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The Spatial Pattern of a Kampong Area in Malang City using a Space Syntax Approach

Study on Depth Calculation and Connectivity using DepthMapX

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Abstract: In Indonesia, a kampong is an urban village region where about 75% of the city populace resides. Of late, kampongs have been drawing the attention of city government authorities with regards to formulation of kampong improvement initiatives and the conservation of kampongs by adhering to specific themes. This includes Malang city as well. Concerning one of the many urban planning challenges regarding sustainability, it is essential to monitor the kampong pattern in Malang. This pattern may be used for creating other kampongs using the template. The space syntax approach is utilised for determining the attributes of the kampong spatial patterns in Malang city. Moreover, kampong patterns were compared to determine the anticipated pattern. Depth computation and map connectivity concerning any theme-based Malang kampongs were used. Computing such patterns requires connectivity and depth computations. Justified plots are mathematical tools used for such computations; the DepthMapX software is used for the same. The present research aims to determine computations used for kampong pattern identification utilised for city planning. This computation will help determine which kampong has the most superior depth and connectivity among the reviewed kampongs and which kampong has the most intricate spatial syntax.

1. INTRODUCTION

The issue of sustainability is an interesting discussion in every concept of development in all cities around the world. To address this global issue, cities in Indonesia have applied the concept of sustainable development to each of their development concepts. However, most cities that have a plan that includes a concept of sustainability in its development do not materialise the aspect of sustainability due to inappropriate city planning (Tutuko & Son, 2018; Gao et al., 2019; Shuting, Leng, & Yuan, 2019; Tutuko et al., 2019).

In developing countries such as Indonesia, urban development has problems caused by a lack of adequate planning. One of the issues with urban planning is that a viable urban form has to be maintained. Indonesia, as one of the developing countries of Southeast Asia, is a country that has a city with very rapid development, especially in the *kampong* area. Urban development

is also accompanied by the development of kampongs that are influenced by the *kampong* tradition and is manifested in the determination of kampong patterns that are also affected by traditions that that handed from generation to generation (Tutuko & Shen, 2014). This study will consider the need to keep a *kampong* pattern that has certain themes. Malang City, as the second-largest city in East Java, is a city that has the characteristics of a colonial city and is full of historic heritage (Subadyo, Tutuko, & Cahyani, 2018). Malang City is a tourist destination city, one of which attracts tourists by developing kampong areas as tourist spots for foreign and domestic visitors. The Malang City government increases the presence of these kampongs, which have certain themes, as a means of growing the urban economy. Further study is needed, by conducting a study of the actual patterns in the city of Malang, to ascertain that the development of kampongs in the city should be maintained.

A research work completed by Kigawa (Kigawa, 2003) concerned ascertaining "Oku" (depth) using spatial contours left by residential development in a Japanese province. This syntactic space technique is useful for ascertaining critical spaces with a resembling pattern concerning architectural aspects for homes and (Machi-ya) and areas. The culture that occurs in an area determines the hierarchy of space in a place, this culture directs and places the function or space where it should be. Cultural activities in the form of ceremonial pathways are used as study cases in determining the depth of spatial arrangement in homes and regions.

On a city scale, Law, Chiaradia and Schwander (Law, Chiaradia, & Schwander, 2012) conducted a study on the development of a city by combining analysis of geometric and analysis of geographical accessibility in the space syntax approach. City growth is evident because mobility is facilitated by the present transportation modes active in the city. Using networks, a framework can be created for geometric structures and geographical aspects (Penn, A et al., 1998; Can & Heath, 2016; Karimi, 2018; Agirbas, 2019). The conclusion obtained is the need for synergy between the previous conditions and technological developments in the social and economic development of the city.

To deal with the universal concern of sustainable development and the deployment of development in the urban regions of Indonesia, it is essential to conduct a research on sustainable development in urban residential regions like *kampong*. It is vital to understand Indonesian kampong patterns to get a fundamental understanding about kampongs to facilitate sustainable urban form. Many research works on sustainable development from different urban perspectives have been conducted, including topics such as economics and politics (Rodríguez-Alegría, Millhauser, & Stoner, 2013; Yi & Ryu, 2015), as well as sustainable development in metropolises, given the impacts of urbanisation (Firman, 1999, 2009; Tutuko & Shen, 2016; Sedyowati, Suhartanto, & Sholichin, 2018; Tutuko, Subagijo, & Aini, 2018; Wikantiyoso et al., 2020; Wikantiyoso et al., 2021). This approach uses the calculation of depth on the justified graph, which is usually done to determine the relationship hierarchy within the space syntax method.

