Associativity of Spatial Nodes to Healthy Living Environments: Insights from Baghdad, Iraq

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Abstract

Urban nodes act as connecting cores of the urban environments, actively contributing to spatial connectivity and the developments of vital locations within the cities. This paper presents the concept of 'spatial associativity' as a dimension of sustainable healthy places in cities. The problem lies in trying to encourage the use of public urban nodes because they possess urban indicators with features that enhance the urban and social interaction aspects and ultimately contribute to improving health.

The study uses a descriptive analytical approach to identify associativity indicators that support the growth of healthy nodes. The "DepthMap8" application was utilized to facilitate the two primary analytical techniques for spatial syntax: axial graph analysis (AGA) and visual graph analysis (VGA). Additionally, the reliability utilizing the Alpha coefficient were ascertained by using SPSS to analyze the research sample and questionnaire. This gives a better understanding of the spatial configuration of space and its impact on human behavior in the study area and to verify the possibility of the health node's sustainability.

The findings show that the spatial formation of the entire area had a substantial impact on the achievement of associativity indicators in the selected urban node through (Connectivity, Legibility, and Integration indicators). Similarly, the research demonstrates some secondary indicators that assist link the area to its urban surroundings, which adds vitality to the process of urban spatial formation and aids in the creation of a healthy urban environment.

Keywords: Associativity, Spatial configuration, Baghdad, vitality, Social cohesion, Healthy spaces.

Introduction

The concept of urban health in cities arose in 1842, when the British government held the "City Health Conference" and published a report, which revealed the living conditions of the population. The government established the City Health Association to undertake the task

of improving the living conditions of residents and addressing health problems in cities. As for the formulation of the concept of health according to the World Health Organization in 1946, it changed the traditional concepts, so health became denoted as a state of physical, mental and social well-being and not merely a person being free of diseases (Barton and Tsourou, 2013). But years later, in 1986, the World Health Organization officially launched the Healthy Cities Movement(Williams, 2013).

Given the importance of global health, the United Nations has set 17 goals, including 231 proposed indicators, as part of its future plans for sustainable development 2030, all of which work to achieve quality of life in the urban environment. It addressed in a balanced and integrated manner the concepts of social, economic and environmental sustainability and development. Healthy cities are linked to Goal 11 of the Sustainable Development Goals, which stipulates "to make cities and human settlements inclusive, safe, resilient and sustainable." This goal includes several concerns, including prioritizing increasing equity and access to safe transportation systems, green and public spaces, promoting physical activity and reducing air pollution, which It contributes to creating a healthy quality of life (De Leeuw and Simos, 2017; de Andrade et al., 2021; Khalid and Abaas, 2021; Majeed and Abaas, 2023).

Here lies the idea of the research, as the research assumes that urban nodes are interactive places that have an important role in achieving healthy urban environments. The research used the spatial dimension to measure the quality of urban associativity. The study aims to find indicators of urban nodes with spatial connectivity in areas with a modern urban fabric to test the possibility of the presence of a health node.

Its objective is to build a cognitive model of the most important features of the associativity in urban nodes that contribute to creating a healthy environment. This requires building a knowledge base on indicators of urban associativity in vital urban nodes.

Theoretical Framework and Literature Review

Healthy environments

The world has witnessed increasing interest in the possibility of achieving urban nodes that achieve a healthy environment, as the concept of health has taken up a space of interest, in response to the challenges facing society, including environmental, economic, social, cultural, urban, and security. Therefore, studies seek to find indicators of a healthy environment, as both McCunn & Arnett in (2022) note that a healthy environment is an environment that seeks to achieve well-being for its residents, through quality infrastructure, positive living with social cohesion and connection to nature (McCunn and Arnett, 2022).

Wei et al. (2023) say that it is linked to social events and activities. The importance of public places in the increase of economic and recreational activities in places with interconnectedness and spatial integration is an important factor in the permanent and frequent presence of people, which enhances the entertainment and revitalization aspect of the city. As Fan et al. (2022) show, the intensity of pedestrian movement is affected by aspects related to spatial characteristics. Accessibility, visibility, and clarity are among the factors most affected by the pedestrian movement in green and blue public spaces, as they are the result of the social response to the built environment and the human movement resulting from the interaction between them (Fan *et al.*, 2022; Majeed and Abaas, 2023). In addition, Tariverdi et al. (2023) show the importance of arrival time and infrastructure, which is a factor influencing the speed of response and disaster management and thus health and quality to achieve healthy living in the city (Tariverdi *et al.*, 2023). Hasa, Altalib & Alzubaidy (2017) also indicate the possibility of achieving healthy and vibrant urban squares through the diversity of land uses, activities that attract residents, encouraging walking, and the use of public transportation, as well as preserving heritage monuments, statues, and monuments and rehabilitating dilapidated ones. Creating a planning and design system for squares concerned with achieving ease of access and activating recreational, cultural and tourism uses to increase social cohesion and economic returns (Hasa, Altalib and Alzubaidy, 2017).

Al-Budairi & Al-Rikabi (2023) also refer to the spatial concept of healthy cities and find that movement, mobility, density and diversity have a role in the health of the people. Radha, Ali & Amin (2020) show the possibility of encouraging walking through indicators related to safety, function, destination, aesthetics, and comfort. Moreover, Brueckner et al., (2022) show the importance of blue spaces in achieving well-being and healthy urban developments. Sustainable urban planning also provides insights, according to Sepe (2018), that the concept of a healthy environment is represented by the presence of green spaces and the quality of public spaces (Khalid and Abaas, 2021). Sugiyama, Thompson & Alves (2008) point out the importance of open spaces related to health and satisfaction with outdoor activities, which include enjoyment, safety, and short paths leading to open spaces.

If these previous indicators are achieved, there may be environmental factors that are not achieved. Thus Abaas & Khalid (2023) indicate the importance of achieving thermal comfort in order to achieve local sustainability. AlObeidy, Dabdoob & Sedeeq (2019) also state that cities that achieve good accessibility rates have a better chance of achieving sustainable urban cities. Hegazi et al (2022) also consider the lack of social presence in heritage and historical places to be a result of difficulties in reaching these important places.

From the above, it is found that there is a close connection between the effectiveness of urban places and the achievement of healthy environments. Salingaros (1998) points out the possibility of analyzing any urban environment into nodes of human activities and connections, assuming that the urban structure is good if it contains a certain percentage of spatial connectivity. The more complex the urban network is, the more connections there are in the network structure, cohesion and life in it.

Thus, it is possible to summarize the concepts and indicators of healthy environments. Many studies have indicated that they support well-being, entertainment, safety, interaction, pride, cultural identity, and accessibility. Other studies have also indicated positive life through the quality of infrastructure, rapid response and disaster management, in addition to the concept of a vibrant environments through the presence of public places, diversity of uses, and activities that attract the people. They encourage walking and using public transportation, preserving landmarks and monuments, and creating a design system that achieves ease of access. Others stress the importance of density of movement in access, vision and clarity. Many other studies have linked the concept of a healthy environment to the level of satisfaction with the outdoor activities that are characterized by safety and short paths leading to open spaces. Needless to say, green and blue spaces are considered essential for achieving well-being.

The concept of associativity (connectionism) is necessary in linking mental concepts with each other to explain the nature of human thought and knowledge. Experience is also the result of a group of complex psychological factors. The process of association may be synchronous and explain the perceptual organization of different visual components combined in one scene. The associations may be sequential and contribute in support and necessary for producing seeds of thought (Walker, 1990; Williams, 2010; Tonneau, 2012). Indeed, the idea of interconnectivity has been used to create knowledge for the recipients, which is represented by the perception of indicators of general urban nodes (Bozic, 2015).

