Assessment of Pedestrian Walkability in the Urban Village with Urban Network Analysis

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Abstract. The quality of the urban environment is one of the important aspects to be researched in a developing country. The city of Bandung is growing and expanding beyond capacities without a city plan. This has led to the emergence of many urban villages. The growth of urban villages with lower middle economic level causes these settlements to have low environmental quality. Tamansari is one part of the urban environment that experiences this phenomenon, which is triggered by the large number of residential employees and students. The purpose of this study was to determine the environmental quality of the urban village (Kampong Tamansari) based on walkability. The method used in this research is a quantitative approach using Urban Network Analysis, a toolbox from ArcGIS that can quantitatively measure how the design of an environment affects access to spatial and amenity spaces and contributes to the flow of pedestrian movements in urban areas. From here, five types of network centrality measures will be formulated on a spatial network including Reach, Gravity Index, Betweenness, Closeness and Straightness. The results show that the Tamansari area in the south of the Pasopati Flyover is more walkable than in the northern part. The northern part is more difficult to access due to the lack of openness of the area's road network to the main roads.

Keyword: Walkability; UNA; Spasial; Network; Urban

1. Introduction
The city will continue to develop in line with the development of its socio-cultural, economic, and political life (Tallo, 2014). The concentration of the development of economic and social activities in urban areas encourages urbanization and high migration in urban areas. Often times, the fast development of cities but the slow control of the government over this area causes the city to develop without direction. One of the effects of this phenomenon is the emergence of urban villages, we usually know as “Kampong Kota”. These settlements pockets occur due to low-income groups of people, difficulty finding work, difficulty paying in installments or renting a house and lack of strict implementation of laws and regulations (Lestari, 2008). This of course affects the quality of the urban environment where most of the urban villages with the economic level of the middle to lower class communities have low quality housing and are even categorized as slums. (Aslim, 2014).

According to LPM ITB in the 1995-1998 period, the existence of identified slum pockets was 121 out of 139 urban villages in Bandung (Lestari, 2008). Meanwhile, the definition of a good city is a city
that can provide life, health, safety and sustainability to its citizens to enjoy their life. One of the factors that make up the best cities in the world is walkability concept (Spek, 2012).

Kampung Tamansari, which is located in the northern part of Bandung, a valley between Jalan Cihampelas and Jalan Tamasari, is an area affected by this problem. Previously, Tamansari was planned as a place for recreation and rest for the Dutch (Permana, 2017) (Sawira, 2018) and it was planned to be a green area close to affordable settlements and offices since the Bandung Technische Hoogeschool, namely ITB, was founded in 1920. Now Tamansari has developed into an area which is unplanned and very crowded due to the growing development of ITB so that there are facilities for student residential areas, commercial areas, culinary areas in the area. Its existence is flanked by main facilities, namely the Bandung Institute of Technology Campus, Zoo, Ciwalk Commercial Area, and Balubur Townsquare.

The Tamansari area is important because there is a network of roads around it that connects people from the main facility to the residence and between the main facilities. The residence distance to the main facility is still within a walking-friendly radius of 350 m. With this distance, the preferred means of transportation should be walking, but not a few students and workers use private vehicles to reach their destination. The development of online transportation also affects their behavior in walking. Previously, from within the area students or workers walked first to get public transportation, now public transportation can be called right in front of their house.

A city is walkable if the entire system of public space corridors is pedestrian-friendly and humans can live without depending on vehicles (Zakaria, 2015). According to Jan Gehl, a walkable city is a city that sided with humans, thinking about the aspects that are seen on a human scale. The walkability itself is not just beautifying the road corridors by adding physical aspects such as trash cans, lights, and others but is able to fulfill the aspects of usability, safety, traversable, comfort, and an attractive environment (Spek, 2012; Forsyth, 2015). Another definition is found that walkability is a measured proxy in the form of criteria and indicators that represent a pedestrian-friendly environment (Forsyth, 2015).