To enrich the aspects of the study of kampong development, the approach of research that will be carried out studies kampong patterns using a comparison between current conditions and previous planning. This approach uses the calculation of the depth of the graph, which is usually done to determine the hierarchy of connectivity and depth in the space syntax method. Through this study, it can provide recommendations that changes in spatial patterns caused by the development of the kampong can be measured and determined.

2. METHODS

To find out the area to be studied, field studies and observations using Google Earth images are needed at 5 kampong locations. The maps are then presented schematically to determine the measurement boundaries. Then a research design is made based on the space syntax approach as the research method used.

2.1 Thematic Kampong in Malang city

Indonesia is one of the countries located in Southeast Asia, which is a vast archipelagic country. So broad that there are 3 time zones. Indonesia is a nation-state, which grew up influenced by many other nations. In the course of its history, Indonesia has also grown under the influence of various languages, customs and religions brought by other nations. Therefore, today there is a wide variety of cultures and languages spread throughout Indonesia. Since the early era of independence until now, Indonesia has grown and divided into 34 provinces, 98 cities and 416 districts (*Figure 1*).

Figure 1. The position of Malang City in East Java and Indonesia (source: Google Maps)

Each city (or district) has many kampongs in it. Kampong is a unique vocabulary found in Indonesia, Malaysia and Singapore. Kampong means the area where people live in the lower middle class in urban areas. In general, the kampong has a unique character, for example, the unique profession of the majority of its citizens, its natural environment, the architecture of its houses or the arrangement of its built environment.

Today several mayors are promoting the Thematic Kampong program, which is an area settled under the administration of the "*kelurahan"* that shows the identity or meaning of a community or region's potential that is highlighted on the outcome of a mutual agreement. In practice, the thematic kampong program is expected to reduce poverty and unemployment; improve

the quality of the residential environment; raise local wisdom in managing potential and solving environmental problems and if possible will turn the kampong into a tourist destination. Malang City also has a program which is also intended to eliminate urban slums. The program is called "KOTAKU", an acronym for the phrase “City Without Slums”. Thematic Kampong will support the program because the development of thematic kampong is oriented to the removal of slums, economic development and tourism.

Malang is a city situated in Indonesia’s East Java province. It is the second largest metropolis after Surabaya in East Java, and the 12th largest city in the country overall. The city is situated on a plateau of 145.28 km2 at the centre of Malang Regency. Along with Malang Regency and Batu City, Malang is part of a provincial unity called Malang Raya. The research work was carried out across five thematic kampongs in Malang: kampong Warna-Warni, kampong Kayutangan, kampong Tridi, kampong Dinoyo Ceramics, and kampong Putih. The five urban kampongs are located at the heart of Malang and boast of a distinct theme, making the kampongs unique and a popular tourist destination.

2.1.1 Kampong Jodipan, Malang City

Kampong Jodipan is a kampong in Malang in the form of a series of houses on the banks of the Brantas River. This *kampong* has “*Kampung Warna Warni*” (*Figure 3*) and “*Kampung Tridi*” (*Figure 4*). The Jodipan kampong itself is located in RT 06, 07, 09, and RW 02), Kampong Jodipan, Malang City and is located on the banks of the Brantas River. This *kampong* is expected to become a new tourist area in Malang for selfie photos. Its colourful walls are expected to attract many people or tourists to come (*Figure 2*). The area of Kampong Jodipan is 49.35 ha, about 200 houses have been painted in various colours.

