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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 area where around 75% of the city population lives. Nowadays, urban villages are getting the attention of city governments with regard to the development of village improvement programs and the preservation of urban villages following certain themes, including in Malang City. Referring to one of the issues in urban planning relating to a sustainable urban form, it is necessary to study the pattern of *kampong* in Malang city as a reference for developing urban villages in accordance with their basic pattern. The object of the research is *kampong* that have certain themes related to urban tourism development in Malang. The determination of this *kampong* pattern uses the calculation of depth and connectivity, which is a mathematical method of justified graphs using DepthMapX software. This method is used to identify the characteristics of *kampong* spatial patterns in Malang city. Furthermore, to identify the expected pattern, a comparison was made between the village patterns by calculating depth and connectivity on maps in several thematic villages in Malang city. The objective of this study is to identify a calculation that will be used in determining the pattern of *kampong* that occurred due to the development of a city. From this calculation, it will be possible to find out which *kampong* experienced changes from its previous planning.

1. INTRODUCTION

1.1 Background

The issue of sustainability is an interesting discussion in every concept of development in all cities around the world. In order 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 actually materialise the aspect of sustainability due to inappropriate city planning (Gao, Tan, Geddes, & Ma, 2019; Shuting, Leng, & Yuan, 2019; Tutuko et al., 2019; Tutuko & Son, 2018).

In developing countries, urban development has problems caused by a lack of proper planning. One of the problems in urban planning is that a sustainable urban form needs 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 urban villages that are influenced by the *kampong* tradition, and is manifested in the determination of village patterns that are also influenced by traditions that run from generation to generation (Tutuko & Shen, 2014). This research will consider the need to maintain 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 village areas as tourist spots for foreign and domestic visitors. The Malang City government increases the presence of these villages, 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 villages in the city should be maintained.

Responding to the global issue of sustainable development, it is necessary to study the pattern of villages in Indonesia to achieve sustainable urban form. To enrich the study of village development, the research approach that will be carried out studies village patterns using a comparison between current conditions and previous planning. 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. Through these studies it is expected that the level of change that will occur in the development period of a village will be determined.

The results of this study are expected to be in the form of the depth of the village in Malang. Through depth and connectivity, it is expected that the pattern of urban settlements in the city of Malang will provide information to the local government on these conditions.

1.2 Sustainable Development in *Kampong*

To address the global issue of sustainable development and the application of development in urban areas in Indonesia, it is necessary to do a study of sustainable development in urban residential areas such as *kampong*. To get the basic pattern of a *kampong*, it is necessary to study the pattern of villages in Indonesia to achieve sustainable urban form. Several studies of sustainable development from various urban aspects have been carried out, including on politics and economics (Rodríguez-Alegría, Millhauser, & Stoner, 2013; Yi & Ryu, 2015), and sustainable development in cities due to the effects of urbanization (Firman, 1999, 2009; Tutuko, Subagijo, & Aini, 2018). To enrich the study of kampong development, the research approach that will be carried out will study village patterns using a comparison between current conditions and previous planning. 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. Through this study, it is expected that the level of change that will occur in the development period of the *kampong* will be determined.

1.3 Depth and Connectivity

This study produces depth ratios in certain rooms as measured by comparing basic depth in Javanese homes. This research is also a development of a study conducted by Tutuko & Shen (2014) in Home-based Enterprises (HBEs), based on determining patterns of development in a home. Furthermore, to further improve the study of sustainable urban form, the space syntax approach through the justified graphs calculation method extends the research to the scale of residential or *kampong* areas.

Research using the space syntax approach that has considered depth calculation has been carried out by Dawson (2002) to calculate the spatial configuration of residential and public buildings. The results of the study were in the form of an understanding of the identification of changes in residential patterns reflected in the spatial configuration of family structure and community behaviour. Depth calculations carried out using justified graphs have been conducted by Dalton & Dalton (2007) to determine the spatial configuration of the object of research.

