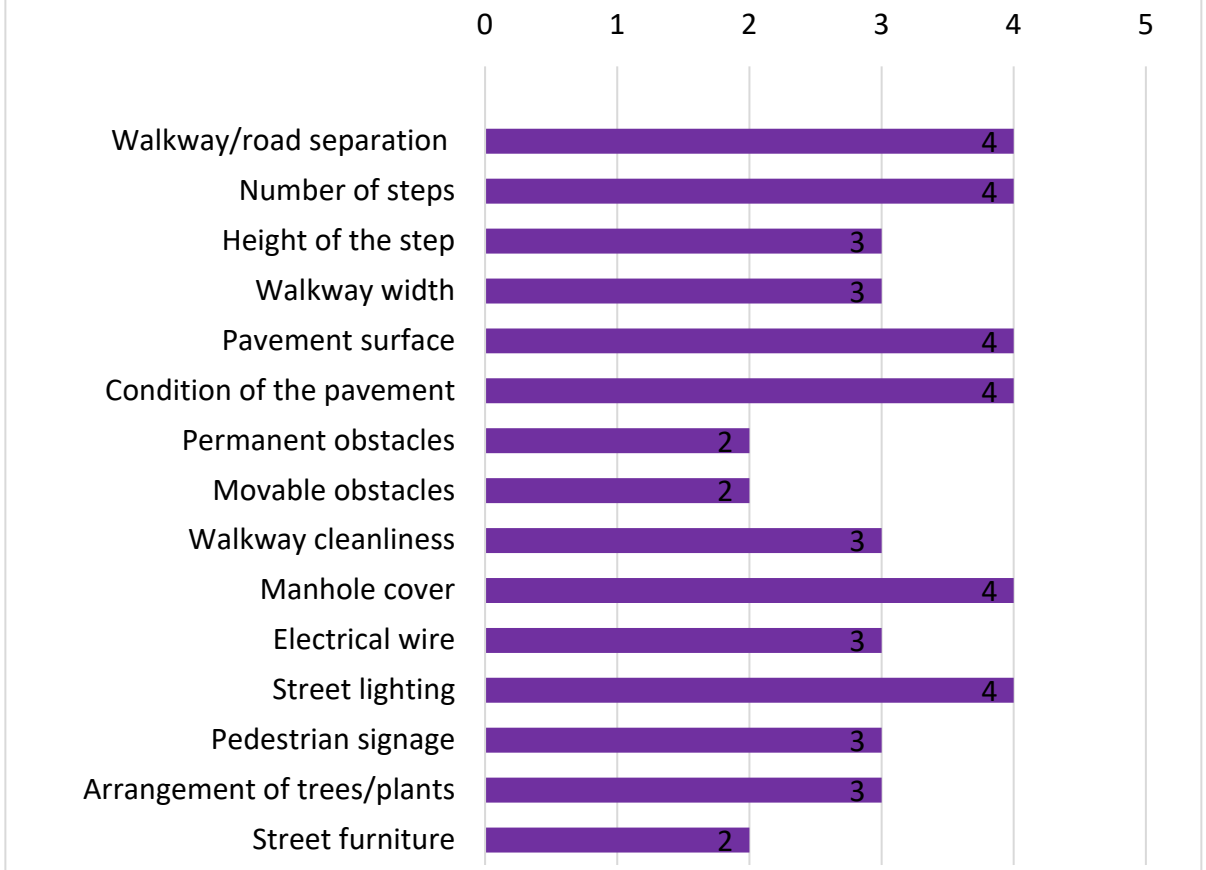
Location PP09-1

Walkability Index	3.615



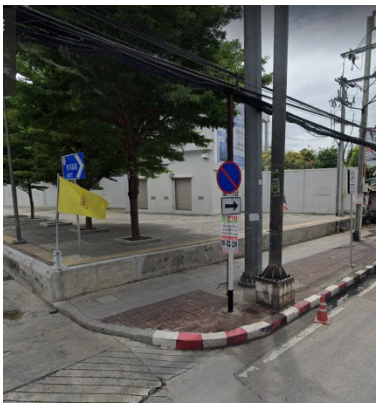






Location PP09-2

Walkability Index	3.212




Location PP09-3

Walkability Index	2.997

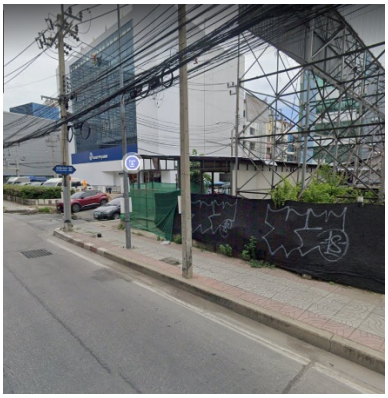






Location PP09-4

Walkability Index	2.825

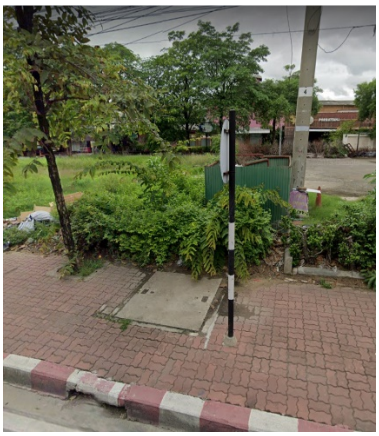






Location PP09-5

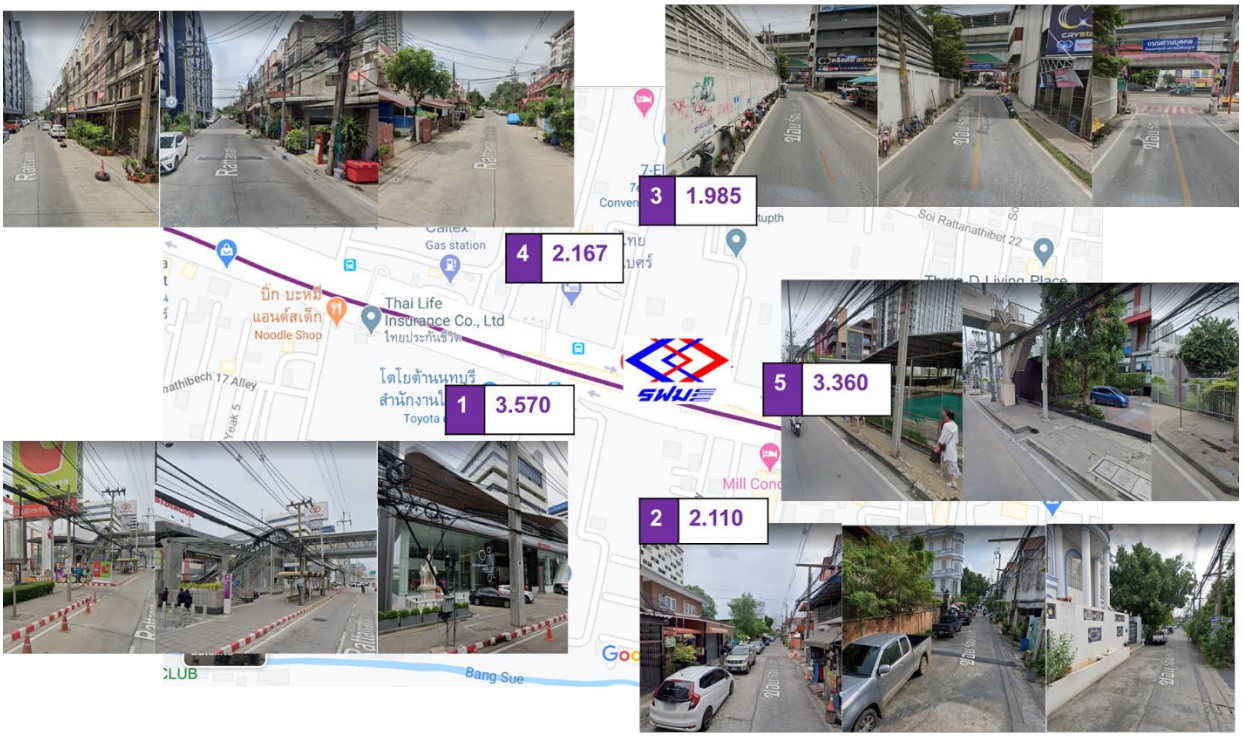
Walkability Index	3.172





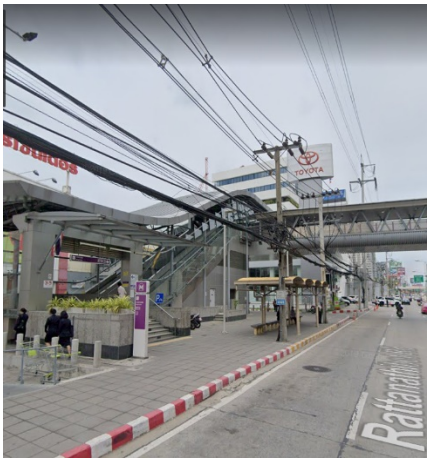
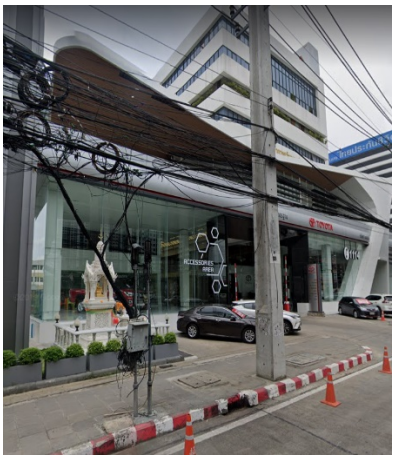


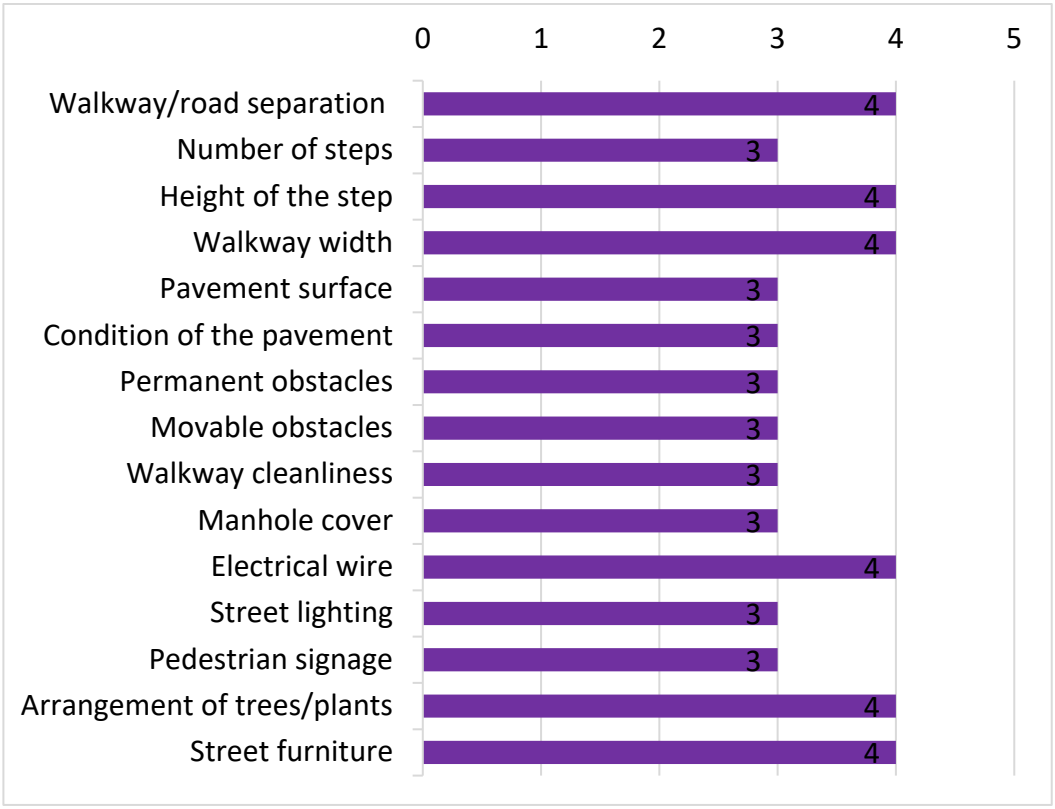
3.3.10 Bang Krasor Station (PP10)



Location PP10-1

Walkability Index	3.570

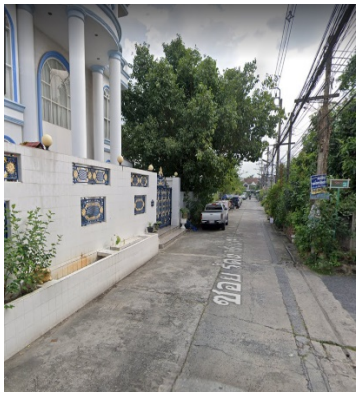




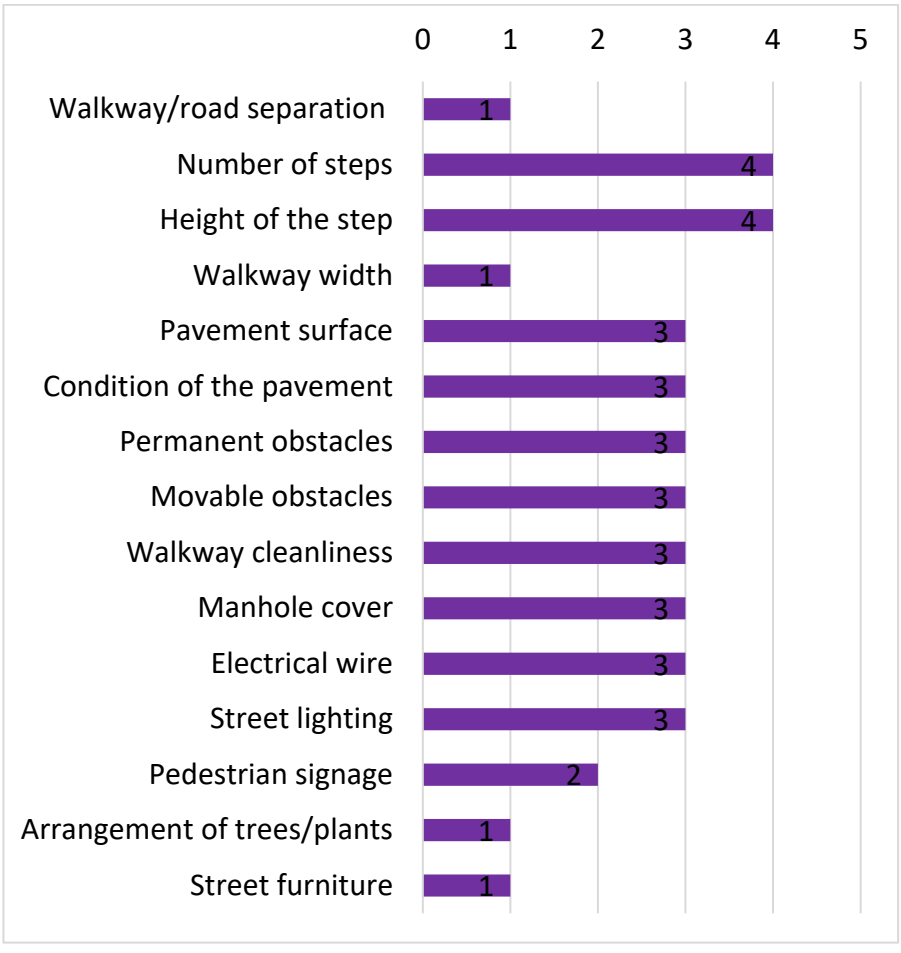


Location PP10-2

Walkability Index	2.110

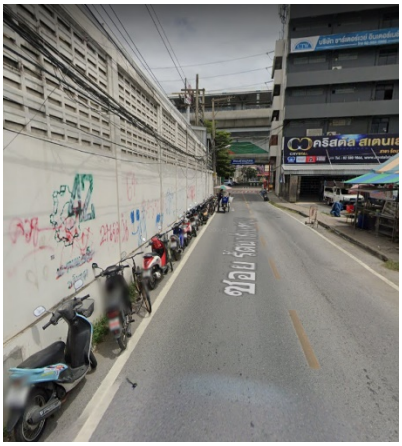
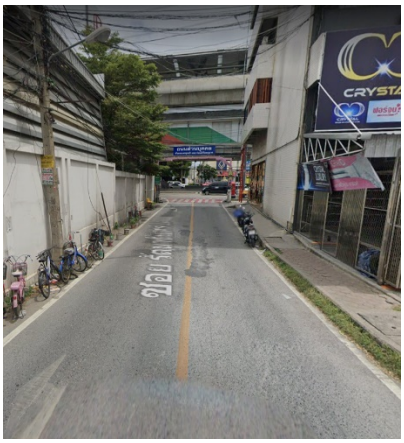