Figure 2. Aerial view of Kampong Jodipan, Malang City

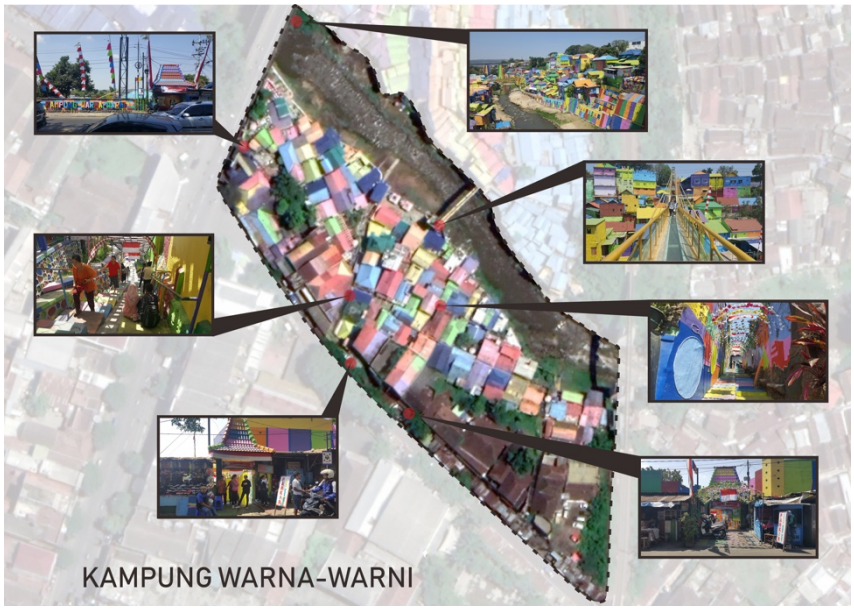


Figure 3. Aerial view of Kampong Warna-warni Jodipan, Malang city

Figure 4. Aerial view of Kampong Tridi Jodipan, Malang city

2.1.2 Kampong Kayutangan, Malang City

Kampong Kayutangan is located behind the main road corridor in Malang city centre, which is Basuki Rahmat street, but the name of the area is known as the Kayutangan Corridor. This kampong is located west of the Brantas River. Revitalization of Kayutangan only took place in the early 1880s. Previously, the Dutch had opened a special settlement for Europeans in the south of the Brantas River. This kampong is claimed as a colonial kampong that is still well preserved. Now, it faces is more attractive after being watched, cleaned and carried out several restored buildings (*Figure 5*).

