Factors Influencing the Preservation of Historic City Centers: The Case of Old Town of Sakon Nakhon City, Thailand

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Received	Reviewed	Revised	Published
11.08.2023	10.09.2023	21.09.2023	30.09.2023

https://doi.org/10.61275/ISVSej-2023-10-09-10

Abstract

There are many historic city centers that were once the centers of cities that face challenges in maintaining their centrality. This results in the loss of their ability to attract economic activities and people, leading to the abandonment of historically valuable architecture and decreased pedestrian traffic.

This research examines the process of transformation of urban centrality in cities through the theory of urban centrality. It identifies the factors influential in preserving centrality of cities, which affects the preservation of valuable vernacular architecture.

It employs a case study approach as a research method, and focuses on the old town district of Sakon Nakhon city. Space syntax methods are deployed to ascertain the spatial relations.

The findings reveal that there are two significant factors contributing to the preservation of centrality in the old town. The first is the urban grid configuration, which influences the creation of natural movement patterns at both the city and local levels. The second is the local street network integrated into the global street network.

Both factors have an impact on the liveliness of the city and the preservation of valuable vernacular architecture, benefiting from increased pedestrian movements resulting from the maintenance of city centrality.

Keywords: Urban heritage; Vernacular row houses; Urban centrality; Space syntax; Natural movement; Street intervisibility

Introduction

Urbanization is a complex dynamic (Alberti et al., 2003) that results in diverse outcomes through the growth and decline processes in the evolution of cities (Alberti & Marzluff, 2004;Beauregard, 1993). It leads to the accumulation of negative externalities on the social and environmental aspects of cities globally (Correia & Roseland, 2022), especially in dense urban core areas that represent the concentration of people, the integration of land use and economic activities (Hillier, 1999).

The rapid development of urban cores has adversely affected the historical environments in many cities (Lin & Luo, 2022). Conversely, the decline of urban cores also contributes to environmental degradation, particularly in historic city centers that were once the centers of cities. They are currently facing economic decline and population displacement resulting in the abandonment of valuable architectural heritage, and rapid deterioration (Thinnakorn & Chanklap, 2022), which are considered negative impacts on the image of the city (Wilson & Kelling, 2011;Jamme, Bahl, & Banerjee, 2018;Millie, 2008).

The main cause of urban decline is the relocation of the urban core to areas with greater economic potential (Laursen, 2008), creating new cities on the outskirts. Commonly referred to as edge cities, they are seen in several small cities in France and Italy (Hillier, 1996a). This phenomenon diminishes the importance of the old city, such as the historical brownfields in Tehran (Ghabouli, Soltani, & Ranjbar, 2023). The Kayutangan area, the urban heritage tourism site in Malang City in Indonesia has recently faced a functional degradation (Pratiwi, Ernawati & Yusran, 2023)

Therefore, there are efforts to preserve the centrality of cities in order to promote a sufficient population that supports diverse economic activities (Jacobs, 1961). Such measures are needed to enhance urban resilience, increasing the ability of cities to adapt to negative situations (Ernstson et al., 2010).

In this context, this research aims to study the process of urban centrality transformation through space syntax theory to analyze the influential factors in maintaining urban centrality. The focus is on studying the historic urban core areas that hold historical significance. Following research questions are posed.

1. What factors influence the maintenance of urban centrality in historically important old town districts?
2. Is the hypothesis that 'old town districts that can maintain urban centrality have a positive impact on preserving valuable vernacular architecture, adapting to and being utilized in modern times, enhancing identity, and fostering vibrancy in the city' valid?.

Theoretical Framework

The understanding of morphological logic in relation to the process of urban centrality can be explained as follows: The theory of urban centrality, as described by Hillier (1999), states that a good urban center should exhibit the phenomenon of a vibrant live center. The primary characteristics of such a center include a central area that has a dense interconnected grid system, allowing options in transportation at high volume. The road blocks are narrow to enable more space for buildings and economic activities, creating an environment where commuters predominantly pedestrians can easily commute and access within the entire area. The second characteristic is the dense local street network within the central area that seamlessly connects and integrates with the global street network (Hillier, 1999).

Two primary characteristics contribute to the generation of natural movement within those central urban areas that is constant and continuous. Importantly, there is a higher tendency to lead to the development of a street network known as 'grid intensification process'. As time passes, these central urban areas will have more potential to accommodate a higher level of natural movement, creating a multiplier effect and transforming into a 'configurational attractor' (Hillier et al., 1993) which creates a positive feedback loop that enhances the ability to attract people and economic activities, leveraging the benefits derived from the movement of individuals to become more concentrated, known as the movement economy process, eventually culminating in the transformation into vibrant live centers. All of these aspects demonstrate centrality as a process (Hillier, 1999).

Characteristics of Urban Centers

Live centers are influenced by the urban grid (Hillier et al., 1993;Hillier, 1996b). The characteristics of urban centers can be summarized into two aspects:

1. The Street Network Supported by the Natural Movement of People

Jacobs (1961) states that streets and sidewalks are indicators of urban quality and social space, where 'pedestrians' act as agents, creating 'eyes on the street' through natural surveillance. This is achieved by maintaining a sufficient number of people on the streets and sidewalks to foster social interactions and enhance vitality within the city (Jacobs, 1961).

Streets and sidewalks that facilitate natural movement support diverse opportunities for social interactions, known as 'virtual Community'. The co-presence of people from various backgrounds results in vibrant pedestrian environments (Hillier et al., 1993;Hillier, 1989). This aligns with the ideas of Gehl, who emphasized the importance of streets and public spaces that must accommodate people at different times and facilitate a variety of social and alternative activities, creating meaningful and attractive urban environments (Gehl, 1987).

2. The Degree of Street Intervisibility in Dense Street Network Reflects the Relationship Between Buildings and Sidewalks

The degree of street intervisibility is a result of the density of entrances and windows, which has an impact on social control and the degree of liveliness on the streets (Tan & Klaasen, 2007).

Jacobs (1961) emphasizes the physical characteristics of buildings and streets. Buildings with active frontage, which means the density of building entrances that directly open onto the street, is the mechanism that create 'eyes on the street' and enhances the ability to attract diverse individuals to use the space at various times (Jacobs, 1961).

Active frontages influence people's behavior, resulting in slower pedestrian movement and increased interactions between buildings and sidewalks (Heffernan, Heffernan & Pan, 2014). This aligns with Gehl's idea (Gehl, 2011) that active frontage, with multiple entrances and windows facing the street, influence people's behavior, motivating walking and the use of public spaces. Conversely, long dead frontages or continuous walls along the street reduce the liveliness of the people on the streets (Gehl, 2011). Therefore, active frontage on the ground floor creates streets welcoming atmosphere which is considered a positive factor that contributes to the overall quality of streets and supporting the liveliness of main streets as public spaces (Carmona, 2015;Yeang, 2000).