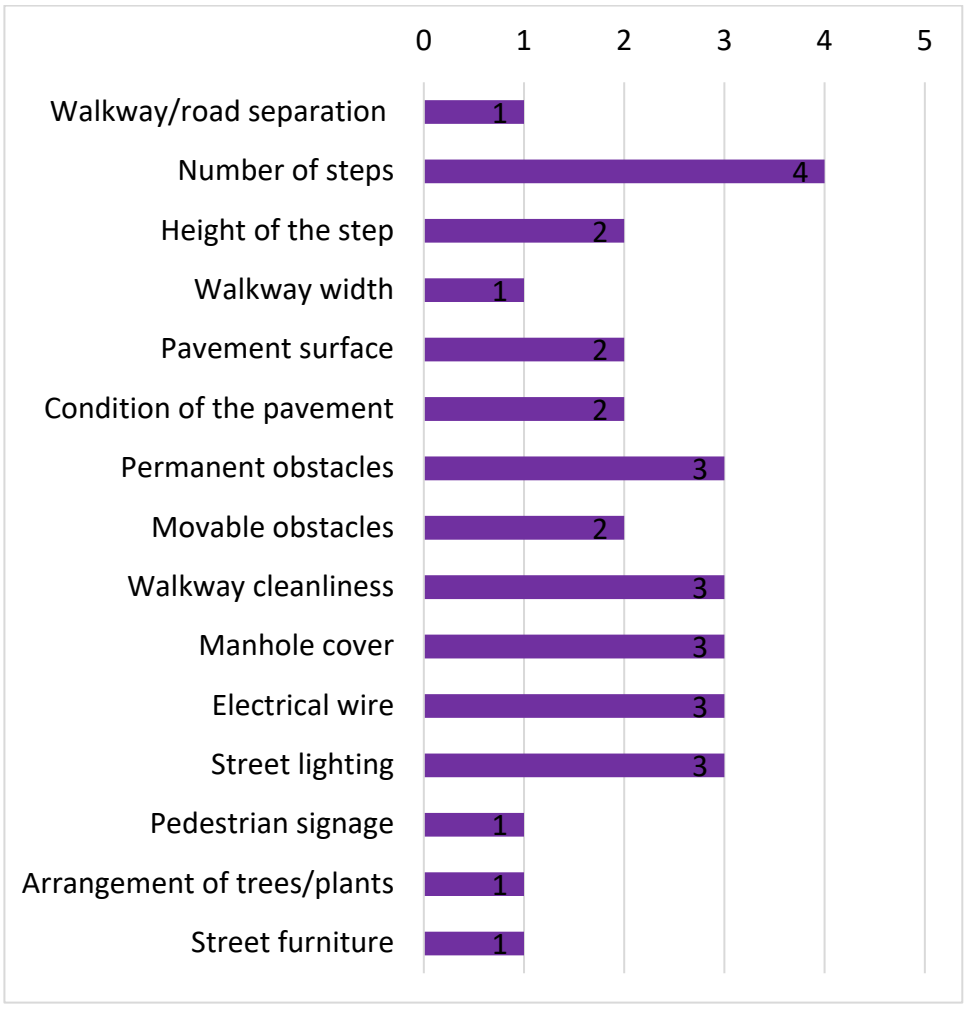




Location PP10-3

Walkability Index	1.985

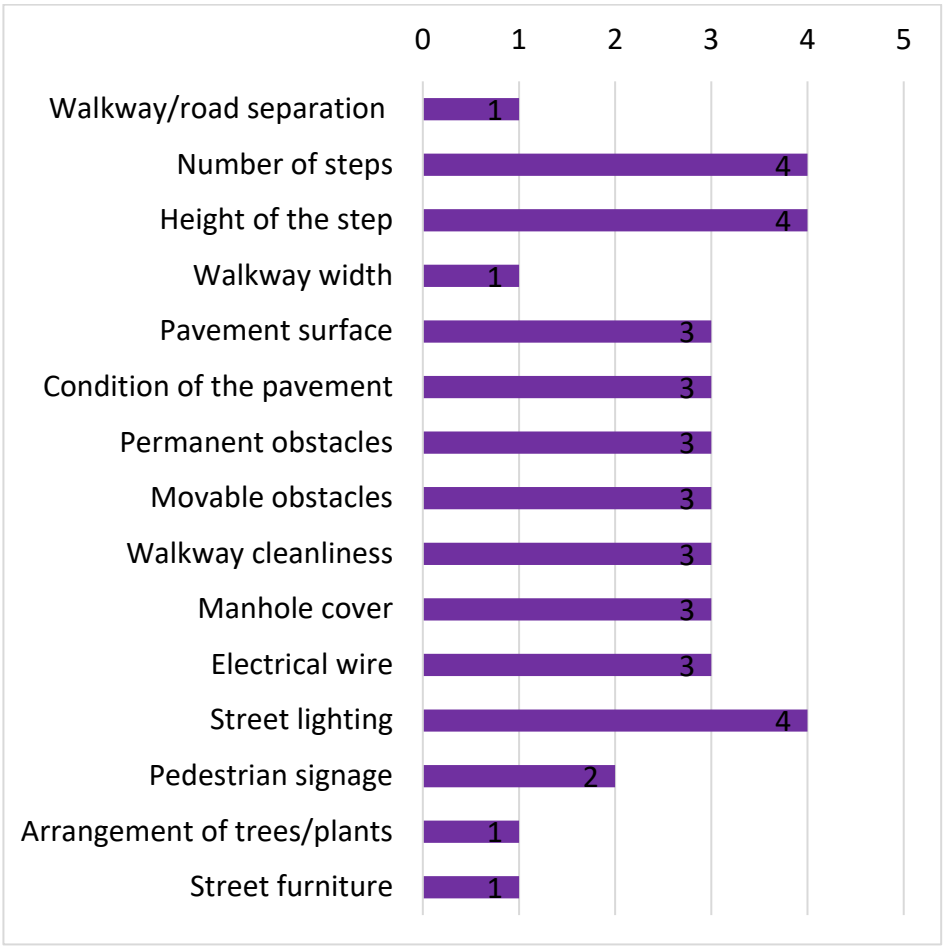



Location PP10-4

Walkability Index	2.167





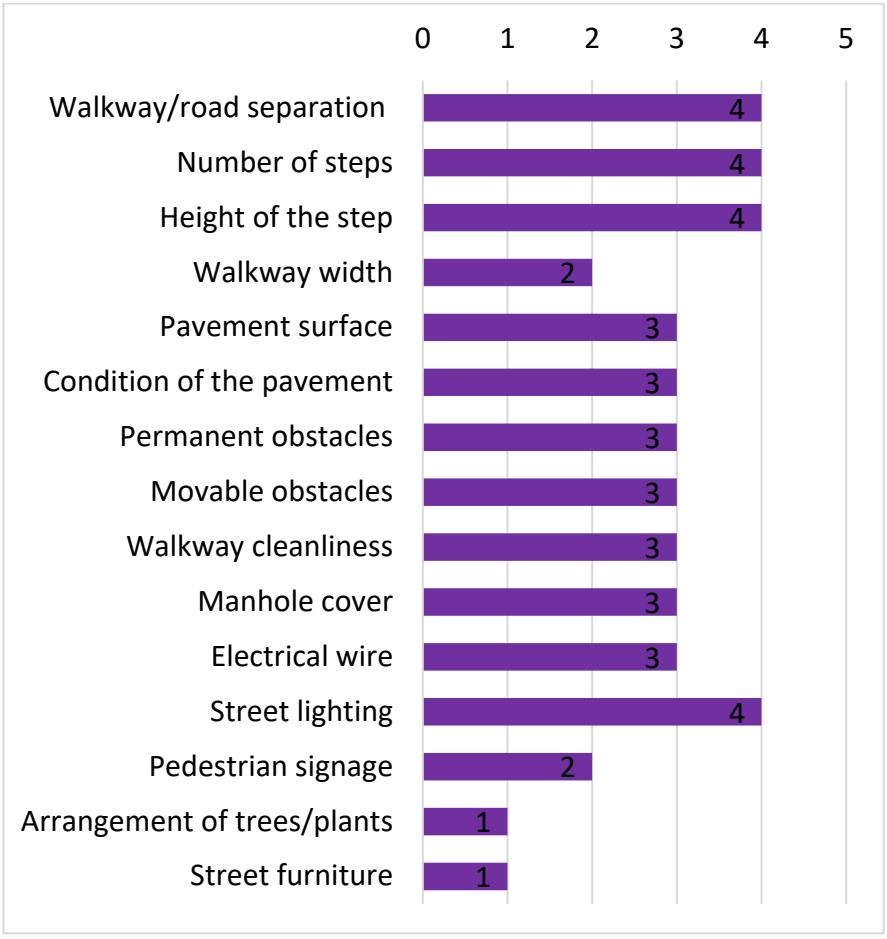


Location PP10-5

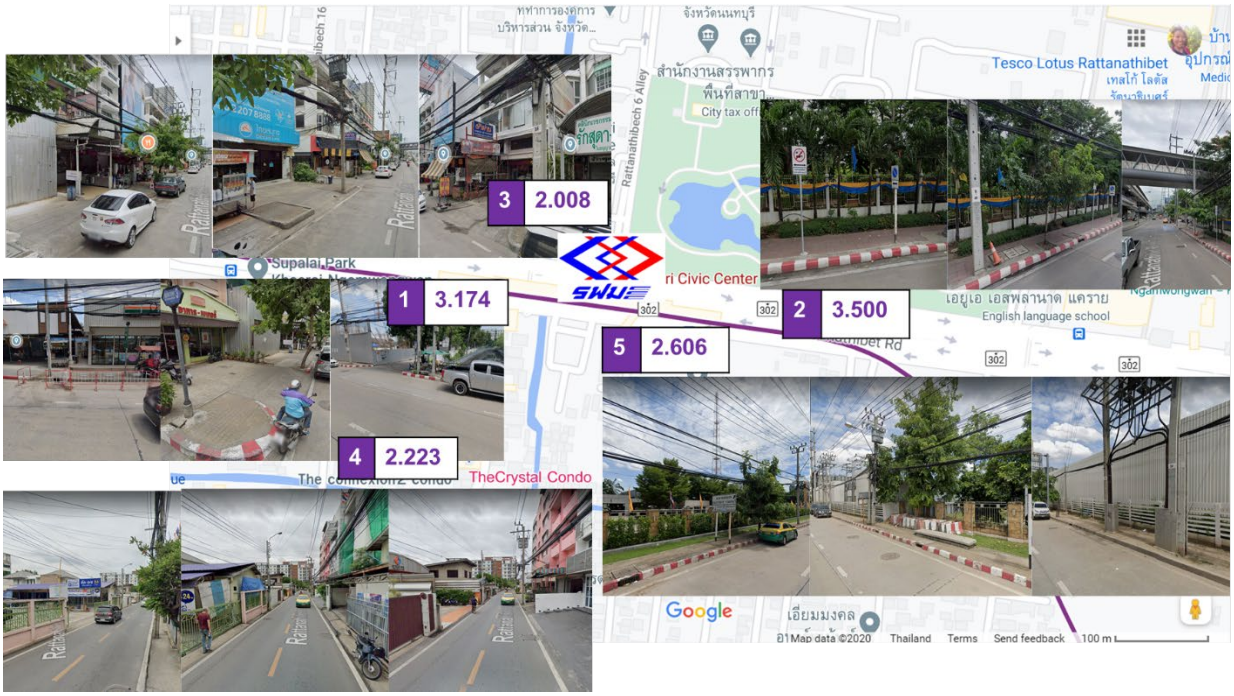
Walkability Index	3.360







3.3.11 Nonthaburi Civic Center Station (PP11)

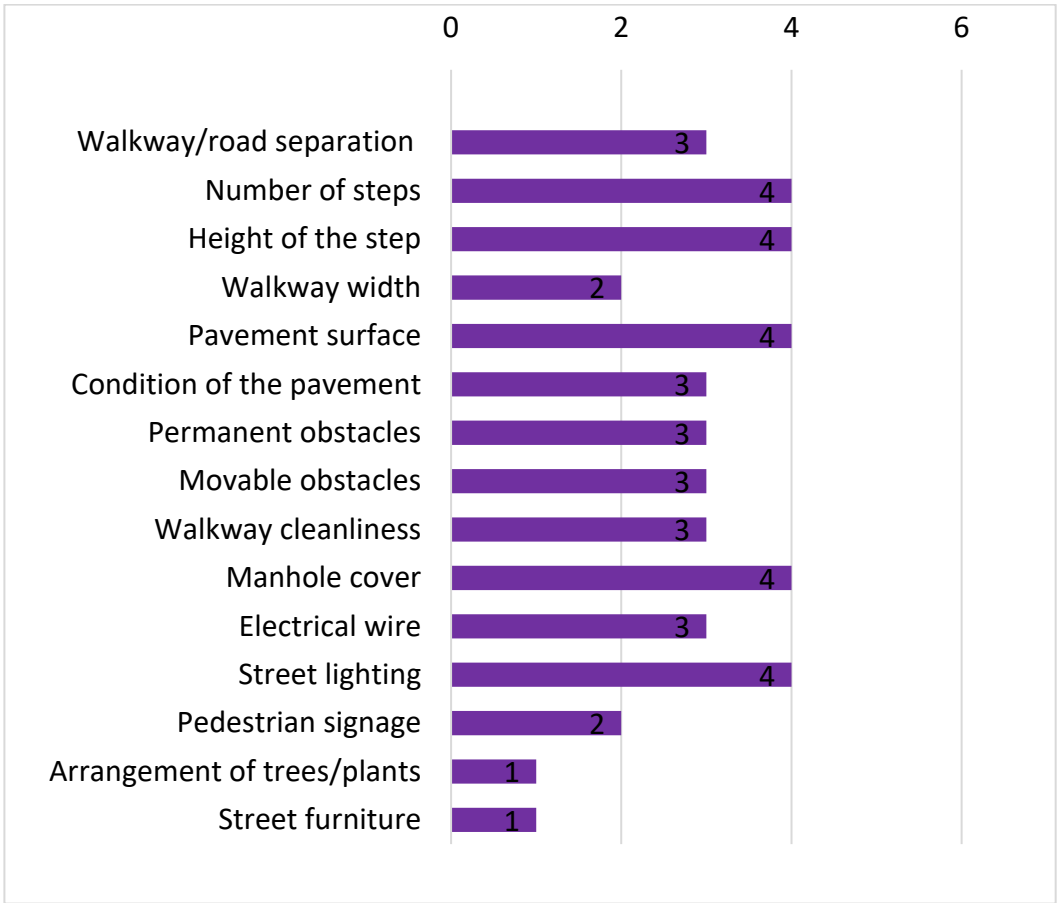


Location PP11-1

Walkability Index	3.174





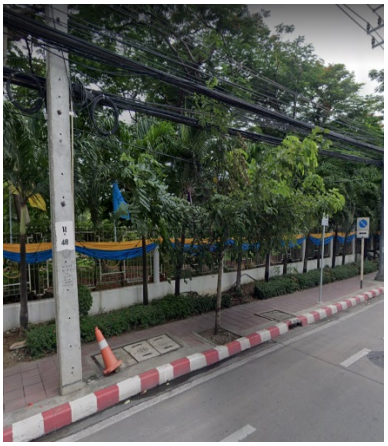


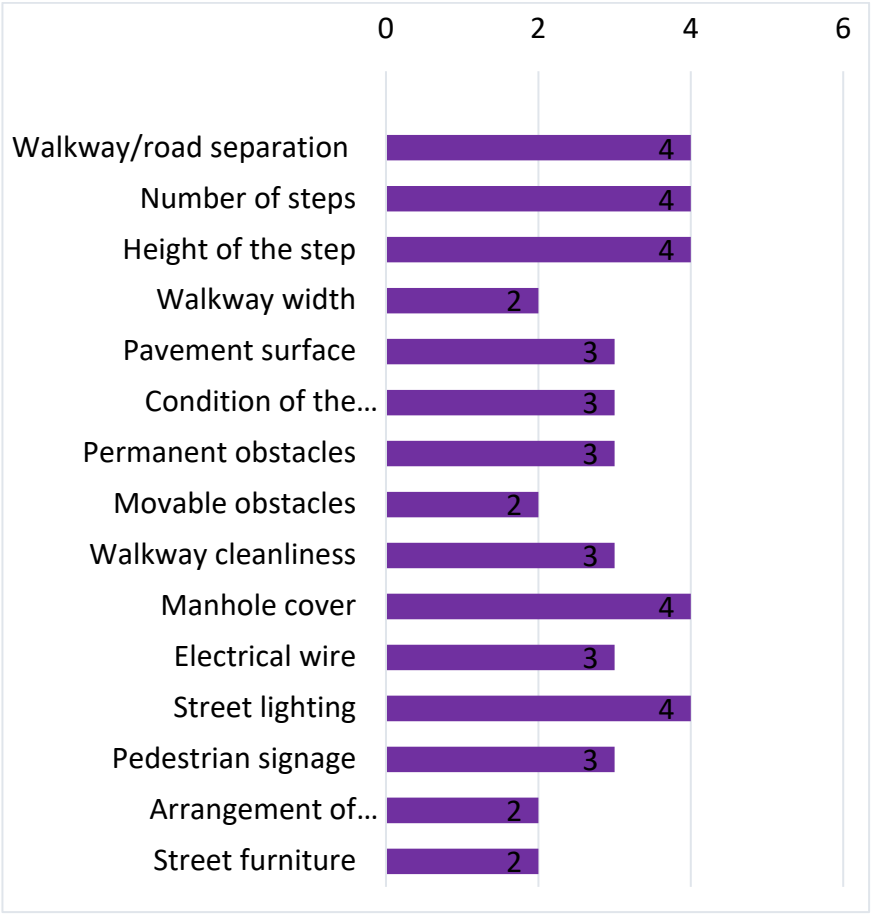
Location PP11-2

Walkability Index	3.500







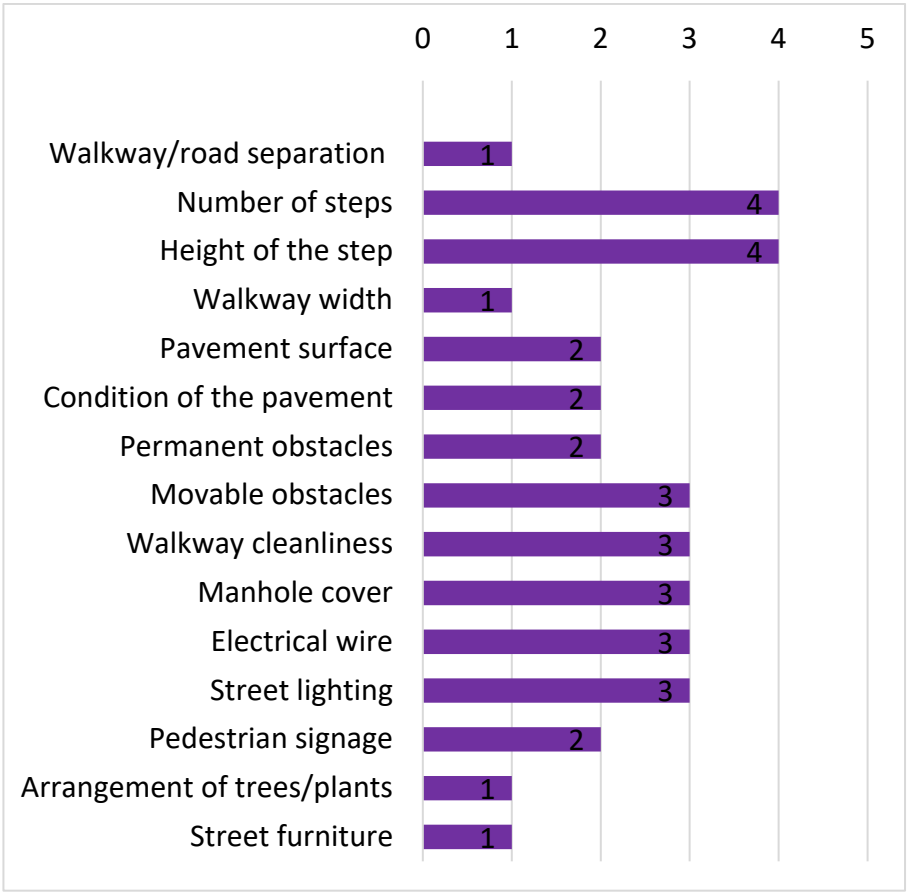


Location PP11-3

Walkability Index	2.008





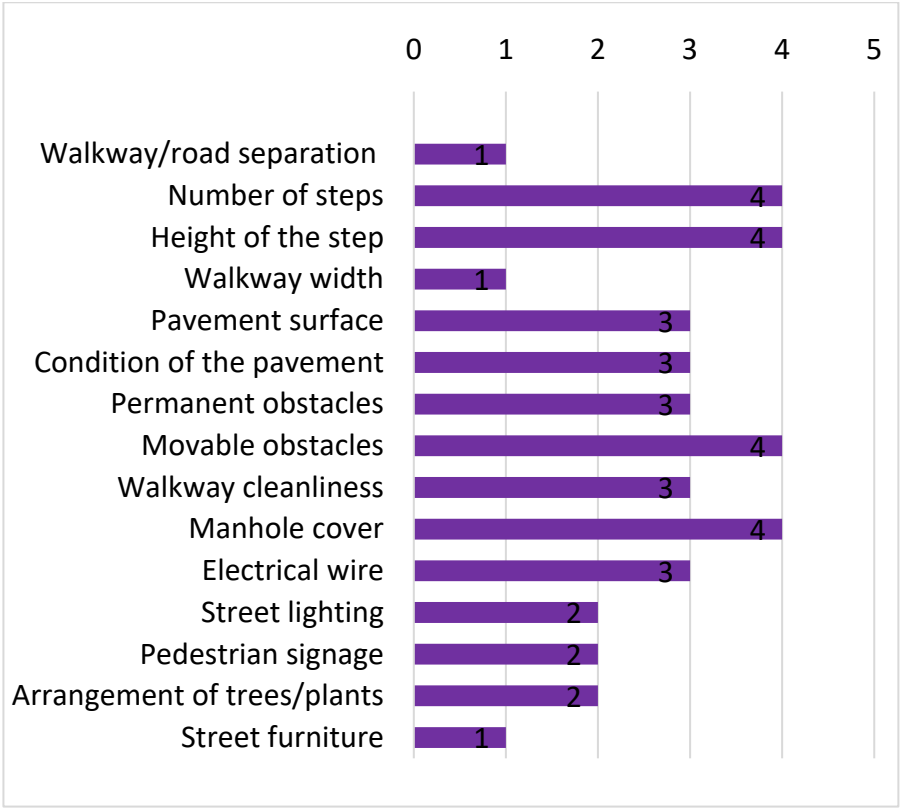


Location PP11-4

Walkability Index	2.223





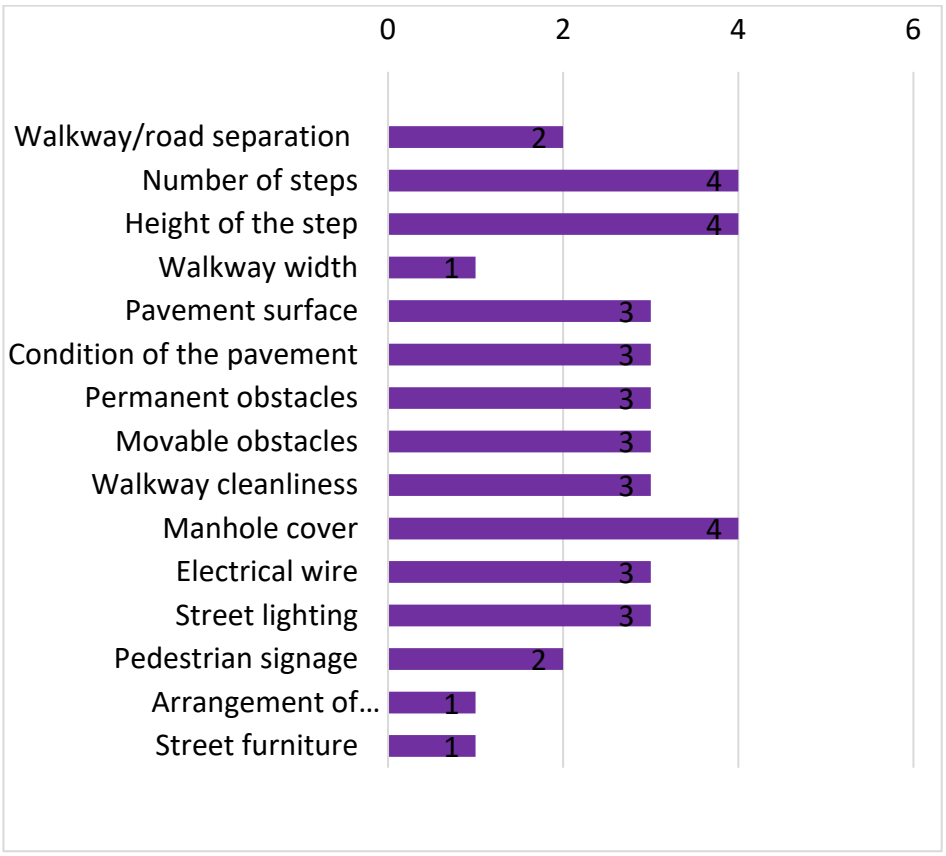


Location PP11-5

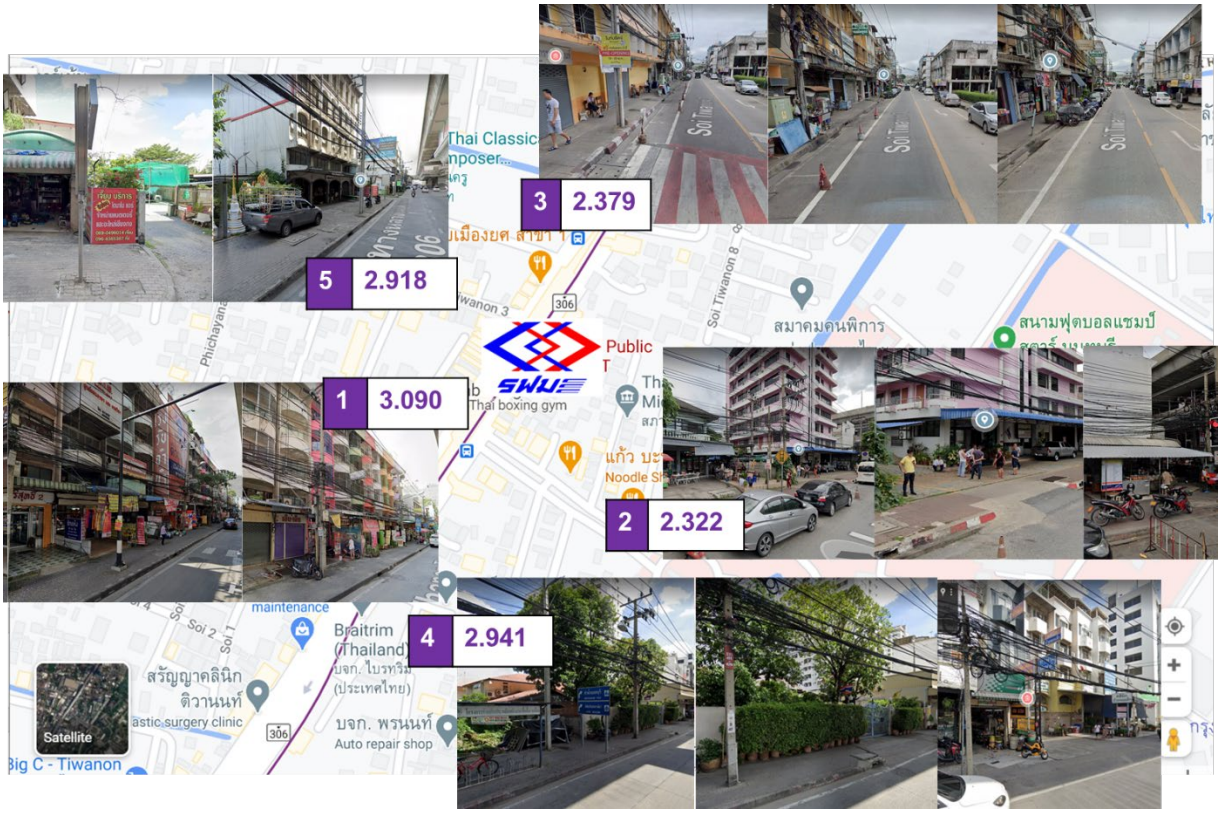
Walkability Index	2.606





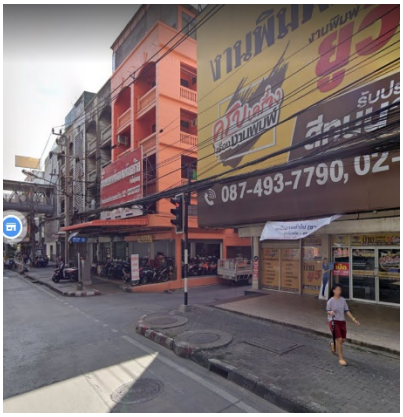


3.3.12 Ministry of Public Health Station (PP12)



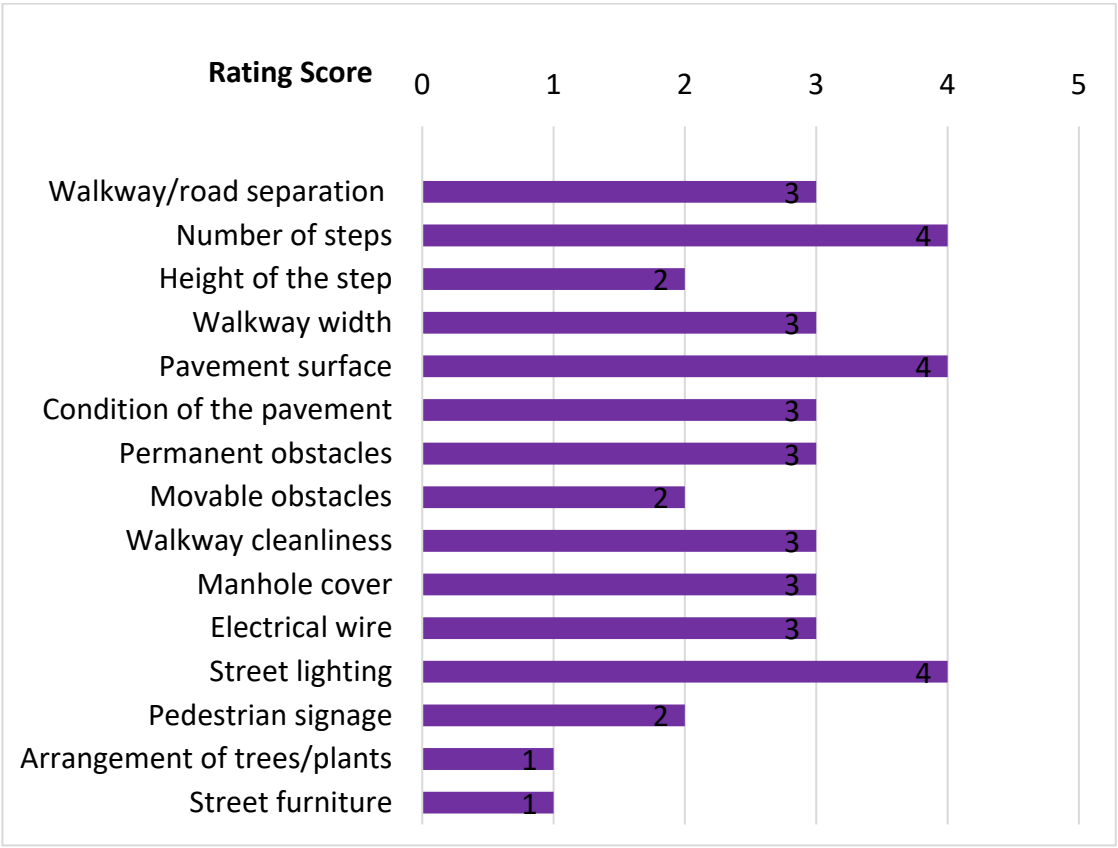
Location PP12-1

Walkability Index	3.090







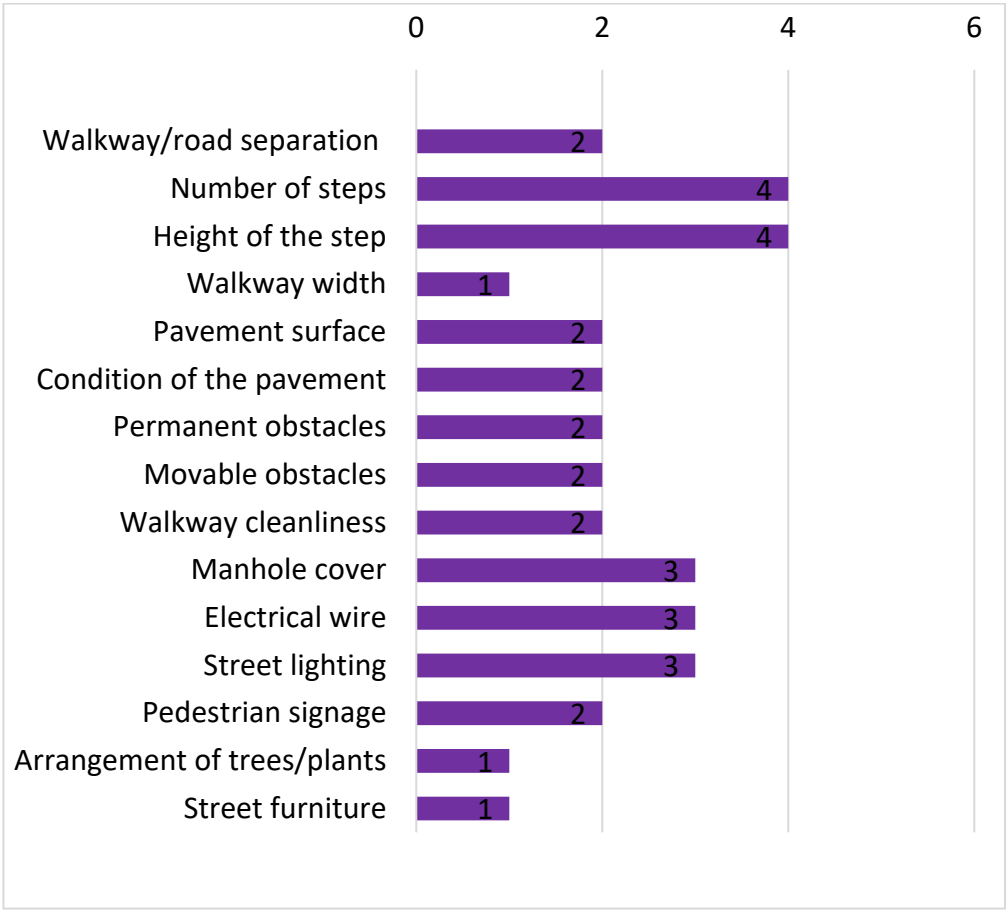


Location PP12-2

Walkability Index	2.322





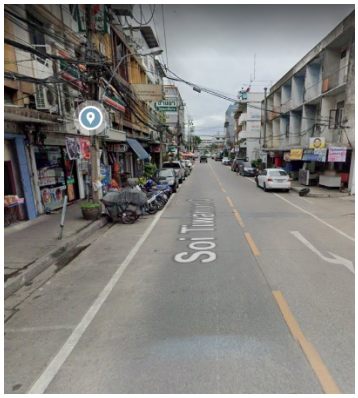


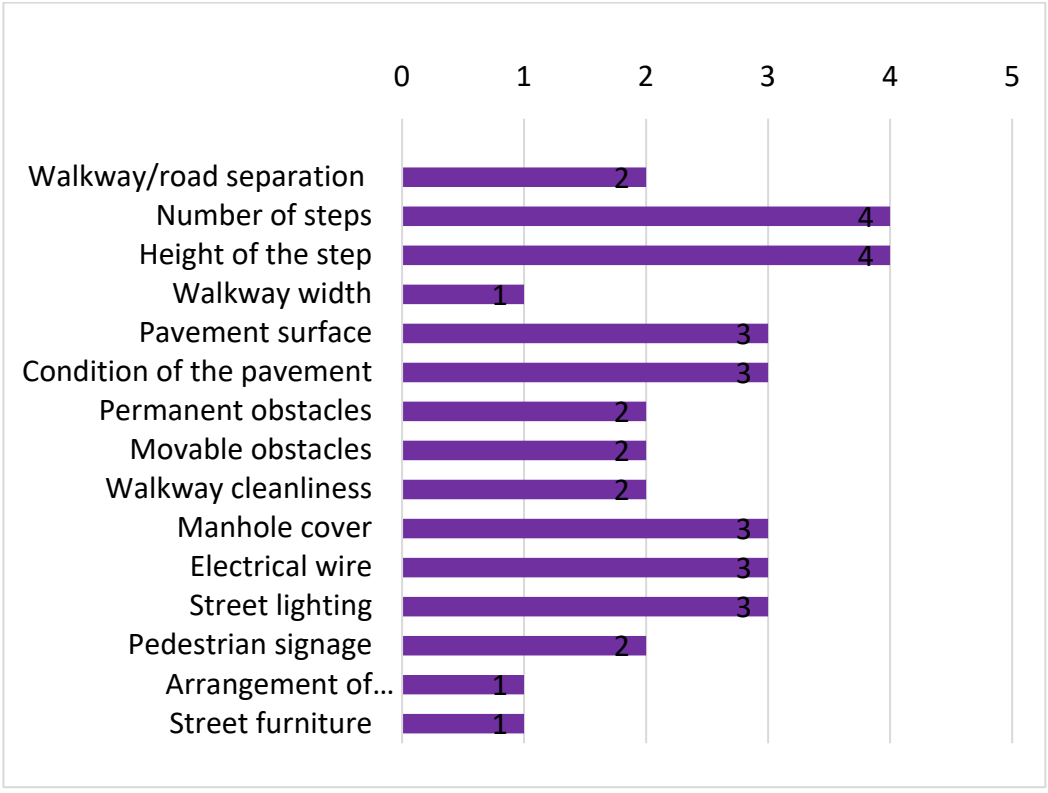
Location PP12-3

Walkability Index	2.379







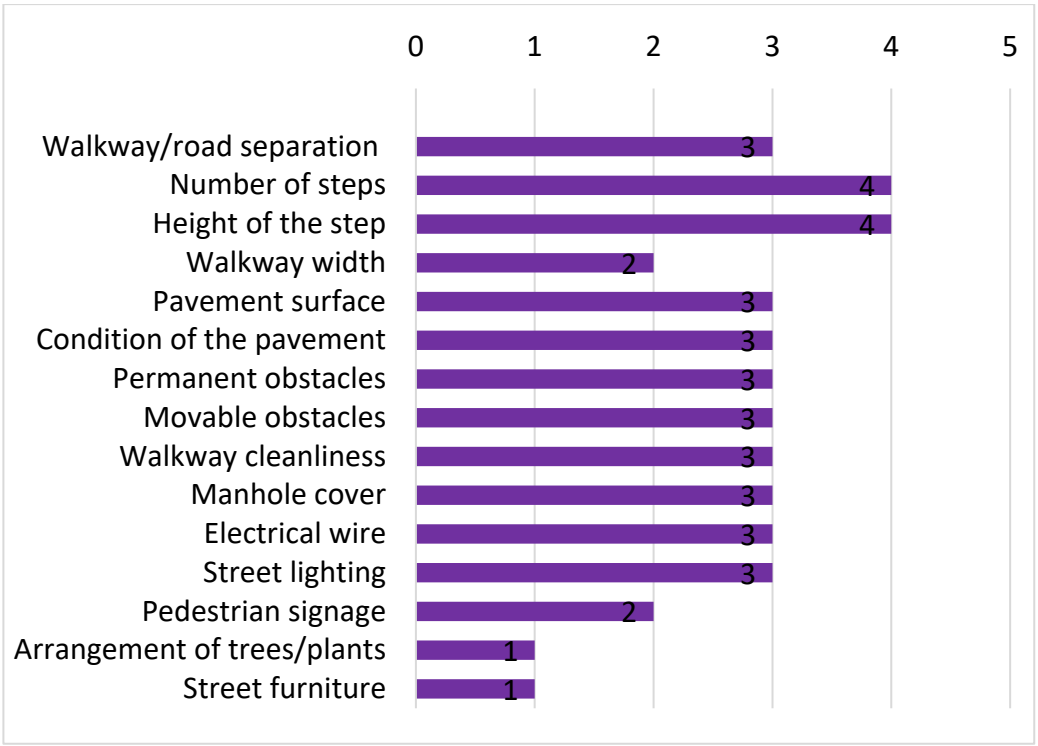


Location PP12-4

Walkability Index	2.941



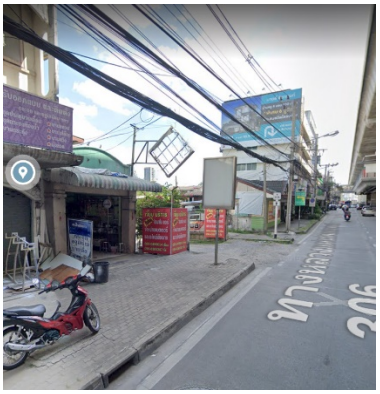




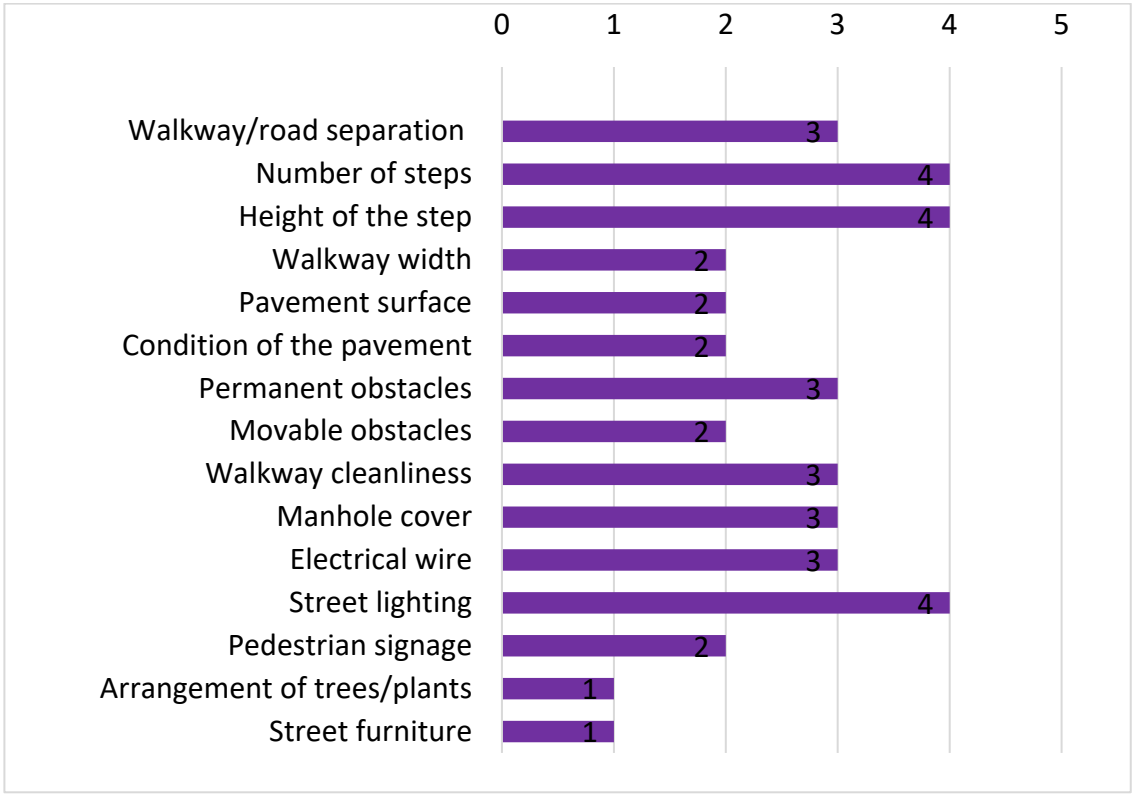
Location PP12-5

Walkability Index	2.918

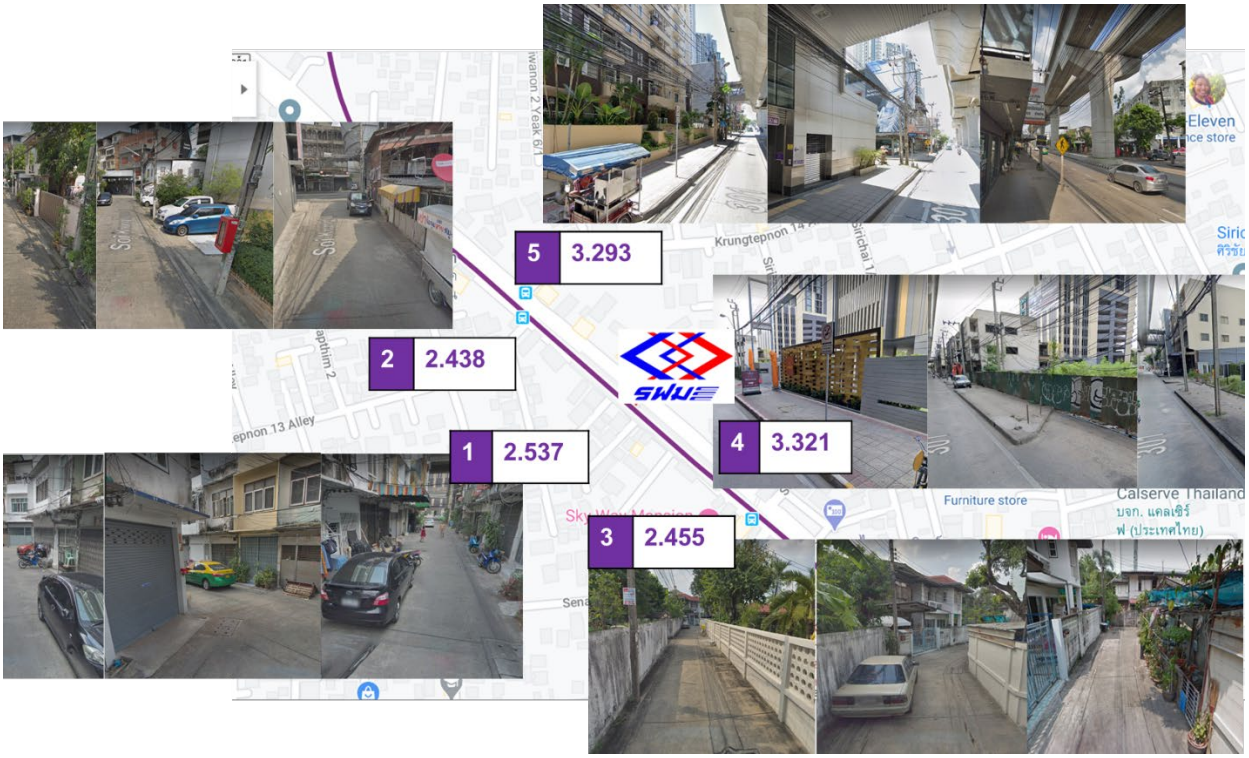








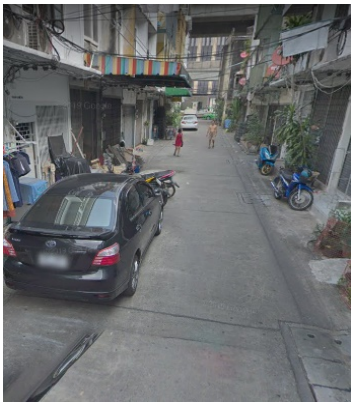
3.3.13 Yeak Tiwanon Station (PP13)