The purpose of this study was to determine the environmental quality of the Kampong Tamansari based on walkability. The Tamansari area is a urban village that grows organically, so there are various pedestrian alternatives that can be traversed. This road network is quite complex so it is not accurate enough to only use origin destination observations and surveys to assess the quality of the environment. Because the patterns and desires of pedestrians are difficult to predict. Therefore, the method used in this research is a quantitative approach using Urban Network Analysis (UNA). The UNA tool allows designers, planners, and transportation experts to measure accessibility and predict the flow of non-motorized movements in cities based on the individual trip resolution of existing networks.

The use of network analysis methods in the urban scope has been carried out since several decades ago, one of which is space syntax (Jiang, 2002; Porta, 2006; Crucitti, 2006). The foundation for the development of spatial measurement of netwok analysis has been found since several centuries ago but it is still considered very expensive and for small scale networks (Sevtsuk, 2012). Most of the existing spatial networks can only accommodate nodes and edges. When exclusively focusing on nodes and edges, it is difficult to interpret the results to the real urban conditions, because buildings which are important elements of a city are not included (Sevtsuk, 2012). Recently, Sevtsuk introduced a new toolbox for spatial network analysis in archGIS namely UNA which accommodates this. This method has been used in research at Cambridge and Somerville MA, in Singapore to plan retail areas in the Punggol area, and to find out pedestrian paths in the MRT plan area in Surabaya (Sevtsuk, 2018).

2. Literature Review
The literature review is devided into four parts, namely walkable city, walkability, network centrality measure, and urban network analysis.

2.1 Walkable City
Urban space as an inseparable part of the spatial structure consists of two basic forms, square and the street (Krier 1979). Good city quality requires good quality road corridors. The road as a public space,
social space, commercial space, activity space, and road corridors reflect the culture of a city (Syarlianti, 2016). Good quality roads will encourage a city to become a sustainable city (Kriken, 2010). The physical quality of urban infrastructure will affect the quality of the urban space (Martokusumo, 2013), especially for pedestrian facilities. Good facilities need to be supported by a development guide as well as an assessment guide, one of the guidelines is the concept of walkability. The walkability concept is an indicator of the feasibility of an area for pedestrians, with the hope of increasing community walking activities in the area (Setianto, 2018). A good street atmosphere will encourage more city residents to walk. Walking encourages zero carbon footprint activity and involves zero cost. This walk is not only limited to young people, but must be able to facilitate elderly residents, residents with special needs, and children.

Walking activity is basically a linear motion that takes a person from one place to another (Gehl, 2010). Walking is a means of transportation that provides flexibility. Pedestrians can easily stop, change direction, accelerate or slow down, change the type of activity to sitting, running, and so on. In today's fast-paced urban life, walking is the most appropriate activity to enjoy important moments in life. According to Jan Gehl, a walkable city is a city that sides with humans, thinking about aspects that are seen on a human scale. Humans influence the design of a city and cities also influence the habits of the people. Humans carry out life, habits, and culture in an urban space consisting of roads and buildings influenced by factors of welfare, health, and the sustainability of human life itself. According to Jan Gehl (2017) in Walking City, there are two aspects that are considered to form a pedestrian city:

1. Physical Aspects, physical aspects cover everything that appears in a city, there are three things, namely infrastructure, roads and open spaces, and buildings.
2. Life, cities are formed due to human habits and human habits can be formed by the design of a city. Therefore, human activity and life are the main factors in designing a city. Cities are designed for human life. There are three aspects related to urban life, namely customs and uses, culture and trends, commercial and economic.

2.2 Walkability

The walkability is associated with a pedestrian-friendly built environment with a variety of activities (Abley, 2005 in Zakaria, 2015). Jeff Spek defines the walkability as not just beautifying road corridors by adding trash cans, beautifying lights, and adding other road elements but able to fulfill four theories about walkability. The four theories are useful, safe, comfortable, and interesting.