Understanding Urban Centrality

Currently, there is an important theory that focuses on studying urban morphology, known as the 'Space Syntax Theory'. This can be employed to investigate urban centrality. This theory provides practical possibilities and measurable results (Karimi, 2012;Hillier & Hanson, 1984). For example, space syntax analysis has been used to study spatial factors in the formation of urban centers in Suzhou, China (Dai, 2004), and to analyze historical maps to understand the growth and development structure of urban spaces in cities in southern Poland (Suchoń & Olesiak, 2021). It has also been employed to investigate the correlation between the arrangement of street networks and density of movements in historic urban cores on the AlKarkh area in Baghdad, Iraq (Albabely & Alobaydi, 2023).

Urban centrality is a process resulting from the morphological dynamics of the city through changes in the street network or urban grids. Therefore, space syntax theory can play a significant role in enhancing the understanding of centrality phenomena. Morphological dynamics have a significant influence on determining the integration value, leading to the growth or decline of urban centers (Hillier, 1996a). Furthermore, space syntax theory can also be used to predict the popularity levels of public spaces, pedestrian and vehicular movement patterns, as well as land use characteristics to assess the ability to maintain urban centrality in the present and the future (Hillier, 1999; Hillier, 1996a;Hillier & Hanson, 1984;Hillier, 2007;Hillier & Sahbaz, 2008; Hillier & Sahbaz, 2005;Hillier, 1988;Hillier et al., 1986;Hillier, Penn, Hanson, Grajewski & Xu, 1993;Hillier & Iida, 2005;Peponis, Dalton, Wineman, & Dalton, 2004;Turner & Penn, 2002).

Review of Literature

The analysis of urban grid networks is considered a crucial foundation of space syntax methods that describe the of cities. Currently, there is a substantial amount of research applying space syntax theory to examine the characteristics of urban grid networks.

The first literature review focuses on identifying the negative factors of configurational characteristics of cities and urban grid networks using space syntax methods.

Paksukcharern Thammaruangsri (2003) studied the morphological aspects of railway terminus areas in central London. Terminus areas are disconnected from the urban system, creating a discontinuity between internal and external spaces. This results in limited pedestrian traffic and leads to the deterioration of these areas. The research found that the internal transport networks within terminus areas act as nodes that are not well-integrated with natural movement. As a result, the recommendation is to reintegrate natural movement into the terminus areas as part of both local and global street networks. This would help mitigate the impacts from negative attractors in these areas and promote configurational attractors at a larger scale (Paksukcharern Thammaruangsri, 2003).

Rattanathavorn & Paksukcharern, and Peerapun (2013) examined the urban grid and spatial centrality of markets in the historic town of Phra Nakorn, Sri Ayutthaya, Thailand, which faced economic decline. The research revealed that the town had a structure of isolated islands, which is viewed as an enclave of relict morphological units. This prevented the expansion of trading areas as usual. Therefore, it was considered necessary to establish an efficient street network to enhance visibility and accessibility. This would facilitate the circulation of people and the continuous distribution of various activities (Rattanathavorn, Paksukcharern, & Peerapun, 2013).

Thinnakorn & Chanklap (2022) studied the characteristics of the urban grid in the old town district of Nakhon Si Thammarat, Thailand, to explain the factors contributing to the current deterioration of the old town. The research found that, firstly, the old town had a concentration of negative attractors, primarily religious and government land use, which hindered the movement economy. This resulted in a shift of the city's center to areas with higher accessibility (Thinnakorn, Chanklap, 2022).

Lv, Wang, & Huang (2023) examined the ancient town of Xixing, a canal town that used to be a center for trade in the east Zhejiang Province, China. Currently, it is facing issues of deterioration. The research revealed that the street network of the ancient town couldn't maintain continuity and connectivity with the urban space, leading to a shift of the center to areas with higher accessibility. This shift transformed the central area from both sides of the canal into a crossroads and a road network within the town (Lv, Wang, & Huang, 2023).

Ye, & Van Nes, (2014) investigated the spatial reasons why Songjiang New Town couldn't attract people and economic activities. The research found that Songjiang New Town had a significant number of cul-de-sac streets in its street network, which resulted in a low level of accessibility, poor connectivity, and a lack of system integration. The recommendation was to establish connections within the large-block cul-de-sac road structure, transforming large blocks into smaller ones and improving interconnectivity to enhance accessibility (Ye, Van Nes, 2014).

From the literature review above, the negative factors of configurational characteristics of cities and urban grid can be summarized as follows: (1) Urban areas with proportions of land use characterized as negative attractors, such as large train stations, religious buildings, and government institutions. (2) Cities with physical space characteristics that constrain their growth, such as cities with island-like features or located along large canals or rivers, becoming enclaves of relict morphological units that hinder expansion based on market mechanisms. (3) Street networks with cul-de-sac characteristics that reduce the internal connectivity of the urban system.

All of these negative factors can be considered as negative attractors that disrupt the grid intensification process following the movement economy process. Consequently, the affected areas are not influenced by market factors and become lacunas in the natural movement system, aligning with Hillier's concept of "cities as movement economies" (Hillier, 1996).

The recommendations from all the aforementioned research endeavors aim to propose a strategy for rejuvenating the natural movement system by enhancing the connectivity of the urban grid with local streets. This approach aims to mitigate the impact of negative attractors in the area and promote the attraction of natural movement of people. It encompasses aspects of both transportation activities and accessibility, aligning with Hillier's notion of natural movement (Hillier, Penn, Hanson, Grajewski, & Xu, 1993).

The second literature review focuses on research that seeks positive factors of configurational characteristics of cities and urban grid using space syntax methods.

Dai (2004) studied the characteristics of the urban grid in Suzhou, China, which promoted the emergence of vibrant central areas. The research found that an urban orthogonal grid can effectively facilitates grid intensification by creating smaller road blocks. This was because the length of roads in the orthogonal grid network were greater than those in other grid patterns, allowing for better connectivity with various areas (Dai, 2004).

Teng, Yang, & Huang (2021) studied the streetscapes of historical areas in Macau during four different historical periods. The research discovered that the old city of Macau retained its central role, comprising important streets, despite changes in the street network over time. This was due to the dense interweaving of old streets, which seamlessly integrated into the global street networks. This influence contributed to the creation of a natural movement that nurtured the old city of Macau, making the town major nodes throughout the historic urban layering (Teng, Yang, & Huang, 2021).

From the above literature review, positive factors of configurational characteristics of cities and urban grid can be summarized as follows: (1) An orthogonal urban grid promotes grid intensification, leading to smaller road blocks and improved street networks connectivity with various areas. (2) Local street networks must be densely interwoven and integrated into the global street network to ensure that the local public spaces are well-nurtured by natural movement resulting from the influence of the global street network.

All of these positive factors align with Hillier's theory of urban centrality (1999), which suggests that the usability of public spaces depends on the ability of the urban grid to create connections with local streets, attracting natural movement of people and economic activities (Hillier, 1999).

In the third literature review, the focus was on research that analyzed the accessibility potential of the urban grid in relation to the perception of historical districts and the preservation of historically significant buildings.

