The study of connectivity at Jalan Slamet Riyadi, Surakarta using the space syntax analysis

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Abstract. Jalan (street) Slamet Riyadi in Surakarta has a pedestrian lane called City Walk located at the centre point of the city. Having been a decade, this pedestrian lane, however, is rarely used. The lack of connectivity may become the reason why it is abandoned. Connectivity is one of the important aspects in sustainable development. This research aims to understand the connectivity at Jalan Slamet Riyadi using the Space Syntax as the analytical instrument. The research procedures employed were (1) creating axial maps by using the Open Street Map (OSM) as the data source, (2) arranging outputs with the field observation, and (3) interpreting the street connectivity using the space syntax analysis with Depthmapx program. The findings obtained from Depthmapx indicate that Jalan Slamet Riyadi has high connectivity and is tremendously integrated. These findings indicate there may be other elements, beside connectivity, able to make the city walk more utilized; and these elements are the availability of supporting facilities and the proximity of the housing area to the activity centre. In conclusion, the research findings can be furthermore included in the policymaking related to the Surakarta City future urban planning that aims to improve connectivity and to achieve sustainable city development.

1. Introduction
The pedestrian lane is one of the most important aspects for city planning. The pedestrian walk development criteria have been issued by the numerous countries, such as New Zealand, Australia, India, US, and South Africa [1-5]. Unfortunately, Indonesia has not had the criteria of pedestrian walk development. Nowadays, the authorities in various cities have been aware about the pedestrians, including the Surakarta Municipality. The municipality started to develop a pedestrian lane along with the main street in 2007 called City Walk Slamet Riyadi. Built more than decade ago, the city walk, however, is but not optimally utilized yet [6], and the lack of connectivity may become the main reason.

Connectivity is one of the crucial aspects characterising complex networks and having ability to make and control connections within two or more points in the spatial structure [7]. Connectivity measures the dimensions by calculating the quantity of spaces directly interconnected in a layout space [7-9]. The quantity of space is measured by referring the concept of distance named ‘depth’. Measurement of connectivity is performed to find the degree of interaction among spaces located nearby.
Space Syntax is one of the methods to measure street connectivity. Space Syntax considers connectivity as the main idea of its thinking [10]. Space Syntax is a method to represent and quantify the spatial layout of streets in the urban spaces, using the topological approach, then creating relations for understanding those spatial layouts impacts on people’s movement [8,11,12]. Space Syntax was developed by the researchers to explain social behaviour by using measurement, and some of the most crucial aspects are connectivity and integration [13]. Integration measures how integrated (or central) the street to a network [14]. Within the Space Syntax concept, streets can be represented as the axial lines, conforming to the straight lines of sight, whose topological relations form the basis of an extensive set of indicators [10].

Space syntax methods have been used as the indicator of street connectivity in neighbourhood research [15]. Positive correlation between the degree of street integration and pedestrian volume have found in the previous researches [16-17]. Streets which can be accessed easily from different lanes means integrated, which will attract more pedestrians [18]. High connectivity represents lot of people use the street. Network connectivity measures accessibility and availability of the direct routes to destinations [19]. The Space Syntax methods provide substantial understanding about the relation between environment characteristics and pedestrian quantities, and, in addition, positive and significant relation between the network connectivity and the pedestrian activity have been proved [9,17,20].

Street connectivity crucial to encourage utilization of the pedestrian - especially for the walking activities [21]. The higher degree of street connectivity is consistently associated with the higher quantity of walking activities [13,14]. Street connectivity measured network connections density and paths directness. Better connectivity leads to shorter paths between the origin and destination, decreases travel distances and creates efficiency in time [19]. Connectivity is one of the critical aspects in sustainable cities [4,19,22-24]. Sustainable street network creates more efficient and more safe environment as well as creates more various choice of transportation modes and routes [19].

This paper discusses the connectivity in Jalan Slamet Riyadi to improve the urban sustainability. Analysis was conducted using DepthmapX software (Space Syntax). The maps used in the software were obtained from Open Street Map (OSM), redrawn by AutoCad to generate axial maps. DepthmapX software analysed the axial maps to produce the connectivity and integration based on the Space Syntax. This paper aims to explain connectivity in Jalan Slamet Riyadi and to identify the degree of the network connectivity existing there.