There are many definitions of walkability, one of which is explained in the diagram (Figure 1) where the walkability is divided into three based on means, outcomes, and proxies (Forsyth, 2015). First seen from the elements that make up a walkable environment, it is concluded that the walkability is a pedestrian environment that is safe and has physical qualities that are in accordance with standards to be able to meet the walking needs of people from one place to another quickly and without obstacles. The second of the expected outcomes from walkability, walkability is an attractive environment with a lively and pleasant atmosphere that can provide more benefits, namely health, environmental sustainability, and social sustainability. The three walkability are a measurable proxy in the form of criteria and indicators that represent a walkable environment which is a comprehensive solution to improving the urban environment.

The diagram (Figure 1) illustrates the minimum conditions that must be achieved to create a walkability, in the bottom diagram is the expected output of a walkability, and the third part is how these are combined into something measurable. So from here we learn that to create a walkable built environment, the design or design must be able to provide (supply) an environment in accordance with the criteria and indicators to be achieved from walkability. Walkability criteria are structured as an effort for designers to create a walkable environment. This criterion can be used as an indicator to measure how friendly the environment is to pedestrians. In the table (Table 1) six criteria are formulated, sourced from the six existing literatures.
Figure 1. Diagram Definition of Walkability
Reference: Forsyth, 2015

Table 1. Walkability Criteria

| Spiek, 2012 | Cambra, 2016 | ITDP, 2011 | P3MI, 2018 | Ministry of Public Works | PPS | Conclusion Criteria |
|-------------|-------------|------------|------------|-------------------------|-----|---------------------|
| The Safe Walk | Commitment | Safety | Safety | Safety | Safe | Safety |
| Coexistence | Mobility | Security | | | | Security |
| The Comfortable Walk | Comfortable | Livability | Comfort | | | Comfort |
| Convival | | | | | | |
| The Useful Walk | Convenience | | | Convenien | | Convenience |
| Conspicuousness | | | | ce and efficiency | | |
| Connections | Pedestrian Accessibility | Connections | Accessible | | | Connections |

The Interesting Walk

| Sensitivity for local context | Context | Attractions & destinations |
| Creative use of street space | Interesting | Inviting & rich in detail |
| Added value both economically, socially and environmentally. | Unique | | |

Reference: Author’s own work, 2020
2.3 Network Centrality Measure
The initial idea of the centrality measure was introduced in the context of a social system, where the aim was to see the importance of the relationship of an individual in a network group (Crucitti, 2006). This centrality measure continues to develop and is used by urban planners and designers, where the initial goal is to see the position of a place is more important than another place because of its more central position. The initial approach is that roads are defined as edges and intersections are defined as nodes. The use of spatial network analysis began in the mid-1980s by Hillier and Hanson, namely the Space Syntax which was used as an approach method. The results show that the network analysis measure is very useful for predicting urban phenomena. Network analysis can help to explain the movement patterns of people in a city, important intersections in a city, the distribution of retail areas in urban environments and human why-finding capacity (Sevtsuk, 2012; Crucitti, 2006).

The space syntax approach is deemed sufficient to save computing costs and can be used on a large scale. But the drawback of space syntax is that the building as a form of urban activity is not included, making it difficult to interpret it into a result. because the activities that are the main reason people want to walk from the point of origin to their destination are lost. Land use or weight of a building is also not considered, so that roads that do not have buildings and roads that have factory or school functions will be assessed the same. So that an analysis tool is introduced, namely UNA, which can accommodate these shortcomings.

2.4 Urban Network Analysis
Urban Network Analysis (UNA) is a toolbox from ArcGIS developed by the City Form Research Group at the Massachusetts Institute of Technology (MIT) that is shared openly with the public. UNA is a series of network analysis which now makes it possible to include the influence of 3D positions and the involvement of building entities as an integral part of an analysis (P3MI, 2018; Sevtsuk, 2012). UNA includes three main elements in an urban area, namely edges which represent a path for road users, nodes which represent intersections and buildings that represent the built environment (Figure 2). In this building element, the building density and land use are calculated to be variables.