Another study, conducted by Kigawa (2003), is about determining "Oku" (depth) by using boundaries in space based on residential patterns and an area in Japan. By using the space syntax approach, important spaces can be identified that have the same similarity pattern for structuring functions, both of those found in a house (Machi-ya) or of a certain area. 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 & Schwander (2012) conducted a study on the development of a city by combining geometric analysis and analysis of geographical accessibility in the space syntax approach. The development of a city can be seen from the mobility that occurs due to the accessibility of existing modes of transportation in the city. As a network, an approach can be made to geometric patterns and geographical conditions of a city. 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 further enrich the knowledge of space syntax by using justified graphs, research was considered at a larger scale, namely that of the *kampong*, with the consideration that spatial planning in the planning of a *kampong* was inseparable from the element of consideration of the depth hierarchy in the concept at hand. Furthermore, to improve the concept of the hierarchy planning arrangement, the thematic village was chosen as the focus of the research. 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.

2. THEMATIC KAMPONG IN MALANG CITY

Malang City is a city located in East Java Province, Indonesia, the second largest city in East Java after Surabaya, and the 12th largest city in Indonesia.

The city is located on a plateau of 145.28 km^2 located in the middle of Malang Regency. Together with Batu City and Malang Regency, Malang City is part of a regional unity known as Malang Raya. The study was conducted in five thematic kampongs in the city of Malang, namely the kampong *Warna-Warni*, kampong *Tridi*, kampong *Kayutangan*, kampong *Dinoyo Ceramic*, and kampong *Putih*. The location of these five urban villages is in the center of Malang and has a special theme, so this village looks unique and becomes an attractive tourist destination for tourists.

2.1 Kampong Jodipan, Malang City

Kampong Jodipan is a village in Malang in the form of a series of houses on the banks of the Brantas River. This *kampong* has "*Kampung Warna Warni*" (Figure 2) and "*Kampung Tridi*" (Figure 3). The Jodipan village 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 1). The area of Kampong Jodipan is 49.35 ha, about 200 houses have been painted with various colours.

Figure 1. Aerial view of Kampong Jodipan, Malang City

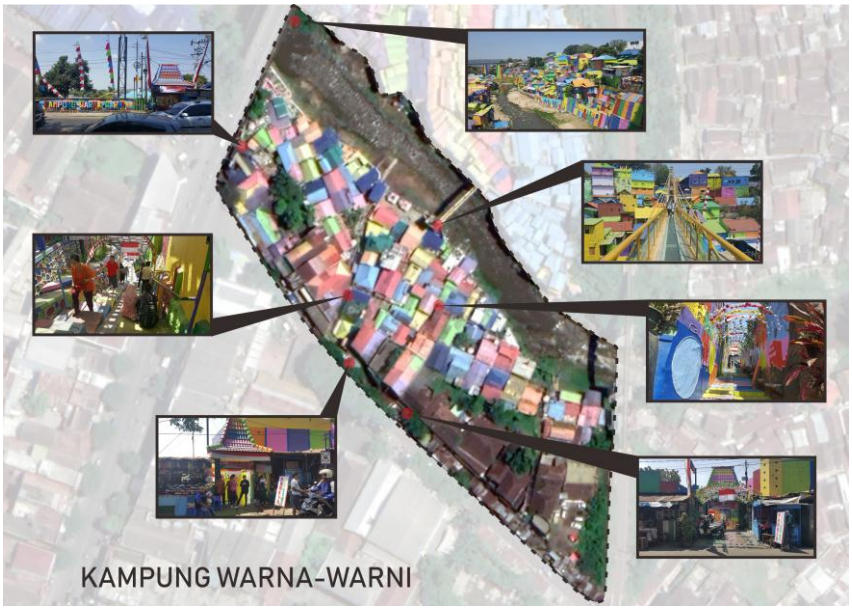


Figure 2. Aerial view of Kampong Warna-warni Jodipan, Malang city

Figure 3. Aerial view of Kampong Tridi Jodipan, Malang city

2.2 Kampong Kayutangan, Malang city

Kampong Kayutangan is located behind the main road corridor in Malang city center, which is Basuki Rahmat street, but the name of the area is known as the Kayutangan Corridor. This village 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 village that is still well preserved. Now, it face is more attractive after being watched, cleaned and carried out several restored buildings (Figure 4).

