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Bangsar South, Kuala Lumpur, Malaysia
21 - 23 February 2017

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The Development of a Spatial Walkability Index Model for Transit Stations based on the Integration of Analytical Network Process (ANP) and GIS

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BACKGROUND

- Transit has becoming one of the key components in enhancing a city's liveability
- Development of transit should always consider how walkable the station is from the demand – every transit trip began with walking (First/last mile)
- Walkability Index had been developed in many cities around the world
  - Survey-based – people's perceptions/preferences/experiences
  - Environmental audits – using GIS spatial analysis
  - WalkScore, Green Score, Transit Accessibility Index etc
- Study will integrate the survey-based study and spatial analysis to develop a walkability index

Walking as First/Last Mile Transit Journey

- London 5C's good walking practice
- Stockholm's City Plan of a more entertaining and livelier walking path
- The presence of built environments along the walking corridor around the transit stations improve the quality of transit services (Jiang et al. 2012; Wey et al. 2016; Din et al. 2016; Todd et al. 2016; Ha et al. 2011)

The Concept of Walkability

- Definition – The comfort level of the pedestrian environment.
- Criteria to measure (TFL, 2005):
  a) **Connectivity** – the footpath should be linked, interfaced, joined, attached and networked
  b) **Convenience** – the footpath is appropriate, useful, proper, suitable and time-saving
  c) **Comfort** – travelling using footpath is easy, pleasant, protected, relaxed, sheltered and untroubled
  d) **Conviviality** – it should promotes entertaining, lively, pleasant and sociable journey
  e) **Conspicuous** – the footpath should be obvious, clear, discernible, distinct and perceptiblE

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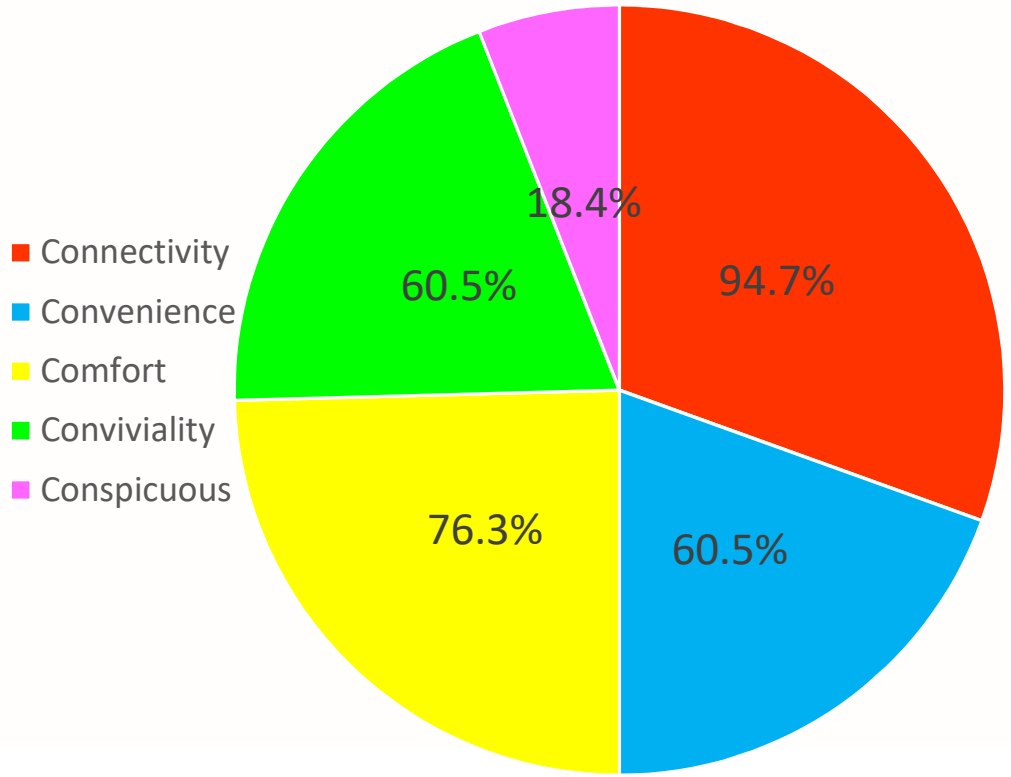
TFL's 5Cs in Previous Literatures