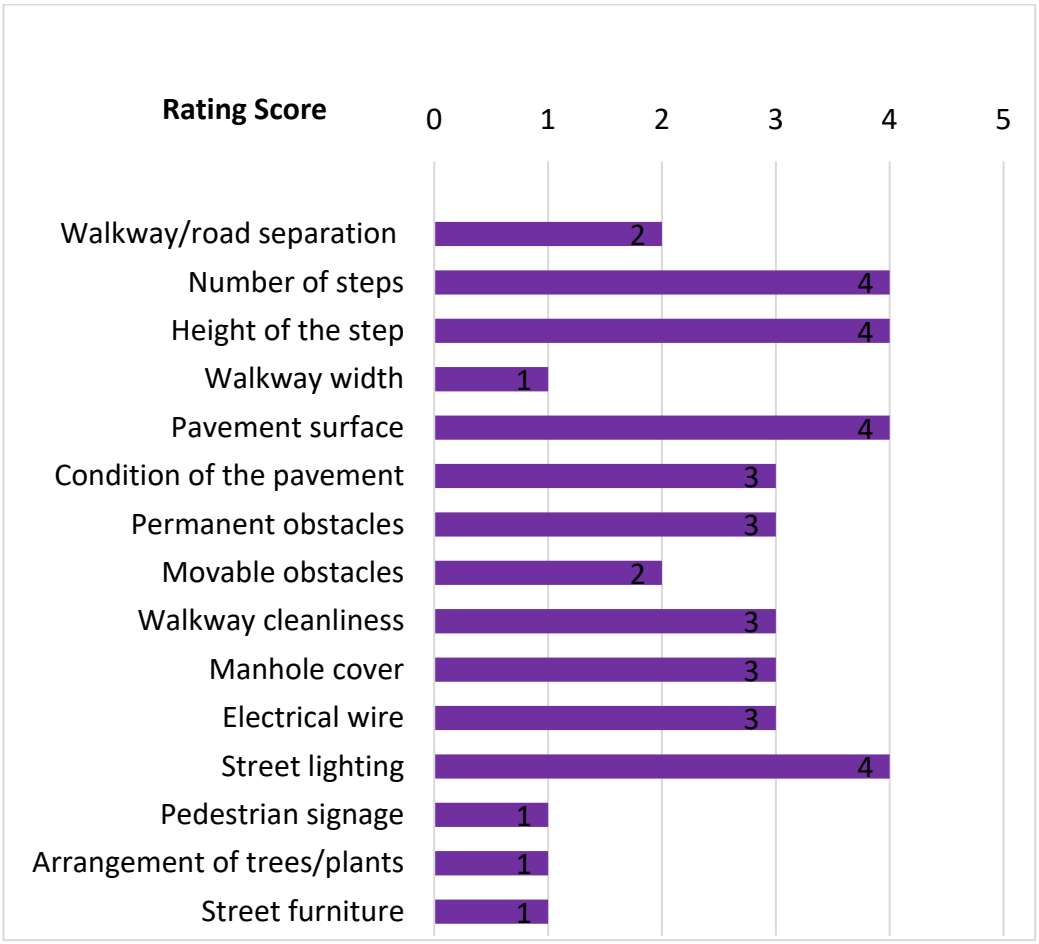


Location PP13-1

Walkability Index	2.537







Location PP13-2

Walkability Index	2.438







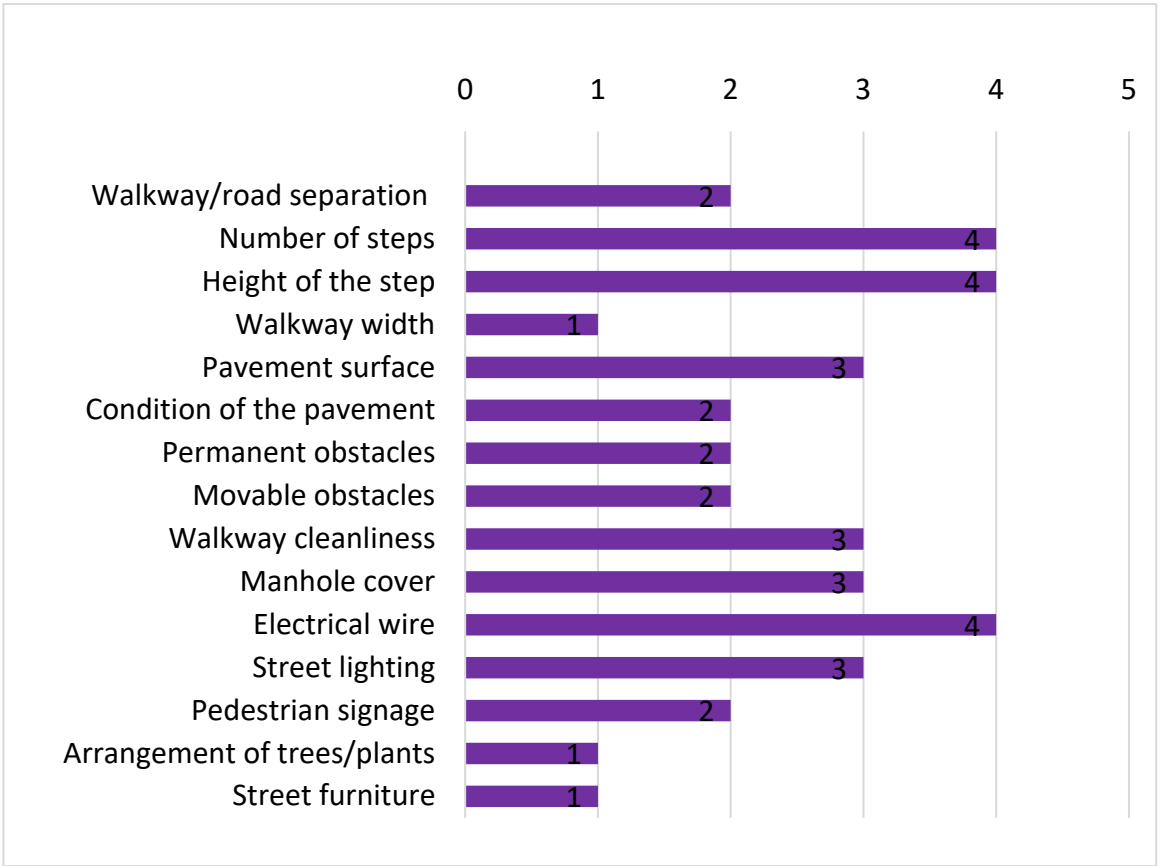


Location PP13-3

Walkability Index	2.455

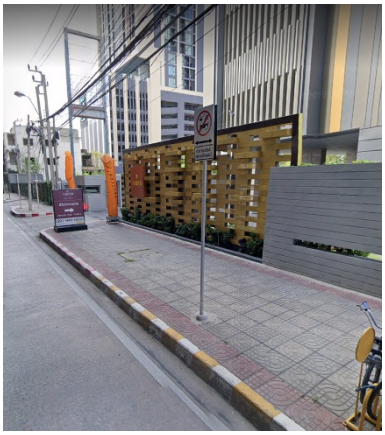


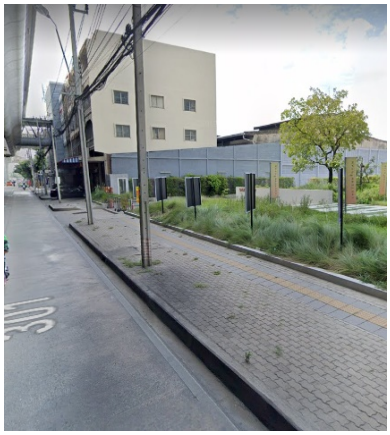


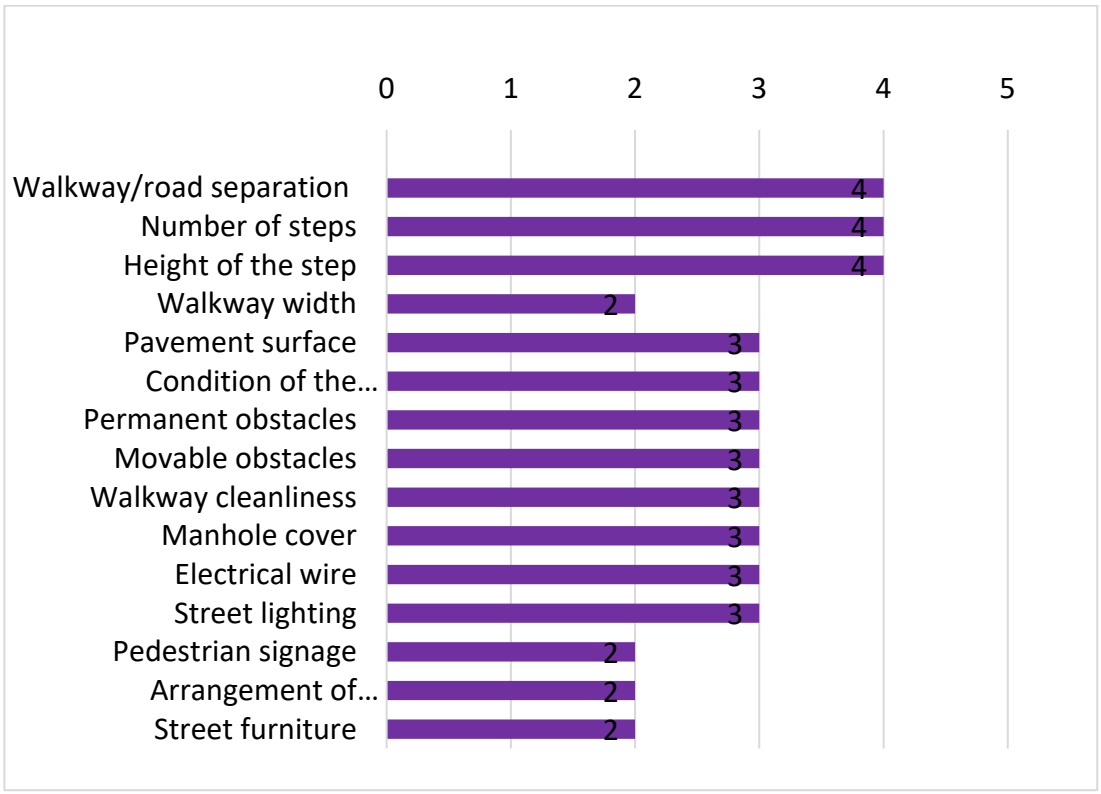


Location PP13-4

Walkability Index	3.321



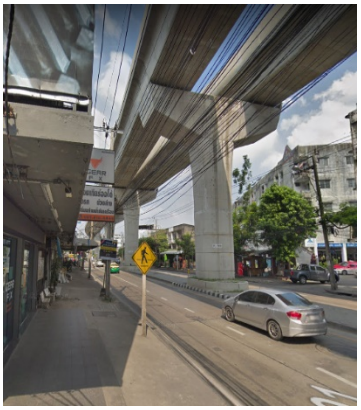


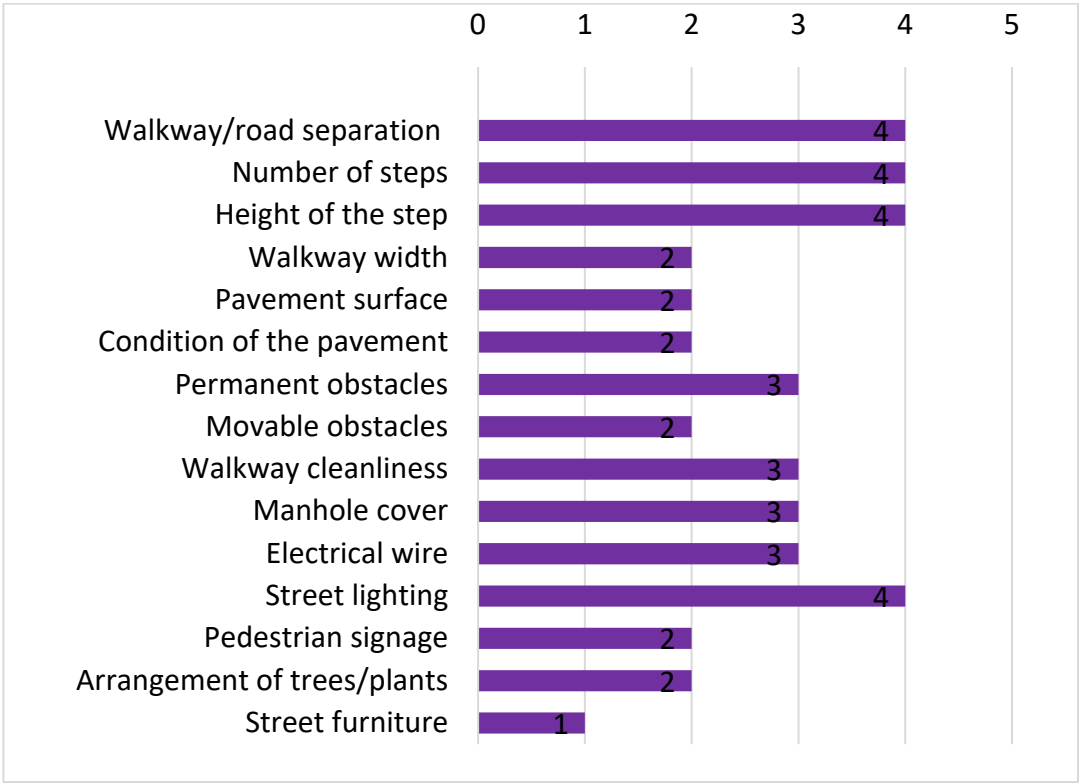


Location PP13-5

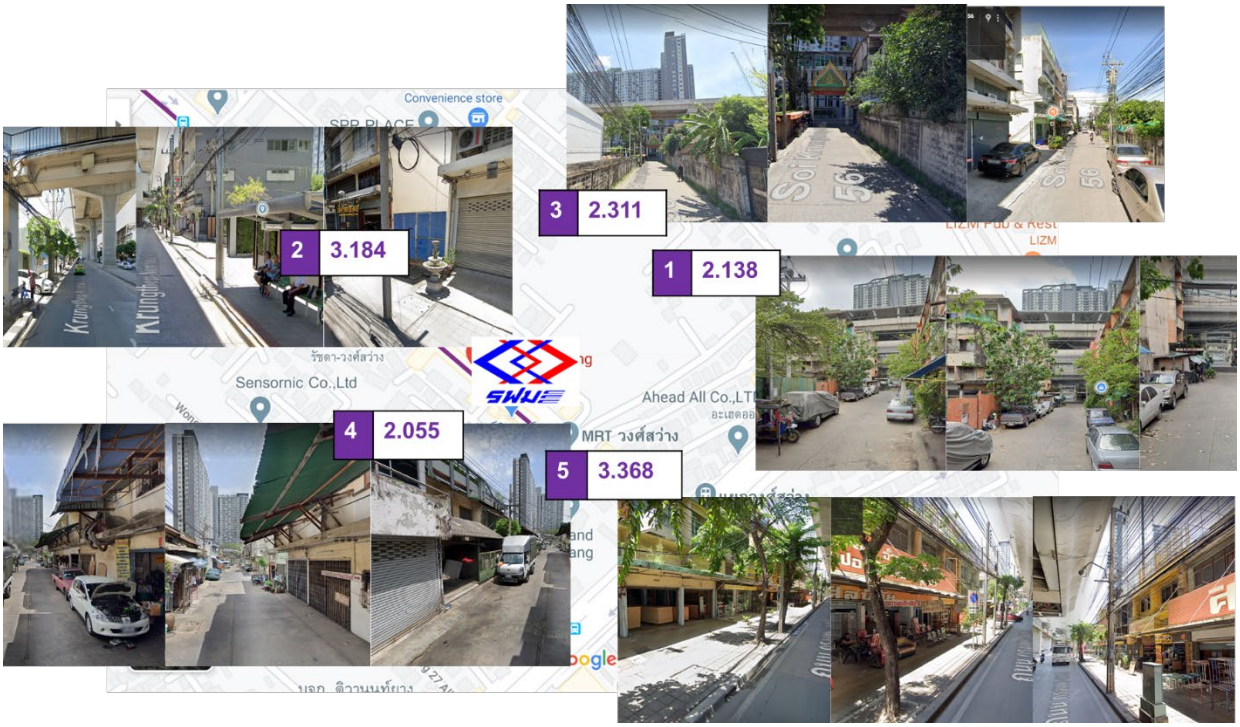
Walkability Index	3.293







3.3.14 Wong Sawang Station (PP14)

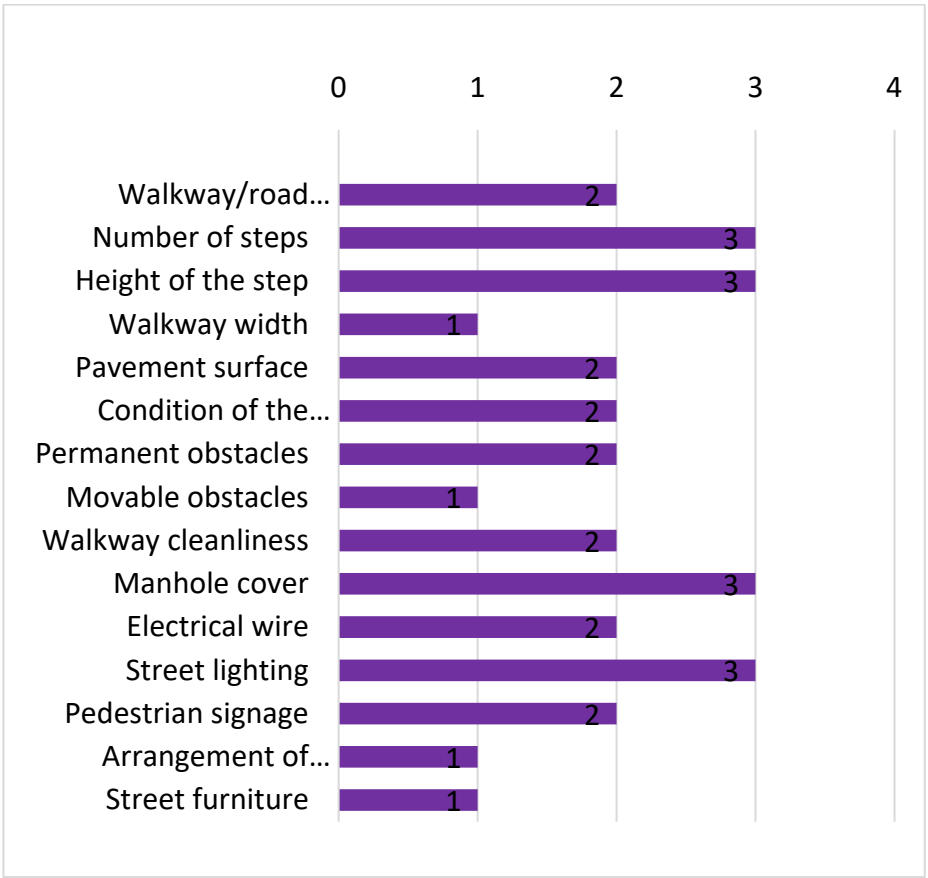


Location PP14-1

Walkability Index	2.138





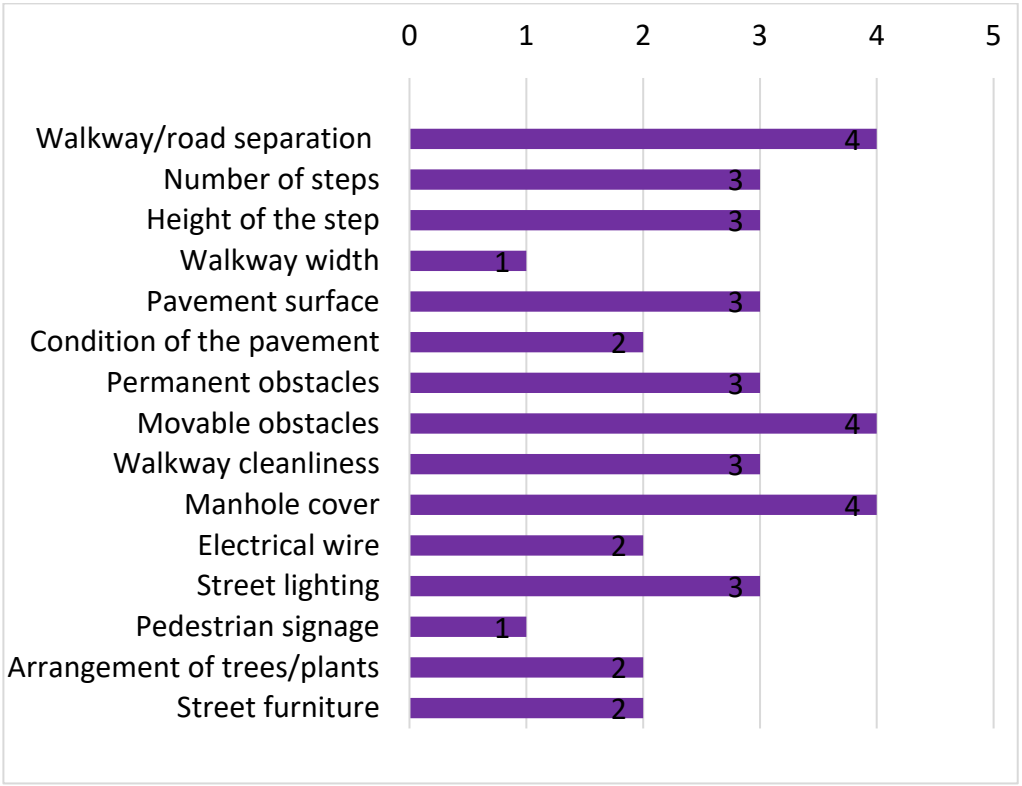


Location PP14-2

Walkability Index	3.184



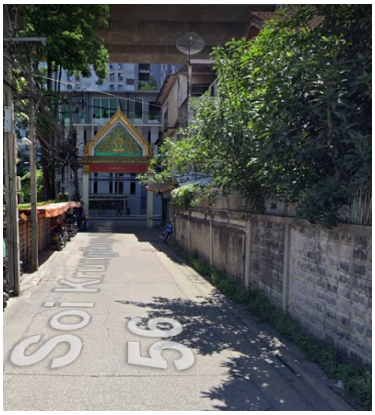


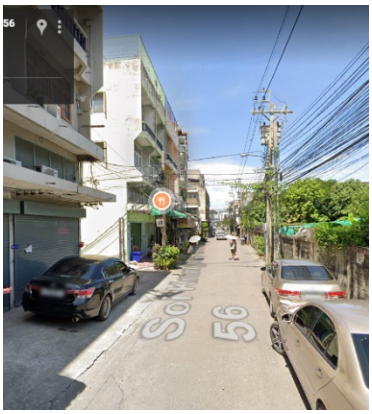


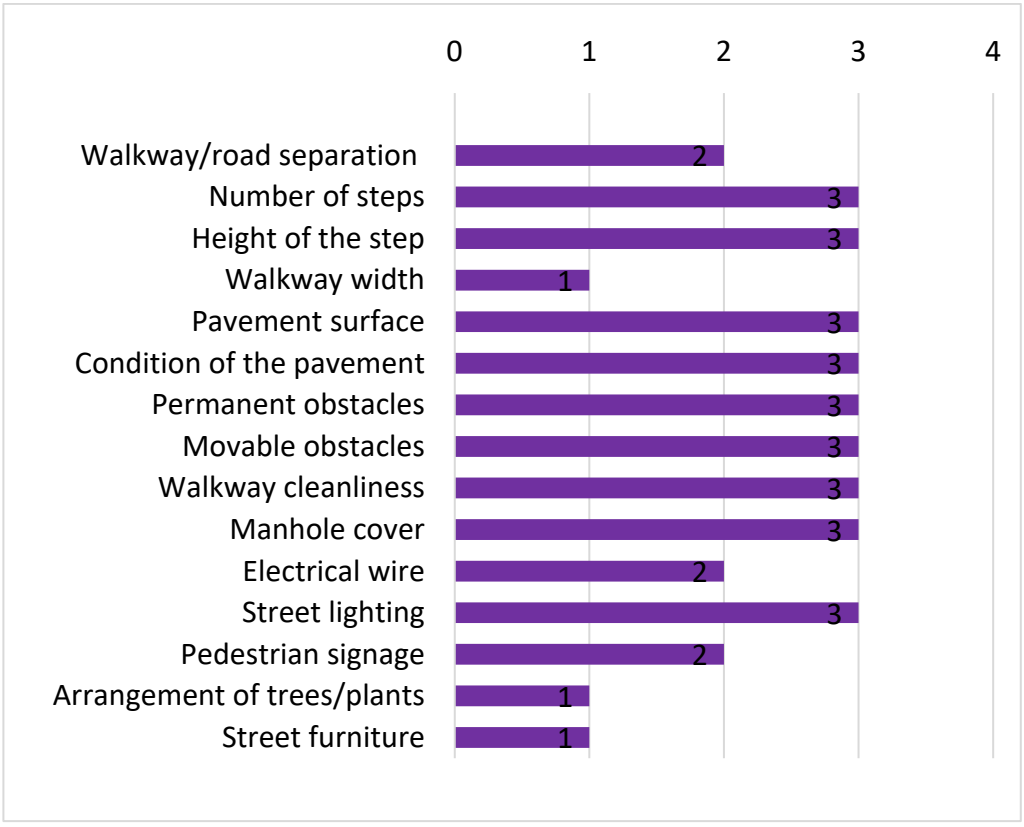
Location PP14-3

Walkability Index	2.311







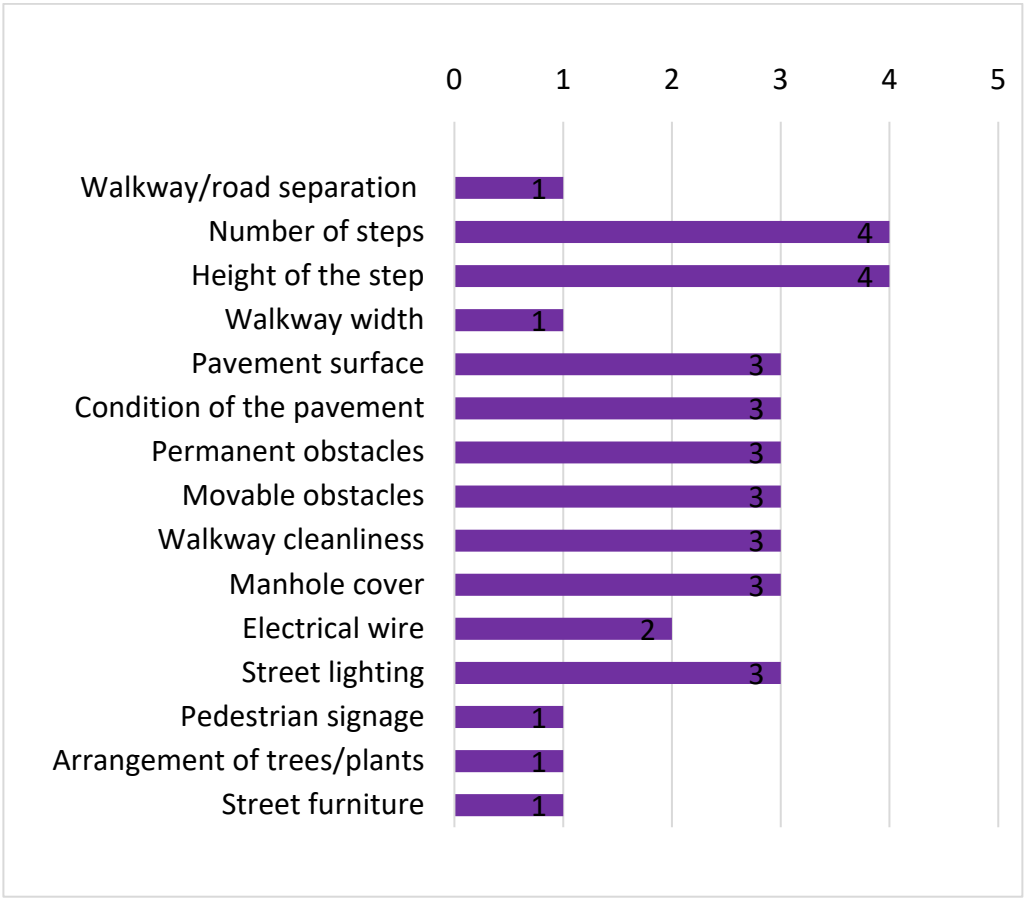


Location PP14-4

Walkability Index	2.055





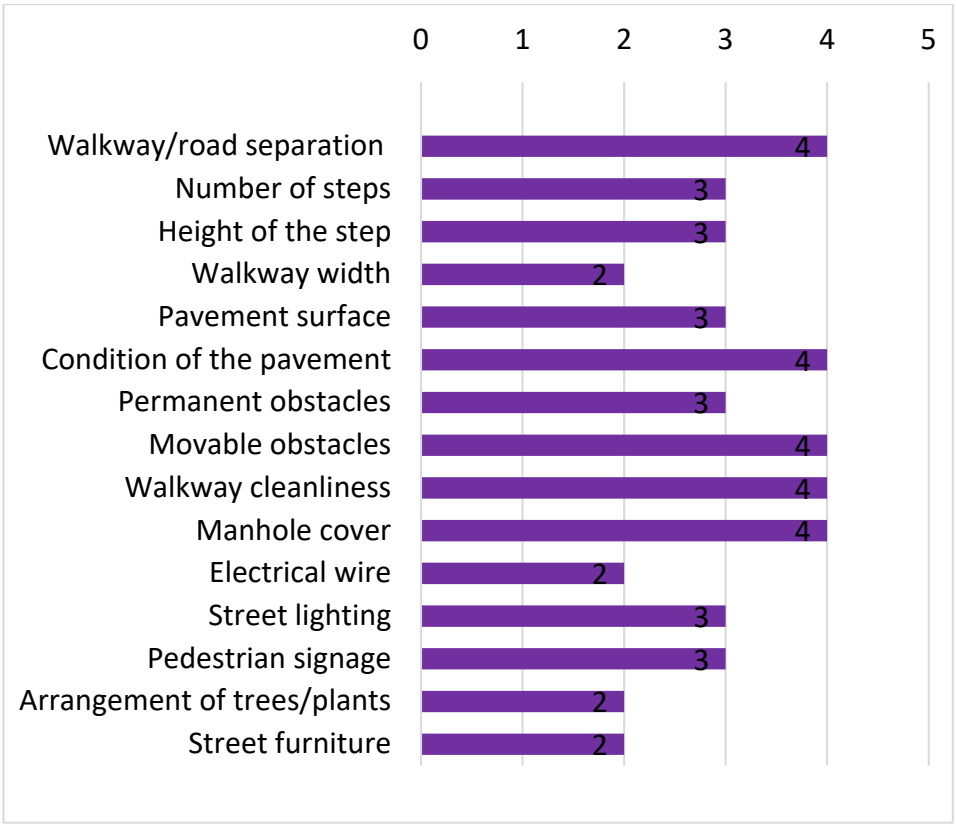


Location PP14-5

Walkability Index	3.368







3.3.15 Bang Son Station (PP15)

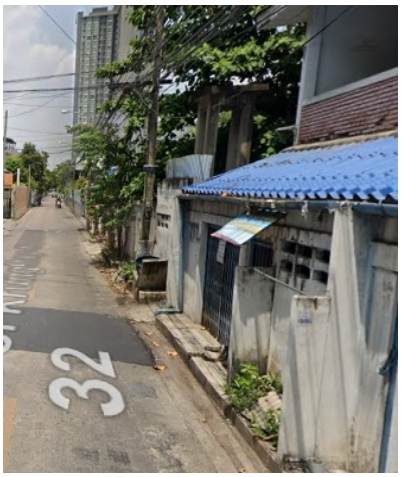


Location PP15-1

Walkability Index	2.246





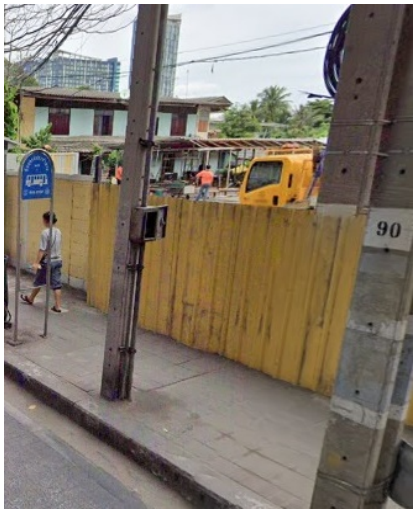




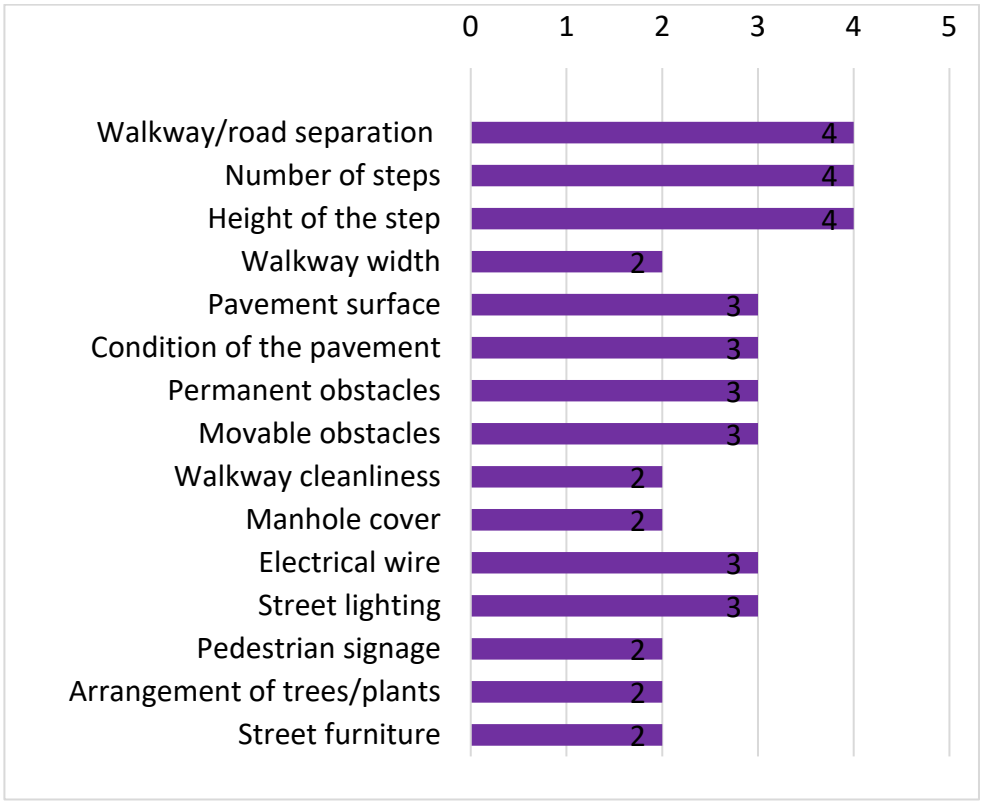
Location PP15-2

Walkability Index	3.162









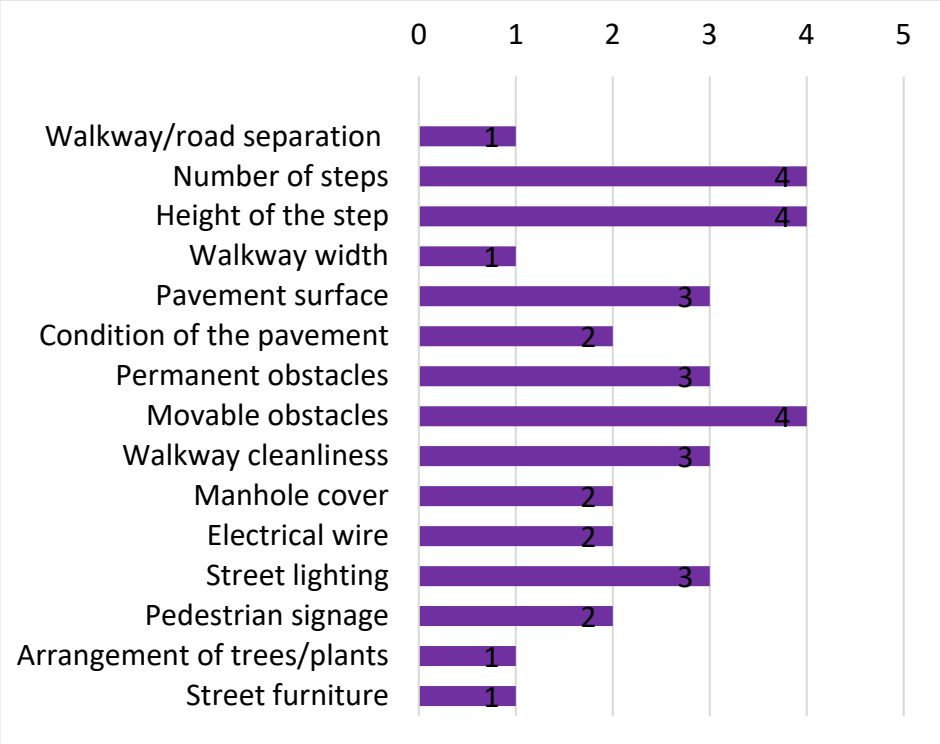
Location PP15-3

Walkability Index	1.997



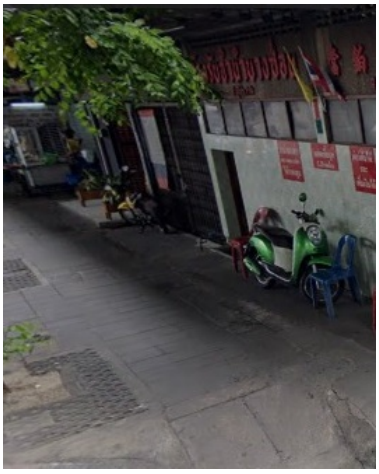






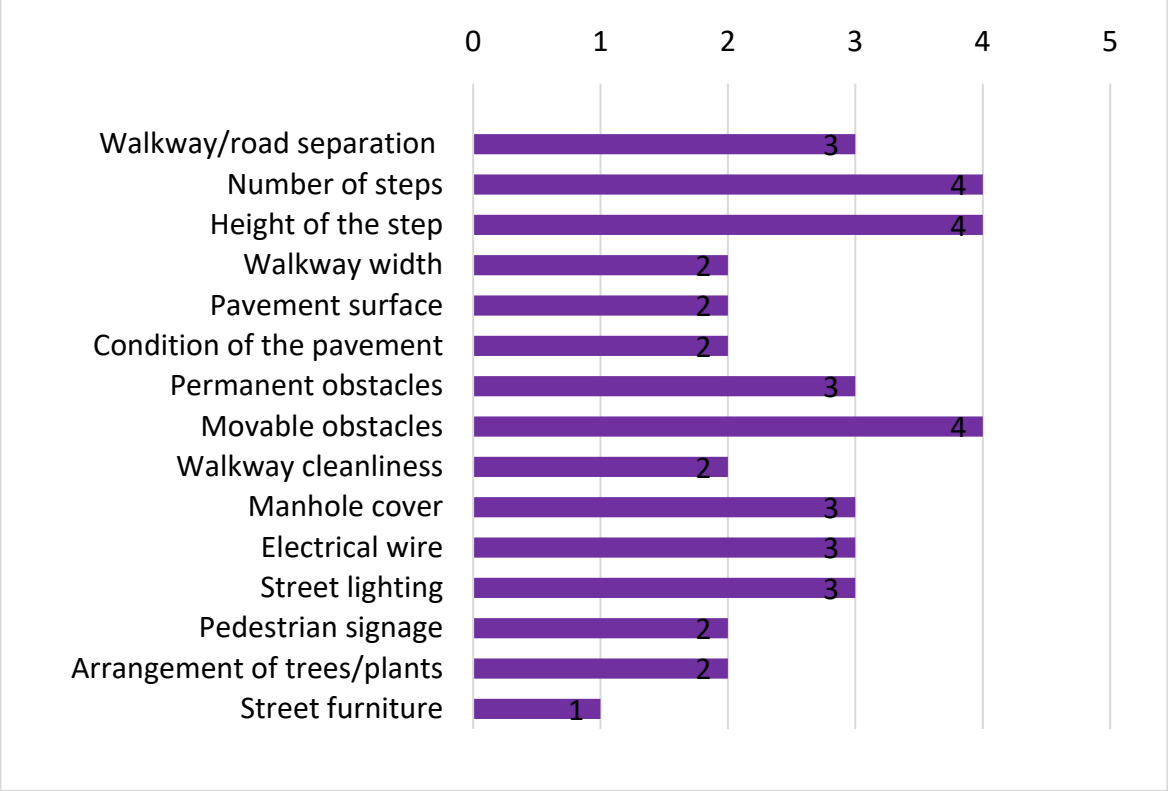
Location PP15-4

Walkability Index	2.895





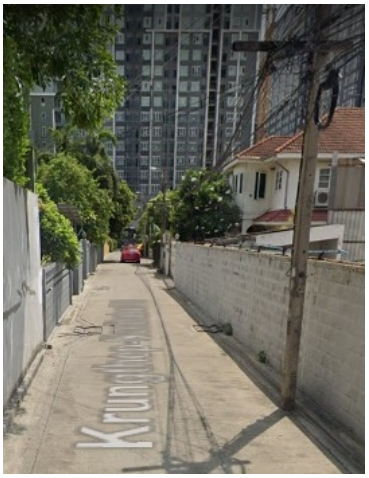


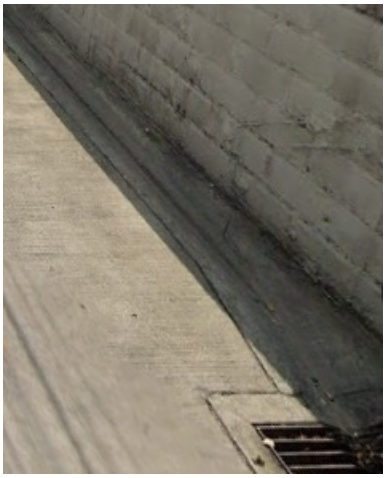


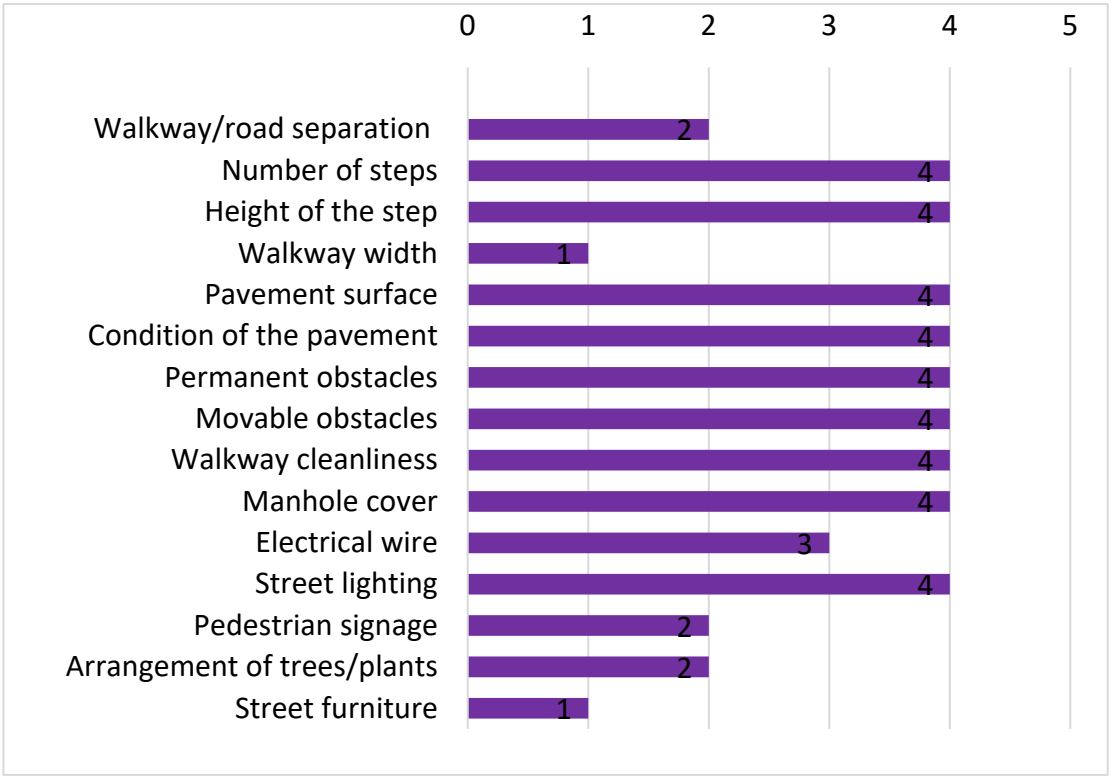
Location PP15-5

Walkability Index	2.826

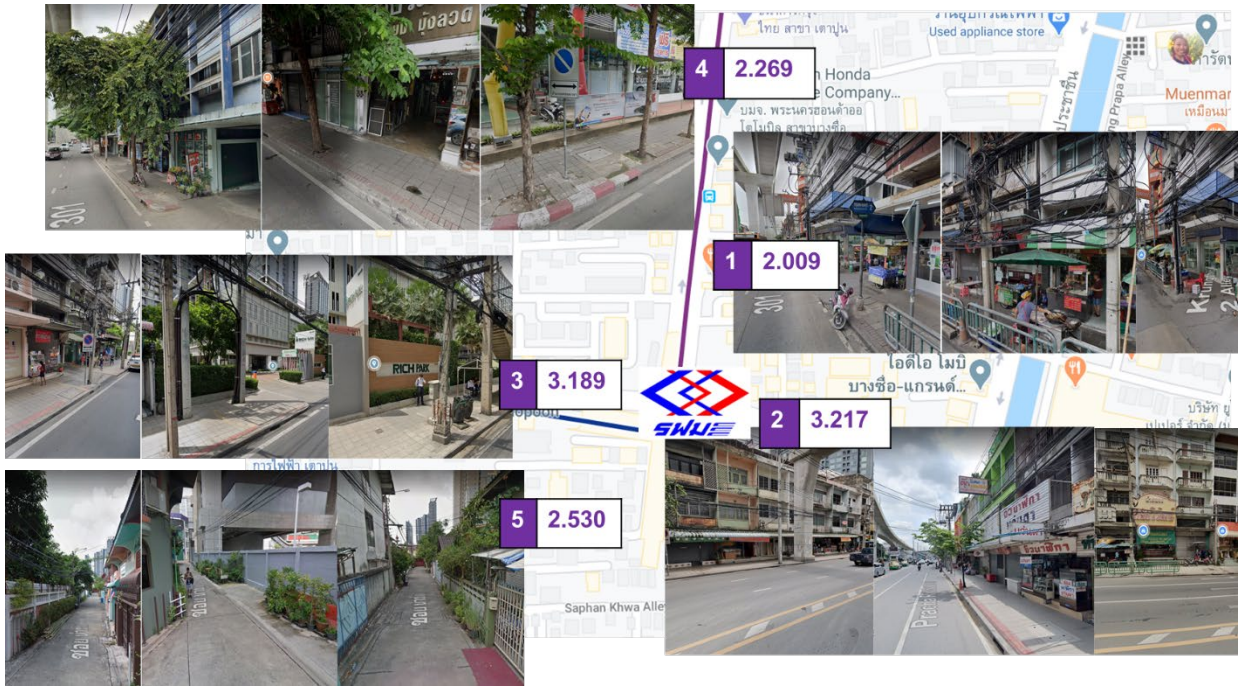








3.3.16 Tao Poon Station (PP16)

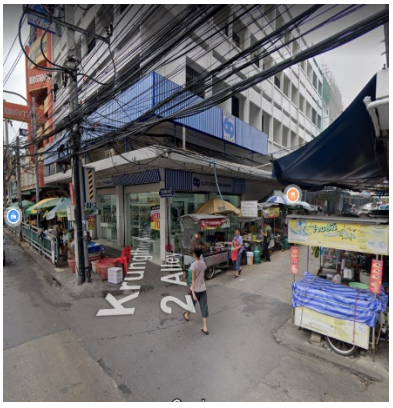


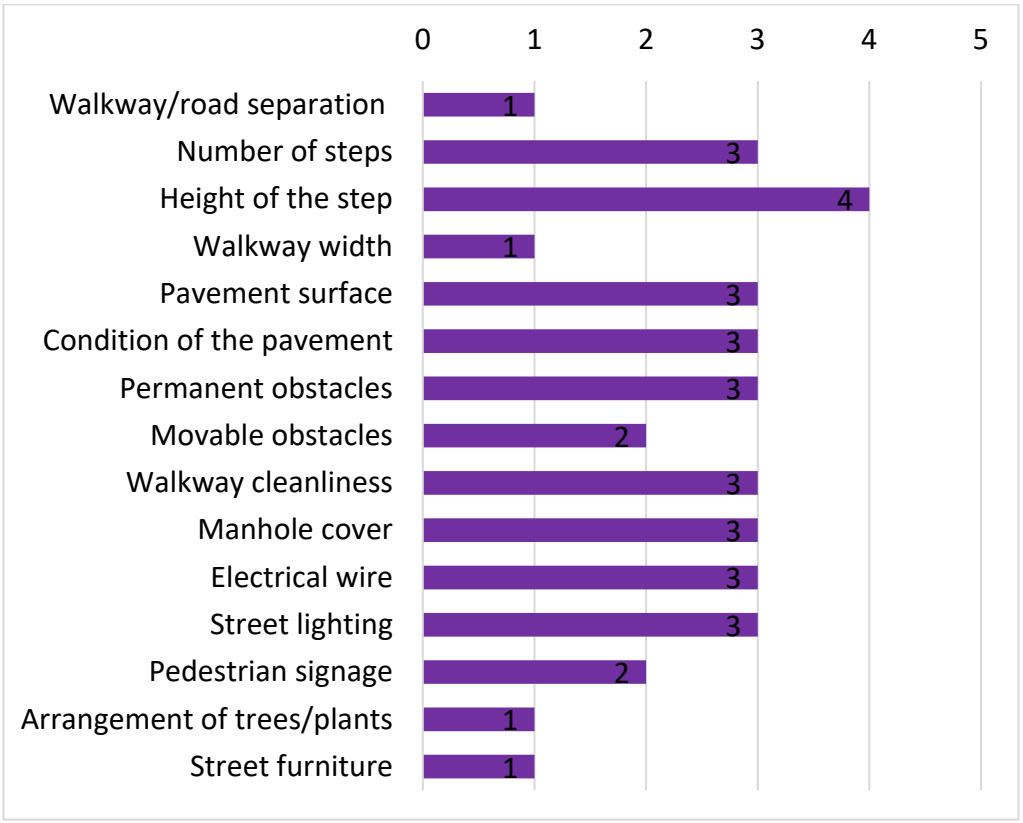
Location PP16-1

Walkability Index	2.009



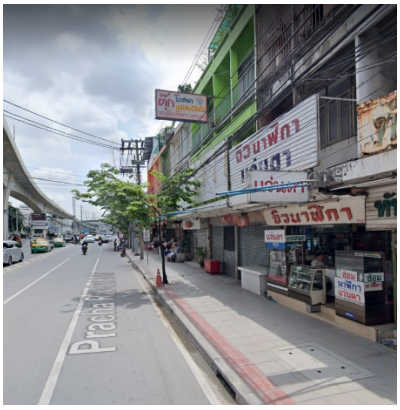


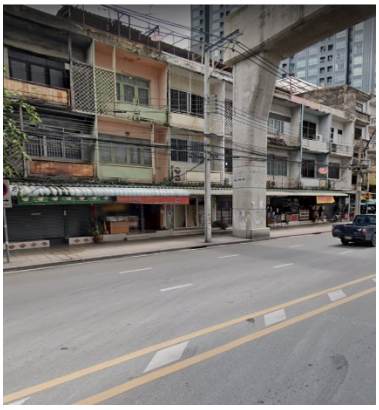




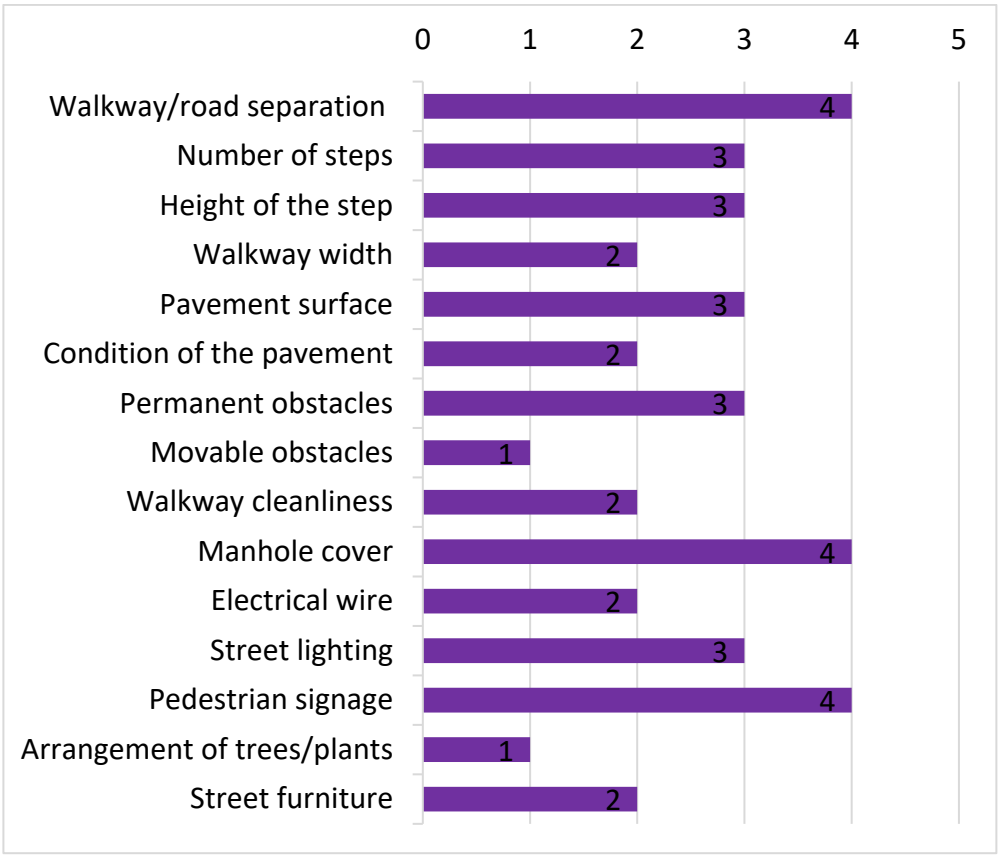
Location PP16-2

Walkability Index	3.217







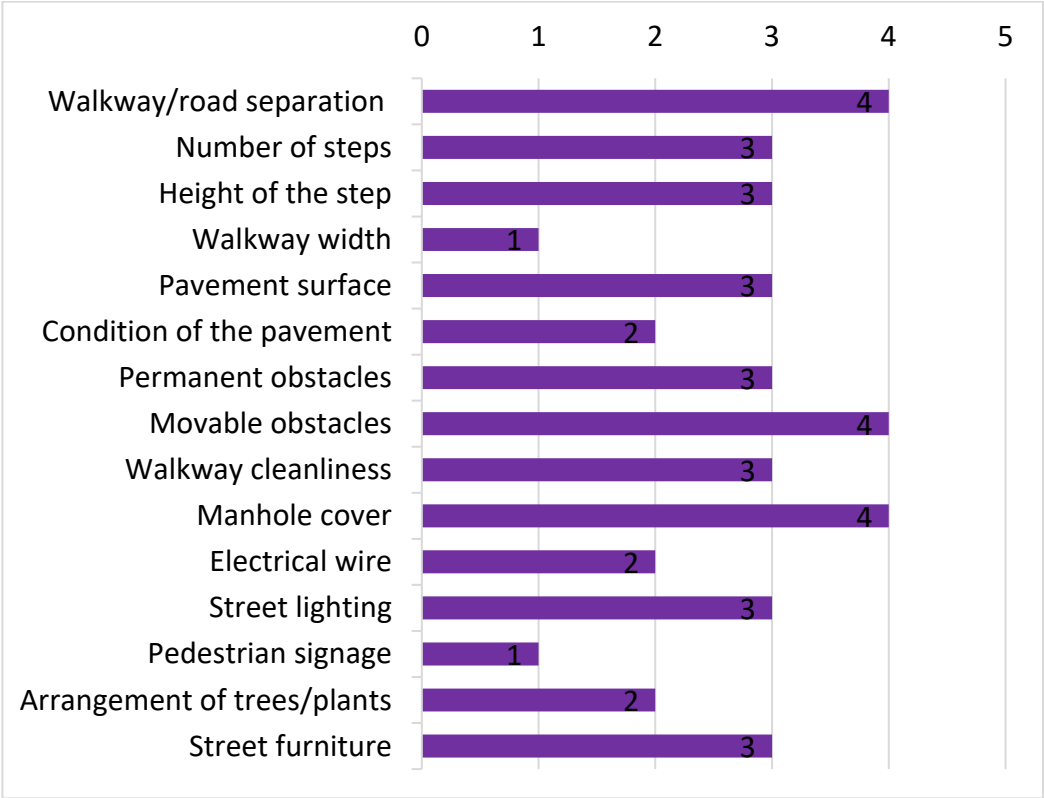


Location PP16-3

Walkability Index	3.189





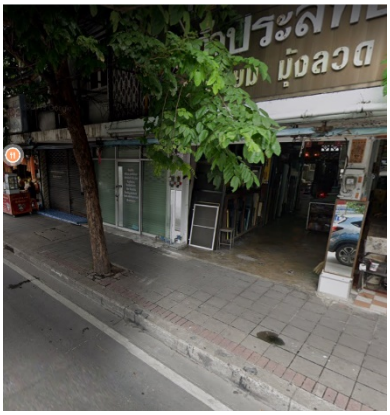


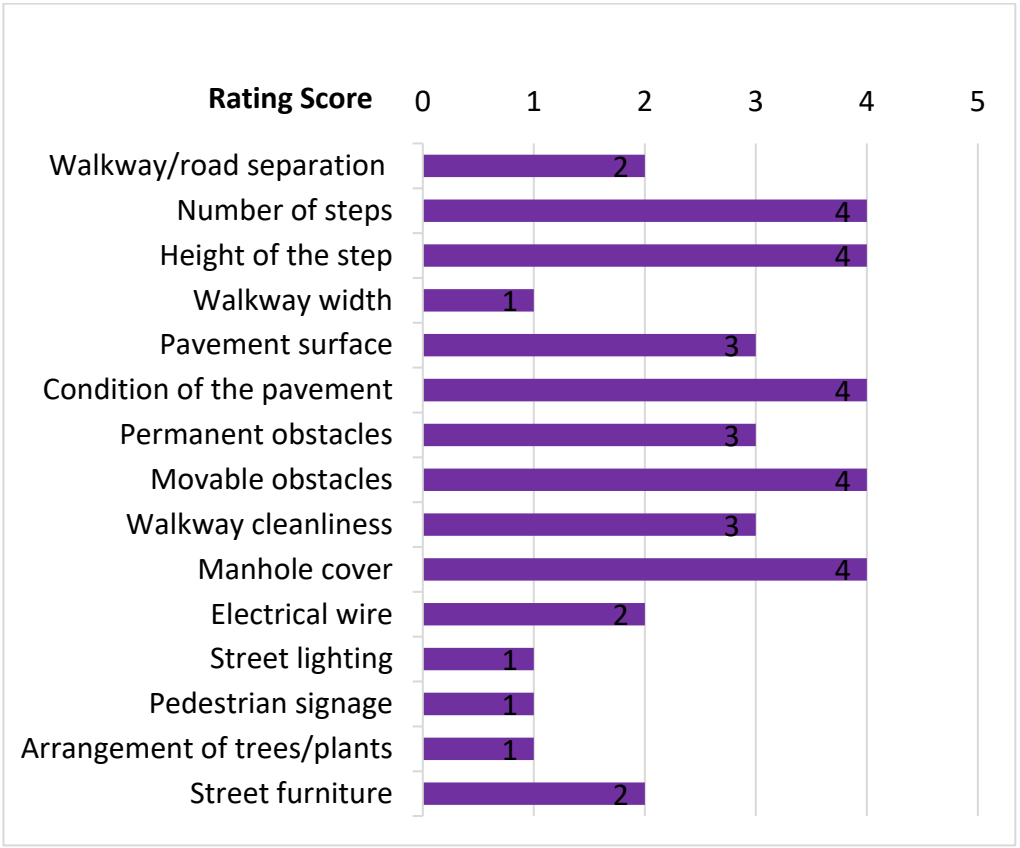
Location PP16-4

Walkability Index	2.269







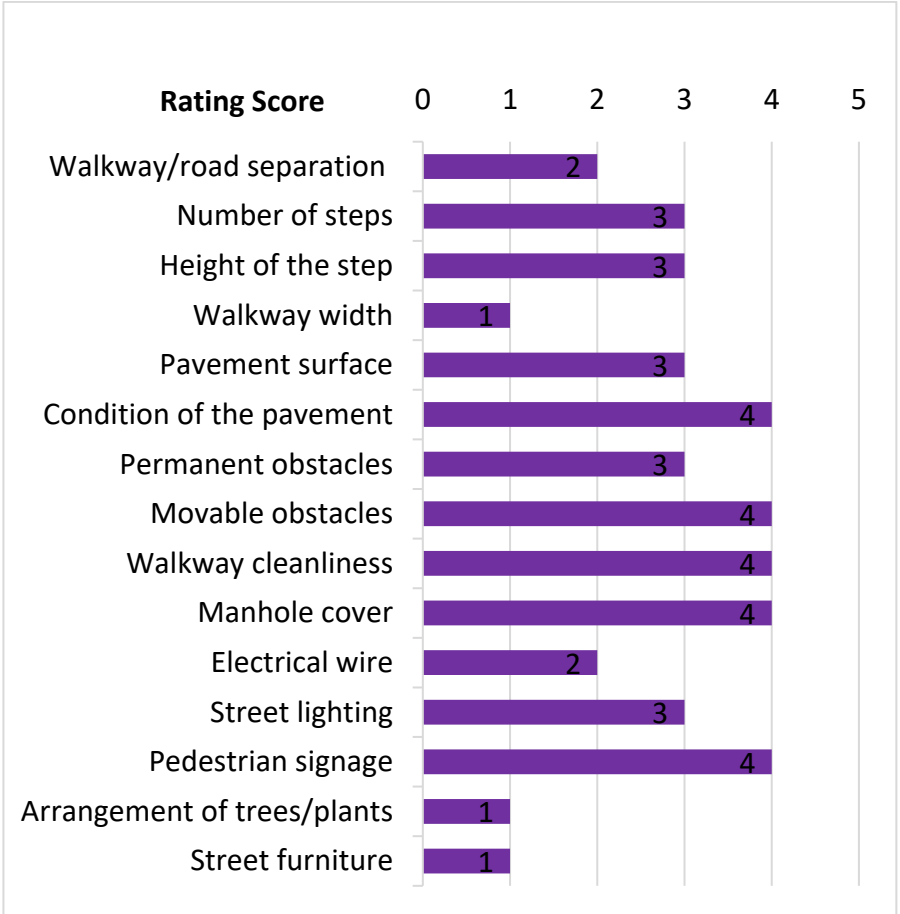


Location PP16-5

Walkability Index	2.530







3.4 Walkability at 5 Blue Line Stations

The walkability of the area around 5 MRT blue line stations were evaluated. The average value of each station is shown in Figure 3.3.

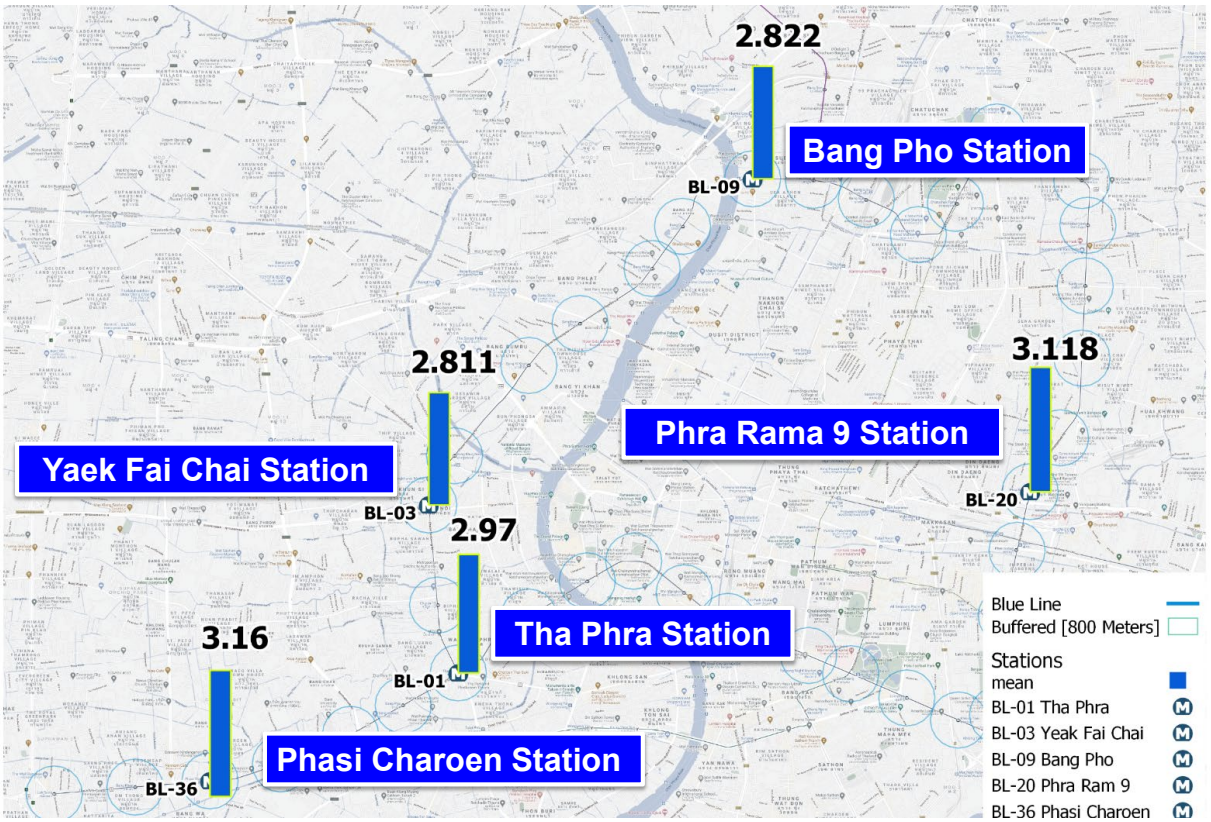
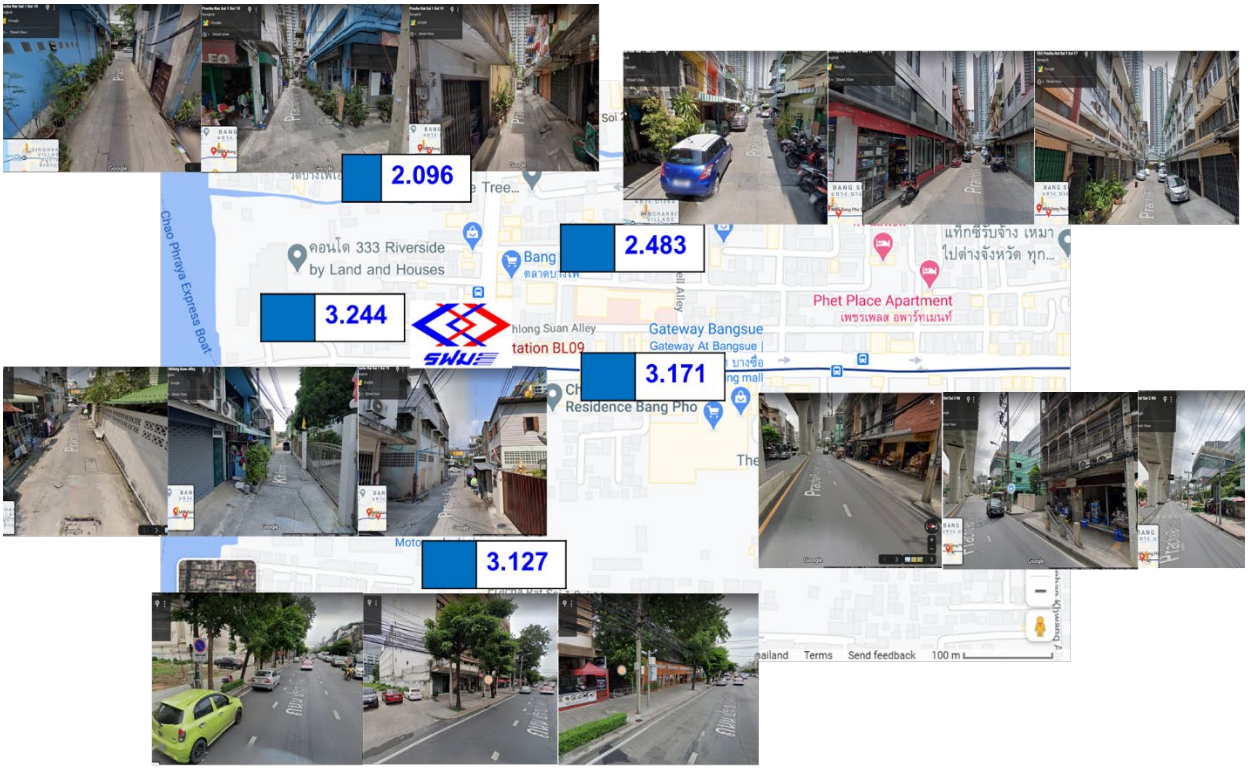


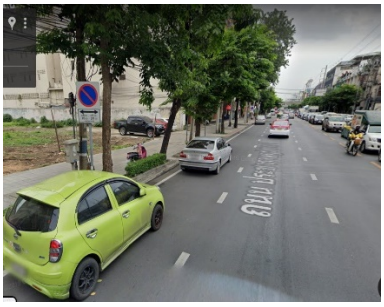
Figure 3.3 Walkability around 5 MRT Blue Line Stations