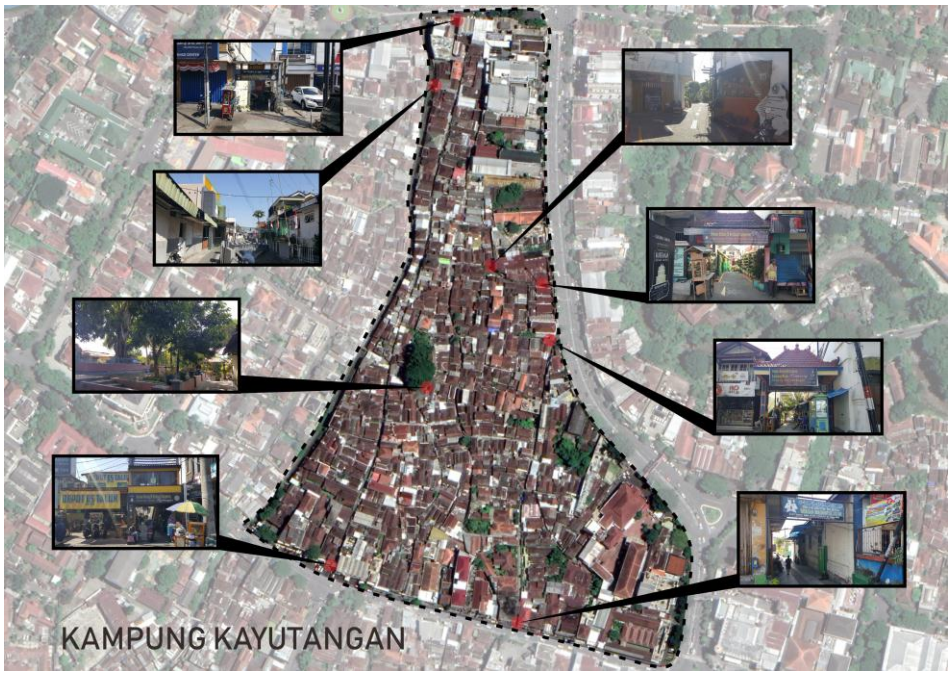


Figure 4. *Aerial view* of Kampong Kayutangan, Malang city

2.3 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 center of the ceramic crafts industry Dinoyo originated from the center of pottery in the area of *Bethek* (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 village, there are a series of shops selling various types of ceramics (Figure 5).

Figure 5. *Aerial view* of Kampong Dinoyo Ceramics, Malang city

2.4 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 village-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 village (figure 6).

