Impact of Street Network Properties on Urban Pedestrian Movement Densities: Insights from Iraq

Saif Albabely[1] & Dhirgham Alobaydi[2]
Department of Architecture Engineering, College of Engineering,
University of Baghdad, Baghdad, Iraq.
saifullah.Mansour2004D@coeng.uobaghdad.edu.iq;
dalobaydi@uobaghdad.edu.iq;dalobaydi@gmail.com

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Abstract

Characteristics of urban street networks and the densities of urban movement have a critical role in shaping the accessibility of urban street networks. Recently, this issue has received the attention of the urban designers. This paper examines the issue of the impact of street network properties on urban pedestrian movements.

It employs the space syntax methodology, with its array of techniques, and analytical tools, to examine a case study in Iraq. The historic urban center of AlKarkh taken as a case study, uncovers these potential correlations. The study illustrates the appropriateness of the space syntax approach in revealing the complexities of urban environments across different cultural and economic settings. It confirms its applicability in integrated data analysis in combination with the conventional research methods, such as field surveys and site observations.

The findings indicate a significant correlation between the degree of global and local integration in both primary and secondary streets and the prevalence of commercial activities and public spaces. In contrast, residential areas characterized by organic developments show lower levels of integration, mirroring their private and isolated characteristics. These results highlight the necessity of integrating both historic and contemporary street layouts in urban design and planning to improve accessibility in such areas. The research validates specific correlations within the unique context of AlKarkh, emphasizing the critical contribution of space syntax analysis in offering detailed perspectives on urban form. The study advocates for further investigations into the application of these insights in urban development policies.

Keywords: Street networks, Movement densities, Space syntax, Integration, Streets.

Introduction

In the context of densely populated historic city centers, the challenge of urban transportation has increasingly captured the attention of urban planners and designers. The complex interplay between land use policies, street networks, and infrastructure significantly influences movement densities within these urban landscapes. At the heart of this discussion is the street network, a crucial factor in determining a city's spatial configuration. Essentially, the

layout and street connectivity directly affect how people navigate and interact with the urban environment, influencing accessibility, safety, and the nature of social interactions (Hillier, 1996; Peponis and Rashid, 1997; Penn et al., 1998; Hanson, 1989,2000; Boeing, 2009; Karimi, 2012; Rashid & Alobaydi, 2015). For example, street networks designed to prioritize pedestrian pathways promote walking and social engagement, whereas poorly connected or perceived unsafe networks might discourage such activities (Rashid, 2019; Rashid and Shateh, 2012). This relationship between street networks and urban dynamics is essential for the urban design field and planning with the goal of creating accessible, vibrant cities (Hillier, 1996; Penn et al., 1998; Alobaydi & Rashid, 2017).

Urban centers are currently facing challenges due to increasing movement densities, driven by growing populations and urban development policies that have not adequately focused on city centers. This increase has led to various urban challenges, including heightened traffic congestion and prolonged travel times, which significantly affect the peoples quality of life and, consequently, the economy of the country (María et al., 2019; Rashid and Bindajam, 2015). The intricate relationship between the distribution of land use and the attractiveness of locales, such as public plazas, marketplaces or parks, plays a crucial role in shaping these movement densities (Peponis and Wineman, 2002). The design and spatial arrangement of such public spaces are key determinants of the pedestrian flow and urban vibrancy (Alobaydi, 2017; Alobaydi & Rashid, 2015).

Similar to the other ancient cities in the Middle East, Baghdad's historic urban cores have undergone two distinct morphological transformations: the organic urban phase and the subsequent modern planning phase. The organic phase is marked by features such as zigzag street network, cul-de-sacs, compact urban blocks, low-rise buildings, and densely populated residential zones, typical of traditional cities (Alobaydi & Rashid, 2016;2017).

In the mid-20th century, Iraq's urban policy shifted to embrace contemporary planning methodologies. This shift aimed to integrate the existing historical centers with new expansions towards the outskirts, introducing elements like a grid-like street layout, zoning laws, rectangular plots for urban development, advancements in transportation infrastructure, and high-rise concrete buildings (Al-Ashaab, 1974; Ceicelea, 2015; Pyla, 0000; Alobaydi, 2017). This combination of old and new urban forms has intensified urban challenges, affecting the distribution of land, economic activities, and the accessibility of the street network. AlKarkh, one of these historical centers, has been particularly impacted by these ongoing challenges.