3.4.1 Bang Pho Station (BL09)

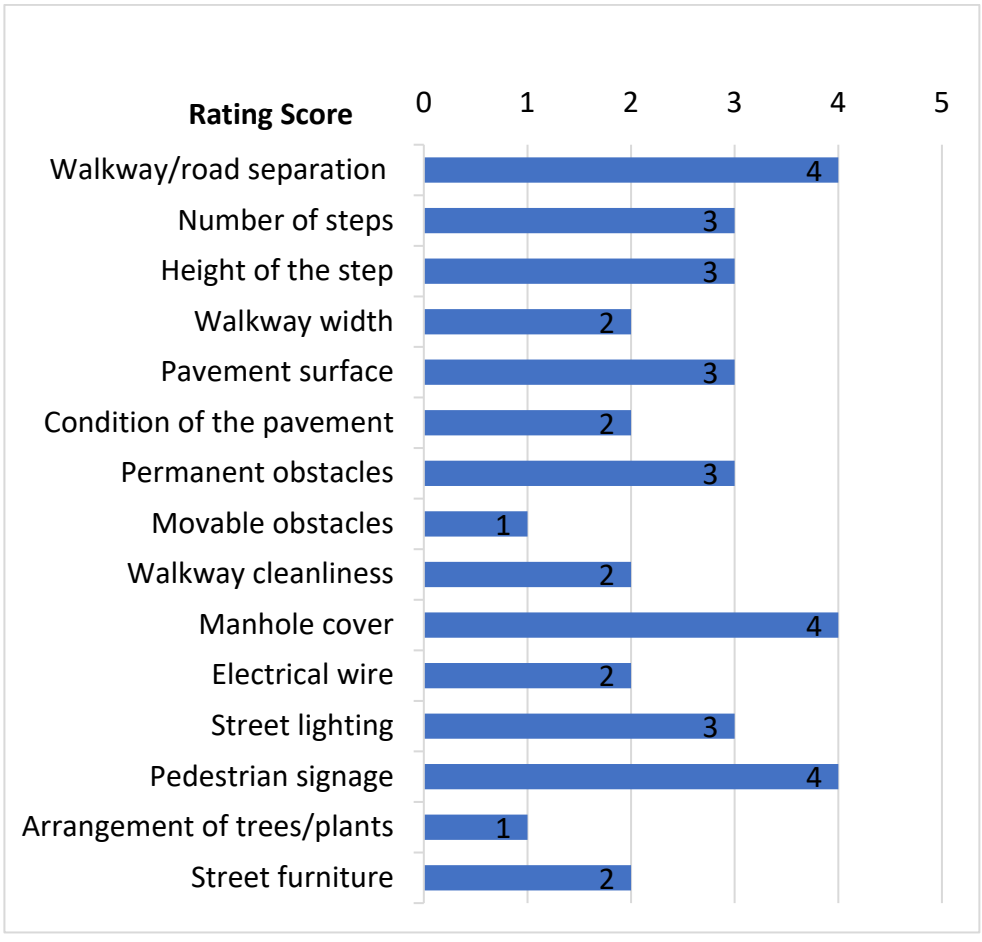


Location BL09-1

Walkability Index	3.217



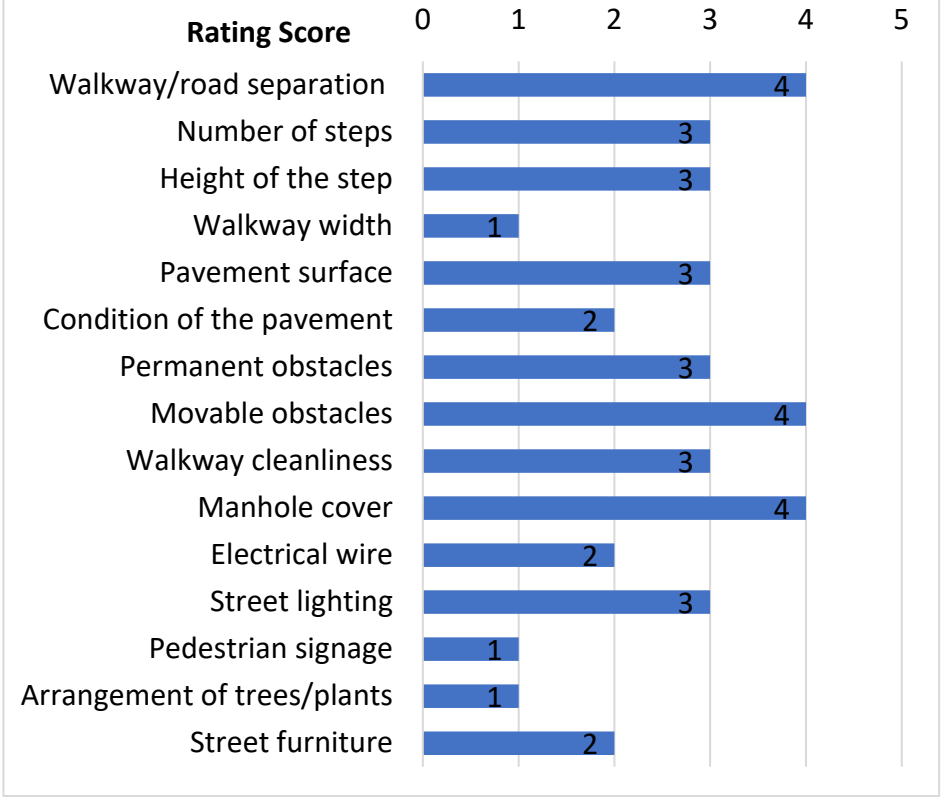




Location BL09-2

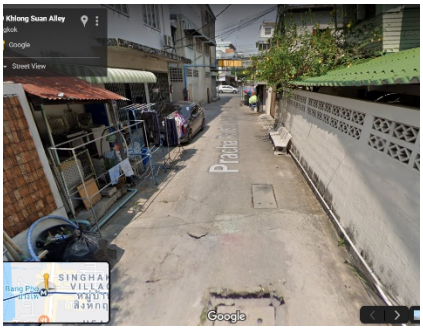
Walkability Index	3.171



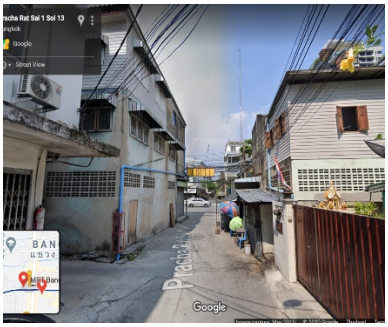


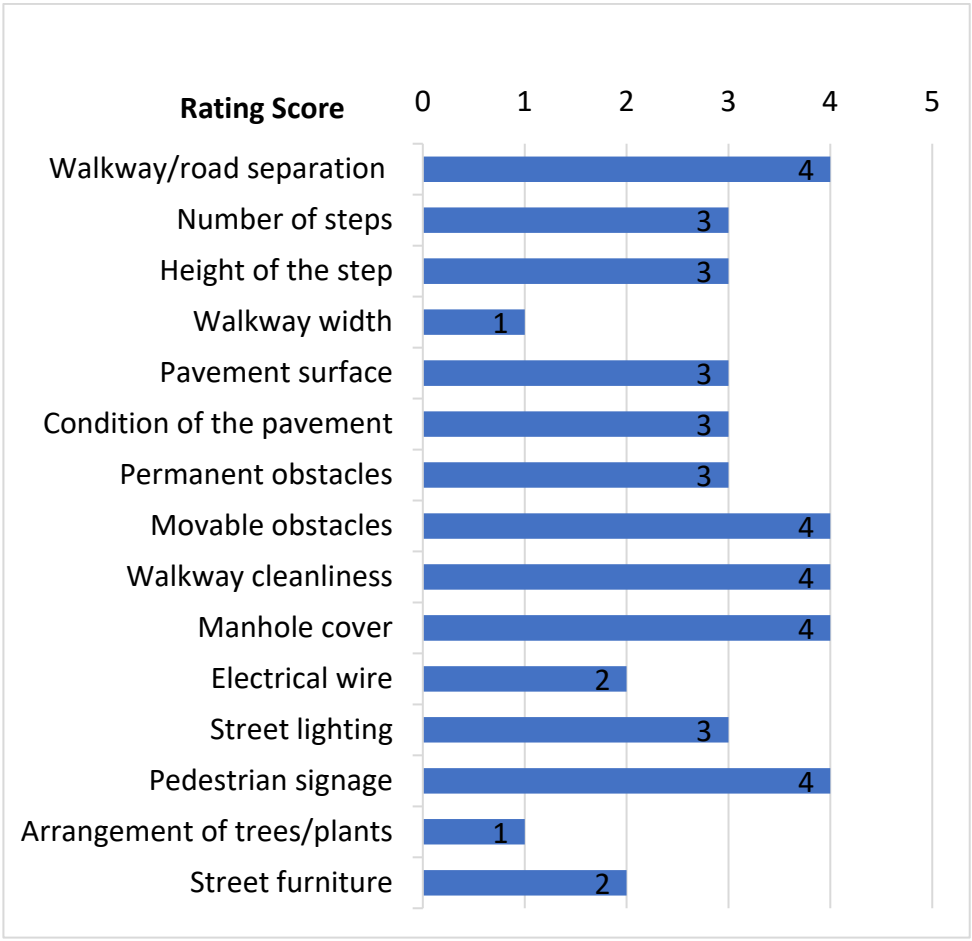
Location BL09-3

Walkability Index	3.244







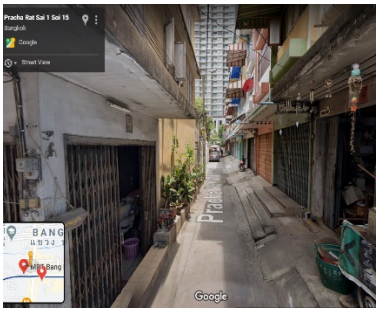


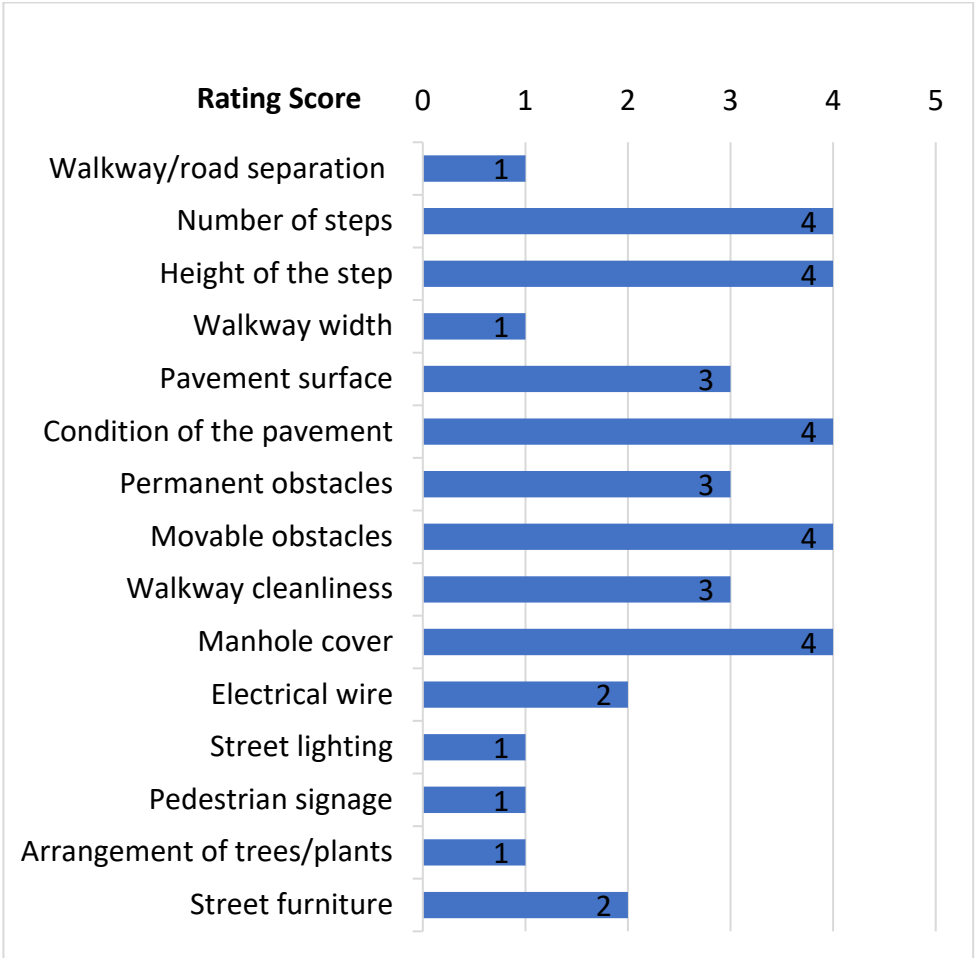
Location BL09-4

Walkability Index	2.096







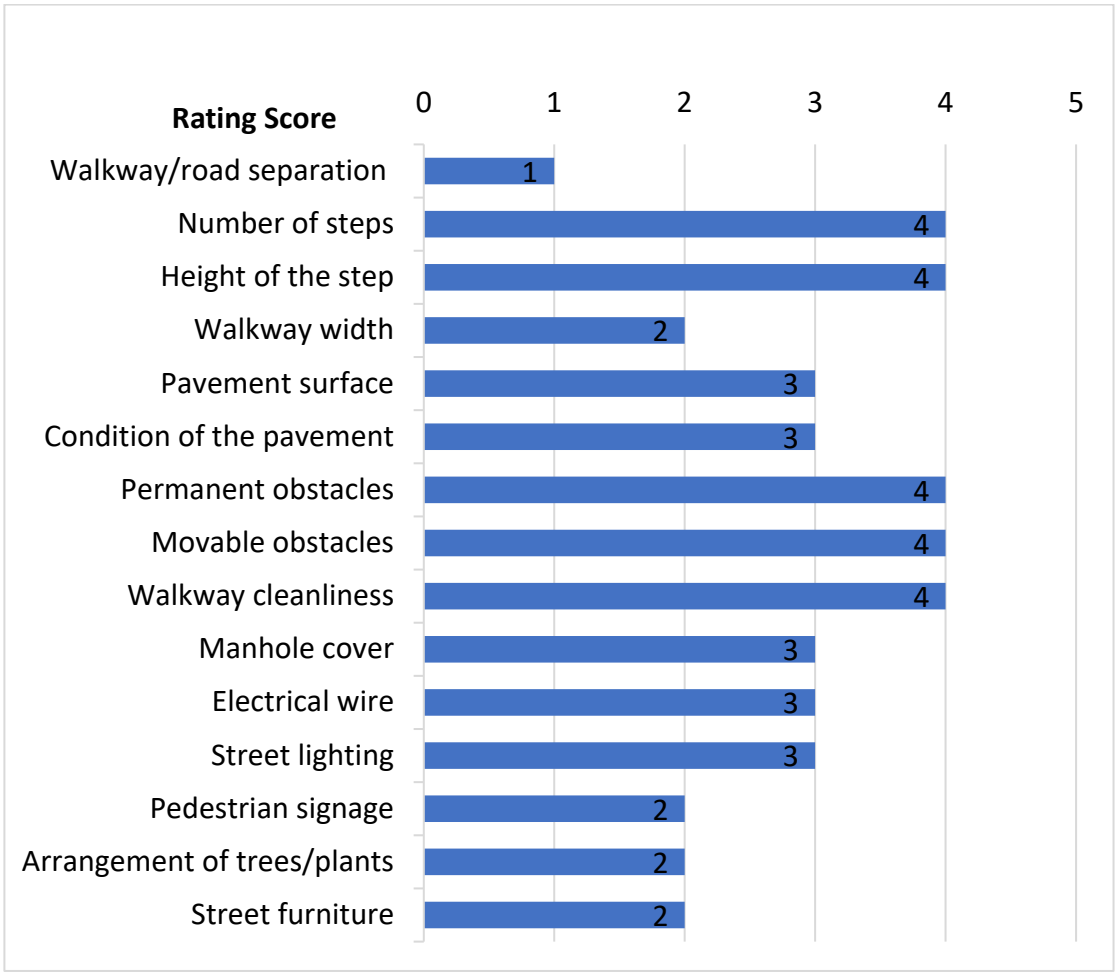


Location BL09-5

Walkability Index	2.382





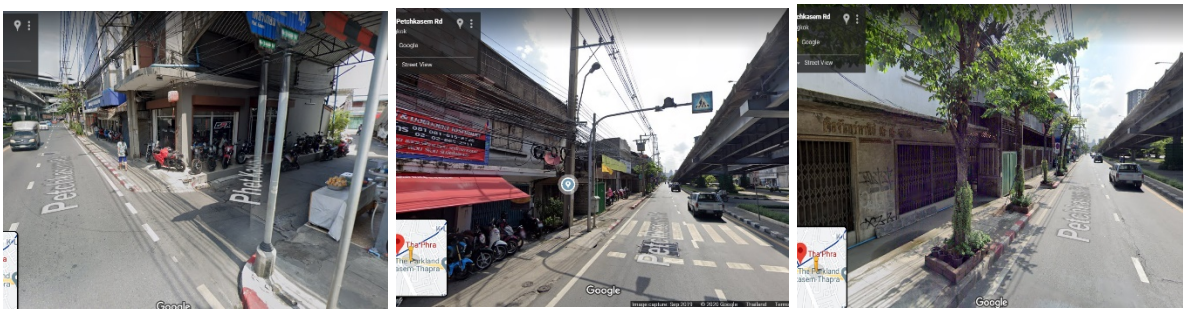


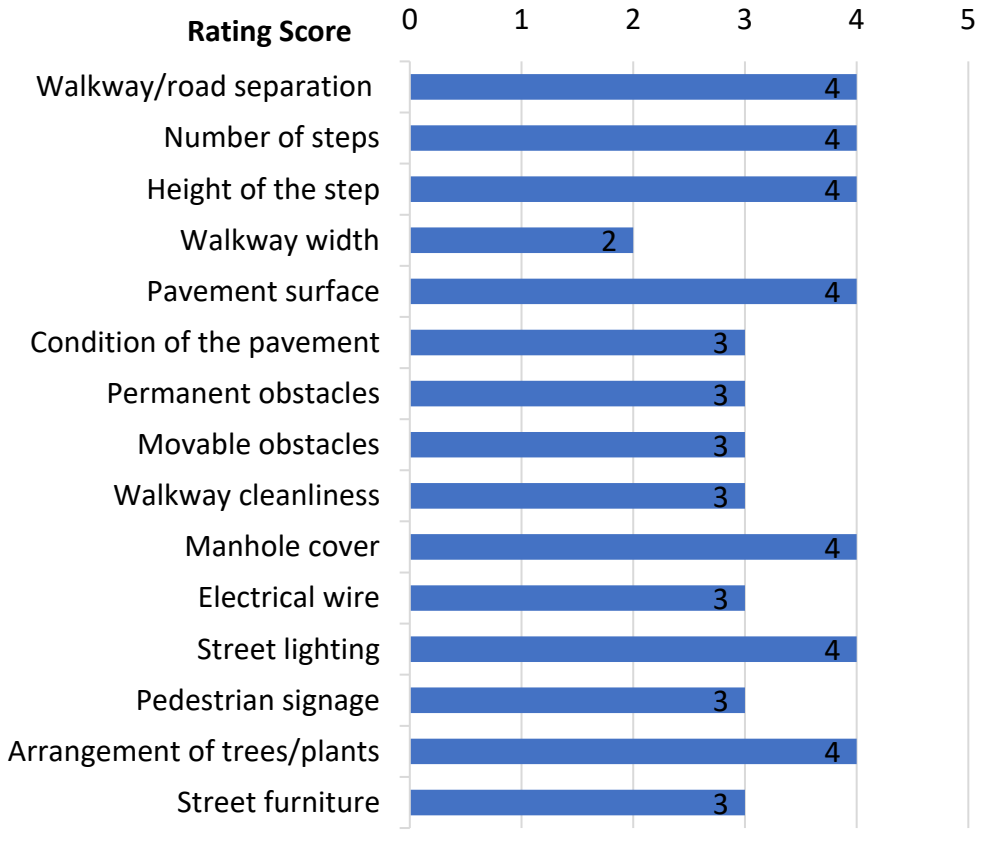
3.4.2 Tha Phra Station (BL01)



