都市構造分析による都心部のインフォーマルセトルメントの類型化： スラバヤのカンポンのスペースシンタックス研究

ナスティオン, タンティ
九州大学大学院人間環境学府都市共生デザイン専攻

黒瀬, 武史
九州大学大学院人間環境学研究院

https://doi.org/10.15017/7337584

出版情報：都市・建築学研究. 47, pp.1-13, 2025-01-15. 九州大学大学院人間環境学研究院都市・建築学部門
バージョン：
権利関係：

都市・建築学研究　九州大学大学院人間環境学研究院紀要　第47号，　2025年　1月
J. of Architecture and Urban Design, Kyushu University, No. 47, pp. 1～13, Jan. 2025

都市構造分析による都心部のインフォーマルセトルメントの類型化：スラバヤのカンポンのスペースシンタックス研究

A Typology of Inner-City Informal Settlements through Urban Structure Analysis: A Space Syntax Study of Kampung in Surabaya

ナスティオン　タンティ、黒瀬 武史
Tanti S.R. NASUTION*and Takefumi KUROSE**

This study analyzes the spatial morphology of inner-city informal settlements, or kampungs, in Surabaya, Indonesia, using space syntax. By examining 16 kampungs, the research evaluates their accessibility and structural complexity through Normalized Angular Integration (NAIN) and Normalized Angular Choice (NACH) metrics. The kampungs are grouped into four typologies based on their spatial configurations, revealing varying potentials for commercial development or residential preservation. The findings highlight the importance of integrating spatial characteristics into urban planning to manage the risks and opportunities these settlements face, especially in balancing their socio-cultural value with growing commercial pressures.

Keywords : Inner-city, Informal settlement, Space Syntax, Urban Analysis
都心部、非公式居住地、スペースシンタックス、都市分析

1. Introduction

Informal settlements are an inseparable part of cities in developing countries. They are home to workers and people of all income levels. Informal settlements are often associated with slums and squatter settlements. However, informality is not confined to a place of poverty; just as every economy has a formal and informal sector, so does every city [1]. Informal settlements are those urban districts that have developed outside state controls over urban design, planning, and construction. The dominant modes of informal production are incremental and self-organized – an informal settlement is generated from many very small practices [2]. Informal settlements accommodate at least a billion people worldwide (UN-Habitat, 2006). In Indonesia, a prominent form of this informal settlement is an urban kampung. In the 1970s, kampung housed 63% of the city inhabitants while occupying only about 7% of the city area of Surabaya, the second-largest metropolitan of Indonesia [3], [4]. The role of kampung is also extended to provide affordable housing for migrant workers, especially in the city centers where jobs and opportunities are available.

The study of informal settlement has been expansive and covered various fields, from sociology, economics, and urban studies to health and politics. These studies mostly explored how the inhabitants and their living environment created a particular relationship within their limited spatial context. Several recent urban studies have developed studies around the body of knowledge on the morphologies and morphogenesis of informal settlements. Dovey et al. [5] attempted to understand the morphogenesis of informal settlements to clarify how informal settlements become slums and that informal settlement is already a form of upgrading unutilized or unurbanized land into habitable neighborhoods. Hutama [6] related the organic spatial layout of a kampung in Jogjakarta to the neighborhood's vibrancy. Husin et al. [7] explored the

*Doctoral Program in Urban Design, Department of Urban Design, Planning and Disaster Management Kyushu University
**Department of Architecture and Urban Design, Faculty of Human-Environment Studies, Kyushu University

pattern of informal architecture of kampungs in Jakarta and how the articulation of space suggested the distribution of activities. Questions about how kampung was formed and developed over time also raise concerns about how kampung will be in the future based on its morphology. Therefore, this research attempted to investigate the morphology of kampungs through spatial syntactic measures and how the street configuration reflected the potential or the problems it could bring to a kampung.

2. The Current Planning and Situation of Inner-City Kampungs in Surabaya

Surabaya has been considering kampung as a part of its urban heritage since the earliest design of its modern master plan in the 1960s. The document also mentioned kampungs' role in providing housing for the citizens and migrant workers (Surabaya Municipality, 1966). Kampung Improvement Program (KIP) transformed kampungs into livable areas (Silas, 1992). The recent master plan, formulated in 2014, also recognized kampungs as high-density housing (Figure 1).

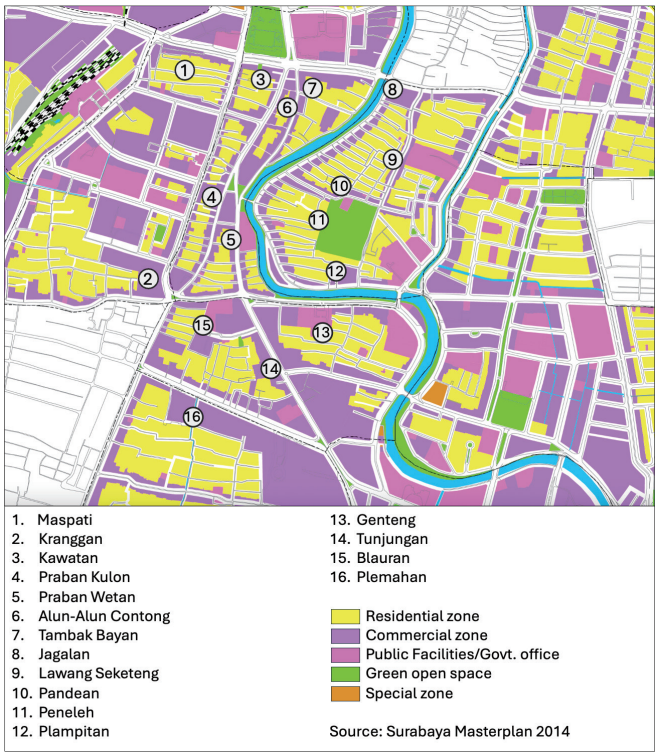


Figure 1 Current zoning plan of Surabaya (Source: Surabaya Master Plan 2014-2034)

The inner-city kampungs were also included as a heritage area, which ensured its protection. However, the current city plan does not address the urban structural characteristics of the district and the risks it creates. It should be realized that there are inner-city kampungs where the commercial area dominates the residential area, for example, Kampung Kawatan (3), Kampung Praban Wetan (4), Kampung Praban Kulon (5), and Kampung Alun-Alun Contong (6). Other kampungs, such as Tunjungan (14) and Plemahan (16), were at risk of encroachment since they were already in close proximity to large commercial facilities.

The inner-city kampungs of Surabaya are in various conditions. Several kampungs are facing vacancy, while the others are well-maintained. Figure 2 illustrates the spectrum of this kampungs' condition in the inner-city area. Many factors contribute to this situation, one of which is the encroachment of commercial activities. While some kampungs are struggling with this issue, more are also thriving [8]. However, the current research on the vulnerability of kampungs are limited. Shirleyana [9] explored the issue through the lens of disaster vulnerability, while Tauran [10] visited the issue of land tenure in Surabaya. Although these researches have addressed essential issues about the vulnerability of kampungs, it is also necessary to see how the morphological dimensions also play a role.