Lynch (1984) Salingaros & Pagliardini, (2016) and Hillier et al. (1987) also mention the concept of interconnectedness, which lies in the ability to access people, activities, resources, services, information, or other places. It is achieved through the quantity and diversity of elements that are accessible. In support, Mulley & Nelson (2020) present the same concept in the field of transportation, indicating that the connectivity value of streets encourages walking, achieves justice, and rewards opportunities and cooperation by reaching green places and transit nodes.

Whyte (1980) provides motivational elements (sitting space, sunlight, trees, water features, food, street access, and triangulation. In addition, Salingaros (2015) mentions attractiveness through symbolism and aesthetics of historical or heritage importance. As Lynch (1984) points out, quality and clarity can be achieved through clear planning and simplicity of

formation, which gives the possibility of visualizing the built environment through well-known elements represented by a sign with a number, name, or a landmark, It is the degree of visual clarity of the spaces that make up the system or the built environment (Lynch, 1984). Within the same concept, Hillier (1996) explains the term Intelligibility. Salingaros (2000) points out the importance of easy identification of nodal spaces, noting the importance of the node being central, such as emanating from the road network system (Salingaros, 2000a).

Hillier et al. (1986) also present the concept of integration by the degree to which spaces are connected or isolated in relation to external space. The space that is more accessible than other spaces is the most integrated space, and is best for gatherings and social interaction (Hillier *et al.*, 1986). Alexander (1987) adds the idea of " wholeness: the concept of wholeness is necessary for the urban environment, not formally, but through communications and overlap in events and activities. Salingaros (2016) also highlights the importance of nodes through their integration and multiple connections with the urban environment (Alexander, 1987; Hillier, 1996; Salingaros and Pagliardini, 2016).

Alexander (2002) says that traditional cities have the importance of cohesion. The gradation on the human scale and the overlap in activities and pedestrian movement achieve cohesion, and the relationship of "consistency in proximity" between the integrated parts consistent with the idea of wholeness, which is the basis of organic cohesion (Alexander, 2002). Salingaros (2000) adds the idea of coupling, which represents a large variety of connected elements to generate unified entities, and this is the basic condition for urban cohesion in the context of complexity (Salingaros, 2000a).

According to Whyte (1980) & Mulley & Nelson (2020), ease of access is one of the most important planning aspects. It includes motor and visual accessibility to activities, events, and green places. It requires providing public transportation and encouraging active movement, to reduce health problems and enhance the physical and mental aspect. The importance lies in accessibility in achieving justice and equal opportunities (Whyte, 1980; Lynch and Hack, 1984; Mulley and Nelson, 2020). In addition to the previously mentioned spatial characteristics, both Hillier (1996) & Salingaros (2015) explain the importance of accessibility, which lie in the balance between total and partial movement and pedestrian and vehicle permeability.

Moreover, Hillier (1999) presents the centralization index by emphasizing the importance of centralization of economic and recreational activities represented by markets, retail places, restaurants. In a topological manner in order to achieve equity in opportunities, their quality is measured through the complementarity of access to those centers due to what they possess. It is attractive to people for a utilitarian or recreational need, which enhances economic and social mobility (Hillier, 1999; Ghazi and Abaas, 2019; Abaas, 2020). Within the same concept, Alexander (2002) explains the concept of 'strong centers', where each consists of multiple smaller strong centers. As in the characteristic of strong centers, it has a field effect resulting from the creation of co-existence (Alexander, 2002).

Hillier (1999) & Salingaros (2015) also mention the relationship between spatial planning, human mobility, and diversity in activities, events, and elements. Within the same concept, Lynch (1964) refers to the necessity of differentiation, enrichment, contrast, diversity of the age of buildings, and diversity of paths (Lynch, 1984). Jacobs (1961) also shows that areas characterized by diversity and density are more attractive and distinctive.

Alexander (1987) also shows the principle of densification of centers to give strength and influence to the urban system. In his theory of spatial syntax, Hillier et al. (1986) provide a framework for studying the density of movement within the built environment and a better understanding of the density and distribution of movement, stressing the necessity of creating social communication and economic movement.

Moreover, studies including Salingaros & Pagliardini (2002) have clarified the design conditions for achieving effective urban nodes, which are centrality, enclosure, and active edges. They point out the importance of surrounding the nodes with a series of buildings that demarcate the boundaries of private and public spaces and form the city's skyline, with the

exception of roads. entering it. Salingaros (2001) also confirms that visual information requires the importance of linear continuity, and that fractional cities consist of a main structure with connected and cohesive secondary structures, and these secondary structures are self-similar, while the human scale appears in all their parts. They are also living cities that have a large number of hierarchical connections between nodes, more than what is found in most modern cities.

Complexity, diversity, and meeting surfaces appear in these cities (Salingaros, 2000a, 2001). Alexander (2002) also demonstrates an understanding of the property of non-separability: continuity must be maintained in order to maintain interconnectedness away from fragmentation. Thus, edges, hierarchy, and flexibility contribute to the transition between the edges of the urban nodal spaces, and contribute to attracting and stopping people. It provides insights into securing connectivity with the rest of the urban environment (Alexander, 2002). As Whyte (1980) explains, higher levels of overall quality of urban life can be enhanced by creating mental representations of the importance of safety and comfort in public spaces. Both Hillier (1986) & Salingaros (2016) consider safety an important factor in the continuity of life and reducing crime in the urban complex(Hillier *et al.*, 1986; Salingaros and Pagliardini, 2016).

It is clear from the above, that the city is an integrated urban system resulting from a spatially interconnected mixture of buildings, spaces, and infrastructure to achieve social, economic, environmental and health goals. Literature presents various indicators of the vitality of spaces and cities. Studies have shown spatial indicators of stimulation, legibility, integration, cohesion, connectivity, permeability, centrality, diversity, density, enclosure, continuity, hierarchy, active edges, and a psychological factor of safety.

This research tests the principles of a healthy urban place based on spatial associativity and connectivity, which includes fourteen principles according to this analysis of previous literature. The goal is to make the urban squares healthy and effective urban nodes.

The following Table shows the vital spatial characteristics of public places.

Table 1: Vital spatial characteristics of public spaces.
Source: Author

Spatial Conception	Definition	References
Connectivity	The ability of getting access to other individuals, groups, events, materials, services, data, or locations.	(Lynch, 1984; Hillier et al., 1987; Salingaros, 2000b; Mulley and Nelson, 2020).
Legibility	Quality that makes the layout clear.	Lynch (1961; Hillier, 1996; Salingaros, 2000).
Integration	The space that is more accessible than other spaces.	(Alexander, 1987; Hillier *et al.*, 1987).
Safety and Security	Feeling of safety and security both physically and psychologically. Protection from traffic, crime,	(Whyte, 1980;Salingaros and Pagliardini, 2016).
Density	Road density and traffic in the built environment.	(Hillier *et al.*, 1986; Alexander, 1987).
Centers	Integrated spatial centralization at many levels and at the overall level.	(Hillier, 1999;Alexander, 2002).
Permeability	The impact of vehicles and pedestrians via several pathways.	(Salingaros, 2000b;Hillier *et al.*, 1986).
Edges	The built-up areas' borders coincide with the site's lines, and the creation of the walkway or urban area comes next	(Alexander, 1977; Salingaros and Pagliardini, 2016).
Enclosure	Spaces whose perimeter is almost entirely surrounded by a series of buildings, with the exception of the roads entering them.	(Salingaros and Pagliardini, 2016).