Author	Occurrence of the Criteria				
	Connectivity	Convenience	Comfort	Conviviality	Conspicuous
Adkins et al (2012)					
Arlie et al (2012)					
Aziah et al (2013)					
Bachok et al (2004)					
Bahari et all (2012)					
Blečič et al (2014)					
Cheshmehzangi (2015)					
Choi et al (2013)					
Erisskon et al (2012)					
Eunji et. Al (2011)					
Ewing & Handy (2009)					
Fang et al (2012)					
Foda & Osman (2010)					
Forsyth & Southworth (2008)					
Hansen et al (2009)					
Kim et al					
Lee & Talen (2014)					
Lopez-bernal (2013)					
Mehta (2008)					
Mehta (2009)					
Moayedi et al (2013)					
Mohd Shariff & Shah (2008)					
Morar et al (2014)					
Park et al (2015)					
Rahimiashtiani & Ujang (2013)					
Raja Ariffin & Zahari (2013)					
Rio (2009)					
Samantha et al (2013)					
Schlossberg & Brown (2003)					
Shamsudin et al (2013)					
Shojaei & Mustafa Kamal (2012)					
Sooil et al (2013)					
Talen (2002)					
Ujang & Muslim (2014)					
Wan Omar et al (2011)					
Wey & Chiu (2013)					
Zakaria & Ujang (2014)					
Zaki et al (2010)					



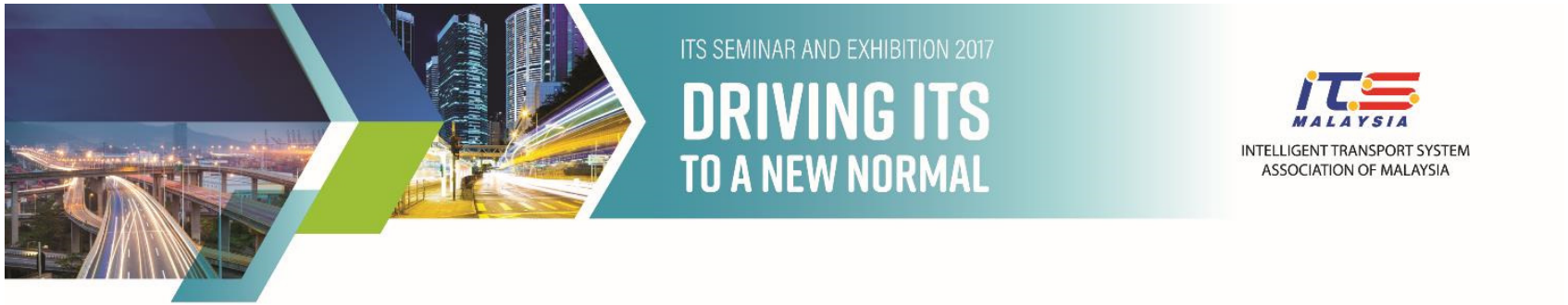
Dependencies between the Walkability Criteria

Author	How Walkable Criteria Depend on each other
Park et al (2015)	Aside from walking purposes, walking distance can be affected by the sidewalk amenities, traffic impact, proximity to the footpath and landscaping elements.
Ha et al (2011)	Crossings, traffic lights and separation from the motorways depend on each other to ensure the safety of a walking route.
Petella (2009)	Risky area affecting the walking behaviour of a person where other safer route to walk on will be chosen instead though it might took a longer time to reach a destination.
Joseph Ackerson (2005)	Street network design affecting the walking distance. For example, cul-de-sac that aims to make u-turn easily for a car, has a different impact on pedestrian where he needs to take a longer time to cross a more wider road than the normal one. This study also highlighted the safety at crossings, proximity to motorway will affect the walking time and distance.