Location BL01-1

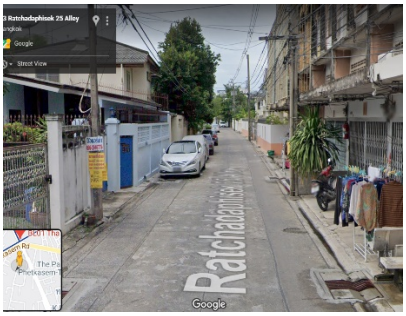
Walkability Index	3.596

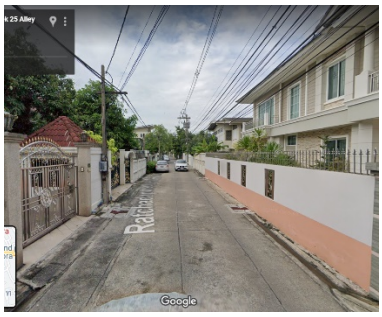




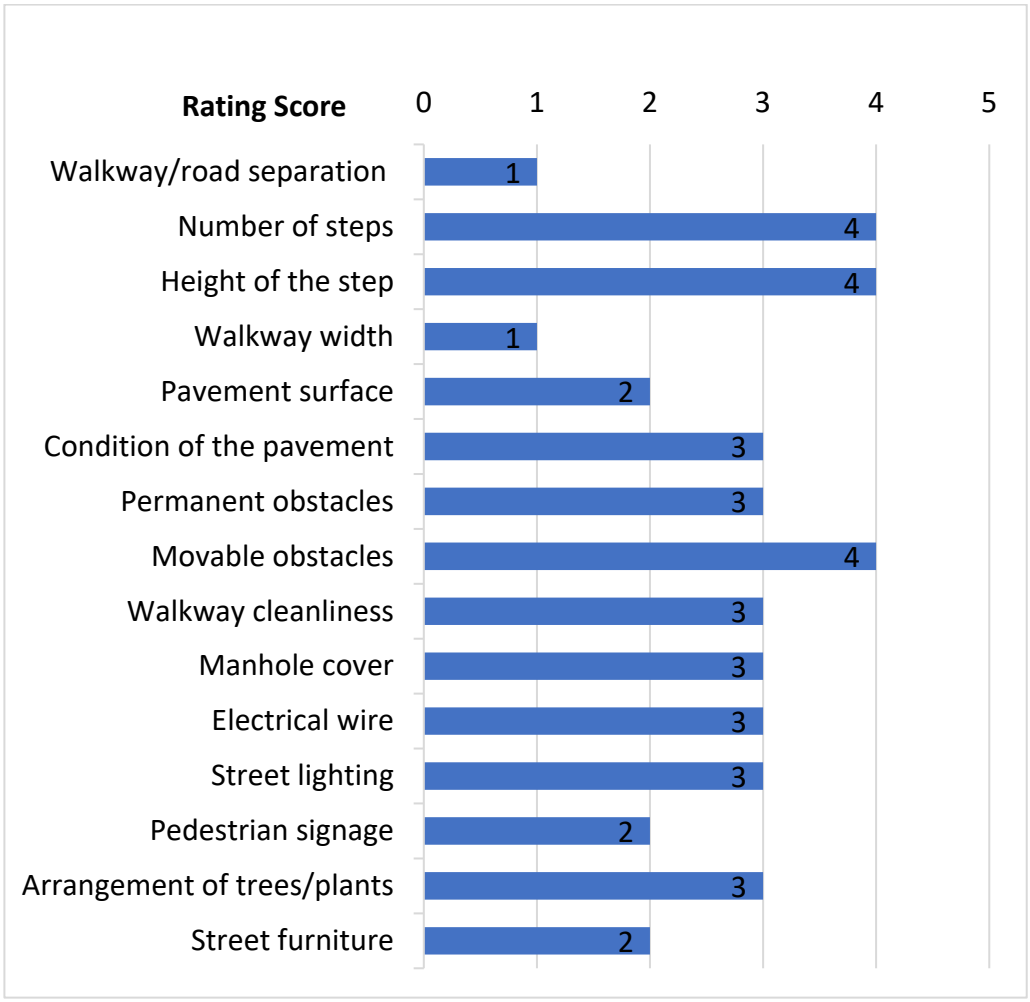
Location BL01-2

Walkability Index	2.122



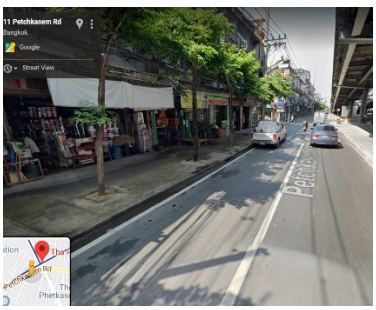




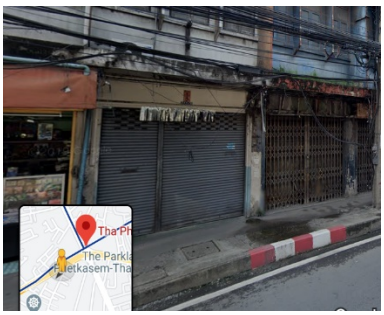


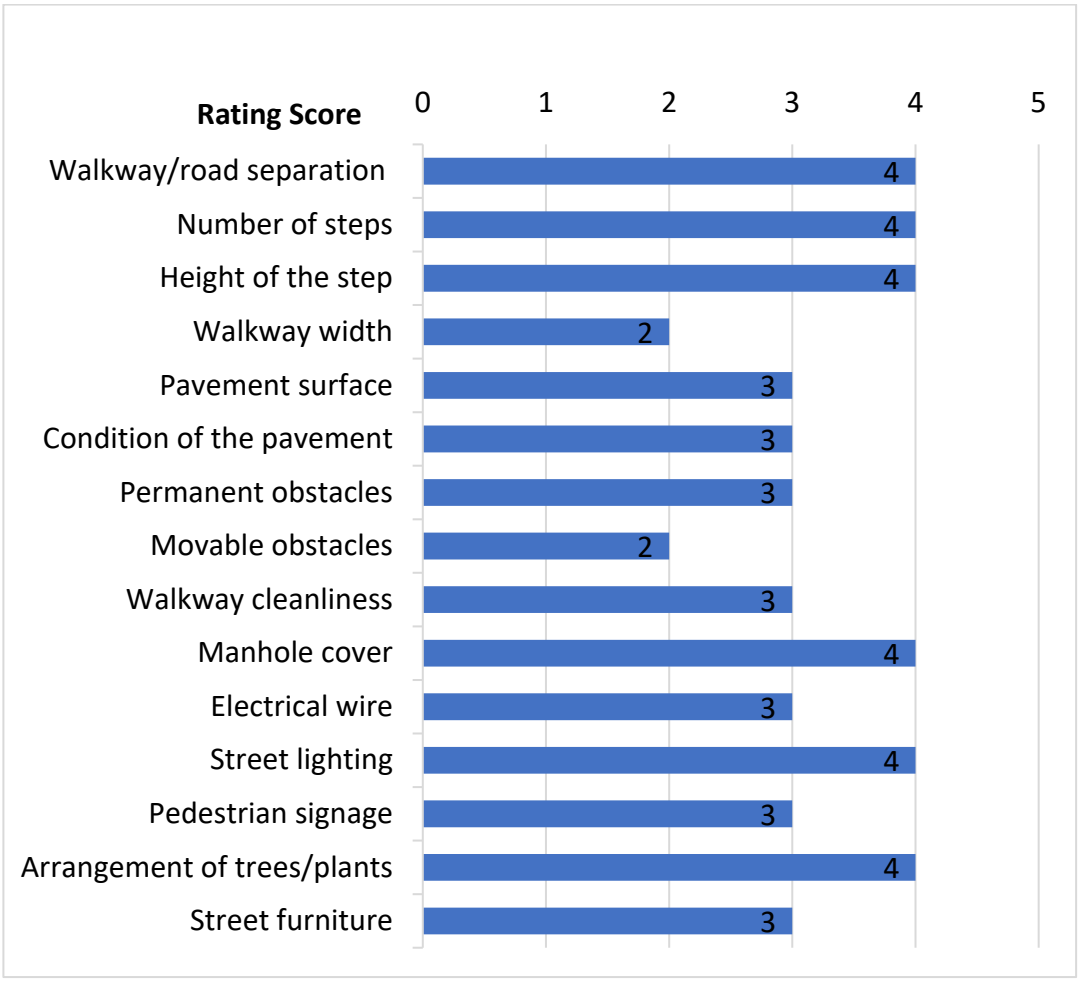
Location BL01-3

Walkability Index	3.531







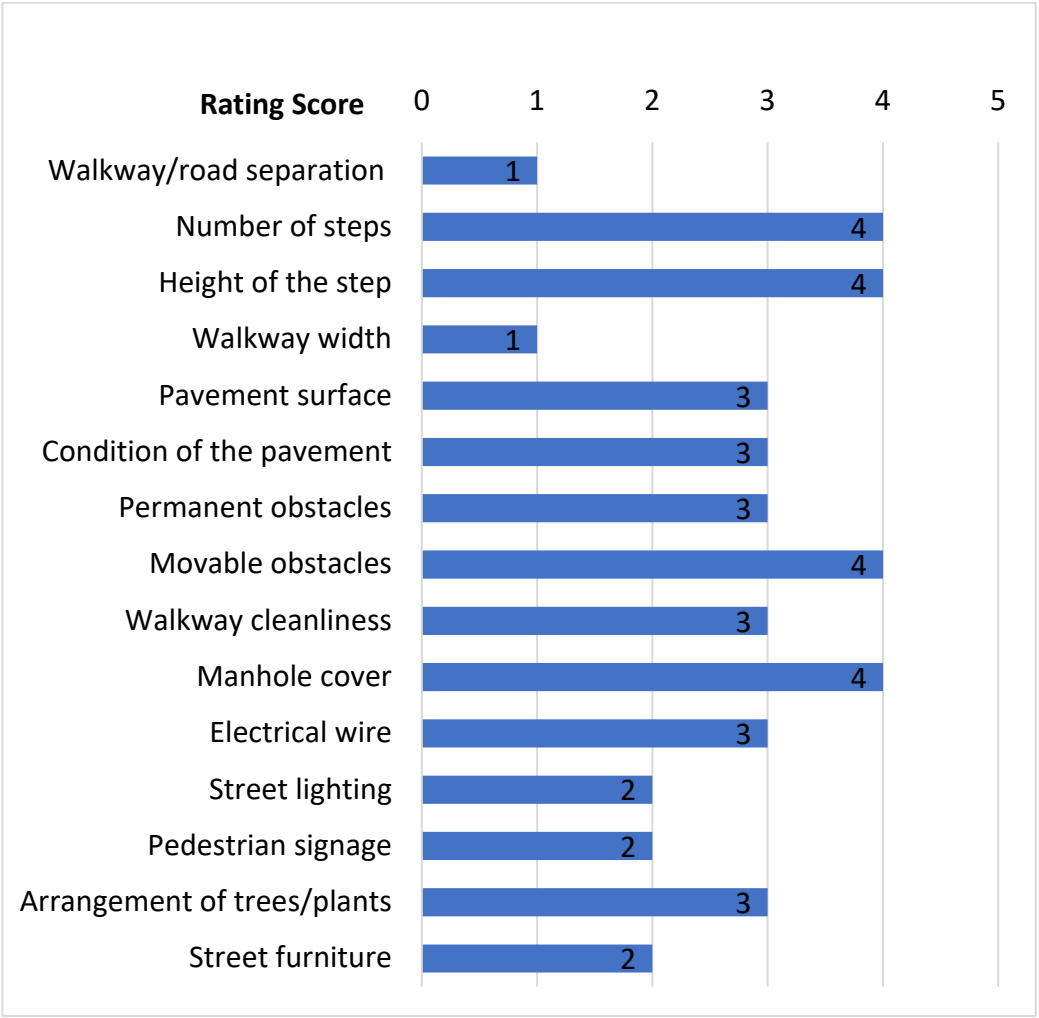


Location BL01-4

Walkability Index	2.241

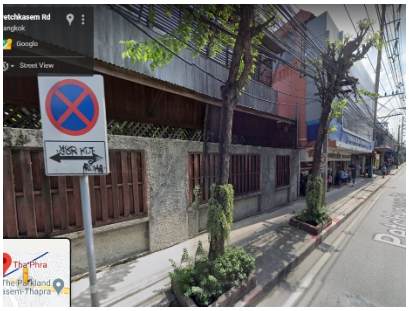


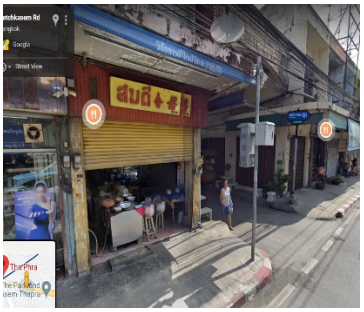


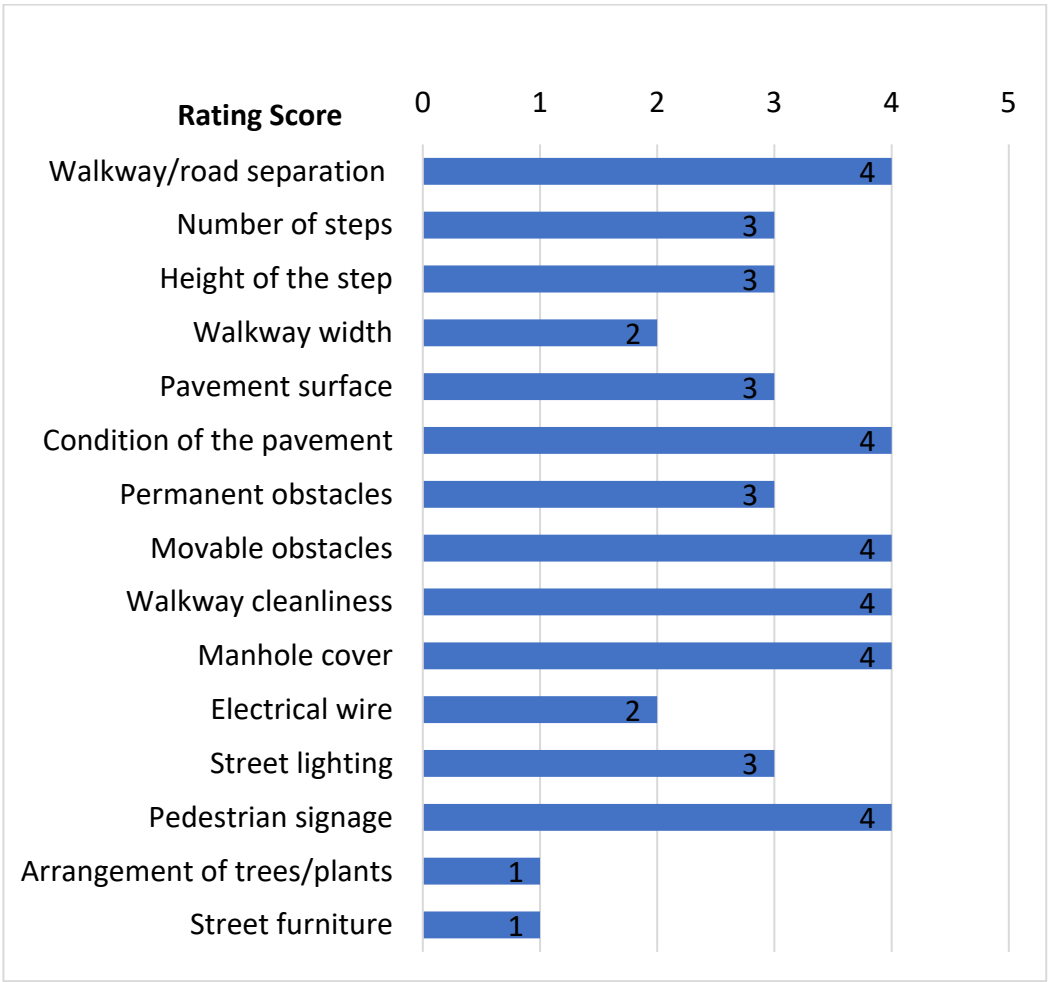


Location BL01-5

Walkability Index	3.361





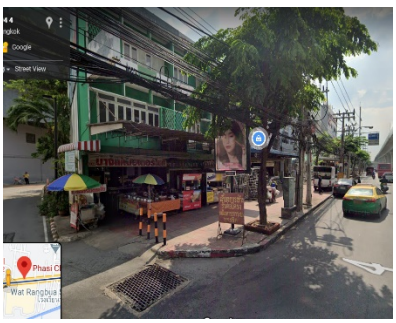


3.4.3 Phasi Cheron Station (BL36)

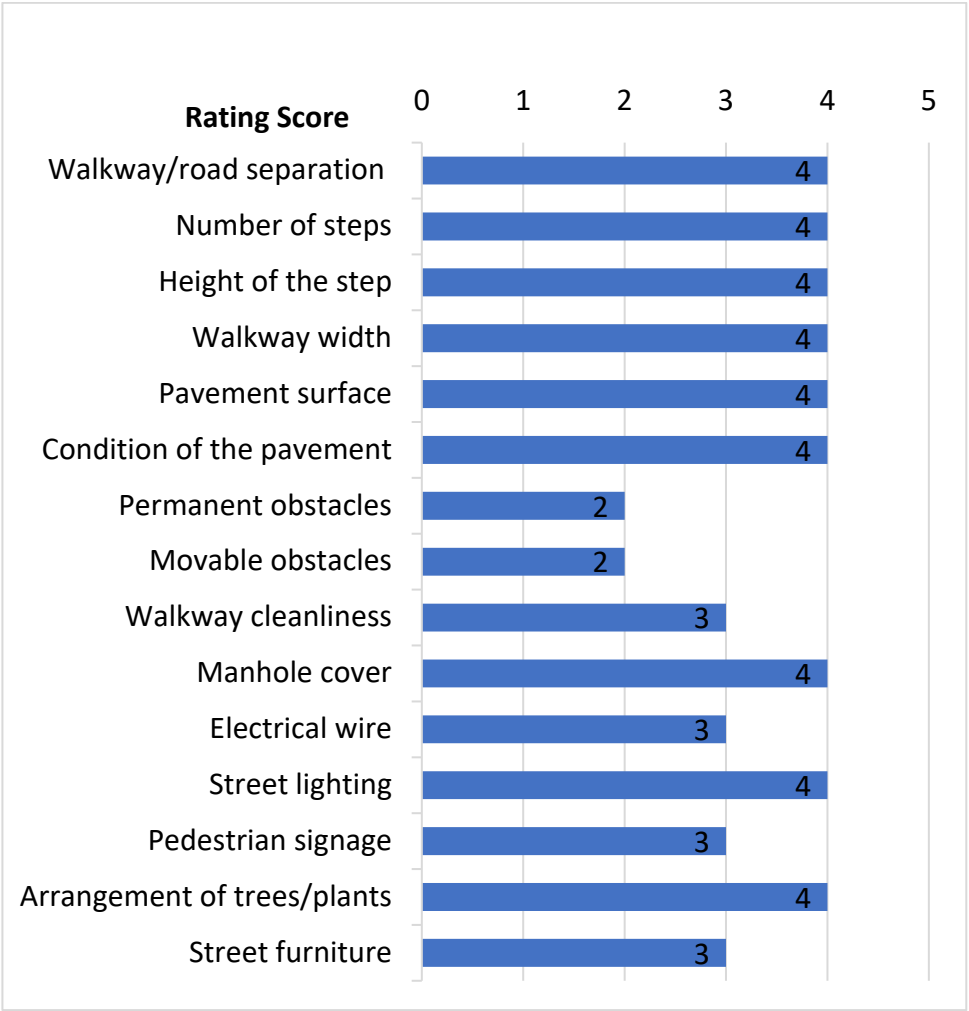


Location BL36-1

Walkability Index	3.757





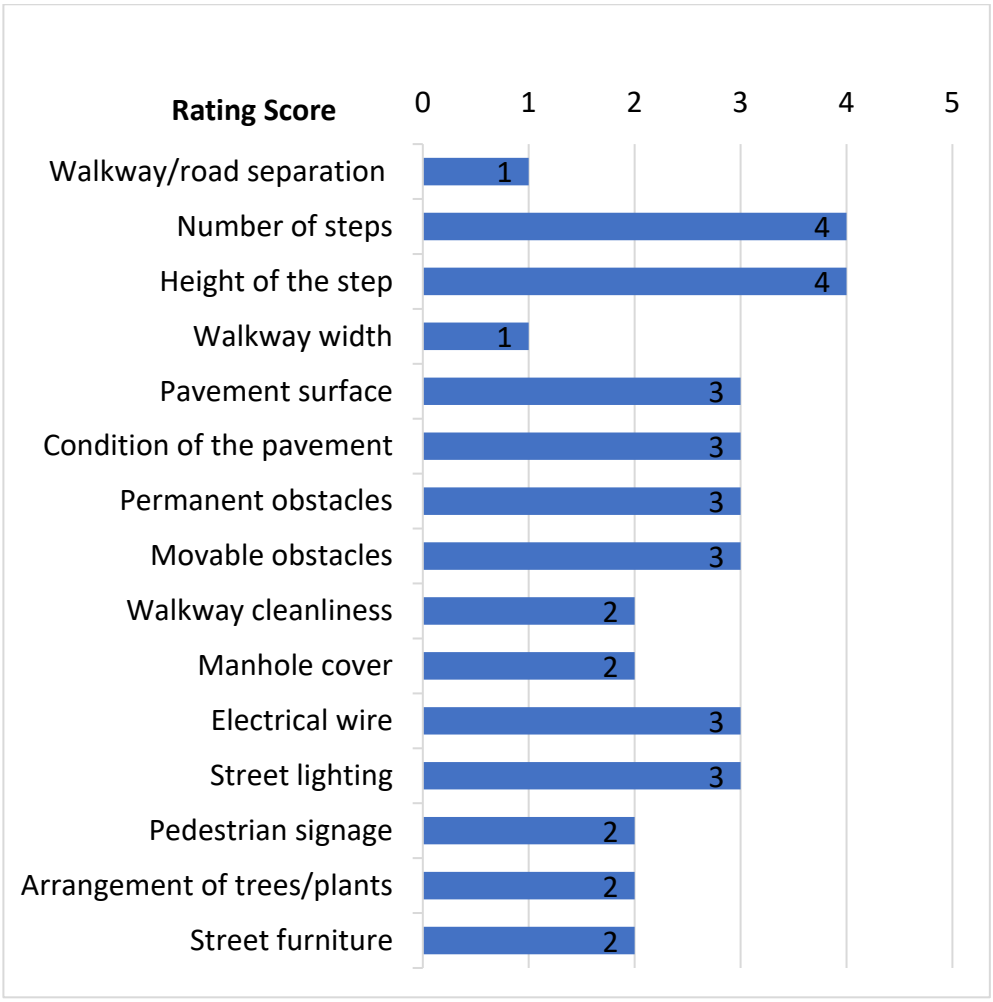


Location BL36-2

Walkability Index	3.212





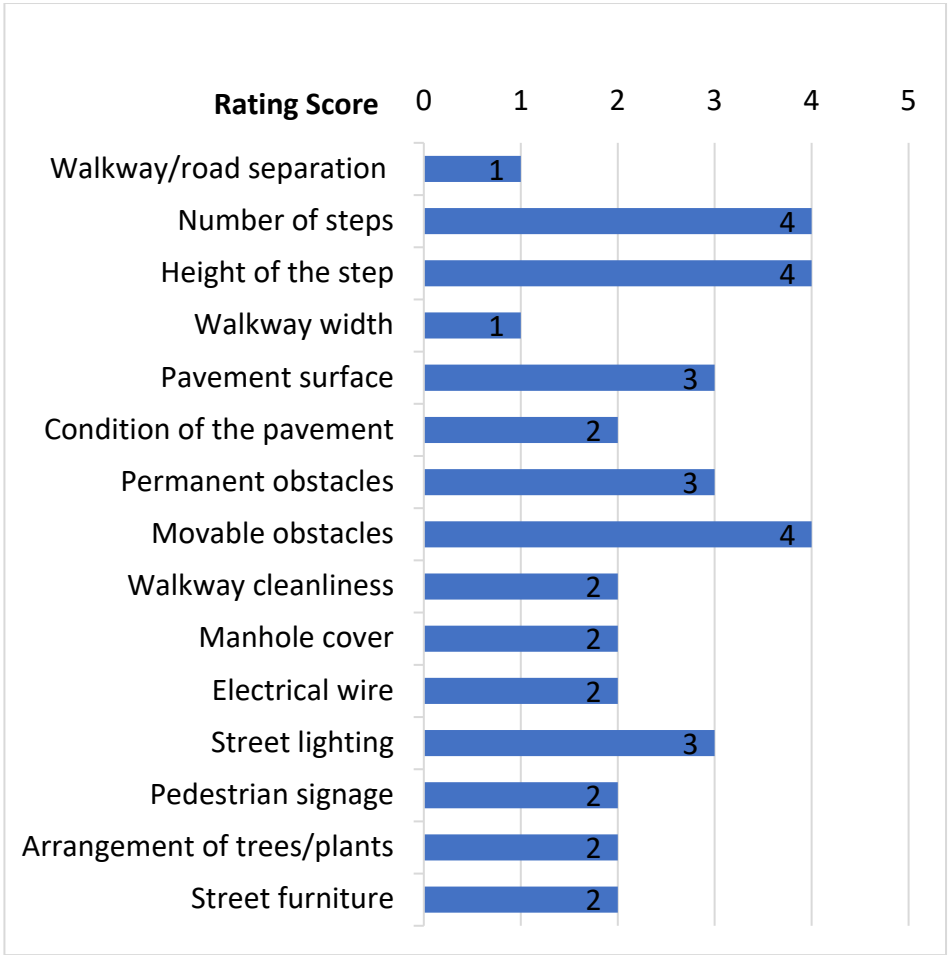


Location BL36-3

Walkability Index	2.997





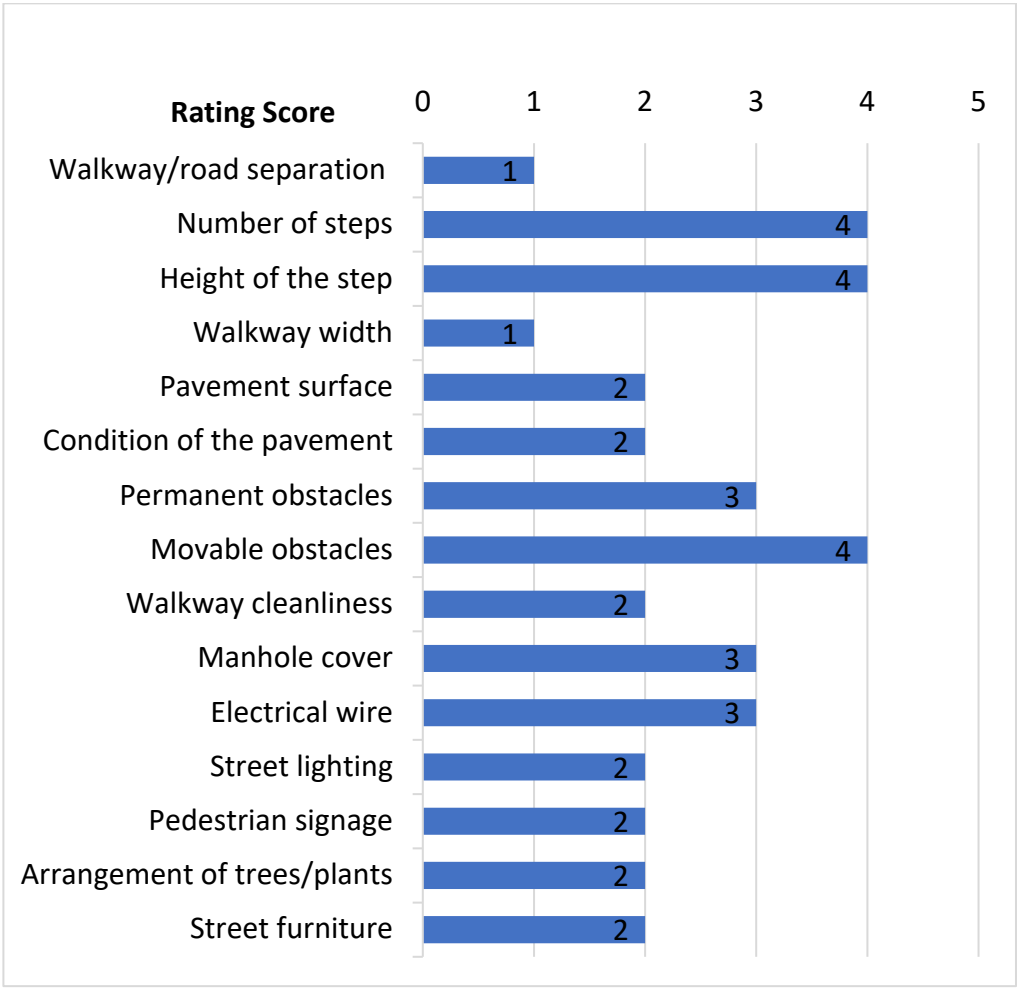



Location BL36-4

Walkability Index	2.012







Location BL36-5

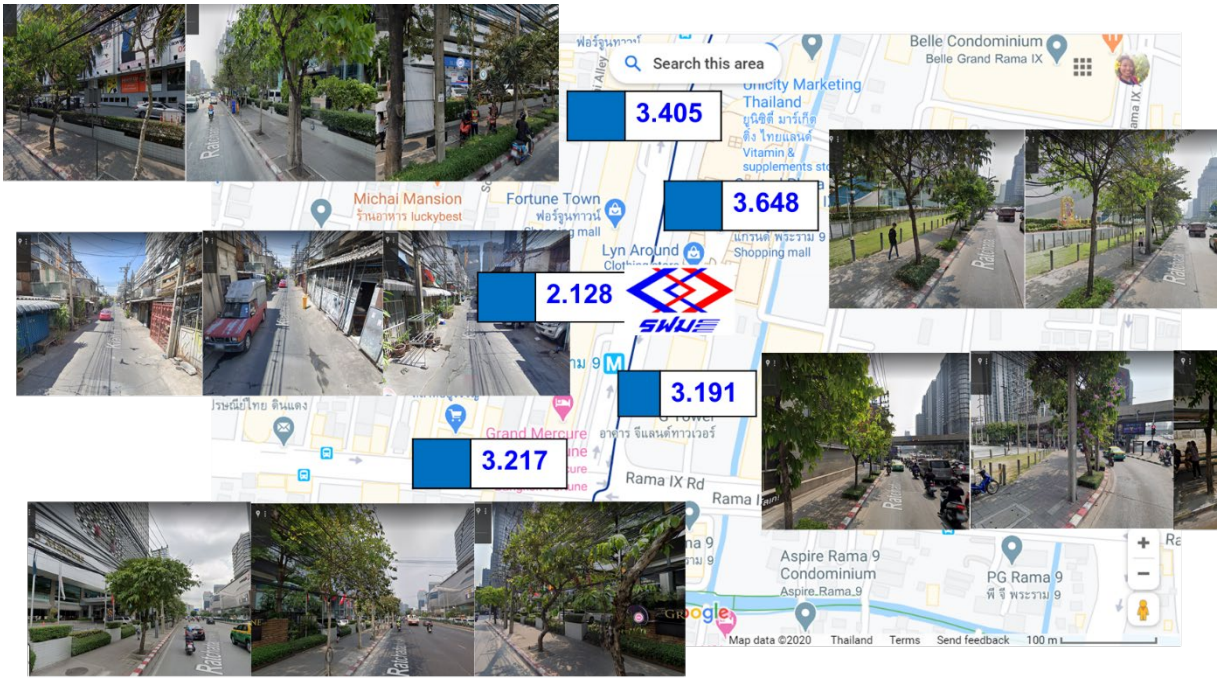
Walkability Index	3.822





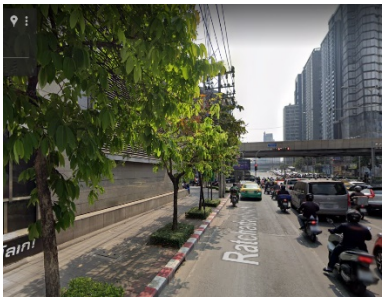
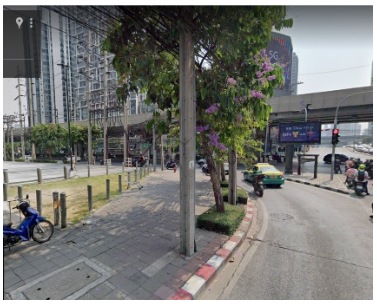
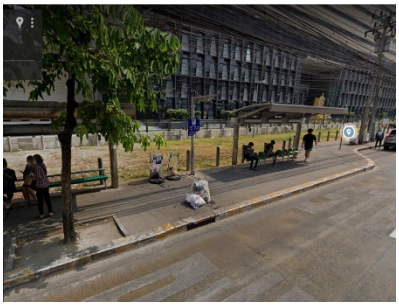


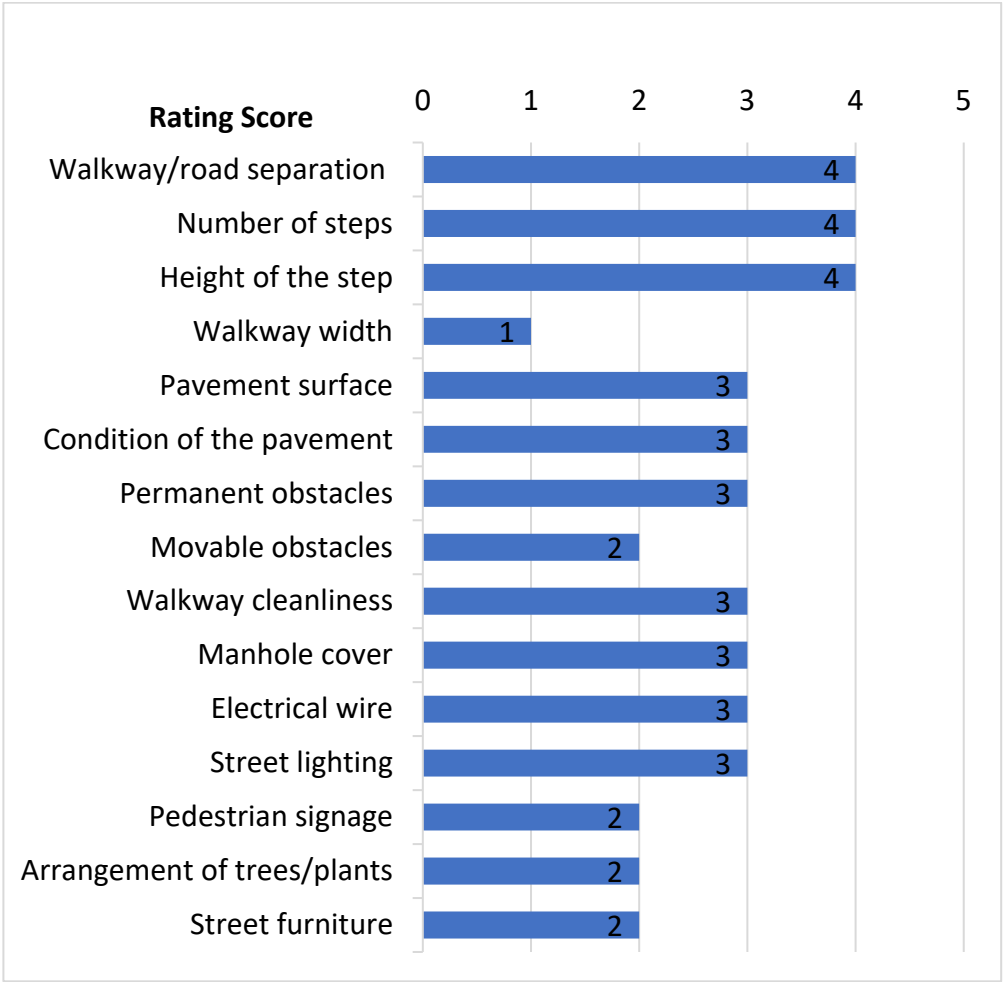
3.4.4 Phra Rama 9 Station (BL20)



Location BL20-1

Walkability Index	3.191



Location BL20-2

Walkability Index	3.648

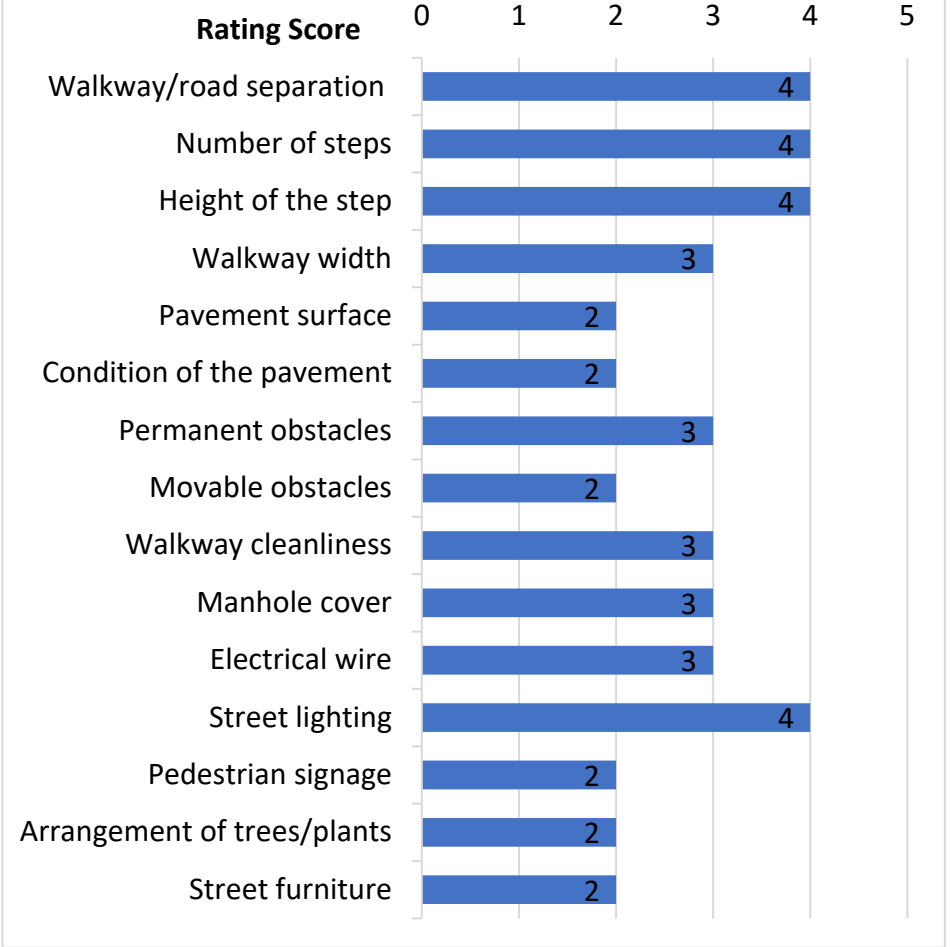




Location BL20-3

Walkability Index	3.405

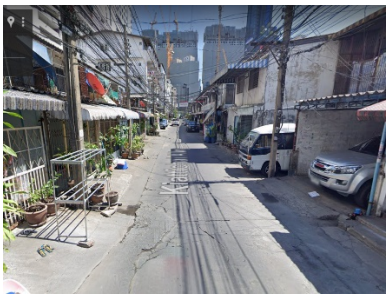


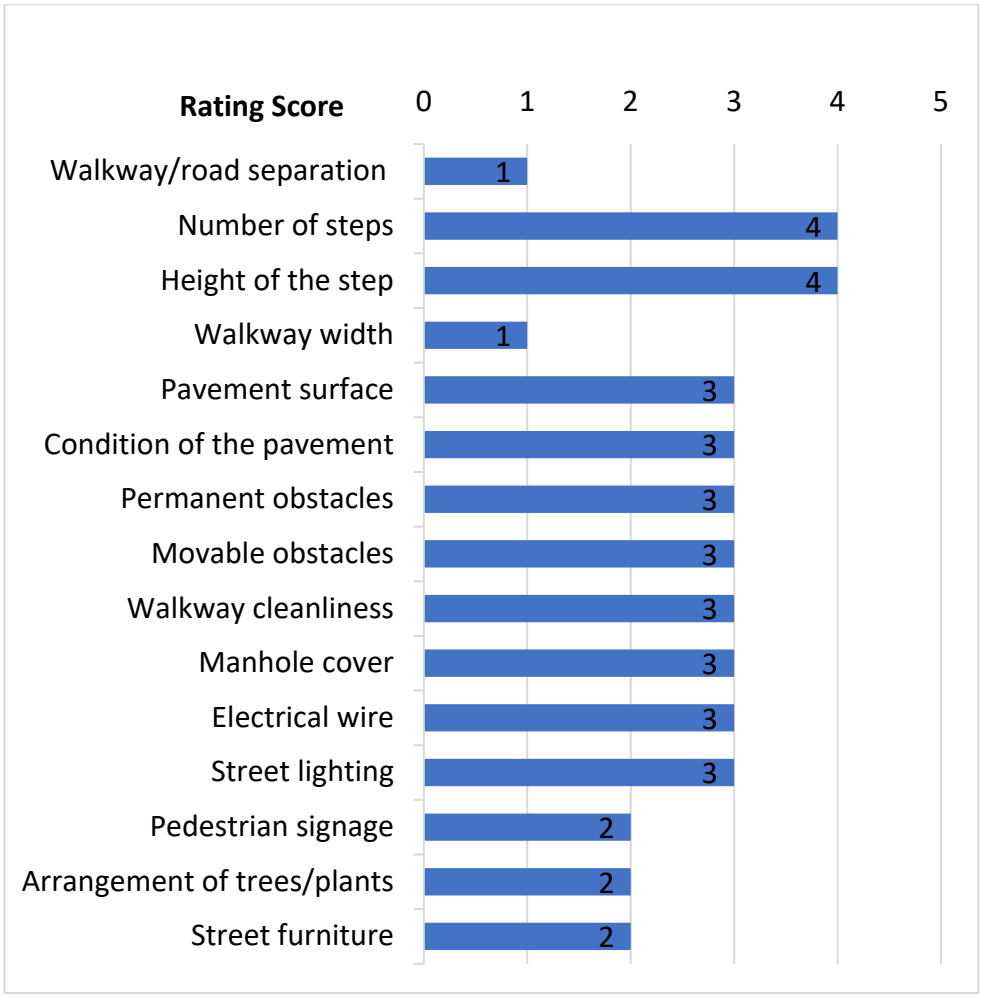


Location BL20-4

Walkability Index	2.128

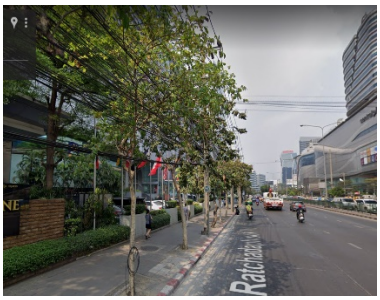
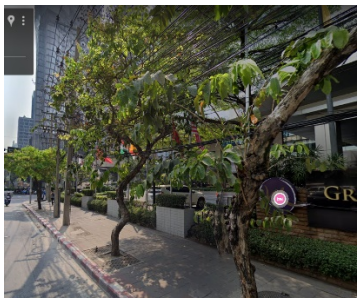


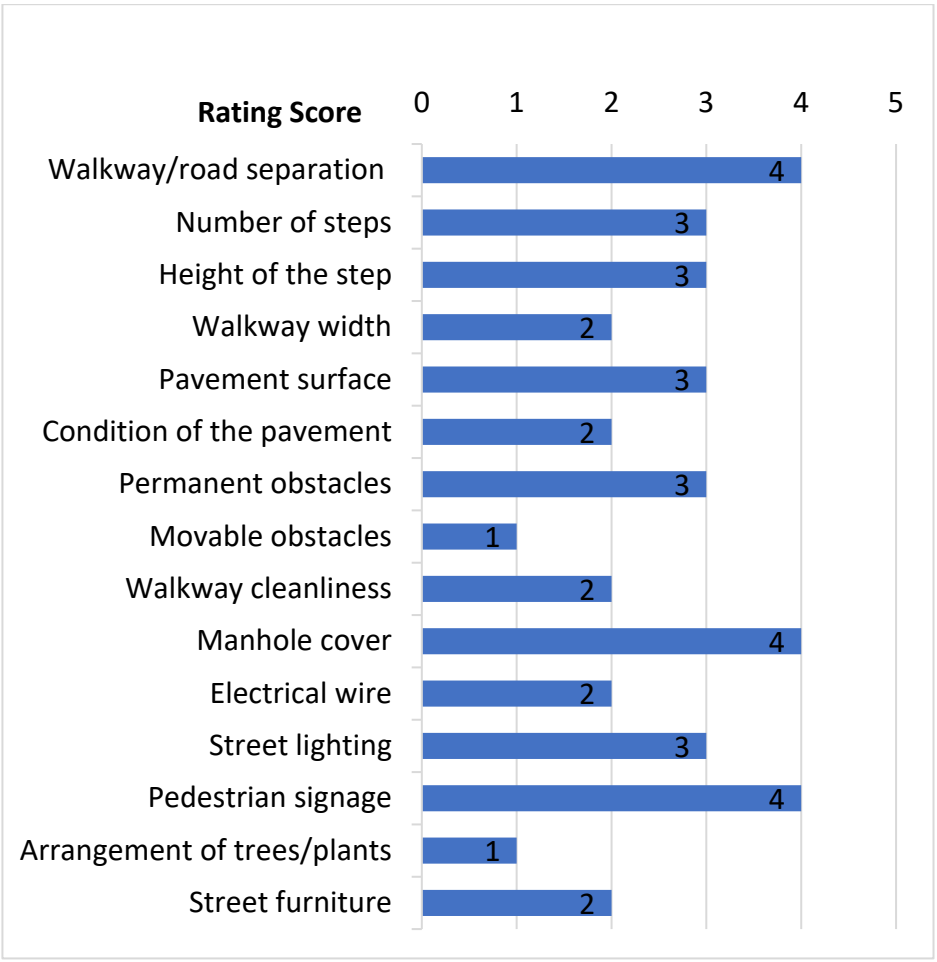




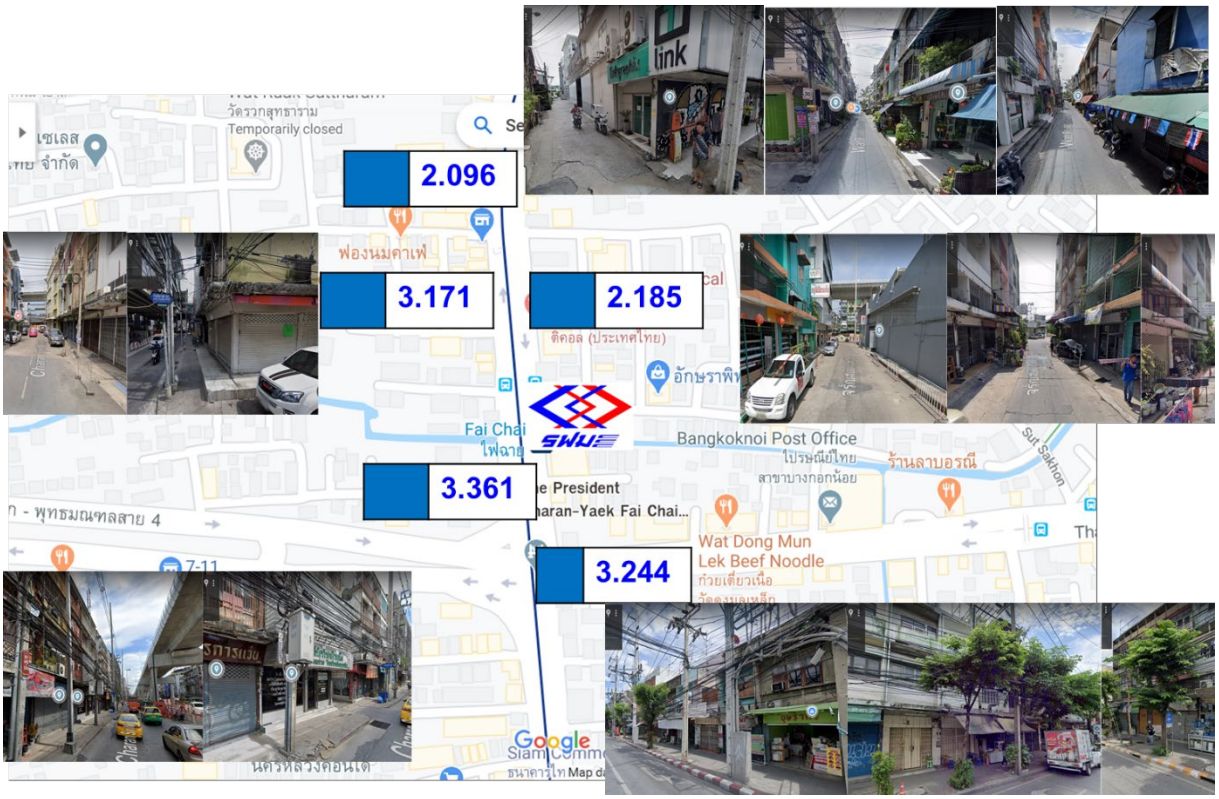
Location BL20-5

Walkability Index	3.217



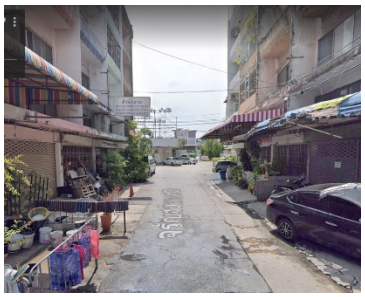
3.4.5 Yaek Fai Chai Station (BL03)

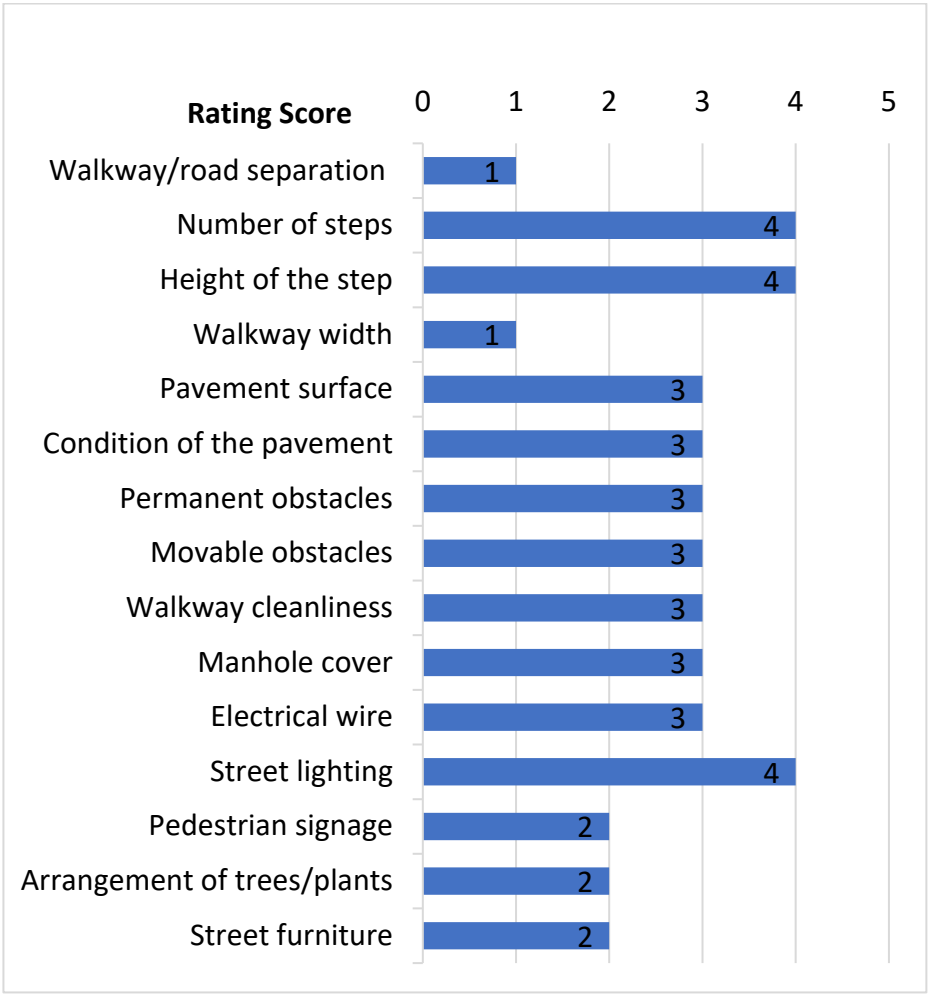


Location BL03-1

Walkability Index	2.185





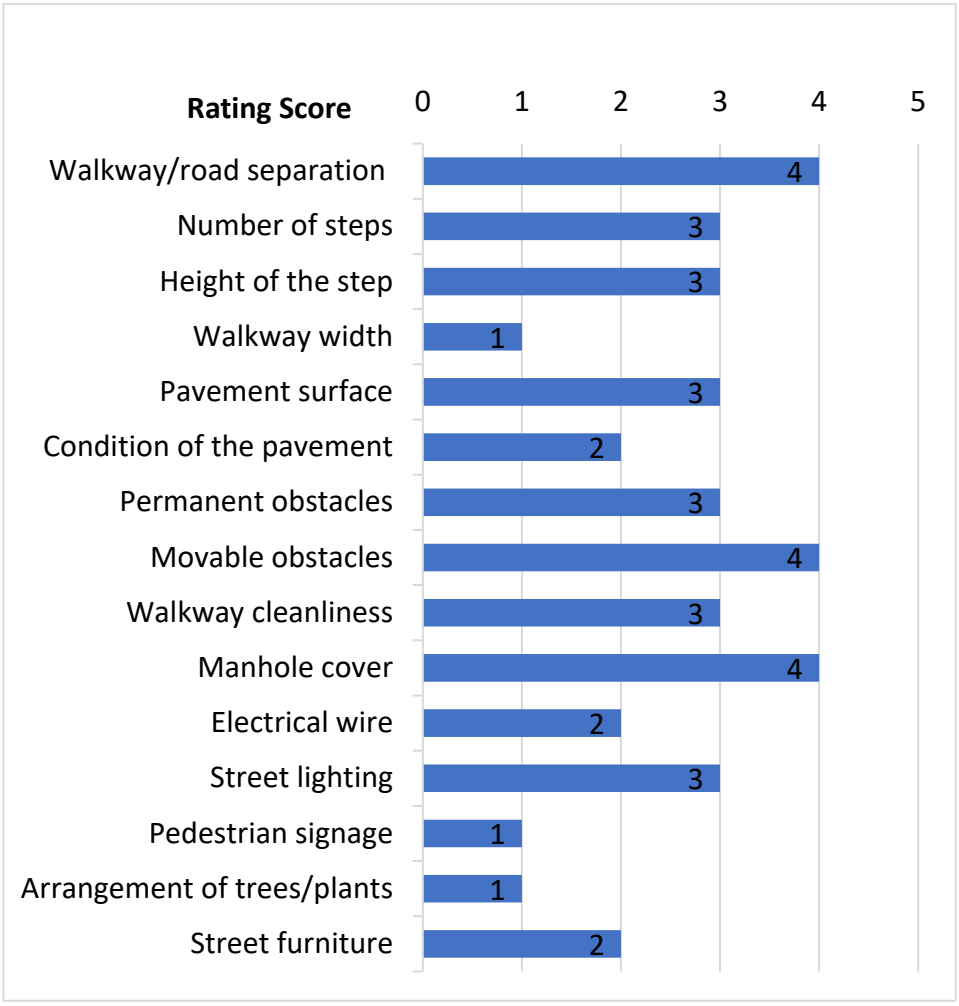


Location BL03-2

Walkability Index	3.171

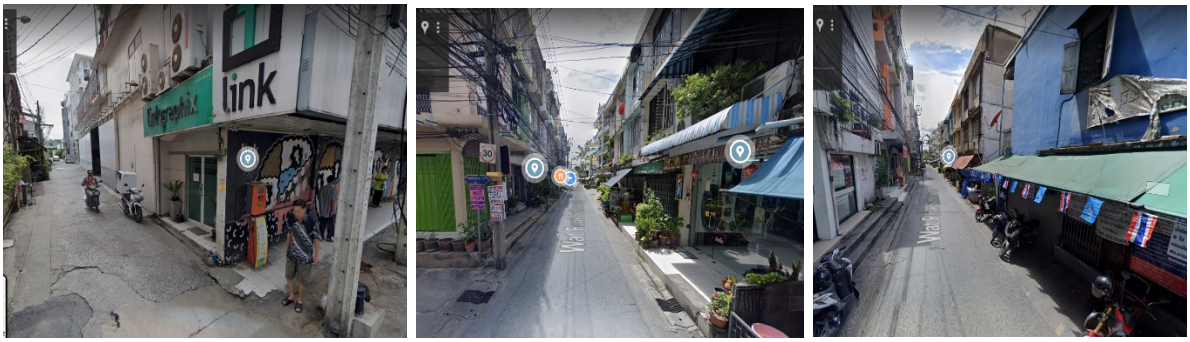


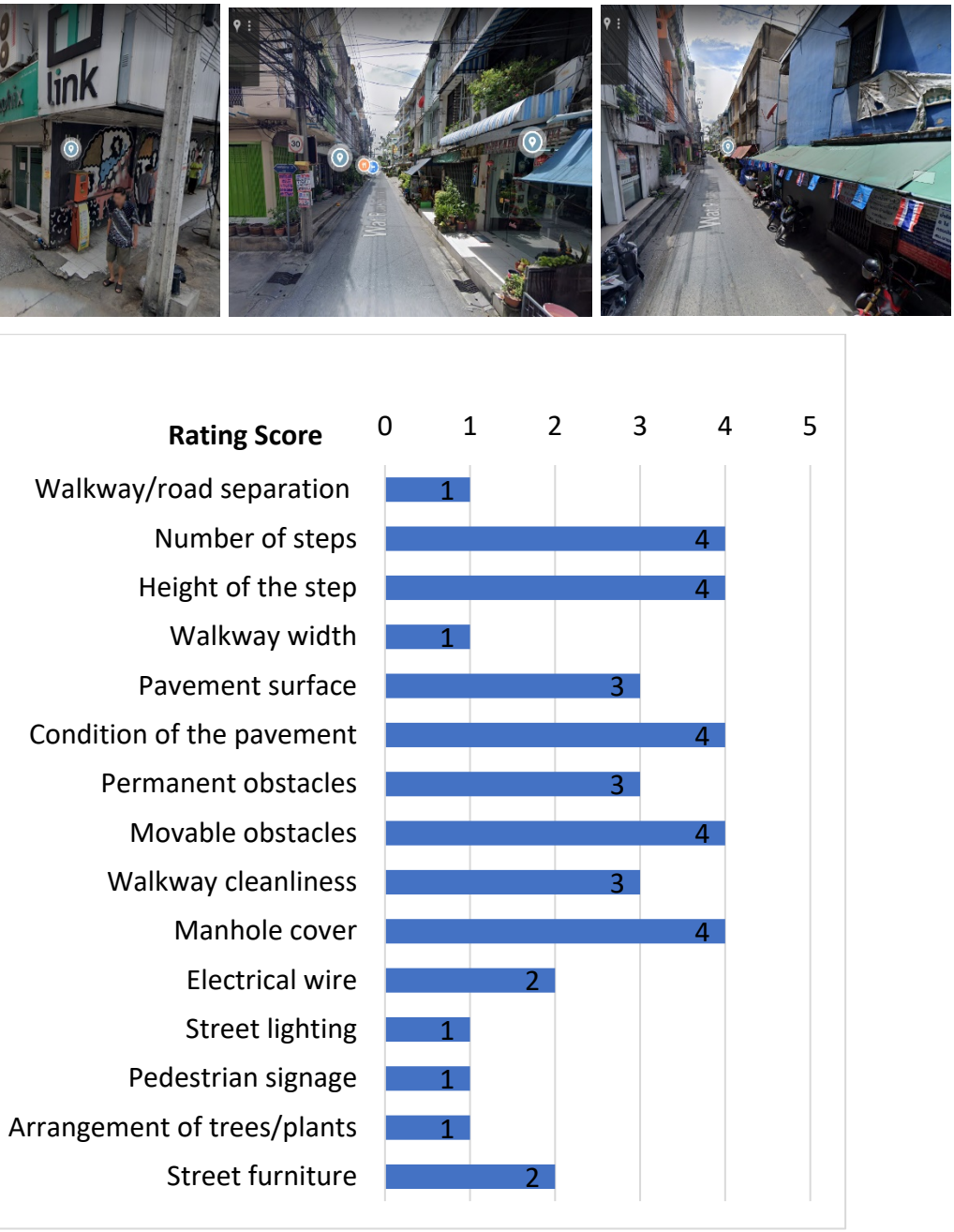




Location BL03-3

Walkability Index	2.096





Location BL03-4

Walkability Index	3.244





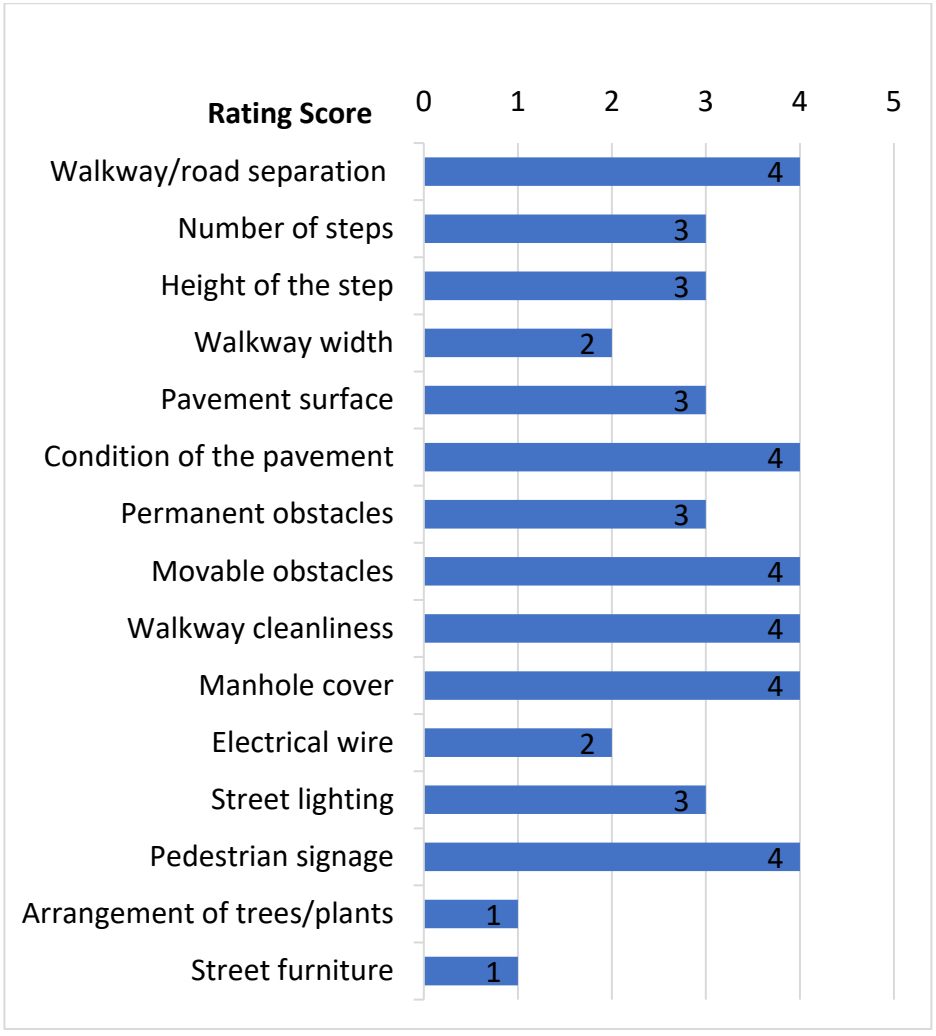


Location BL03-5

Walkability Index	3.361







3.5 Walkability at 3 Green Line Stations

The walkability at representative locations around 4 stations of the BTS green line are evaluated. The average value of each station is shown in Figure 3.5.