In contemporary urban centers, especially those enriched by historical layers, the challenges associated with the densities of road network movements are increasingly pressing. Achieving a nuanced comprehension of the interplay between land use distribution, transportation infrastructure, and the attractiveness of public spaces is critical. Urban planners and designers are tasked with weaving these elements together to cultivate urban environments that are not only sustainable but also vibrant and conducive to the well-being and productivity of the community. This holistic approach, integrating both the physical layout and the socio-economic fabric of the city, ensures that urban development strategies are aligned with the goals of enhancing accessibility, safety, and fostering social interactions within these dynamic spaces (Alobaydi et al., 2017).

In this context, this research delves into the intricate dynamics between pedestrian flow and urban spatial configuration, focusing on how the geometric and physical attributes of streets such as their width, length, and connectivity, influence pedestrian movement and contribute to a seamless urban experience. Its objectives are as follows.

1. To shed light on urban density dynamics and their effect on city life.
2. To uncover the relationship between pedestrian traffic intensity and land use characteristics across different urban zones—commercial, residential, mixed-use
3. To provide urban planners and designers with insightful guidance, leveraging the interplay between pedestrian movement and land use patterns to foster the development of efficient, vibrant, and livable urban spaces.

Review of Literature

To further understand these global urban challenges, particularly in the realm of road network movement densities and their impact on city life, a thorough review of existing literature is imperative. This exploration will shed light on the breadth of research conducted in this area, identifying gaps in knowledge and highlighting successful strategies employed by the urban centers worldwide. Such a review is essential for building upon the foundation of current urban design and planning practices, guiding future policies and regulations, and developing innovative solutions to address the complex challenges faced by historic and modern urban landscapes alike.

The complex interplay between urban morphology and transportation infrastructure plays a pivotal role in shaping mobility patterns within cities, particularly those with historical significance. Studies have consistently shown that factors such as accessibility and travel time are instrumental in fostering lively street-level interactions (Hillier, 2013; Karimi, 2012; Hasgül, 2015). Historical cities, despite their rich cultural and economic values, often grapple with the challenges posed by evolving transportation and land use, leading to issues such as congestion, diminished green spaces and heightened commercialization. These issues, in turn, can exacerbate traffic, create parking dilemmas, and endanger pedestrian safety (Kanani, 2011; Basee, 2022; Alobaydi, Al Hashimi, 2023). Thus, reconciling the preservation of historical urban fabric with contemporary urban needs emerges as a critical task (Tsitman, 2018; Karim and Khattak, 2017; Alobaydi, Alsaffar, 2023).

Pedestrian dynamics form a crucial aspect of urban studies, emphasizing the significance of walkability—a factor associated with numerous benefits including reduced traffic congestion, lowered emissions, and enhanced community bonds (Kubat, 2013). Karime & Khattak (2017) have investigated the relationship between the built environment and pedestrian activities in Rawalpindi, Pakistan, using both observational methods and statistical analysis to understand how environmental characteristics influence pedestrian behavior. Similarly, Givoni & Rietveld (2007) have focused on the elements affecting satisfaction of the rail passengers, notably the quality of access journeys to train stations. To add to this, Auld & Mohammadian (2012) provide a comprehensive overview of urban transportation systems, discussing their designs, operations, historical evolution, and the challenges they face, such as pollution, congestion, and social inequities.

Recent scholarly work further explores the nuanced relationship between urban design, spatial arrangement, and its implications for pedestrian movement, space utilization, and heritage conservation. In this connection, Berghauser Pont, Stavroulaki, and Marcus (2019) have introduced a novel approach for defining urban types, merging network centrality with built density to examine their effects on pedestrian movements across several European cities. Their methodology underscores the importance of empirical validation in creating urban typologies that can predict and explain pedestrian flow patterns.