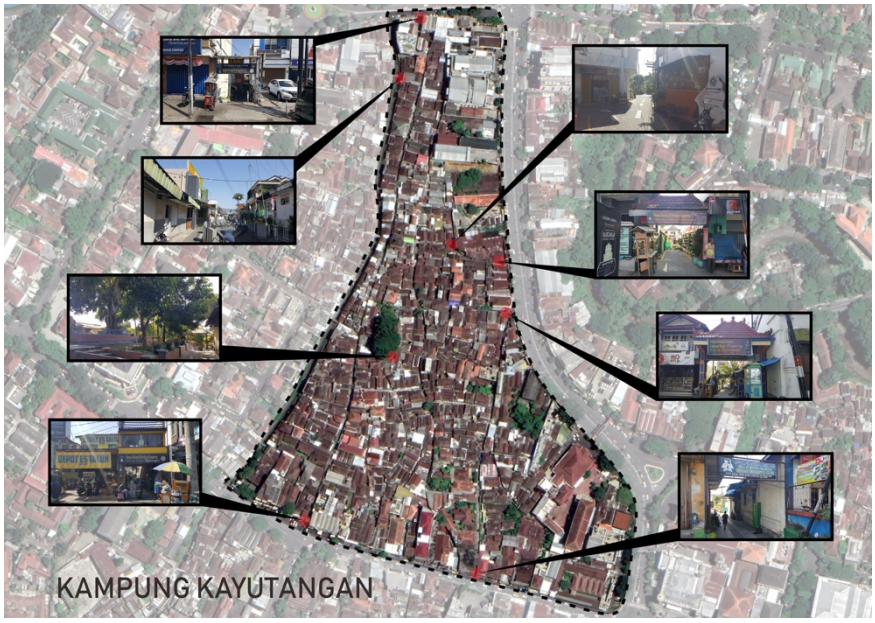


Figure 5. Aerial view of Kampong Kayutangan, Malang city

2.1.3 Kampong Dinoyo Ceramics, Malang City

This area is located in the Dinoyo area to the west of the Malang city where there is a Dinoyo ceramics factory that has been closed since 2003. The factory which was established in 1957 was one of the pilot projects. The centre of the ceramic crafts industry Dinoyo originated from the centre of pottery in the area of *Bethek* (the 1930s). One distinctive feature is that its products are patterned. Over time, there was an innovation in porcelain ceramics (1955) by replacing the use of clay (paddy soil) with white soil (porcelain). At that moment, the Government began to establish a ceramic factory as a model. The factory produces a variety of household appliances products such as plates, cups, mugs, and others. After the separation of production units that occurred in 1968, further developing new ceramic products (ornamental ceramics). Along with the establishment of the factory, the majority of the people in this region work as craftsmen and sellers of ceramics. Not surprisingly, if along the road in this kampong, there are a series of shops selling various types of ceramics (*Figure 6*).

Figure 6. Aerial view of Kampong Dinoyo Ceramics, Malang city

2.1.4 Kampong Putih, Malang City

The establishment of Kampong Putih was since August 5, 2017 and was inspired by Kampong Putih in China. Besides being the pride of the residents, Kampong Putih is expected to become an alternative destination for thematic-contextual kampong-based tourism destinations in the axis of Malang. Kampong Putih is inhabited by residents of RT 01 to RT 07. However, the houses that have been painted white are concentrated in RT 04, 05 and 06. Kampong Putih is located in the Brantas river banks. This kampong is neat and clean so that it reflects the meaning of "white" in this kampong (*Figure 7*).

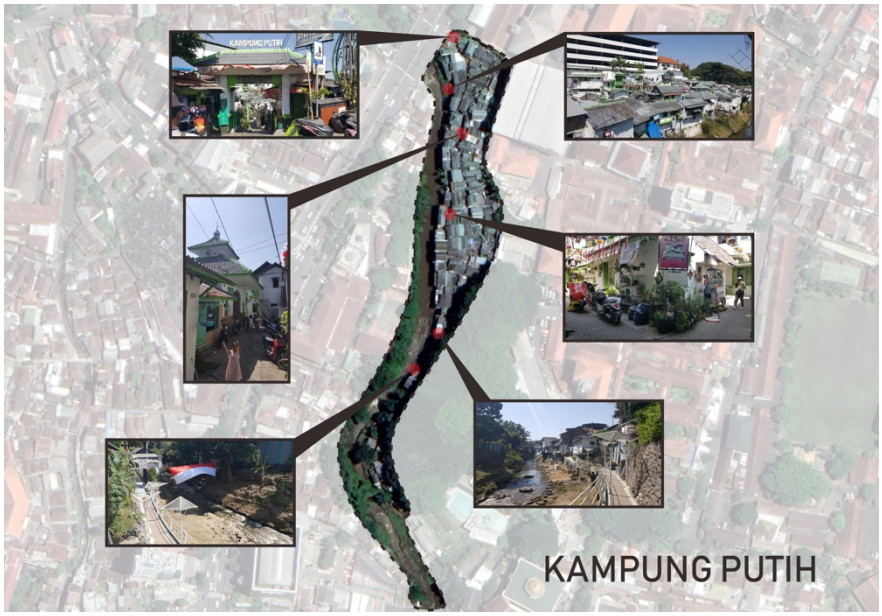


Figure 7. Aerial view of Kampong Putih, Malang city

2.2 Space Syntax Approach

This research carries out depth calculation on *kampong* in Malang City. The justified graphs method is used to calculate the depth based on geometric patterns and the accessibility of functions contained within the *kampong*, as well as spatial arrangement in each *kampong* pattern. As per Dalton & Dalton (Conroy-Dalton & Dalton, 2007), space syntax is a concept and technique associated with the relationship between intricate spatial structures and the humans occupying them. The space syntax technique can be deployed for large sized metropolitan regions and complex human colonies and structures (Hillier & Hanson, 1989; Hillier, 1996; Dawson, 2002; Hillier, 2007). In performing calculations, the method used is to perform syntax space analysis (*Figure 8*). The results of the study are measurements of the identification of settlement patterns that are reflected in the calculated spatial configuration.

