A reliable method for visibility analysis of tall buildings and skyline: a case study of tall buildings cluster in Jakarta

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ABSTRACT
Visibility is an important factor for decision-making regarding the visual quality of the skyline of modern cities which dominated by tall buildings. The basic method of visibility is referred to the concept of targeted isovist which represents the visible portion of the target area of tall buildings. This paper presents a reliable method of visibility analysis for tall building clusters, examining all unobstructed views of those clusters from surrounding streets and their impact on the shape of skyline, using Jakarta as a case study. The visibility algorithm was developed with Grasshopper and building models were simultaneously simulated using Rhinoceros 3D. The results are presented with a color segment that represents the percentage of visible viewpoints and the visible area of a building’s facade. The results showed that building height configurations, the location of buildings, the relation to the street, and the distances of various viewpoints have a significant effect on the rate of visibility. Moreover, the level of visibility of tall building clusters determines the shape of the skyline. The proposed visibility analysis method is expected to be an essential tool in the planning and design of tall buildings in a clustered organization for shaping the city skyline of the future.

1. Introduction
1.1. Background
As the most prominent part of an urban landscape, tall buildings easily alter the panoramic view of the city skyline. The impact of tall buildings on the environment, urban areas, and sustainability has been discussed by many researchers (Haber 1977; Gonçalves 1997; Lee 2007; Hang et al. 2012; Ali and Al-Kodmany 2012; Cho and Kim 2015). Besides, the visual impact of tall buildings and their skylines have also drawn significant attention (Lim and Heath 1994; Perez and Pazos 2014; Yusoff, Noor, and Ghazali 2014; Samavatekbatan, Gholami, and Karimimoshaver 2015; Czyńska and Rubinowicz 2016). The tall buildings, a building whose height dominates its surroundings, can modify a cityscape and the shape of a skyline. Therefore, it is necessary to consider the compatibility of the building with its surroundings, the visibility of the building from different viewpoints such as main streets, public areas, or other buildings, and the spatial layout of other tall buildings to ensure an attractive skyline. The characteristics of their locations, building height arrangements, and other circumstances need to be considered in a study of visibility analysis. Visibility studies have been utilized for a long time for landscape, architectural, and urban studies to calculate the view of a structure or element in the spatial environment and most of them have been based on two-dimensional (2D) representation (Hanson 1994; Batty 2001; Turner et al. 2001; Garnero and Fabrizio 2015). However, the number of visibility studies of tall buildings was very limited, especially those with three-dimensional (3D) representations.

Modern cities usually have a central business district or mixed district that contains a group of tall buildings. It is a challenge for the designer to strengthen the skyline by creating focal points that will be visible from all directions. Focal points in the vertical dimension created by tall buildings may provide visual references that improve spatial orientation and navigation. Furthermore, the more visible a building is, the memory of the place becomes stronger (Appleyard 1969).

The impact of a tall building in modern cities is significantly greater than that of an ordinary scale building. By virtue of their size and widespread visibility, such buildings have the potential to have a great impact on many different aspects, such as environment, sustainability, and the skyline. Modern cities with clusters of tall buildings often afford wide visibility from all directions. Therefore, the placement and construction of tall buildings should be carefully planned to showcase visibility and retain the city skyline. This paper elaborates on the visibility analysis using the new method and discusses the findings of the analysis. For this purpose, a group of tall buildings in the city center of Jakarta was selected as a case study. The analysis is carried out from different viewpoints, which is essential to determine the skyline of Jakarta.
1.2. Objectives of the research

The primary objective of this research is to propose a visibility analysis method to assess the visibility of tall buildings cluster by evaluating their visual quality on the skyline. In order to reach this objective, we develop an algorithm to analyze the visibility of 3D building models of tall buildings cluster. The algorithm was created with Grasshopper, one of the most widely used programs by designers, which can be integrated with Rhino 3D modeling tools and supported with parametric environmental plugins. Ladybug is an environmental analysis plugin that has the ability to simulate visibility analysis in a parametric environment. To our knowledge, there is no research that examines the combination of the aforementioned tools in an integrated visibility analysis of tall buildings and skylines.