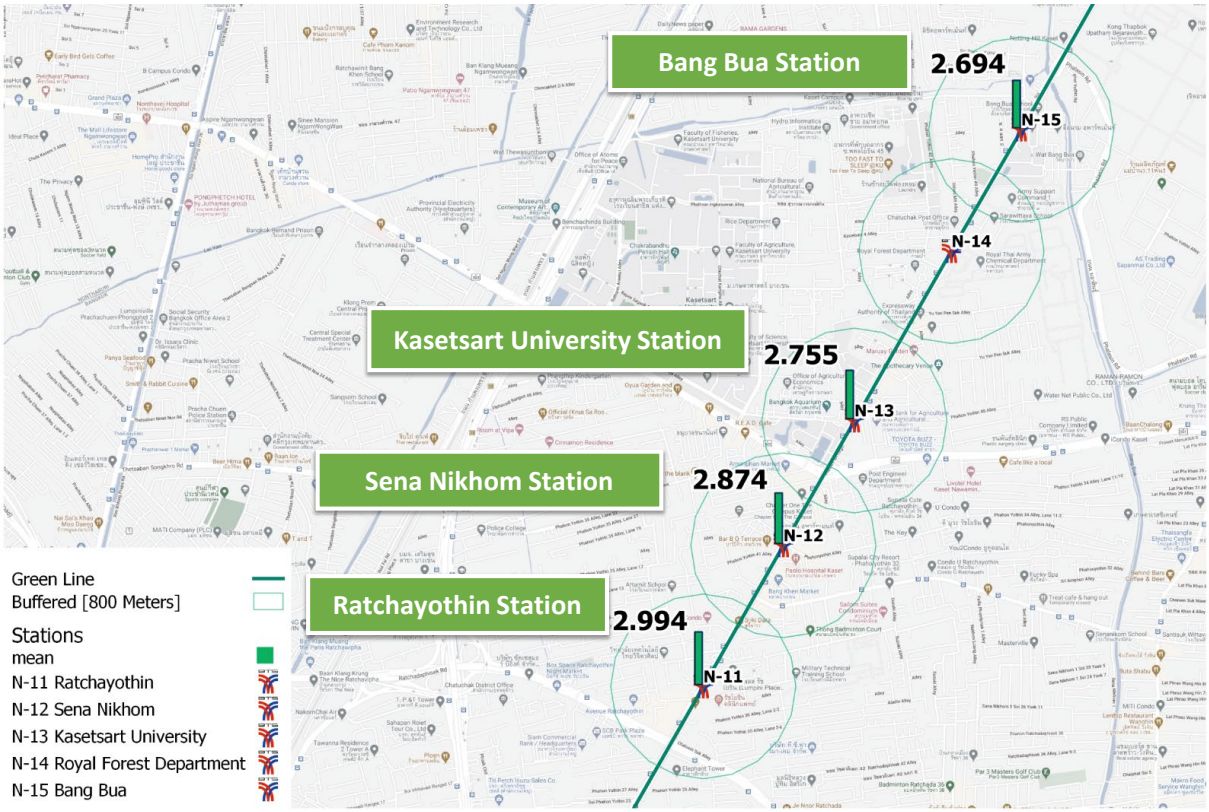
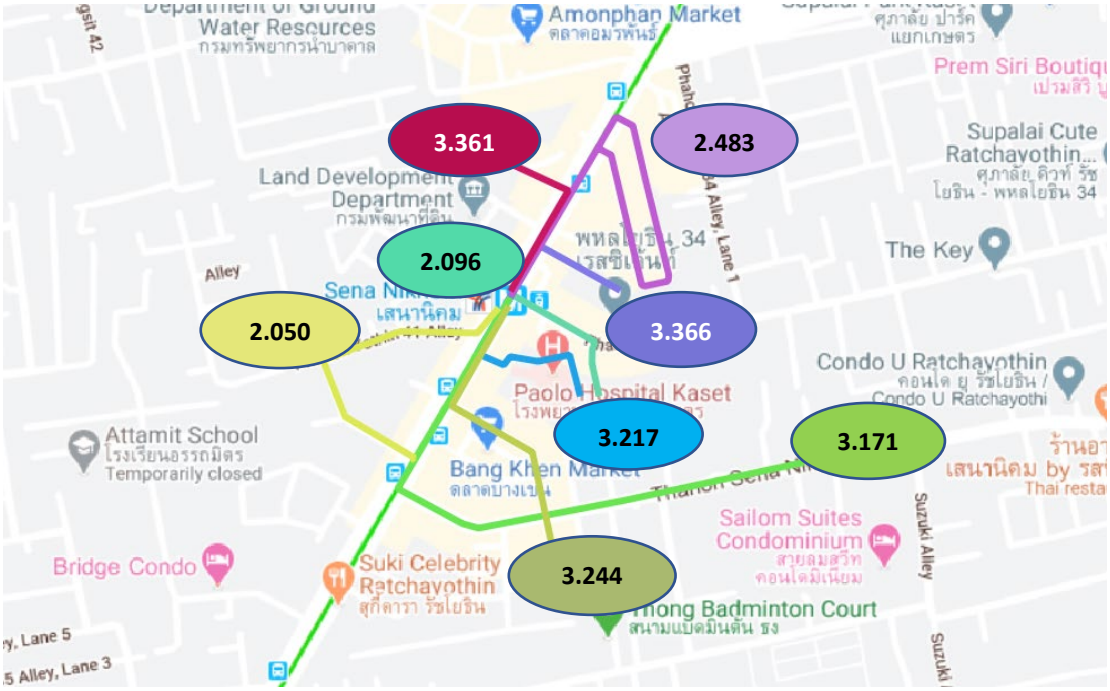


Figure 3.4 Walkability around 4 MRT Green Line Stations

3.5.1 Sena Nikhom Station (N12)

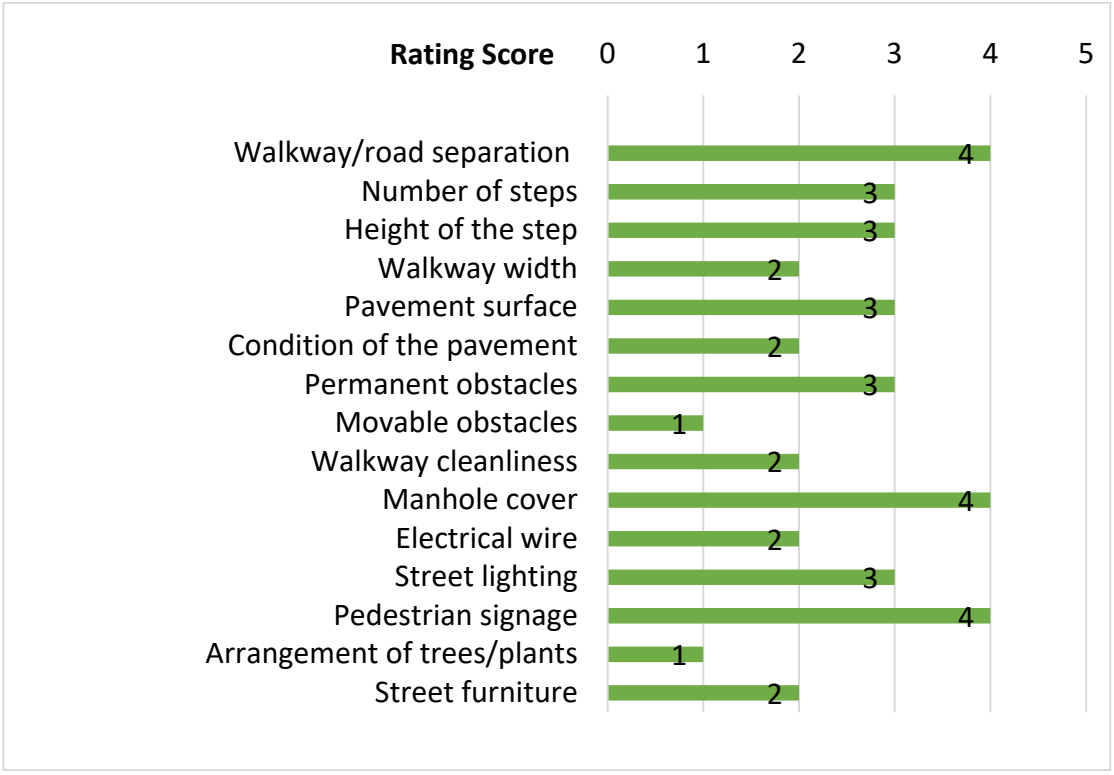


Location N12-1

Walkability Index	3.217





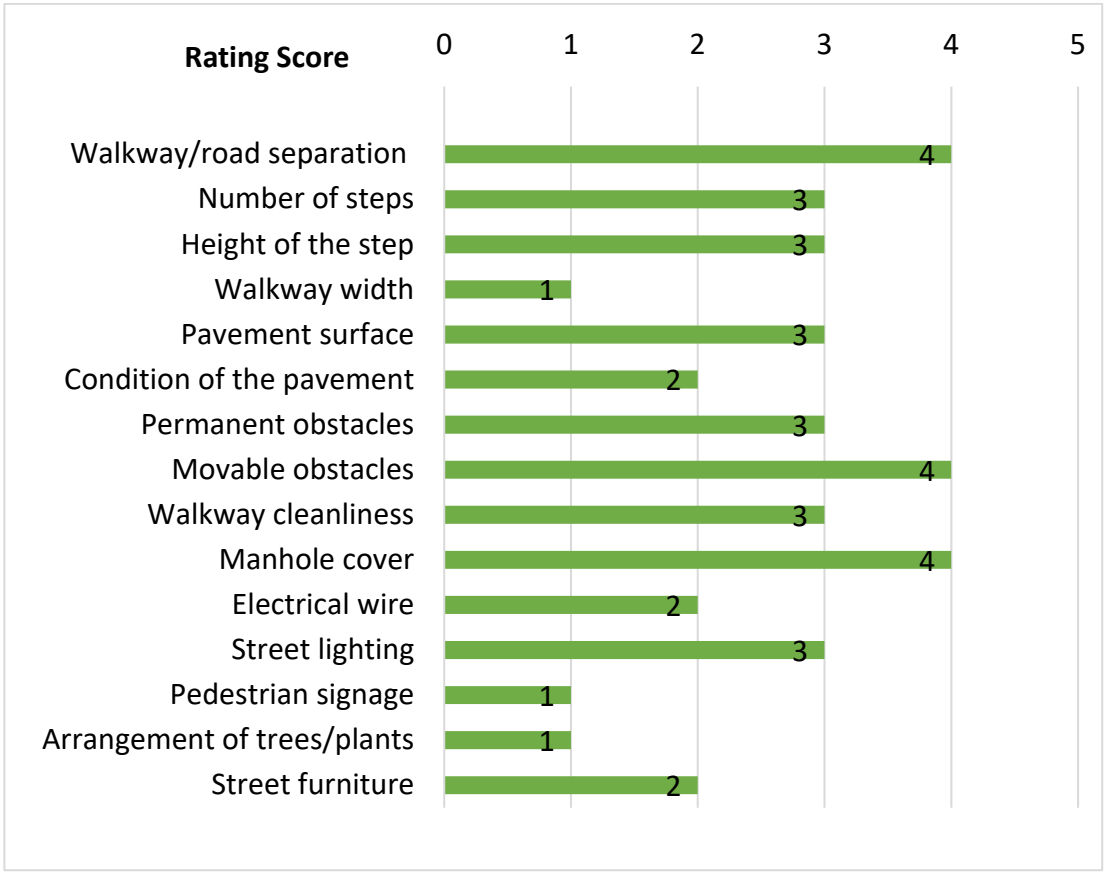


Location N12-2

Walkability Index	3.171

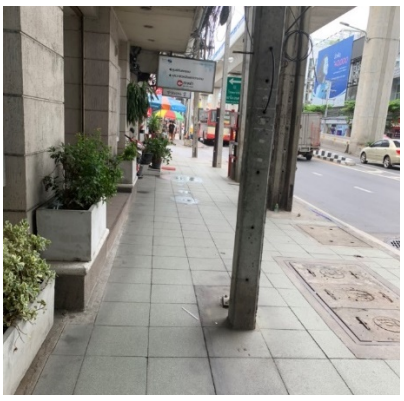


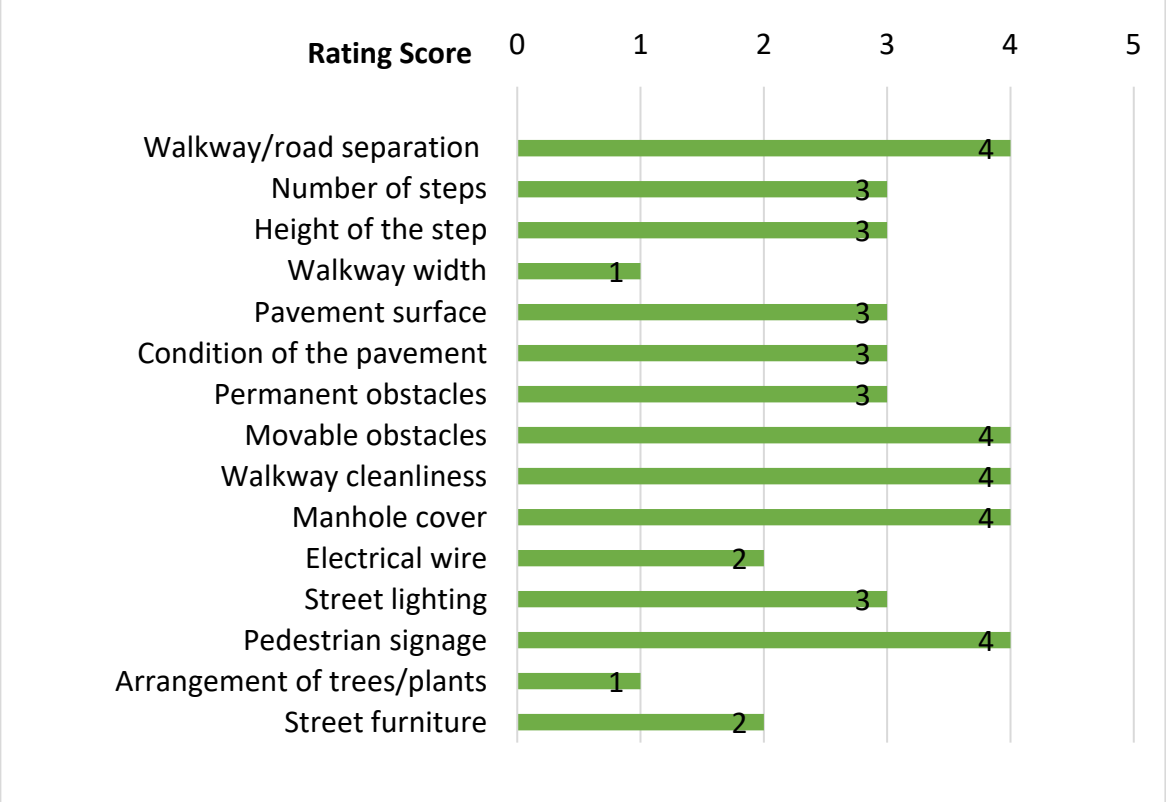




Location N12-3

Walkability Index	3.244

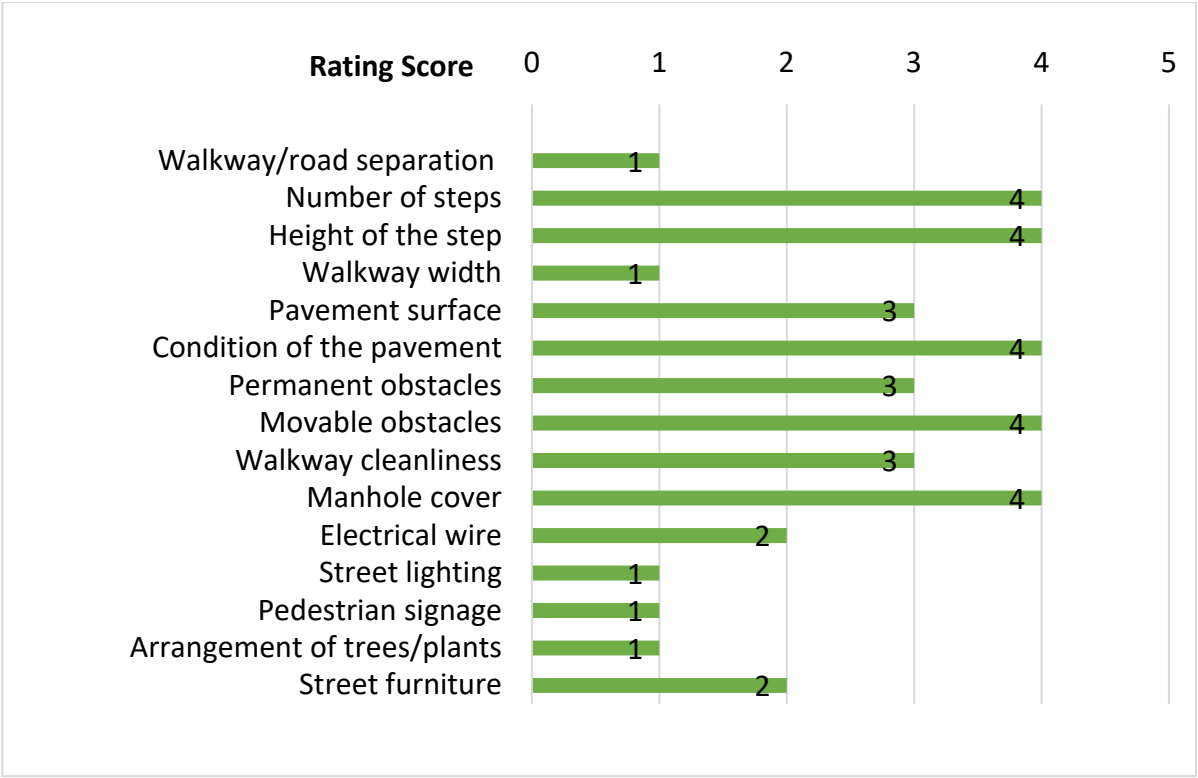



Location N12-4

Walkability Index	2.096



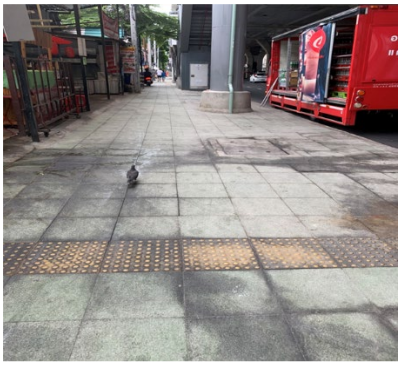




Location N12-5

Walkability Index	3.361







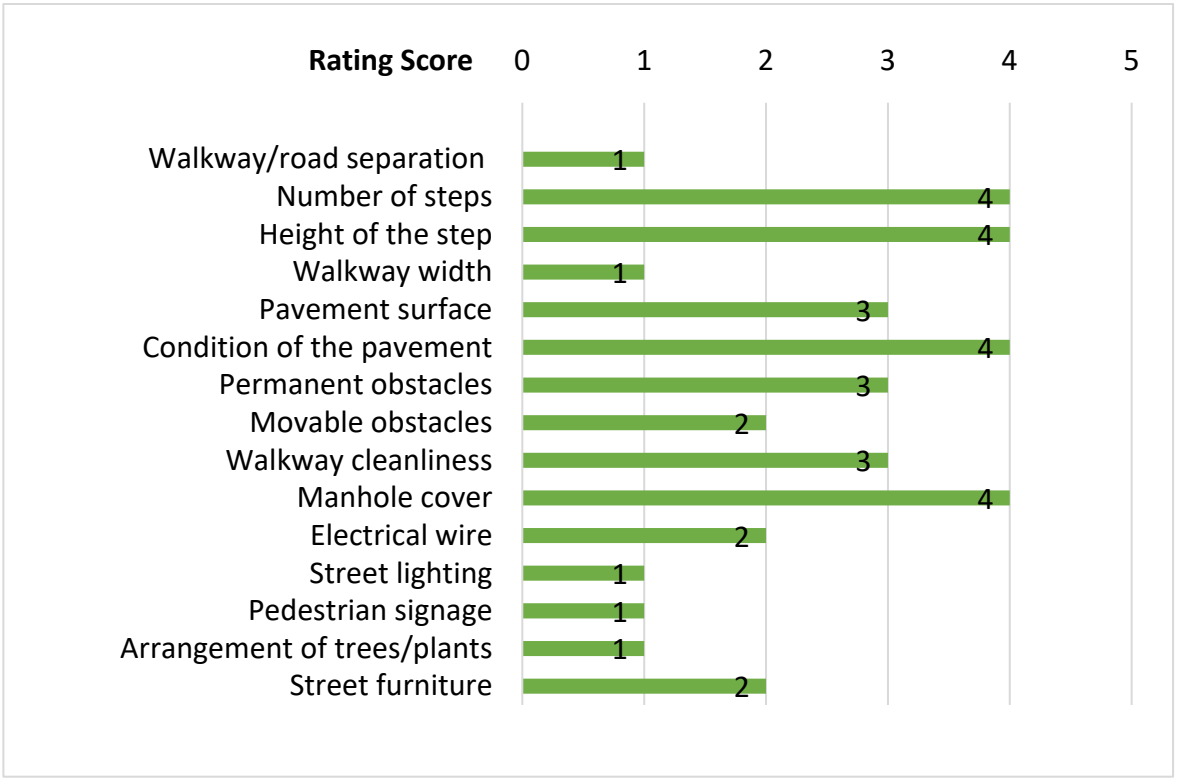


Location N12-6

Walkability Index	2.050







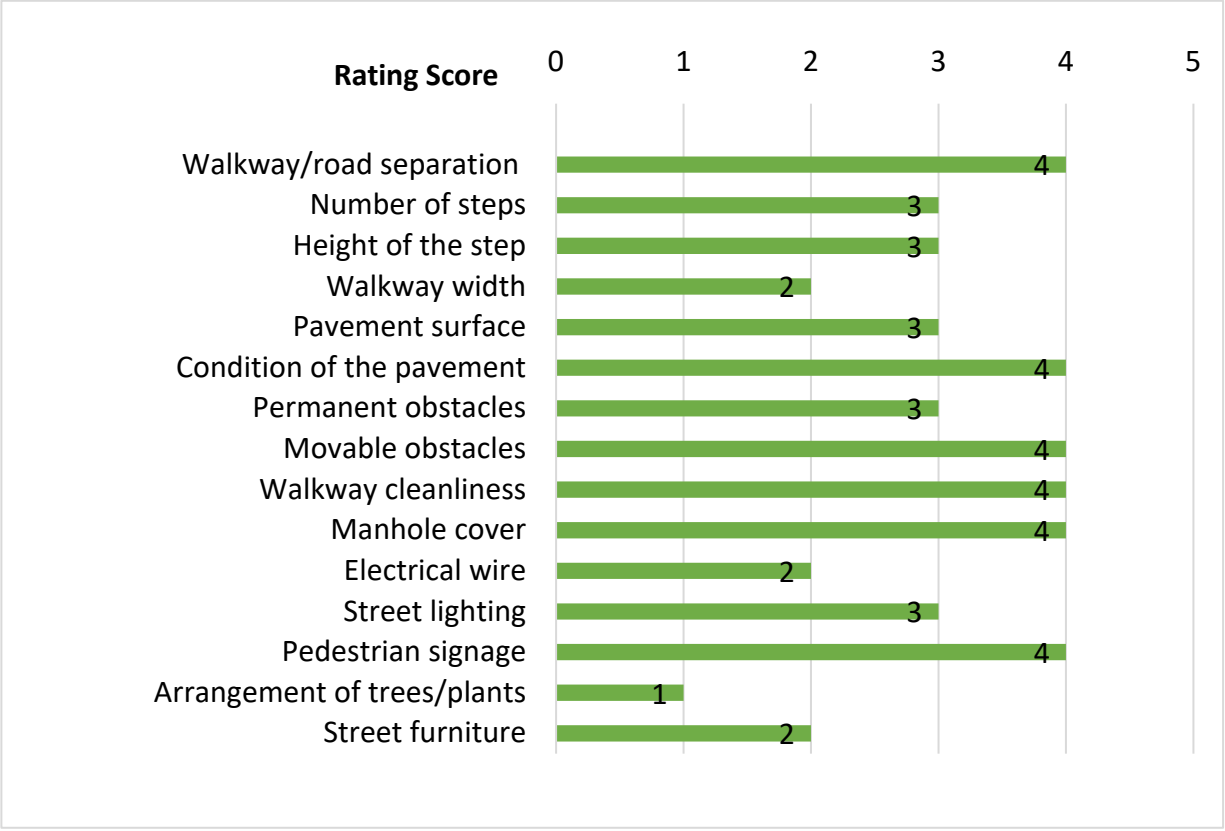
Location N12-7

Walkability Index	3.366









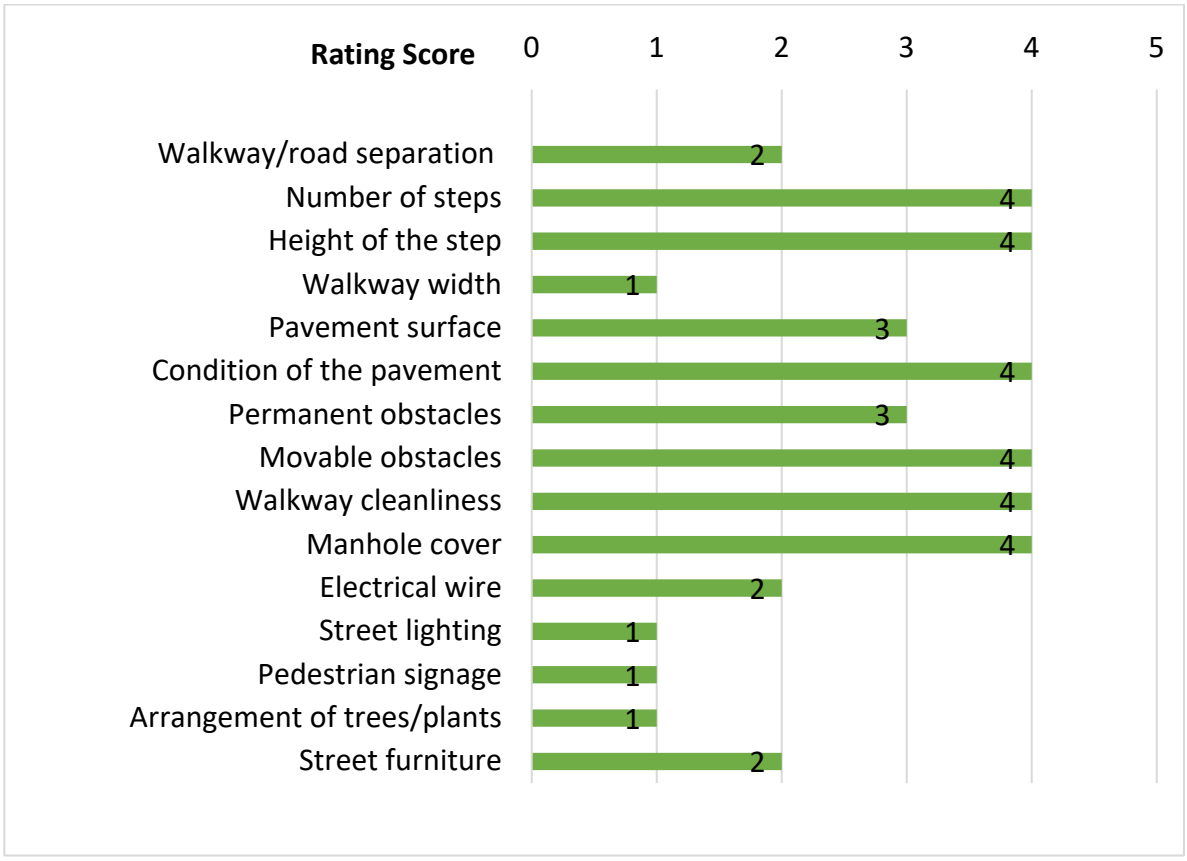
Location N12-8

Walkability Index	2.483

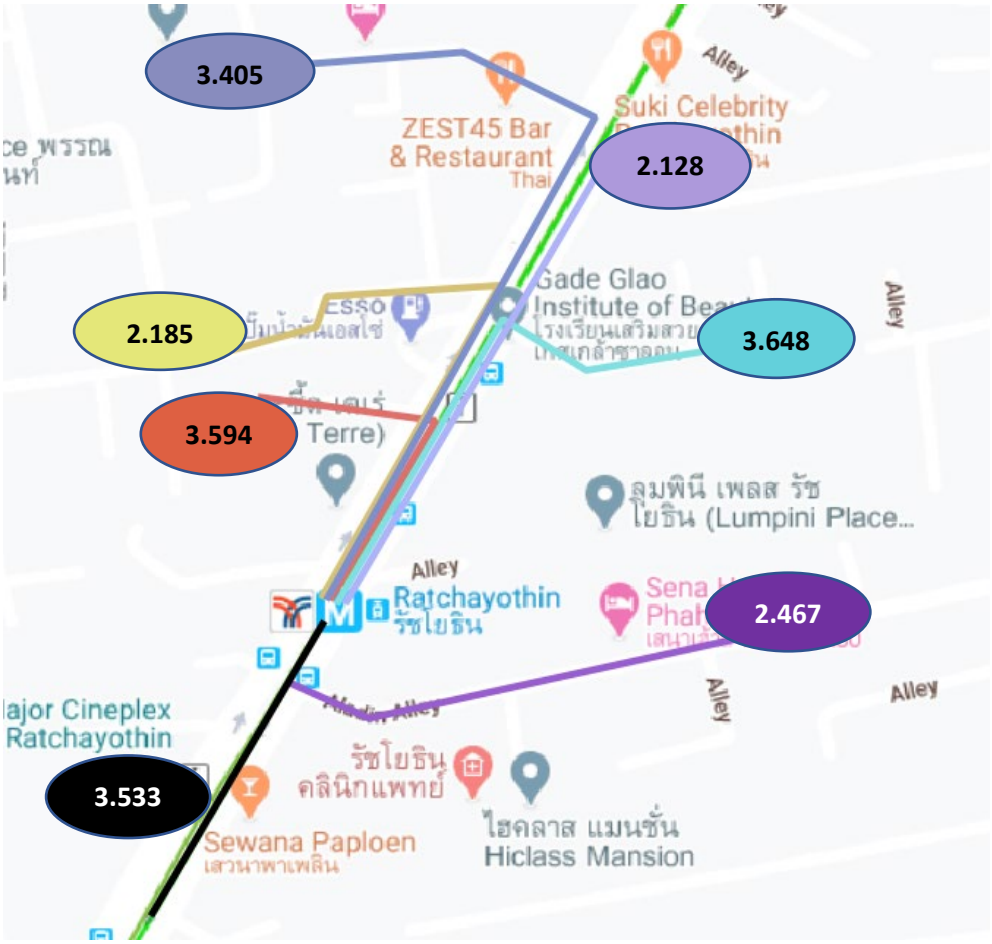






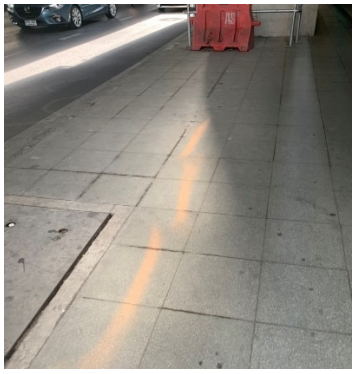


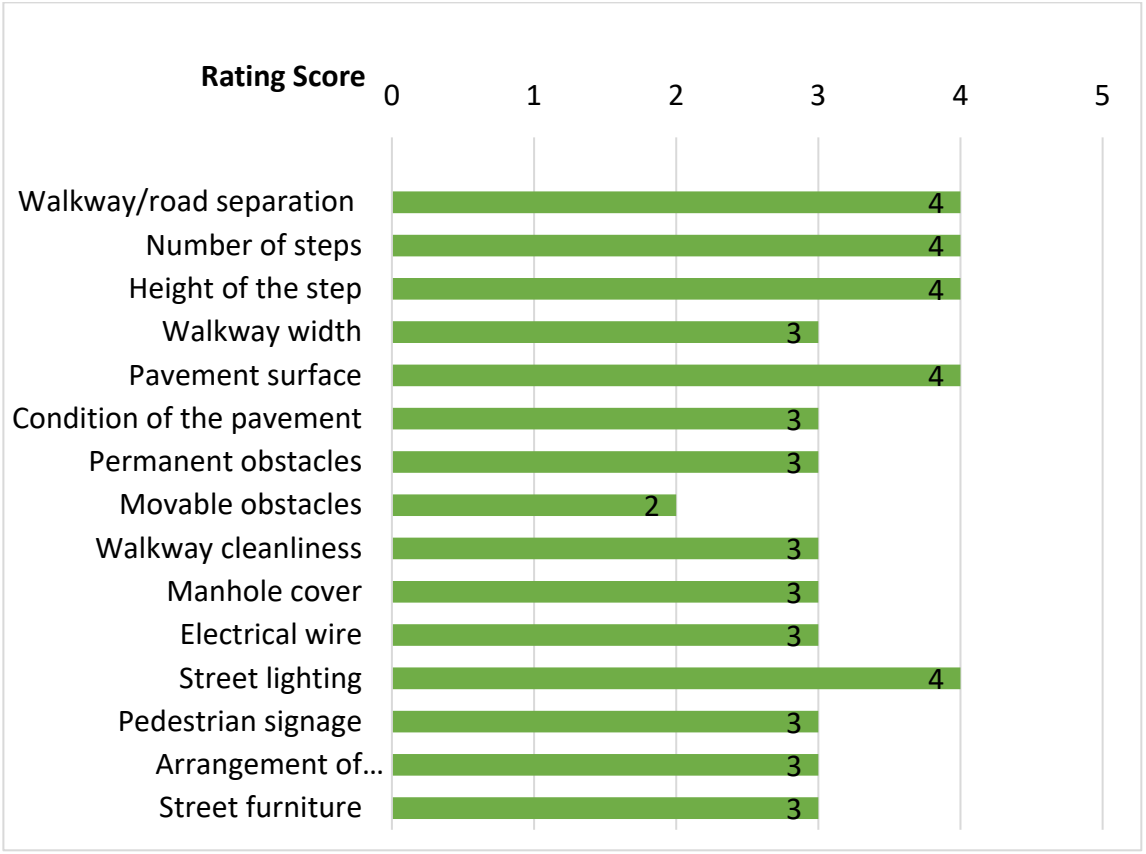
3.5.2 Ratchayothin Station (N11)