Figure 2 Different conditions between two different inner-city kampungs

3. Methods

This research applied space syntax analysis because it enables the measurement and comparison of syntactic qualities among several studied areas. A Road Center Line (RCL) map was

chosen because it has the potential to foster improved space syntactic measures through the success of a combined road-center line model analyzed using angular weighted betweenness within a metric radius [11]. The automated OSM RCL models capture and preparation with good ASA performance also facilitate more standardized and rapid city space syntax analysis [12]. The RCL map was cleaned and simplified prior to its use, as suggested by Kolovou et al. [13].

In DepthmapX, this map will be transformed into a segment map and used to analyze syntactic measures such as connectivity, integration, and choice. The measures taken in this study were Normalized Angular Choice (NACH) and Normalized Angular Integration (NAIN), which will be used to calculate the Z-Score, the NAIN mean, and the NACH Score. The Z-Score will be used to prepare the four-point star model. The NAIN mean and the NACH Score are processed in SPSS for hierarchical clustering. Figure 3 represents the research step by step.

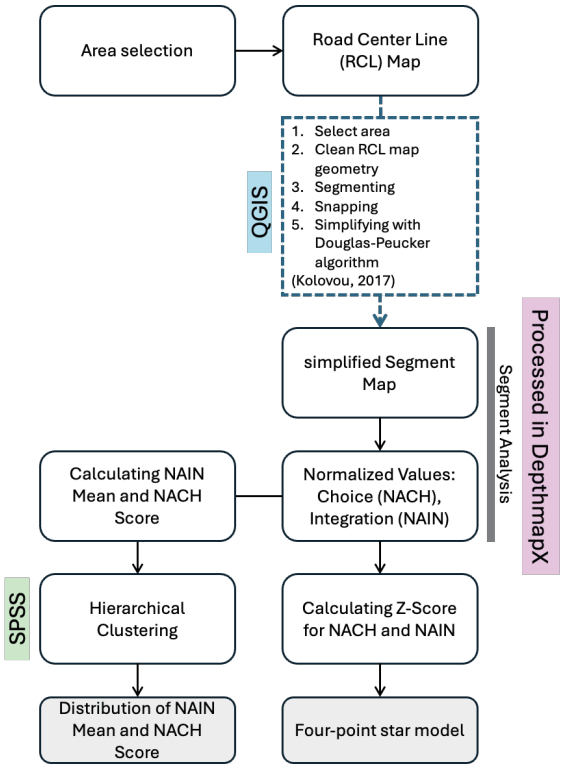


Figure 3 Research Framework (Source: Authors, 2024)

3.1 Area Selection

Observed areas were selected from several criteria. In this research, the observed kampungs were inner-city kampungs. From the literature study [14], [15], [16], inner-city kampungs comply with these conditions:

a. It consists of one neighborhood
b. The kampung existed before or during the colonial occupation
c. It is located around the city center's commercial area and possesses a high density.

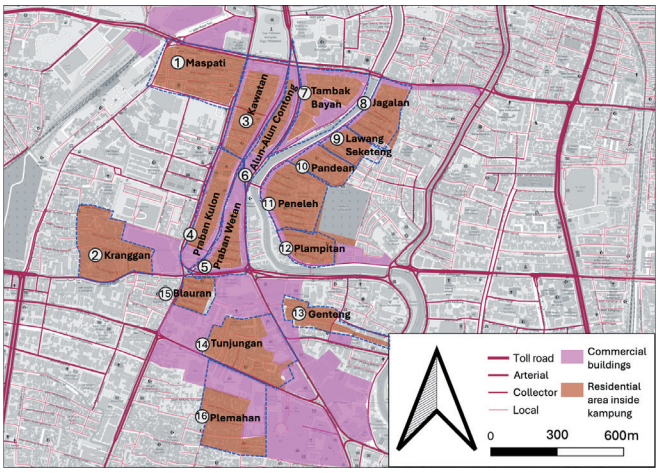


Figure 4 Surveyed kampungs location (Map source: Open Street Map, edited by Author, 2024)

The map shown in Figure 4 illustrates the location of surveyed inner-city kampungs. These kampungs are located around the arterial and collector streets and are surrounded by commercial facilities. Kampungs like Tunjungan and Plemahan are close to one of the most extensive commercial facilities, Tunjungan Plaza. Other kampungs in the northern part, such as Maspati, Kawatan, and Alun-Alun Contong, are situated in the arterial streets of Surabaya. Around these streets, commercial facilities such as markets, shopping centers, and storage buildings were built because of their proximity to the train stations and harbor.

3.2 Space Syntax Analysis

The use of Space Syntax for urban studies has enabled researchers to understand the spatial structures of the city and the importance of the relations between the social and spatial aspects of the city. Space syntax analysis involves the syntactic properties of a city model and is represented through the map. The key is how each part of a network is integrated into a more extensive network. From this, several syntactic measures can be obtained. For example, integration is a measure of distance from any space of origin to all others in a system. Meanwhile, connectivity measures the number of spaces immediately connecting a space of origin. Another measure, such as choice, measures how likely an axial line or a street segment is to be passed through on all shortest routes from all spaces to all other spaces in the entire system. These

measures enable the understanding of how accessible a place is and how one place is in synergy with the other.

3.2.1 Normalized Angular Choice (NACH) and Normalized Angular Integration (NAIN)

In Space Syntax theory, Normalised Angular Integration (NAIN) and Normalised Angular Choice (NACH) are important measures used to evaluate spatial configuration, especially in urban environments. These metrics aid in understanding movement patterns, accessibility, and the overall functioning of spaces by examining how different locations are interconnected through angular distances.

NAIN measures how easily a space can be reached from other spaces in the system, taking into account angular changes between paths. It indicates global integration and is based on the idea that spaces with fewer angular turns are easier to access [17]. NAIN is derived from Angular Integration (AI), which calculates the total angular change required to travel between all pairs of nodes in a system. By normalizing this measure, NAIN allows for comparing spaces across different spatial systems or scales, making it easier to identify highly integrated areas. Spaces with high NAIN values tend to be central and attract more movement because they are more accessible from other parts of the system [18]. In urban studies, NAIN is often used to assess the permeability of street networks and predict the flow of pedestrians and vehicles [19].

On the other hand, NACH measures the degree to which a space functions as a through-route or "choice" space in the system. It evaluates how often a space falls on the shortest paths, or least angular distance routes, between all other pairs of spaces in a network. NACH reflects the likelihood of a space being used for through-movement, serving as a proxy for spatial centrality or prominence [11]. Spaces with high NACH values are critical in connecting different parts of the system and often serve as major thoroughfares or commercial hubs [19]. Like NAIN, NACH is also normalized to account for variations in network size and complexity, facilitating comparisons between different environments. NAIN and NACH are crucial in understanding spatial dynamics within urban planning and architecture. While NAIN focuses on how easily a space can be reached, NACH highlights the importance of spaces as movement corridors. Together, these metrics provide a comprehensive view of the functionality of spatial layouts, helping urban planners design more efficient, accessible, and navigable environments [20].