This objective helps us to determine the design factors for designing tall buildings cluster by comparing the visibility of two tall buildings cluster in the city center of Jakarta. For example, the form of the cluster, the arrangement between tallest and other taller buildings within the cluster area, and the strategic location of the cluster area and viewpoint might have an impact on their visibility and the skyline.

2. Jakarta’s tall building development

Jakarta experienced rapid growth and development during the last decade, which has radically transformed the urban landscape. The urbanization process in Jakarta has transformed a vast area of former agrarian settlements and lower structures into the world’s ninth-largest city with extensive tall building construction (Strange and Dobrowolski 2016). New settlement typologies such as the apartment were introduced to distinguish the urban elite from the urban majority, along with other formal development projects such as office towers, shopping malls, mixed-used buildings, and elevated highways. Tall building development has occupied a large area in urban space and has placed irregular footprints over much of Jakarta. These buildings are concentrated exclusively in the Sudirman-Thamrin corridor, along Gatot Subroto, and Rasuna Said streets. The so-called “Jakarta Golden Triangle,” where the major administrative, commercial, and financial centers and luxurious housing estates, condominiums, and hotels have significantly changed both the appearance and the spatial order of the metropolis.

There are two areas within the Jakarta golden triangle where many tall buildings are gathered, the Sudirman Central Business District and Mega Kuningan (Figure 1). These development areas have been designed to ensure that people can have all the amenities within the complex to increase the efficiency of urban land-use and to prevent traffic jams. This concept has been the trend from planners and developers, particularly in Jakarta, which has heavy traffic. Under these circumstances, the inclusion of residential apartments integrated with offices, hotels, and recreational facilities within a single urban block project strengthens their position in the property market and economy (Kenichiro 2001). Geographically, Jakarta’s tall building clusters are located in the center of the

![Figure 1. Sudirman central business District and Mega Kuningan within Jakarta golden triangle area.](image-url)
city with a low topographic profile, surrounded only by man-made structures without any natural landscape features such as hills or mountains. However, the attractive view of tall buildings can be seen as a catalyst to improve the quality in the surrounding area. It should be controlled carefully so that beneficial visual, function, and environmental qualities can be optimized (Prasetyoadi 2011). The visual aspects of Sudirman Central Business District and Mega Kuningan area also need to be studied as related to the architecture, planning, and urban design context.

3. Visibility: the concept of an Isovist

Visibility has been studied in several distinct fields of research, such as landscape, environmental, urban, and architectural studies for many decades. Recently, visibility analysis has been extended from a two-dimensional to a three-dimensional approach, and Yang, Putra, and Li (2007) have verified that 3D visibility indices are more effective than 2D indices. The popular technique for undertaking visibility analysis in architecture and urban space is the concept of the “isovist,” and for terrain and landscape studies it is the concept of a “viewshed.” Isovist was used as a basic concept that corresponds with the context and the purpose of this research.

Isovist, defined as the spatial environment space representing the visual field from a vantage point, was originally presented by Tandy (1967) in the field of landscape studies and first conducted in architectural studies by Benedikt (1979). Isovists could be represented in a two-dimensional or three-dimensional model for quantifying the visible space, the resulting isovists in a single polygon representing the total of all visible volume and space from a specific location. As shown in Figure 2, the visible space, isovist $V_x$, has been generated from the set of line segments joining the vantage point $x$ and radiates out from $x$ to the boundary-point $v$.

Most previous research in visibility analysis employs the isovist to calculate the viewing capability in all directions. Conversely, several recent studies have taken advantage of isovist methods to generate a limited capability of human vision or the visual field from a vantage point related to the context or specific direction view, such as a landmark, park, etc. According to the purpose direction of the view from the origin point, the geometry of isovist can be distinguished as panoptic, constrained, and targeted (Lonergan and Hedley 2016).

Panoptic isovist is the capability of viewing a 360° angle in all directions from the origin point with an omnidirectional gaze (Figure 3 (a) and (d)). The concept of the panopticon, derived from Jeremy Bentham’s theory, is a building structure with an origin point able to view all directions (Semple 1993). Panoptic isovists are commonly used to assess the visual openness from all angles at once. A well-known application of panoptic isovist concept is controlling crime in a city by using a complex closed-circuit television (CCTV) in a public space (Fyfe and Bannister 1996).