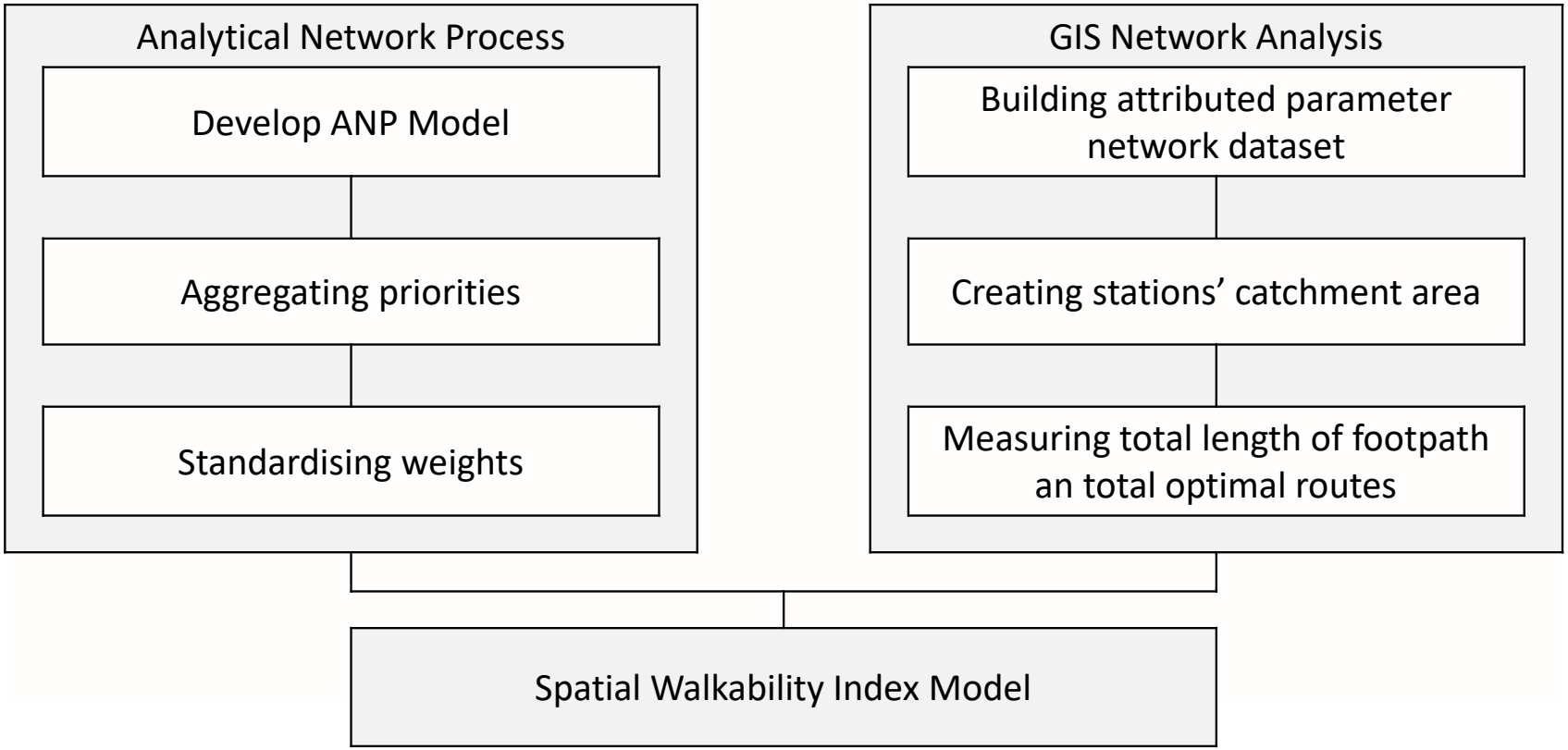
Problems?

1) Only a few studies include clarity and familiarity of pedestrian walkway.

2) Some of the criteria depends on each other. i.e. waiting time at traffic lights and taking a detour to avoid risky/threatening area will affect the overall travelling time.