2. Research method
The maps used for analysis consist of the Jalan Slamet Riyadi, including 100 M surrounding area. The maps data were obtained from the Open Street Maps/OSM (See Figure 1). OSM was created by Steve Coast in 2004 as the collaborative project to create world map that can be edited for free and publicly available [25]. The study about connectivity and using data from OSM already conducted by some researchers previously [26-28].

Figure 1. The layout of open street maps
Figure 2. The layout of DepthmapX
The axial maps for the analysis were developed by taking accurate maps and drawing a set of intersecting lines through all the spaces between buildings, in order to identify connection and the circulation between the area [29]. The next steps were matching axial maps with the field observations, redrawing them by Autocad software and making adjustment, so they can be input in the spatial analysis software, DepthmapX (see Figure 2 and 3). It is an open source spatial analysis software (using Space Syntax) for spatial networks on different scales [30].

![Figure 3. The actual maps of research observations (up) and its axial maps (bottom). The research location is shown by the yellow rectangle.](image)

3. Result and discussion
The analysis conducted using DepthmapX is for axial analysis focusing on connectivity and integration. Connectivity measures the number of streets connected each other with Jalan Slamet Riyadi and measures the degree of integration in Jalan Slamet Riyadi to the network.

The axial analysis calculates global integration measurements based on the maps (as a whole). The default ‘n’ will measure to all reachable lines [31]. Radii used in axial analysis were ‘n, 2, 3, 5, 7’. Mostly, radius 2 was used for calculating local depth in walkable urban regions while Radius 5 and 7 were used more to observe vehicular movement on a global level.
Figure 4. Connectivity in axial analysis

Table 1. Streets connectivity values in the axial analysis

| Street Number | Street Name            | Connectivity Value |
|---------------|------------------------|--------------------|
| 1.            | Slamet Riyadi          | 82                 |
| 2.            | Transito               | 12                 |
| 3.            | Agus Salim            | 7                  |
| 4.            | Kusumoyudan           | 4                  |
| 5.            | Parangliris VI        | 5                  |
| 6.            | Parangliris IV        | 5                  |
| 7.            | Perintis              | 24                 |
| 8.            | Sido Asih Barat       | 2                  |
| 9.            | Satrio Wibowo Barat   | 4                  |
| 10.           | Nogososro             | 2                  |
| 11.           | Tri Busono            | 3                  |
| 12.           | Dr. Wahidin           | 6                  |
| 13.           | Sutowijoyo            | 4                  |
| 14.           | Nawang Wulan          | 2                  |
| 15.           | Bhayangkara           | 8                  |
| 16.           | Museum                | 3                  |
| 17.           | Honggowongso          | 8                  |
| 18.           | Gambir Anom           | 3                  |
| 19.           | Karonsih              | 3                  |
| 20.           | Gatot Subroto         | 11                 |
| 21.           | Jawa 13               | 3                  |
| 22.           | Yos Sudarso           | 13                 |
| 23.           | Trisula               | 4                  |
| 24.           | Wijaya Kusuma         | 8                  |
| 25.           | K. H. Hasyim Ashari   | 7                  |
| 26.           | Kalimosodo            | 3                  |
| 27.           | Pakoe Boewono         | 6                  |

| Street Number | Street Name            | Connectivity Value |
|---------------|------------------------|--------------------|
| 28.           | Jend. Sudirman         | 6                  |
| 29.           | Imam Bonjol            | 9                  |
| 30.           | Banda                  | 5                  |
| 31.           | K.H. Ahmad Dahlan      | 6                  |
| 32.           | Teuku Umar             | 9                  |
| 33.           | Diponegoro             | 20                 |
| 34.           | Raja                   | 2                  |
| 35.           | Kartini                | 6                  |
| 36.           | Jawa IV                | 3                  |
| 37.           | Gajahmada              | 8                  |
| 38.           | Prof. DR. Supomo       | 8                  |
| 39.           | Cipto Mangunkusumo     | 10                 |
| 40.           | Sutomo                 | 8                  |
| 41.           | Kalitan                | 3                  |
| 42.           | dr. Moewardi           | 14                 |
| 43.           | Teratai                | 3                  |
| 44.           | Melati                 | 8                  |
| 45.           | Menur                  | 4                  |
| 46.           | Hasanudin              | 24                 |
| 47.           | Kemuning               | 3                  |
| 48.           | Kemuning 1             | 2                  |
| 49.           | Dr. Radjiman           | 10                 |
| 49.1          |                       | 20                 |
| 50.           | Ronggowarsito          | 22                 |
| 51.           | Yosodipuro             | 14                 |
| 52.           | Parang Kesit           | 23                 |

The research findings show Jalan Slamet Riyadi has high connectivity indicated by red colour line (see Figure 4) with 82 as the value. It means Jalan Slamet Riyadi has the highest street users among the other streets. The lowest values, on the other hand, are at Jalan (street) Sido Asih Barat, Nogososro, Raja
and Kemuning 1 where all of these streets only score 2 (see Table 1). The table of numbered streets surrounding Jalan Slamet Riyadi (limited to connected directly to Jalan Slamet Riyadi) and their connectivity values are shown in Table 1.