Diao & Lu (2022) employed the theory of place narrative to explore strategies related to the rejuvenation of Haiyan, Zhejiang. The research revealed that street networks with high accessibility potential promote the accessibility of cultural resources and the walkability of the inner city which impact the preservation of cultural heritage and improve the logical coherence of the historical 'storyline' when it is narrated (Diao & Lu, 2022).

Zou, Liu, Cheng, Lei, & Ge (2023) created a model to examine the relationship between the street-built environment (SBE) and street vitality in historic areas and evaluate the influence of SBE on street vitality, focusing on Wuhan, China, as a case study. The research found that the spatial distribution of historically significant buildings with commercial usage adaptations was closely related to the spatial distribution of street vitality (Zou, Liu, Cheng, Lei, & Ge, 2023).

Hegazi, Tahoon, Abdel-Fattah, & El-Alfi (2022) assessed the spatial factors affecting the vulnerability of heritage buildings in historic Cairo, Egypt. The research discovered that heritage buildings located in areas with high traffic and activity levels might face challenges due to inappropriate usage (Hegazi, Tahoon, Abdel-Fattah, & El-Alfi, 2022).

From the literature review above, it is evident that the urban grid of historical districts with high accessibility potential can enhance the preservation of cultural heritage and heritage buildings by facilitating easy access and creating efficient perceptions. However, there are contrasting research findings that suggest that urban grids with high accessibility potential can have negative effects on heritage buildings due to inappropriate activities, and the presence of a large number of people passing through.

In summary, both the positive and negative factors of configurational characteristics and the urban grid can influence urban accessibility and the preservation of the city's centrality. Furthermore, the passage of people through these areas can either enhance the space's utility or cause damage to the buildings.

However, in the context of Thailand's historic urban areas, the focus on conserving and revitalizing cities still primarily emphasizes the physical design of architecture and the city itself. It does not consider issues related to configurational characteristics and urban grid, which have a significant influence on maintaining the city's centrality.

Therefore, the research aims to identify the factors influencing the preservation of the city's centrality in historically significant urban areas in Thailand. A case study of the old town district of Sakon Nakhon city is conducted to compare both the positive and negative factors related to configurational characteristics and the urban grid, as identified in the literature.

Research Methodology

The research methodology of this study is based on a case study research approach, with the old town district of Sakon Nakhon city serving as the case study area. The data collection process consists of the following steps:

1) Preliminary field data collection to identify research issues.
2) Registering the number of vernacular row houses to determine the location and use of the buildings.

3) Registering the number of building entrances and adjacent windows facing public spaces to identify the direct connections between the entrances and the streets/public areas.
4) Literature review and analysis of concepts, theories, and related research works related to urban centrality changes to establish the theoretical framework.
5) Examination of the secondary data of the old town district of Sakon Nakhon city from historical records, land use maps, and aerial photographs depicting the evolution of the street network over different time periods.
6) Creation of axial maps using Geographic Information System (GIS). The maps are created at two levels:
- Global-level axial maps, shown in wide-angle images illustrating changes over time, focusing on the main street network accessible by vehicles.
- Old town district -level axial maps, encompassing the entire street network, including main roads and pedestrian pathways within the community.

Research Analysis

1. Analysis of the Centrality Process Using Space Syntax Methods

The research analysis employs space syntax methods to enhance understanding of the phenomena of centrality based on the theory of urban centrality (Hillier, 1999). These methods were utilized through the 'Depthmap' software for the analysis of morphological logic (Turner, 2004), to support the belief that the spatial configuration of urban street networks has a significant impact on the natural movement patterns of people, influencing economic activities, land utilization, and predicting the location of urban centers (Hillier, 1999;Hillier & Hanson, 1984;Hillier et al., 1993;Van Nes,2002; Kitchen & Schneider, 2007).

The result of the urban street networks research analysis using space syntax methods has been extensively validated and has shown a significant correlation of 60-80% between moving potentials derived from computational analysis and movement rates observed in the actual settings (Hillier et al., 1993;Hillier & Iida, 2005;Peponis, Dalton, Wineman & Dalton, 2004;Turner & Penn, 2002;Penn & Vaughan, 1995).

2. Urban Centrality Analysis Principles Using Space Syntax Methods

The analysis using space syntax methods helps explain the spatial characteristics of cities and enhances understanding of the socio-spatial organization of built environments (Yamu, Van Nes & Garau, 2021).

The analysis begins by creating a configurational model of urban street networks, including the publicly accessible areas (Hillier, 1996b;Dawson, 2003). The urban street networks are then divided into visible subspaces called "convex spaces" that encompass the entire network. These convex spaces are represented by the fewest and longest straight lines on the street network and the city public spaces, called the 'axial lines (Hillier, 1996b). As it forms a continuous network, it can be represented as an "axial map." The process can be analyzed using computer software such as 'Depthmap' to calculate the integration value of each axial line (Hillier, 1996b;Al_Sayed, et al., 2014).

The results obtained from the analysis of the axial map can be used to analyze the level of accessibility of urban street networks in each street segment (Hillier, 2001). The processing provides an integration value and displays the axial map in various color lines, ranging from the warmest color (red line) representing high integration value to the coolest color (navy blue line) representing low integration value. This visualizes the structure of the urban grid, often referred to as a 'deformed wheel' (Hillier, 1996b).

3. Results from Space Syntax Analysis

The results obtained from the analysis of the axial map using space syntax methods provide statistical values of axial lines, which can be compared between axial lines or systems. These values can be used to analyze the process of urban centrality by measuring various metrics (Hillier, 2007).

3.1 Integration Value

This metric reveals the complexity of accessibility to different street segments and can be used to predict the usage of the street network and public spaces. It can be measured at two levels:

Level 1 Global Integration Value (Rn, n step) measures the connectivity of selected streets with all other streets in the system. This measurement, known as "radius n," represents the overall relationships. Thus, it highlights the primary streets at the city level.

Level 2 Local Integration Value (R3, 3 steps) measures the connectivity of selected streets with the subsequent two street connections, without counting the entire system. This measurement, known as "radius 3," represents specific relationships. Therefore, it reveals the preference for certain streets at the local level.

The characteristics of urban centrality, according to the theory of urban centrality, reflect the areas with high integration value of the street network via the axial map (represented by warmer colors) which is a dense and well-connected network. This suggests that the street network has a higher capacity to attract economic activities and people to move through and move to the area compared to other regions (Hillier, 1999).

3.2 Synergy value

This is an index that reflects the relationship between global integration value and local integration value. It indicates the extent to which a local street network is well connected or integrated to the global street network. Therefore, an area with a high synergy value indicates that the city has public pathways that are preferred and utilized both at the global and local levels. Thus, the metric integration achieved through natural movement at high levels of the overlapping global and local street networks demonstrates the characteristics of a 'live center' (Hillier, 1996b).