Then UNA also introduced weighted spatial representations on network elements. Each building will be assigned a weight whose weight corresponds to the actual characteristics of the corresponding structure in the city. Measurable elements such as building area, building volume, population, type of work, and others can be included in this application. One of the toolboxes can be used to calculate five types of network centrality measures on a spatial network including Reach, Gravity Index, Betweenness, Closeness and Straightness. The UNA tool that will be used in this research is a device attached to the ArcGIS toolbox.

2.4.1 Reachness. Reach is the value given by a building from the surrounding buildings at a certain range. This value is influenced by the weight of each of the surrounding buildings. Figure 3 illustrates

![Figure 2. Graph represent Building and Nodes](Reference: Sevtsuk, 2012)
how the range index works visually from building point I to r. The reach value is influenced by the size of the building, density and density of the road network.

Figure 3. Visual Illustration of the reach index
Reference: Sevtsuk, 2012

2.4.2 Gravity Index. Gravity index has a slightly different application to reachness. Reachness only considers the value of the reach of each destination, while the gravity index adds a spatial independent factor that makes the cruising range of an object on a building decrease when the exploration is made. The study of gravity is commonly used in the transportation sector to consider land use factors against displacement patterns.

2.4.3 Betweenness. Betweenness describes a building location that has a high level of affordability between two destinations. The higher the level of affordability is related to its weight, the higher the betweenness value of the building will be (P3MI, 2018). Therefore the building will be the meeting place for the two destinations. If you pay more attention, it is calculated by the value of the betweenness it has, that the higher the value is owned by a building, it can indicate that the higher the intersection is influenced by the weight of the surrounding buildings.

2.4.4 Closeness. Closeness describes the level of closeness between a location and other locations around it within a certain distance. Proximity does not use the weight of the building inside but purely only how far the building is from neighboring buildings.

2.4.5 Straightness. Straight can be described in terms of straight or direct, not continuing the journey if it finds an intersection. Straight gives an assessment of a building in the same road segment. At first glance it is a bit contradicting betweenness, but on the contrary straightness gives a high value to the building which is at the farthest part of the equilibrium so that it can show the value of how easily the building can be accessed from the road.

3 Method
The method used in this research is a quantitative approach using Urban Network Analysis. The analysis steps in this study started from entering attribute data, topological analysis, network analysis, and finally running the UNA simulation. Data to be entered into UNA is divided into main data and supporting data. The main data consist of three main urban elements, buildings, roads and intersections. Supporting data are building height, walking distance data, and building weight data.
3.1 Study Area
The area data needed in the design area is located at a radius of 350 m from the center point of the Tamansari area. To get valid data on a radius of 350 m, the minimum data entered in the UNA application is with a radius of 700 m. Because the Tamansari area is located between three points Ciwalk, ITB, and Balubur, from each of these points a radius of 700 m is drawn so that the data on the Tamansari area becomes valid. So that we get the regional delineation for the UNA application as shown in figure 5. With an area of the southern part of Tamansari covering an area of 0.267 km² and an area of the northern part of Tamansari covering an area of 0.302 km².
3.1.1 Building Data of Tamansari. Tamansari building data is the main data that is entered into the UNA input data. The building shape data that is entered is obtained from the shp data obtained from the Bandung City Spatial Planning Office. The building data that is entered into the Tamansari is in accordance with the delineation of the area that is input into the application, which consists of a total of 8,000 building elements that must be completed with attribute data.

The attribute data that must be completed is the building function in accordance with the ITBx table, building area, building height, and building volume. ITBx is a table of provisions for activities and land use in an urban area issued by the local government. For building function data and building height can be obtained in two ways. First through google street map and second through field survey. For urban areas, all field surveys were conducted by recording one by one the functions and height of the building. As for the other main roads, get a google street view first and a field survey for areas that are not visible or have changed functions. The following is the function of the building in the planning area divided into seventy-two categories (Figure 6) according to the categories found in the ITBx table.