On the other hand, Valença, Moura, and Morais de Sa (2023) have investigated the intricate task of re-allocating road spaces in urban areas, proposing a site selection framework that incorporates network centrality and other metrics to identify areas ripe for dynamic space reallocation. Their work is critical for navigating the competing demands on urban space, particularly in zones of high centrality. In the same light, López-Baeza (2023) have discussed how the surge in online shopping and the rise of micro-mobility trends threaten urban vitality, suggesting that strategically placed micro-logistic hubs could maintain the vibrancy of public spaces while mitigating carbon emissions. This proposal highlights the role of digital tools and transdisciplinary methods in urban planning. Simultaneously, Rashid and Bindajam (2015) emphasize the importance of spatial configuration and accessibility in preserving the historical essence of urban areas, as illustrated by their study on the Old City of Jeddah. They advocate for heritage planning approaches that respect the unique socio-cultural contexts of Islamic cities (Berghauser Pont, Stavroulaki, & Marcus, 2019; Valença, Moura, & Morais de Sa, 2023; López-Baeza, 2023; Rashid & Bindajam, 2015).

Globally, the correlation between movement densities and urban development factors has been well-documented. In Latin America, low-density development and insufficient

transportation infrastructure have been pinpointed as primary causes for increased movement densities and congestion (Alobaydi et al., 2017; Rashid, 2015). In contrast, studies from the United States attribute high vehicle miles traveled and extended commuting times to urban sprawl and low-density land use (Ewing, Cervero, 2010). European research suggests that proximity to public amenities can encourage non-motorized modes of transportation, effectively reducing movement densities (Mueller et al., 2018). Furthermore, an investigation in Cairo, Egypt, reveal that the design and accessibility of public spaces play a crucial role in attracting pedestrian activities (Quttainah, 2016). These findings underline the importance of integrating urban development policies, land use planning, and public space design to address urban movement density issues effectively.

Despite the wealth of research, a noticeable gap exists in understanding movement patterns within the historical context of AlKarkh's urban matrix. A detailed analysis focusing on how the characteristics of the street network affect pedestrian movement in this area is essential. Addressing this gap is vital for developing strategies that enhance walkability and protect the cultural heritage of historic urban districts.

Theoretical Framework

A theoretical framework for this study is anchored in the interplay between urban design, pedestrian dynamics, and the socio-cultural fabric of historic urban centers. It draws upon the foundational principles of space syntax theory to examine how the spatial configuration of street networks influences movement patterns within an existing urban environment (Hillier and Hanson, 1989, 1998). This approach underlines the hypothesis that the structural properties of street networks—such as connectivity, integration, and entropy—significantly affect the pedestrian movement densities and, by extension, the vibrancy and accessibility of urban spaces.

At the core of this framework is the concept that urban street networks are not merely physical infrastructure but are integral components of the city's sociocultural structure, influencing interactions, movements, and activities (Albabely and Alobaydi, 2023;Albayati and Alobaydi, 2023;Alobaydi, Al-Saaidy and Al-Askary, 2023)

The theory posits that higher levels of street integration and connectivity facilitate greater pedestrian movement and accessibility, contributing to urban vitality and the economic prosperity of public spaces (Hillier, 1989, 2005, 2007; Hillier et al., 1993). Conversely, lower levels of integration, often found in residential areas with organic development patterns reflect a more private and isolated urban fabric, leading to reduced pedestrian flows.

This research extends the application of space syntax beyond its traditional analytical boundaries, integrating it with empirical data obtained from field surveys and site observations in the historic core of AlKarkh. By doing so, it endeavors to provide a comprehensive understanding of the relationship between street network design and urban movement, incorporating both quantitative analysis and qualitative insights. The framework thus acknowledges the complexity of urban environments, considering the influence of historical development, sociocultural contexts, and economic factors on urban form and function.

Furthermore, the theoretical foundation of this study is built upon the premise that the reconciliation of historical urban textures with contemporary urban needs is paramount for sustainable urban development. It recognizes the challenges that historic urban centers like AlKarkh face, including traffic congestion, pedestrian safety, and the preservation of cultural heritage. By examining the case study through the lens of space syntax and urban design theories, the research underscores the necessity for urban design and planning strategies that harmoniously blend the old with the new, ensuring accessibility while safeguarding architectural and historical legacies.

The theoretical framework also draws attention to the global applicability of space syntax analysis, suggesting its potential to inform urban design and planning practices in diverse sociocultural and economic contexts. It advocates for a multidisciplinary approach to urban planning, where insights from space syntax analysis are integrated with socio-economic

considerations, heritage conservation efforts, and community engagement to foster accessible, safe, and vibrant urban spaces.