Viewpoints that have a limitation in viewing direction, such as human vision, can be described as constrained isovist (Figure 3 (b) and (e)). An example of the use of a constrained isovist can represent the potential of the viewpoint of a camera to capture a landscape object or fixed-location CCTV camera with a limited view and direction to the room. The visibility relationship between the observer and observed objects might be used to describe the capability to view in all directions or limited angles, and also for some specifically targeted object. The targeted isovist only represents the visibility of target geometry and cannot visualize all space that an observer can see (Figure 3 (c) and (f)). It only shows the visible portions of the target space and the gaze path between the observer and the target space. The shape of a target space can be a point, area, or volume.

4. Method

There are many studies in architecture and urban space analysis using isovist to measure the visibility of the spatial environment for such locations as

![Figure 2](image_url)

Figure 2. (a) The area of isovist $V_x$ visible from the vantage point $x$. (b) The radials of line segments joining the vantage point $x$ to the boundary $v'$. 
rooms, streets, buildings, or open spaces (Batty 2001; Turner et al. 2001; Morello and Ratti 2009; Lonergan and Hedley 2016). These studies show that the concept of an isovist can be applied to dividing private and public rooms, predicting the impact of a building on an urban form, calculating the visible area from a street or city square, or for other purposes that use visibility analysis to interpret a discerned object and space in the spatial environment.

Other recent studies have applied similar ideas of visibility to the analysis of tall buildings. Various methods for performing visibility analysis of tall buildings have been developed recently. Rød and van der Meer (2009) used GIS-aided visibility analysis to assess the visual impact of a planned high-rise building. Based on the distance to the building, dominance can be measured as the level of visibility of the building from any observation point. The role of tall buildings in a cluster can be perceived visually as the visual coverage and cumulative visibility of tall buildings in GISc-based-visibility analysis (Van der Hoeven and Nijhuis 2012). Karimimoshaver and Winkemann (2018) also introduced ArcGIS to calculate the visibility on the single tall building by means of the measurement of the ratio of the visible area of the building to the visual field.

The aforementioned programs are standalone applications that do not support 3D modeling (Koltsova, Tunçer, and Schmitt 2013) to visualize the visibility result in three dimensional. Moreover, it is known that GIS work on the previous study was operated in 2D. The current program is hard to offer solutions for advanced 3D spatial analysis commercial and needs to improve the inability to deal with structures such as building with any precision (Bishop 2002; Guney et al. 2012; Lonergan and Hedley 2016). 3D simulation is important in the visibility analysis of the verticality of tall buildings because of adding the vertical dimension, the field of view can be seen from a vantage point with a circular rotation and from the ground to the sky. It can provide the insight of more real-perceived volumes in a 3D space. Based on the 3D isovist method, Czyńska and Rubinowicz (2016) provided the visual impact size (VIS) to identify how much is visible of the planned tall building from all locations in the city. However, the analysis program to perform VIS method was developed by C++, and up to now, the executable program is not commercially available. Reproducibility of program language might be difficult for the architect to apply due to the short deadline during the design phase and their limitation of programming language skills.

Due to the aforementioned limitations, this research proposes the analysis tool for visibility study using Grasshopper and Rhino 3D that expected to be user-friendly and able to present the analysis in three-dimensional models. This comprehensive tool allows for geometric creation, simulation, and visualization within one interface (Roudsari, Pak, and Smith 2013). The features in the proposed method are providing several advantages for architects and designers in tall buildings visibility analysis, either in the design phase or evaluation of existing tall buildings. The step of visibility analysis method by Grasshopper and Rhino as follows.