3.2.2 NAIN Mean and NACH Score

Hillier et al. [19] mentioned that both NAIN and NACH could be used to represent the foreground and background structure of a city. Furthermore, they can explain the implications of those values regarding the planning process through the relationship of these values. Friesen [21] summarized these implications in his taxonomy of settlement as shown in Table 1.

Table 1 Taxonomy of settlements [21]

	Local-to-global Planning (Low NACH Score)	**Global-to-local planning (High NACH Score)**
Micro-economic priorities (High mean NAIN)	• Both foreground and background networks maximize random contact. • Background network clustered around a well-integrated foreground network. • Foreground network deformed by the exigencies of the background network's development. • Dense patterns in the city's background network reflecting culturally specific preferences for the mixing or segregation of social categories.	• Highly structured grid, tending in most cases towards orthogonal order. Little deformation of background or foreground networks.
Socio-cultural priorities (Low mean NAIN)		• Both foreground and background networks defined by the city's administrative or cultural centers and the space surrounding them. Foreground network serves a representational function.

3.2.3 Generating four-point star model

Hillier et al. [19] compared 50 cities with different scales and areas. To enable this, they combined the mean NAIN or mean NACH (background structure) with the max NAIN or max NACH (foreground structure). They applied these four measures in a four-pointed star model using Z-scores or standard scores. A positive Z-score indicates that the value is above the mean, and a negative Z-score indicates that the value is below the mean. In this way, they are able to compare cities with one another to describe the degree of integration of their foreground networks to their background networks.

For generating the four-pointed star model, the following equations for calculating the Z-scores are applied for both the NAIN and NACH values [22]:

$$\overline{X}_{max} = \frac{\sum_{i=1}^{n} X_{max}(i)}{n}$$

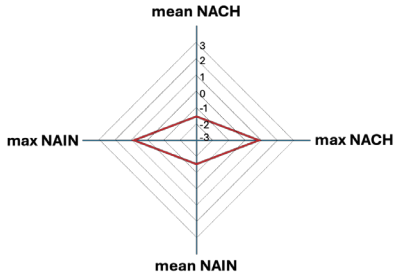
$$Z_{max}(i) = \frac{X_{max}(i) - \bar{X}_{max}}{\bar{s}_{max}(i)}$$

where X_max (i) denotes the maximum value of the area (i) and (n) represents the number of observed areas.

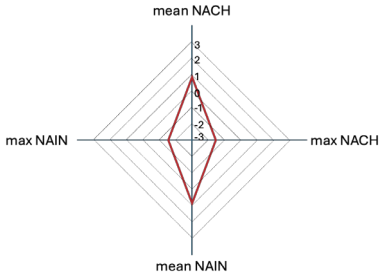
$$\overline{X}_{mean} = \frac{\sum_{i=1}^{n} X_{mean}(i)}{n}$$

$$Z_{mean}(i) = \frac{X_{mean}(i) - \bar{X}_{mean}}{\bar{s}_{mean}(i)}$$

where X_mean (i) denotes the mean value of the area (i) and (n) represents the number of observed areas. (S) is the standard deviation from the (n) areas, X_max is the maximum value, and X_mean is the average value for NACH or NAIN from an observed area. Because the great majority of spaces in cities are in the background network, the mean values for NACH and NAIN represent the to- and through-movement in the background network, and the maximum values represent the to- and through-movement potentials in the background.



(a)



(b)

Figure 5 A conceptual comparison between (a) strong foreground and (b) strong foreground structure in four-point star model

Figure 5 illustrates two situations based on the mean and maximum values of NAIN and NACH. In Figure 5(a), max NACH and max NAIN were stretched toward the positive maximum, while the mean NAIN and NACH were on the lower negative. The situation where the max values are higher indicates a stronger foreground network than the background. A strong foreground means that the main streets are well-integrated and vital. Meanwhile, the weak background structure indicates that the foreground network might segregate the area and that there might be discontinuities in the background network. The opposite situation is illustrated in Figure 5 (b).

4. Findings

4.1 The Distribution of Kampungs Based on NACH Score and NAIN Mean Values

The sixteen surveyed kampungs were distributed based on the NACH Score and NAIN Mean values, as shown in Figure 6. The NAIN Mean values represent how easily the residential area—in this case, the kampung—can be reached from the main streets. The higher the value, the easier it is to reach the kampung. Meanwhile, the NACH Score indicates the quality of the background structure. The higher the NACH Score, the more complex the kampung structure.

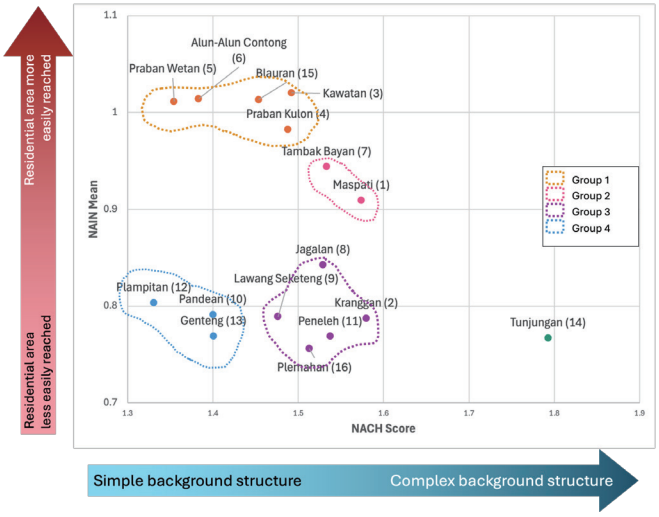


Figure 6 Distribution graphic of 16 kampungs based on NAIN Mean values and NACH Score (Source: Authors, 2024)

Through hierarchical clustering in SPSS, the sixteen kampungs were divided into four groups based on their accessibility (NAIN Mean). The first group is kampungs with NAIN values in the range of 1.0. This group includes Praban Wetan (no.4), Alun-Alun Contong (no.6), Blauran (no.15), Kawatan (no.3), and Praban Kulon (no.5). The second group includes Tambak Bayan (no.7) and Maspati (no.1). The remaining groups have NAIN mean values lower than 0.9 with different ranges of NACH Scores. The third group is Plampitan (no.12), Genteng (no.13), and Pandean (no.10). The fourth group comprises Lawang Seketeng (no.9), Plemahan (no.16), Jagalan (no.8), Peneleh (no.11), and Kranggan (no.2). Kampung Tunjungan (no.14), with its extreme NACH Score, becomes the outlier in this cluster analysis.