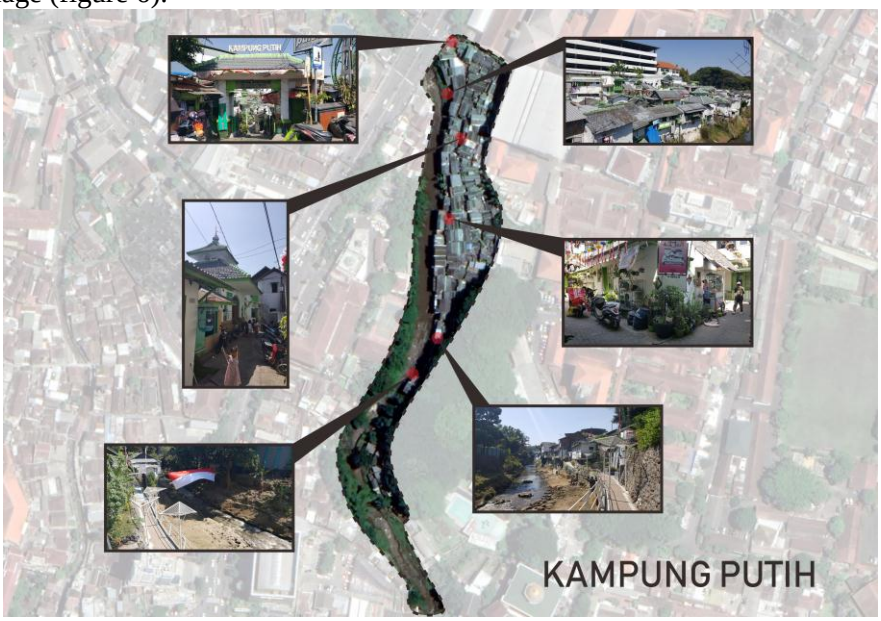


Figure 6. *Aerial view* of Kampong Putih, Malang city

3. METHODS

3.1 Space Syntax Approach

According to Dalton & Dalton (2007), space syntax is a theory and technique related to the relationship between complex spatial structures and the humans in them. This approach can be applied to large-scale urban areas and complex settlements and buildings (Hillier, 1996, 2007; Hillier & Hanson, 1984). The essence of all syntax space analysis is the concept of network graphs (Figure 7).

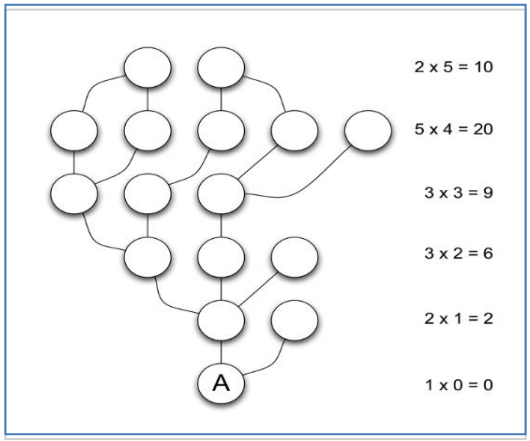


Figure 7. *Justified Graphs* (Dalton & Dalton, 2007))

3.2 DepthMapX

This study will use 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 villages 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.

3.3 Steps of Calculation

The steps required to determine DC are as follows:

1. Digitizing of five maps (*kampong Warna-warni kampong Tridi, kampong Kayutangan, kampong Dinoyo Ceramics, and kampong Putih)*. It is necessary to insert the map image into the DepthMapX program. The DepthMapX program can only import maps from DXF files (Turner, 2007).

2. Process converting from raster image to vector in order to be processed in AutoCAD. Improve the map from line to polyline to ease the calculation running time of the DepthMapX program.
3. Determine the depth of Kampong Jodipan.
4. Statistical calculation of the data generated from the DepthMapX program.

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 behavior moving and going somewhere (Hillier & Hanson, 1984). This calculation used space syntax analysis including Angular Step Depth (ASD), 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.

4. RESULTS AND DISCUSSION

4.1 Results

In conducting the calculation, a starting point calculation was required. The predefined maps had to be converted into Visibility Graphs (VGA). Next, on the VGA map Visual Step Depth calculation (VSD), Angular Step Depth (ASD), Metric Step Shortest-Path Angle (MSSPA), Metric Step Shortest-Path Length (MSSPL), and Metric Step Line Distance (MSLD) were conducted to find the depth of the map. The starting point was determined to be the main entrance of the *kampong*, the gate (*gapura*) was chosen. Simultaneously, from that result the connectivity that occurs in the VGA map can also be known (Figure 8-12).