4. Research Analytical Process Stages

Based on the literature review of the theory of urban centrality and the study of the morphological transformation of urban center areas, as well as the analysis of urban centrality processes using space syntax methods, the research process can be outlined in stages as follows:

4.1 Analysis of the Integration Value that Changes Over Time

Using space syntax method. The process starts by creating a map using Geographic Information System (GIS) through the generation of an axial map based on the axial lines of the street network that evolve through the historical development of the city since its inception shaped by social and economic forces according to different periods. Then, the axial map depicting the changes over time will be processed using space syntax methods through the 'Depthmap' computer program to assess the transformation processes and identify the current positions of urban centers.

4.2 Examination of the Characteristics of the Street Network Supporting Urban Centrality

Using space syntax method, aligned with the theory of urban centrality are employed to assess which spatial factors contribute to the high levels of natural movement within the urban center areas (Hillier et al., 1993). The synergy value is a statistical measure used to evaluate the factors.

4.3 Studying the Relationship Between Global Integration Value (RN) and Street Intervisibility

This involves two steps:

4.3.1 Analysis of the Degree of Street Intervisibility to Illustrate the Degree of Interface between Buildings and Streets

Street intervisibility shows the spatial relationship between private and public spaces, specifically the degree of interface between buildings and streets, known as the "interface map" (Hillier & Hanson, 1984). This analysis focuses on the micro-scale spatial analysis that impacts street life (López & Nes, 2007;Van Nes & Yamu, 2021). Therefore, street segments exhibiting a high level of street intervisibility reveal the spatial potential that signifies the liveliness of the city (Van Nes, López, 2010). The analytical approach for studying street intervisibility is adapted from relevant research (López & Nes, 2007; Van Nes, López, 2010;Shu, 2000;Van Nes, 2005) and involves the following steps:

1) Registering the number of building entrances and adjacent windows facing public spaces to identify the direct connections between the entrances and the streets/public areas. The visibility and accessibility properties from buildings to streets are crucial. The interaction patterns between building-street interfaces can be categorized into three formats.

   Format 1: Building fronts with entrances and windows directly facing the street, utilizing the ground floor that are visible and accessible to people for commercial purposes. This format is considered 'Active Frontages' with a value of 1.

   Format 2: Building fronts with entrances and windows directly facing the street, utilizing the ground floor that are visible and accessible to people for residential purposes. This format is considered 'Semi-Active Frontages' with a value of 0.5.

   Format 3: Building fronts without direct connections to the street, where activities inside the buildings are not visible due to closed doors or fences. This format is considered 'Non-Active Frontages' with a value of 0.

2) Measuring the degrees of street intervisibility for each main street segment involves the following variables:

$$\text{Degrees of street intervisibility} = (AF \times LSeg) / NB$$

AF = Total value of active frontages within the street segment

NB = Total number of buildings in the street segment (excluding government buildings and temples)

LSeg = Length of the street segment

3) The degrees of street intervisibility data for all street segments are standardized using Z-score normalization to establish and organize the range of degrees of street intervisibility and assigned color codes to enable the comparison of differences among each street segment as follows:

- Highest level: Greater than 1.0 represented by red axial lines.
- High level: Between 0.5 and 1.0 represented by orange axial lines.
- Moderately high level: Between 0 and 0.5 represented by yellow axial lines.
- Low level: Between 0 and -0.5 represented by green axial lines.
- Lowest level: Between -0.5 and -1.0 represented by blue axial lines.
- Very low level: Less than -1.0 represented by turquoise axial lines.

4) Create an axial map that illustrates the degrees of street intervisibility of the urban grid.

Therefore, street segments with high degrees of street intervisibility indicate dense active frontages, making them easily visible and with high tendency to attract pedestrian passing, which have the potential to generate 'eyes on the street' from the ground floor by enhancing social control, natural surveillance, perception of safety, degrees of street life, and the liveliness of the city.

4.3.2 Analyzing the Relationship between Global Integration Value (RN) Analysis and the Street Intervisibility

The analysis aims to demonstrate that the high integration value global street networks have the ability to attract people and economic activities, creating interactions between buildings and streets. This significantly evidences the degree of street intervisibility.

The Case Study: The Old Town District of Sakon Nakhon city, Thailand

This research examined a case study which is the old town district of Sakon Nakhon city. It is a historically significant city with a unique urban morphology influenced by the Khmer civilization. It features vernacular wooden row houses, which hold historical values and continue to be utilized as part of the urban fabric, dispersed along the main road network.

The old town district of Sakon Nakhon city is located in the municipal area of Sakon Nakhon city, in the northeastern region of Thailand. It is enclosed by ancient walls and the moat, forming a rectangular shape with sides of approximately 1,500 meters in length, covering about 2.25 square kilometers (Fig. 1).

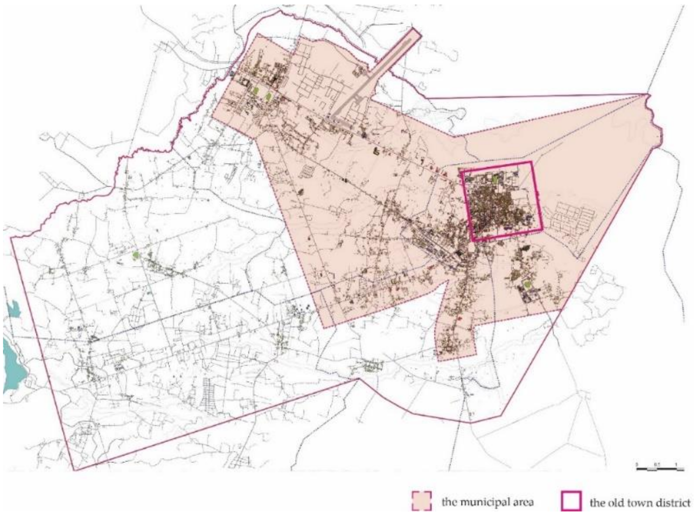

Fig. 1: The old town district located within the municipal area of the city
Source: Thinnakorn (2007)

The urban morphology that showcases the identity of the old town district of Sakon Nakhon city consists of several important components: (1) The shape of the old town district according to the Khmer civilization that illustrate the original moat surrounding the old town district into a rectangular shape with earth mounds and deep moats used for water storage, divided into layers according to the characteristics of the area. (2) The local street network which is the original network of winding roads served as pedestrian routes connecting the internal and intercommunity areas. (3) The global street network which comprised of eight main roads interconnected in a grid system to connect communities that had temples within the old town district. (4) The shop houses with unique architectural structures scattered along the main roads. They are vernacular wooden row houses, with a maximum height of two stories. The ground floor is used for commercial purposes, with wooden shutters between the pillars. The upper floor is used for residential purposes (Fig. 2).

Fig. 2: Urban morphology of the shop row houses that represent the characteristics of the old town district of Sakon Nakhon city
Source: Thinnakorn (2007) and Authors

The old town district of Sakon Nakhon city was once the city's center, characterized by a grid system of eight main roads. It was densely populated with residential areas, commercial buildings, government offices, and temples.