Figure 7 shows each group based on its location. Group 1 is located along the main circulation route. These kampungs can also be accessed from at least two major roads that facilitate access to the kampung. Group 2 is the kampungs with the primary road on their north side. Although these kampungs can

be accessed from several main roads, these roads are not the city's main circulation routes. In addition, some residential parts of the kampung can only be accessed through certain entrances. Lastly, Groups 3 and 4 consist of the kampungs with more limited access to the main road than the previous two groups or are not located on the main circulation route of the city. Although Tunjungan is in the city's commercial center, access to the residential area is limited.

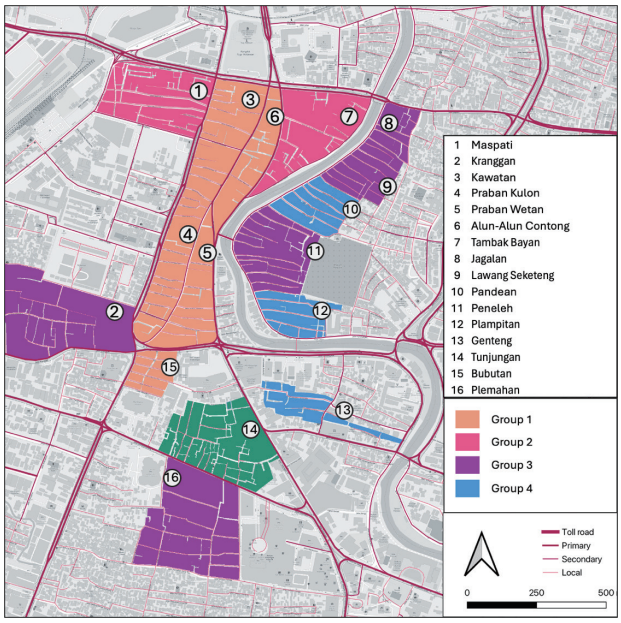


Figure 7 Map showing the distribution of kampungs (Source: Authors, 2024)

The kampungs also have varying NACH Scores. The variation in these values indicates the complexity of the structure within the kampung, which can be observed from its street pattern. When defining street patterns, Brindle [23] described them as grid and tributary. The grid networks' links are connective, allowing them to provide alternative routes, thus creating a higher 'through' movement. On the other hand, tributary networks are more hierarchical, and the roads have a specific catchment and only minimal route choices.

The grid networks also represent a formal structure, while the tributary represents an informal one [24]. In the case of the inner-city kampungs, those with lower NACH scores are closer to a formal structure, and vice versa. This formal/informal description does not necessarily represent how the settlement was developed since the informal settlement has an incremental process.

4.2 Comparative Analysis of Kampungs

Comparing the foreground and background structure between kampungs can be conducted using the four-point star analysis, as Hillier and Iida [20] have done. While their research was on a city scale, this research experimented on a smaller scale: a group of settlements in a particular urban area.

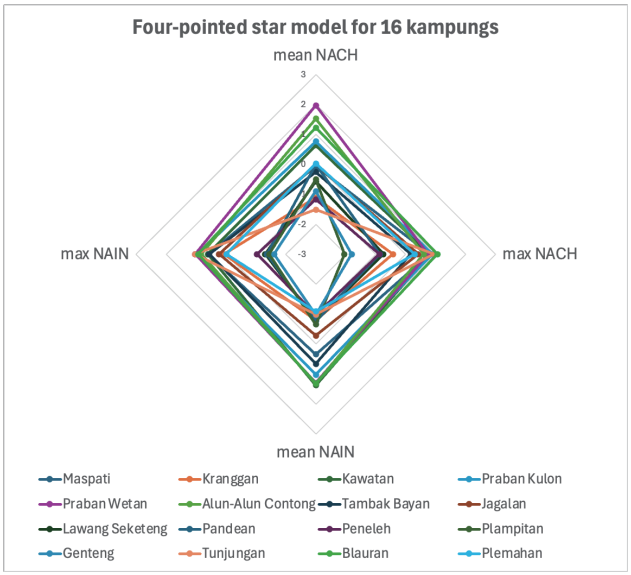
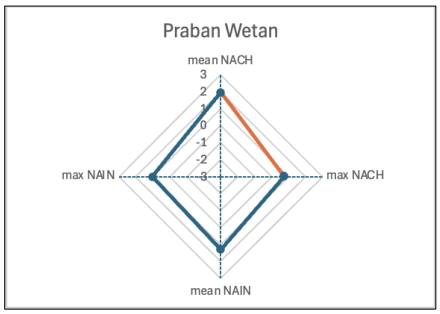
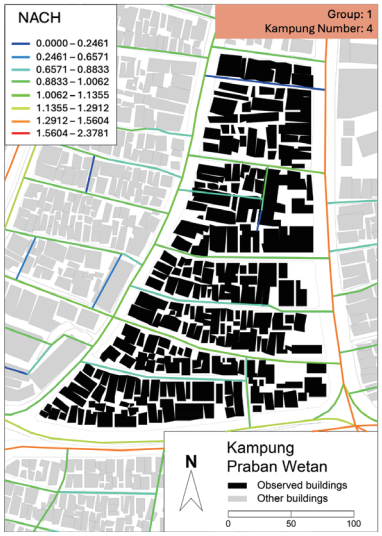


Figure 8 Four-point star model of the 16 kampungs (Source: Authors, 2024)

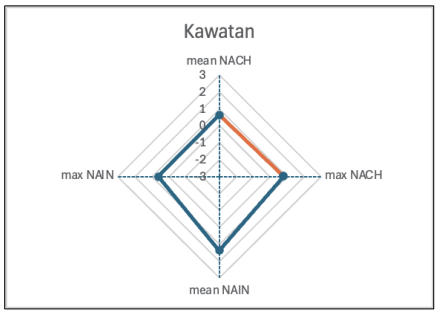
Although on a different scale, this method is proven to be able to compare how each kampung has its peculiarities regarding its foreground and background network. The maxNAIN and maxNACH in Figure 8 indicate the to- and through-movement potentials of the foreground network on the vertical axis. In contrast, the horizontal axis represents the to- and through-movement potentials of the background networks. These indicators will compare two kampungs within the same group defined in Section 4.1.