Location N11-1

Walkability Index	3.533

Location N11-2

Walkability Index	2.467





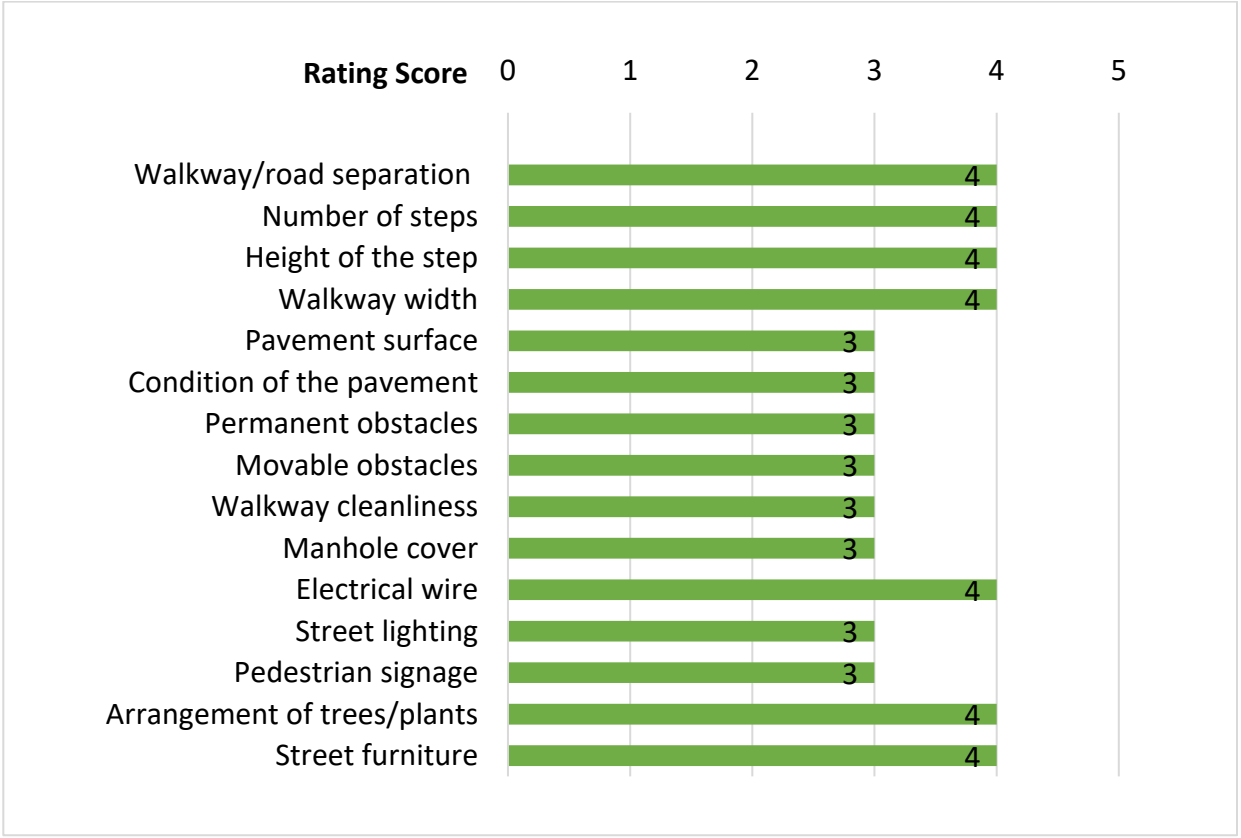


Location N11-3

Walkability Index	3.648





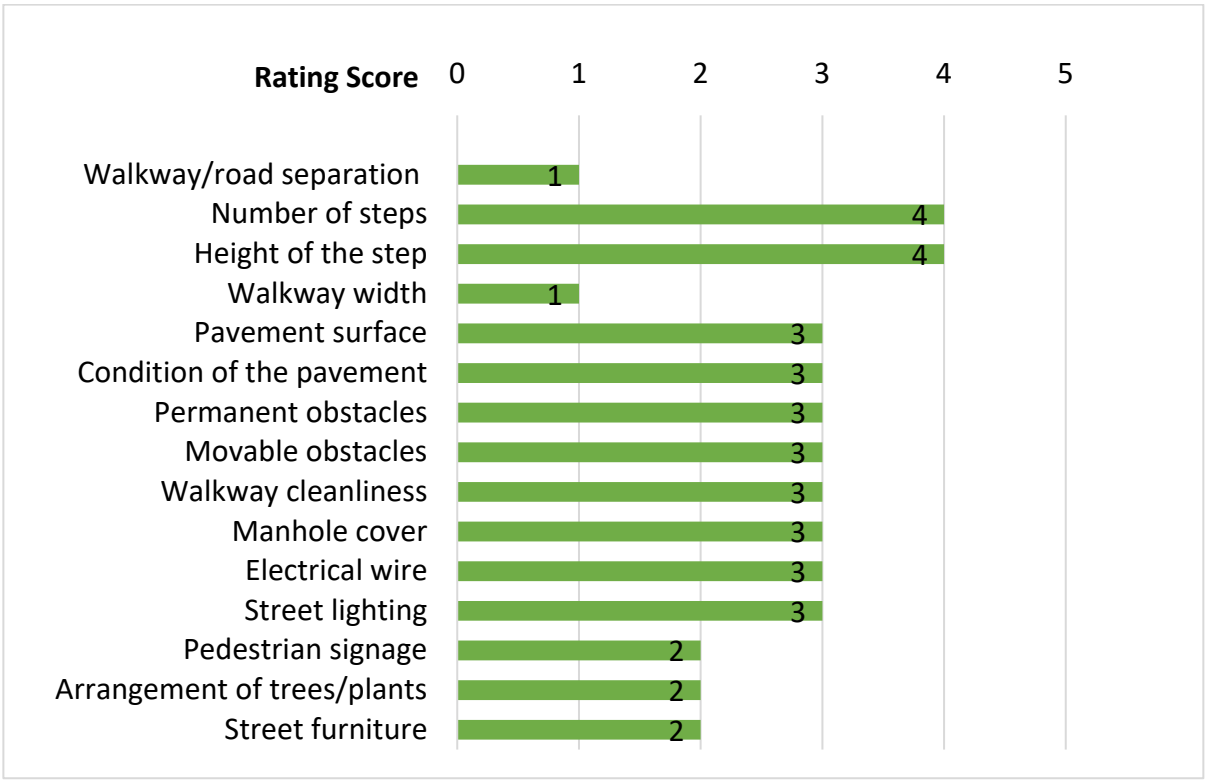


Location N11-4

Walkability Index	2.128







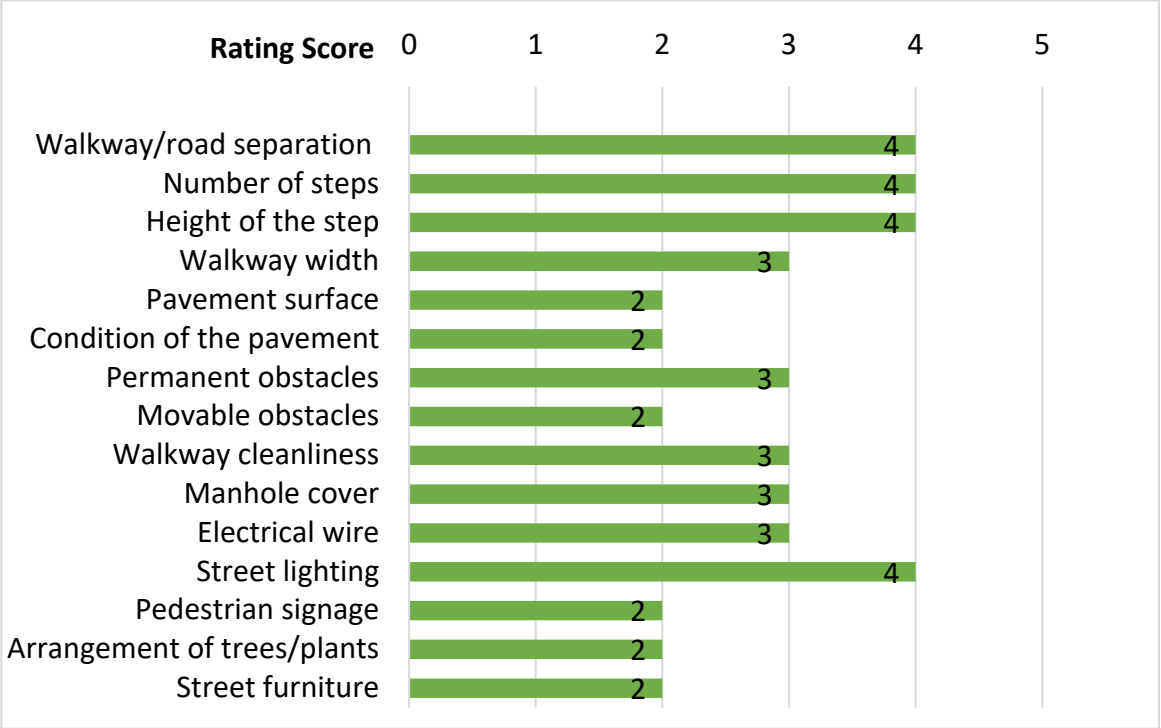
Location N11-5

Walkability Index	3.405







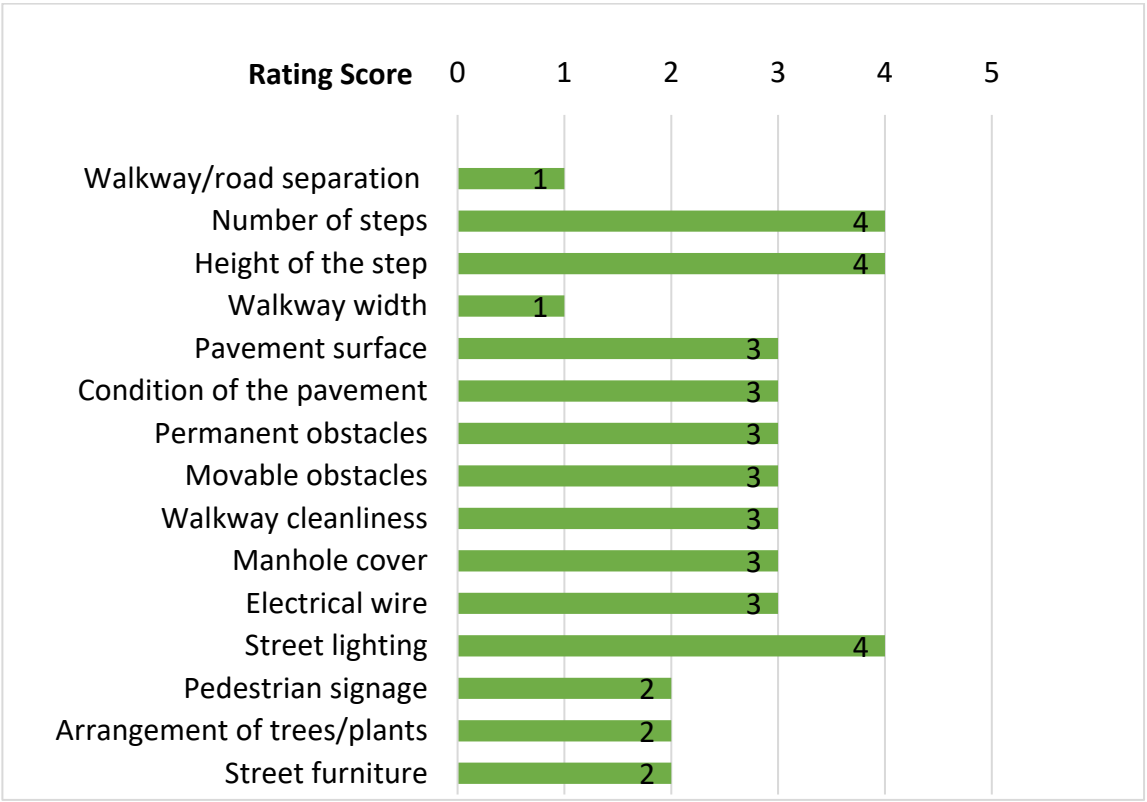


Location N11-6

Walkability Index	2.185







Location N11-7

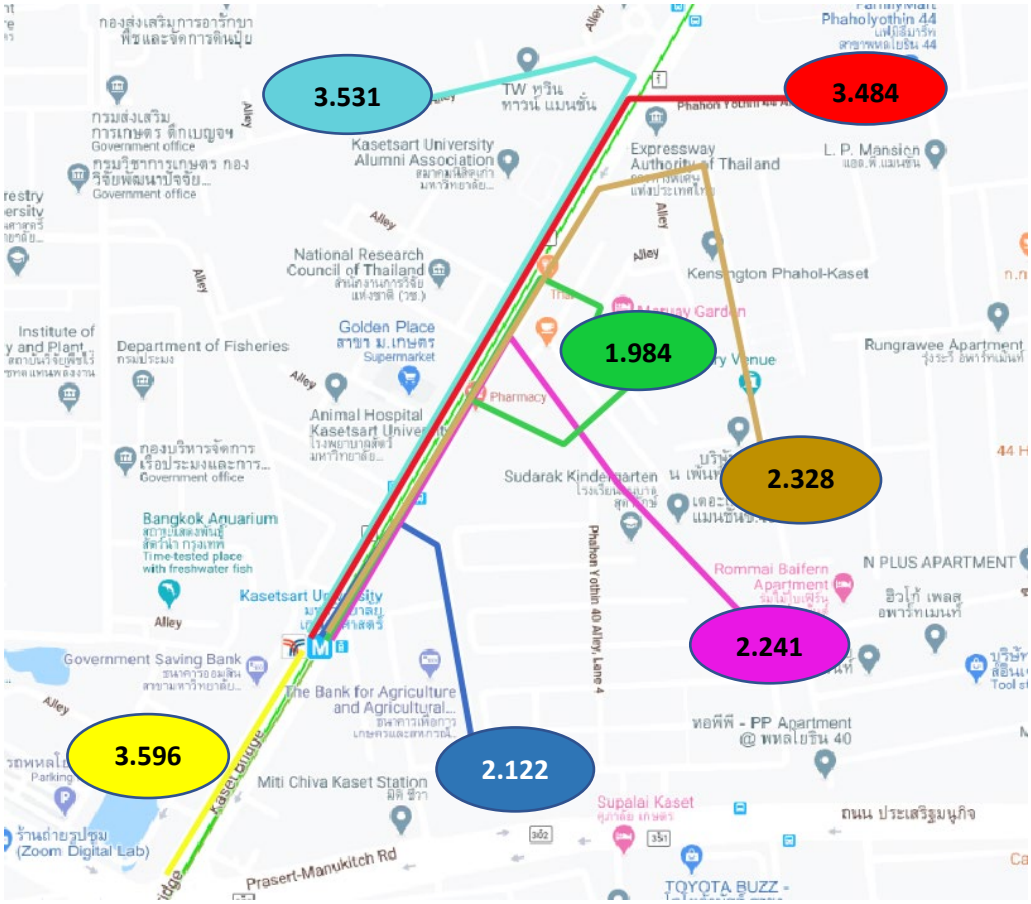
Walkability Index	3.594







3.5.3 Kasetsart Station (N13)

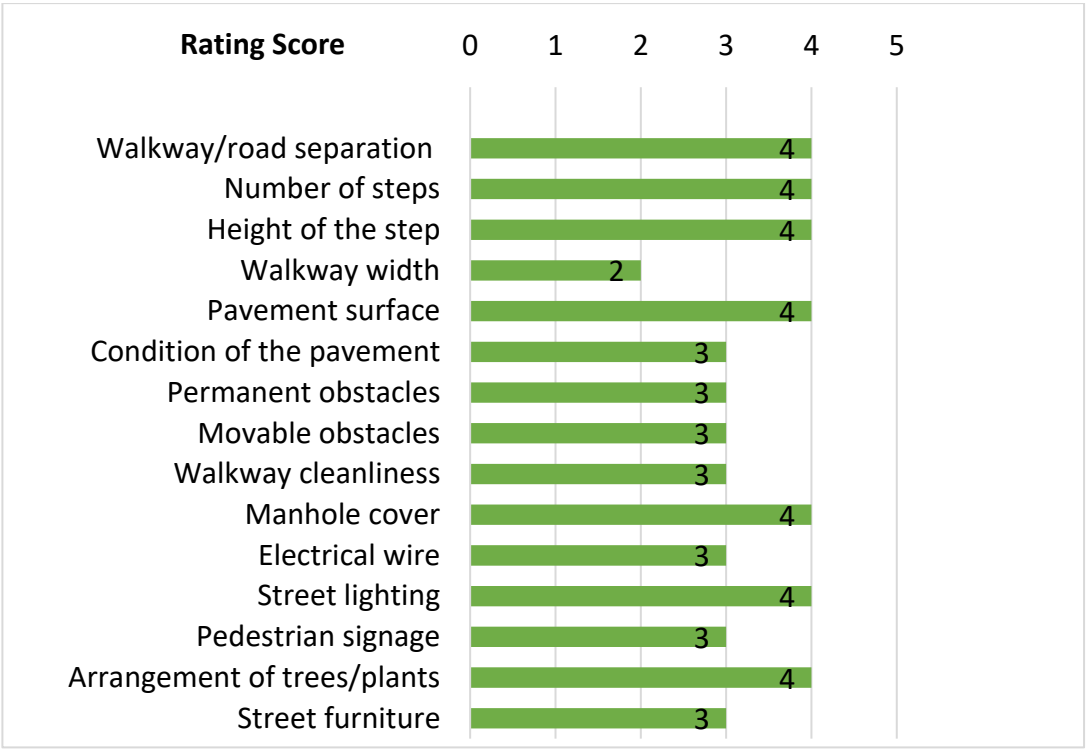


Location N13-1

Walkability Index	3.596





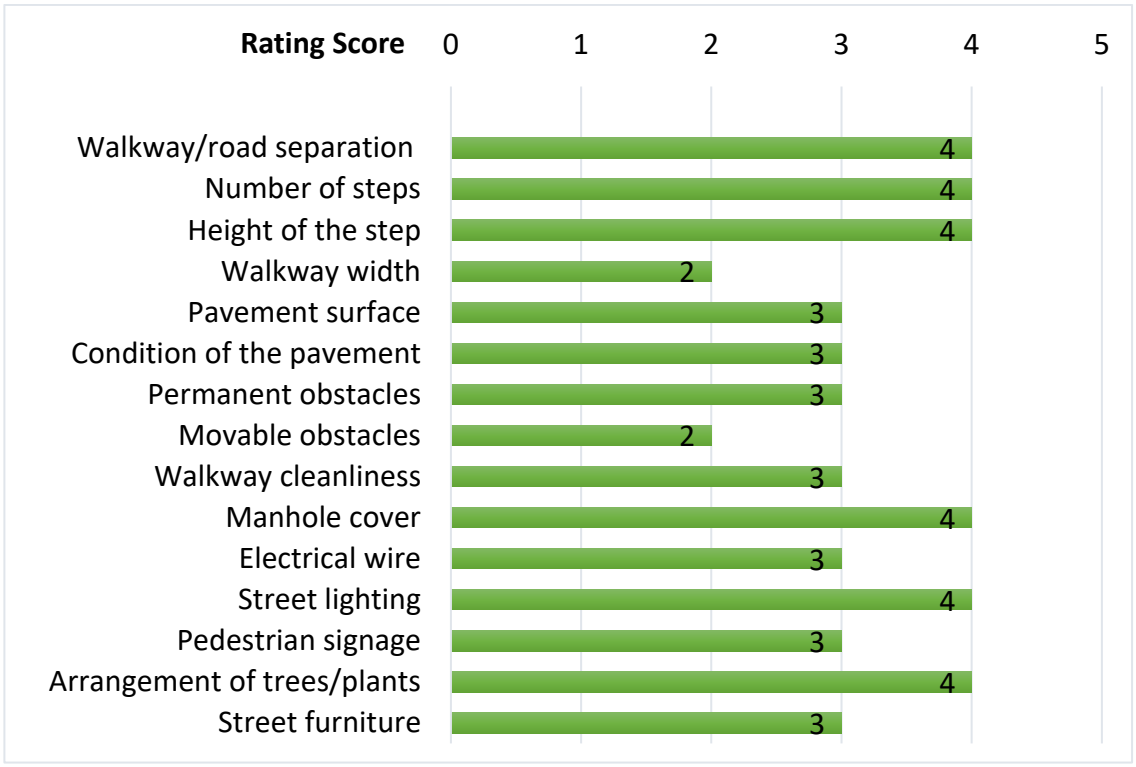


Location N13-2

Walkability Index	3.531





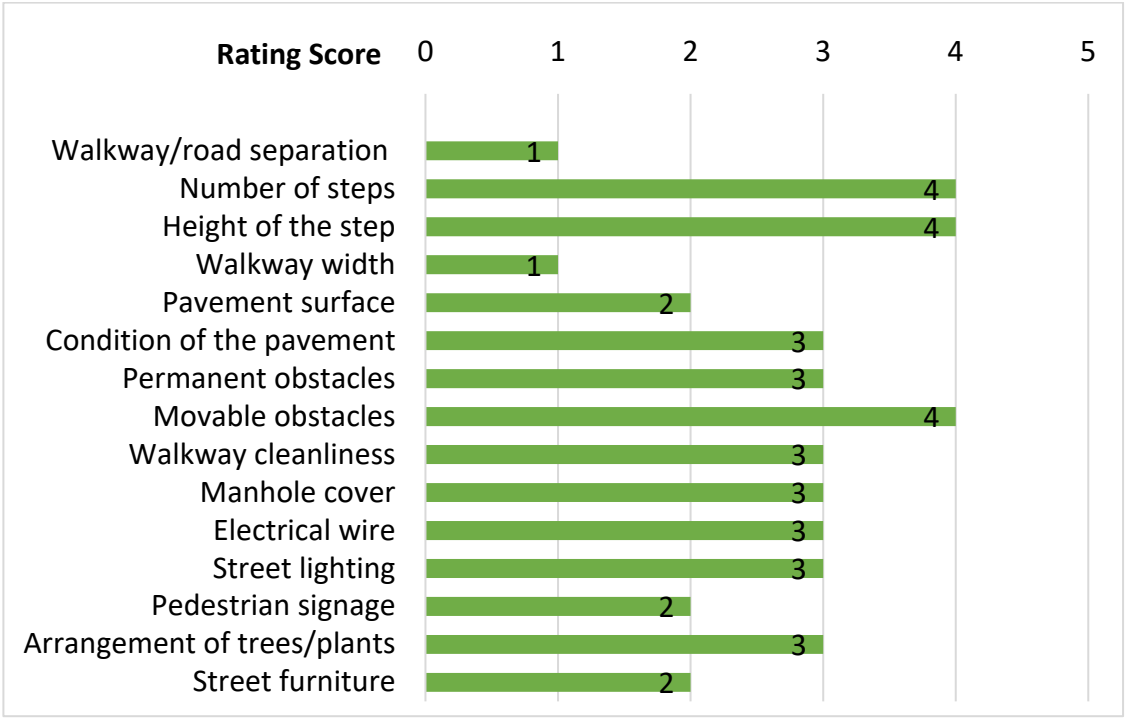


Location N13-3

Walkability Index	2.122





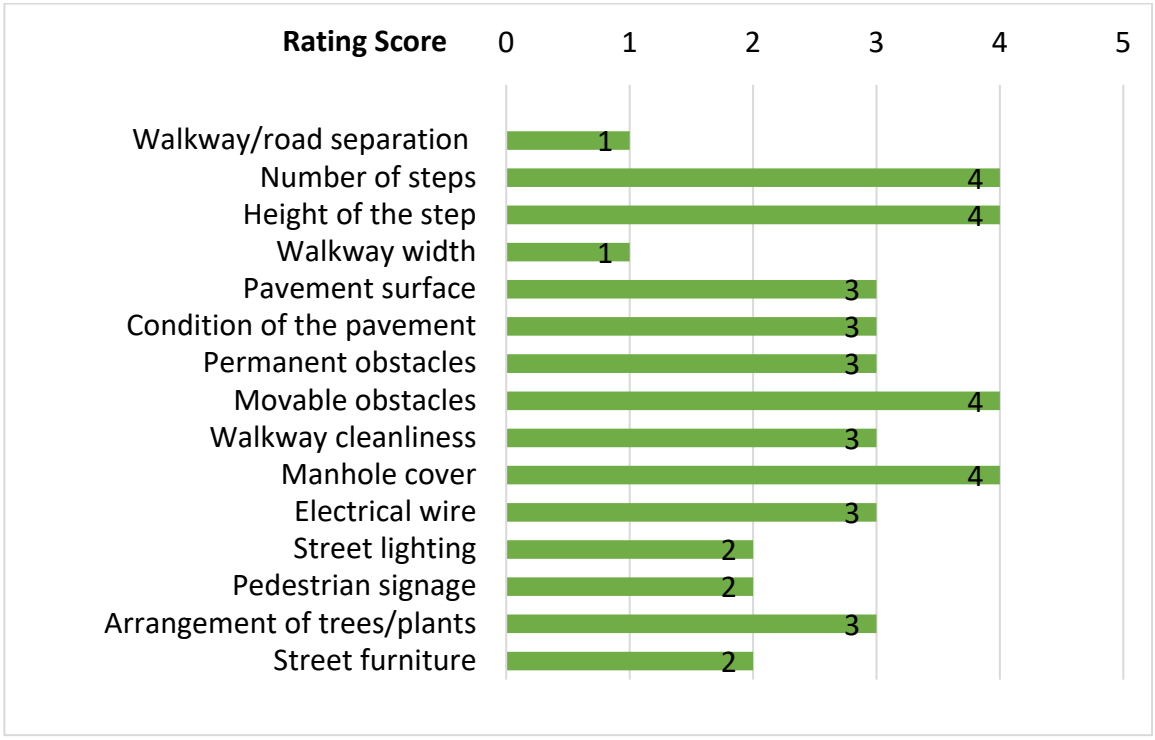


Location N13-4

Walkability Index	2.241





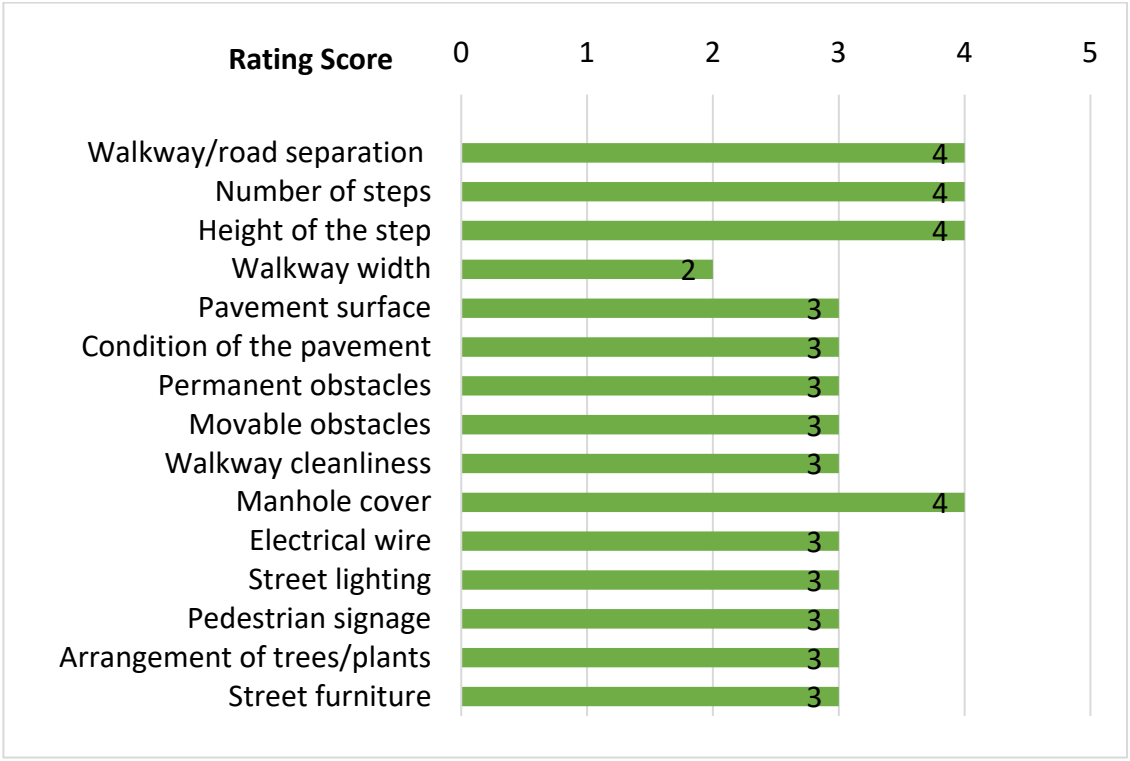


Location N13-5

Walkability Index	3.484





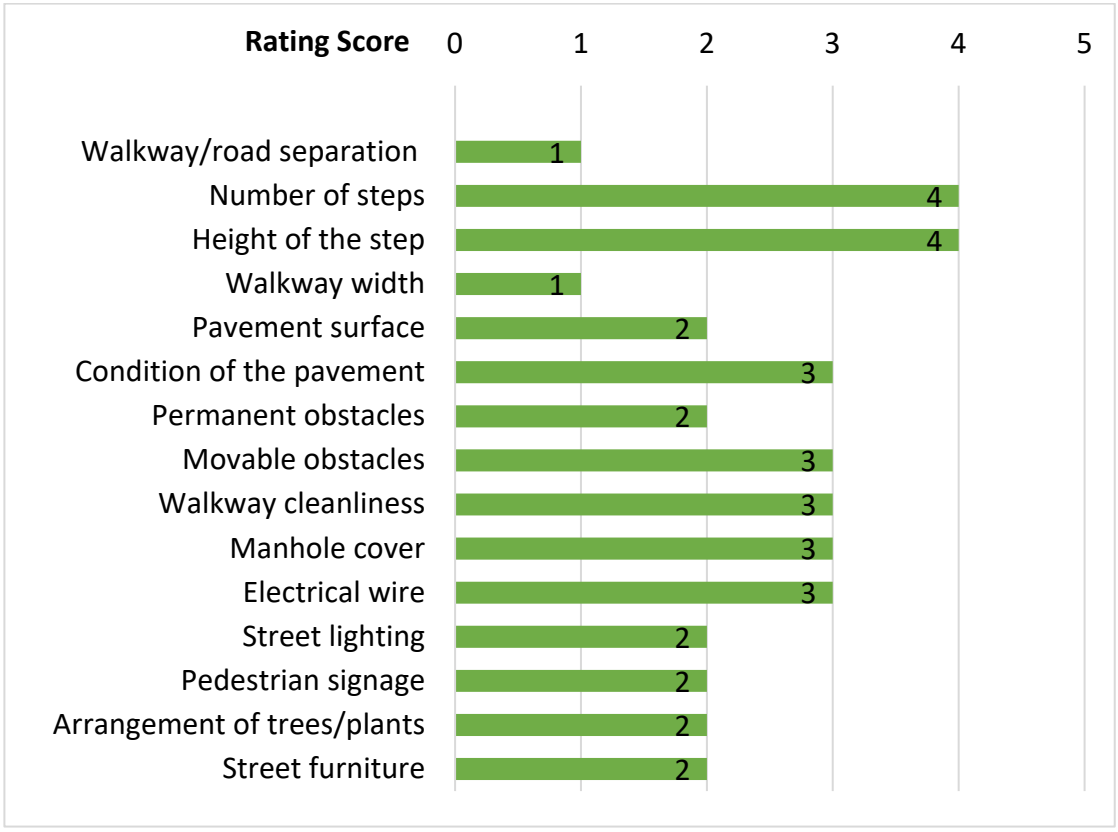


Location N13-6

Walkability Index	1.984





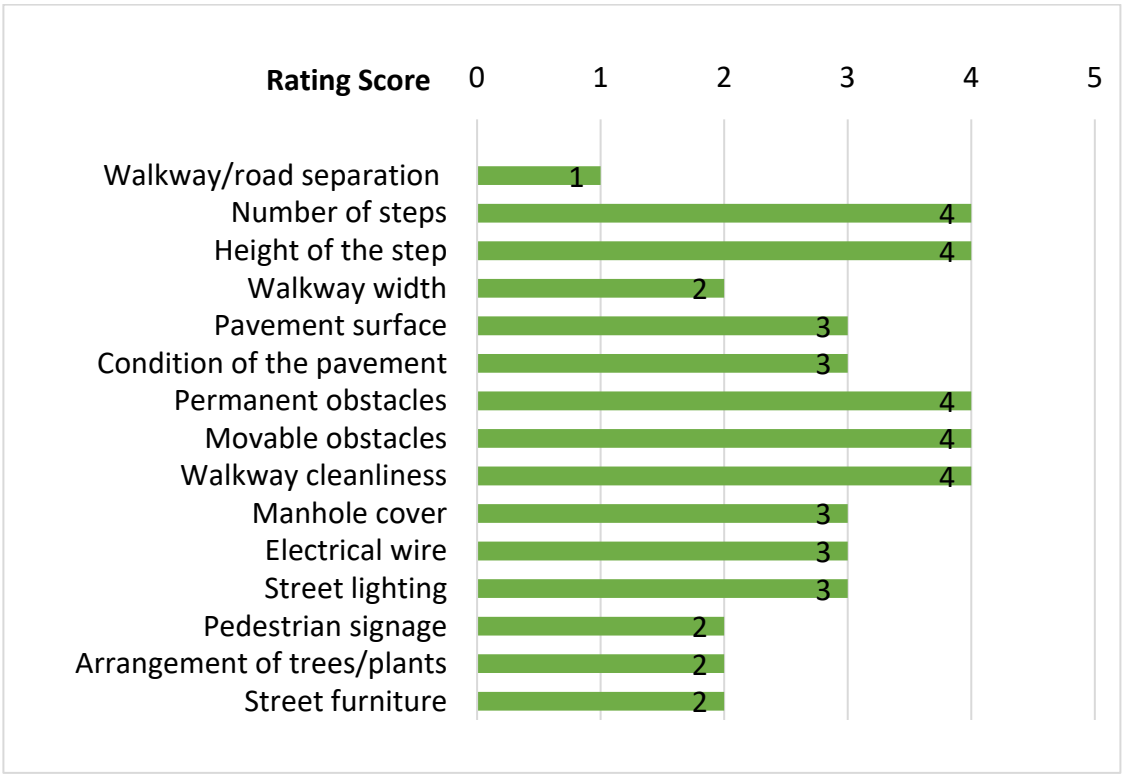


Location N13-7

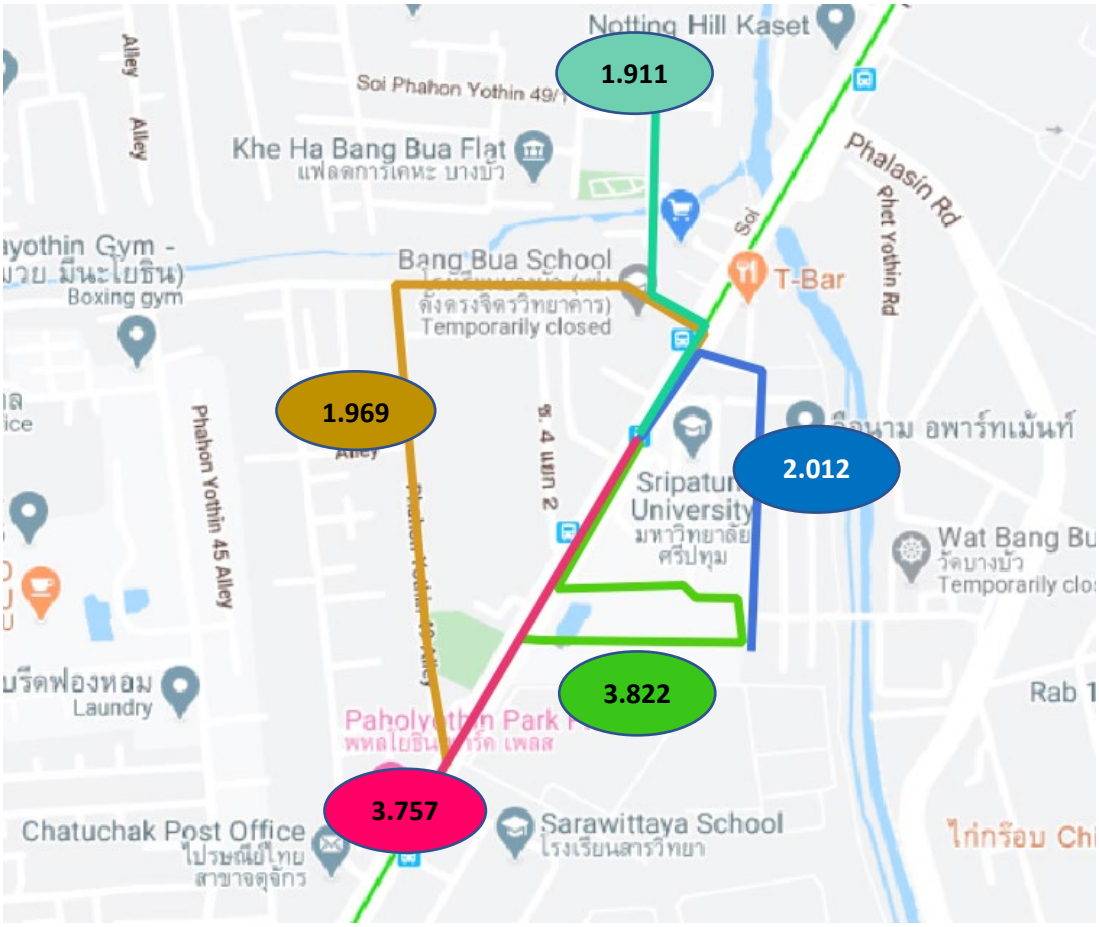
Walkability Index	2.328







3.5.4 Bang Bua Station (N15)



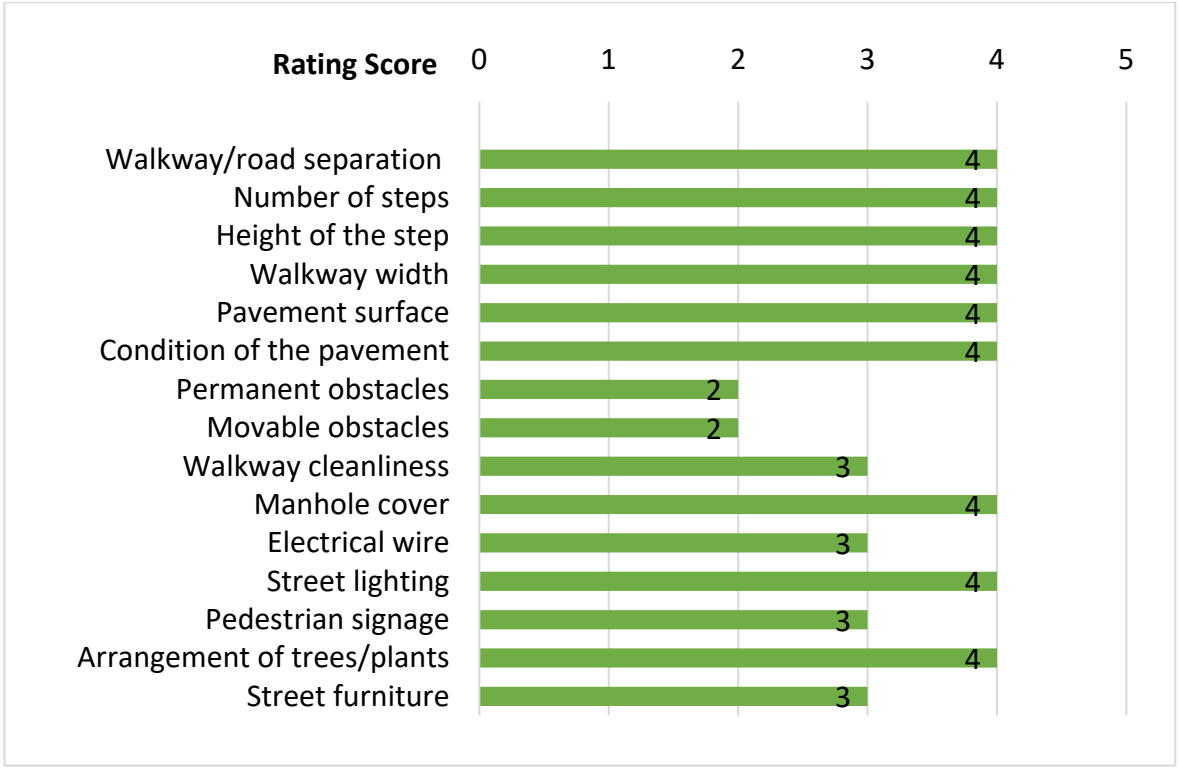
Location N15-1

Walkability Index	3.757







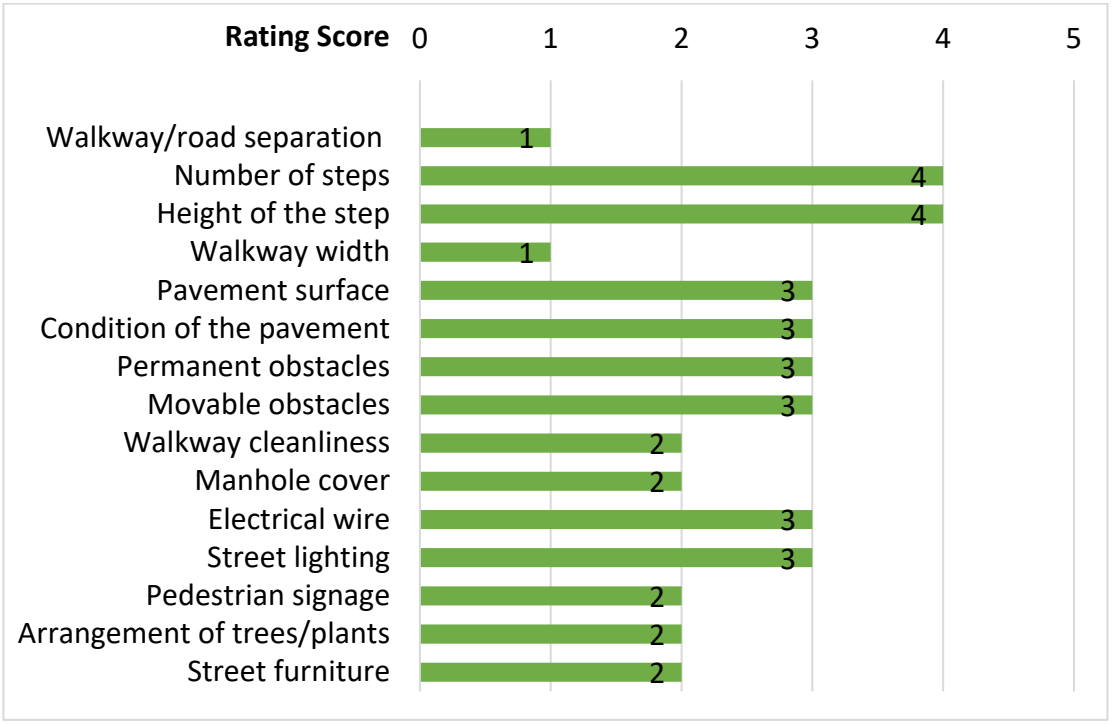


Location N15-2

Walkability Index	1.969







Location N15-3

Walkability Index	1.911







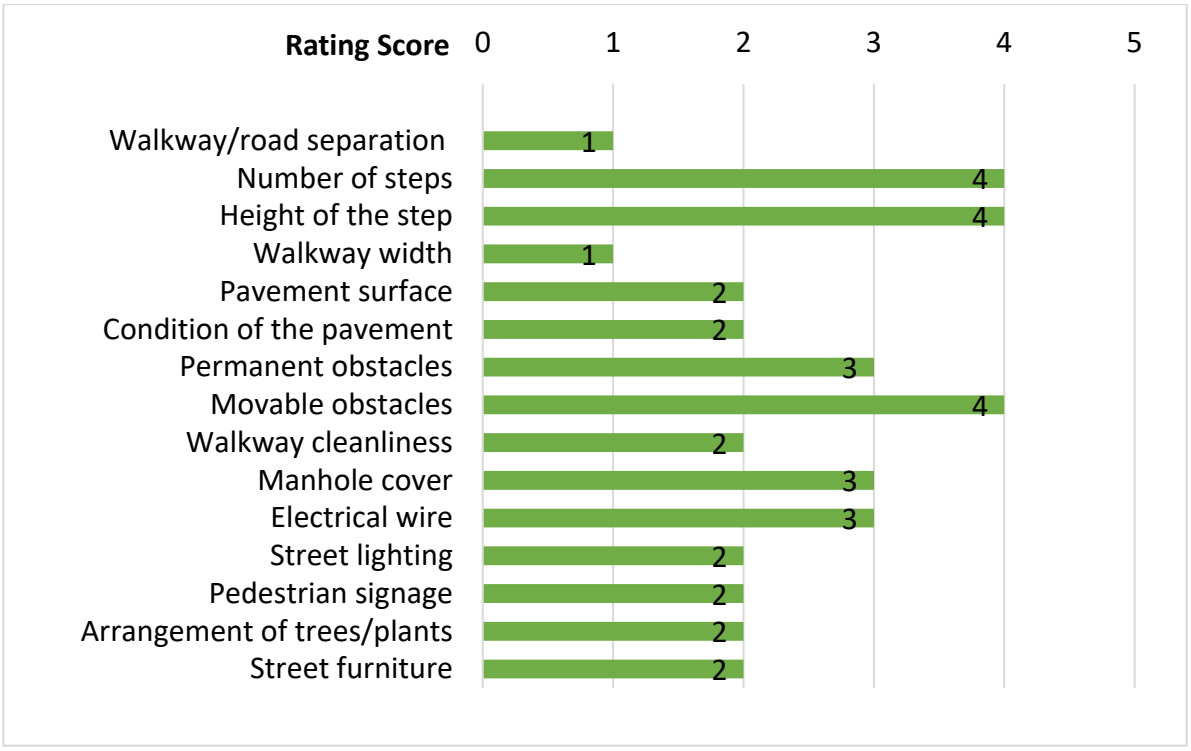


Location N15-4

Walkability Index	2.012





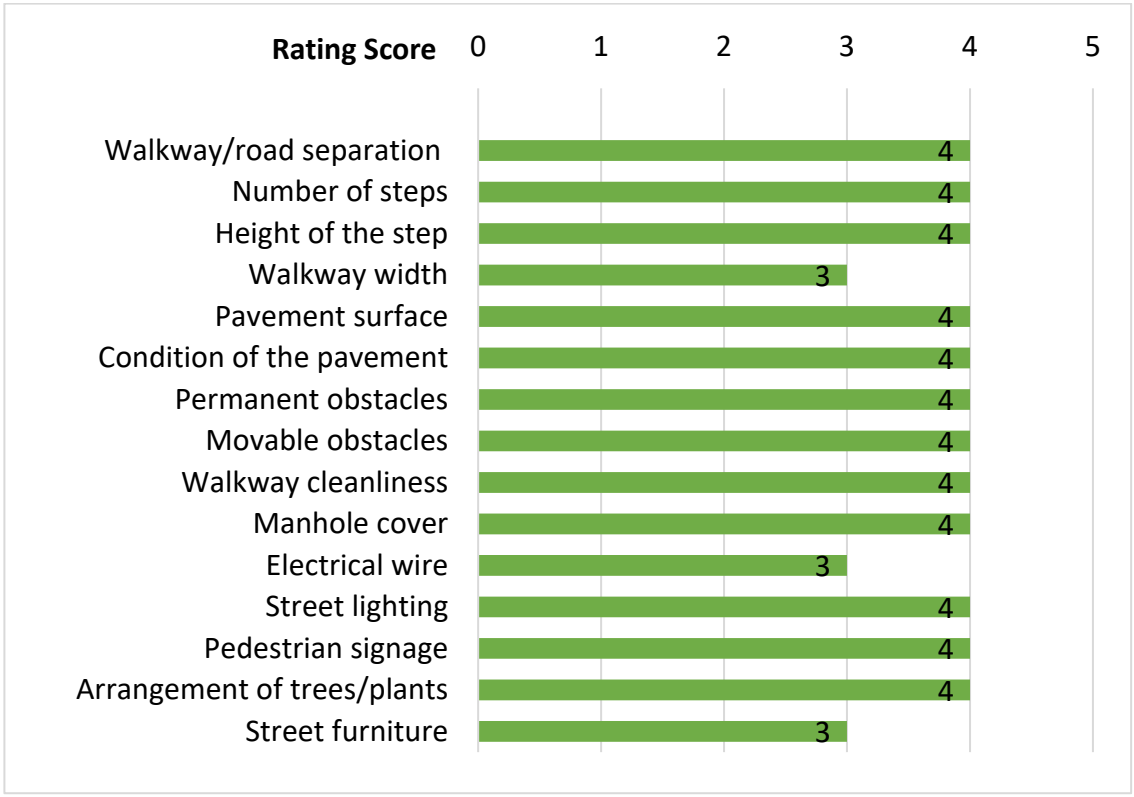


Location N15-5

Walkability Index	3.822







3.6 Walkability in the Station Catchment Area

Walkability in the catchment area of 3 stations of green line was evaluated. The results are shown in Figure 3.5. It is obvious that the walkability values vary considerably in different area, ranging from less than 2 to more than 3. The area near Kasetsart University station, inside the campus, has relatively higher walkability comparing with the residential areas near Sena Nikhom station or the west side of Ratchayothin station. This is mainly due to the high density of the area where the narrow walkway is not separated from the road surface. This finding clearly indicates an urgent need to improve the walkability in the area to provide better accessibility to station by walk.

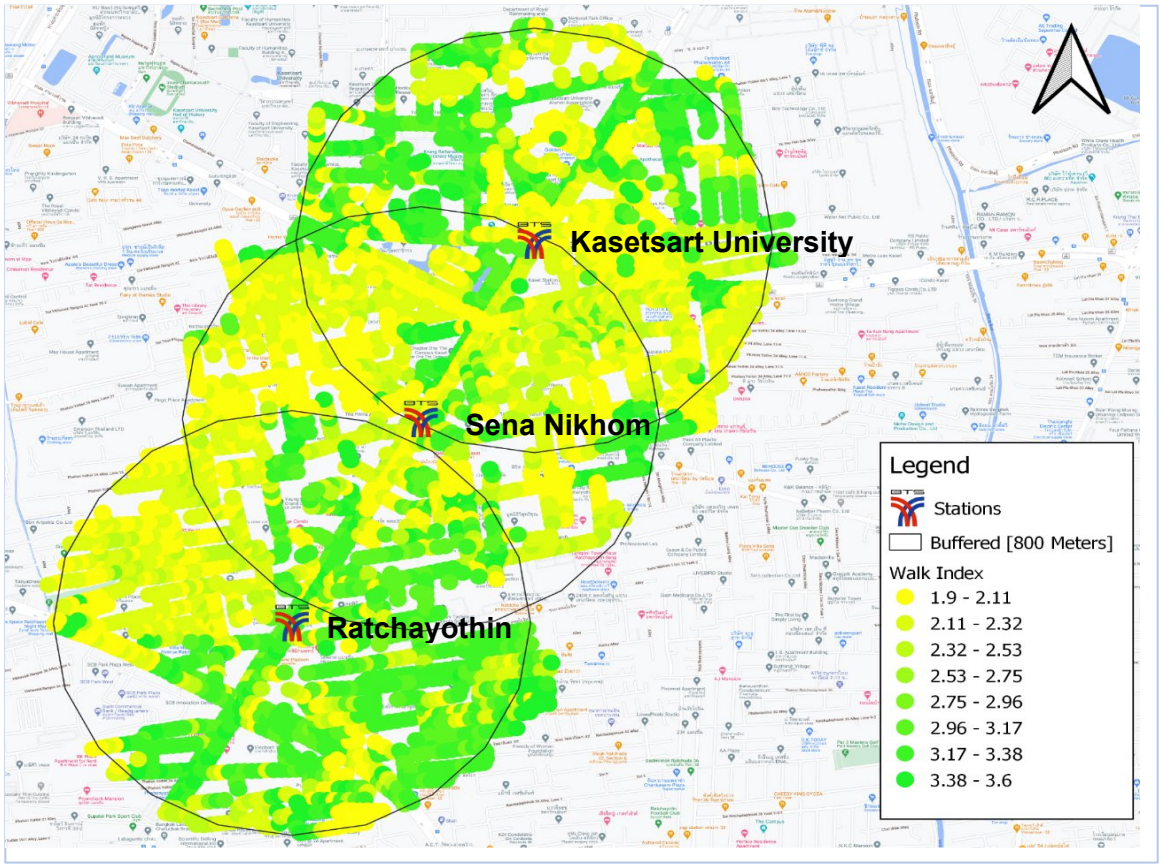


Figure 3.5 Walkability in the Station Catchment Area

CHAPTER 4 PERCEIVED WALKABILITY

4.1 Pedestrian Survey

4.1.1 Survey Items

The questionnaire survey consists of 4 parts as follows:

- **Part 1**: **Personal information**:
  - Gender, age, marital status, occupation, education, income Vehicle availability, etc.
- **Part 2**: **Present travel and walking behavior**:
  - Average travel time (one way) from residence to work or school.
  - Average travel distance (one way) from residence to work or school.
  - Modes of transport commonly used per day.
  - Walking time per day
  - Walking purpose, etc.
- **Part 3**: **Attitude and preference of walking** using 7-rating scale (from totally agreed to totally disagreed). The statements may include:
  (1) I think walking is a time-saving mode of transport.
  (2) I think walking is a cost-saving mode of transport.
  (3) I think walking is a healthy mode of transport.
  (4) I prefer walkway with easy access for people with special abilities.
  (5) I prefer walkway with proper street lighting.
  (6) I prefer wide, levelled, and clean walkway.
  (7) I prefer reduced and/or slow traffic on road.
  (8) I prefer walkway free of obstacle.
  (9) I prefer pedestrian bridge at crossing.
  (10) I prefer vendor or shops available along the walkway .
- **Part 4**: **Walkway evaluation** of selected walkway sections. The respondents were presented with photos taken from three locations and asked to evaluate each walking environment from different aspects such as:
  - Physical conditions:
    - Width
    - Level

        - Separation from road traffic
        - Pavement condition
        - Smoothness
        - Cleanliness
    - Convenience:
        - Presence of obstacle
        - Greenery or tree
        - Shading or roof
        - Pollution level
    - Safety and security:
        - Traffic safety
        - Road crossing
        - Crime safety or security
    - Attractiveness:
        - Nearby activities
        - Liveliness
        - Furniture such as bench or sculpture

(a) Attitude of Walking and Walkway Preference



(b) Attitude of Walking and Walkway Preference



Figure 4.1 Sample Questions: Walking Preferences and Walkway Evaluation

4.1.2 Method and Samples

Target survey respondents are workers and students who usually walk to/from railway stations daily. The survey was conducted through 2 channels: personal interview and online.

(1) Personal interview

Pedestrians around 4 railway stations were personally interview by random sampling. The interview was conducted in weekdays during February 2021. The number of respondents is 361.



Figure 4.2 Pedestrian Interview

(2) Online survey

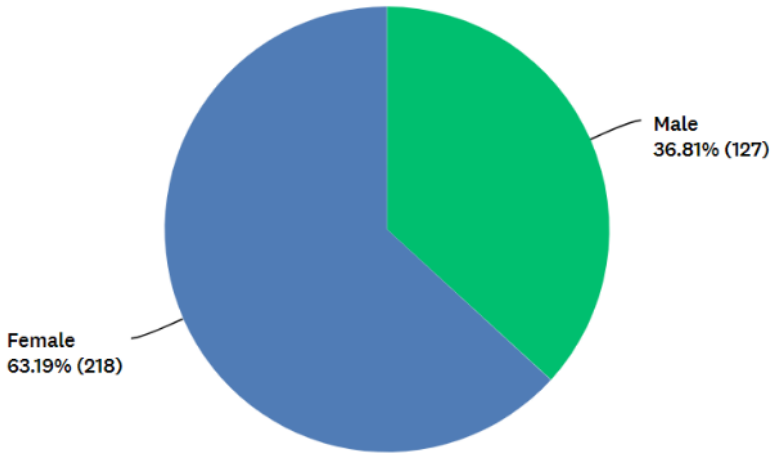
The online survey was conducted on the internet platform: surveymonkey.com. The number of respondents is 350.

4.1.3 Respondent Characteristics

The characteristics of samples in terms of gender, income, occupation, mode of transport and their walking preferences are summarized as follows.

