International Journal of Sustainable Development and Planning
Vol. 20, No. 10, October, 2025, pp. 4345-4360
Journal homepage: http://iieta.org/journals/ijsdp

The Sustainable Defensive Space in Neighborhoods with Different Planning Patterns - A Comparative Analytical Study in Iraq

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https://doi.org/10.18280/ijsdp.201022

Received: 12 September 2025
Revised: 12 October 2025
Accepted: 17 October 2025
Available online: 31 October 2025

Keywords:
defensive space, secure environment, urban environment, planning pattern, sustainable development, space syntax, Babylon

ABSTRACT

Cities are undergoing continuous morphological transformations, resulting in a contrast between the planning patterns of residential neighborhoods with traditional organic fabrics and modern grid patterns. This study aims to understand urban morphological transformations and their impact on security and sustainability in cities, focusing on the relationship between urban planning patterns (organic and grid) and the concept of "sustainable defensive space." The research is grounded in a theoretical framework that combines Neuman's defensive space theory and Heller and Hanson's space syntax theory, providing a basis for analyzing how city structural characteristics influence urban security. The study used a quantitative and qualitative analytical methodology. It was conducted in two adjacent residential neighborhoods in Babylon. The data from plans, aerial photography, and field visits. The analysis aims to measure characteristics such as integration, connectivity, control, and street network depth to identify differences in "sustainable defensive space" between different planning patterns. The study concludes with practical recommendations for urban planners to enhance the design of residential neighborhoods in Babylon and other cities with similar contexts, aiming to improve security, social cohesion, and environmental sustainability.

1. INTRODUCTION

The concept of defensive space was proposed by Oscar Neuman in 1970s, which has since gained popularity across many fields in urban planning and design. This interest was largely due to the social decline and rising crime rates sweeping the urban landscape. Like many other architects, planners, and criminologists, Neuman sought to understand the influence of the physical environment on feelings of safety and discouraging crime. In his book (Defensive Space), which was published in 1972, he argued that defending against crime in urban areas depended on the spatial organization and planning of the areas. Neuman then described defensive space as the spatial structures structured to support positive neighborhood interactions. Thus, the space becomes a protective space within the built environment [1].

The advancement of planning thought and increasing recognition of the intricate challenges in urban areas have demonstrated how the aspect of security can no longer be the only focus of urban quality of life. It was from this perspective that this study delved into the defensive space concept as part of the more comprehensive sustainable framework. Generally, this concept seeks to integrate the traditional security principles, along with the social, ecological, and economic urban sustainability dimensions. This mixture can create residential areas that, over time, are physically secure, lively, diverse, and environmentally friendly. As such, this study focused on the relationship between certain variables of urban morphological structure and other components of sustainable defensive space in two different neighborhood planning patterns. The analysis was oriented towards the spatial planning level that relied on indicators concerning Neuman's defensive space characteristics and Hillier's space syntax methodologies, integrating sustainability dimensions as the primary consideration.

Babylon, Iraq, has undergone various transformations in its urban morphologies, which have led to the emergence of the traditional (organic) and modern (grid) patterns coexisting in the same area. For this reason, the urban region was taken as a case study to examine the sustainable defensive space components in two neighborhoods (traditional and modern) in Babylon. Two adjacent neighborhoods within the city center were selected, in which the traditional and modern neighborhoods were Al-Mahdiya and Al-Qadiyah, respectively. The theoretical framework of sustainable defensive space was then applied to assess the potential that each neighborhood has. The relationship between urban structure with planning pattern differences and the creation of a sustainable defensive environment was also examined.

2. THEORETICAL FRAMEWORK

2.1 The concept of defensible space and its importance

The relationship between crime and the spatial environment was first emphasized in 1961 with Jacobs's work "Eye on the Street" theory [2]. Later, Jeffery [3] developed the theory of "Crime Prevention through Environmental Design" (CPTED), which emphasized the possibility of preventing criminal behavior through effective environmental design, proposing three strategies: access control, natural surveillance, and the promotion of territoriality through the design of land, streets, and houses to encourage social interaction and define ownership, in addition he stressed the importance of maintenance and management as complementary tools in crime prevention.

This was followed by Newman's proposal [1] of the "defensible space" theory, which aimed to reduce crime through the design of the built environment. Newman [1] defined defensive space as "a model of residential environments that prevents crime through the physical expression of a self-defending social fabric" through his five principles (territoriality, natural surveillance, image preservation, access control, and activity support). In 1979, Cohen and Felson introduced the "Theory of Everyday Behavior," suggesting that crime requires three elements: potential offenders, potential victims, and the absence of intense supervision [4]. Clarke [5] proposed the "Situational Crime Prevention Theory", which focuses on reducing the opportunity for crime by changing situational conditions. Wilson and Kelling [6], "Broken Windows Theory", subsequently introduced an environmental management perspective to CPTED.

In 1984, Bill and Julienne [7] developed the concept of their theory "space syntax" to explain design from a social perspective. Hillier asserted that space, as an extension of everyday life, is analyzable to understand the impact of using a series of spaces on pedestrian traffic, safety, and economic vitality. His theory relies on computational techniques to model factors such as crime patterns, land use, and pedestrian traffic. He concluded that quiet, less connected (and isolated) areas typically suffer from higher crime rates. At the same time, pedestrians more frequently use streets with high accessibility, and the degree of accessibility is related to pedestrian activity. He also linked the lack of outward-facing housing to fear and anxiety among pedestrians, emphasizing that an effective and well-defined movement pattern is a means of controlling crime in residential neighborhoods [7].

Wen et al.'s study [8] summarized crime prevention theories, where the first-generation CPTED theory formed the basic framework of the theory and established its six basic elements (territoriality, surveillance, access control, goal enhancement, and image maintenance). The second-generation CPTED theory then added four main components (social cohesion, community bonding, community culture, and threshold capacity). This was followed by the third-generation CPTED theory, which is based on the fundamental concept of community livability, combining public health and sustainability [8], as shown in Figure 1.

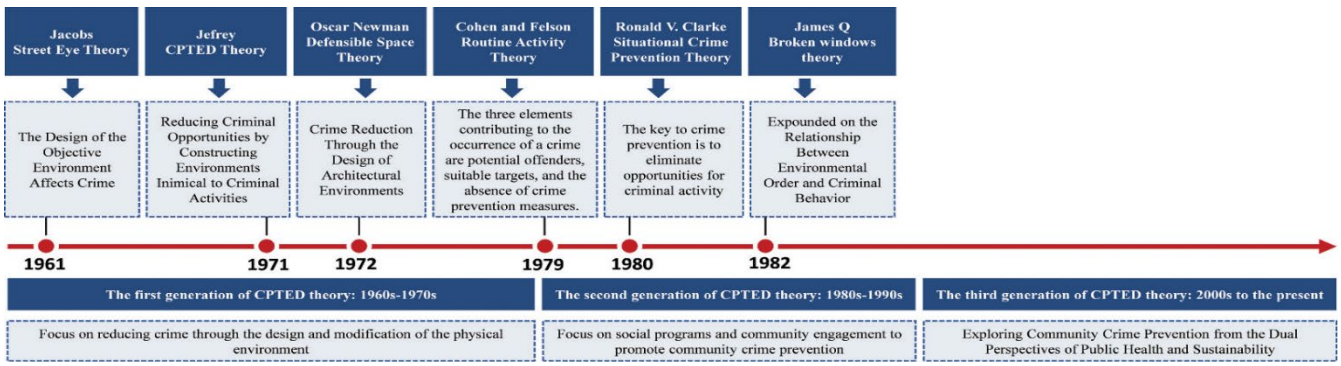


Figure 1. Environmental design and the prevention of criminal theory development process map [8]

2.2 Characteristics of the spatial environment and its relationship to safety

According to Conzen and Whitehand, spatial structure analysis includes the study of urban fabric elements, including street patterns, building blocks, urban spaces, green spaces, and land uses [9]. Research into the relationship between the spatial environment and safety involves identifying environmental elements and exploring the connection between specific types of these elements and criminal behavior, providing a basis for environmental design to achieve safety and a sense of security [8].

2.2.1 Street patterns

Streets constitute an essential part of urban space and are the most widely used public spaces in the daily lives of residents. Criminal activities unfold based on key points in the daily activities of perpetrators or victims, as well as the paths that connect these points [10]. Road patterns (grid/organic), their size, and hierarchy affect access, user identification, and social life, and are linked to the formation of defensive space [1, 2, 7].

Pedestrian and vehicular traffic density, as well as street length, affect the "eyes on the street the grid shape links to crime, as high-traffic roads in the neighborhood center reduce interaction and natural surveillance [11]. Creating unsafe spaces and reducing defensive spaces in neighborhoods with high permeability due to major arteries [12] (see Figure 2).

