A study of walkability in Surabaya urban park utilizing the space syntax

F Wahyono¹, B Soemardiono², T Noerwarsito³

¹Master Student, Department of Architecture, Sepuluh Nopember Institute of Technology
²Associate Professor, Department of Architecture, Sepuluh Nopember Institute of Technology
³Professor, Department of Architecture, Sepuluh Nopember Institute of Technology

Email: Fandhywahyono.19081@mhs.its.ac.id

Abstract. The urban parks are open spaces that accommodate people to do various activities. One of the most popular activities is walking. Human experience essentially leads pedestrians to have specific spatial dimensions and configurations in a park. Space syntax exists as a tool to explore the characteristics of the spatial configuration and the influence of the visitors on their activities through their perceptions. Space syntax has been widely applied in urban and human movement studies, despite rarely applied within the scope of urban parks. This study aims to address the debate and offers a new technique in applying the space syntax method. This research employed quantitative methods in interpreting the concept of Walkability and evaluated the design of urban parks by spatial exploration. The result determined the scope of research within the park, the configurational relationships between spaces as well as the visual connection and continuity of the human line of sight. This principle was developed and illustrated based on the three urban parks in Surabaya.

1. Introduction

Urban parks have been regarded as spaces for social interaction and activities [1]. Urban parks are one part of the green open spaces with ecological, economic, aesthetic, socio-cultural, and health functions [2]. Numerous developing countries utilize parks as place that encourages people to walk as a form of a physical activity offering mental and physical relaxation [3]. Walking becomes the main activity in the park, by which visitors can explore any available attraction within the built environment. In addition, accessibility and choosing a walking route in the park affect park visitors’ experience and satisfaction level [4]. Based on a previous empirical finding, it was found that park feat research related to one's walking experience [5].

Meanwhile, landscape theory argued that humans have spatial dimensions and configurations that feasibly affect their experience [6], examined through spatial-based research. Therefore, a research method that utilizes syntax space as a tool is thus required. Syntax space has been widely applied in several scientific studies regarding human movement on a city scale. Unfortunately, the program is infrequently applied in some scientific research projects within the study scope of parks. This study aims to address the different arguments and to provide a term of reference for interpreting the characteristics of spatial configurations of urban parks in Surabaya. The developed and illustrated rules included the
urban parks with the best socio-cultural effectiveness index in Surabaya, such as Bungkul Park, Apsari and Ronggolawe [7]. The findings are expected to evaluate the design of the three parks and provide a term of reference for interpreting the spatial characteristics of the parks through exploration and visitors’ perception.

2. Methods
This study utilized descriptive quantitative methods, expected to interpret the concept of Walkability and evaluate the design of the three urban parks by conducting spatial exploration. The study emphasizes various techniques of data collection and interpretation [8]. Quantitative evaluation was carried out to eliminate subjectivity in analysing and understanding complex relationships. Therefore, a quantitative approach enabled the visitors’ perception of the existing reality by avoiding the analysis, conducted before the previous research.

Space syntax theory argued that activities within the spatial structure system affect movements and interactions, resulting in reciprocal relationships [9]. Space is considered a discontinuous system that follows specific rules in its configuration. This configuration concept is directly related to the nature of space, applied to interpret the urban environment, from landscapes to urban areas. Cohesion among park configurations is defined as the permeability among many elements of the park in an ecosystem. This concept is expected to become independent learning towards developing landscape and spatial architecture objectively and accurately.

Syntax space has two focuses, such as: (1) identification of space and human linear mobility in an ecosystem, and (2) spatial studies and roles in a landscape [10]. The intense mobility and accessibility of visitors to open space manifest their experience in a system [10]. Urban parks, including the relationship between activity zones and pathways, are parts of the spatial landscape. The activity zone was designed to accommodate the needs of park visitors for interaction. In contrast, pathway design designed the pedestrian path to fulfilling circulation needs to improve the community’s welfare. Meanwhile, the role of syntax space examined the characteristics of the city park space configuration in Surabaya. According to this case, emphasis was provided to the scope of walking. In sum, the following Figure 1 illustrates the stages of this study.