**Step 1: Selection of tall buildings area and data compilation**

There are tall buildings clustered in the central business district and mixed-district in Jakarta city, the
Sudirman Central Business District and Mega Kuningan. The location of those buildings is strategically located within the golden triangle of Jakarta with a low topographic profile. The developers chose those areas to develop the premium-class tall buildings corresponding with their vision. The growth of tall buildings will increase their impact on all aspects, including the visual aspect. The object to be analyzed are the buildings with more than 100 meters in height, typically defined as a tall building. The architectural height and the location were derived from the CTBUH and Emporis database.

Step 2: 3D Buildings model

The tall buildings in the Sudirman Central Business District and Mega Kuningan areas were modeled using Rhino 3D. The data map of the location, which has been transformed from Open Street Map, includes topography that has been neatly organized into computer-aided design (CAD) files. Buildings have then been erected over terrain in accordance with its building elevation data. Each building geometry was created as a surface, so it can convert into a brep (composition of multiple surfaces) for the input component in Grasshopper. These building models were then shading in different colors to mark their elevation (Figure 4). The precision of tall building modeling was confirmed using direct field visits, aerial photography, and the lasts Google street view images.

Step 3: Visibility analysis

The visibility analysis uses Grasshopper as a tool that connects with Rhino 3D. This platform supports an interactive operational setting between the analysis and 3D modeling. Ladybug component was used in Grasshopper to evaluate the visibility of building geometry from a set of viewpoints. The specification of viewpoints is where an examination of tall buildings can be viewed from the ground level (street). Tall buildings and their skyline shape that views from the street can provide information about how the city is organized and as the lead directions within the city (Attoe 1981). Therefore, the first vision to the tall buildings was obtained from the height of the human eye-level set at 1.5 m above the ground level. The second vision is that from which the skyline can be experienced, that is, from high vantage views with the assumption that the observers were viewing from a height above 100 meters. The latter can be viewed from the building's floor, observation deck, or a camera drone.

In Figure 5, a set of viewpoints are generated from a curve that represents the line of the street and divided to create 3 points of intersections. Then, the position of coordinate ‘r’ of these three points is set in 1.5 meters on first vision and 100 meters on the second vision. The reason for placing the three viewpoints on each street is to find the most precise results and the position with the most visible viewpoint on that street.

In accordance with the street that surrounds the cluster area, the distance to the area of tall buildings cluster in Sudirman CBD from street #1 is 478 m, from street #2a is 905 m, and the distance to the area of tall buildings cluster in Mega Kuningan from street #2b is 667 m, from street #3 is 802 m, and from street #4 is 599 m.

![Figure 4. 3D representation of tall buildings in Sudirman Central Business District and Mega Kuningan areas.](image)

![Figure 5. The algorithm to set the position of viewpoints.](image)
Figure 6 shows the algorithm of visibility analysis using the Ladybug ‘view analysis’ component. The algorithm requires the following inputs of geometry, context, and viewpoint:

1) Geometry, the 3D building models that will be tested for visibility analysis and have been created in Rhino. The concept of targeted isovist is used to represent the relationship between the observer and the target geometry, i.e., tall buildings.

2) Context, the geometry that could block the view from the viewpoint to the buildings. We input the same building geometry that acts as a building tested for visibility and acts as a visual barrier.

3) Viewpoints are set points from the main streets around the building areas to achieve the highest degree of reliability and to discern which street has the most buildings in view.

Some of the input parameters, such as grid size and distance from the base, are also arranged in a small number to achieve an accurate visibility analysis of the test geometry.

The outputs of the analysis that we use to generate into data are view study result, view study mesh, average view, and pt is visible. Several algorithms are needed to process these outputs (Figure 7). The ‘Mesh Threshold Selector’ component was used to determine how much the areas of the buildings are visible (Figure 7 (a)). The output of view study result should be connected to the input of the analysis result and the output of view study mesh should be connected to the input mesh so that the result of visible area can be obtained. We also input the level of perform to find out how much area that only visible by one viewpoint (level of perform set in 67%), visible by two viewpoints (level of perform set in 34%), and visible by all viewpoints (level of perform set in 0%). In Rhino, the level of the visible area of 3D building models is presented in

![Figure 6](image1.png)

*Figure 6.* The input parameters of Ladybug view analysis component.