Street layout patterns influence visual permeability (grid patterns are more permeable than organic ones due to their straight streets and clear boundaries) and accessibility (connected grids offer higher accessibility than unconnected ones) [13]. Dead ends are safer because they have fewer users and strangers [14]. This is linked to the potential for movement, density, and fewer “eyes on the street” [15], which enhances defensibility. Street grids are classified into four categories: primary, secondary, local, and dead-end [16]. Urban form is classified as grid, organic, or parallel

(distorted/fragmented) [17] (Figure 3).

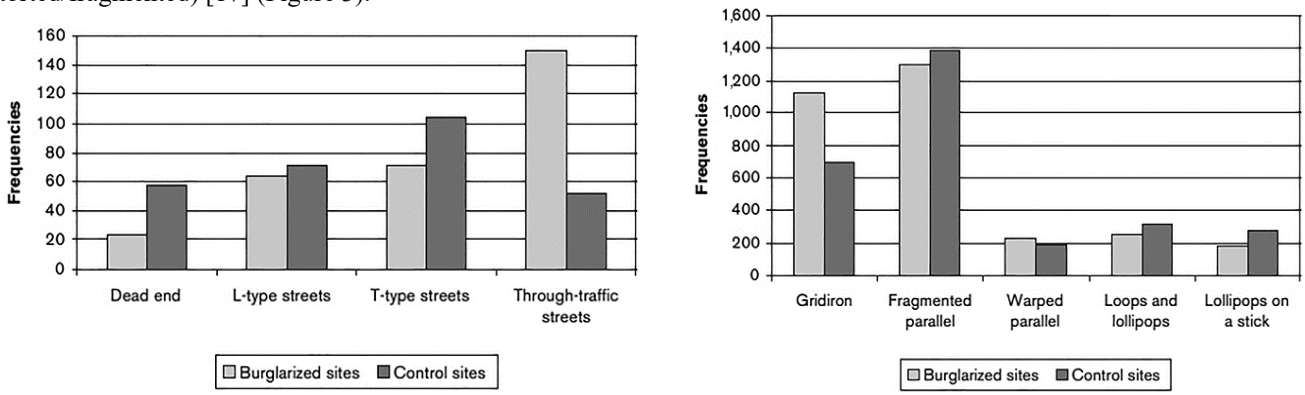
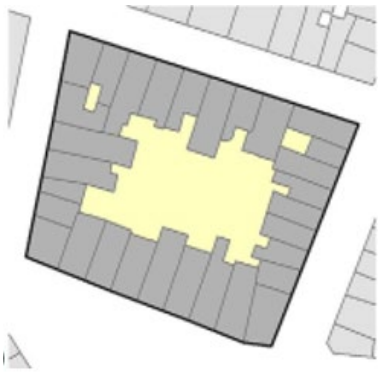
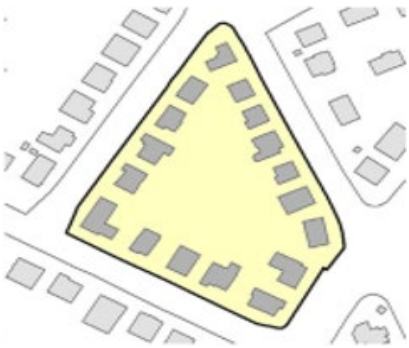


Figure 2. Street morphologies and theft rate [12]



(a) No permeability

(b) Medium permeability



(c) High permeability

Figure 3. Different patterns of building blocks and their effect on the permeability of the urban environment [18]

2.2.2 Block patterns and urban spaces

The block pattern is an indicator of the degree of flexibility and permeability in the urban environment. Block size can determine the ease of access from one point to another, with smaller blocks being more permeable [19]. Space patterns differ based on the degree of privacy they offer, which affects the permeability of the environment [20]. The way blocks and spaces relate to each other plays a key role in urban design, as the social, cultural, and economic aspects of a neighborhood's residents are connected to the properties of building density [21].

Spaces (gardens, squares, parks, and playgrounds) are viewed as the spatial elements of a neighborhood that contribute to enhancing lifestyle and make the well-being better, in addition to offering recreational spaces. Safe for children to play, it is directly connected to security and surveillance [1]. In urban planning, improving street landscape features and increasing street usage can decrease the percentage of crime [22]. Figure 4 illustrates the effect of building configurations and urban blocks on the permeability of the urban environment.

2.2.3 Land use

Criminology-based studies have examined how crime is distributed across different spaces, exploring the connections between specific land use types, such as commercial and residential areas, and crime rates, as well as their impact on the types and severity of crimes [23]. Stucky and Ottensmann [24] found higher rates of violent crime in non-residential areas, whereas Anderson et al. [25] found that crime rates in mixed-use areas, which combine commercial and residential properties, were lower than in purely commercial areas. Areas with low mixed-use properties tend to affect neighborhood safety, whereas land use diversity enhances safety [2]. Land use is characterized by its variable nature, as function is a human-dependent behavior that ultimately affects the physical form of a city, causing it to lose much of its Features and character, leaving only its general appearance [9].

2.3 Sustainable defensible space

Traditional defensible space theories, especially those advanced by Neumann, have greatly enriched the knowledge regarding the link between physical design and security. Nonetheless, contemporary urban issues have demanded an alternative approach. Rather than merely preventing crime, the more difficult goal that should be achieved is to foster positive

and sustainable urban environments. Therefore, a safe built environment is a necessity for societal development and a pre-condition for urban sustainability [26]. This concept is reflected in the United Nations Sustainable Development Goals. Goal 11, refers for inclusive, safe, resilient, and sustainable cities [27]. Safety is no longer viewed in isolation. Rather, this element can be integrated with wider societal objectives, such as environmental sustainability, social justice, and economic prosperity. In this context, the sustainable defensible space concept then emerges as a conceptual framework that can merge the principles of security with various urban sustainability facets. This study also proposed and aimed to determine the components of environments that were safe and could provide a comprehensive and sustainable quality of life for their residents. Such studies focusing on heritage and traditional urban settings have underlined the critical importance of the social dimension, how it weaves into community life, strengthens cultural identity, and creates meaningful spaces for social interaction [28].

The spatial organization of a neighborhood (linear, clustered, central, and grid) has a significant impact on its sustainability, as design standards and principles, such as mixed land use, open spaces, public transportation, and walkability, are critical and influential [29]. The concept of incorporating green design principles into the development of sustainable cities, along with integrating high-tech, environmentally friendly, and sustainable approaches into CPTED practices, was proposed to enhance urban safety [30].

According to the above, sustainable and defensible space can be defined as a planning and design approach that aims to create safe urban environments by integrating traditional defense space principles with the overarching goals of environmental, social, and economic sustainability. This approach ensures the long-term safety and well-being of residents while conserving resources and enhancing community cohesion. Figure 4 represents the conceptual model for sustainable defense space.

Figure 4. Characteristics and dimensions of sustainable defensive space
Source: Authors

2.4 Applications of defensive space theories in the local and regional contexts

Although Western theories, such as "defensive space," "CPTED," and "spatial structure analysis," have provided effective analytical tools for understanding the relationship between urban design and security, their application in Arab urban contexts—particularly Iraqi ones—remains limited and requires adaptation to local social and cultural characteristics. One study regarding urban security compared traditional and modern neighborhoods in Sulaymaniyah. The study stated that diversification of uses could promote a sense of ownership, which could lead to the sense of security felt by the residents [31].

Seven security attributes were recognized from another study conducted in a traditional area of the city in Najaf. These characteristics include: movement and access, physical structure, control, ownership, protection, land use, management, and maintenance. This aligns with Neuman's concept of natural control, but within an Iraqi context based on belonging to place [32].

There was also research explaining that safety and security were pivotal in ensuring the vitality of urban spaces. The study determined that safety could notably impact the creation of an urban space that was vibrant and sustainable in the study area (Al-Mutanabbi neighborhood, Kufa, Iraq). Five safety-related factors that influence the vitality of urban space were identified. These factors are: traffic safety, crime prevention, control of public space, density, and accessibility [33].

A study of gated residential neighborhoods In Jordan found that in spite they met residents' need for a sense of security, they deepened social and spatial disparities. This necessitated the adoption of planning policies based on urban integration to reduce feelings of isolation [34].

Defensive space theory (Neuman), spatial structure analysis (Heller), and the three dimensions of sustainability complement each other to form a coherent analytical framework. Neuman identifies social objectives (such as natural control), Hiller provides quantitative metrics (such as

control and integration) to measure the ability of urban form to achieve these objectives. The sustainability dimensions ensure that solutions are viable in Iraqi urban contexts experiencing rapid morphological transformations and increasing urban pressures, such as the city of Babylon.

In this regard, this study employed Western theories while testing their practicality in the context of Iraq (Babylon). Particularly, this study uniquely merged these theories with a local reality that combined organic heritage and the network pattern to formulate an analytical framework aimed at enhancing urban security in Iraq.

2.5 Planning patterns for residential neighborhoods

2.5.1 The traditional (organic) pattern

The traditional (organic) planning of Arab cities has its roots in pre-Islamic settlements. It is represented that the relationship between people and their environment played a central role. With the rise of Islamic towns, this approach evolved into a cohesive urban entity with an organic layout [35]. This pattern was spontaneous, not pre-planned. It is shaped by the way people interacted with their cultural and natural surroundings, as well as by the influences of time and place, giving each city its own unique character [36]. Traditional urban patterns also relied on the active involvement of local communities in shaping their environment, which fostered a strong social and cultural cohesion [37].