![Method framework](Source: Author’s Document, 2021)

3. Results and Discussion

3.1. Case Study: Surabaya Urban Parks
Elements of a park that tend to be complex and diverse caused many problems in applying the space syntax method. The problem covered park scale units and their analysis. The addressed this issue by reviewing the three phenomenal parks in Surabaya, such as Bungkul Park (9,000 sqm), Apsari Park
(5,300 sqm), and Ronggolawe Park (3,900 sqm). Therefore, the object of attraction and its connection with the pathway as a link between the activity zones were considered in this study. Pedestrian linkage, park attractiveness and accessibility refer to the ease of reaching and walking is a form of mobility in the most basic accessibility system. In the walkability system in the park, the elements of movement and accessibility are an essential aspect, which is a connecting tool between park and pedestrian activity zones. It is interesting to discuss the Walkability in these three parks due to the very significant differences between these three park typologies.

3.2. Scope of Analysis

In contrast to urban planning and architecture, urban parks have the elements of a more complex and structured landscape. However, park elements could function as an object frequently defined as a pseudo boundary. For example, there is high vegetation along the pathway, although visitors could still walk across the vegetation to get to a particular place. Nevertheless, this kind of situation presents a problem in determining research boundaries. The purpose of identification is to explore the characteristics of urban parks' spatial configuration that affects pedestrians, focusing on the accessible space for the visitors. A pedestrian path refers to an area designed for people to walk, and in most cases, visitors generally walk on the provided paths. Therefore, the scope of the analysis includes a space function and be limited by the accessibility of people. The following are the limitations of the analysis, which only include the activity zones and the pathways (figure 2).

Figure 2. Boundaries of the analysis of urban parks in Surabaya according to activity zones and pathways. (Top (left): Apsari Park (Right): Bungkul. Down: Ronggolawe)
Source: Author’s Document, 2021

As explained in the Figure 2, parks consist of pathways and activity zones that vary in size and shape to one another. For the reference of this study, the segmentation of the pathways refers to paths that do not have any tracks on them. In other words, when visitors walk across the path, then they must follow the provided path. The basis of the activity zone includes a space that was intentionally designed to accommodate any activities done by the visitors. This zone includes a plaza, playground, skateboard track, futsal ground, and food court. The scope of the analysis can influence how space is defined and potentially enable social interaction. For example, the eastern part of Ronggolawe Park Plaza has vegetation and benches, but these objects can be considered part of the plaza.

The scope must be based on the purpose of the study and the function of the space itself if this study aims to review the behaviour of people walking in urban parks. These activity zones were designed to accommodate human activities rather than walking. Therefore, they should be seen as spaces connecting pathways. That is, each zone would be seen as a compound unit. This is different from the research objective, which explores how park visitors use park facilities, especially the walking hierarchy across sub-areas determined carefully and thoroughly. In this case, the sub-areas were considered as a unit of space for analysis.
3.3. Application of Space Syntax in the Study of Walkability in Surabaya Urban parks

The concept of Walkability measures the ability of humans to move from one point to another in an area or landscape [11]. The parameter used is proximity to distance or permeability. If it is correlated with syntax space, the most appropriate method for conducting spatial configuration research based on the level of permeability is axial and convex analysis [12]. The axial representation used in calculating movement is considered the essential function of the pathway so that movement is represented by a line that connects the entire space.

The first step in applying space syntax is to establish an interpretation and reducing the park layout to several segments. However, vegetation in urban parks brings complexity in producing multiple representations. Therefore, axial and convex maps are less suitable for use on a city park scale, implying that limitations should be set beforehand. Furthermore, the convex map has a few challenges in defining clear boundaries of each activity zone and its relationship. On the other hand, axial maps in terms of vegetation in parks provide a greater degree of visual connection that may conflict with its genuine accessibility. Moreover, the vegetation becomes quite a significant obstacle for identifying barrier objects during the visibility analysis; thus, the researchers ignored vegetation in this study. The section below will discuss and review the designs of the three urban parks in Surabaya.