The second result is integration. Integration is the model of potential destinations in the system. The streets are ranked from the most integrated to the most segregated [13] indicated two colourful lines; the red lines for the integrated streets and the blue lines for segregated streets (see Figure 5). Generally, integration shows how many people are possibly to be in a certain space, and it is considered according to the level of social gatherings and retail activities [32].

The most integrated street is Jalan Slamet Riyadi shown values 3.18 point and the most segregated street, with only 1.43 points, is Gambir Anom (see Table 2). This result tells that Jalan Slamet Riyadi involves the most social and retail activities among the others, and it also implies that there are more street users on this street. The numbered streets surrounding the Slamet Riyadi Street (the ones connected directly to Jalan Slamet Riyadi and their integration values are shown in Table 2.

The finding concludes that Jalan Slamet Riyadi has the highest connectivity and integration values. These facts explain that this street has the biggest number of street users. Jalan Slamet Riyadi consist of several potential conjunction points [33], which means that the number of motor vehicles passing this street is considerably high. This street, in addition, is located in the middle of the city as the busiest economic centre [34-35]. Thus, the research results are matched with the actual situation.

![Figure 5. Integration in the axial analysis](image)

![Figure 6. Contrast differences in density of motorized users and pedestrians in Jalan Slamet Riyadi.](image)

![Figure 7. Several cars and none of pedestrians on Jalan Slamet Riyadi Streets are seen from above.](image)
Table 2. Streets integration values in the axial analysis

| Street Number | Street Name       | Integration Value |
|---------------|-------------------|-------------------|
| 1             | Slamet Riyadi     | 3.18              |
| 2             | Transito          | 2.43              |
| 3             | Agus Salim        | 2.37              |
| 4             | Kusumoyudan       | 2.27              |
| 5             | Parangliris VI    | 2.34              |
| 6             | Parangliris IV    | 2.27              |
| 7             | Perintis Kemerdekaan | 2.47       |
| 8             | Sido Asih Barat   | 2.23              |
| 9             | Satrio Wibowo Barat | 2.27            |
| 10            | Nogososro         | 1.46              |
| 11            | Tri Busono        | 2.26              |
| 12            | Dr. Wahidin       | 2.32              |
| 13            | Sutowijoyo        | 2.27              |
| 14            | Nawang Wulan      | 2.23              |
| 15            | Bhayangkara       | 2.30              |
| 16            | Museum            | 2.24              |
| 17            | Honggowongso      | 2.31              |
| 18            | Gambir Anom       | 1.43              |
| 19            | Karonsih          | 2.24              |
| 20            | Gatot Subroto     | 2.33              |
| 21            | Jawa 13           | 2.23              |
| 22            | Yos Sudarso       | 2.31              |
| 23            | Trisula           | 2.23              |
| 24            | Wijaya Kusuma     | 2.29              |
| 25            | K. H. Hasyim Ashari | 2.28          |
| 26            | Kalimosodo        | 2.23              |
| 27            | Pakoe Boewono     | 2.40              |

| Street Number | Street Name       | Integration Value |
|---------------|-------------------|-------------------|
| 28            | Jend. Sudirman    | 2.40              |
| 29            | Imam Bonjol       | 2.32              |
| 30            | Banda             | 2.30              |
| 31            | K.H. Ahmad Dahlan | 2.29              |
| 32            | Teuku Umar        | 2.29              |
| 33            | Diponegoro        | 2.33              |
| 34            | Raja              | 2.23              |
| 35            | Kartini           | 2.29              |
| 36            | Jawa IV           | 2.23              |
| 37            | Gajahmada         | 2.31              |
| 38            | Prof. DR. Supomo  | 2.29              |
| 39            | Cipto Mangunkusumo| 2.25              |
| 40            | Sutomo            | 2.25              |
| 41            | Kalitan           | 2.23              |
| 42            | dr. Moewardi      | 2.31              |
| 43            | Teratai           | 2.23              |
| 44            | Melati            | 2.26              |
| 45            | Menur             | 2.27              |
| 46            | Hasanudin         | 2.47              |
| 47            | Kemuning          | 2.23              |
| 48            | Kemuning I        | 2.23              |
| 49            | Dr. Radjiman      | 1.86              |
| 49.1          |                  | 1.88              |
| 50            | Ronggowsatiso     | 1.93              |
| 51            | Yosodipuro        | 1.85              |
| 52            | Parang Kesit      | 2.00              |