Continuity	Clear space created by the framed frontages of buildings.	(Salingaros, 2001).
Stimulus	Seating space, sunlight, touch, food, street access, and triangulation.	(Whyte, 1980; Hillier *et al.*, 1986; Salingaros, 2000b)
Coherence	Scale complementarity between the construction components of a collective form.	(Alexander et al., 1987;Salingaros, 2000).
Diversity	A multi-dimensional phenomenon and the system would decline without it	(Jacobs, 1961; Lynch,1962)
Hierarchy	The process generates interconnected units that are defined on several distinct scales from small to large.	(Salingaros, 2000a;Alexander, 2002).

Most studies have addressed the issue of spatial characteristics related to vital urban nodes. Some studies have touched on indicators of a healthy environment and spatial nodes. However, the creation of healthy urban nodes has not been addressed. This research assumes that urban nodes are interactive places that have an important role in achieving healthy urban environments.

The following figure shows the mechanism for creating a healthy node.

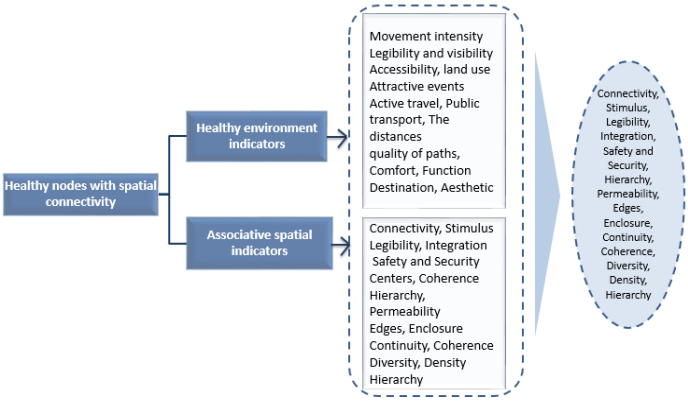

Fig. 1: Creation of a healthy node.
Source: Authors**.**

Research Methodology

This study uses different research approaches to study the issue. It employs a case study method, conducting a questionnaire, statistical analyses, and syntax analysis. These methods were combined to develop a reliable and comprehensive methodology to guide the research process.

The researcher collected basic data from maps based on www.openstreetmap and images from the Department of Research and Studies in the Baghdad Municipality. However, to ensure that the information is up to date, the data were supplemented and updated through field visits and observations.

Questionnaire

The questionnaire generates descriptive data. The study uses 100 questionnaires, which are analyzed quantitatively using SPSS. The questionnaire questions were placed in a Google form (https://forms.gle/QXAd9f5G8sPov15NA), and the indicators were quantitatively analyzed. The questionnaire period was between July 13-19, 2023. The area is approximately 500 m from the Al-Wathiq Square area. A five-point Likert scale was adopted to measure

behaviors and preferences by expressing a specific opinion with five options: strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1), and the reliability of the quantitative results was measured, using the analytical program SPSSx. The result of the Cro-Nebach Alpha coefficient was 0.86, which indicates the existence of credibility and stability of the questionnaire.

The questionnaire provided valuable insights into the indicators that were put to the test by the venue users, visitors or shop owners. The arithmetic average of the acceptability rates (agree, strongly agree) was taken and summed to obtain the acceptability rate for all the indicators, then divided by the number of indicators to obtain the acceptability rate, in the same way for the rejection and neutrality rates. When SPSS analysis was conducted to find out which ones weighed the most, it was found that accessibility had the highest was the acceptability rates, followed by clarity and then integration.

Space Syntax Theory: Depth Map

This analysis is carried out according to the theory of Space Syntax. Hillier (1989) defines space syntax as a family of techniques for representing and analyzing spatial structures. Space Syntax is a set of theories and tools that are used to analyze spatial structures based on specific applications in urban sciences. The Space Syntax scale was used as an indicator of street connectivity in the research to create active living spaces (Hillier and Hanson, 1989). Montello (2007) states that spatial syntax aims to describe how human-made places such as buildings and urban space networks are formed, especially how to articulate and harmonize them. Batty (2022) indicates that spatial syntax primarily focuses on the geometry and topology of the street network, and considers it the starting point of spatial interactions. Metrics of accessibility, integration, and choice are used mainly in the spatial interaction model (Batty, 2022).

This analysis aims to understand the basic relationship between spaces and spatial formation. The theory of space syntax was built primarily on the premise of social logic (Hillier and Hanson, 1989). The procedures are as follows:

- Create a state diagram using a program. (Auto cad).
- Export the file in dXf format to (Depthmap8) program.
- Axial map analysis to obtain important measurements and relationships using Axial Graph Analysis (AGA), and Visual Graph Analysis (VGA).

Create a sectional map. The axial map is divided into parts using different metric radii Rn, R3. Depthmap processes different types of analytical techniques. Inputs and outputs for the selected analytical methods are highlighted in (Fig.2).

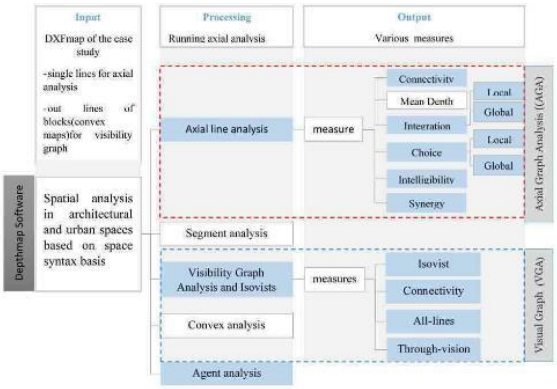

Fig. 2: Different analyses in Depthmap software (the used are highlighted with light blue). Source: Authors.

Case Study: **Al-Wathiq Square**

Al-Wathiq Square is an open urban square located in the Al-Wahda neighborhood (Alawiyah neighborhood) in the Eastern Karrada district in the center of Baghdad on the Rusafa side. The history of the area dates back to the 1930s, and it is inhabited by multi-religious Iraqi families. Al-Wathiq Square is located in the center of the area, and the streets have been designed based on a geometry resembling a palm, with three main streets branching out from it: 62, 52, and 42, heading towards the peripheral squares of the site with the Al-Wahda neighborhood area. These are the Abdul Qader Al-Jazairi Square, Investigations Square, and Uqba Bin Nafi.

The reasons for choosing the Al Watheq Square are due to its location, as it is in the middle of the Al Wahda residential neighborhood. The area enjoys a diversity of activities such as commercial centers, banks and restaurants. In addition, the municipality of Baghdad has witnessed a rehabilitation campaign in 2017-2018, completely rehabilitating furniture, walkways and sidewalks of the courtyard while adding a children's play area and shading structures (Abaas, 2021; Majeed and Abaas, 2023). It has been named so because it contains a monument to the Abbasid Caliph, who trusts in God. In addition, it has spatial characteristics that may suit the research goal of finding healthy nodes. It is as shown in the Fig.3.

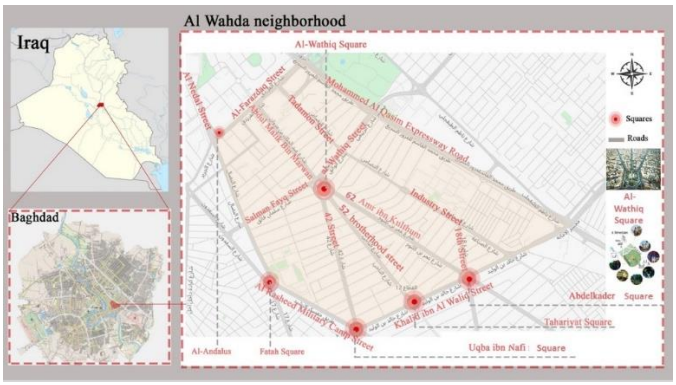

Fig. 3: Location of Al-Wahda District, Baghdad and Iraq - main streets and squares.
Source: Authors.