Research Methodology

This research investigates pedestrian movement densities and the accessibility of historic road networks in AlKarkh historic core in Baghdad, Iraq. It employs case study methodology within which it utilizes the innovative space syntax approach. It connects the capabilities of DepthmapX software to analyze an axial map, a reflection of the spatial configuration of street networks in this case study.

Through analysis, it quantifies the syntactic characteristics of the street networks in AlKarkh historic core in Baghdad, employing mathematical metrics to assess integration, choice, entropy, and connectivity levels. The construction of an axial map, a cornerstone of the space syntax methods and techniques, requires the delineation and graphical representation of the most extensive and interconnected routes (called axial lines) within the spatial network. This graphical tool is instrumental in dissecting the intricacies of the urban street network, laying the groundwork for a nuanced exploration of pedestrian dynamics in the urban settings see Figure 3.

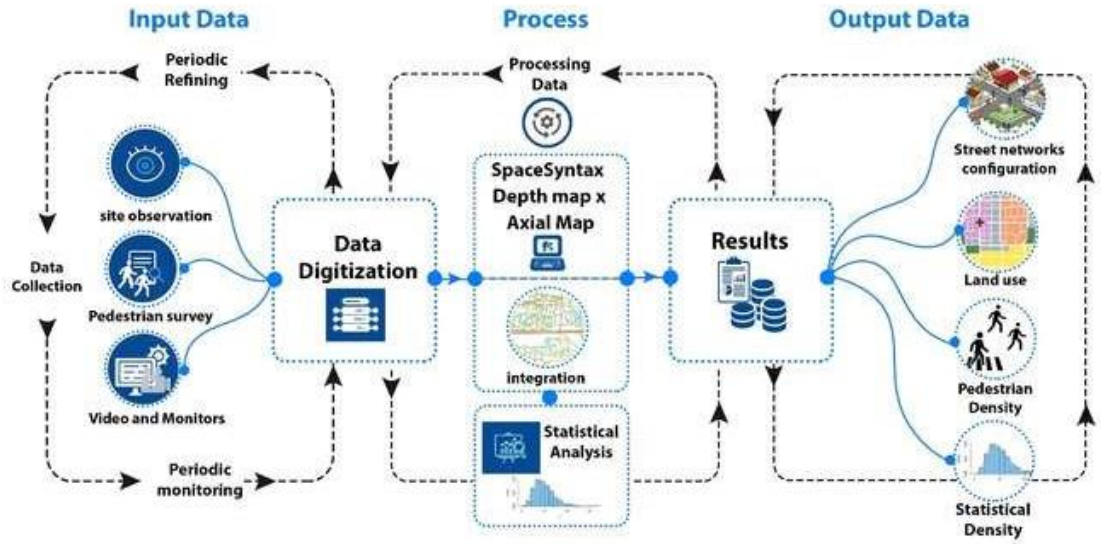


Fig. 3: The conceptual Framework.
Source: Authors.

The methodology is structured into two primary phases: data collection and research. The first phase involves the systematic gathering of relevant data, while the second phase encompasses a detailed investigation and analysis of the collected data.

The Case Study: AlKarkh Historic Core

Placed along the Tigris River banks, the city of Baghdad, with historical roots stretching back to the 8th century, was catapulted into prominence under the auspices of Abbasid Caliph al-Mansur. Evolving into a beacon of trade, cultural sophistication, and scholarly excellence, Baghdad has significantly influenced the historical landscape of the Middle East, see Figure 1.

Within this bustling city lies the district of AlKarkh, a testament to Baghdad's historical and developmental narratives. Despite its transformation through various socio-economic, political, and cultural shifts, AlKarkh has consistently preserved its cultural and historical importance within the fabric of Baghdad. Known for its vibrant marketplaces, demographic diversity, and architectural heritage, the district stands as a rich tapestry of culture (Pieri, 2005; Alobaydi, 2017, Hakim, 2013).