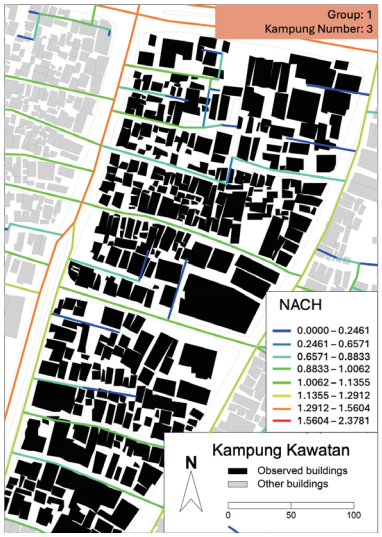
Kampung Praban Wetan (no.4) and Kampung Kawatan (no.3) belong to Group 1 with high NAIN Mean values. Kampungs with high NAIN mean values can be interpreted as easily reached from the main streets. The background network is clustered around a well-integrated foreground network. In Praban Wetan and Kawatan case, every alley has direct access to the main road. However, the difference between the two kampungs came from the NACH. Compared to Kawatan, Praban Wetan has a higher mean NACH, which means that the kampung's background network is relatively straight. The color distribution in Figure 9(a) shows continuous green lines in the background grid, indicating a strong background structure. On the other hand, Kawatan is as well integrated as Praban Wetan but has a weaker background structure or segregated parts inside the background structure. Several alleys are dead ends, and those not directly connected to the main street are isolated, as shown in Figure 9(b).





(a)



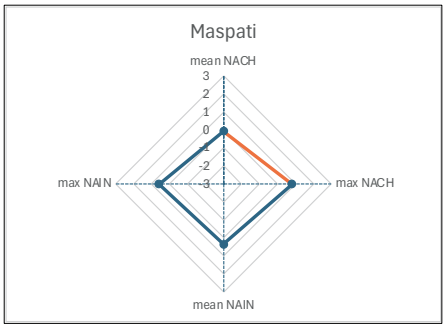


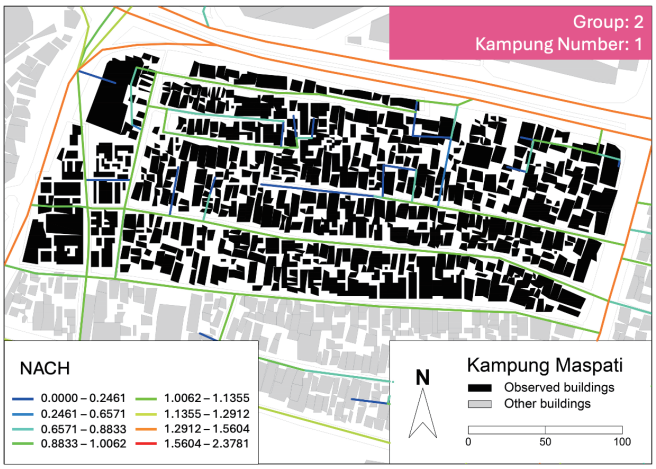
(b)

Figure 9 Four-star models and maps of (a) Kampung Praban Wetan (no.4) and (b) Kampung Kawatan (no.3)

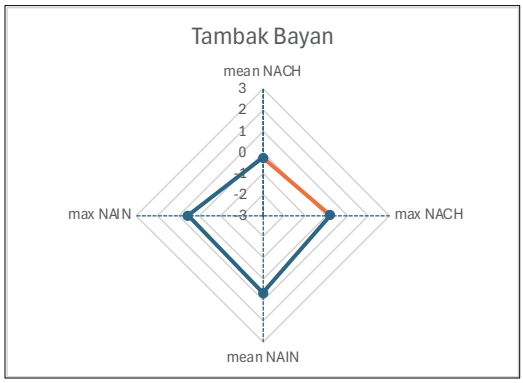
Group 2 has a slightly lower NAIN value than the previous one. Both kampungs in this group have a strong foreground structure and are well-integrated. The foreground structure in Maspati (no.1) is more prominent than the background. The roads surrounding the kampung have a high NACH value that indicates their importance in the city's circulation. In Tambak Bayan (no.7), most residential streets are connected to the main road. Its foreground structure is slightly stronger than Maspati, and it is also stronger than its background structure.

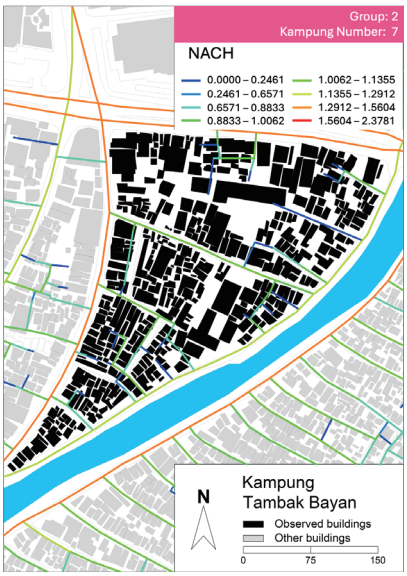
The two kampungs possess quite similar NACH Scores, but it should be noted that Maspati has a less straightforward structure than Tambak Bayan. In Maspati, the alleys are longer and forked, while in Tambak Bayan, they are straight and clear. While there are also forks in the alleys, they are still conveniently located close to the main street and connect one alley to another instead of segregating them. Figure 10 illustrates both kampungs and the NACH value on their streets.





(a)



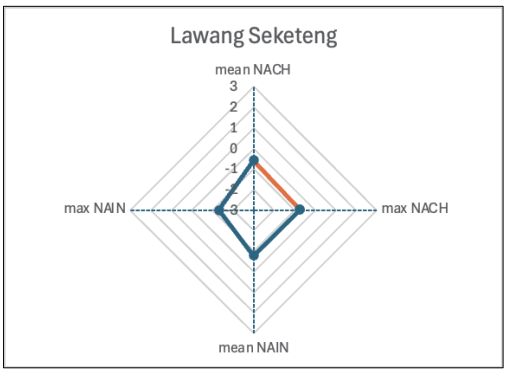


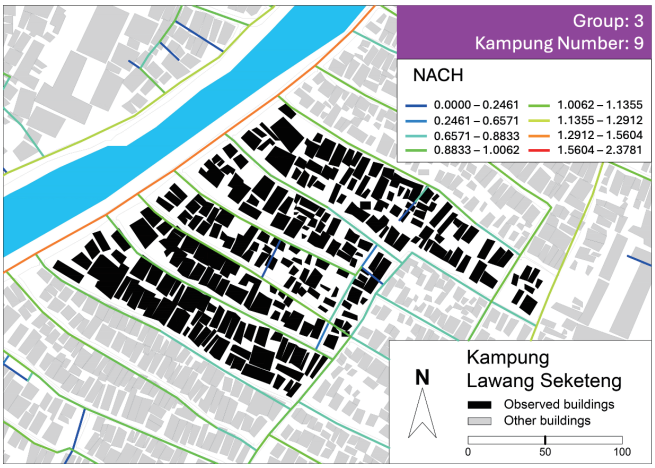
(b)

Figure 10 Four-star models and maps of (a) Kampung Maspati and (b) Kampung Tambak Bayan

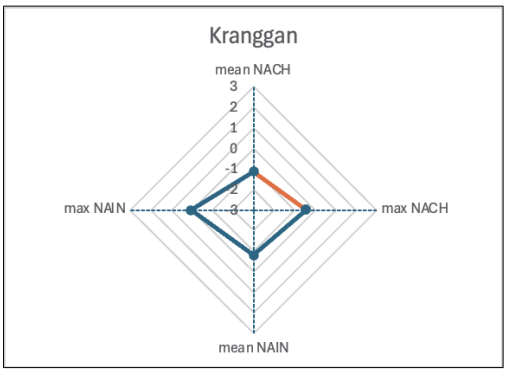
The third group consists of less integrated kampungs than the previous ones. Their low NAIN mean values also mean that the residential areas are not well connected to the main road from the main street. Under average maxNACH also shows that the roads in the foreground were not highly significant on the urban scale. Kampung Lawang Seketeng (no.9) and Kampung Kranggan (no.2) are included in this group.