Traditional cities felt alive. Streets and alleys twisted and turned naturally, creating a rhythm that guided people effortlessly through their daily lives. There were no rigid divisions—markets, squares, homes, and workspaces all flowed into one another, making it easy for neighbors to meet, trade, and socialize [35] in Figure 5.

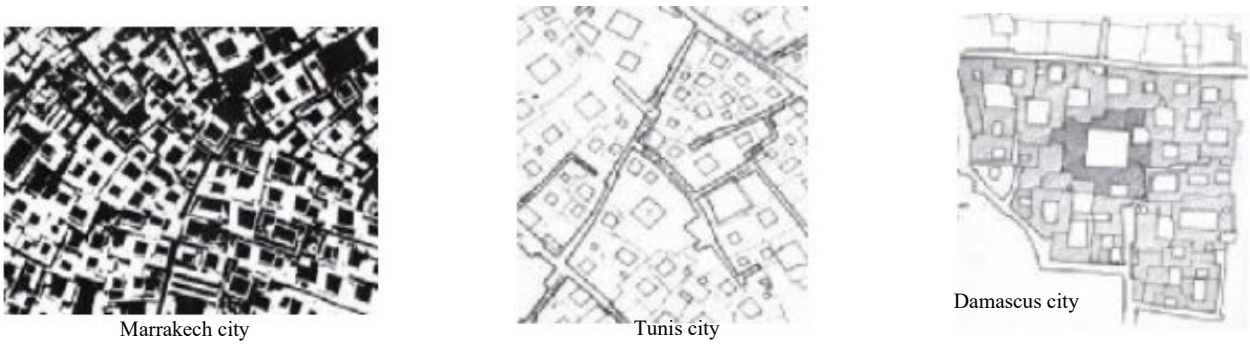


Figure 5. Patterns of traditional urban fabric in ancient Arab cities

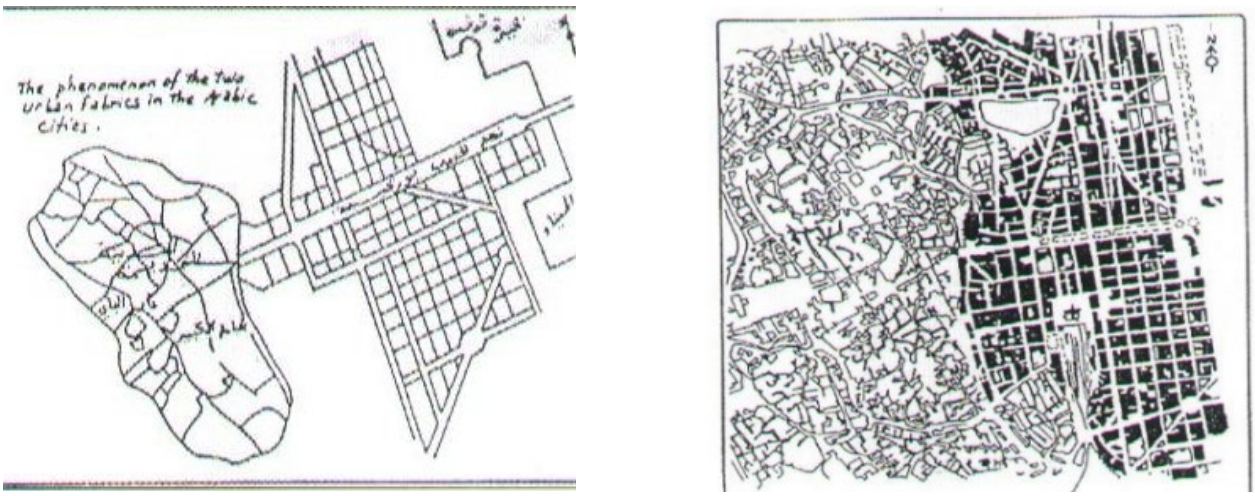


Figure 6. The Arab city (old and modern Tunis) showing the first modern growth characterized by grid divisions (duality of urban pattern)

The residential units were designed in a way that they looked the same in shape and size, and were built really close to each other, forming a single entity. The design philosophy also incorporated privacy and protection at all levels in the planning, spatial relationships, and architectural details. In addition, the physical characteristics of these residential units responded to the environmental, socio-cultural, and religious factors of the Islamic city [38]. Its urban fabric was functionally integrated and multi-functional, blending the social, economic, religious, and recreational aspects [35]. These characteristics gave the traditional pattern its distinction compared to other patterns, as its urban and social elements were integrated according to social factors and values. However, with time and expansion, different urban patterns emerged, stripping the traditional city of its unique character.

2.5.2 The contemporary pattern (grid)

The Arab city has witnessed transformations that led to the emergence of new urban patterns, such as the modern (grid) pattern, as a result of high population growth, diverse land uses, and the technological and scientific data of the era. This has led to changes in the characteristics of urban structure, with the establishment of grid or radial urban centers.

As shown in Figure 6, traditional planning has blended with

contemporary planning, along with the construction of wide roads and the disruption of the old fabric [39].

The contemporary planning thought has often been prepared by Western planners (such as the Doxiadis Foundation) in many Arab cities, paving the way for the grid pattern in modern towns and neighborhoods. The adoption of modern Western forms and patterns has led to hybrid formations between the modern and the ancient. The contemporary urban pattern [40] is characterized by the following:

• Wide open spaces in the neighborhood (due to the access of cars), and in front of and around residential units (such as gardens), distinguishing the modern house from the ancient.

• Wide open spaces relative to the size and mass of the buildings, which visually separate the blocks and weaken the cohesion between the residential units, eliminating the unity and integration between the houses and the surrounding spaces at the general level.

• A single, repetitive pattern, where each neighborhood may include more than one design model repeated on both sides of the street.

From this, we find that the traditional city (characterized by an organic pattern) was based on its emergence from social needs, characterized by proximity and the resulting familiarity and social security. This structure was a cohesive fabric resulting from the organic nature of development that characterizes traditional cities, a cumulative process that evolved from the inside out, based on social morphology. Meanwhile, the inorganic structure (grid pattern) is based on functional logic. The first is based on human relations that lead to a cohesive social urban structure characterized by vitality, where the frequency of visits to urban spaces increases.

Thus, the social presence that signifies security and reassurance is enhanced. The second is based on functional relations, as it is concerned with functional areas (residential, industrial, commercial areas, etc.). This is considered a procedural behavior by humans at certain times in an organizational process to contain various events and activities according to their spatial requirements, which reduces the frequency of these areas and thus the decline of convergence and the absence of social presence, suggesting isolation and loss of security.

Through the theoretical studies reviewed, the most critical variables for sustainable defense space and measurement indicators were identified in Table 1.

Table 1. The variables and indicators of sustainable defense space

Main Dimension	Primary Variable	Possible Measurement Indicators
Security dimension (Neuman principles)	Effective Natural Surveillance	- Clear visibility from windows and doors toward public spaces - High visibility resulting from activities - Design of entrances and exits
	Access Control	- Clear boundaries between public, private, and semi-public spaces - Design of main entrances to neighborhoods and buildings - Presence of dead ends or restricted access roads
	Territorial Reinforcement	- Signs of ownership and care for spaces (decoration, maintenance) - Resident use of adjacent semi-public spaces - Design that defines "zones of influence" for residents
Social dimension	Social Cohesion & Interaction	- The presence and use of shared public spaces (squares, courtyards, parks) - Opportunities for spontaneous encounters - Design that encourages walking and meeting
	Inclusivity & Accessibility	- Design that takes into account the needs of diverse groups - Providing safe and comfortable paths for all - The absence of physical or social barriers
	Local Identity & Sense of Place	- The presence of distinctive landmarks - Design that reflects local culture and history - Resident participation in shaping their environment - A sense of pride in the area
Environmental dimension	Green Spaces	- Percentage of green spaces - Quality and distribution of green spaces (parks, street trees) - Use of local and appropriate plants and improvement of the local climate
	Sustainable Mobility	- Availability and quality of pedestrian and bicycle paths - Proximity to public transportation - Design that reduces reliance on private vehicles
	Environmental Management	- Energy efficiency (lighting, building design) - Waste and stormwater management - Use of environmentally friendly building materials
Economic dimension	Vitality & Mixed Use	- -The presence of diverse small businesses within or near the residential fabric - Supporting the local economy
	Life-cycle Costs & Maintenance	- Quality and durability of materials used - Ease of maintenance of buildings and public spaces - Long-term operating costs (energy, water)
	Adaptability & Economic Resilience	- The ability of buildings and spaces to adapt to changing needs - Diversification of local economic opportunities - Not relying on a single economic resource

3. METHODOLOGY

Based on the theoretical framework presented above, Figure 7 illustrates the complete analytical path of the research, to show how each conceptual dimension was translated into quantifiable or field-based indicators, to ensure the coherence of the methodological structure and the clarity of the link

between theory and practice.