![Figure 7](image2.png)

*Figure 7.* (a) Algorithm for the visible area by ‘Mesh Threshold Selector’ component (b) Algorithm for the percentage of visibility from each viewpoint.
a different color. The most visible area of the building façade from the street is marks blue, the worst visible is marked in yellow, and red marking indicated no visibility. Furthermore, the percentage of visible view from each viewpoint can be obtained by changing the output of ‘view analysis’ component (pt is visible) with some algorithms as shown in Figure 7 (b).

**Step 4: Cross-section representation**

The 3D visualization analysis results can be presented in a cross-sectional display of buildings. This cross-sectional display shows the structure or shape of the skyline. Through this, the composition between the high area as a focal point and the transition to the lower-scaled buildings as visual relief can be observed. A cross-sectional representation was drawn from the viewpoints that have high-quality visibility.

### 5. Findings

This research compared the visibility analysis of tall buildings in the Sudirman Central Business District and Mega Kuningan areas. The level of visibility from viewpoints and the average view from streets to the Sudirman Central Business District and Mega Kuningan are presented in Figure 8 and Table 1. In this research, the visibility of tall buildings in a cluster related to their skylines was investigated and their visible area was calculated using Grasshopper. The analysis only calculates the inter-visibility between observers to the tall buildings that unobstructed by other tall buildings within a cluster. Based on the visibility analysis results, we can observe the most visible viewpoint to see the buildings.

In the case of the Sudirman Central Business District area, from two streets where the viewpoints are tested, the results show that the average view of the tall buildings from street #2a has a higher than from street #1. Specifically, the buildings in Sudirman Central Business District viewed from street #2 can be more visible if seen from viewpoint 3 (vp2a-3). On the other hand, street #1 which has a lower average view is caused by the height of the building in the front line of the observer’s distance is relatively close.

Furthermore, if the observer moves along street #2b and turns to street #3 and street #4, they can experience the view of tall buildings in Mega Kuningan area. The result shows the average view of the buildings in Mega Kuningan is high from street #3 with a high visible viewpoint from vp3-2 then followed by street #4 from vp4-3 and street #2b from vp2b-3. The viewpoints which have a lower percentage of view are vp2b-1, vp3-3, and vp4-2.

![Figure 8. The visible viewpoints to the buildings from the ground and a high vantage view.](image)

| Area | Sudirman CBD | Mega Kuningan |
|------|--------------|---------------|
|      | Street #1 | Street #2a | Street #2b | Street #3 | Street #4 |
|      | Jend. Sudirman (Vp1) | Jend. Gatot Subroto (Vp2a) | Jend. Gatot Subroto (Vp2b) | H.R. Rasuna Said (Vp3) | Prof. Dr. Satrio (Vp4) |
| Percentage view: | 13.2 | 10.4 | 9.4 | 20.3 | 18.2 |
| Viewpoint 1 (%) | 7.1 | 14.7 | 14.6 | 22.0 | 14.5 |
| Viewpoint 2 (%) | 11.4 | 17.0 | 20.3 | 17.7 | 19.0 |
| Viewpoint 3 (%) | 10.57 | 14.03 | 14.77 | 20.00 | 17.23 |
| Average view (%) | 322,228 | 355,084 | 198,622 | 237,975 | 229,069 |

*Visible area from; all viewpoints*
Another result from a comparison between the visibility of buildings in Sudirman Central Business District and Mega Kuningan can be seen from the color segment of the percentage of visible viewpoints. Table 2 shows the view quality of tall buildings in both tall buildings’ clusters from all three tested viewpoints on each street. The images are presented in the elevation perspective view and cross-sectional display. These images were obtained from the visibility result of all viewpoints from the ground. The green and blue colors indicate that the visibility of the building can be seen by two to three viewpoints and the yellow is visible from one viewpoint. The average view from the street #2a to the tall buildings in Sudirman Central Business District and the average view from the street #3 to the tall buildings in Mega Kuningan is higher than the

Table 2. The quality of tall buildings cluster from the visibility result of all viewpoints from the ground.