Gender

(a) Personal interview



(b) Online survey

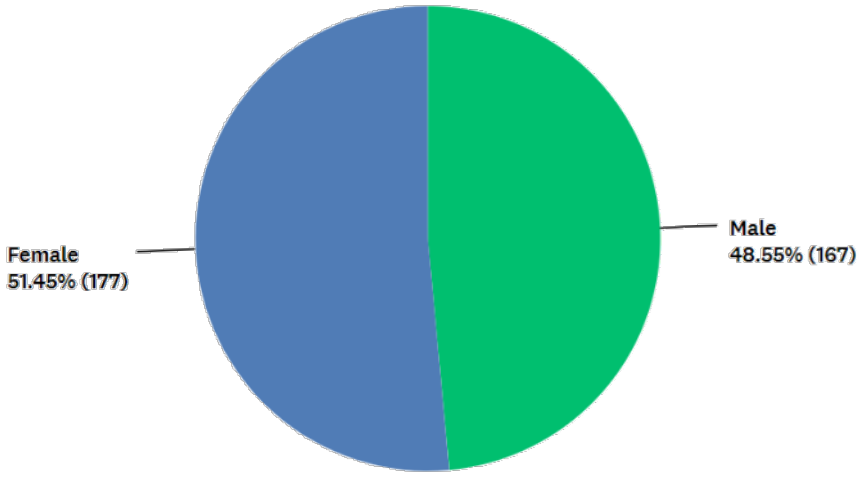
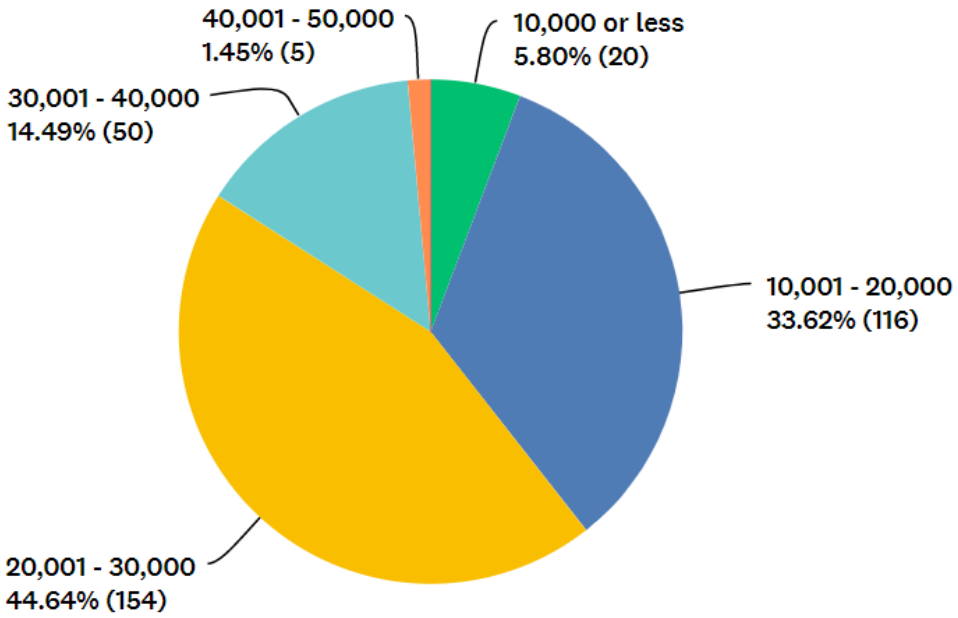


Figure 4.3 Gender of the Respondents

Personal Income

(a) Personal interview



(b) Online survey

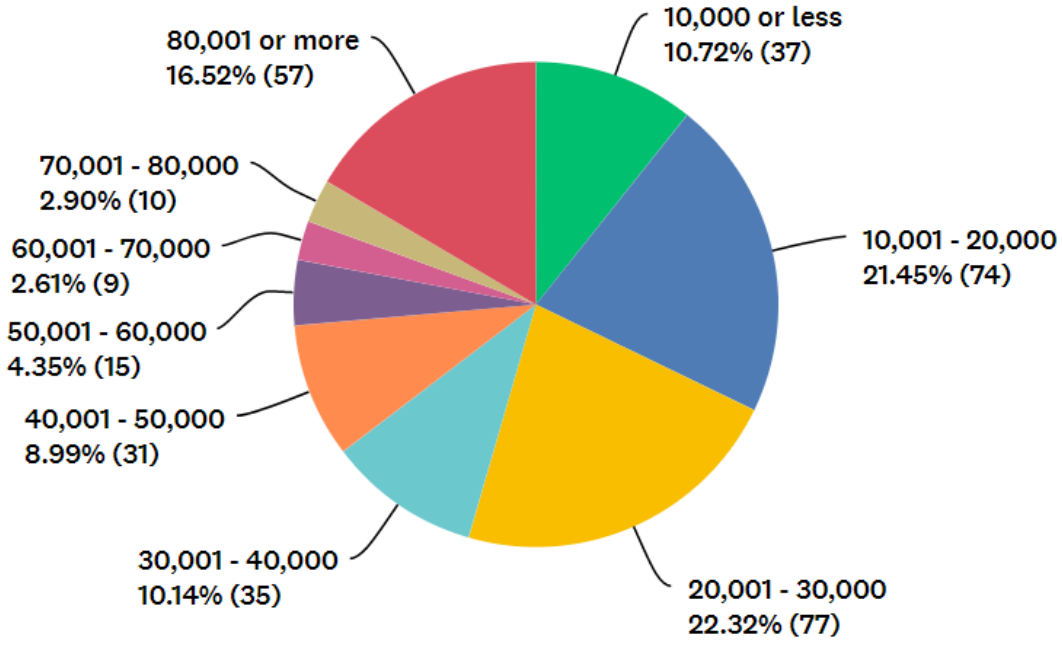
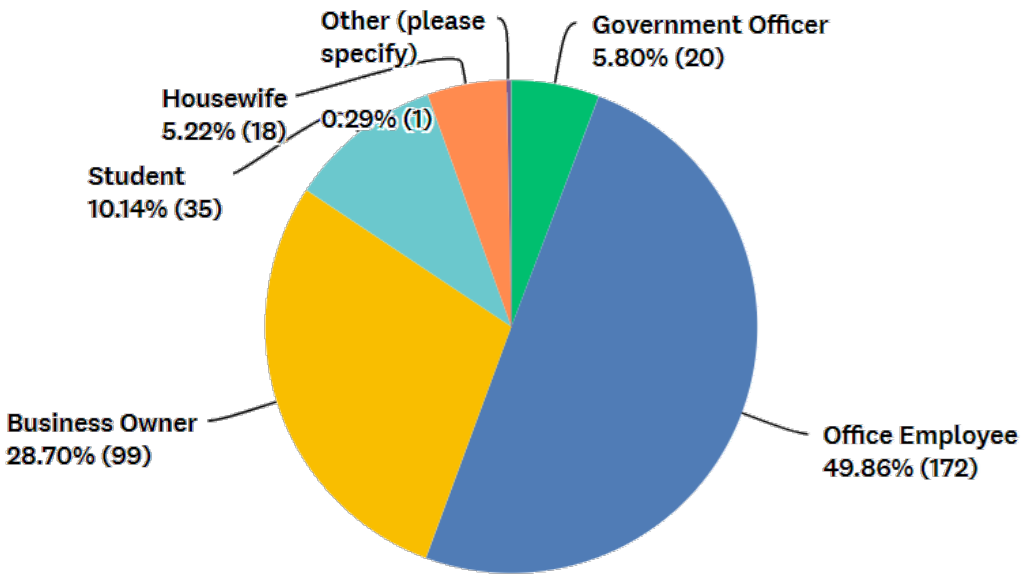


Figure 4.4 Income of the Respondents

Occupation

(a) Personal interview



(b) Online survey

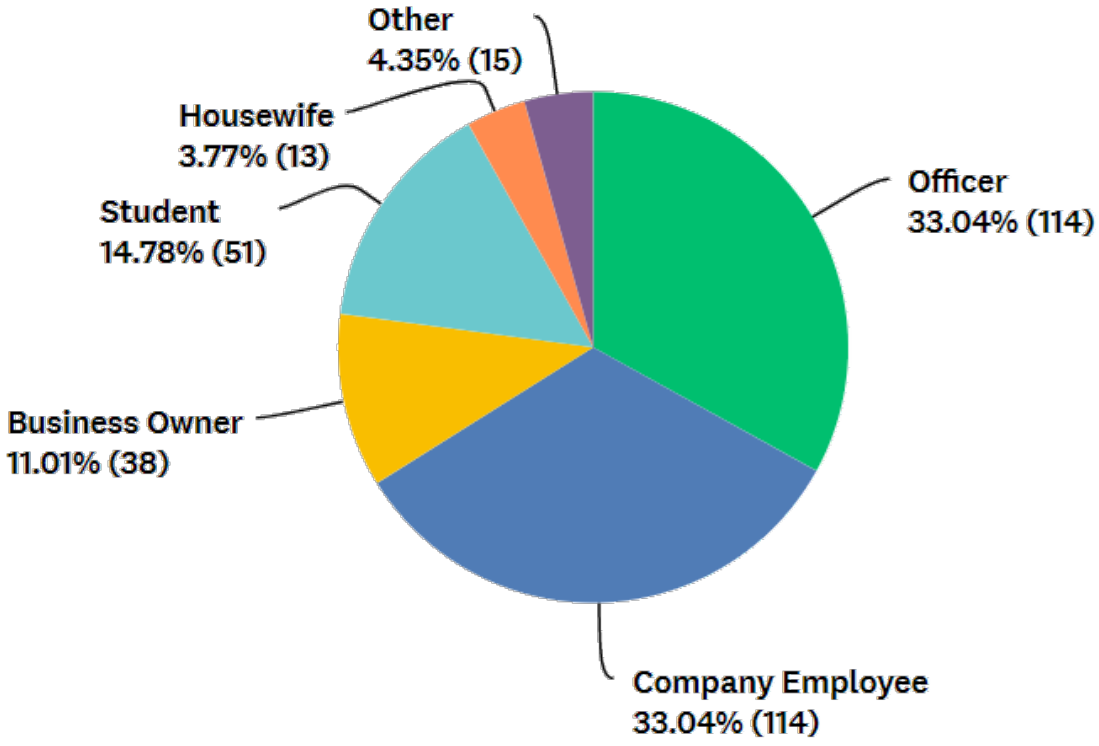
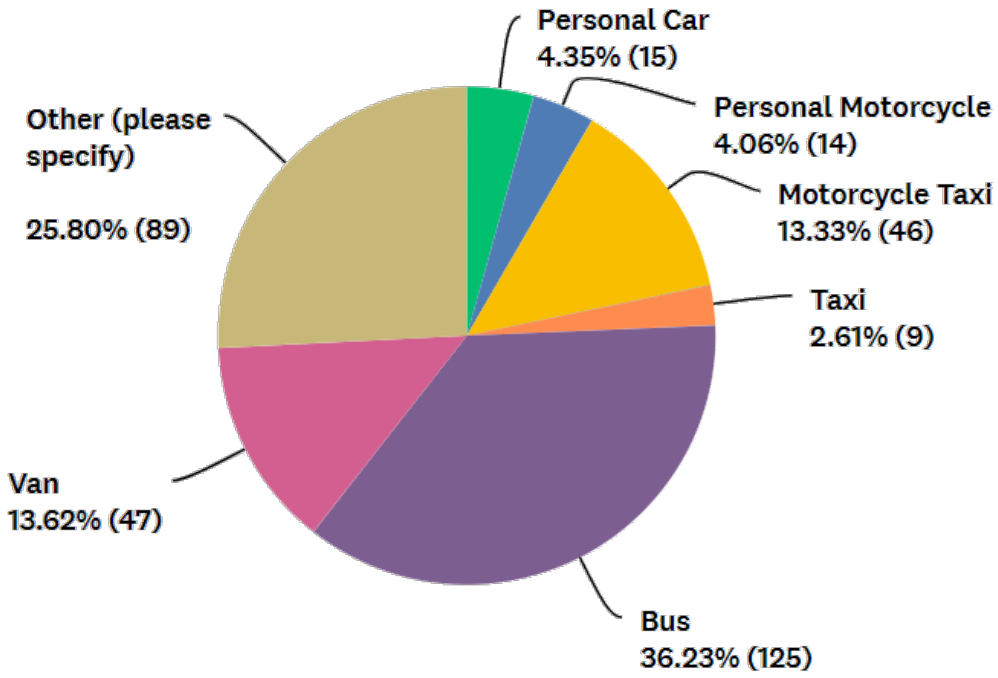


Figure 4.5 Occupation of the Respondents

Main Mode of Transport

(a) Personal interview



(b) Online survey

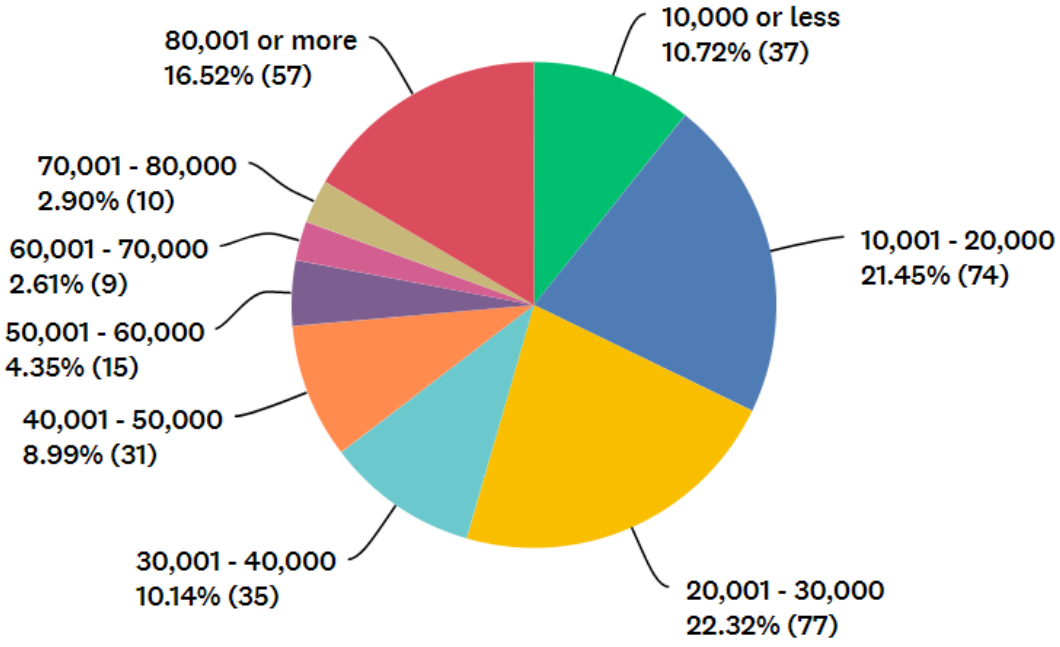
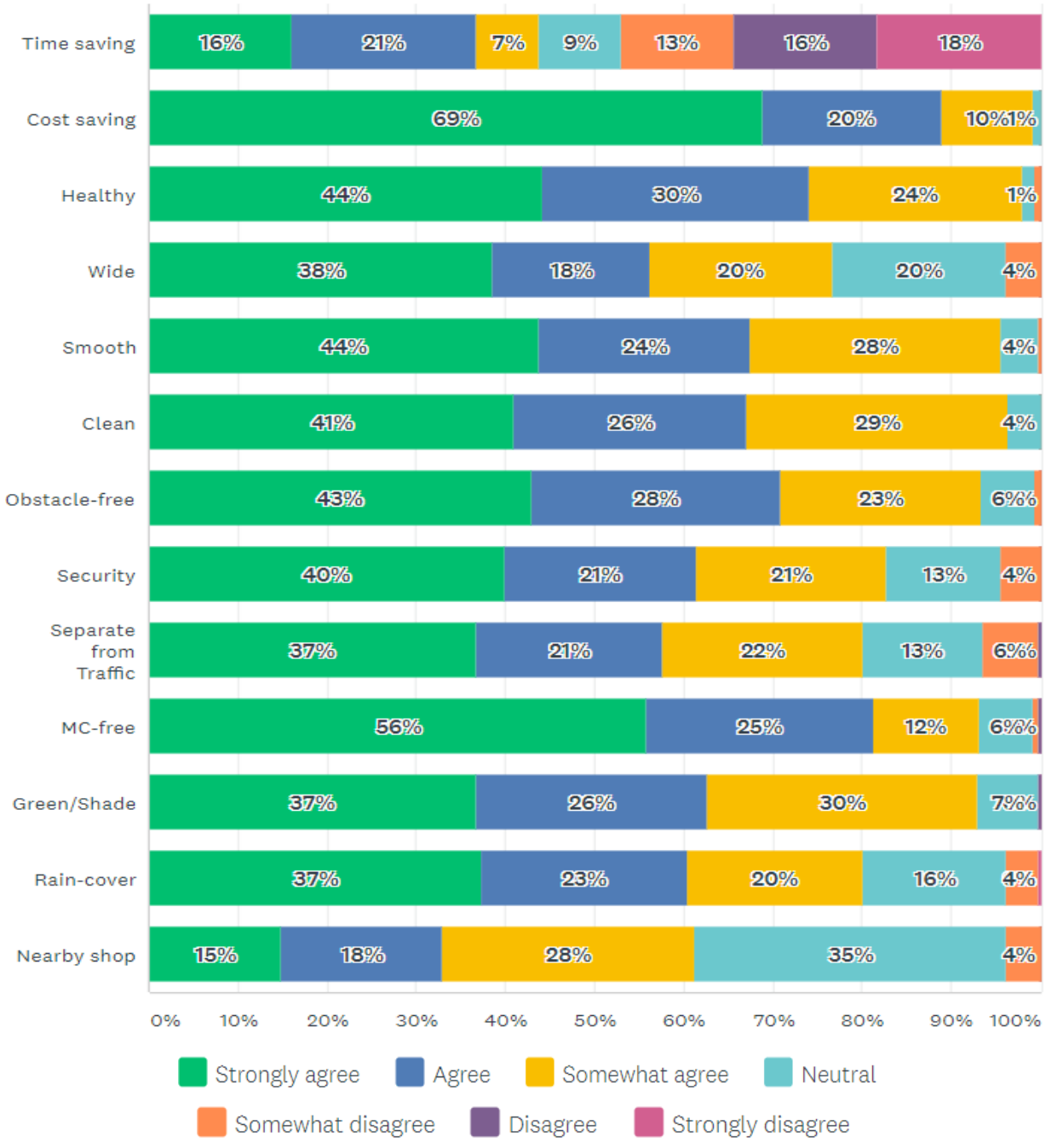


Figure 4.6 Mode of Transport of the Respondents

Walking Preferences

(a) Personal interview



(b) Online survey

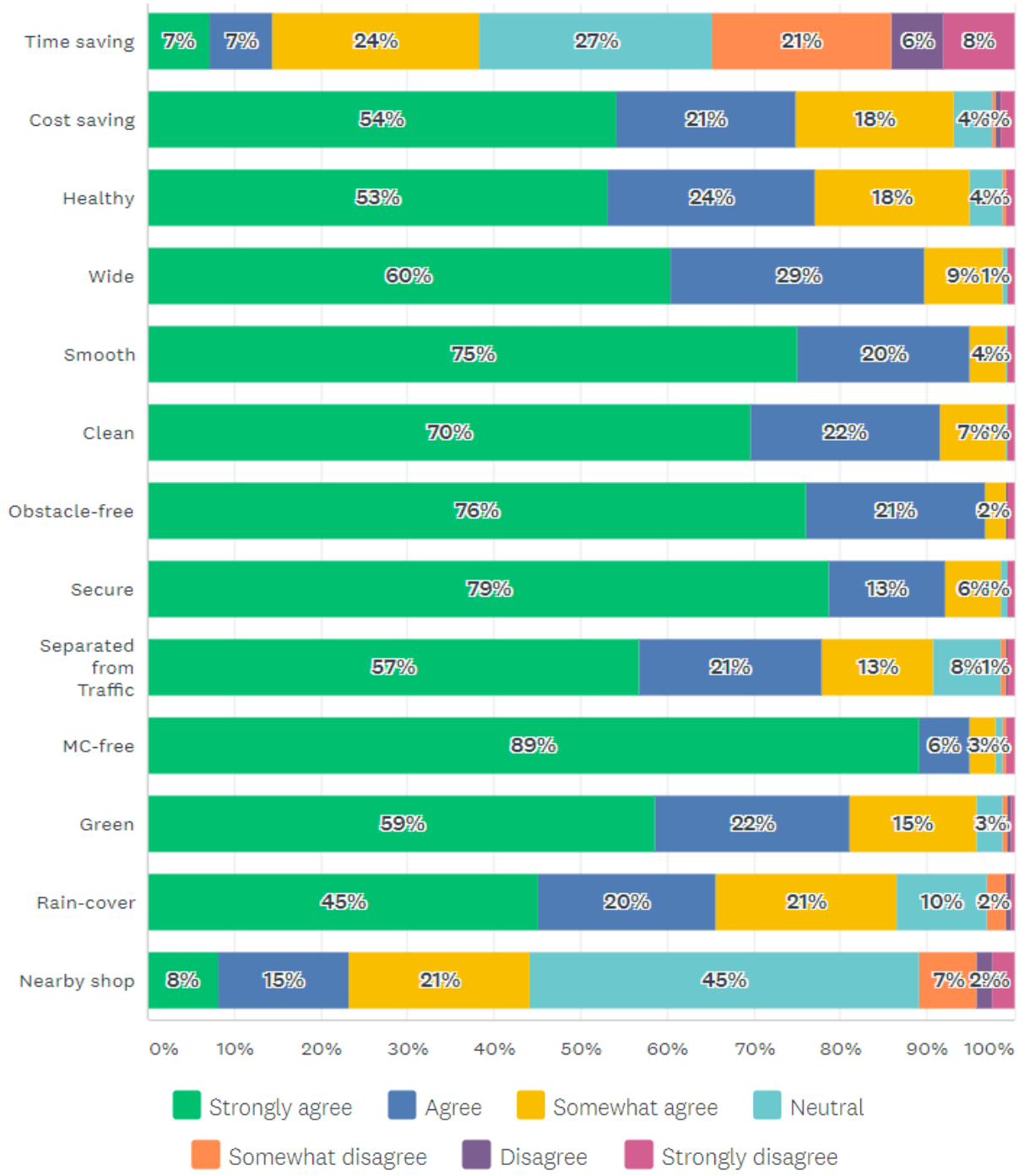


Figure 4.7 Walk Preferences of the Respondents

4.2 Descriptive Statistics

The descriptive statistics of the data obtained from the personal interview is show in Table 4.1.

Table 4.1 Descriptive Statistics

	Mean *Statistic*	*Std. Deviation* *Statistic*	*Skewness* *Statistic*	*Kurtosis* *Statistic*
aHealthy	6.20	.853	-.571	-.876
aWidth	5.74	1.256	-.462	-1.147
aSmooth	6.12	.916	-.473	-1.144
aCleanliness	6.07	.915	-.370	-1.200
aObstacleX	6.12	.937	-.729	-.341
aCrimeSafe	5.86	1.203	-.661	-.729
aTrafficSeg	5.75	1.264	-.647	-.668
aMotorcycleX	6.35	.885	-1.271	.857
aTreeShading	5.96	.973	-.369	-1.091
aRainCover	5.80	1.220	-.600	-.853
wRoadSep	3.74	2.218	-.225	-1.697
wWidth	3.52	2.146	.277	-1.361
wPaveCond	4.97	1.116	-.002	-.513
wObsTmp	4.96	.921	-.234	-.107
wManhole	5.36	1.167	-.203	-.850
wTree	3.70	1.431	.237	-1.248
rSmooth	4.51	1.610	-.228	-1.174
rClean	4.87	1.228	-.401	-.464
rObstacleX	3.96	1.630	.019	-1.218
rShading	4.10	1.546	.007	-1.208
rSafeCrime	4.69	1.419	-.458	-.899

4.3 Exploratory Factor Analysis

In theory, latent variables are factors that cannot be quantified such as safety, comfort, reliability although they influence individual behavior and perceptions. Because of either their intangibility, these variables do not have a measurement scale, or their intrinsic subjectivity (i.e. different persons may perceive them differently). Identification of latent variables requires supplementing a standard survey with questions that capture users' perceptions about some aspects of the alternatives (and the choice context). The answers to these questions generate perception indicators that serve to identify the latent variables. Otherwise, these latent variables could not be measured.

Walkability is affected by various tangible factors such as physical dimension, facility provision, cleanliness, obstacle, nearby activities, etc. It was evaluated by employing the conventional walkability items (Ozawa et al., 2020), as presented in the previous chapter.

As walkability is perceived differently by different persons that have different socio-economic status and attitudes of walking. These factors includes preception of physical condition, convenience, security, traffic safety, attractiveness, etc. The latent variables of walkability are explained by the walkway condition (i.e., physical walkability measure) and the pedestrian's characteristics and from the alternatives through structural equations. These latent variables, at the same time, explain the perception indicators through measurement equations.

The validity of the walkability perception was evaluated by Exploratory Factor Analysis (EFA), to condense the large number of items into a smaller, more controllable set of dimensions (Hair et al., 2019). EFA was conducted on the variables using SPSS 27. The rotated component matrix is obtained from a Varimax rotated principal component analysis (PCA). A factor loading of ≥0.5 is considered practically significant as this denotes a variance of 25% accounted by the factor (Hair et al., 2019).

Three items of perception factors (width, traffic safety, and nearby shopping) were deleted during the iteration owing to their low loading, low communalities, and cross-loaded nature for more than one factor. Items were reduced to three factors with total variance of 74.056% where the Kaiser–Meyer–Olkin (KMO) value is 0.931, indicating adequate sampling. EFA results for the factors are summarized in Table 4.2. The Cronbach's alpha (α) values are greater than 0.70, indicating that the scale is reliable. The construct reliability values are greater than 0.7. The average variance extracted are

greater than 0.5. All of these indicators are greater than the minimum recommended values (Hair et al., 2019).

Table 4.2 Result of Explanatory Factor Analysis

Factor	Items	Standardized Loading	Communalities	Variance	Cronbach's alpha (α)	Construct Reliability	Average Variance Extracted
Need	aTrafficSeg	0.891	0.813	31.997%	0.950	0.956	0.689
	aCrimeSafe	0.868	0.875				
	aCleanliness	0.868	0.674				
	aWidth	0.863	0.796				
	aObstacleX	0.862	0.804				
	aRainCover	0.862	0.899				
	aSmooth	0.844	0.612				
	aHealthy	0.782	0.777				
	aTreeShading	0.756	0.715				
	aMotorcycleX	0.677	0.754				
Objective Walkability	wTree	0.930	0.744	26.522%	0.936	0.962	0.786
	wWidth	0.921	0.801				
	wCleanliness	0.913	0.824				
	wRoadSep	0.883	0.474				
	wManhole	0.881	0.573				
	wObsPerm	0.877	0.794				
	wPaveCond	0.794	0.712				
Perceived Walkability	rObstacleX	0.841	0.718	15.536%	0.876	0.882	0.601
	rSmooth	0.815	0.777				
	rClean	0.784	0.617				
	rShading	0.750	0.657				
	rSafeCrime	0.677	0.884				

Factor 1, Need, included 10 items: traffic safety, crime safety, rain protection, wide, clean, obstacle free, smooth, healthy, shading, and absence of motorcycle running, with EFA loadings of 0.677 to 0.891. Factor 2, Objective Walkability, included 7 items: road separation, width, tree, pavement condition, manhole, permanent obstacle, with EFA loadings of 0.794 to 0.930. Factor 3, Perceived Walkability, included 5 items: no obstacle, smooth, clean, shading, and crime safety, with EFA loadings of 0.677 to 0.841, respectively.

Latent constructs identified through the EFA were used for the Confirmatory Factor Analysis. The model comprises three latent factors: (a) need, (b) objective walkability, and (c) perceived walkability, respectively. By using AMOS 27 software, the measurement models for each of these factors is estimated and modified by excluding observed variables with low loading (< 0.5) and non-significant loading. The goodness-of-fit of the estimated model was judged satisfactory and verified the developed measurement models. These will be used for the subsequent structural analysis to be presented next.

4.4 Structural Equation Model

Based on the CFA result, a structural model of walkability is developed to examine the relationship amongst the latent constructs. The first exogenous latent variable, Objective Walkability, is explained by six indicators: road separation, width, tree, pavement condition, manhole, permanent obstacle. The second exogenous latent variable, Need, is explained by ten indicators: traffic safety, crime safety, rain protection, wide, clean, obstacle free, smooth, healthy, shading, and absence of motorcycle running. The endogenous latent variable is explained by six perception indicators: no obstacle, smooth, clean, shading, and crime safety, respectively. The maximum likelihood estimation was done by AMOS 27 software. The paths between latent variables are tested. The structural model with standardized coefficients is shown in Figure 4.8 where the goodness-of-fit indicators are reported. The normed chi-squared value (CMIN/df) is 3.846, GFI=0.942, AGFI=0.923, CFI=0.973, and RMSEA=0.049. The model is judged acceptable as they are within the recommended ranges of CMIN/df<5, GFI >0.9, CFI> 0.9, RMSEA<0.08 (Hair et al., 2019).

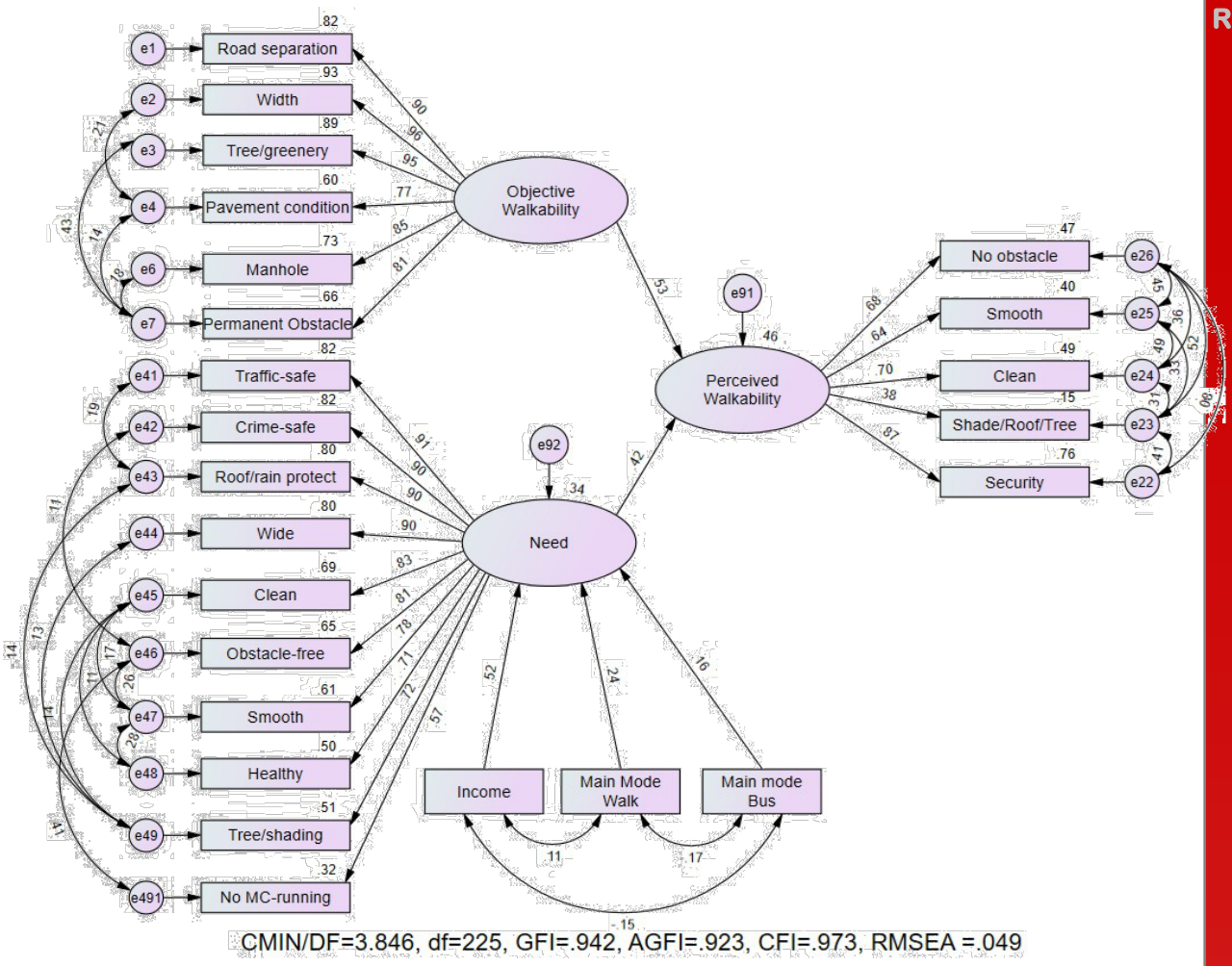


Figure 4.8 SEM Model of Walkability Perception

Path coefficients of the structural model are summarized in Table 4.3. It is found that Perceived walkability is influenced by Objective Walkability and Need with standardized regression coefficients of 0.53 and 0.42 respectively. Socio-economic characteristic has influence on Need as shown by the significant coefficient of Income. The walking habit, as represented by Walk as main mode and Bus as main mode variables, also has direct influence on Need, with standardized coefficient of 0.24 and 0.16 respectively.

Table 4.3 Path of the Structural Model

	Estimate		S.E.	C.R.
	B	**β**		
Objective Walkability → Perceived Walkability	0.294	0.527	.019	15.401***
Need → Perceived Walkability	0.412	0.422	.031	13.459***
Walk main mode → Need	1.216	0.238	.127	9.587***
Bus main mode → Need	0.389	0.162	.060	6.525***
Income → Need	0.697	0.516	.034	20.292***

*** p< 0.001 (two-tailed)

4.5 Perceived Walkability

The value of 'perceived walkability' variable (factor score) from the model shown in Figure 4.8 is determined for each respondent at every sample location and called 'Perceived Walkability Index'. The perceived walkability index is calculated for each of 50 sample sections that was used in the stated preference survey. The average value and its standard deviation are shown in Table 4.4 where the objective walkability is given for comparison. It is found that the values of perceived walkability indices are mostly lower than objective walkability indices. This is interpreted that the walkability is generally not perceived as high as it is expected from the physical point of view, but the other factors are also expected such as safety and convenience. The standardized values of objective walkability and perceived walkability are illustrated graphically for clearer comparison in Figure 4.9.

Table 4.4 Perceived Walkability Index

Sample Section	Line	Station	Objective Walkability Index	Perceived Walkability Index	
				mean	s.d.
1	Green	Kasetsart University	6.96	4.92	0.60
2	Green	Kasetsart University	3.37	3.48	0.98
3	Green	Sena Nikhom	5.61	4.30	0.73
4	Green	Sena Nikhom	3.50	3.49	0.93
5	Green	Ratchayothin	8.02	4.89	0.72
6	Green	Ratchayothin	3.42	3.56	0.83
7	Green	Bang Bua	7.68	4.92	0.57

Sample Section	Line	Station	Objective Walkability Index	Perceived Walkability Index	
				mean	s.d.
8	Green	Bang Bua	2.56	3.86	1.09
9	Blue	Bang Pho	6.03	3.51	0.57
10	Blue	Bang Pho	2.58	3.70	0.90
11	Blue	Tha Phra	7.51	4.95	0.91
12	Blue	Tha Phra	2.81	4.08	0.81
13	Blue	Phasi Charoen	5.64	4.75	0.75
14	Blue	Phasi Charoen	2.91	3.41	0.98
15	Blue	Phra Ram 9	6.17	3.92	0.59
16	Blue	Phra Ram 9	3.53	3.43	1.02
17	Blue	Yaek Fai Chai	6.41	4.95	0.90
18	Blue	Yaek Fai Chai	4.96	2.98	0.82
19	Purple	khlong Bang Phai	6.95	4.88	0.61
20	Purple	khlong Bang Phai	3.37	3.55	0.88
21	Purple	Talad bang Yai	5.63	4.60	0.67
22	Purple	Talad bang Yai	3.91	3.92	0.92
23	Purple	Sam Yaek Bang Yai	5.65	5.19	0.79
24	Purple	Sam Yaek Bang Yai	3.52	3.91	0.88
25	Purple	Bang Phlu	8.02	4.72	0.60
26	Purple	Bang Phlu	3.69	3.63	0.70
27	Purple	Bang Rak Yai	7.68	4.99	0.79
28	Purple	Bang Rak Yai	3.11	4.25	0.64
29	Purple	Bang Rak Nok Tha It	6.05	5.07	0.84
30	Purple	Bang Rak Nok Tha It	2.55	3.01	1.15
31	Purple	Sai Ma	7.87	5.08	0.39
32	Purple	Sai Ma	2.38	3.44	0.63
33	Purple	Phra Nang Klao Bridge	5.81	4.87	0.69
34	Purple	Phra Nang Klao Bridge	2.92	3.65	0.95
35	Purple	Yaek Nonthaburi 1	6.62	5.01	0.62
36	Purple	Yaek Nonthaburi 1	4.08	4.03	0.61
37	Purple	Bang Krasor	6.96	4.92	0.53
38	Purple	Bang Krasor	3.37	3.48	0.83
39	Purple	Nonthaburi Civi Center	5.61	4.30	0.56
40	Purple	Nonthaburi Civi Center	3.50	3.49	1.00
41	Purple	Ministry of Public Health	8.02	4.89	0.53
42	Purple	Ministry of Public Health	3.42	3.56	0.54
43	Purple	Yaek Tiwanon	7.68	4.92	0.61
44	Purple	Yaek Tiwanon	2.56	3.86	0.96
45	Purple	Wong Sawang	6.03	3.51	0.44
46	Purple	Wong Sawang	2.58	3.70	1.07
47	Purple	Bang Son	7.51	4.95	0.55
48	Purple	Bang Son	2.81	4.08	0.84
49	Purple	Tao Poon	5.64	4.75	0.71
50	Purple	Tao Poon	2.91	3.41	1.00

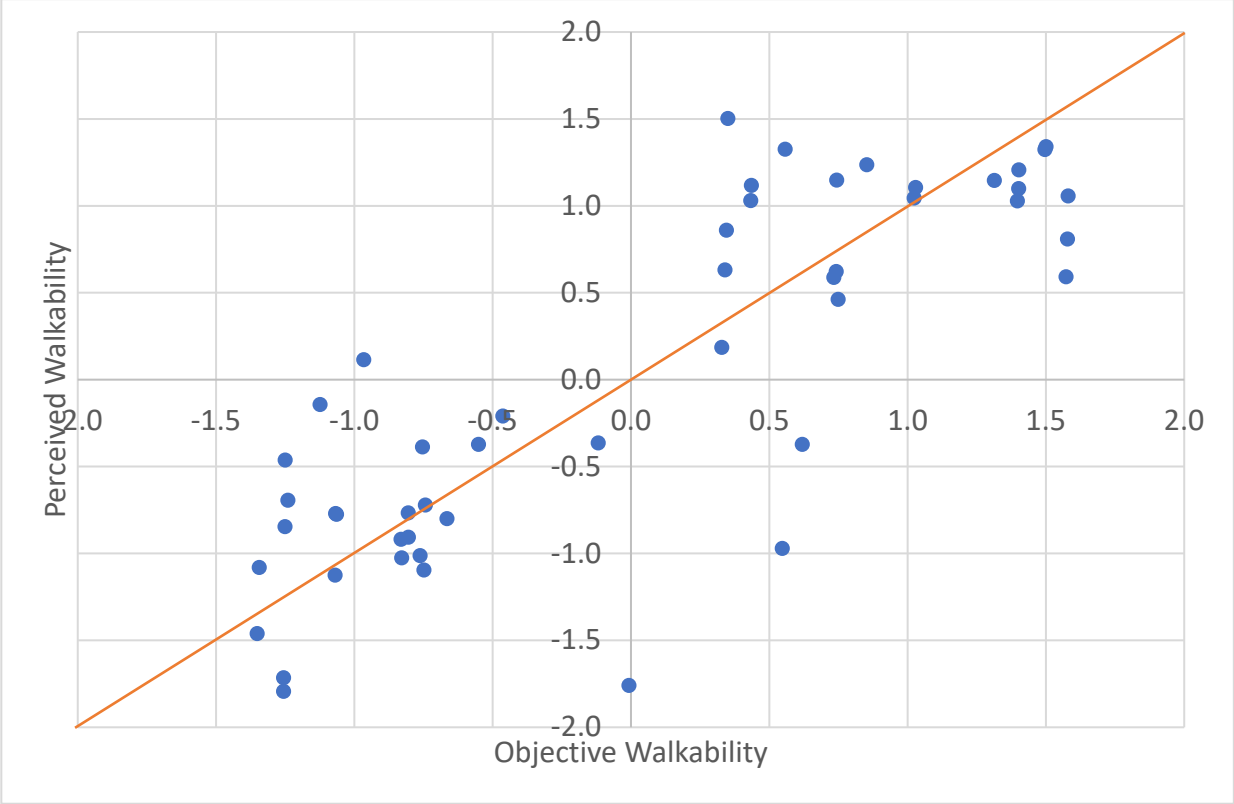


Figure 4.9 Standardized Value of Perceived and Objective Walkability

CHAPTER 5 CONCLUDING REMARKS

5.1 Walkability

This study evaluated the walkability along 25 urban railway stations in Bangkok. It also evaluates the walkability in the 800-m station catchment area of three stations of green line. It is found that the walkability varies significantly between different locations. The walkability on main road is generally larger than that of small road, or literally called Soi in Thai language. Typical examples are shown in Figure 5.1. Similarly, it is found that station walkability is larger for stations in the inner area than stations in the outer area. Typical examples are shown in Figure 5.2.

a) Main road *b) Small road (Soi)*



Figure 5.1 Different Walkability on Main Road and Soi

a) Inner area or city center *b) Outer area or suburb*



Figure 5.2 Different Walkability in the Inner and Outer Areas

5.2 Perceived Walkability

This study determined the perceived walkability based on the loadings of objective factors in the structural equation model. The model was estimated by using the data obtained from the pedestrian questionnaire survey. The estimated model was judged satisfactory by the goodness-of-fit indicators. The perceived walkability index is determined for the sample sections. The results showed that the perceived walkability is generally lower than the objective walkability, which was evaluated based mainly on the physical structure.

Considering the factors influencing walkability, the priority of factors that are found in this study are compared with that of the previous studies in Table 5.1. For the objective walkability, as this study is based on Ozawa et.al. (2020) the results are therefore similar. However, this study found that more weight is found given to trees or planting along the walkway, based on the result of EFA and SEM. For the perceived walkability, this study found similarly to Bivina et.al.(2019) in which security or safety is the most important. However, this samples in this study in Thailand give more priority to cleanliness and convenience than pavement quality whereas the samples in India (Bivina et.al., 2019) give more priority to pavement quality, which is basic need, than convenience and safety, which is upper need of walking.

Table 5.1 Priority of Walkability Factors

Objective Walkability		**Perceived Walkability**	
Ozawa et.al.(2020)	*This study*	*Bivina et.al.(2019)*	*This study*
1. Walkway/road separation	1. Width	1. Safety and security	1. Security
2. Manhole	2. Trees/plants	2. Pavement quality and width	2. Cleanliness
3. Width	3. Walkway/road separation	3. Convenience such as cleanliness, obstacle, shaded etc.	3. Convenience such as presence of obstacles
4. Electrical wire	4. Manhole	4. Nearby traffic	4. Pavement quality
5. Street lighting	5. Obstacles		5. Trees/planting
6. Obstacles	6. Pavement condition		
7. Pavement surface			
8. Cleanliness			
9. Pavement condition			
10. Trees/plants			

5.1 Recommendation

Based on the findings summarized above, this study proposes the followings for policy and implementation.

5.1.1 Improvement of Walkway

As it is found that walkability is really perceived lower than expected. Consideration should be given to improve not only physical structure but also the other factors relating to convenience and safety of pedestrian. The walkway must be wide enough to walk conveniently without obstacles such as electric pole or advertisement. An improvement image is shown in Figure 5.3. A recent area redevelopment project at Chulalongkorn Soi 5 is shown in Figure 5.4. This can be considered as a good example of improvement in Bangkok where the walkway is reconstructed and well-integrated with the road. Another example of practical improvement of walkway in the corridor of urban railway, BTS line in central area of Bangkok, is shown in Figure 5.4, where the pavement is in good condition, no permanent obstacles that impede walking to stations, and proper planting providing shade. This altogether significantly improve walkability and encourage walking.

a) Present



b) Image of Improvement



Figure 5.3 Image of Walkway Improvement



Figure 5.4 Sidewalk along Chulalongkorn Soi 5 Street



Figure 5.5 Sidewalk along BTS in Central Bangkok

However, improving the at-grade walkway is not always easy. Sometimes there is no enough space to expand the width of walkway or planting tree or putting roof is sometimes also difficult. Noise and air pollution caused by nearby car traffic will also be unpleasant. If these conditions are not easily improved, an elevated walkway connecting directly with stations will sound interesting, as illustrated in Figure 5.6

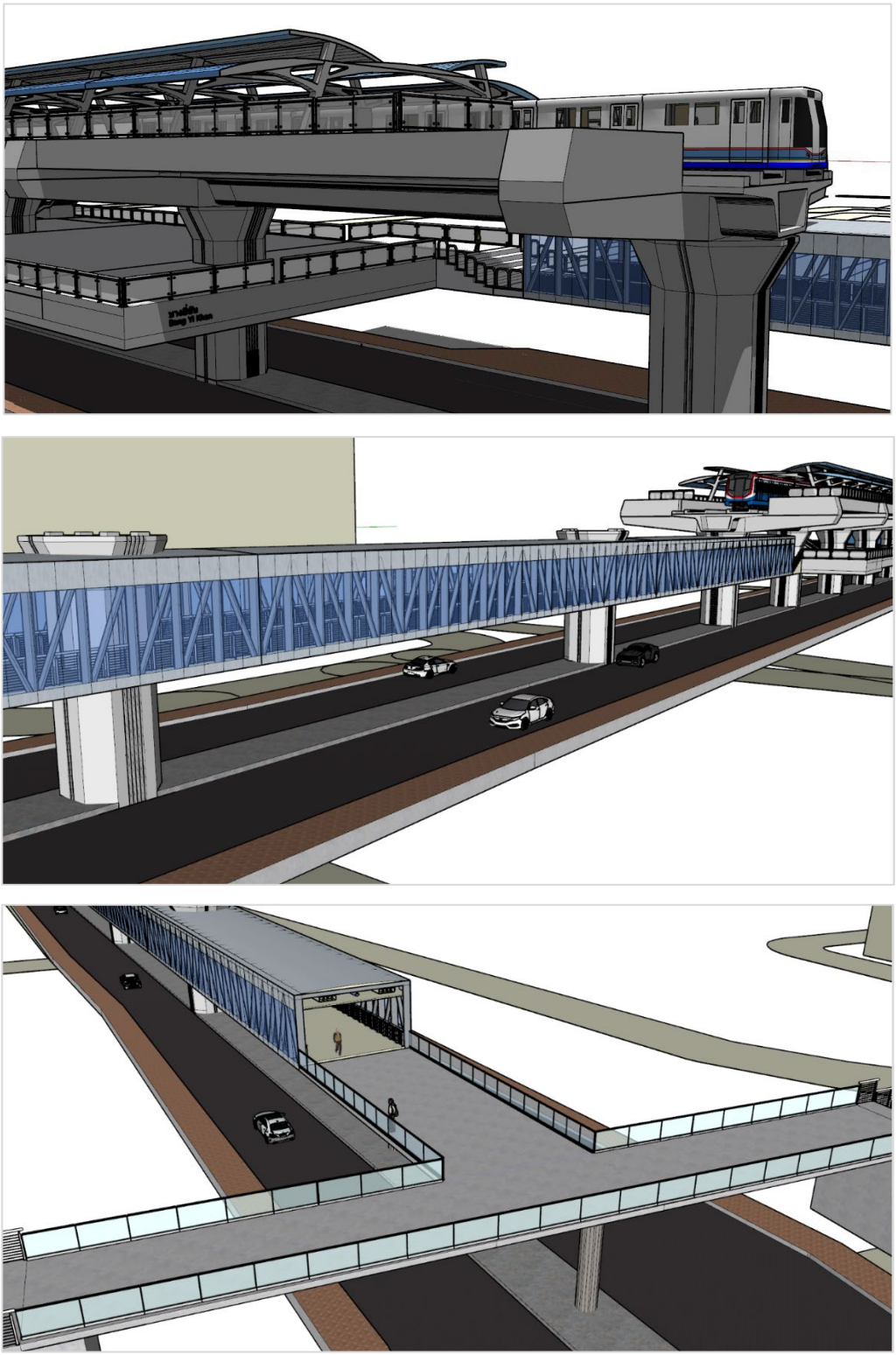


Figure 5.6 Elevated Walkway

5.1.2 TOD policy integration

Based on Transit Oriented Development, previous research shows that the combination of raised density, mixed land use, street connectivity, and walkability improvements reduces automobile travel and increases both non-motorized and public transport travel. Since walking is the most natural, healthy, clean, cheap, and inclusive mode of transport, walking is the foundation for sustainable and equitable access and mobility in a city. Recognize it as the primary mode of travel is essential to the success of TOD policy. On the other hand, walking can also be the most enjoyable, safe, and affordable way of getting around, if walkways and streets are attractive, vibrant, secure, uninterrupted, well protected from road traffic. Moreover, walking will be more pleasant if shop vendors and services are available along the route. Complete walkways and crossings must fully support all users in compliance with locally applicable or international standards. Unfortunately, walkway has not been officially developed and tightly integrated with the railway development in Thailand. This study foresees an urgent need of a walkway or street design guideline and strongly recommends for further study.

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