The analysis includes dividing the spaces into dynamic spaces represented by streets, and a stable represented by the squares, as in the Fig. 4, from the right, and from the left. The Fig. 5 shows the uses of the area.

Fig. 4: Analysis of the area into stable and dynamic spaces the street network.
Source: openstreetmap.

Fig. 5: Land uses in the Al-Wahda neighborhood area.
Source: Authors.

Findings and the Discussions

Depth map program

The analysis is carried out on the basis of converting line maps into graphs and measuring the spatial properties of nodes through the use of mathematical formulas (Ferati, Saidi and Limani, 2019; Otsuka *et al.*, 2019; Eskidemir and Kubat, 2020).

Axial Graph Analysis (AGA)

Axial maps were applied at the global and local levels to examine the possibilities of movement and accessibility for vehicles and pedestrians in different radii. The higher and warmer the color, according to the color gradation from more red to less blue, includes the following characteristics:

A. Global properties: At the global level to examine the accessibility of vehicles and the most options, the higher the Rn values, the greater the integration and choice of the vehicles, as in the following:

1. Global integration: It indicates that the space with the most access and communication from the rest of the spaces is the most integrated and has the best social interaction. According to the analysis, the integration rate showed 0.904, and the values range between 1.481-0.427. The highest values are at Al-Nidal Street, 1.4, Al-Farazdaq Street, 1.3, and Al-Wathiq Complex, 1.1. It appears according to the color gradation from the most complementary red to the least complementary blue. As shown in the (Fig.6).

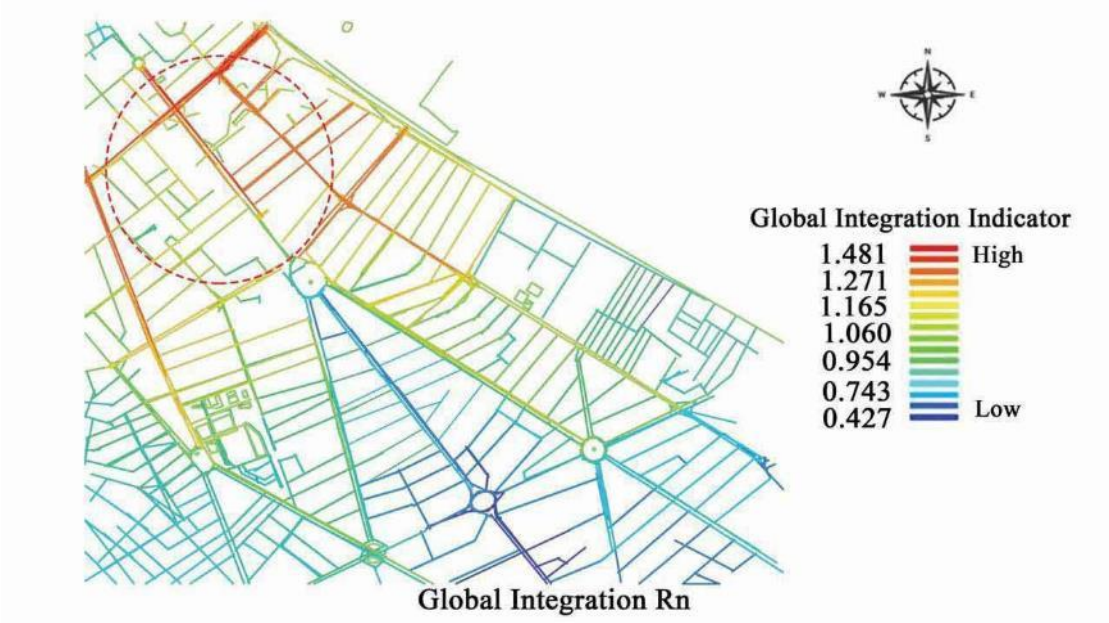

Fig. 6: The global integration Rn.
Source: Authors

2. **Global choice**: It represents the degree of control of a space over the permeability of its neighboring spaces. The most option is the shortest path that connects the parts of the structure with each other and with its external surroundings, regardless of the axial steps. The index showed that the rate was 3756.21, while the highest value was 94351. At Al-Tadamon Street, then Al-Farazdaq Street, then Al-Nidal Street, and the values converge in the rest of the area to reach the lowest value of 0. According to the color gradation, it ranges from more red to less blue. It is as in the fig. 7.

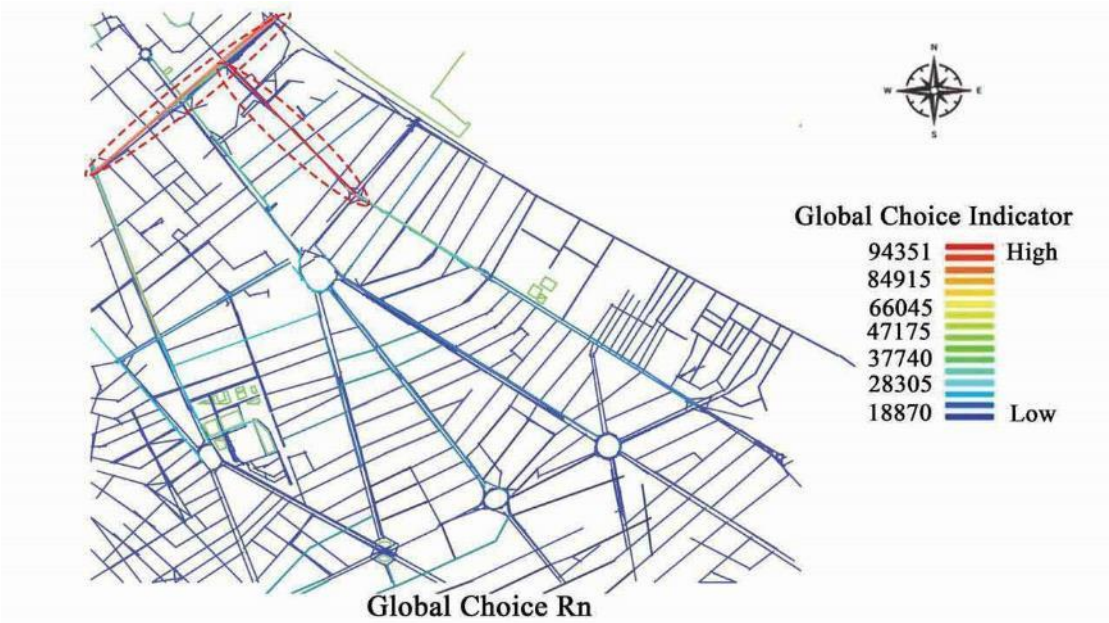

Fig. 7: The global choice Rn.
Source: Authors

B. **Local properties**: The nature of the relationship between one space and its direct neighboring spaces, which is:

1. **Connectivity**: The value of connectivity is calculated through the number of spaces directly connected to the space. High values represent a high degree of cohesion of the urban structure and a low value represents isolation and disintegration. According to the analysis of the region, it was found that the average values of this indicator 5.127 and high values 27 extend From the Al-Wathiq Square to the Street 62 (Aar Bin Kulthum) all the way to Abdul Qader Al-Jazairi Square. The connectivity values in the region are close and the value is less than 1. According to the color gradation, it ranges from more red to less blue, as in the fig.8.