| Location              | Street | Viewpoint | Perspective View | Viewpoint | Elevation | Visibility | Percentage |
|-----------------------|--------|-----------|------------------|-----------|-----------|------------|-------------|
| SUDIRMAN CBD          | #1 Jend. Sudirman | Vp1-1 | (13.2%) | Vp1-2 | (7.5%) | Vp1-3 | (11.4%) |
|                       | #2a Jend. Gatot Subroto | Vp2a-1 | (10.4%) | Vp2a-2 | (14.7%) | Vp2a-3 | (17.0%) |
|                       | #2b Jend. Gatot Subroto | Vp2b-1 | (9.4%) | Vp2b-2 | (14.6%) | Vp2b-3 | (20.3%) |
|                       | #3 H.R. Rasuna Said     | Vp3-1 | (20.3%) | Vp3-2 | (22.01%) | Vp3-3 | (17.67%) |
|                       | #4 Prof. Dr. Satrio      | Vp4-1 | (18.2%) | Vp4-2 | (14.5%) | Vp4-3 | (19.0%) |

Location: Jakarta  Tested viewpoints: 3 VP/Street  Viewpoint height: 1.5 meters  Visibility level of buildings surfaces:  
- green: visibility seen viewpoints  
- blue: low visibility -1 viewpoint  
- yellow: medium visibility -2 viewpoints  
- purple: high visibility - all viewpoints
other. This is indicated by the area of the buildings that can be seen from two to three viewpoints on the street. Different from the view from the street #1, only a few buildings can be seen by two to three viewpoints, almost of tall buildings in Sudirman area only visible by one viewpoint. The reason is that the tall buildings in Sudirman area are close to the street #1.

From the presented color, the quality of the focal point of the tall buildings cluster has been obtained. The highest part of the cluster is identified as the focal point of the tall buildings cluster. It can be seen in the cross-sectional display, from all viewpoints, the focal point of the cluster in Mega Kuningan is clearly more visible than in Sudirman.

The analysis of the second vision is from high vantage views with heights above 100 meters. From the results in Table 3, the highly visible viewpoints are significantly not different from the analysis of the first vision (the ground), which is from street #3 (vp3-2) in Mega Kuningan and street #2a (vp2a-3).

Based on the visible viewpoints, the shape of the skyline can be observed. Table 4 presents a comparison of skyline variation in two areas of study. The skyline of Sudirman Central Business District and Mega Kuningan, see from the most visible viewpoint (street #2a and #3), respectively, shows that the building height transition is dropping away from the highest point of the skyline. While tall buildings are seen from other streets (street #1, #2b, and #4), which have lower visibility, the skyline shape shows an irregular transition between large-scale buildings and small-scale buildings. Moreover, some of the buildings that have a similar height and stand closely make a monotonous part of the skyline. The gradual transition and variation of buildings height are required to create the skyline looks more attractive (Al-

### Table 3. The percentage view of tall buildings in Sudirman CBD and Mega Kuningan from high vantage view.

| Area       | Sudirman CBD | Mega Kuningan |
|------------|--------------|---------------|
|            | Street #1 Jend. Sudirman (Vp1) | Street #2b Jend. Gatot Subroto (Vp2b) | Street #3 H.R. Rasuna Said (Vp3) | Street #4 Prof. Dr. Satrio (Vp4) |
| Percentage view (%) | 14.6 | 11.5 | 16.5 | 21.6 |
| Viewpoint 1 (%) | 9.5 | 16.6 | 24.2 | 19.6 |
| Viewpoint 3 (%) | 13.4 | 17.5 | 20.9 | 20.9 |
| Average view (%) | 12.50 | 15.67 | 21.67 | 19.57 |
| Visible area (m²) | 359,800 | 381,164 | 218,020 | 253,744 |

1Visible area from all viewpoints

### Table 4. Variety of the skylines of tall buildings cluster in Jakarta viewed from a significant viewpoint on streets around the cluster.
Kodmany 2012). This work shows that the viewpoints vp2a-3 and vp3-2 are the best positions for observers or visitors to explore Jakarta skyline both from the ground and high views.

