The Study of Connectivity and Network Degree toward Mitigation Strategy for Resilient Kampung in Indonesia (Case Study: Kampung Taman Sari, Bandung)

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Abstract. This study investigates the resilience of kampung settlement based on connectivity for developing mitigation strategy in urban context. Kampung Taman Sari, Bandung, is chosen as a case study of this paper. Kampung, the main urban settlement type of every city in Indonesia, is an informal settlement, with minimum urban services and facilities, therefore inhabitants who living there are more vulnerable in the response of disaster evacuation. This paper studies a deep understanding of the morphological configuration of Kampung based on connectivity and networks which define and show the degree of capability to prepare, respond, recover, and survive in the face of disaster. Depth map simulation and Space Syntax is used to analyze the degree of connectivity and network. The result shows the key relation of connectivity and accessibility of movement evacuation, not only for human movement but also rescue team, including the transportation.

1. Introduction
Disaster risk management trend in 21st century is going to emphasize on preparedness and cycle of disaster risk more than only focus on recovery strategy (IPCC, 2012). One of the strategies in disaster risk preparation is mitigation or evacuation planning. Evacuation is a potential measure to reduce loss of life in a time of disaster or threat of disaster [1]. Understanding the way in which pedestrians move around their environment is important for evacuation planning [2]. Two main approaches have been developed to address the issue of pedestrian movement analysis, modelling and simulation. The 1st approach, defined as configurationally analysis, focuses on the physical environment by representing and quantifying aspects of the spatial configuration or morphology. The 2nd approach, pedestrian simulation, takes human behavioural issues into consideration [3].

In Environmental psychology study, people and spaces are connected by spatial visualization, visual representation, and visibility [4]. Thus, people use them to get the direction quality of navigation. Visualization is used as a variable to determine the most chosen eco-friendly environment by a pedestrian in their route to a destination [5]. Visual connection set as the interaction between the people’s
sense of visualization with the physical environments [6][7][4]. Visual representation is taken from the street environment in how people engage the space [8]. The level of people activities connection in streets is shown by street connectivity [8]. One of the factors of street connectivity is visibility, which defined as the connection between pedestrian and street environment.

In the theory space syntax, UCL Depthmap predicates a variety scales from building and small urban areas in analysing street network connectivity which able to find out the spatial integration of human with space. Connectivity represents to the relative spatial interconnection of a system or a network (for example, network of streets) [9], and these streets connection can be helping people to move in an urban environment by walking, biking, or driving [10]. In addition, connectivity is a factor, particularly for patterns design of street networks to indicate how pedestrian can adapt the street environment and conduct the usable space [11], moreover to determine the walkability in the neighbourhoods [12].

2. Method

The goal of this study is to identify the spatial connectivity to determine the level of evacuation easiness in the term of disaster, especially a fire disaster in Kampong Taman Sari, Bandung. The spatial connectivity analysis applies a based methodology of Space Syntax that quantifies the main of three parameters, they are connectivity, integration, and visual step depth [13]. In this study, spatial connectivity was analysed based on the street network patterns found in one of the densely populated residential areas in Kampong Taman Sari. The analysed spaces represent existing road sections consisting of the main road / highway (Jalan Taman Sari) and secondary roads and tertiary roads that connect the main road with the residential area of the Kampong Taman Sari. The measurement of connectivity is carried out to identify the level of interaction of each street segment on nearby streets. The connectivity value is used to measure the level of intelligibility by correlating the connectivity value with the integrity value. The connectivity value is determined by the number of streets connected directly to the location of the observation point. The higher the connectivity value, the more streets connected to the observation point, and vice versa. Integrity measurement is carried out to determine how far the position of a street segment is from other sections. Integration value is an important measure to indicate the higher integration values of a space [14] and it will correspond with better permeability and accessibility of this space [15].

The distance parameter used in measuring integrity is called step depth. The lower the number of step depths, the higher the integrity value. Roads with high integrity values are well connected to the observation room. The more rooms that are connected directly to the observation room, the higher the integrity value of the space. The value of integrity does not only involve rooms that are directly connected, but also other rooms that are not directly connected to the observation room. The intelligibility value shows the level of correlation between local scale measurement (connectivity) and global scale measurement (integrity). The intelligibility value is to show that the pedestrian can recognize and realize the spatial structure area in the spatial configuration area. The highest intelligibility value depicts the predictive of environmental cognition within the environment, while the lowest intelligibility value shows that the spatial structure might not be recognize partially so that pedestrians will tend to lose around this area [16].

2.1 Data Analysis for Visibility Graph Analysis (VGA) using Depthmap

In Depthmap, Visibility Graph Analysis (VGA) is a Space Syntax technique developed by Turner and his colleagues [17] to assess how visible any point in the spatial configuration is from any other point. The visibility is applied to be an independent variable measured that consist of three dependent variables, which include; Connectivity, Integration HH, and Step Depth. (1) Connectivity quantifies as a direct connection of nodes to each individual node in connectivity graph [18]. In addition, it can measure the local visual relationship between each space and its contiguous neighbours [14], (2) Integration defines integration derived by Hillier and Hanson (1984) that it depicts and important measure of local and global visual permeability, researchers indicate the higher integration values a space correspond with
better permeability and accessibility of this space [15]. (3) Step Depth identify the number of steps from a node to other nodes, the fewer step depth means the shortest distance in a connectivity graph [10]

3. Result of Analysis
The result of visibility graph for the street network in Kampong Taman Sari is as shown Figure 1. According to this delineation, the observation depicts three typologies of street (Figure 1), namely, A typology has <1 metre, B typology has 1-2.5 metre, and C typology has >2.5 metre. Meanwhile, the simulation reveals that the lowest connectivity value is 3, while the highest connectivity value is 121. This defines that the point is regarded from 121 locations in the street network and most viewed area which connected and popular from various locations.

![Figure 1. (a) Observing existing area, (b) Connectivity graph map](image)

Integration value (Figure 2) is an important measure to indicate the higher integration values a space [14] and it will correspond with better permeability and accessibility of this space [15]. According to this simulation, the integration value reveals that the highest integration value is 2.01434 and the lowest integration value is 0.694112. This value can be assumed that Kampong Taman Sari area has lack of permeability and accessibility.

![Figure 2. Integration graph map](image)

Step depth value (Figure 4) in street connectivity defines the convenience for a pedestrian to move. When the level of value is the lowest, this means the pedestrian need have fewer steps and it will make easier for pedestrian to move in this street network, and vice versa. This simulation for step depth reveals that the lowest step depth value is 5.10995 and the highest step depth value is 12.9261. So, these fewer steps mean, pedestrians are easier to move from one destination to other destination around this area.
4. Finding and Discussions

From the visibility graph in Figure 2, it is known that the highest connectivity value shown in red is on the road section where the observation point is located (black dot). This means that the intensity of pedestrian movement passing through these roads is high. From the street network pattern, it could be seen that the high intensity of movement is caused by the number of roads that are directly connected to this point. The graph reflects pedestrians who live in the kampong easily recognize and identify the street for evacuation. Meanwhile, the lower value in the graph also reveals privacy of streets which mean the less viewed area and the low connectivity. This also defines the level of privacy area in this street can be determined.

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