Figure 8. Connectivity of *Kampong Warna-warni*

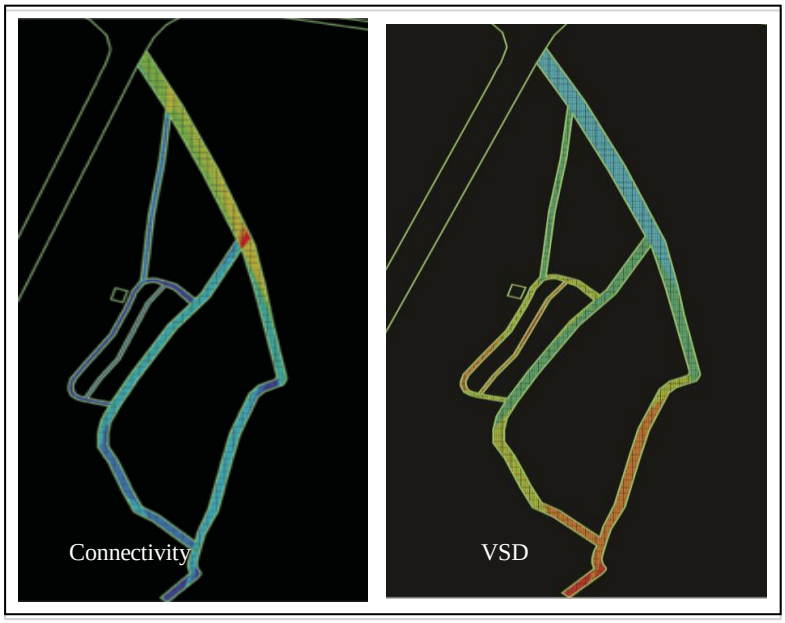


Figure 9. Connectivity of *Kampong Tridi*

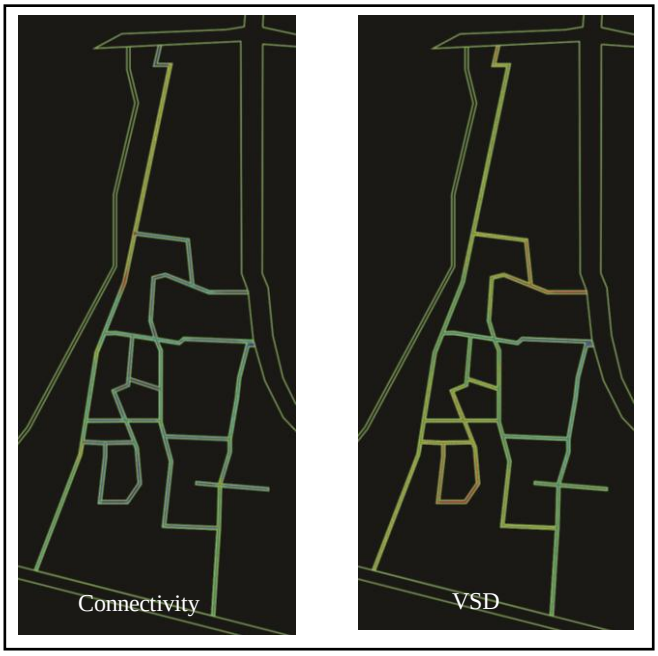


Figure 10. *Connectivity and Depth* of *Kampong Kayutangan*

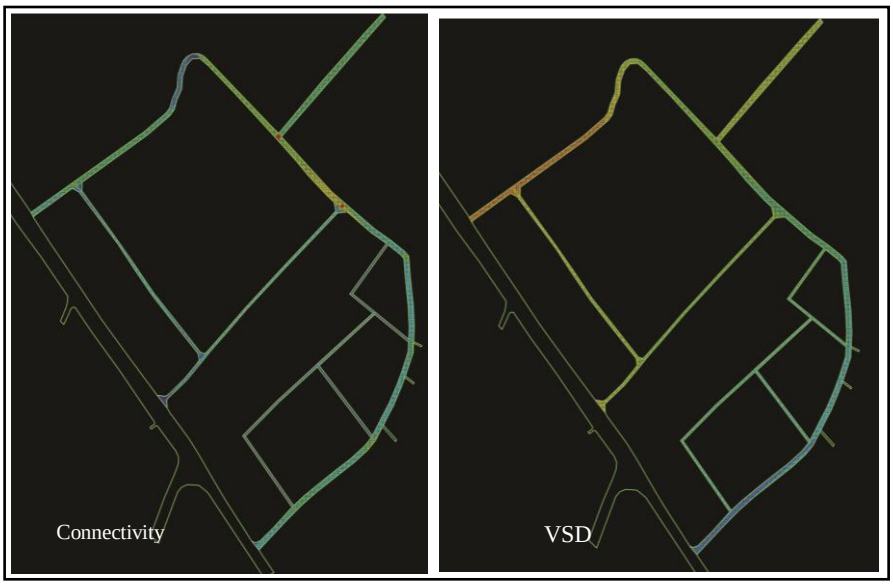
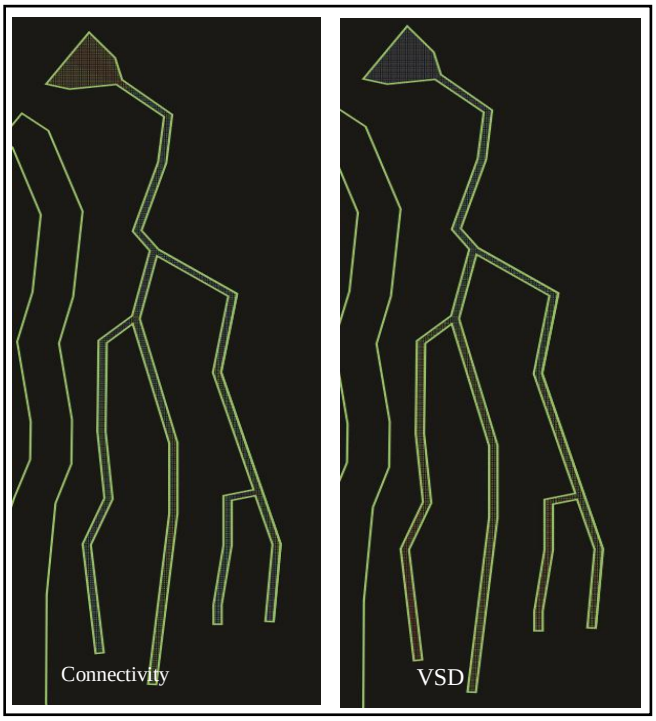