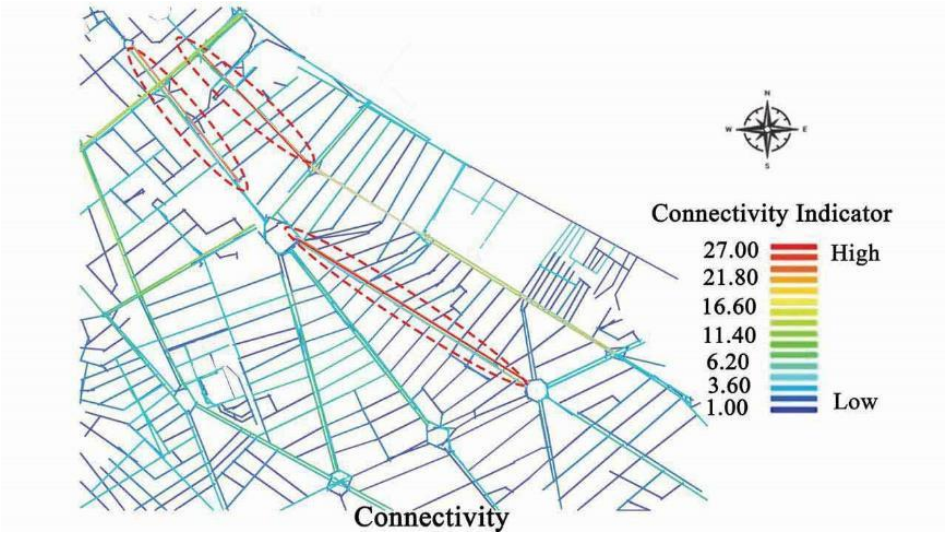

Fig. 8: Connectivity.
Source: Authors.

The fig. 9 on the right also shows the amount of access from the main streets of the region to the Al-Wathiq Square node, and on the left the fig.10 shows the linear access rate.

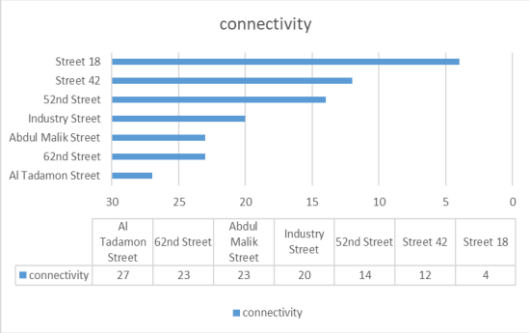

Fig. 9: highest associativity values according to the streets in the Al-Wahda neighbourhood area (Depth map).
Source: Authors.

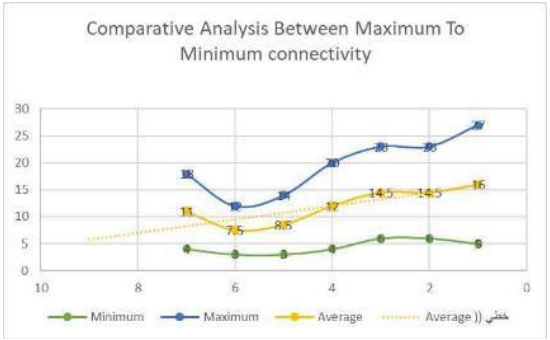

Fig. 10: Resulting average of all values (Depth map).
Source: Authors.

2. **Local integration**: It represents the amount of connectivity of a specific space within a part of the urban structure. It explains the hierarchy of the local movement of pedestrians and their access to the space. It is calculated at a depth of 3 steps. The average of this indicator was 2.074 and the high values of local integration were 3.827. In the District 902, the areas near Al-Watheq Square, part of Al-Watheq Street and Salman Faeq Street, and the lowest value was 0.422 which is outside the area. According to the color gradation it ranged from more red to less blue. It is as in the fig. 11.

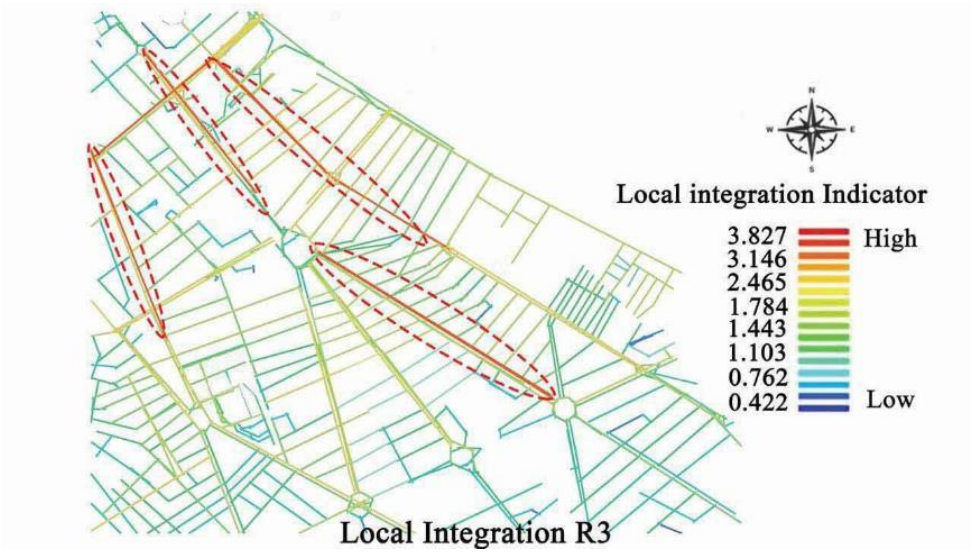

Fig. 11: Local integration.
Source: Authors.

3- **Local choice (Control)**: The Local choice feature values range from 5.837 to 0.086 with an average of 0.999, with high values observed in the commercial and entertainment areas in the Industry Street and 62nd Street areas, which enjoy easy access to them. In contrast, residential areas within the center have lower choice values, reflecting their limited accessibility and low levels of activity. That is, less influence on movement in the residential area, which creates an atmosphere of privacy for the residents. According to the color gradation, it ranged from more red to less blue. It is as in the fig.12.

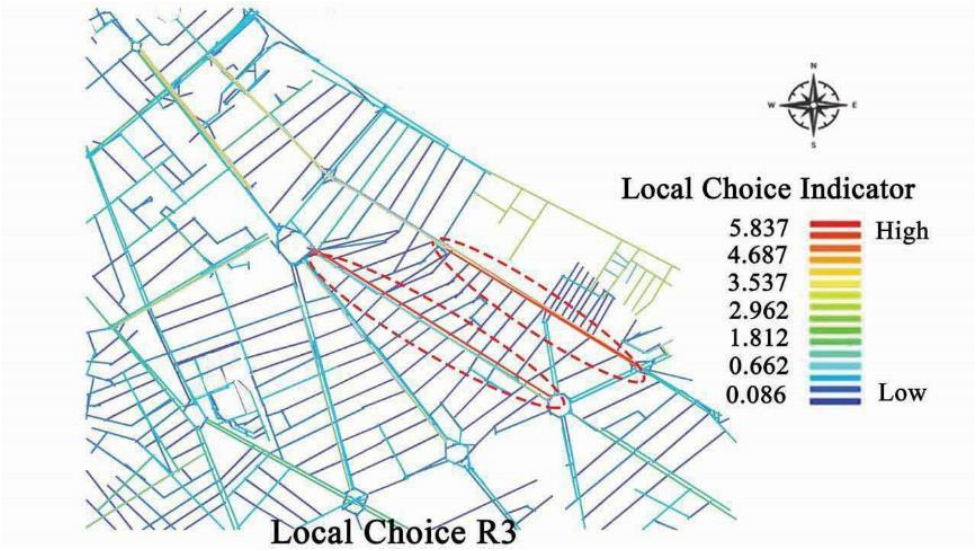

Fig. 12: Local choice.
Source: Authors.

Intelligibility: It results from the compatibility of the index of global integration and connectivity, which gives the urban environment intelligibility. The diversity of parts in the environment results in clarity to the recipient (Lehman, 2005). The Pearson correlation coefficient indicated that there was a weak direct relationship between the indicators of connectivity and global integration, and the value of the linear regression coefficient was R^2 = 0.171454, as in the fig. 13.