Currently, the city's street network has expanded beyond the boundaries of the old town district, becoming the location for government offices and the new city center. This has led to changes in the accessibility of the street network and the shift of the city center towards a street network with higher accessibility. Nevertheless, preliminary surveys reveal that the old town district of Sakon Nakhon's street network still maintains a densely populated economic activity network, which serves as crucial attractor nodes for local residents and tourists. This phenomenon has allowed the vernacular row houses located along the main roads of the old town district to adapt and find contemporary uses (Fig. 2).

Therefore, based on these observations, it becomes apparent that the old town district of Sakon Nakhon can serve as a theoretical representation leading to an empirical investigation into the factors influencing the preservation of historic city center.

Findings

1. Analysis of the Integration Value of the Street Network

It is observed that this has changed over time and has been divided into 3 periods:

1. Period 1901
2. Period 1961, 1982 and
3. Period 2022, which yielded the following diagrams of global integration values.

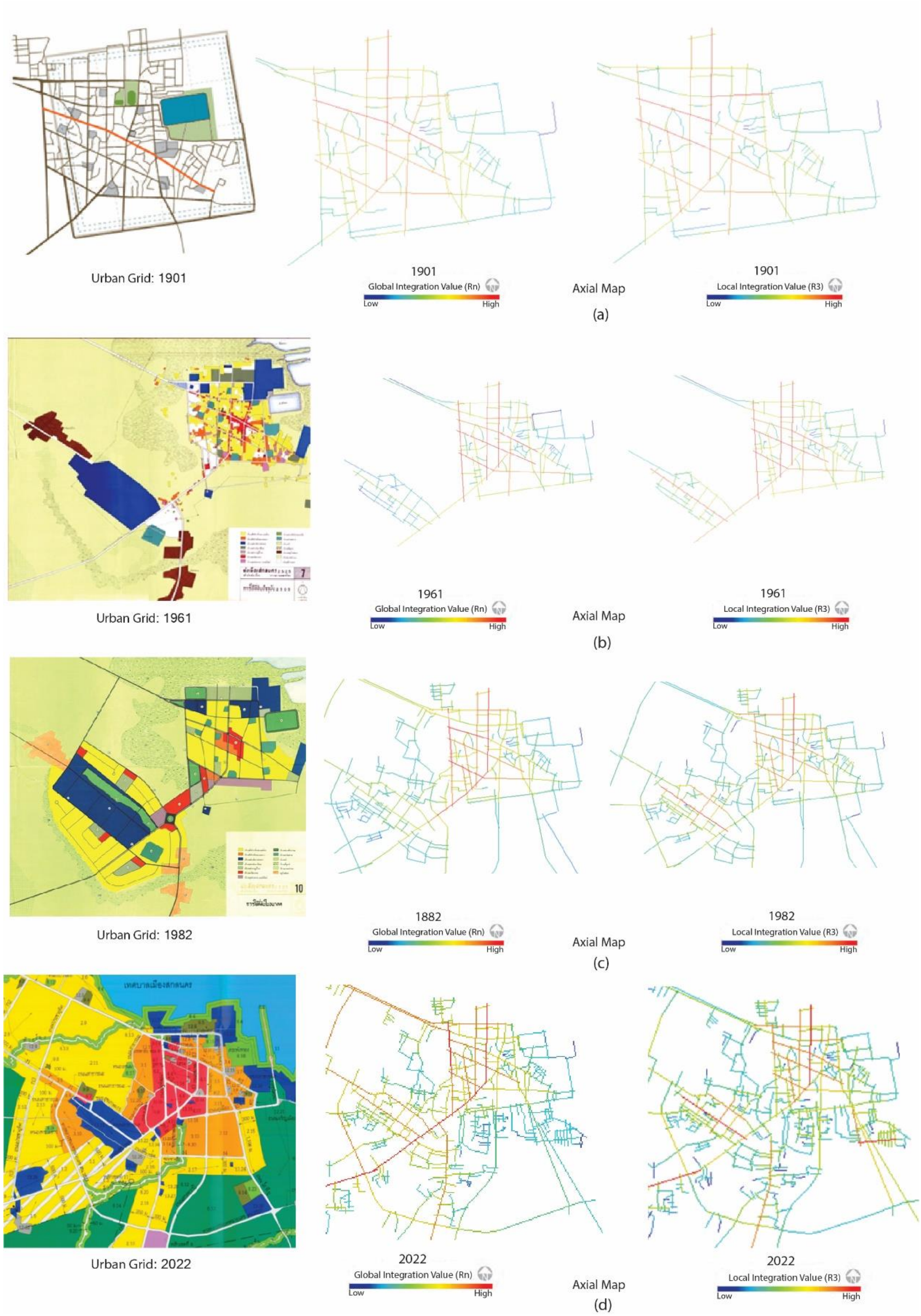

Fig. 3: Analysis of the Integration Value of the street network of the old town district of Sakon Nakhon city which changed over time.

1.1 The First Period, 1901

This was the period when the grid system street network has been built to connect the temples. It has overlapped with the original street network which has been narrow bullock cart lanes and pedestrian lanes for local mobility within the community.

The 1901 axial map analysis that displays the global integration value (RN) and local integration value (R3) shows that the warm color tones were widely distributed throughout the grid system street network, which served as the main roads in the old town district. This pattern aligned with the historical establishment of the city. This was the period of vernacular wooden row houses densely clustered along the main roads to accommodate increased levels of natural movement. The roads with high level of natural movement were Chareonmueang Road and Suk Kasem Road. The intersection of these two roads and the areas nearby emerged as the central area of the city and an important economic zone (Fig. 3a).

1.2 During the Periods of 1961 and 1982

The street network expanded beyond the boundaries of the old town district, resulting in the establishment of administrative centers and new urban areas.

The 1961 and 1982 axial map analysis that display the global integration value (RN) and local integration value (R3) showed that the original commercial zone within the old town district maintained its status as the central area of the city, with high integration value demonstrated by the density and spreading from the intersection of Chareonmueang Road and Suk Kasem Road. This indicated a high degree of natural movement and reflected the potential of attracting people and economic activities.

Additionally, the expanding road network around the new administrative center illustrated the direction of urban growth, creating a new local-level central area out-side the old town district. This was evident in the local integration value (R3) analysis, where the axial lines in the area surrounding the new administrative center were prominently displayed in red, signifying a distinct new local-level central area (Figs. 3b and 3c).

1.3 The Third Period, 2022

The current old town district of Sakon Nakhon city There has been the development of main roads connecting between the old town district, the new administrative center, and the road network surrounding the new administrative center. This has resulted in the emergence of a new city with a denser transportation network to accommodate economic growth.

The 2022 axial map analysis that displays the global integration value (RN) and local integration value (R3) showed that the original commercial zone within the old town district exhibited a clustering pattern of the transportation network, with a strong presence of the red axial lines interconnecting systematically and a widespread distribution of warm color tones along the main road network. This indicates that the transportation network in the city is fostered by the natural movement at a higher and widespread level which demonstrates a configurational attractor that has the ability to attract people and economic activities. This finding confirms that the old town district continues to maintain its status as the central area of the city, despite the expansion of the transportation network beyond the boundaries of the old town district. This is in alignment with the current land use plan that designates that the original commercial zone within the old town district shall be an area with high-density commercial land use (Fig. 3d).