Figure 11. *Connectivity* and *Depth* of *Kampong Dinoyo Ceramics*



Figue 12. *Connectivity* and *Depth* of *Kampong Putih*

After determining the VSD, ASD, MSSPA, MSSPL, and MSLD, statistical analysis was performed on the Visibility Graphs (VGA) that had been made (Table 1).

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

Depth on VSD and ASD in Kampong Warna-warni is higher (12 and 5.21) than in Kampong Tridi (5 and 2.37). This is caused by the many access routes to the Kampong Warna-warni area. Whereas in kampong Kayutangan and kampong Dinoyo Ceramic the depth is relatively the same (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

Connectivity in Kampong *Warna-warni* is also higher (6200.03) than in Kampong *Tridi*, this is caused by more varied access and circulation, which causes high connectivity. While the lowest is kampong *Kayutangan* (837.82). But the highest total connectivity was in the kampong *Dinoyo Ceramic* (39905), this was due to a T-junction connecting all access to the village.

4.2 Discussion

In accordance with the purpose of this research, it is necessary to conduct a comparative study of depth and connectivity. Based on Table 1 and Table 2, it can 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 physical environment has non-social content and that society does not have spatial content. Environmental performance is evaluated in terms of general physical attributes, such as high buildings and high-rise housing schemes failing in terms of social acceptance (Asif, Utaberta, Sabil, & Ismail, 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 due to a lack of understanding of the relationship between society and spatial organizations (Hillier & Hanson, 1984). 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. This indicates that the hierarchy of spaces in *Kampong Warna-warni* is higher than in other *kampongs*.

Basically, the graph is undirected and has no weight so that long and short lines are reduced to dimensionless vertices, thus effectively removing metric distances from the analysis. Longer lines in an axial map tend to have a greater number of intersections with each other. Lines, more connected in the graph and tend to be shallower or more integrated. The measure of spatial

integration for each line is the average depth of that line from all other lines in a specified number of steps (or radius) (Penn, 2001). 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 village 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 villages as shown on the map.

What is interesting from the results of this study is that there are similarities in the total depth in the three *kampongs* (*kampong Kayutangan, kampong Dinoyo Ceramics,* and *kampong Putih*), while the significant differences in the high and low positions are in the *kampong Warna-warni* and *kampong Tridi*. This shows that the higher the depth, the more hierarchy in the village. It can be stated that access to the village 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*.

5. 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 center). 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 expected that the calculation results will be used in determining the development of *kampong* patterns that occur due to the development of the city. From this calculation, it will be possible to identify which *kampongs* need to be considered in future planning.

For future research, designing a simulation to facilitate depth analysis seems useful. It is necessary to test other *kampongs* in Indonesia, as well as those in other countries. Planners and city governments can determine the deviation in the development of a *kampong*, so as to provide a basis for sustainable planning directives in line with sustainable urban form.

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