Synergy: The results of synergy were also shown through the linear relationship of the variables of global integration and local integration (Hillier, 2007). Synergy represents a relationship between the part and the whole and indicates the amount of homogeneity in the urban environment, as the Pearson correlation coefficient indicated the presence of a moderate direct relationship and reached a value of R^2 = 0.449489 (Lehman, 2005), which indicates the presence of urban cohesion, as in the fig.14.

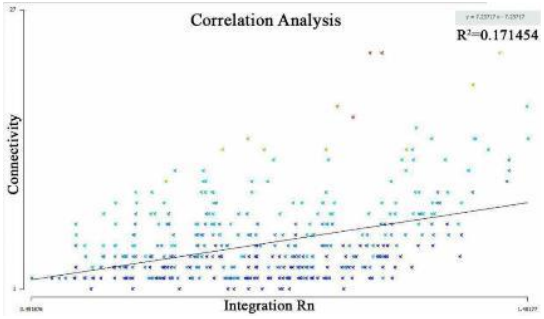

Fig.13: Correlation between Integration vs. Connectivity- Intelligibility (right). Drawn by authors.

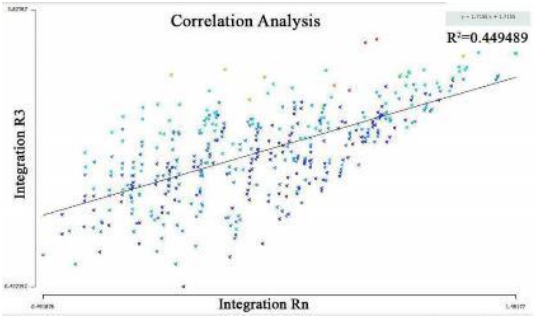

Fig.14: Correlation between Global vs. Local integration -Synergy (left). Drawn by authors.

Following table 3 shows the results of the study.

Table 2: The results of the study using the Depth map program.
Source: Authors

Attribute	Minimum	Average	Maximum
Integration Rn	0.424	0.942	1.481
Global choice Rn	0	3741	94351
Connectivity	1	5.127	27
Local integration	0.422	2.074	3.827
Local choice	0.086	0.999	5.837
Intelligibility	0.171		
Synergy	0.449		

2. Visual Graph Analysis (VGA) results

Visual Connectivity In (VGA) areas and isovist field of view in depthmap which are closely related to people's field of vision and perceptions of space, and thus their tendency towards social presence in urban space. As shown in the Al-Wahda neighborhood area, the field of vision and visual communication appears at Al-Amana Garage and the Uqba Bin Nafi Square area, followed by Khalid Bin Al-Walid Street and the Muhammad Al-Qasim Expressway intersection area with Al-Wathiq Street and the opposite street, Al-Fath Square, and therefore these areas are considered to have better clarity and visual flow as in the Fig.15A. Table 3 represents the optical connection with the maximum and minimum values according to the results of the Depth map program.

As for the analysis of all the lines that show an integration of the vision, the analysis shows a visual axis from Abdul Malik Street from the upper part of the area, Al-Wathiq Square, with Street 52 from the lower part of the area, and this indicates that Al-Watheq Square is visually integrated, as in the Fig.15B.

As for the motor behavior (Agent), according to the program (depth map), it is related to the amount of movement concentration in the urban environment, and through it is possible to predict the amount of human motor behavior and the amount of its concentration. The results showed the concentration of movement at Khalid bin Al-Walid Street and the squares connected to the street and the area at Al-Fath Square and the area behind the university technology at Muhammad Al-Qasim Highway. This result contradicts the presence according to the questionnaire and observation, as they are more present on streets 62, 52, and 42 due to the presence of entertainment places such as restaurants, cafes, and commerce, and this is consistent with what Hillier indicated in his theory of the natural movement economy. (Hillier, 1996) as in the Fig.15C.

While Through-vision, the longest possible view is at the side of the peripheral squares connected to Khalid bin Al-Walid Street and the area located at Muhammad Al-Qasim Highway, as in the Fig.15D.

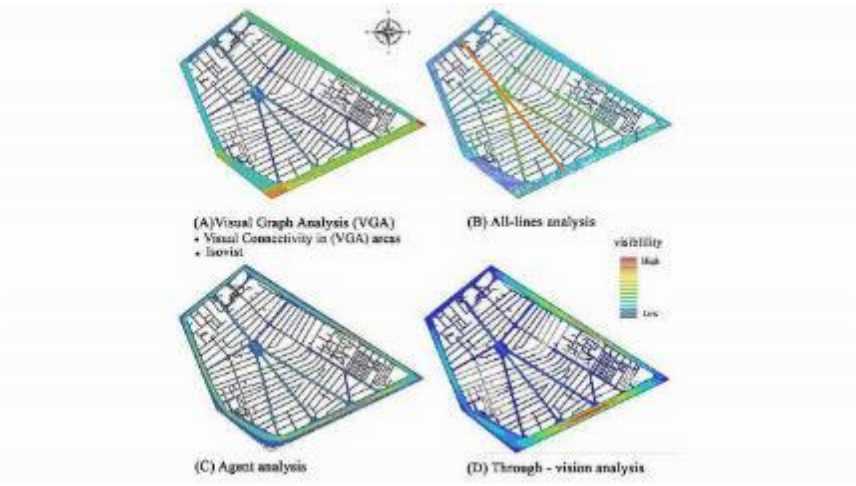

Fig. 15: (A) Visual Graph Analysis (VGA), Connectivity in (VGA) areas, Isovist (Depthmap), (B) All-lines analysis, (C) Agent analysis, (D) Through-vision analysis.
Source: Author by depth map.

Table 4: Association with the maximum and minimum values according to the results of the Depth map program.
Source: Author by depth map.

Attribute	Maximum	Average	Minimum
Connectivity	4322	1264.72	1
Point First Moment	5.736	816450	10
Point Second Moment	9.88	8.66	100
Isovist Area	430448	126644	201.77
Gate Counts	170	24.84	1

(B) Results of the Questionnaire

1. **Stimulus**: Opinions were ascertained whether the area is interesting and has a reputation that encourages frequenting it. Is the area comfortable to use? Does it appear gloomy to users, does it make you feel sad when sitting or looking at it, does it achieve a symbolic or historical identity, and does it have furniture (seats, umbrellas, lighting, waste containers), does the area have relaxing factors such as seating and shading areas? Are there places for children to play? Is there constant maintenance and cleanliness in the place? After taking the arithmetic average of the set of acceptability rates, the acceptance rate for the total questionnaire questions was 51.33%; the rejection rate 22.38%; and the neutrality rate was about 26.63%.

2. **Legibility**: A set of questions were presented focused on: Does the square contain a distinctive landmark? Is it easy to recognize? Is it surrounded by buildings? Is it considered an origin node in the transportation network with a clear axis? Is it easy to reach through public transportation? Does it have visual and physical comfort factors? Are there significant signs and a name for the node that pedestrians can recognize? Do they have clear connection points with the paths for pedestrians and vehicles? The acceptance rates were 81.01%; the rejection rates were 1.75%; and the neutrality rates in opinion were 17.25%.

3. **Integration**: Taking aspects such as: Does it have direction inside the node for pedestrians and outside for the recipient? Does it have the factors of exploration in terms of seeing new and enjoyable experiences? Is there movement most of the time, especially in the evening? Is there a diversity of uses and buildings within the area? Does it contain different activities and

events? Were there many contacts with other arenas within the region, which resulted in acceptance rates of 73.17% and rejection rates of 1.83%, while it seemed neutral at about 25.00%?