However, the difference between the quantity of motorized user and pedestrians has been found (see figure 6), the left line shows motor vehicles and the right line shows the pedestrians. According to previous studies, Jalan Slamet Riyadi can be categorized as good and comfortable street and this street has already connected the city activities in the scale of pedestrians [34,36-37]. In connection with Jalan Slamet Riyadi, mobility can be categorized as good, comfortable, and accessible to urban activities [34,36-37]. The intersections in this street has low accident rates [38], but the accessibility of the streets still needs improvement [34]. Those factors seem not enough to draw pedestrians. Therefore, this study did not give clear answer about why the pedestrian not optimally utilized yet.

There are several possibilities, first, the absence of pedestrian attractors and pedestrian generators such as residential, commercial, office, recreational places or any other land use that serves as the starting or destination point for pedestrian trip during a particular time at Jalan Slamet Riyadi. Pedestrian generators and attractors play important role in supporting walkability, one of important parts of sustainable cities [39-40]. Secondy, that this neighbourhood is not a mix land use while Cervero [41] and Frank [42] studies indicate that increasing levels of mix land use at the trip origins and destinations escalates walking activities, and the third possibility is the lack of amenities, such as food sellers. The previous study suggests that the presence of street food sellers and food trucks can attract pedestrians [43-44]. Lastly, Tim Althoff research states thatIndonesian is the population with the lowest number of people who walk [45]. There is difficulty in conducting this study, namely the limitation in drawing
maps; so it could affect the result and may vary based on the width of maps. The extensive maps of a city could produce better axial analysis, but OSM did not offer axial data map about Surakarta City; perhaps it is due to of the lack of contributors. Therefore, the authors need to redraw all the maps for this study, and that is why the result may be a bit different though it does not change the overall result.

4. Conclusion
The result shows Jalan Slamet Riyadi has high level of connectivity and integration. The result was consistent with the number of street users though not with the number of pedestrians. The lack of pedestrian generators and attractors near that area, the less varied land use function, and the less street amenities might be the causes of this condition. These findings can be an important step for the future researches.

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References
[1] SMEC 2014 NMT facility guidelines Available at http://cocreatesa.nl/wp-content/uploads/2016/09/NMT-Facility-Guidelines.pdf Accessed 25-12-2018
[2] N Z Transport Agency 2009 Pedestrian planning and design guide Available at https://www.nzta.govt.nz/resources/pedestrian-planning-guide/ Accessed 25-12-2018
[3] Western Australia Department of Transport011 Planning and designing for pedestrians: guidelines Available at https://www.transport.wa.gov.au/mediaFiles/active-transport/AT_WALK_P_plan_design_pedestrians_guidelines.pdf Accessed 25-12-2018
[4] Indian Roads Congress 2012 Guidelines for pedestrian facilities Available at https://go.itdp.org/download/attachments/60296563/IRC%202012%20%28Guidelines%20For%20Pedestrian%20Facilities%29.pdf?api=v2 Accessed 25-12-2018
[5] Office of Transportation 1998 Portland pedestrian design guide Available at https://www.portlandoregon.gov/transportation/article/84048 Accessed 25-12-2018
[6] Wardhani I S 2018 Malam hari ala malioboro di citywalk Slamet Riyadi Solo, kenapa tidak? Available at https://soloraya.solopos.com/read/20181203/489/956539/malam-hari-ala-malioboro-di-citywalk-sl amet-riyadi-solo-kenapa-tidak Accessed 10-07-2019
[7] Bafna S 2003 Space syntax: a brief introduction to its logic and analytical techniques Environ. Behav. 35 17-29 DOI: 10.1177/0013916502238863
[8] Hillier B, Hanson J and Graham H 1987 Ideas are in things: an application of the space syntax method to discovering house genotypes Environ. Plan. B Plan. Des. 14 363-85 DOI: 10.1068/b140363
[9] Hillier B, Penn A, Hanson J, Grajewski T and Xu J 1993 Natural movement: or, configuration and attraction in urban pedestrian Environ. Plan. B Plan. Des. 20 29-66 DOI: 10.1068/b200029
[10] Cambra P, Moura F and Goncalves A 2017 On the correlation of pedestrian flows to urban environment measures: a space syntax and walkability analysis comparison case Proceedings of the 11th Space Syntax Symposium 11th International Space Syntax Symposium Available at https://www.researchgate.net/publication/319956237 Accessed 25-12-2018
[11] Hillier B and Hanson J 1984 The social logic of space (Cambridge: Cambridge University Press)
[12] Koohsari M J, Owen N, Cerin E, Giles-Corti B and Sugiyama T 2016 Walkability and walking for transport: characterizing the built environment using space syntax Int. J. Behav. Nutr. Phys. Act. 13 DOI: 10.1186/s12966-016-0448-9
[13] Al-Sayed K 2014 Space syntax methodology (London, UK: Bartlett School of Architecture, UCL)
[14] Emo B 2017 Space syntax · Depthmap · Network Analysis tutorial Available at https://ethz.ch/content/dam/ethz/special-interest/gess/cognitive-science-dam/images/COG%20Teaching/Tutorial/15MAY%20Depthmap%20network%20analysis%20tutorial.pdf Accessed 7-10-2019