![Figure 6. Tamansari Building Data based on ITBx Table](Reference: Author’s own work, 2020)

3.1.2 Tamansari Pedestrian Network. The pedestrian network data is the main data that is entered into the UNA. The pedestrian network data is obtained from the SHP data obtained from the Bandung City government. The pedestrian network data entered into UNA is only in the form of road axles. Before simulating the pedestrian network data, it is then readjusted its suitability according to the field survey. The pedestrian network in the urban village is not found in the shp, so it must be recorded by field survey and marked one by one (Figure 7). Completeness of the data required about the road is the name of the road, road width, road hierarchy, and road length.
3.1.3 Building Height Data. Building height data is needed to calculate the volume of the building. So from this volume it is assumed that the capacity of each building. Building height data is obtained through Google Street and direct field surveys. This building height data will be entered in the attribute table contained in the ArcGIS file.

3.1.4 Search Radius Input Data. Search radius data is an additional variable that is entered into the UNA application. Search radius data is adjusted to Indonesian conditions, namely using a radius of 350 m.

3.1.5 Weight of Activities Value. The design location in this study is also in the city of Bandung. Therefore, it is relevant if the weight of the impact value of the activities to be used takes the calculation results from case study one, namely the UNA research in Dipati Ukur, measured as previously explained.

3.2 Data Abalysis Step

3.2.1 Enter attribute data into the table. The data obtained are building data, building naming, building function, building height, building area and volume, and building value weight. All of them are entered one by one into the attribute table in ArchGIS.

3.2.2 Topological Analysis. Topological analysis is carried out for building and road data, this analysis is carried out to check the accuracy of the data that has been entered. The application will automatically...
detect if there are buildings or roads outside the predetermined criteria. Such as the building geometry is too small or the buildings are overlapping one another.

3.2.3 Network Analysis. In the pedestrian network analysis, the data entered is the center line of the road or center line. The width of the road can be entered into the attributes of the road data, according to the design requirements. In this road data, information can be entered one-way or not, turning signs right or left, and other traffic conditions.

3.2.4 Urban Network Analysis. In the UNA analysis all data that has been prepared can be entered. Building data will be converted into point form after building typology analysis. The input of this analysis is the provision of columns for road data resulting from network analysis with a predetermined scenario. Under this column there will be five centrality options, namely Reach, Gravity Index, Betweenness, Closeness, and Straightness. The analysis can be carried out one by one or all five options at once.

The building weight can be entered in the available column. The search radius is the distance that is determined as the subject's range value or in this case the value is closer to the walking distance data which is 350 meters.

4 Result and Discussion

In this study, from the five centrality measure options, only four centrality measures will be used to assess the walkability of the Tamansari area. There are four centrality measures that we will use in this study, namely Reachness, Straightness, Closeness, and Betweenness. UNA's running tools were started from the volume of impact activities (VNDK). The VNDK is the value obtained by considering the area of a building with the value of the activity impact on a building.

The VNDK represents how much a building affects an environment. In the results of the analysis (Figure 9) the red color shows a high Vndk value, namely in the campus area (ITB, UNISBA, UNPAD, and UNPAS), health facilities (Boromeus hospital, Hasan Sadikin Hospital (RSHS), biopharma, and hospitals. advent), shopping centers (balubur, ciwalk, superindo, ace hardware living plaza, and riau junction), apartments and hotels (judin apartments, pulmaan hotels, fave hotels, and mariot hotels) and schools (SMA Pasundan 8). It also shows that these buildings are facilities that attract large numbers of people. In the area of the Tamansari village there are four main magnets that become people to walk on, namely ITB, Ciwalk Balubur, and UNISBA.
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4.1 Reachness Index