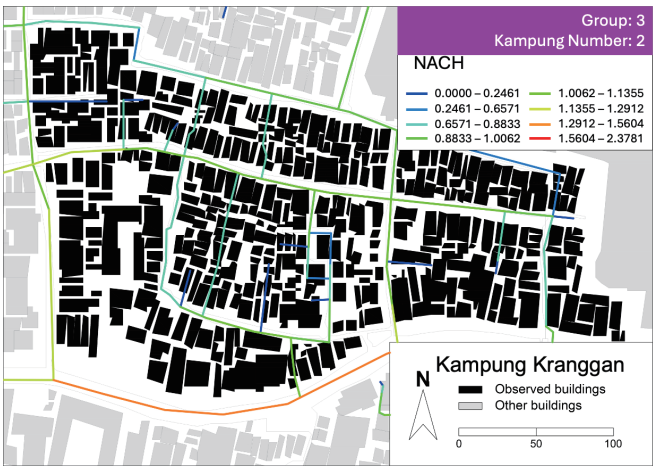
Kampung Lawang Seketeng's background structure is stronger than its foreground. The alleys that connect to the main road show fragmented background areas defined by the foreground structure, which makes the structure less complicated and more grid-like. In contrast, Kampung Kawatan has a weaker background structure than its foreground. The alleys create a more hierarchical order from the main street, segregating them from the other parts of the city, thus resulting in relatively little through-movement potential.





(a)



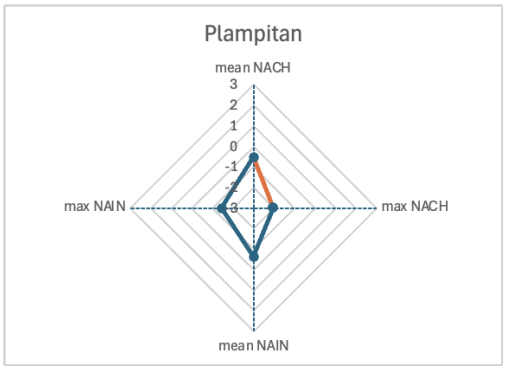


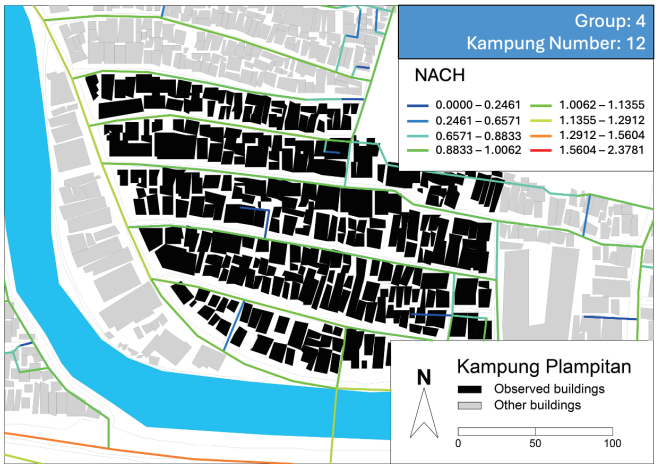
(b)

Figure 11 Four-star models and maps of (a) Kampung Lawang Seketeng and (b) Kampung Kranggan

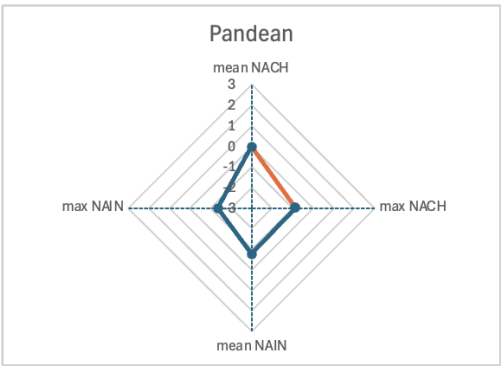
The last group includes kampungs with the lowest NAIN Mean and NACH Score values. These kampungs have limited access or are located along less significant roads. Kampung Plampitan and Pandean are located along the Kalimas River of Surabaya. These kampungs' primary access comes from the single road on the west side. The low NACH Score indicates

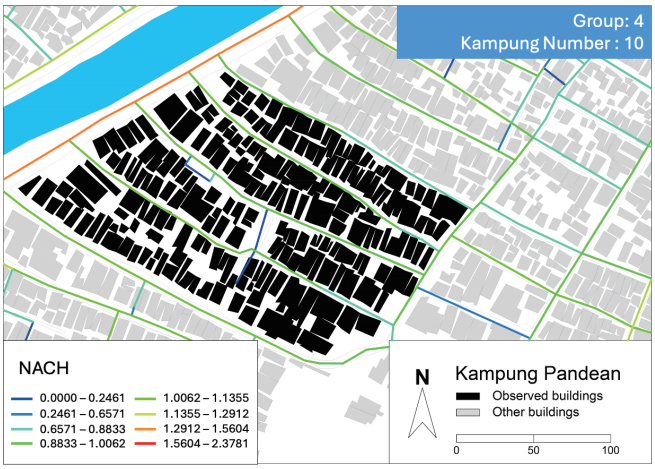
Kampungs in this group are similar: the background structure is much stronger than the foreground. This characteristic shows that the kampungs' alleys are distributed along the main road, creating a grid-like structure, as shown in Figure 12. This structure type allows separation from one alley to another.





(a)



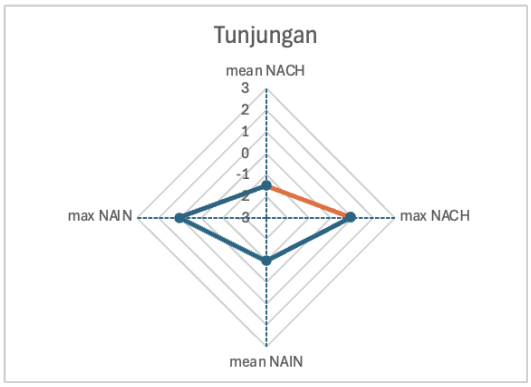


(b)

Figure 12 Four-star models and maps of (a) Kampung Plampitan and (b) Kampung Pandean

The outlier among the sixteen surveyed kampungs is the kampung in the Tunjungan area. It has a low mean NAIN, which means the residential area lacks accessibility, although it is located between two prominent roads in the business area. It also has an extremely high NACH Score compared to the other kampungs. It shows a vastly different NACH in the foreground and background structures.