3.3.1. Convex Analysis

The space in the three urban parks was determined by vegetation and spaces with a high permeability level. These characteristics brought new challenges in interpreting the public sphere and its relationship. This section will discuss the challenges and how to apply convex analysis in the three parks.

In interpreting space and boundaries, we need to determine the unit of scale that will be the scope of our research. As mentioned earlier, spaces of different sizes and shapes were designed for different functions. For example, the activity zone serves as an element of space, while the pathway segment is circulation. These characteristics have become a differentiator with other elements of the city. For example, city streets were designed to meet the needs of human movement; thus, they are seen as multiple spaces.

On the contrary, park features are classified into the scope of activity zones and pathways. Each scope of the pathway was interpreted as a walking space, whereas the activity zone was interpreted as a space for staying and doing activities. The following is an example of pathway and activity zone segmentations interpreted as public spaces.

The boundaries between activity zones were interpreted based on the function of the space itself and its design objectives. Pathways and activity zones have different functions. Therefore, they should be seen as separate spaces and boundaries. For the closest path, the boundaries between them must be determined. For example, if three pathway segments meet at one point, this meeting point should be seen as a boundary. When the visitors are at this meeting point, they will be brought under three different paths and activity zones.

Therefore, the paths and the activity zones must be viewed as two different spaces with boundaries around them even though the two spaces are close to each other. It should be noted that this division involves the subjectivity of the researchers, and its suitability must be evaluated based on the research objectives. Based on the explanations and approaches above, the three urban parks' paths and activity zones were analyzed based on the convex map through DepthmapX (Table 1).
Table 1. Convex map analysis

| Urban Park Name | Link | Global Integration |
|-----------------|------|--------------------|
| Bengkulu Park   | ![Bengkulu Park Diagram]  | ![Global Integration Diagram] |
| Apsara Park     | ![Apsara Park Diagram]   | ![Global Integration Diagram] |
| Ronggolawe Park | ![Ronggolawe Park Diagram] | ![Global Integration Diagram] |

Source: Author’s Document, 2021

Table 2. Summary of park assessment based on convex map analysis

| Urban Park Name | Attributes  | Minimum | Maximum | Average |
|-----------------|-------------|---------|---------|---------|
| Bengkulu Park   | Connectivity| 1       | 2       | 1.6     |
|                 | Integration | 0.35    | 1.05    | 0.63    |
| Ronggolawe Park | Mean depth  | 1.5     | 2.5     | 2       |
|                 | Node Count  | 5       | 5       | 5       |
| Ronggolawe Park | Connectivity| 1       | 2       | 2       |
|                 | Integration | -1      | -1      | 0       |
|                 | Mean depth  | 1       | 1       | 1       |
|                 | Node Count  | 3       | 3       | 3       |

Source: Author’s Document, 2021
The analysis results indicated five activity zones in Bungkul Park, and the northeast is the most integrated part. On the other hand, there are three activity zones in Apsari Park with no integrated section. As for Ronggolawe Park, three activity zones and parts in this park are generally impartial. It must be noted that the pathways and the activity zones have different spatial characteristics and functions. The spatial characteristics of the park did not have much impact on the configuration relationship. Therefore, the same weight was given to pathways and activity zones (table 2).

3.3.2. Axial Map Analysis

The difference between visual and spatial accessibility in parks poses a significant problem in applying axial analysis. This section will address this issue and propose methods for analysing axial maps.

When compared to architecture and urban planning, landscapes provide complete visual access from both subjects, such characteristics affected the mismatch between spatial accessibility and people's point of view. For example, people can see buildings across from a pond, but they do not have direct spatial access to buildings. Under these circumstances, the visual connections in these three parks do not affect their movement directly, so they cannot follow their visual access line. However, at different times, climate change and the addition of vegetation in the park will bring more complexity to the park's visibility. Therefore, if the study explores how people walk in a park, axial lines should be drawn within areas people can walkthrough.