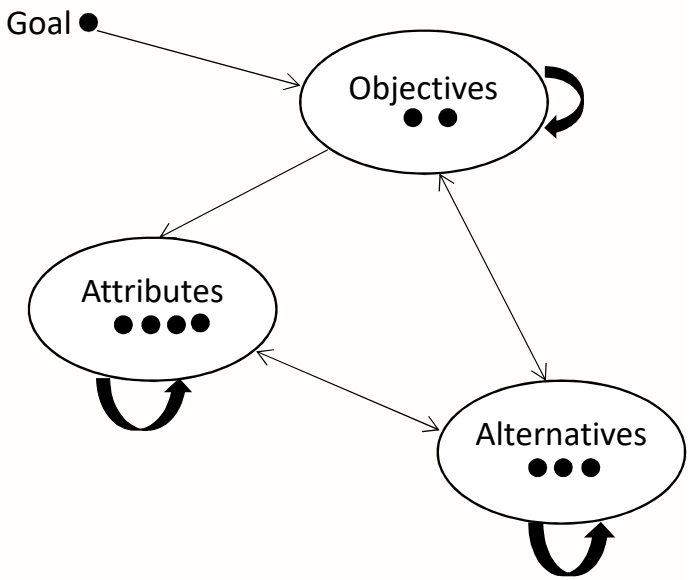


Framework of the Spatial Walkability Index Model



MCDA - Analytical Network Process

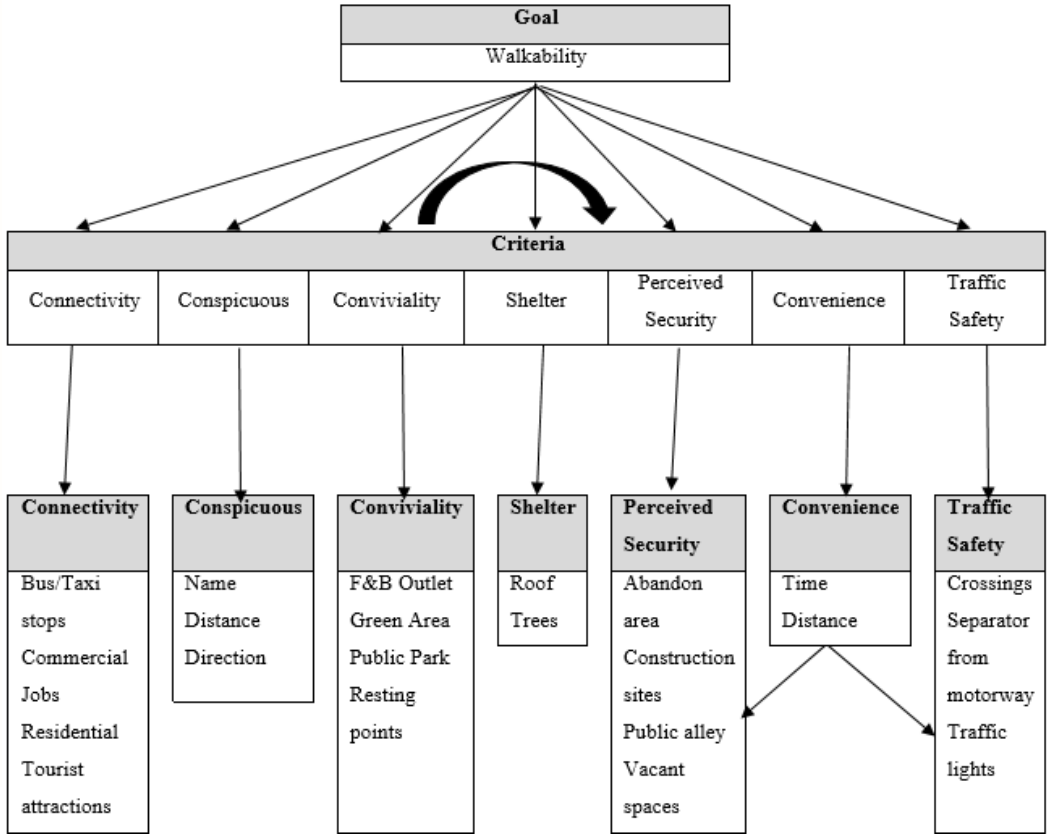
- Pairwise comparison method to derive priorities (Saaty, 2012)
- Represent by network with clusters containing nodes and connected by links signify its dependency
- Does not has top-bottom hierarchy
- Allow interdependencies between criteria