4. **Coherence**: The questionnaire focused on the following questions: Is there consideration for the human scale? Is there convergence in the places of events and activities to achieve dense pedestrian movement? Is there contrast and diversity (in texture, shape, and colour), Are there strong associations between links, sectors, or blocs? Are there Visual continuity of the interfaces and elements used. Does the area have an element of sociability? The result of acceptance for the questionnaire was 49.67%, while the rejection rates were 5.84%, and neutrality was 44.50%. We find that the factor of taking into account the human scale was the largest percentage of adopting neutrality due to the height of the roofs, palm trees and the caliph, which made these elements unaware of the landmarks when sitting; as for the diversity and contrast in colour, shape and texture between their opinions on the use of diversity in texture at the floor level using pebbles. The smooth aspect of the garden makes it clearly invisible to the visitors of the square. As for the neutrality of the visual continuity of the facades and elements, it is due to the spatial dimension of the buildings and the lack of continuity of their height within one line, which makes them not continuous, and there are spaces between the buildings. As for the rest of the aspects addressed by the index, there is no problem in the convergence of places of events, activities and communications with links, sectors or between blocs. As for the sociability element, they indicated the presence of sociability, as it witnesses the presence of families in the evening when the environmental conditions are good and the children use the playing areas. In order to address the defect in this indicator, it is necessary to increase and diversify the roofs and create outdoor activities that achieve the participation of families in expressing their opinion regarding the event, which creates social cohesion according to the theory of (triangulation) referred to by Whyte. He also stressed the necessity of having kiosks, fountains and trees.

5. **Connectivity**: Opinions were expressed on: Is there equitable access and equality of opportunities? Is there easy access to the green areas and different places within the complex? Is visual associativity achieved? Is it possible to reach the square on foot from the area? Is public and private transportation associable? The result of acceptance was around 85.80%, while the percentage of disagreement was 0.60%, while the percentage of neutrality was about 13.60%. The acceptance percentage was found to be the highest among the rest of the indicators.

6. **Permeability**: The questionnaire focused on aspects related to whether there is visual permeability from places farther from the node, whether there is permeability for vehicles inside the square, and whether pedestrians can access it. The acceptance rate was 65.33%, and the rejection rate was about 23.66%, while neutrality was rated 11.00%.

7. **Centres**: The questionnaire addressed two aspects: the first is whether it is considered a centre within the Al-Wahda neighbourhood area as a whole, and the other is whether there is interest in the floors, streets, and connecting architectural elements at the level of the part. The acceptability was 65.50%, the rejection was around 3.00%, and the neutrality was 31.50%.

8. **Diversity**: Opinions on the following questions represent: Is there diversity in activities, events, and elements? Is there diversity in the age of buildings? Is there diversity in facades? Is there diversity in seating places to achieve comfort for users? Is there diversity in pedestrian and vehicle paths? Diversity in the local materials used. The diversity index received acceptance rates of 46%, rejection rates of 13.84%, and neutrality of 39.00%. From the opinions, it is found that the diversity of facades was mostly characterized by neutrality because it is modern. The region witnesses from time to time, the removal of buildings and their replacement with buildings. It is new, which makes it lack heritage buildings. As for the

variety of paths, it was neutral, according to the questionnaire. This is due to the lack of allocating bicycle paths or special parking spaces for them, and there is no consideration for people with special needs. The other aspect that was rejected was represented by the materials used on the floor, as it was indicated that they were not Local and imported. The problem is that they are of a quality that does not suit the local environment in Iraq.

9. **Density**: The opinions were: Is there a constant density of pedestrian traffic during the day? Is there residential density? Is there density in activities such as industrial, economic, recreational and commercial? Is there density in the nodes, that is, are there other vital squares within the area? There is overcrowding in those nodes, whether pedestrians or vehicles. Is the density of pedestrian traffic constant during the day? The acceptance rate was 67.80%, the rejection rate was about 2.60%, and the neutrality rate was about 29.60%.

10. **Enclosure**: The questionnaire addressed the following aspects: Do the buildings surrounding the node appear to be well-maintained and not high-rise? Do the buildings contain partitions that allow for a shade area or balcony? Are there roofs and trees? The acceptance rate was 57.00%, and the rejection rate was about 11.00%. Neutrality was about 32.00%.

11. **Continuity**: The questionnaire focused on the following questions: Is there continuity of life during the day, which enhances safety? Is there continuity in the divisions of the facades and the city skyline? Is there continuity in the unity of details with what surrounds them, which makes them not disconnected from the context? The result of the questionnaire was: Achieve Acceptance rates were about 55.33%, rejection rates were about 5.00%, and neutrality was 39.67%.

12. **Hierarchy**: Focus on three aspects: Is there a gradation in spaces, a gradation in privacy, and a multiplicity of standards? We find that the results achieved an acceptance rate of about 37% and a rejection rate of 14.67%, while neutrality was around 47.67. %, which makes the acceptance rate for this indicator the weakest compared to the rest of the types of theoretical indicators. There was acceptance regarding the gradation of spaces. At the same time, privacy was not accepted due to the presence of high buildings on the street, which affects the privacy of the residential areas located behind them, as well as the presence of public places. This makes it widely accessible and widely accessible to strangers, which may hinder the residents' privacy due to the possibility of private cars parking on side streets. The multiplicity of standards also witnessed neutrality, and this result is consistent with the diversity index regarding the humanitarian standard, which also witnessed neutrality, which makes this aspect an indicator of the defect in the region in terms of specificity and multiplicity of standards.

13. **Active edges**: Five aspects were addressed in the questionnaire: Are there basic entertainment and diverse activities, are there various commercial activities, does the edge area (the outskirts of the square) handle transit and stopping flexibly, is there an amount of noise and pollution around the node, is there a connection between the square and Given the context, the acceptance rate according to opinions was 64.25%, the rejection rate was 4%, while the neutrality rate was about 31.75%.

14-**Safety**: He touched on four aspects that have an impact on this indicator, which are: Do you feel safe when visiting the area? Is there lighting in the place? Is there a false area in the complex that is difficult to reach or can be hidden from view? Is there good monitoring of the place? From passers-by, women, or neighbouring buildings, the result of the questionnaire was an acceptance rate of 71.75%, a rejection rate of 16%, and a neutrality of 12.25%

From the results above, it is found that most of the indicators achieved acceptance rates with the exception of the hierarchy index, followed by diversity, then cohesion, as previously explained after analyzing the descriptive data quantitatively.

After analysing the indicators and obtaining the weight of each indicator, we find that Al-Wathiq Square, according to the questionnaire, achieves the indicators of the urban health node. The measuring ruler shows the basic spatial characteristics (connectivity, legibility, integration), followed by security and safety, then secondary spatial characteristics, which are (density, centres, permeability), edges, enclosure, continuity, stimulus, coherence, diversity, hierarchy).

Following Table shows the results of the indicators of acceptability and rejection and their weights according to the quantitative analysis of the questionnaire results, node health indicators and acceptance rates achieved from the questionnaire, as in the Fig.16.

Table 5: Acceptance and rejection rates according to the questionnaire.
Source: Authors.