The reach index shows the achievement between one building and another in an environment with a certain radius. The simulation in this area uses a radius of 350 m. The results of this reach index are influenced by three factors, building size, denser the space, and tighter road network. In this simulation, the value of the activity impact is added as one of the variables. In the area, it can be seen that buildings that have a high VNDK value have a significant impact on the surrounding environment, marked in red in the area around the building (Figure 10). The Boromeus Hospital which is adjacent to UNPAD in the surrounding area shows a red color, this means that the two buildings have a high enough impact on the surrounding area. In an area that is close to Ciwalk and RSHS, it produces the same results as Boromeus Hospital and UNPAD.

Balubur Market and UNISBA Campus also have a high influence on the surrounding urban villages as indicated by the dominance of red and yellow. Affordability in this area is high due to the high area density and is flanked by high-value buildings, namely Pasar Balubur and UNISBA. UNISBA itself is green because it doesn't have a big influence from the surrounding area. Meanwhile, the urban kampung which is located in an area of leisure to the north is yellow to green, which is a moderate value because of the high density but the low opening distance. There are many dead ends in the urban villages and there are also no buildings that have a big impact on the environment.

In the service trade area around Jalan Dago and Jalan Riau, the results are fairly even. This is influenced by the adjacent activity points, namely Riau Junction, Superindo, Living Plaza, Pullman, and
Gedung Sate. In fact, if you look at the VNDK value it is not too high, it reaches red, but because of the high space density of the building and the road network has many openings it results in an even and far distribution.

Figure 10. Reahness Index within 350 meter Network Radius from each Building in Tamansari Area

Reference: Author’s own work, 2020

4.2 Straightness Index

Straightness Index shows the reachability of straight access. The more straight access to the point the higher the value. Straightness can be used to measure or determine a landmark from a location or nodes that can be seen from a distance. Buildings that get red results indicate that the building is easy to see and structurally the city makes orientation easier for pedestrians.

Buildings that are located on a planned road network show high yields. This shows the ease of orientation of the area, namely the roads in Teuku Umar and Imam Bonjol (Figure 11). Jalan Dipenogoro to Jalan Maulana Yusuf shows high results because the road is straight and there are many accesses to it. High yields are also found in the complex to the southwest of the area near Jalan Sederhana, where the road access is straight, with a grid structure, and the block size is not too long, which is 125 m. Jalan Dago and Jalan Cihampelas are straight roads but the results look moderate and there is not much red color this is because the accessibility to this road is less with longer block sizes, which are around 300-400 m.

In the urban village in the southern part of the area close to UNISBA also shows high results dominated by orange to red. This is because first, there is a lot of access from the main roads Tamansari and Cihampelas to the settlements of the urban villages. The two structures of the southern kampong are more neat and orderly so as to facilitate orientation and there are not many dead ends. The three block sizes in the southern urban village area are below 190 m, which indicates that they are relatively pedestrian friendly (Figure 12).
Whereas in the urban village north of the Pasopati bridge, in the Kebon Bibit area and the Plesiran area, the results are low, indicating that this area is difficult to reach and not visually permeable (Figure 12). If we look at the existence of a zoo, it is one of the factors that causes the Kampong Tamansari to be closed from the main Tamansari road. If we see there are only two accesses to the urban village, namely from Jalan Plesiran and Jalan Kebun Binatang. If we look at the structure of the northern part of the township, it is more irregular than the southern part, this makes orientation very difficult for pedestrians. From these results, we can see that this factor could be one of the reasons for the lack of access through this urban village as a shortcut route from Tamansari to Cihampelas, even though if we look at it it is still within a walking radius.
4.3 Closeness Index
Closeness index shows the value of isolation of a building from its surrounding environment. The redder the color indicates that the building is more difficult to access. In the simulation results in the planned area, there are no results that show red color, this is because the access is well planned (Figure 13). In the northern part of the Kampong Tamansari there are ten points in the area which are orange towards red, while in the southern part of the Kampong Tamansari there are only four points (Figure 14). This shows that the southern area of Kampong Tamansari is less of a dead end than the northern area. If we look at the UNISBA building, it shows an orange color this is due to the large mass of the building and the position of the building is located in the middle of the road with a few intersections so that the building is more difficult to access or has little access to the building.