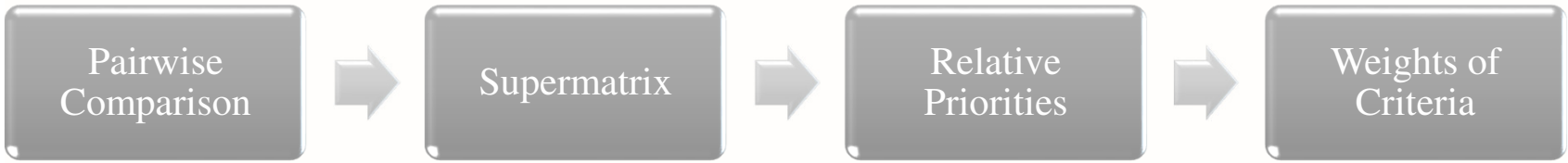
ANP in Previous Walkability Studies

Author	Aim and Purposes of Study
Ha et al (2011)	- In Seoul - Used 6 parameters - intersection safety, traffic safety, street design, land use mix, perceived safety and local integration. - Intersection safety and traffic safety depend on each other - Prioritise each parameters then scored each route having the parameters based on their priorities
Kim et al (2011)	The study is the extension of Ha et al (2011) but focuses on the mobility, safety and comfort.
Wey & Chiu (2013)	- In Taipei – for MRT stations - Assess public's preferences on government's technical requirements in footpath planning - Each requirements depends on each other - Final output is rank of criteria preferred by the citizens

ANP Decision Model



How ANP Prioritise Criteria?



- Using software Superdecision to process the rating from pairwise comparison to derive the priorities for the criteria
- The priorities will be synthesised by using supermatrix –
  1. Unweighted supermatrix: a 2D matrix reflecting dependencies between the clusters (questionnaire values)
  2. Weighted supermatrix: Product of the unweighted supermatrix with cluster matrix containing the eigenvectors of the supermatrix
  3. Limit matrix: Values of weighted supermatrix are raised which are then normalised
- The normalised values form the weightage of the criteria

GIS Roles in Developing the SWIM

- Infamous to be used for display purposes – create map
- Can be a great platform for analysing and modelling walkability
  - Is very good in manipulating data for spatial analysis and modelling purposes
  - Capable in analysing walkability through its network analyst (shortest path, catchment area, etc)
- Previous studies:-
  - Transit stops catchment area by using network analyst service area analysis in Alexandria
  - Used intersection density, land use diversity, jobs area density, etc