In the foreground, the street has a high maximum NACH value – showing its role as a main street or byway. However, the background structure is a complicated tree structure with intersections and dead ends, which lowers its potential as a through-street. In this case, the inside of the kampung is highly connected to each other, but it is separated from another part of the city.



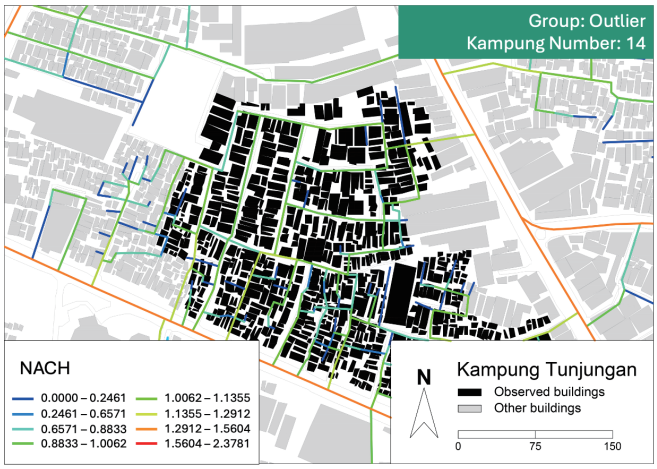


Figure 13 Four-star model and map of Kampung Tunjungan

The range of NAIN and NACH also indicates a similar process of kampung growth. Nilsson and Gil [25] mentioned that the organic growth process results in the evolution of the fine-grained minor road (background) network connecting houses to the closest street. In contrast, the high-degree main roads (foreground) network is more stationary or undergoes a very slow development. Many planned cities started with an organic growth process or have grown on an organic core but then had a modern road system imposed on them, like Paris.

Looking at the surveyed kampungs, a weaker background structure means that this organic process was more likely to occur, while a stronger background structure indicates that the kampung was more likely to follow a pre-existing structure, whether it is provided by natural features (river, canal) or man-made features (street, pathway).

5. Discussion

As mentioned earlier in Section 2, the current master plan of Surabaya has not considered the urban structural characteristics of the inner-city kampungs area and the problems or potential it may bring. Based on the analysis, the surveyed kampungs have different characteristics based on their NAIN and NACH values. These characteristics combined could show how a kampung can be seen from a different perspective for its planning.

The surveyed kampungs were also grouped based on the NAIN and NACH characteristics. The grouping of these kampungs also indicates their planning taxonomy. Based on the taxonomy by Friesen [21] in Section 2.2.2, we can consider the kampungs based on their planning, as shown in the table below.

Table 2. The grouping of kampungs based on the planning taxonomy

	Local-to-global Planning (Low NACH Score)	Global-to-Local Planning (High NACH Score)
Microeconomics Priorities (High NAIN Mean)	Praban Wetan Alun-Alun Contong, Blauran, Kawatan, Praban Kulon	Tambak Bayan, Maspati
Socio-cultural Priorities (Low NAIN Mean)	Plampitan, Pandean, Genteng	Jagalan, Lawang Seketeng, Kranggan, Peneleh, Plemahan, Tunjungan

Kampung, such as Alun-Alun Contong or Praban Wetan, has a high mean NAIN with a low NACH Score, indicating a grid-like structure that is highly integrated into the main street. A high mean NAIN suggests an ease of accessibility that facilitates trade, movement, and random contact between different groups. The background network is also clustered around a well-integrated foreground network, enhancing the possibility of commercial use. Based on these characteristics, kampungs in group 1 have the potential – or risk – to be developed as commercial areas. The current situation in the street has shown such activities where buildings on the outside shell were utilized as shops while the buildings on the inside were either empty or transformed into storage (Figure 14).

Figure 14 Existing condition of Kampung Alun-Alun Contong (no.6)

Kampung Tambak Bayan and Kampung Maspati have a relatively high mean NAIN and NACH Score. They possess the ease of accessibility and commercial potential, but some parts of the kampung are too far from the main street. These kampungs will have the most potential for commercial activities in the area closest to the main street, while the inner parts should be able to retain their residential use. Kampung Maspati has been established as a heritage kampung by Surabaya Municipality. This recognition affected the physical condition of the kampung. Kampung Tambak Bayan, although having characteristics similar to Maspati's, was not as well-maintained. The comparison between these two kampungs can be seen in Figure 15.

(a) (b)

Figure 15 Existing condition of (a) Kampung Maspati (no.1) and (b) Kampung Tambak Bayan (no.7)

Kampung Plampitan and Pandean have low mean NAIN and NACH Scores. The lack of accessibility means it is likely to be developed with socio-cultural considerations instead of microeconomic considerations. Since the NACH Score is also low, whether the current structure encourages the mixing of social groups or segregates them should be observed. Since these kampungs lack commercial activities, the residential function is still prominent. Thus, the physical condition is quite similar, and the kampungs are well-taken care of, as shown in Figure 16.

(a) (b)

Figure 16 Existing condition of (a) Kampung Plampitan (no.12) and (b) Kampung Pandean (no.10)

Lastly, the kampungs with low mean NAIN and high NACH Scores will also have less commercial potential. Its residential area can retain the socio-cultural value. With a high NACH Score, the kampungs have a well-connected street in the background, thus having less potential for group segregation. These kampungs are also well-maintained. In Tunjungan, the residents also have a close-knit relationship [26]. However, although these kampungs do not possess a high microeconomic priority, they are only partially risk-free. Kampungs adjacent to commercial facilities development will likely lose their resilience because of the encroachment.

6. Conclusions

Through the spatial syntactic values, sixteen kampungs were compared and contrasted. It resulted in four groups of kampungs based on their mean NAIN, which indicates accessibility, and NACH Scores, which indicate the complexity of the structure. The NAIN and NACH in their mean and max values also represent the relationship between these kampungs' foreground and background structure. Altogether, these indicators allow us to understand the complexity of kampung configuration. It also enables us to see what potential or risk brought along with it. In general, mean NAIN values show whether the planning priorities are toward the microeconomic or socio-cultural, while the NACH explains whether the structure is continuous or fractured. The findings of this study reveal the diverse morphological characteristics of inner-city kampungs in Surabaya, highlighting their unique potential and challenges.

Kampungs with high Mean NAIN but low NACH Scores demonstrate significant accessibility and integration with main streets, making them vulnerable to commercial encroachment.

However, those with higher values for Mean NAIN and NACH Scores have the potential for commercial activities in areas closest to the main street while maintaining the residential area on the inner part. In contrast, kampungs with lower Mean NAIN and NACH Scores exhibit socio-cultural resilience through retained residential functions. These kampungs, however, needed to be observed because the lack of accessibility might cause segregation in the community. Similarly, those with lower Mean NAIN and higher NACH scores also retained residential function with well-connected streets.