Properties	Sample direction (weight)	indicator	Acceptance rate	Rejection rate
Basic spatial properties	1	Connectivity	85.8	0.60
	2	Legibility	81.01	1.75
	3	integration	73.17	1.83
	4	safety	71.75	16.00
Secondary spatial properties	5	Density	67.8	2.60
	6	Centres	65.5	3.00
	7	Permeability	65.33	23.66
	8	Edges	64.25	4.00
	9	Enclosure	57.00	11.00
	10	Continuity	55.33	5.00
	11	Stimulus	51.33	22.38
	12	Coherence	49.67	5.84
	13	diversity	46.34	13.84
	14	Hierarchy	37.67	14.67
Total rates			**62.28%**	**9.01%**

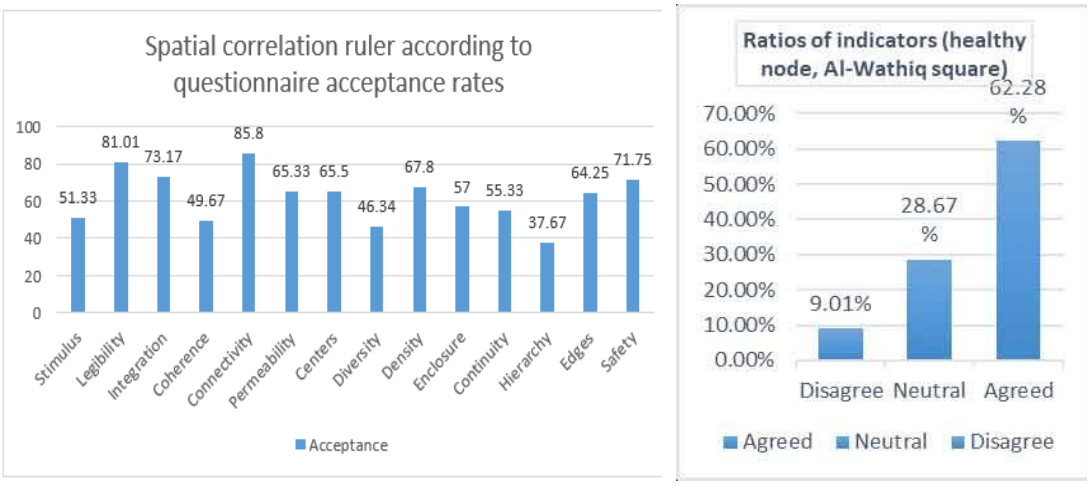

Fig.16: The indicators and acceptance rate (left). The graphical ratios the (right).
Source: Authors.

Conclusions

The purpose of the research was to identify associative node indicators in order to develop a model for defining sustainable, healthy urban spaces. This was accomplished by running them through spatial configurations of one of Baghdad's urban nodes. A descriptive analysis was carried out utilizing two methods: the depth map program and a questionnaire form.

The analysis of the depth map program shows that most of the features of spatial cohesion were achieved, making the Al Wahda neighborhood area a healthy environment. The axial maps help give an understanding of the characteristics of local and global integration (vehicle and pedestrian movement) at the site level. The global and local option index (vehicle and pedestrian movement) provide an explanation of access and physical influence to Al-Wathiq Square. The findings show that the main streets enjoy integration and choice, which made the square enjoy the characteristic of integration within the Al-Wahda neighborhood area. In addition, Al-Wathiq Square enjoys high permeability (vehicles-pedestrians) according to the comprehensive and localized option characteristic. The Connectivity feature also contributes to the interpretation of the structure cohesion index. In addition, the visual maps contribute to giving an understanding and visualization of visual access and motor behavior through the Agent feature.

According to the questionnaire, the research also found that there are a number of indicators that contribute to increasing the efficiency of the node more than others, and they were classified into basic spatial indicators and other secondary spatial indicators. After analyzing the weights of the questionnaire results, accessibility was at 85.8%, clarity at 81.01%, integration at 73.17%, and security at 71.75. % etc. In the introduction to the measurement ruler, the study concludes that the Al-Wathiq Square node possesses spatial features that make it achieve a lively and healthy environment for the Al-Wahda neighborhood area, as noted in the Table 5, which shows the percentages achieved by the measurement process for each indicator of the node Spatial health.

The acceptance rates for all the indicators are 62%; the rejection rates are 9%; and the non-acceptance rates are 28%. Although there is a need to strengthen some indicators such as diversity, hierarchy and cohesion, all the indicators share with each other in order to achieve a healthy environment. It is not possible to achieve the index of accessibility to Al-Wathiq Square unless it is accompanied by clarity of access and integration, as well as the possibility of access for vehicles and walking to the square. To achieve high attraction from users, there must be an environment that stimulates people to come to the square, as well as the availability of a large number of services, commercial and entertainment shops.

It was noted that the restaurants and cafes helped to come to the area and created a density of traffic, which enhanced the safety factor in the area. This indicates that visual and spatial accessibility is not the only factor that determines the success of accessibility to places, but rather it is considered one of the basic indicators.

The study concludes that the main streets of the area and their connections to the surrounding peripheral squares supported and contributed to the importance and vitality of the central square, while the diversity of recreational and service activities helped to improve pedestrian flow and spatial communication in the Al-Wathiq Square. Thus, the research objective is achieved by assessing the interconnectivity and effectiveness of the node as a long-term healthy node. Thus, these indicators can be incorporated into architecture as an integrated matrix that serves as a standard for measuring the associativity of healthy nodes., as noted in the Table 6.

Table 6: Healthy and sustainable urban nodes
Source: Authors.

Indicator	Type of analysis	Verification rate
Connectivity	The axial maps (AGA) show that Street 62 represents the most connection with the Al-Wathiq Square node leading to Abdul Qader Al-Jazairi Square from the lower part of the square, while the upper part is more connected at Abdul Malik Street, which makes the square achieve a connection from both sides.	V.Q. (85.8%) Connectivity (1-27)
Legibility	Used by analyzing axial maps and Intelligibility property, correlation coefficient is low Intelligibility	V.Q. (81.01%) Through the axial maps, the correlation coefficient indicates a value of 0.171, which is weak for clarity in the structure.
Integration	nalysis of the axial maps showed the integration of pedestrian and vehicular movement at the Al-Wahda neighborhood site, and also shows the most integrated and isolated areas of the site.	V.Q. (73.17%) High value for integration
Safety		V.Q. (71.75%)
Density	Visual Graph Analysis, Agent showed that the density of people was at the outer borders of the Al-Wahda neighborhood area, which constitutes no inconvenience to the residents of the area.	V.Q.(67.80%) Visual Graph Analysis.
Centers	Depth map analysis: The square is central in location according to local and global integration indicators.	V.Q (65.50%) Integrated axial maps within the site.
Permeability	Analysis of axial maps (Depth map) showed the possibility of physical influence for pedestrians and vehicles according to the global and local choice.	V.Q (65.33%) There is high permeability to the square.
Edges	Analysis of the axial maps showed, according to the connectivity index, the strongest connections of the square from the upper and lower parts of the area, which makes its edges have a spatial connection location.	V.Q (64.25%) Contact rates are high.
Enclosure		V.Q (57.00%)
Continuity	Visual Graph Analysis shows visual continuity. The penetration of the square from 52nd Street towards Abdul Malik bin Marwan is achieved through the Analysis of all the lines, Through-vision feature.	V.Q (55.33%) Verified according to Visual Graph Analysis within the analysis of all the lines property, it shows visual continuity from the edges towards the corresponding area.
Stimulus	The analysis feature of all the lines, Through-vision, integrates the vision and penetrates the arena visually, allowing the ability to see the motivating factors in the arena to come to it.	V.Q (51.00%) Visual Graph Analysis shows a visual axis that penetrates the arena visually through the analysis of all the lines.
Coherence		N.V.Q (49.67%)

	Using axial map analysis, high values of connectivity indicate the cohesion of the urban environment, while the Synergy index showed an average value of the cohesion of the physical structure of the Al Wahda neighborhood area.	Through axial maps, the correlation coefficient indicates the average cohesion value for the region Synergy 0.449.
Diversity		N.V.Q (46.34%)
Hierarchy	Analysis of the axial maps showed that residential areas are more isolated, which makes them enjoy privacy, since the integration index indicates the hierarchy of pedestrian and vehicle movement, and thus the amount of privacy for residents in the area can be graduated.	N.V.Q(37.67%) Axial maps for global and local integration. Achieved a gradual increase in privacy for residents.

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