[15] Baran P K, Rodriguez D A and Khattak A J 2008 Space syntax and walking in a new urbanist and suburban neighbourhoods J. Urban Des. 13 5-28 DOI: 10.1080/13574800701803498

[16] Lerman Y, Rofè Y and Omer I 2014 Using space syntax to model pedestrian movement in urban transportation planning Geogr. Anal. 46 392–410 DOI: 10.1111/gean.12063

[17] Hajrasouliha A and Yin L 2014 The impact of street network connectivity on pedestrian volume Urban Stud. 52 2483-97 DOI: 10.1080/00420980.2014.944763

[18] Koohsari M J, Oka K, Owen N and Sugiyama T 2019 Natural movement: A space syntax theory linking urban form and function with walking for transport Health Place 58 DOI: 10.1016/j.healthplace.2019.01.002

[19] Zlatkovic M, Zlatkovic S, Sullivan T, Bjornstad J and Kiavash Fayyaz Shahandashti S 2019 Assessment of effects of street connectivity on traffic performance and sustainability within communities and neighborhoods through traffic simulation Sustain. Cities Soc. 46 DOI: 10.1016/j.scs.2018.12.037

[20] Hillier B and Iida S 2005 Network and psychological effects in urban movement Spatial Information Theory Lecture Notes in Computer Science ed A G Cohn and D M Mark (Springer Berlin Heidelberg) 475–90 DOI: 10.1007/11556114_30

[21] Gilmour H 2007 Physically active Canadians Health Rep. 18 45-65 Available at https://www.ncbi.nlm.nih.gov/pubmed/17892251 Accessed 25-12-2018

[22] Greenberg E 2009 Sustainable streets: An emerging practice APA Planning Advisory Service Report 78 73-84 Available at https://www.researchgate.net/publication/289784373_Sustainable_streets_An_essential_emerging_practice_Accessed 25-12-2018

[23] Porta S and Renne J L 2005 Linking urban design to sustainability: formal indicators of social urban sustainability field research in Perth, Western Australia URBAN Des. Int. 10 51-64 DOI: 10.1057/palgrave.udi.9000136

[24] Randall T A and Baetz B W 2001 Evaluating pedestrian connectivity for suburban sustainability J. Urban Plan. Dev. 127 Available at https://ascelibrary.org/doi/10.1061/%28ASCE%290733-9488%282001%29127%3A1%281%29 DOI: 10.1061/ASCE%200733-9488-28001%29127%3A1%281%29 Accessed 25-12-2018

[25] Ramm F, Topf J and Chilton S 2010 OpenStreetMap: Using and Enhancing the Free Map of the World (UIT Cambridge)

[26] Blečić I, Cacchini A, Congiu T, Fancello G and Trunfio G A 2015 Evaluating walkability: a capability-wise planning and design support system Int. J. Geogr. Inf. Sci. 29 1350-74 DOI: 10.1080/13658816.2015.1026824