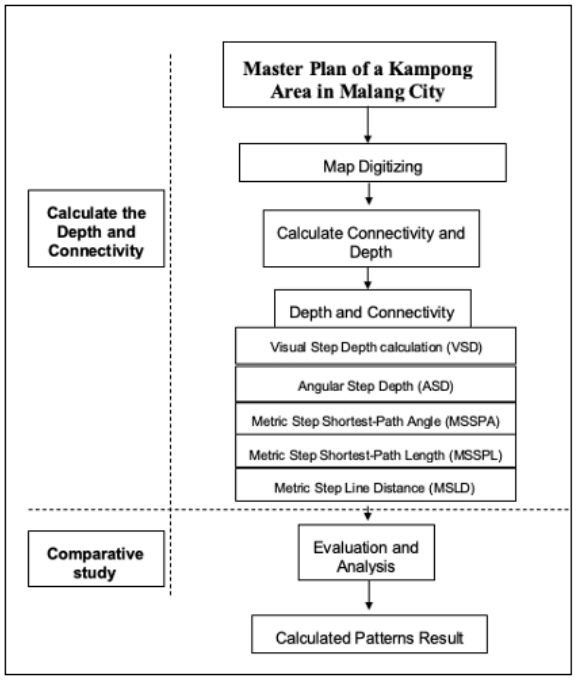


Figure 8. Research Design

This calculation used the DepthMapX program to find the depth and connectivity of maps that have been adjusted to the format. The resulting data is in the form of numbers and then statistical analysis is carried out. The selection of DepthMapX is based on conformity with the calculation method that is often used if using the space syntax approach (Turner, 2007). Another advantage is that statistical analysis and visualization of depth calculations and connectivity can be obtained to make it easier to visualize the results of calculations.

In this study, DepthMapX functions as a simulator calculating data depth. Before arriving at this process, map data collected from several thematic kampongs in the city of Malang will be digitalized from the raster image (JPG) format to vector (DXF) using the AutoCAD program. Following this, the map is imported into the DepthMapX program for calculation. Measurements were made on the main road in the five kampongs without giving the functions contained in the kampong's map. From the existing circulation, analysis is carried out on the axial lines that represent the road network on the map.

Furthermore, to add spatial analysis, the calculation is based on distance and angular depth. This is needed to get a more detailed calculation based on human behaviour moving and going somewhere (Hillier & Hanson, 1989). This calculation used space syntax analysis including Angular Step Depth (Turner), which is the calculation of depth based on angular views; Metric Step Shortest-Path Angle (MSSPA), to calculate the shortest relative path distance at a certain angle; Metric Step Shortest-Path Length (MSSPL), to calculate the shortest relative path distance at a certain length and Metric Straight-Line Distance (MSLD), to calculate the direction of a straight line with a certain distance. The colour coding is needed to help to determine the level of connectivity and depth of a spatial syntax using axial lines. Axial lines with high values are typically red or orange, and low values are pale blue or violet, with intermediate values distributed along a colour gradient between them.

To determine DC, it required steps as follows:

1. Digitisation of the five targeted maps (i.e., *kampong Warna-Warni, kampong Tridi, kampong Kayutangan, kampong Dinoyo Ceramics,* and *kampong Putih*). Inputting all map images into the DepthMapX program one at a time. Notably, only files in DXF format can be imported by this software(Turner, 2007).
2. AutoCAD software can process raster images and output vector files. Converting lines into polylines helps by decreasing the time-intensive calculation using DepthMapX software, e.g., determining *kampong Jodipan's* depth.
3. DepthMapX program will generate calculation of statistical data.