6. Discussion

In this research, the visibility study as an important factor regarding the visual quality of tall buildings cluster on the skyline was analyzed using Grasshopper. The method has been proposed to evaluate the design of tall buildings cluster related to the context by their visibility. The design factor of tall buildings cluster can be determined through the study cases of two central areas of tall buildings cluster in Jakarta.

Several previous research has analyzed the visibility study of tall buildings in their impact on the skyline and offered in various methods. Most of these studies only analyzed a single tall building or a collective of single buildings that geographically dispersed. Whereas the analysis on the group of tall buildings in a specific area also important since they have a greater impact on the skyline. The design quality of tall buildings cluster can be determined by visibility analysis presented in this research. The method presented in this research can be a new way to examine the existing and proposed design of tall buildings cluster, in regard to improve the skyline of the city. This method is reliable, simple, and easy to use for architect to analyze the visibility of tall buildings.

Based on the analysis results, the influence of some factors such as distance, the arrangement of building heights, the layout, and the location of buildings from the street determined the quality of the view. This analysis identifies a viewpoint to see the buildings as much as possible related to the configuration of the building’s position. The distance of viewpoint to the buildings was relatively far to obtain the best visibility of the buildings in both Sudirman Central Business District and Mega Kuningan. Although there is a viewpoint with a greater distance, it cannot be considered to be visible if there are many buildings outside the visual cone or blocking other buildings behind. In one line of sight, the buildings with higher facades that are located behind other buildings can still be visible from the viewpoint. However, that does not mean the building-scape in this area can only be visible from one street side. It is still possible to be seen by the observer from any direction even with low visibility.

Tall buildings that spread out from the cluster to the street edge or merge with neighboring clusters may hurt the visibility quality and the area’s identity. Thus, it is better that tall buildings should be confined to a circular or square area so that it will be clearly identifiable and appear as a cluster from all directions. For instance, tall buildings in Mega Kuningan are placed far from the edge of the city’s main street with a circular layout. It allows buildings to be visible from the street and recognized from the different angles.

Moreover, the focal points created by grouping tall buildings into cluster intensifies the skyline and provides a focused attention. Hence, the visibility of focal point from any vantage point is important. The focal point can be identified from the visibility of the highest buildings among other tall buildings within the cluster. The top of the building is the part that must be visible enough to provide the visual references of the significant places and landmarks.

7. Conclusion

The proposed method is mainly using Grasshopper and integrated with Rhino 3D for modeling the tall buildings. The use of Grasshopper tools allows for an analysis of the buildings geometry, algorithmic simulation, and visualization of the result within one interface. This method reveals itself to be particularly efficient for visibility analysis on specific views or vantage points by using the Ladybug plugin. It is clear that the level of visibility of tall buildings impacts the form of the skyline. The method presented in this research can be a new way of planning tall building construction singly or in a group in terms of analyzing visibility and the skyline in the city.

The analysis result by using this method can inform the final strategy which describes the consideration of the design of tall buildings cluster which proposed to minimize the negative impact of development on the existing skyline. A skyline that is shaped by the height of tall buildings in a cluster should drop down from the highest part to the periphery. This configuration always has high visibility and helps mediate with the surrounding lower heights. Tall buildings should vary their height to add to a lively and diverse skyline and to avoid a uniform or repetitive response to the skyline. The ordering of building heights should conform to a vision cone to maximize visibility. Tall buildings proposed outside a cluster can weaken its strength and the legibility of the skyline.

The main purpose of this method was to assess the concept of the tall buildings within the city’s center in terms of visibility and their contribution in forming the city’s skyline. This research focuses on tall buildings within a group and their view from the street and high vantages. Although this research is adequate to evaluate the visibility of tall buildings and the skyline of which they are a part on existing buildings, this method certainly can be used during the design phase to propose buildings in a cluster to cultivate a highly visible view from all directions and
enhance the skyline. Although the observer’s targeted view is tall buildings, further work on the application of the proposed visibility analysis tool can be expanded to the effect of other circumstances to the tall buildings. The other circumstances that recognized in the visual field, such as waterfronts, trees, or open spaces, can act as visual obstacles and interrupt the visibility of tall buildings or it may act as a visual relief to the observer.

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