[27] Dunn A, Hanson B and Seeger C J 2018 Evaluating Walkability in the Age of Open Data: OpenStreetMap and Community-level Transportation Analysis J. Digit. Landsc. Archit. 119-29 Available at https://gispoint.de/fileadmin/user_upload/paper_gis_open/DLA_2018/537642013.pdf Accessed 10-07-2019

[28] Lu X 2017 The Development and Deployment of Walkability Assessment Models for Built Environments (Aalto University School of Engineering Department of Built Environment)

[29] UCL Space Syntax 2019 Axial map Space Syntax_Online Training Platform Available at http://otp.spacesyntax.net/term/axial-map/ Accessed 15-8-2019

[30] UCL 2016 depthmapX: visual and spatial network analysis software Bartlett Sch. Archit. Available at https://www.ucl.ac.uk/bartlett/architecture/research/space-syntax/depthmapx Accessed 15-8-2019
[31] Turner A 2004 Depthmap 4, A researcher’s handbook depthmapX Available at http://varoudis.github.io/depthmapX/ Accessed 5-9-2019

[32] Hillier B 1996 Cities as movement economies Urban Des. Int. 1 41–60 Available at https://discovery.ucl.ac.uk/id/eprint/1403/1/Hillier_Cities%20as%20movement%20economies.pdf Accessed 15-8-2019

[33] Rudyatmo H 2018 Informasi kinerja pengelolaan lingkungan hidup daerah tahun 2018 (Surakarta: Dinas Lingkungan Hidup Kota Surakarta Provinsi Jawa Tengah)

[34] Harsono K, Arsandrie Y and Setiawan W 2015 Identifikasi kenyamanan pejalan kaki di city walk Jalan Slamet Riyadi Surakarta Sinektika J. Arsit. 13 33-42-42 Available at http://journals.ums.ac.id/index.php/sinektika/article/view/703 Accessed 15-8-2019

[35] Rosyidah M, Yulianto B and Legowo S J 2017 Analisis potensi demand, ability to pay (atp) dan willingness to pay (WTP) BST Koridor 1 dengan adanya sistem contra flow di Jalan Brigjen Slamet Riyadi pada instansi pemerintah Matriks Tek. Sipil 5 Available at https://matriks.sipil.ft.uns.ac.id/index.php/MaTekSi/article/view/738 Accessed 15-8-2019

[36] Djumiko D 2013 Fungsi city walk Jalan Slamet Riyadi Kota Surakarta Tek. Sipil Dan Arsit. 13 Available at http://ejournal.utp.ac.id/index.php/ITSA/article/view/198 Accessed 15-8-2019

[37] Krisnawati E 2013 Studi keberadaan city walk terhadap fungsi peruntukan (Study kasus City Walk Jl. Slamet Riyadi Surakarta) Tek. Sipil dan Arsit. 13 Available at http://ejournal.utp.ac.id/index.php/ITSA/article/view/388 Accessed 15-8-2019

[38] Wiraguna A, Mahmudah A M and Setiono S 2017 Analisis daerah dan titik rawan kecelakaan pada ruas jalan kolektor sekunder di Kota Surakarta Matriks Tek. Sipil 5 Available at https://matriks.sipil.ft.uns.ac.id/index.php/MaTekSi/article/view/853 Accessed 15-8-2019

[39] Urbanism C for the N 2015 What is new urbanism? Available at https://www.cnu.org/resources/what-new-urbanism Accessed 23 April 2019

[40] USF L M 2015 N 56th Street Walkability Assessment (Florida) Available at https://ppms.trec.pdx.edu/media/project_files/Walkability_Assessment.pdf Accessed 15-8-2019

[41] Cervero R 1988 Land-use mixing and suburban mobility (UC Berkeley: University of California Transportation Center)

[42] Frank L D and Pivo G 1994 The Impacts of Mixed Use and Density on The Utilization of Three Modes of Travel: The Single Occupant Vehicle, Transit, and Walking. Transportation Research Record Journal of the Transportation Research Board 1466 44-52 Available at https://www.researchgate.net/publication/235358160 Accessed 15-8-2019

[43] Ball J 2002 Street Vending: A Survey of Ideas and Lessons for Planner (Chicago: American Planning Association)

[44] Wessel G 2012 From Place to nonplace: a case study of social media and contemporary food trucks J. Urban Des. 17 511-31 DOI: 10.1080/13574809.2012.706362

[45] BBC Indonesia 2017 Data ponsel dunia: Orang Indonesia paling malas berjalan kaki Available at https://www.bbc.com/indonesia/majalah-40577906 Accessed 15-10-2018