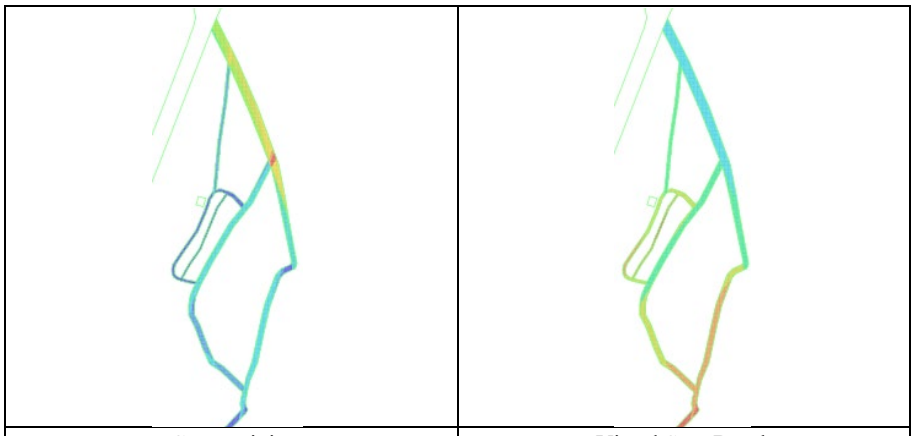
3. RESULTS AND DISCUSSION

3.1 Results

A specific initiation point was required to start the computations. Visibility Graphs (VGA) were obtained by converting existing maps. Subsequently, map depth was determined using Visual Step Depth calculation (VSD), Metric Step Shortest-Path Angle (MSSPA), Angular Step Depth (Turner), Metric Step Line Distance (MSLD), and Metric Step Shortest-Path Length (MSSPL). A gate (*gapura*) is the primary entrance route to a kampong, and it was identified as the starting coordinate. Subsequently, connectivity challenges can be ascertained using the VGA map. (*Figure9-1313*).