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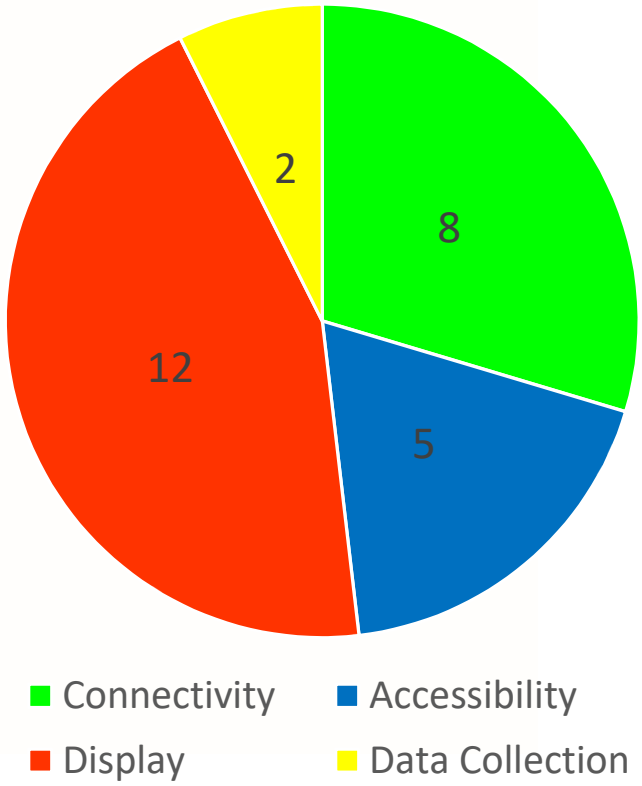
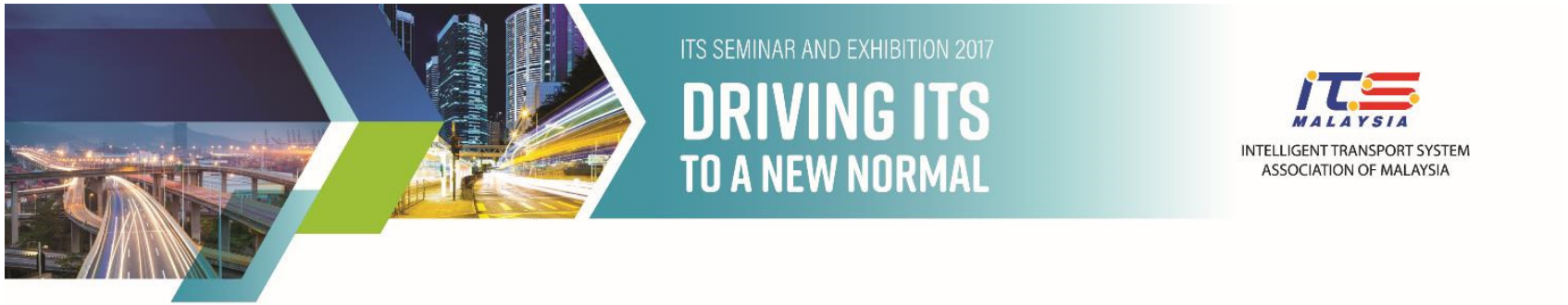
GIS in Previous Walkability Studies

Author	Connectivity	Accessibility	Display	Data Collection
Ballester et al (2011)				
Blecic et al (2015)				
Cubukcu et al (2015)				
Foda & Osman (2011)				
Ha et al (2011)				
Lee & Talen (2014)				
Lee et al (2013)				
Leslie et al (2007)				
Morar et al (2014)				
Murekatete & Bizimana (2015)				
Park et al (2015)				
Reyer et al (2014)				
Schlossberg et al (2007)				
Stockton et al (2016)				
Wey (2014)				
Zaki et al (2010)				





Spatial Analysis to Develop Walkability Index

Modelling the impendence distance between the station and possible demand

1. Determine the catchment area of the stations
2. Measure the total length of footpath in catchment area.
3. Measure the total length of routes chosen by the analyst in each catchment area – will be the routes having the preferred parameters and avoiding any risky area.

$$\textbf{Spatial Walkability Index} = \frac{\textbf{Total Length of Chosen Routes in Catchment Area}}{\textbf{Total Length of Footpath in Catchment Area}} \times 100$$

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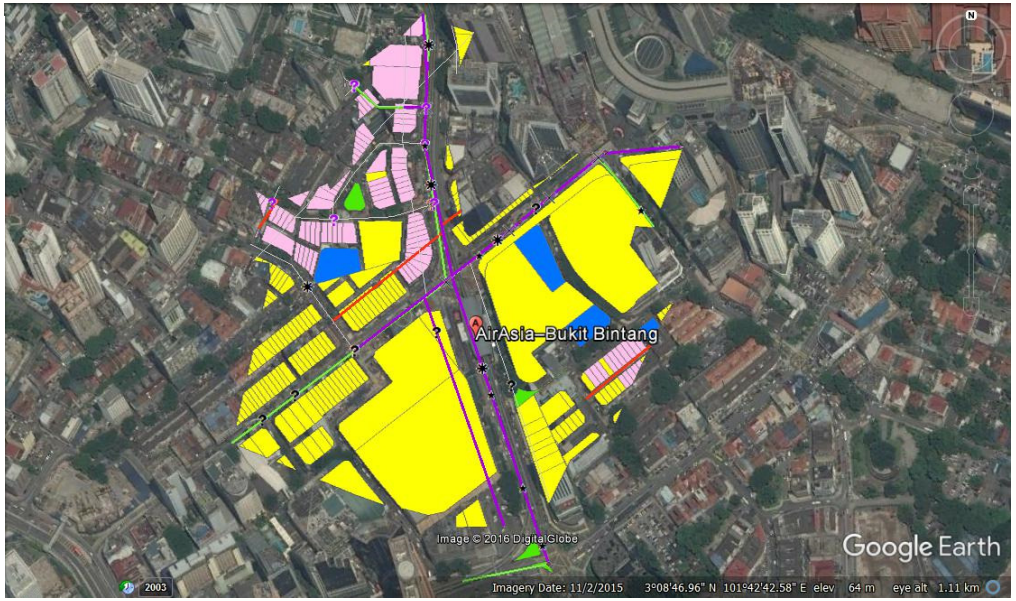
Pilot Bukit Bintang