This paper presents a comprehensive analysis of the characteristics of the selected residential neighborhoods (traditional and contemporary patterns) through studying the maps to identify the planning and design characteristics that contribute to achieving the elements of a safe environment. A comparative case study approach was employed for two adjacent residential neighborhoods in the center of Hillah city, Babil Governorate, Iraq (Figure 8).

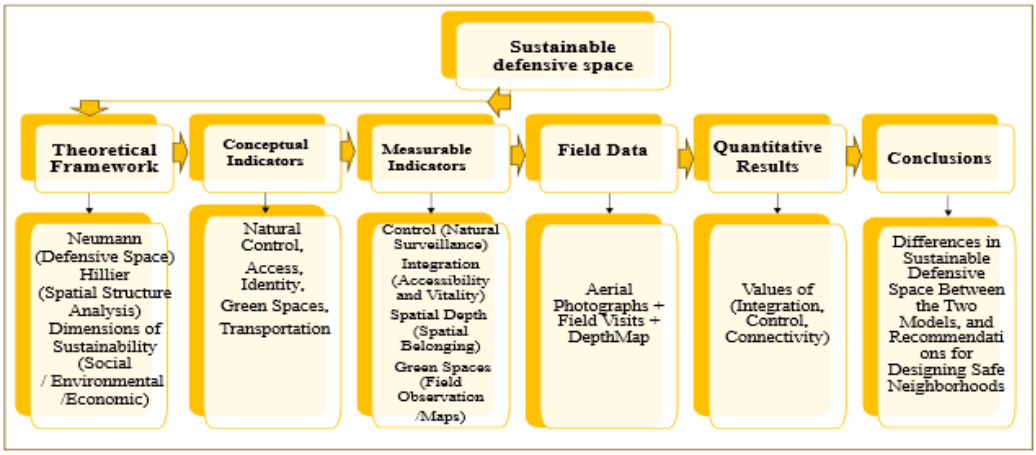


Figure 7. Research methodology

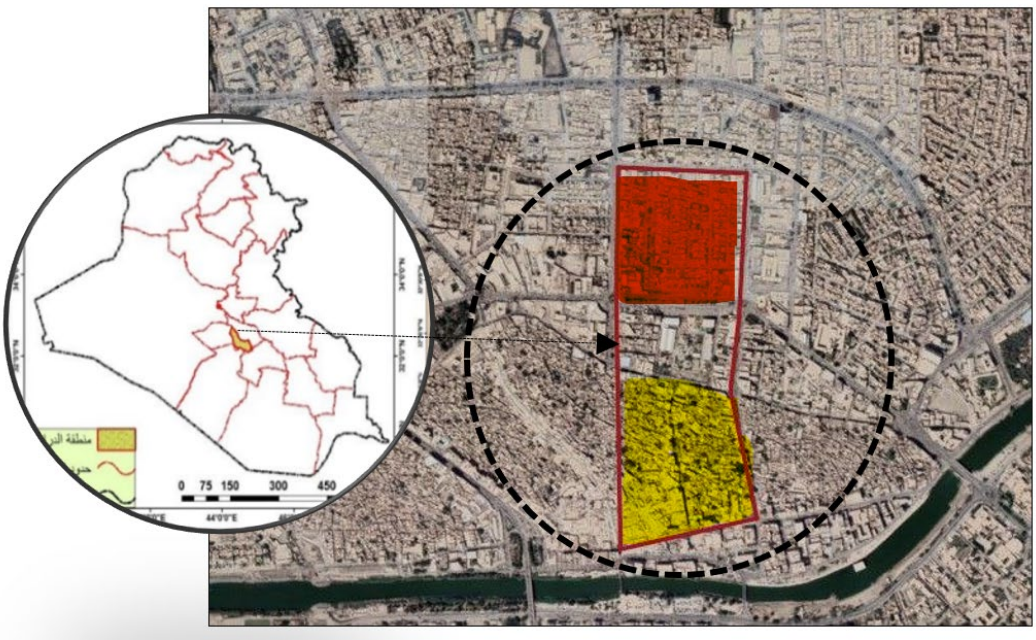


Figure 8. Case studies (Al-Mahdia neighborhood and Al-Qadiya neighborhood)

These neighborhoods are Al-Mahdiya, which represents the traditional organic planning pattern, and Al-Qadiya, which means the modern grid planning pattern. These two neighborhoods were selected based on specific criteria, including clear contrast in planning and morphological patterns, geographical proximity (which helps reduce the impact of some general contextual variables), and the presence of relatively similar social and economic characteristics among their residents. Data was collected from many sources to assure the comprehensiveness of the analysis:

- Spatial data and current, precise baseline maps of the two studied neighborhoods were obtained from official sources, including urban planning departments and municipalities, along with recent aerial photographs.
- Physical characteristics, patterns of space utilization, regional markers, and the overall quality of the urban environment were evaluated through direct surveys of the two neighborhoods.

The relationship between the components of the residential space and their organization was studied through Heller's space syntax theory to understand the deep structure of urban spaces. The examination was based on the premise that the physical configuration of space had the capacity to make predictions regarding the social structure type that impacted the space.

When the urban structure was reconstructed through axial lines, indicating movement directions and areas of vision within the urban space, it became evident that there were also other ways of understanding the relationships between physical space, human behavior, and social interactions.

The methodology focused on a morphological analysis of the urban structures via the spatial relationships of urban

structure elements (mass and space).

All open spaces outside of the buildings were connected to the largest available open area. These drawn lines could be called sight or axial lines and indicate regions of the possible intersection of movement and vision. The lines then converged and signified the hypothesized maximum human vision range in urban spaces [41]. This study also used the UCL 10 Depth Map software for the quantitative and metric analyses (integration, connectivity, control, depth, and clarity) of the street systems for each neighborhood. The analysis then helped in determining the hierarchy of streets in the chosen areas from the most crowded to the least crowded. Streets that experienced significant traffic were referred to as integrated, whereas those with minimal usage were termed isolated.

The resulting color-coded map ranged from the most integrated to the most isolated axes of vision. Specifically, the most integrated routes were the general routes of the area, through which most individuals passed while travelling from one location to another. These routes were termed integrated core because they formed the heart of the area with respect to movement organization. Alternatively, isolated routes were the ones that were used to reach particular points on that street [39].

A systematic field technique composed of repeated site visits, field behavioral observations, and semi-structured opinion surveys with selected residents was carried out to measure their perceptions of security (levels of privacy, control over access, and perceptions of risk) for the Al-Qadiyah and Al-Mahdiya neighborhoods. In this case, the target was to find coherence between analytical data and the users' realities. Resultantly, the traditional urban fabric and spatial features (a gradation of semi-private spaces, winding paths, and natural visual barriers) of Al-Mahdiya appeared to facilitate individual and collective privacy. This process was the reason why residents' evaluations of security were greater. Conversely, the open network fabric of Al-Qadiyah was perceived by residents to be less secure. There was also a greater disagreement among residents' evaluations of safety. Such evidence then illustrated that the urban design of neighborhoods, which incorporated spatial privacy principles, could improve the sustainability of defensive spaces and the quality of social security.

4. DISCUSSION OF THE RESULTS

From both field and analytical studies, the development of the Al-Qadiyah neighborhood and its contemporary planning pattern have been a part of the natural urban expansion of the city of Hillah since 1965. The neighborhood lies at the outskirts of the old area and features a grid-planned layout, which corresponds to the rapid pace of urban growth during the second half of the 20th century. In opposite, the traditional Al-Mahdiya neighborhood is bordered by Al-Ray and Abu Al-Qasim Streets, forming the major roadways in the area. Access for pedestrians is also restricted to a grid of narrow alleys, which are approximately 1 m or 1.5 m wide. This neighborhood is next to the Grand Hillah Market, which is a covered commercial passageway about 900 m long and 3 m to 4 m wide. Movement of people is almost exclusively on foot, complemented, to a limited extent, by the manual transit of goods using handcarts. The Al-Mahdiya neighborhood also borders the Grand Hillah Market, a covered commercial passageway approximately 900 meters long and three to four meters wide, traffic is primarily limited to pedestrians and the transport of goods by handcart.

In contrast, Al-Qadiya neighborhood features a contemporary urban design based on a grid-planned layout, prioritizing vehicle traffic on its 8- to 10-meter-wide lanes. Residential units are arranged in straight lines on both sides of the streets with regular dimensions and paths. The area between the Al-Mahdia and Al-Qadiya neighborhoods is centered on the People's Park. This large recreational area features a playground and serves both the old and new neighborhoods adjacent to it (Figure 9).