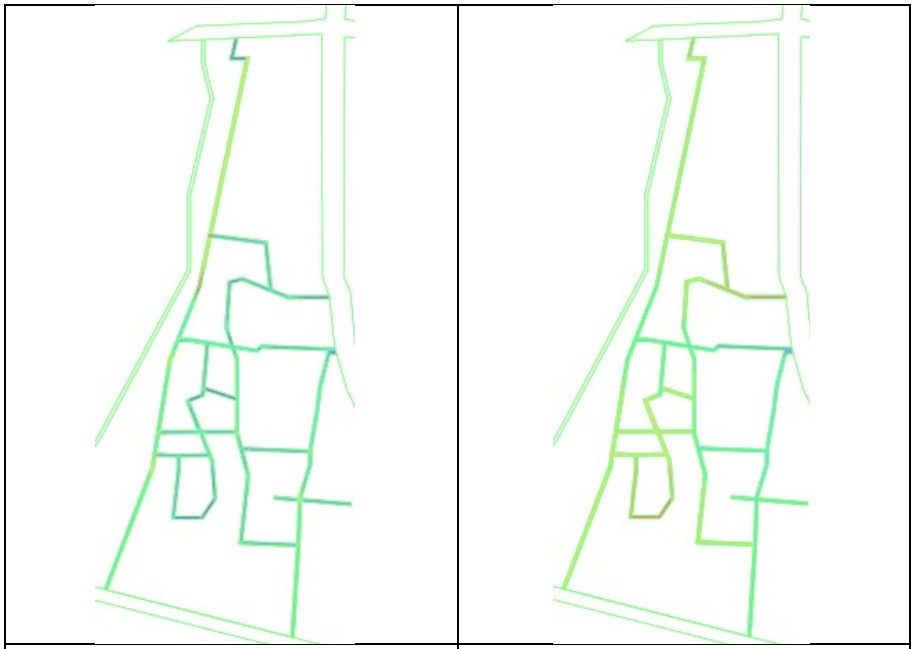
Connectivity	Visual Step Depth

Figure 9. Connectivity and VSD (Visual Step Depth) of *Kampong Warna-warni*



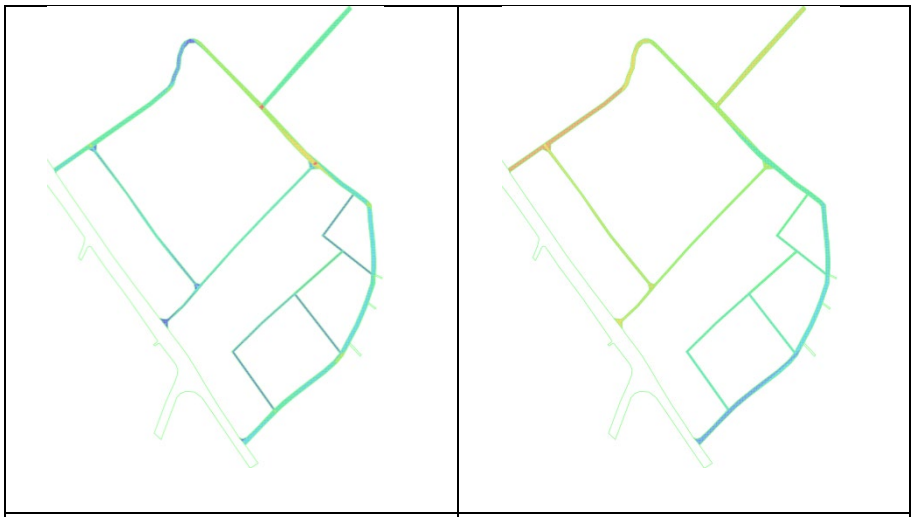
Connectivity	Visual Step Depth

Figure 10. Connectivity and VSD (Visual Step Depth) of *Kampong Tridi*



Connectivity	Visual Step Depth

Figure 11. Connectivity and VSD (Visual Step Depth) of *Kampong Kayutangan*



Connectivity	Visual Step Depth

Figure 12. Connectivity and VSD (Visual Step Depth) of *Kampong Dinoyo Ceramics*

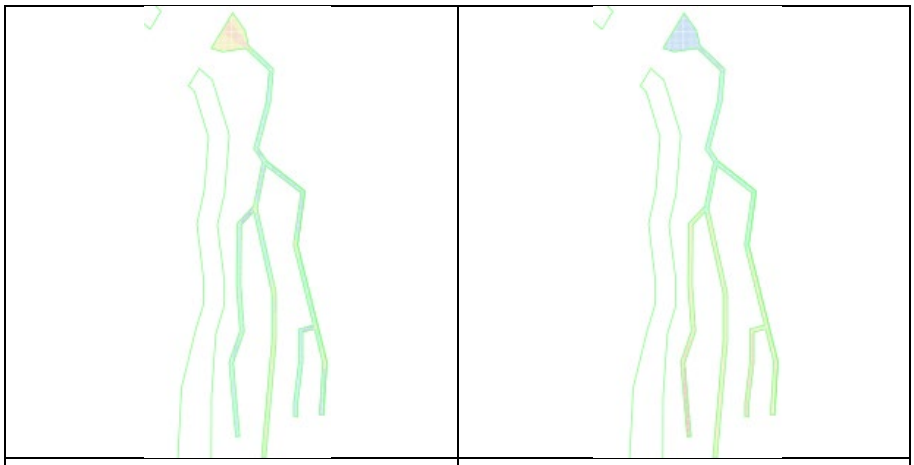


Figure 13. Connectivity and VSD (Visual Step Depth) of *Kampong Putih*

Table 1. Depth Calculation

No.	Kampong	VSD	ASD	MSSPA	MSSPL	MSLD
1	*Warna warni*	12	5.21	5.94	229.74	192.48
2	*Tridi*	5	2.37	3.07	226.33	212.94
3	*Kayutangan*	8	3.88	4.02	14560.4	10200
4	*Keramik Dinoyo*	9	3.28	3.12	59481.5	37036.3
5	*Kampung Putih*	8	3.41	3.43	11135.4	10627.2

Statistical techniques were used to analyse Visibility Graphs (VGA) after completing MSSPA, VSD, ASD, MSLD, and MSSPL (*Table 1*). *Kampong Warna-warni* has ASD and VSD depths of 5.21 and 12, significantly more than 2.37 and 5 for *kampong Tridi*. These numbers are the consequence of several access paths to *Warna-Warni*. On the other hand, *kampongs Kayutangan* and *Dinoyo Ceramic* have almost equal depths (8 and 9).