Therefore, it can be observed that the urban grid configuration of the old town district of Sakon Nakhon city has a significant influence in maintaining its status as the city center. This has resulted in the scattered vernacular row houses, along the main road network, being nurtured by the widespread natural movement persisting from the past until the present (Figs. 4 and 5).

Fig. 4: The relationship between the global integration value (Rn) and the position of the vernacular row houses.

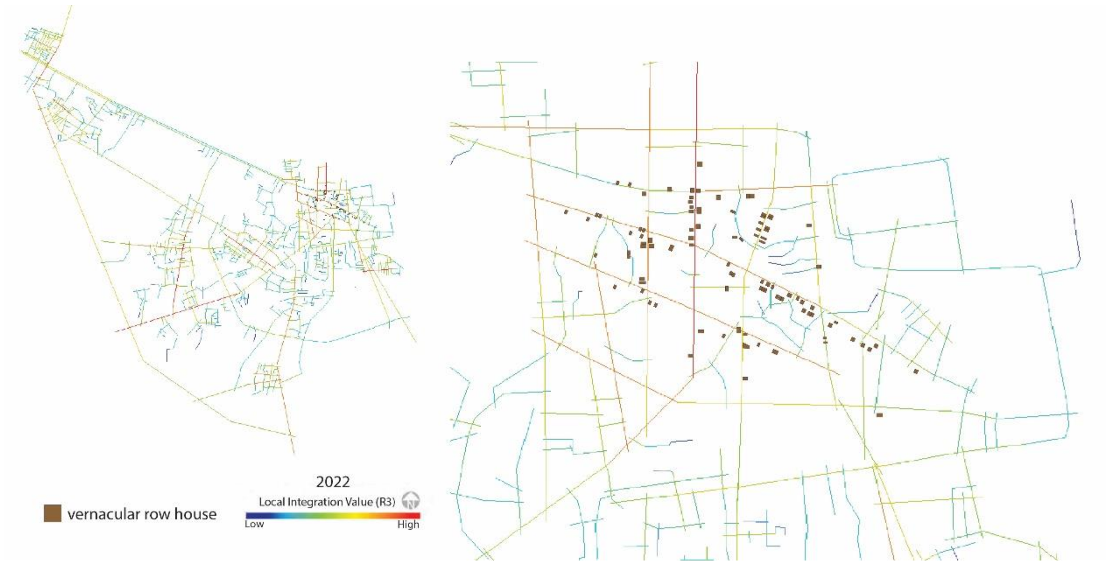

Fig. 5: The relationship between the local integration value (R3) and the position of the vernacular row houses.

2. Characteristics of the Street Network Supporting the Centralization of the City
The analysis is divided into two levels: an overview of the global level and specific level only within the boundaries of the old town district. The results of the analysis on the axial map that changed over time using space syntax methods, are as follows.

Table 1: The statistics of synergy value using space syntax methods.

Year	Global Level: Overview synergy value	Specific Level: the old town district synergy value
1901	0.72204	0.72204
1961	0.74879	0.86055
1982	0.52974	0.79934
2022	0.40587	0.77390

2.1 Analysis of the Synergy Value of the Overview of the Global Level

The analysis focuses on a global level analysis, combining the old town district and the new administrative district. The axial map analysis considers only the street networks accessible to cars and motorcycles, excluding small pedestrian pathways used within the community. This study aims to examine the spatial potential that supports the city's centralization at the global level. The results of the analysis are as follows (Table 1):

In 1901, the roads were interconnected in a grid system overlapping with the original street network within the old town district. The analysis found that R^2 value was 0.72204, indicating a relatively high level of synergy value. This suggests that the local street network can effectively connect and relate to the global street network. As a result, the global street network demonstrates good potential for transportation, with diverse public routes preferred by people at both the global and local levels.

Later, in 1961, the street network system has expanded beyond the boundaries of the old town district. It continued to expand and become denser from 1982 until the present. It was found that the synergy value showed a decreasing trend following the expansion of the city street network. Initially, it had a high value of 0.74879 in 1961, then it has decreased to a moderate level of 0.52974 and 0.40587 in 1982 and 2022, respectively. This indicates that the relationship between the global integration value and the local integration value decreased compared to before the expansion of the street network outside the old town district. It suggests that the preferred traffic routes at the global and local levels diverged because the street network became more complex, consisting of main roads used for global level transportation and smaller street network used for community transportation. The hierarchical nature of the street network became more pronounced.

2.2 Analysis of Synergy Value at the Specific Level of the Old Town District

The analysis focuses on analyzing within the boundaries of the old town district. The axial map analysis considers only the street networks accessible to cars and motorcycles, excluding small pedestrian pathways used within the community. This study aims to examine the spatial potential that supports the centrality of the city for the people residing in the old town district. The results of the analysis are as follows (Table 1):

The synergy value of the local street network, or R^2 value, in 1901, 1961, 1982 and 2022 were 0.72204, 0.86055, 0.79934, and 0.77390, respectively. This indicates that the old town district has a high correlation between the global integration value and the local integration value. It signifies the ability of the community street network to connect or relate as part of the global street network in the old town district. Therefore, the old town district has public routes preferred by people at both the community and global levels, which overlap. This increases the opportunities and density of traffic, which are important factors in creating a vibrant city and in indicating in centrality.

3. Analysis of the Relationship between the Global Integration Value and the Degree of Street Intervisibility

The analysis focuses on processing the street network that can be traversed by cars and motorcycles, as well as small pedestrian networks used for commuting within the entire community. This is done to study the degree of street intervisibility of building's ground levels, which indicates the level of active frontages of buildings that interact with main streets. The study results are processed using statistics for each segment of the streets and converted into an interface map as follows:

3.1 Analysis of the global integration value within the old town district

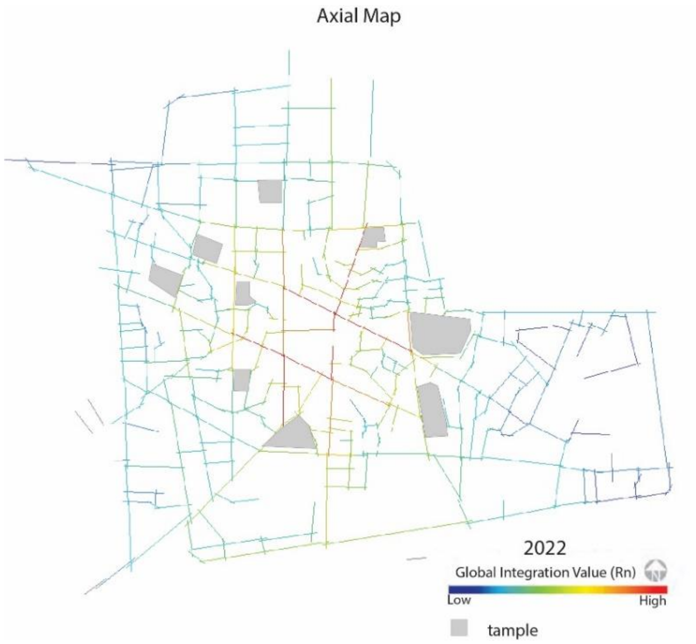

Fig. 6: The map shows the global integration value within the old town district

From the global integration value map, it is evident that the axial map represents the global integration value of the old town district, which is processed by considering the all the street networks. It reveals that the central urban area of the old town district has a high global integration value, as indicated by the dense red axial lines within the central area. These lines extend throughout the street networks in warm color tone, including main roads and small pedestrian pathways used for local commuting. This signifies an increased potential for pedestrian access within the central area of the old town district.