There is an argument about the validity and comparability of axial maps with the fewest lines [13]. Landscapes have the potential to identify several lines that trigger debates. If this research was to identify the walking behaviour of park visitors, the activity zone should be seen as a connection that connects the pathway segments. The activity zone tends to be connected to a pathway.

Thus, the configuration of the intersection provides alternative options with a high level of accessibility for pedestrian, as illustrated in Table 3.

Table 3. Axial map analysis

| Urban Park Name | Axial Map (Local Integration) | Axial Map (Global Integration) |
|-----------------|-------------------------------|-------------------------------|
| Bungkul Park    | ![Bungkul Park](image1)       | ![Bungkul Park](image2)       |
| Apsari Park     | ![Apsari Park](image3)        | ![Apsari Park](image4)        |
| Ronggolawe Park | ![Ronggolawe Park](image5)    | ![Ronggolawe Park](image6)    |
The results above indicate that 12 axial lines can represent Bungkul Park, and the northern part of the park is the most integrated area. On the other hand, Apsara Park was identified presenting the 65 axial lines, and the northern part of the park is the most integrated area. Meanwhile, Ronggolawe Park has 131 axial lines (table 4).

3.3.3. Implementation of VGA (Visibility Graph Analysis)

This method aims to measure the socio-spatial characteristics of open space by mapping the layout into a grid pattern [14]. This method provides a quantitative analysis, modelling, and understanding of how park visitors can use and perceive space [15]. Like the space syntax technique, VGA is based on a graphical representation of the landscape geometry. First, the representative graphics, the garden is articulated into a pattern. Then, the pattern is converted into a graph where each unit represents a grid. The advantage of this method is the visibility analysis which can preserve the geographical properties of the corresponding points. However, when visibility analysis was applied to parks, vegetation challenged identifying objects that block the eye. At the same time, the discrepancy between visual and spatial accessibility was still a matter of debate in determining the area of analysis.

First, objects that obstruct the eyes, such as vegetation or walls, must be initially identified. However, tall objects such as trees and electric poles should not be limited because these objects are likely not to limit the overall human visual. For example, when a person can see the tip of an electric pole, the electric pole should not be considered an object that blocks the visual view. Second, in general, people are directly involved in activities or walk in the park, so the area's visibility directly affects the experience of park visitors. Therefore, the two loci must become the attention of the researchers in the analysis. As a result, objects that have the potential to block people's views must be observed first. These objects, which included building structures and vegetation at the human eye level, were not included. Second, identification of human behaviour in walking in the park towards the activity zone and the path could be concluded that the visibility of places that are not accessible to humans does not affect the experience of park visitors. Third, the visibility of activity zones, park features, and pathways with a parallel view of the human eye was extracted into VGA (Visibility Graph Analysis).

4. Conclusion

This study aims to produce a term of reference for applying the syntax space method in interpreting the spatial characteristics of the urban park, especially those related to Walkability. When we applied syntax space in the park, the scope and boundaries were essential in influencing the analysis results.
In the convex map analysis, the scope and boundaries of the research area must be determined based on the research goals. For example, if the research had a goal to compare the use of pathways that tend to be different, each lane segment should be considered as a scope. Similarly, if a sub-zone of the activity zone is used, it should become part of that zone.

A radical problem often faced in the axial map analysis was determining the axial line representing the activity zone. Different techniques could generate different numbers of axial lines. Therefore, the results will affect the relationship of the park configuration itself. Objects in the activity zone must be considered consistently. This is to ensure that similar rules are enforced.

The purpose of this study is more exploratory regarding the visibility of activity zones and pathways. Nevertheless, the results of VGA (Visibility Graph Analysis) could not be excluded from the analysis. However, the results of the visibility analysis were based on the entire park area, not on the accessible area. In conclusion, if VGA (Visibility Graph Analysis) is limitedly conducted in the inaccessible areas, different results are projected to appear in all parks. Therefore, further studies are encourage addressing the limitation of this study.

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