The primary difference in the planning patterns and urban formations in both case studies resulted in noticeable differences in the function and use of space. In contrast to the more organized grid layout in Al-Qadiyah, the traditional Al-Mahdiya neighborhood possessed a marked predominance and dominance of pedestrian traffic. This observation was indicative of the more traditional mode of living, in which car ownership and use were minimal, and the organic streets with their narrow dimensions were more geared towards pedestrian mobility. As car ownership and use seemed to be on the rise, there now emerged a need to plan and construct wider streets for contemporary transportation requirements, resulting in the emergence of planning patterns that conformed to such requirements.

Figure 9. The transportation axes and the fabric of the two neighborhoods
Source: Authors

An analysis of the land use distribution in the traditional Mahdia neighborhood reveals that commercial activities are concentrated along the main routes of Al-Ray Street and Abu Al-Qasim Street, as well as in the area adjacent to the covered market. In contrast, the residential area occupies an intermediate position between these commercial areas and is served by a grid of narrow, winding alleys, some of which have closed ends.

In contrast, the modern Al-Qadiya neighborhood exhibits a different pattern of commercial use distribution, as these activities are concentrated outside the neighborhood's main residential area and on its outer periphery. This is reflected in the high price of land within the neighborhood's boundaries on all four sides. The residential area, which constitutes the most significant part of the neighborhood, is served by a grid of lanes primarily dedicated to vehicle traffic, which intersect with pedestrian paths that utilize the same infrastructure as the vehicle lanes. Residential units are arranged on both sides of

these streets in a straight line and along clear, defined paths (Figure 10). Space syntax analysis of the case studies was conducted by importing the pre-prepared axial maps into Depth Map UCL (Figure 11).

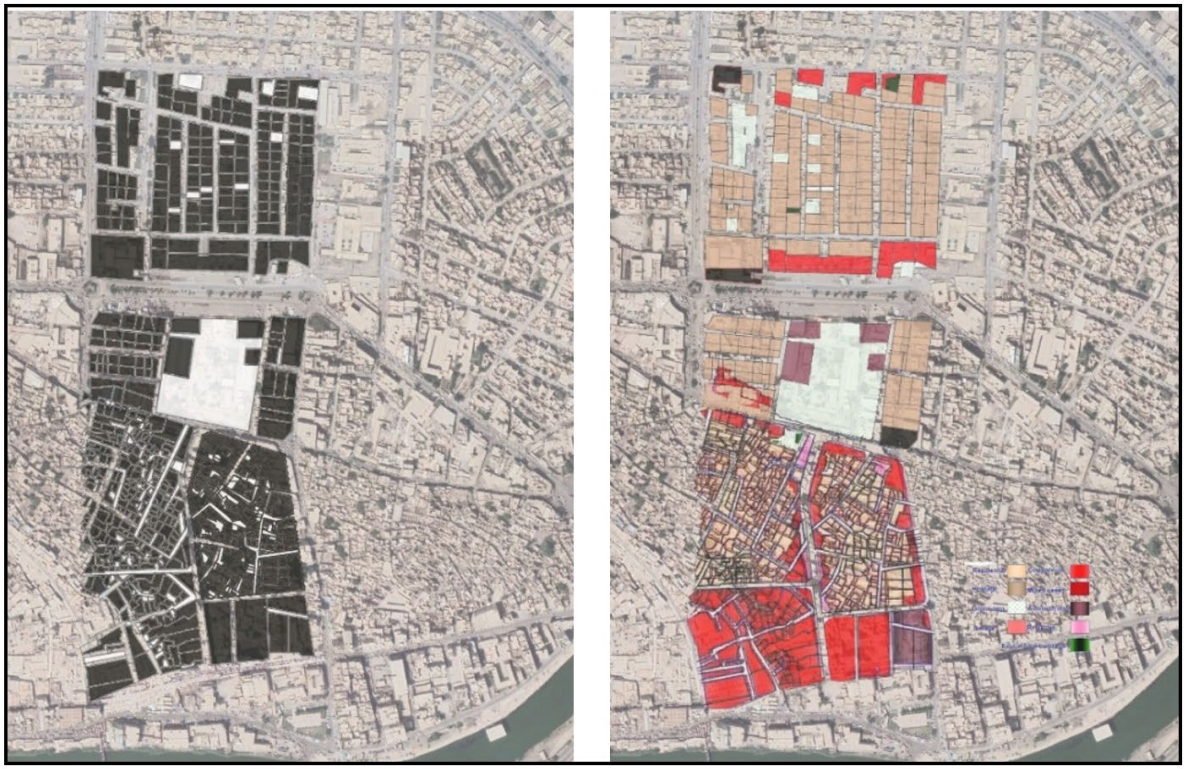


Figure 10. Land use, mass and void analysis
Source: Authors

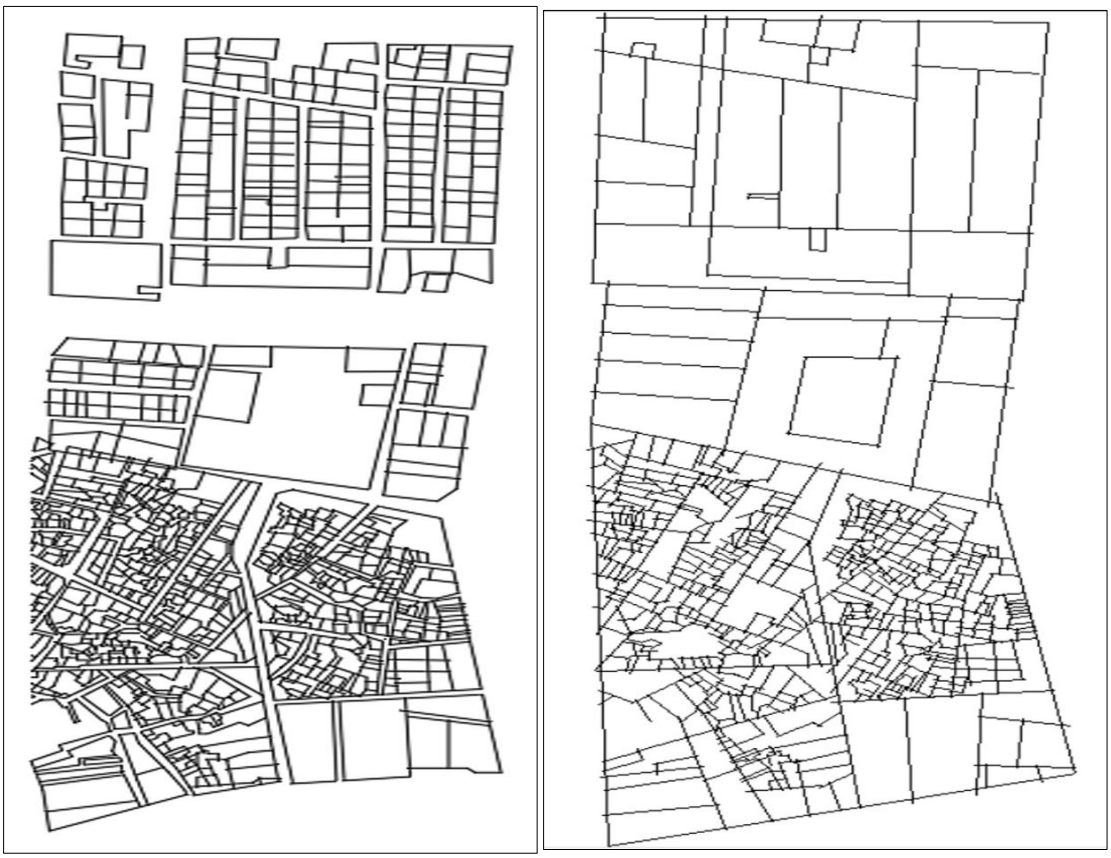


Figure 11. The densest axes as a result of spatial composition analysis
Source: Authors

The resulting axial maps display a gradient in the intensity of use and expected activities of the axes, expressed as color-coded intensity, ranging from red (highest intensity) to blue (lowest intensity). Accordingly, axes colored red represent those with the highest expected use.