Although there is widespread land use of the temple type within the old town district, which is considered a negative attractor hindering movement economy and inhibiting the city's growth according to market mechanism, the traditional pedestrian street network plays a role in mitigating the impact of these negative attractors within the area. By creating sub-blocks within the blocks formed by the intersections of the main roads of the old town district, it enhances the connectivity of the street network within the district and promotes intensified pedestrian movement in the central area of the old town.

3.1Analysis of the Street Intervisibility

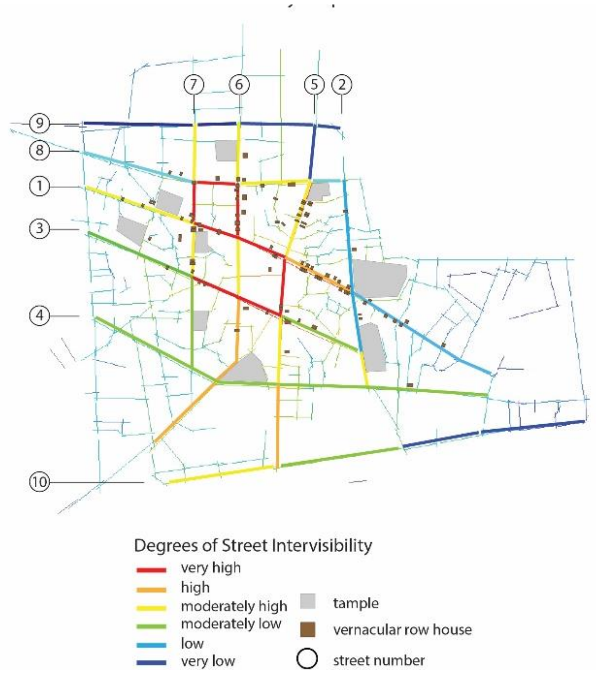

Fig. 7: The figure shows the map of the degree of street intervisibility of the main streets.

Table 2: The table presents a summary of the statistical values for the global integration value and the degree of street intervisibility.

Street number	Street name	Average value of percentage of active frontages per total building (maximum)	Average value of density of active frontages per 100 meters (maximum)	Average value of degrees of street intervisibility (DoSI) (maximum)	Average value of integration (RN) (maximum)
1	Charoen Mueang	76.60 (83.61)	19.90 (23.81)	0.2668 (0.3903)	0.9912
2	Rueang Sawat	34.60 (53.00)	6.11 (11.42)	0.1337 (0.2501)	0.8516
3	Kamchat Phai	65.39 (74.11)	18.22 (25.45)	0.2550 (0.3636)	0.9627
4	Rop Mueang	62.63 (79.79)	13.70 (22.02)	0.1632 (0.1852)	0.7910
5	Chai Pha Suk	61.47 (90.00)	16.58 (25.13)	0.2142 (0.3300)	0.9601
6	Sookkasem	76.47 (90.91)	21.15 (31.47)	0.2467 (0.2968)	0.8876
7	Prem Prida	54.86 (81.61)	13.77 (27.95)	0.2127 (0.2954)	0.8493
8	Mankhalai	48.76 (61.11)	7.39 (12.46)	0.1973 (0.3194)	0.7916
9	Sai Sawang	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.6705
10	Khu Mueang	56.38 (89.86)	5.16 (13.68)	0.1259 (0.1982)	0.6945

From the street intervisibility map, it is found that (Table 2):

1) The highest average value of degree of street intervisibility is observed on Charoenmueang Road (number 1), with a value of 0.2668. The positions of street segments with the highest degree of street intervisibility calculated are 0.3903 and 0.3863, represented by red lines on the street intervisibility map. Charoenmueang Road has an average percentage of active frontages of 76.60% of all buildings located on both sides of the road. It also has an average density of active frontages of 19.90 units per 100 meters of Charoenmueang Road.
2) The second-highest average value of degree of street intervisibility is found on Kamjatpai Road (number 3), which is equal to 0.2550. The positions of street segments with the highest degree of street intervisibility on Kamjatpai Road are 0.3636 and 0.3139, shown as red lines on the street intervisibility map. Kamjatpai Road has an average percentage of active frontages of 65.39% of all the buildings located on both sides of the road. It also has an average density of active frontages of 18.22 units per 100 meters of Kamjatpai Road.
3) The third-highest average value of degree of street intervisibility is found on Suk Kasem Road (number 10), which is equal to 0.2467. The positions of street segments with the highest degree of street intervisibility on Suk Kasem Road is 0.2968, shown as red lines on the street intervisibility map. Suk Kasem Road has an average percentage of active frontages of 76.47% of all the buildings located on both sides of the road. It also has an average density of active frontages of 21.15 units per 100 meters of Suk Kasem Road.
4) The fourth-highest average value of degree of street intervisibility is observed on Chai Pha Suk Road (number 5), which is equal to 0.2142. The positions of street segments with the highest degree of street intervisibility on Chai Pha Suk Road is 0.3300, shown as red lines on the street intervisibility map. Chai Pha Suk Road has an average percentage of active frontages of 61.47% of all the buildings located on both sides of the road. It also has an average density of active frontages of 16.58 units per 100 meters of Chai Pha Suk Road.

Therefore, from the street intervisibility map, it can be seen that areas with high degrees of street intervisibility are represented by red lines. These dense areas are located around the city center of the old town district of Sakon Nakhon. This aligns with the current municipal master plan that utilizes the land for high-density commercial activities. Additionally, the street intervisibility map shows that the positions of vernacular row houses are densely clustered and correlated with streets with high degree of street intervisibility.

The survey of vernacular row houses reveals that out of a total of 72 houses, 58 of them have active frontages at the ground level used for commercial purposes, 12 are used as residential units, and only 2 are not utilized. This indicates that vernacular row houses continue to be a part of the old town district, maintaining their interaction with the main roads and contributing to the character of the old town in Sakon Nakhon (Figs 8 and 9).