The spatial configuration analysis also underscores the importance of a balanced foreground and background network in fostering livability and accessibility. These insights emphasize the need for tailored urban planning strategies that protect the socio-cultural value of kampungs while addressing their vulnerabilities, particularly in areas with high commercial pressures or fragmented spatial networks. By integrating spatial characteristics into urban policies, these settlements can better navigate the risks and opportunities of modernization.

Surabaya, with kampungs as a part of its urban history, has protected inner-city kampungs. However, the current situation shows that a plan for the future of kampungs should also consider potential development other than residential areas, especially when its morphological dimension has shown it. This research, however, only partially reveals the potential and risk that kampungs will face in the future. It has not taken into account the complexity of land ownership – which is a main issue in informal settlement – or the market potential of these inner-city areas. Further research about how kampungs were developed and progressed can also be developed from this study.

References

[1] K. Dovey and R. King, "Forms of Informality: Morphology and Visibility of Informal Settlements," *Source: Built Environment*, vol. 37, no. 1, pp. 11–29, 2011, [Online]. Available: https://www.jstor.org/stable/23289768

[2] H. Kamalipour and K. Dovey, "Mapping the visibility of informal settlements," *Habitat Int*, vol. 85, pp. 63–75, Mar. 2019, doi: 10.1016/j.habitatint.2019.01.002.

[3] J. Silas, "Marginal Settlements in Surabaya, Indonesia: Problem or Potential?," *Environ Urban*, vol. 1, no. 2, pp. 60–70, 1989.

[4] J. Silas, "Government-community partnerships in kampung improvement programmes in Surabaya," *Environ Urban*, vol. 4, no. 2, pp. 33–41, 1992.

[5] K. Dovey, M. van Oostrum, I. Chatterjee, and T. Shafique, "Towards a morphogenesis of informal settlements," *Habitat Int*, vol. 104, Oct. 2020, doi: 10.1016/j.habitatint.2020.102240.

[6] I. A. W. Hutama, "The Hidden Structure of Organic Informal-like Settlements in Jogjakarta City: An Investigation of Socio-Spatial Relationship in an Urban Kampung," *IOP Conf Ser Earth Environ Sci*, vol. 158, p. 012003, May 2018, doi: 10.1088/1755-1315/158/1/012003.

[7] D. Husin, J. Prijotomo, and B. Sugiharto, "The Informality of Urban Kampungs in Jakarta: A Model of an Architectural Form," 2021.

[8] P. Setijanti, S. T. Ekawati, A. S. Mahendra, T. S. R. Nasution, S. Firmaningtyas, and M. A. Yaqin, "Embracing Transient Migrant toward Smart Living at Kampung in Surabaya," in *Proceedings of the Built Environment, Science and Technology International Conference (BEST ICON 2018)*, SCITEPRESS, 2022, pp. 84–89.

[9] S. Shirleyana, S. Hawken, and R. Y. Sunindijo, "City of Kampung: risk and resilience in the urban communities of Surabaya, Indonesia," Oct. 16, 2018, *Emerald Group Holdings Ltd.* doi: 10.1108/IJBPA-02-2018-0025.

[10] T. Tauran, "Beyond the informal settlement: The land tenure situation of urban kampungs in Surabaya, Indonesia," Dec. 02, 2021, *IOP Publishing Ltd*. doi: 10.1088/1755-1315/916/1/012010.

[11] A. Turner, "From axial to road-centre lines: A new representation for space syntax and a new model of route choice for transport network analysis," *Environ Plann B Plann Des*, vol. 34, no. 3, pp. 539–555, 2007, doi: 10.1068/b32067.

[12] L. Donegan, "Tuning in: Investigating OSMnx RCL model preparation methods for Angular Segment Analysis." [Online]. Available: https://www.researchgate.net/publication/362762224

[13] I. Kolovou, J. Gil, K. Karimi, S. Law, and L. Versluis, "Road Centre Line Simplification Principles for Angular Segment Analysis," in *Proceedings of the 11th Space Syntax Symposium*, Lisbon, 2017.

[14] L. R. Ford, "A Model of Indonesian City Structure," 1993.

[15] S. Funo, *Surabaya—The Origin, Formation,*

Transformation and Metamorphosis of Southeast Asian Cities. Kyoto: Kyoto University Press, 2021.

[16] G. H. Krausse, "The Kampungs of Jakarta, Indonesia: A Study of Spatial Patterns in Urban Poverty," University of Pittsburgh, Pittsburgh, 1975.

[17] B. Hillier and J. Hanson, *The Social Logic of Space*. Cambridge University Press, 1984. doi: 10.1017/CBO9780511597237.

[18] B. Hillier, *Space is the Machine*. Cambridge University Press, 1996.

[19] B. Hillier, T. Yang, and A. Turner, "Normalising least angle choice in Depthmap and how it opens up new perspectives on the global and local analysis of city space Normalising least angle choice in Depthmap and how it opens up new perspectives on the global and local analysis of city space," *The Journal of Space Syntax*, vol. 3, no. 2, 2012, [Online]. Available: http://www.journalofspacesyntax.org/

[20] B. Hillier and S. Iida, "Network and Psychological Effects in Urban Movement," in *Spatial Information Theory*, A. G. Cohn and D. M. Mark, Eds., Springer, 2005, pp. 475–490. doi: 10.1007/11556114_30.

[21] J. Friesen, "Star-Models and Urban Development: An ethnographic and historical examination of the connection between urban form and spatial-cultures," in *Proceedings of the 11 th Space Syntax Symposium*, 2021.

[22] A. van Nes and C. Yamu, *Introduction to Space Syntax in Urban Studies*. Cham: Springer International Publishing, 2021. doi: 10.1007/978-3-030-59140-3.

[23] R. E. . Brindle, "Living with traffic : twenty-seven contributions to the art and practice of traffic calming, 1979-1992," in *Traffic Engineering Practice*, 4th ed., K. W. Ogden and D. W. Bennett, Eds., ARRB Transport Research Ltd., 1996, p. 371.

[24] J. J. Samper Escobar, "Physical space and its role in the production and reproduction of violence in the 'slum wars' in Medellin, Colombia (1970s-2013)," Massachusetts Institute of Technology, 2014.

[25] L. Nilsson and J. Gil, "The signature of organic urban growth: Degree distribution patterns of the city's street network structure," in *The Mathematics of Urban Morphology*, D'Acci, Luca., Springer Basel, 2019, pp. 93–121. doi: 10.1007/978-3-030-12381-9_5.

[26] T. S. R. Nasution and T. Kurose, "The Value of Living in an Inner-City Settlement: A Study of Physical and Psychological Aspects of Attractiveness in Kampung Ketandan, Surabaya," *Journal of architecture and urban design, Kyushu University*, vol. 43, pp. 39–50, 2023, doi: https://doi.org/10.15017/6788791.

（受理：令和 6 年 10 月 22 日）