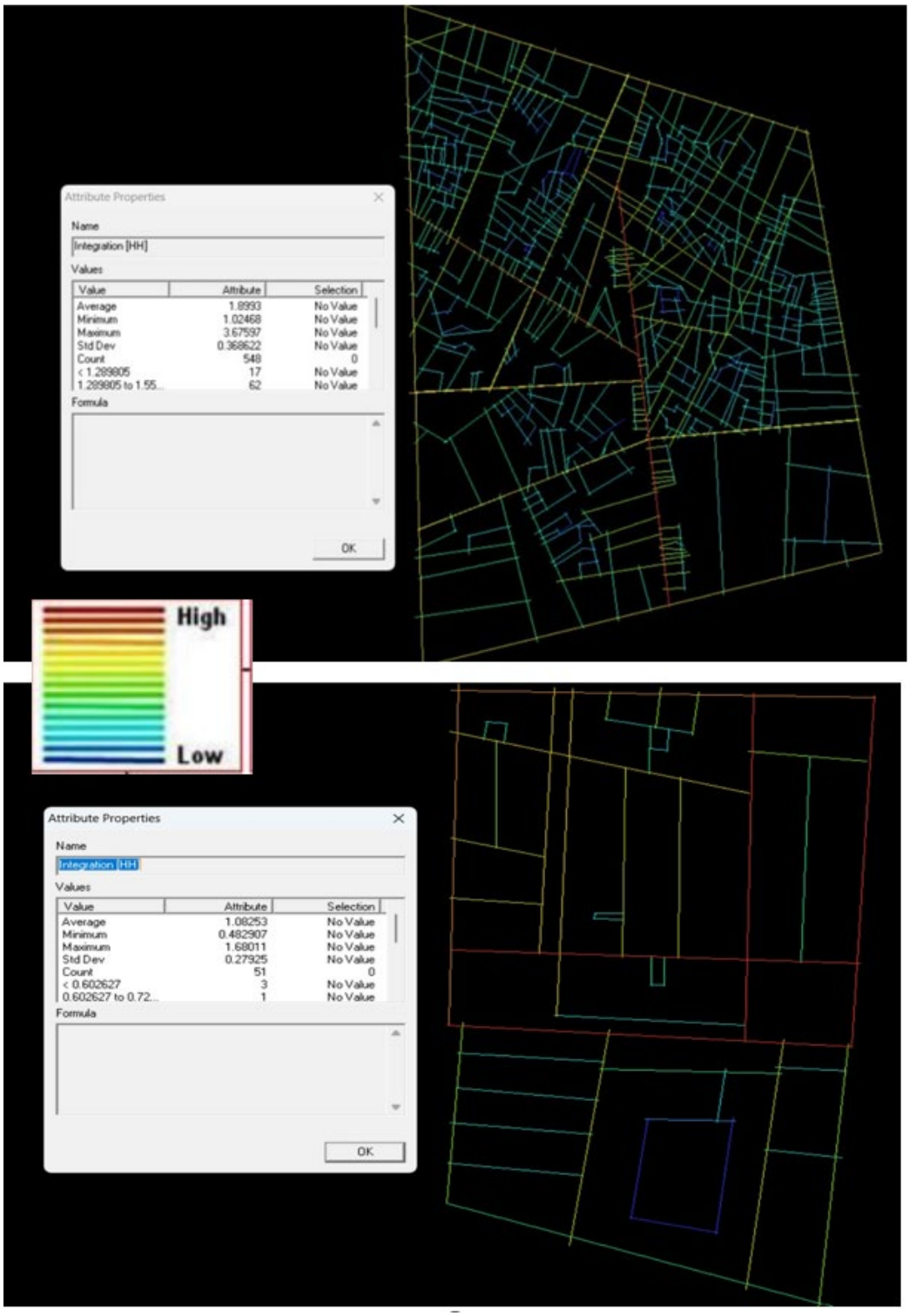


Figure 12. Axial maps of the integration property for the two study areas (Al-Qadiah+Al-Mahdia)
Source: Authors

When applying this analysis to the axial maps of the modern area (Al-Qadiah neighborhood), it was observed that the red axes, which indicate the highest expected use density, are concentrated in specific routes. However, these axes showed relatively lower connections to other principal transportation axes surrounding the neighborhood. This may be explained by the fact that the interconnected internal roads, despite their straightness, may lead to a relative limitation in mobility flexibility and direct access through shortcuts, as access to some internal axes requires traveling relatively longer distances (Figure 12).

In contrast, the axial maps prepared for the old area (Al-Mahdia district) revealed that the red-colored traffic axes, representing the highest expected use in terms of accessibility,

are distributed in a manner that highlights the presence of a dense grid of internal roads with high potential for pedestrian use. This area is characterized by multiple connections between its various streets, providing multiple access from any point within the urban fabric, which is reflected in the expected density of street use.

The results of the axial map analysis, as shown in Figure 13, revealed that the axes with the highest control values were concentrated in the central core of the old urban structure (Al-Mahdia district). In opposite, control values decreased for axes located in the inner parts of this traditional neighborhood. These results indicate the dominance of specific movement axes in the distribution of expected traffic flows and activities within the old district. It is assumed that the high control values in these axes may contribute to enhancing the sense of safety among their users by increasing natural surveillance capabilities.

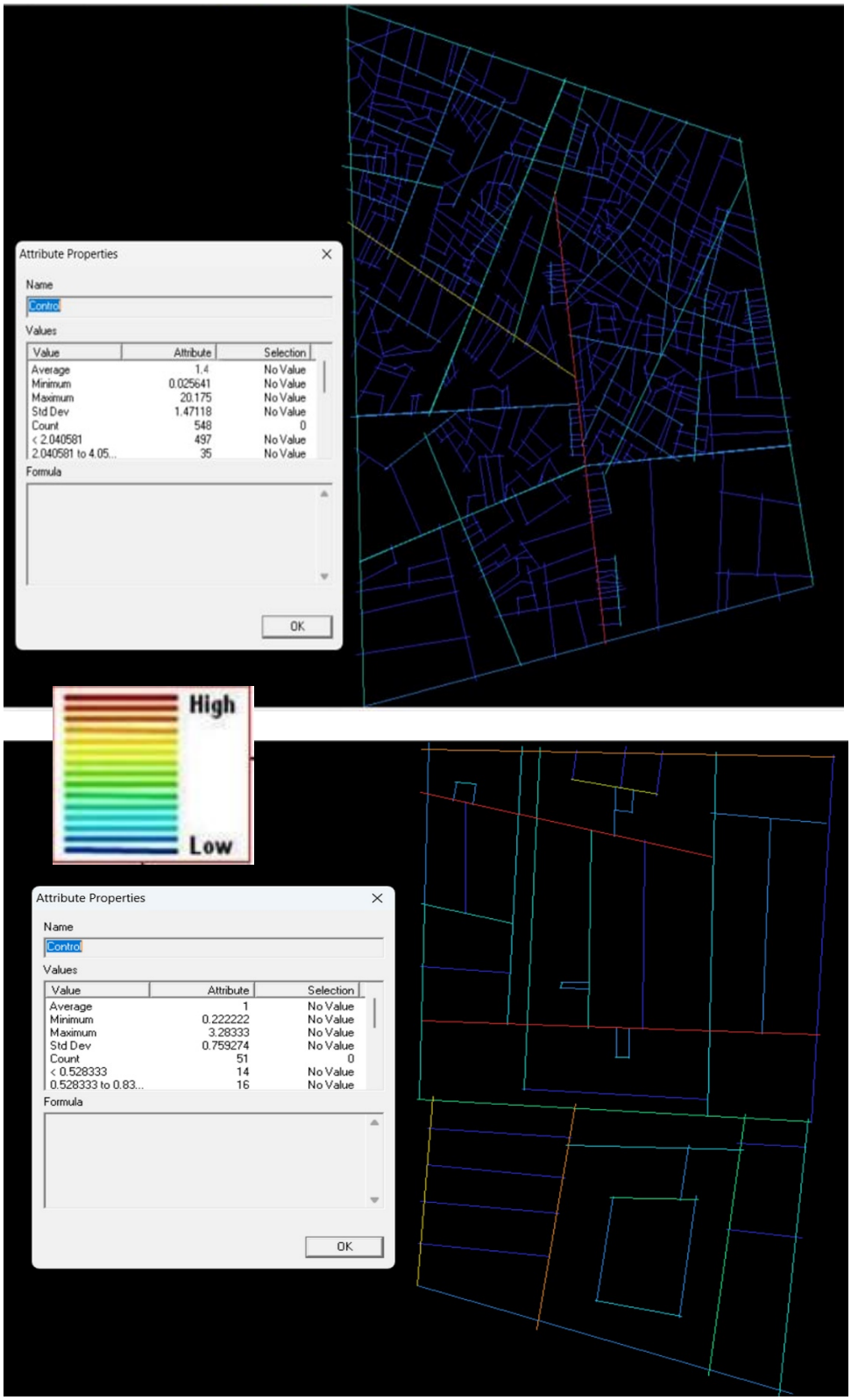


Figure 13. Axial maps of the control characteristic for the two study areas (Al-Qadiah+Al-Mahdia)
Source: Authors