![Closeness INDEX](image)

**Figure 13.** Closeness Index within 350 meter Network Radius from each Building in Tamansari Area
*Reference: Author’s own work, 2020*

![Maps](image)

**Figure 14.** (a) Northern Kampung Tamansari (b) Southern Kampung Tamansari
*Reference: Author’s own work, 2020*
4.4 Betweenness Index

Betweenness index shows the value of the building against other buildings that are affected by the intersection. If a building is located on a road with many intersections, it will show a red result which indicates more access. After pairing it with the block size layer, it shows that it also affects the results, if the block size is small or below 190 m, the results show that the building is easier and is often reached by pedestrians. If we look at the area around Teuku Umar and Hasanudin, the size between the blocks is smaller, which is below one hundred meters, so that there are many intersections on these roads. This resulted in the two roads being easier to access and the surrounding buildings receiving great value for their simplicity. The second example is in the complex area around the simple area where high levels of betweenness are found due to the small block size. If we look at the village area of the city of Tamansari, there are many high betweenness values found because many intersections are formed due to the growth of organic settlements. But if we pay attention, the results are more orange to red which is located in the southern part of Tamansari village compared to the north. Because in the north there are more dead-end points than in the south.

![Betweenness Index within 350 meter Network Radius from each Building in Tamansari Area](Reference: Author's own work, 2020)

4.5 Discussion

The VNDK results show that the main facilities in the Tamansari area are Balubur Market, Ciwalk commercial area, and UNISBA, and ITB has an influence on the surrounding environment to become an active and busy area. These supporting facilities make the urban village area of Tamansari a fairly high achievement within a radius of 350 m, indicated by the dominance of the results from orange to red. In terms of the length of the road or the block size of the area in the Kampung Tamansari, when viewed from the Betweenness Index results, it shows that the block size is under 190 m which means it...
is quite pedestrian friendly. The results of the closeness index show that the number of isolated or dead-end areas is more in the northern part of Kampong Tamansari. The straightness results show that the northern kampong Tamansari is more difficult to pass and access compared to the southern part of Kampong Tamansari and is also more confusing in terms of pedestrian orientation. From the results of the four centrality measures above, it is found that the northern urban villages have lower results according to the criteria mentioned above respectively compared to the southern urban villages. So that the southern part of Kampong Tamansari is more walkable than those in the north.

5 Conclusion
From the result it is found that the northern urban villages have lower results according to the criteria mentioned above respectively compared to the southern urban villages. So that the southern part of Kampong Tamansari is more walkable than those in the north. UNA can be considered effective enough to be used in assessing environmental quality based on walkability quantitatively for complex environmental cases such as urban villages. The reason for being able to predict the desire to walk from an urban village environment is quite complex and requires a long time when using qualitative methods or origin destination surveys.

UNA tool allows designers, planners, and transportation experts to measure accessibility and predict the flow of non-motorized movements in cities based on the individual trip resolution of existing networks. Entering building elements and building weights into the centrality network measure makes the analysis results close to the original environmental conditions. When viewed from the analysis results with walkability criteria, UNA cannot accommodate all aspects of these criteria. The criteria that can be evaluated from the results of the UNA analysis if we look at them are connectivity, convenience, and diversity. Connectivity is described from the four centrality measure results. Ease of view from the results of straighness and closeness. Diversity is manifested from the existing building functions and can be seen from the reachness results. UNA cannot facilitate all the criteria of the walkability concept, namely such as security that cannot be seen from this network analysis, as well as the physical quality of the invisible pedestrian paths.

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