Legend

- Crossings
- F&B Vendor
- Resting Point
- Signage-direction
- Signage-distance
- Signage-name
- Traffic light
- Alley
- Separator
- Trees
- Commercial Area
- Jobs
- Public Parks
- Residential Area
- construction site
- Vacant Space



Total Length of Footpath in Catchment Area (m)	7856.375795
Total Length of Optimal Routes in Catchment Area (m)	5064.213933
Spatial Walkability Index (%)	64.45992

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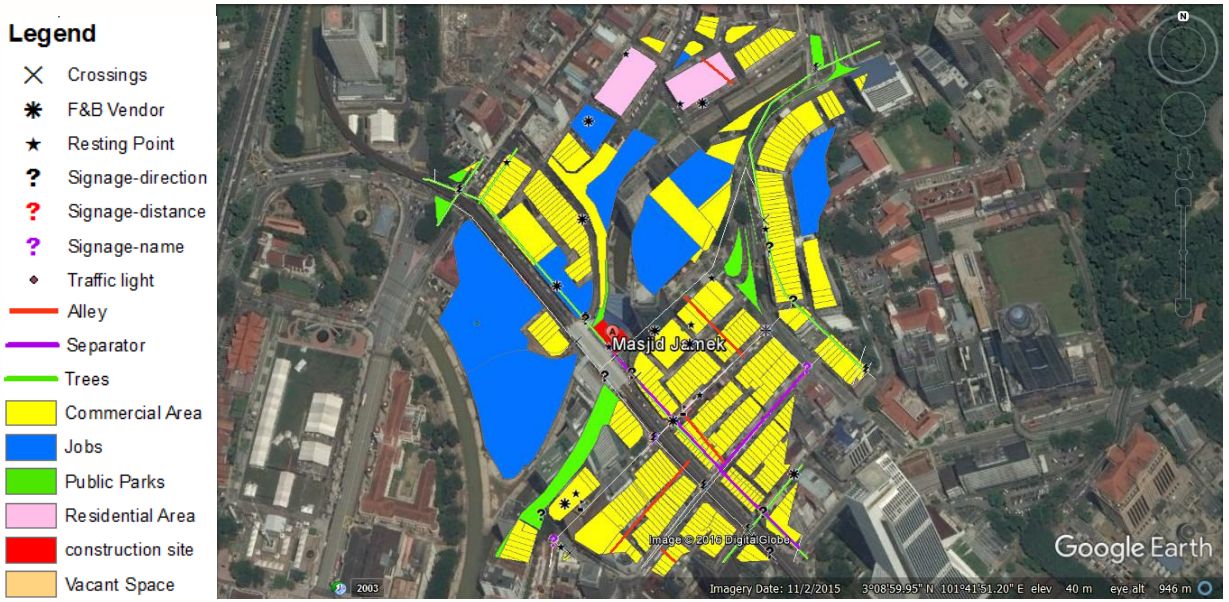
Pilot Masjid Jamek



Total Length of Footpath in Catchment Area (m)	11755.05539
Total Length of Optimal Routes in Catchment Area (m)	7684.939179
Spatial Walkability Index (%)	65.37561

Conclusion

- The index will reflect how walkable the stations are
- The stations will be ranked from the most to the least walkable station
- The index will aid in identifying whether the station complement the TOD concept of walkability
- It can also be used as a reference for future development of the transit station for other cities having similar demographic as the study area

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Thank You