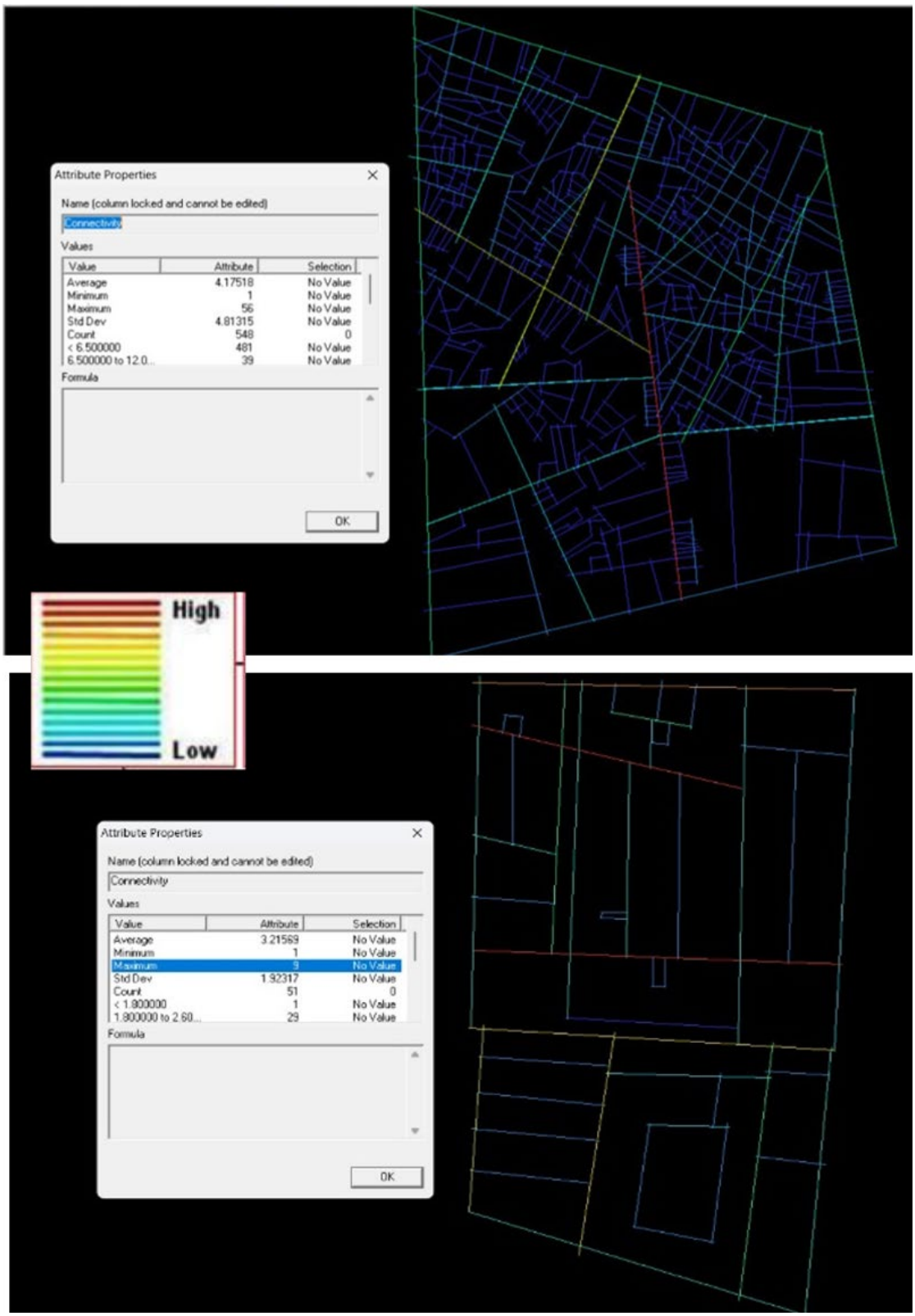


Figure 14. Axial maps of the connectivity characteristic of the two study areas (Al-Qadiah+Al-Mahdia)
Source: Authors

An analysis of the spatial composition characteristics of the old district (Al-Mahdia neighborhood) revealed high levels of cohesion and permeability. This is reflected in its direct connection to a large number of visual and movement axes, in addition to the high control values shown by previous results in its central axes. These spatial characteristics indicate that the old district has a high potential to attract visitors and enhance the legibility and spatial intelligibility of its urban fabric. In contrast, an analysis of the new district (Al-Qadiah neighborhood) revealed relatively low levels of connectivity. This indicates a limited ability of spaces within this fabric to effectively connect with other surrounding or internal spaces, which can be described as low-efficiency spatial connectivity (Figure 14).

An analysis of the connectivity/integration and control characteristics in the old area (Al-Mahdia district) reveals that

its principal axes showed high values for both of these measures. These spatial characteristics directly contribute to achieving defensive space components, as high control over movement axes enhances the natural surveillance capabilities of residents. This distribution of Connectivity and Control values also contributes to the creation of a clear hierarchy of the street network, progressing from the most important and vital axes to the less important and more private ones. This spatial arrangement, in addition to potential surveillance, is assumed to enhance the sense of safety of users as they navigate these movement axes.

Furthermore, the spatial depth index of the area was analyzed, which is measured by the average number of steps or changes in direction required to move between different parts of the urban fabric. The results revealed a clear differentiation in depth levels; the shallow spaces, which correspond to public commercial areas, were characterized by lower depth values and ease of access.

In contrast, Deep Spaces residential areas with high privacy had higher depth values, indicating that they required a greater number of steps or changes of direction to reach than the principal axes (Figure 15).

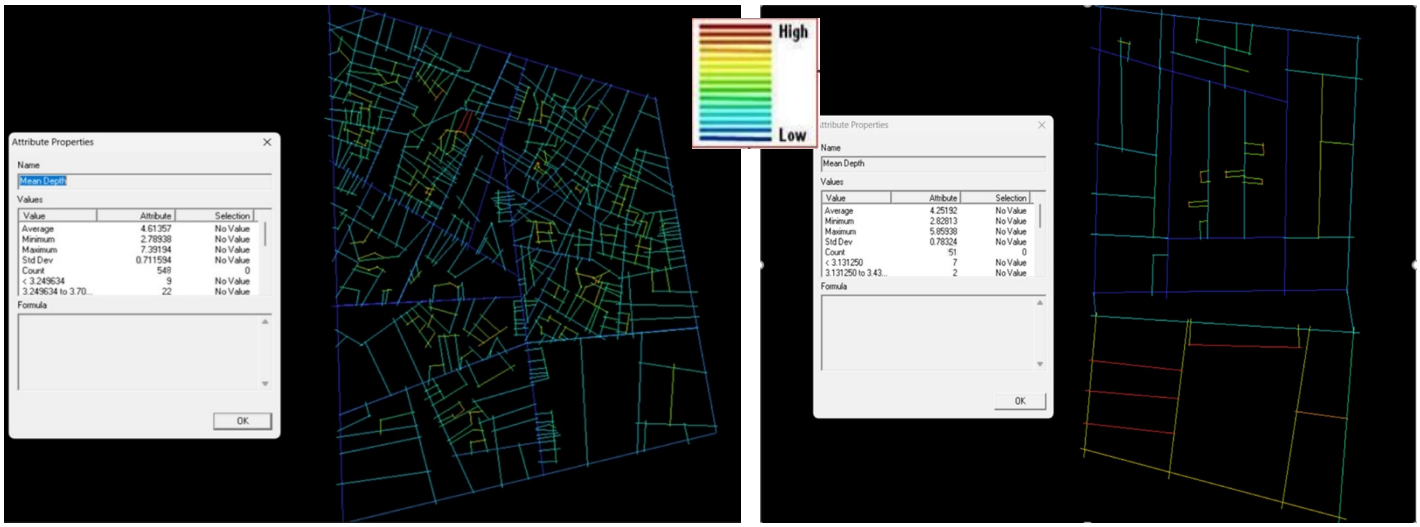


Figure 15. Axial depth maps of the study areas (Al-Qadiah+Al-Mahdia)
Source: Authors

Table 2. Characteristics of sustainable defensive space in traditional and contemporary patterns

Main Dimension	Primary Variable	Relationship to the Traditional (Organic) Pattern	Relationship to the Contemporary (Network) Pattern
Security dimension (Neuman's principles)	Enhanced Natural Surveillance	-Narrow streets and compact buildings provide good surveillance of adjacent spaces. -Some winding roads may obstruct views from farther away.	-Straight, wide streets may provide greater visibility. -Surveillance may be reduced if buildings are spaced far apart or facades are inactive.
	Access Control	-Dead ends (alleyways) provide natural access control. -A clear extension of privacy from the main street to the inner alleys.	Permeability may be too high, reducing control. -The boundaries between public and private may be less apparent in some designs.
	Territorial (Reinforcement)	-A strong sense of belonging to the area may reinforce its regional identity. -Small shared spaces (courts) support this.	-The sense of territoriality may be weaker if spaces are open and undefined. -A uniform design may reduce the individual expression of territoriality.
social dimension	Social Cohesion & Interaction	The design of the outdoor space often encourages interaction with nearby vehicles.	-Fewer opportunities for interaction. -Requires conscious design to create points of convergence.
	Local Identity & Sense of Place	-Passports are often powerful and rooted in their history and evolution. -Distinctive architectural details.	-Identity may be less clear in standardized or imported designs. -Requires effort to create a distinct identity.
Environmental dimension	Green Spaces	-Formal green spaces may be limited. -Scattered trees line the streets.	-Greater opportunity for allocating green spaces. -Parks may be large and central, or distributed.
	Sustainable Mobility	-Walking is the primary mode of transportation.	Opportunity to design adequate infrastructure for pedestrians, bicycles, and cars.
Economic dimension	Vitality & Mixed Use	Often characterized by mixed use (residential and small-scale commercial). -Lively traditional markets.	Strict functional segregation may result in residential areas that are "sleepy" during the day.
	Adaptability & Economic Resilience	Traditional buildings may be somewhat adaptable. -Diverse traditional craft and commercial activities.	Modern designs may be less flexible if they are intended for a single function. This depends on the area's economic planning.