Table 2. Connectivity

No.	Kampong	Average	Min.	Max.	Std. Dev.	Total
1	*Warna warni*	6200.03	217	15799	4607.67	34567
2	*Tridi*	1584.94	51	4676	1057	9647
3	*Kayutangan*	837.82	133	2494	506.18	16503
4	*Keramik Dinoyo*	3508.51	127	10346	1760.65	39905
5	*Kampung Putih*	3004.16	508	6353	1340.45	30447

Warna-Warni has better connectivity (6200.03) compared to *Tridi*. Circulation and several access routes contribute to better connectivity (*Table 2*). Kampong *Kayutangan* is the lowest, with an 837.82 connectivity value. However, kampong *Dinoyo Ceramic* has the highest overall connectivity value of 39905 because a T-junction links all paths to the kampong.

3.2 Discussion

Aligning with the research objective, it is vital to conduct contrasting assessments concerning connectivity and depth. Based on Table 1 and Table 2, it could be seen that the depth and the connectivity in each kampong depend

on the form of the areas. As well as this, the connectivity that is found in the area depends on the access and streets in the areas.

The spatial analysis explains that the external/physical environment has non-social content and that society doesn't have spatial content. Environmental performance is evaluated in terms of general physical attributes, as well as high buildings and multi-story housing schemes failing in social acceptance terms (Asif et al., 2018). Furthermore, modern and innovative spatial organizations are needed, opposed to those that tend to produce lifeless and lonely environments that are associated with organic spatial patterns observed in the practice of vernacular and that cause damage to modern schemes in consequence of lack of understanding of the relation between society and spatial organizations (Hillier & Hanson, 1989). With the approach of space syntax in calculating the pattern of *kampong* in urban areas, patterns can be known through depth and connectivity produced through the DepthMapX program. *Kampong Warna-warni* is more complex in its accessibility to the *kampong* and the variety of streets in the *kampong* areas. It suggests that spatial hierarchy in the *kampong Warna-Warni* is more significant compared to the others.

This graph has acyclic nature, and its weight is such that short and long routes are not rendered to dimensionless points. Hence, metric distance is no longer relevant to this assessment. The longer paths observed in the axial map tend to have a higher number of crossings. The lines on the graph are more connected and have less depth or are integral. The spatial integration metric corresponding to a line is the average line depth when determined from other lines using a particular step count (radius)(Penn, Alan, 2003). In this study also considered distance and curvature which are considered visually for the movement and hierarchy of space. This is intended to get a more comprehensive measurement of space syntax. In this calculation, *kampong Dinoyo Ceramics* is higher than in other *kampongs*. This is because this kampong has more variation in the measurement of the shortest relative path distance at a certain length and the direction of a straight line with a certain distance. Although observations on the ground did not seem as much access to other kampongs as shown on the map.

This research provides an interesting insight concerning the resemblance in the overall depth of the studied *kampongs* (*Kayutangan, Putih,* and *Dinoyo Ceramics*). The low and high points vary significantly for *kampongs Tridi* and *Warna-Warni*. This shows that the higher the depth, the more hierarchy in the kampong. It can be stated that access to the kampong is affected by the number of intersections and paths arranged at that location. This is what shows the level of spatial syntax which is different in each *kampong*.

4. CONCLUSION

Based on the results and discussion, it can be found that the characteristics of the *kampong* pattern differ, despite being located in an adjacent location with the same environmental potential (in the city centre). Furthermore, to get the calculation of the depth and connectivity of the *kampong* pattern a comparison was made of the results of calculations using DepthMapX, such that significant differences were found. The main differences are partly due to the multiplication of access to *kampongs* and variations in road access within the *kampong*. It is anticipated that the computation outcomes will be employed for ascertaining *kampong* development patterns produced due to urban

development. These computations are expected to help determine the *kampongs* requiring future attention.

The measurement does not include aspects such as vegetation, public space, and other facilities, but measures the main circulation in the area without giving the function of the existing space. Future work will be carried out on research that includes these aspects to measure the ratio of depth compared to other kampongs. For further research, designing a simulation to ease depth analysis seems useful. It is necessary to test other kampongs in Indonesia, as well as those in other countries. Urban planners and city administrations can use the data to ascertain kampong development deviation in order to build a framework for sustainable planning practices aligning with sustainable urban architecture. (Turner, 2007)

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