Fig.8: Vernacular row houses distributed along the main road
Source: Authors

3.2 Relationship Between Global Integration Value (RN) and Street Intervisibility

The analysis of the relationship between global integration value (RN) and street intervisibility utilizes Simple Regression Analysis (SRA) using the SPSS program. The analysis results are as follows:

Based on the preliminary dependent variable testing, it was found that all variables follow a normal distribution, as indicated by the Kolmogorov-Smirnov test. The Sig. values of the variables is the degree of street intervisibility and global integration value (RN) of each street segment equals 0.20, which is higher than 0.05. Therefore, it can be considered that the variables have a normal distribution. Additionally, the Pearson correlation test showed a linear relationship with significant causation between the independent and dependent variables. Hence, based on the preliminary testing, it is evident that all variables can be subjected to Simple Regression Analysis (SRA). The results of the correlation test are as follows:

Table 3: The table displays the statistical values from the correlation between the global integration value (RN) and the degree of street intervisibility.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.645	0.416	0.402	0.77351266

Coefficients

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-2.827	0.543		-5.210	0.000
	Integration_RN	3.318	0.621	0.645	5.341	0.000

From the Model Summary and Coefficients table (Table 3), it is found that the variables have a statistically significant relationship. The R Square value is 0.416, indicating that the global integration value explains 41.6% of the relationship with the degree of street intervisibility. The equation is $Y = -2.827 + 3.318X$ (Y represents the degree of street intervisibility and X represents the global integration value).

Based on the testing of the relationship between the global integration value and the degree of street intervisibility, it is found to be statistically significant. The map of the global integration value aligns with the degree of street intervisibility, indicating that the old town district of Sakon Nakhon city continues to maintain its central role in the city.

Discussion

The results of the study on the Integration Value of the street network in the old town district of Sakon Nakhon, as it changes over time, demonstrate that the old town district continues to maintain its centrality in accordance with the theory of urban centrality (Hillier, 1999). This centrality is sustained by natural movement at both the local and global levels, following the movement economy process (Hillier, 1996b). The configuration of the urban grid, which intertwines systematically, creates a "configurational attractor" (Hillier et al., 1993), resulting in the presence of small block-sized streets within walking distance. This encourages the attraction of people and economic activities more than in other areas (Hillier et al., 1993). Therefore, the main street network in the old town district serves as a location for vernacular row houses, accommodating the natural movement of people from the past to the present.

By examining the characteristics of the street network that supports the city's centrality through the analysis of synergy value, both at the overview of the global level and the specific level of the old town district, it was found that for the analysis of the overview of the global level, the changes of the street network due to the expansion of the city resulted in a hierarchy of street networks. This hierarchy revealed that the preferred routes used by people for the global and local levels traffic are different. The preferred routes for global level traffic were typically main roads that had the potential to attract traffic flow and economic activities at a higher level. Meanwhile, the secondary street network was used for community level traffic.

Next is the analysis at the specific local level, it was found that the grid configuration system in the old town district has a high Integration Value, which corresponds to the high synergy value. This indicates that the community street network is well connected and part of the global street network. There is metric integration through natural movement at both the global and local levels that are overlapping, meaning that within the old town district, the preferred routes for both global and local levels traffic are the same. This allows for dense and inclusive free-flowing traffic throughout the area, which significantly influences the attraction of economic activities and people. This is a crucial characteristic of a vibrant live center, as described by the theory of urban centrality (Hillier, 1999).

Additionally, the location of vernacular row houses along the main roads in the old town district is influenced by natural movement at both the local and community levels. This has implications for the sustainability of vernacular row houses, which benefits from the increased traffic flow. These findings align with the idea that the design of urban communities to be functional does not solely depend on the characteristics of public spaces but also relies on the capabilities of the urban grid to establish connecting relationships with local streets, attracting people to travel through. Conversely, designing urban communities without considering the local level spatial relationships influenced by the urban morphology at the local level hinders the creation of natural movement in the designed area and tends to result in underutilization (Hillier, 1999;Hillier et al., 1993;Hillier & Penn, 1988).

Lastly, the analysis of the relationship between the global integration value and the degree of street intervisibility reveals that the urban grid configuration of the old town district supports its centrality as a city center. It exhibits characteristics of a configurational attractor (Hillier et al., 1993), which affects the diversity of people and economic activities in the city center and contributes to its urban buzz (Hillier, 1999; Hillier et al., 1993;Hillier, 1996b). This is evident in buildings with a high degree of street intervisibility, known as active frontages. These buildings have a significant number of doors that open directly onto the street network in the city center of the old town district. They play a crucial role in increasing opportunities for social interactions among people, buildings, and streets, supporting the liveliness of the main roads as public spaces (Hillier, 1989;Heffernan, Heffernan & Pan, 2014;Yeang, 2000). They act as mechanisms for creating 'the eyes on the street' and contribute to natural surveillance, indicating the quality of the city (Jacobs, 1961;Gehl, 1987).

Therefore, the high degree of street intervisibility is influenced by the urban grid configuration, turning the old town district of Sakon Nakhon city into a 'place' that attracts people and commercial activities, fostering interactions between buildings and the spaces on both side of the street (Hillier, 2007;Hillier et al., 1993;Hillier, 1996b).

This finding has clear implications for urban conservation and city design, particularly in the context of historic city centers that have been the traditional focal points of urban life. Preserving the centrality of the city center as a vibrant place and ensuring the continued existence of valuable architectural spaces that can be utilized in the evolving cityscape are crucial (Fig. 9). It highlights that the key lies not solely in the characteristics of urban design and architecture, but in the spatial configuration that allows for the integration of local urban grids into the global urban grid. This integration transforms local movement into an integral part of global movement, reinforcing the ability to maintain a lively and thriving city center as a vital hub.

Fig. 9: (a) vernacular row houses before renovation in 2007 and (b) the vernacular row houses after renovation by building owners in 2022.
Source: Thinnakorn (2007) and Authors

Conclusions

The study findings indicate that the old town district can maintain its centrality as a city center, driven by two significant factors.

First, the urban grid configuration, which is systematically interconnected and influences the creation of natural movement, fosters the vitality of the city center.

Second, the old town district has a local street network that can integrate into the morphology of the global street network.

Interaction between these two factors as shown by the statistics of synergy value using space syntax methods which the data enables the old town district to attract people and economic activities, as evidenced by the density of economic activities and the utilization of the ground floor spaces that have active frontages that signify the interaction between building entrances and streets.

This is particularly evident in vernacular row houses, of which architecture has historical values and have been developed and improved by building owners to capitalize on the increased pedestrian traffic. Consequently, these buildings adapt and become part of the urban fabric of the present. On the contrary, if these vernacular row houses are not located in areas with active natural movement, they tend to be underutilized and eventually abandoned. This leads to the loss of the city's identity, as observed in several cities.

The results of this study can contribute to a better understanding of the processes of growth and decline of urban centers, expanding perspectives on conservation, urban revitalization, and urban design. It highlights the influence of the urban morphology on the sustainable preservation of architectural heritage that benefits urban city planners and designers in the development and revitalization of historic city districts to maintain their ability to attract people and economic activities as live centrality.

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