Table 3. Numerical results from the axial maps

Indicator	Al-Mahdiya				Al-Qadiah				T-Value	P-Value
	Average	Min	Max	Std	Average	Min	Max	Std		
Integration [HH]	1.8993	1.02468	3.67597	0.3686	1.08253	0.482907	1.68011	0.27925	19.3	0.000
Connectivity	4.17518	1.0000	56.0000	4.81315	3.21569	1.0000	9.000	1.92317	2.8	0.005
Control	1.4000	0.025641	20.175	1.47118	1.0000	0.222	3.2833	0.759274	3.2	0.0016
Mean Depth	4.61357	2.78938	7.39194	0.711594	4.25192	2.82813	5.85938	0.7324	31	0.000
Talol depth	2517	1525	4048	386.5	210.627	146	384	48	42	0.000

The results of the spatial depth analysis indicate that the average number of steps required to traverse the old area (Al-Mahdia district) is approximately 4048. This indicator reflects the high level of depth in its spatial structures and confirms the presence of a precise gradation in its urban structure.

In contrast, traversing the entire modern area (Al-Qadiah district) requires an average of only 384 steps, indicating a lower level of spatial depth compared to the old area. When comparing the two areas based on the spatial depth variable, it becomes clear that the locations of residential hubs in the old area, particularly those located in the more isolated areas or farthest from the main entrances, enjoy a high degree of spatial privacy, which is consistent with the high depth values in these parts of the urban fabric.

Through the previous analysis, it is possible to understand the characteristics of sustainable defensive space and its connection to both traditional and contemporary patterns, as illustrated in Table 2. Table 3 presents the numerical results of the axial maps, along with an explanation of the basic algorithms.

The basic algorithms used in the Space Syntax analysis to measure the quantitative spatial characteristics of residential neighborhoods include:

- Connectivity Calculation Algorithm: This determines the number of spaces directly connected to each space and forms the basis for constructing a graph representation of the urban fabric.
- Depth Calculation Algorithm: The shortest visual distance (in steps) from each space to the other spaces in the system is calculated using graph search algorithms (such as BFS).
- Mean Depth (MD) Calculation Algorithm: The equation $MD=K-1\ \sum DK$ is applied to each space, where the sum of the depths is used to measure its centrality or "peripheralness."
- Integration Algorithm: MD values are converted to a relative asymmetry (RA) index via the equation $RA=2(MD-1)/(K-2)$, allowing for comparison of integration scores between different spatial systems.
- Control Value Algorithm: It is calculated for each space using $Ev=\Sigma(1/n)$, where n is the number of direct connections between neighboring spaces, measuring the extent to which a space influences its immediate surroundings.

5. CONCLUSIONS

This study sought to explore and analyze the components of sustainable defensive space in residential neighborhoods with contrasting planning patterns, through a comparative analysis of the traditional organic-pattern Al-Mahdiya neighborhood and the modern grid-pattern Al-Qadiya neighborhood in Babylon, Iraq. Based on a theoretical framework that integrates the principles of conventional defensive space, space syntax theory, and dimensions of urban sustainability, the following conclusions, as shown in Figure 16, were reached:

First: Both traditional and contemporary planning patterns possess inherent characteristics and attributes related to achieving the components of sustainable defensive space. The conventional organic pattern in Al-Mahdiya neighborhood, thanks to its precise gradation of privacy, its alley grid that enhances access control, and its human scale that encourages social interaction, has demonstrated strong potential in achieving certain aspects of social security and territoriality. However, it may face challenges regarding comprehensive visual permeability, accessibility for all segments of society, the provision of adequately planned green spaces, and the application of modern environmental sustainability standards.

Second: The grid pattern of the Al-Qadiya neighborhood offers good potential in terms of visibility, ease of movement, and the possibility of allocating open spaces and public facilities in an organized manner. However, this pattern may lead to a weakened sense of territoriality and reduced opportunities for spontaneous social interaction due to wide streets and functional segregation. This may also increase reliance on cars, which could negatively impact some dimensions of social and environmental sustainability and create security challenges in large, insufficiently monitored public spaces.

Third: Regarding the dimensions of sustainable defensive space, the Al-Mahdia neighborhood was found to achieve better the components of social sustainability related to spontaneous community cohesion and a deeply rooted local identity, thanks to its human scale and organic design. While the Al-Qadiya neighborhood has greater potential to achieve aspects of environmental sustainability through the planned development of green spaces and infrastructure, it requires more conscious design to enhance social interaction and prevent isolation. Regarding the economic dimension, Al-Mahdia demonstrated small-scale economic vitality intertwined with housing, while Al-Qadiya tends toward functional segregation, with services concentrated in specific areas.

Fourth: The importance of moving beyond the traditional approach to urban security, which focuses solely on crime prevention, and adopting a comprehensive perspective that integrates safety with quality of life, spatial justice, environmental sustainability, and economic vitality. Sustainable defensive space requires a delicate balance between these dimensions.

Fifth: Applying the principles of sustainable defensive space requires moving beyond stereotypical planning solutions and focusing on contextual solutions that combine the advantages of different approaches, responding to the specific needs of the population and the local environment in Hillah.

Sixth: Applying the principles of sustainable defensive space requires a participatory approach that includes planners, architects, decision-makers, and the local community to ensure

that design solutions meet the actual needs and reflect the cultural and social values of the population.

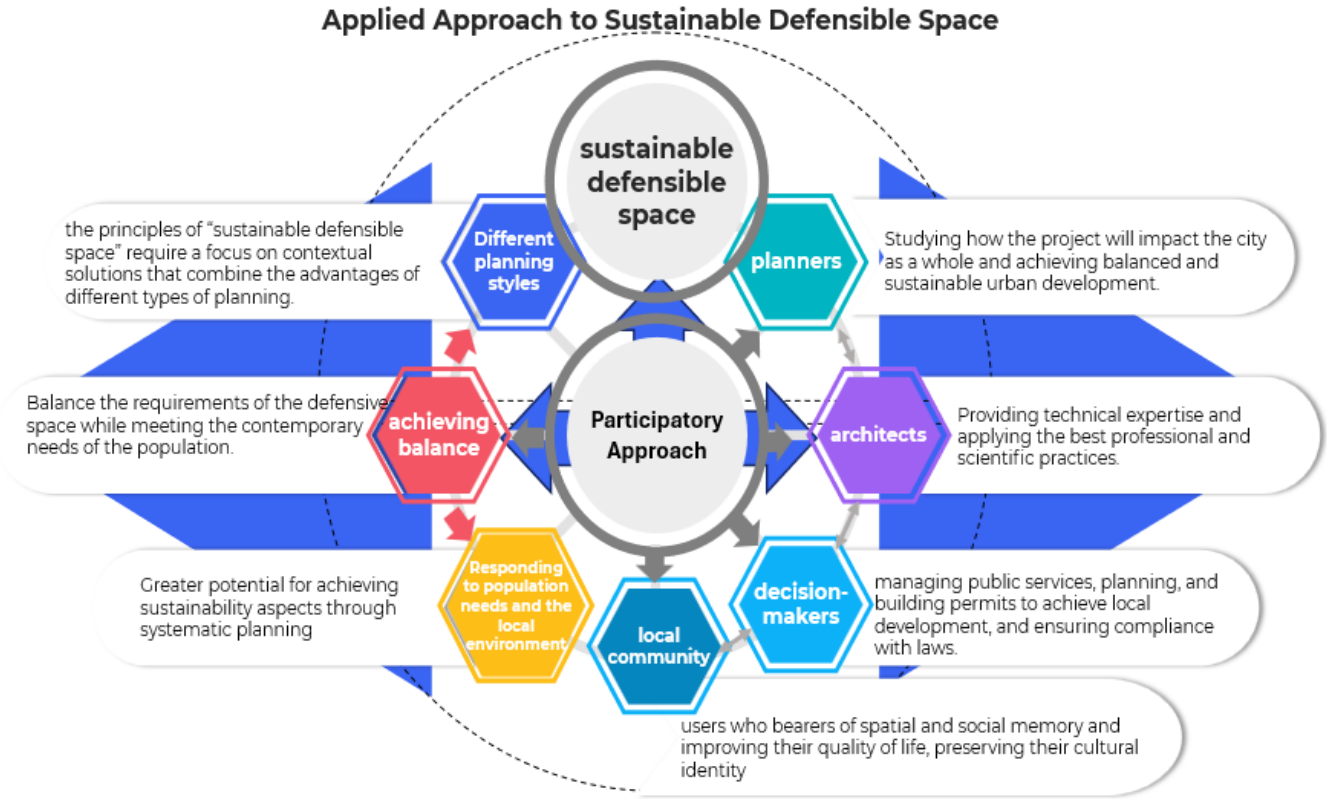


Figure 16. Applied approach to sustainable defense space
Source: Authors

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