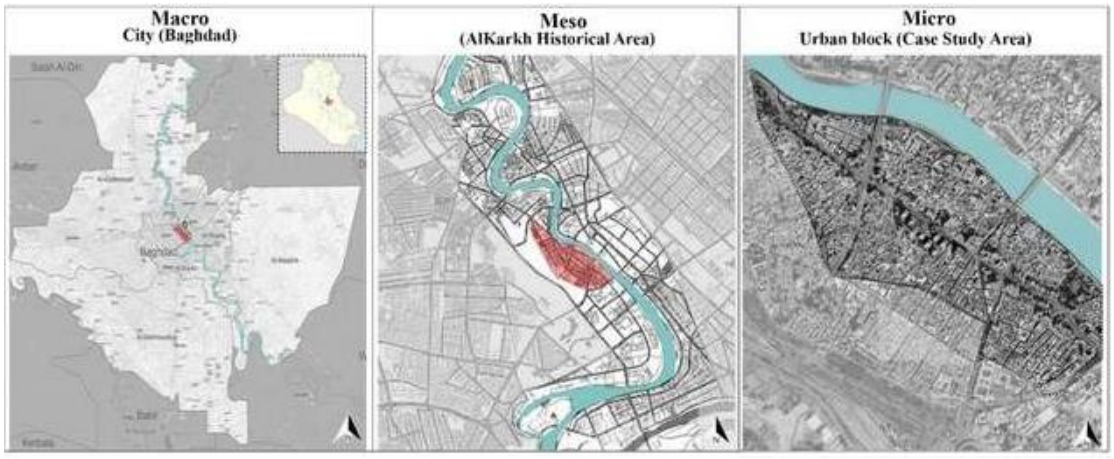
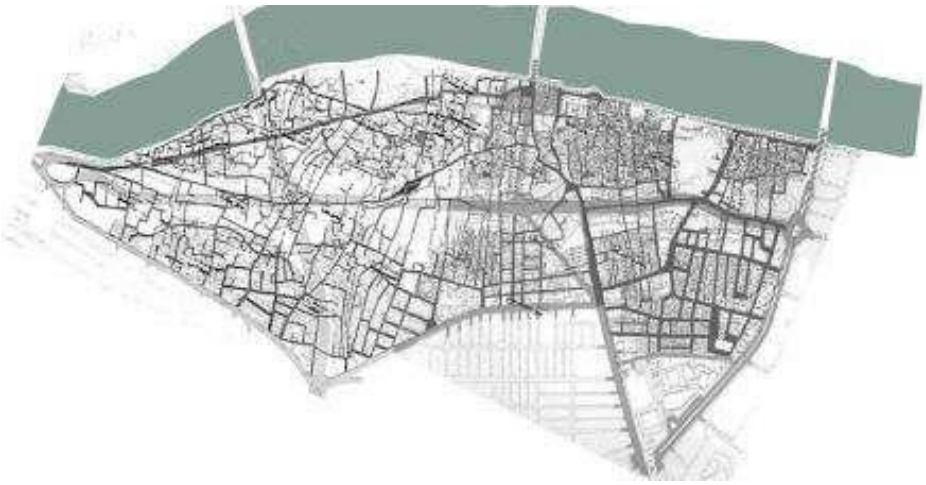


Fig. 1: AlKarkh Historic Core in the Map of Baghdad, Iraq.
Source: Municipality of Baghdad.

The urban fabric of AlKarkh has seen significant changes, particularly in its transportation infrastructure and development strategies, leading to pressing urban dilemmas (Al-Ashab, 19974; Al-Hasani, 2021; Pieri, 2008, 2016; Pyla, 2008). Challenges such as escalating traffic congestion and compromised pedestrian safety highlight the need for a harmonious integration of modern urban development with the conservation of the district's distinctive identity and architectural legacy.

Reflecting the urban design principles common to traditional Iraqi and Arab-Islamic cities, AlKarkh is characterized by a network of narrow alleys, serpentine paths, and cul-de-sacs, embodying the traditional Arab Islamic emphasis on privacy. The district is home to historic marketplaces like Al-Fleihah Market and Al-Samaatcha Market, which remain pivotal to Baghdad's economic vitality. Nevertheless, the surge in commercial activities has led to a critical shortage of parking, exacerbating the congestion of vehicles and impacting the fluidity of pedestrian movement (Alobaydi, 2017; Hakim, 2010; Hakim, 2013), as depicted in the Figure 2.



A

B

Fig. 2: A plan of AlKarkh area- A. the organic fabric 1837 and B. the modern grid 1982, Source: AlKarkh development project, Alousi associates.

Data Collection

Data collection was executed utilizing a descriptive quantitative methodology. Researchers pinpointed pivotal monitoring stations across streets and intersections within the study area. These locations were selected based on their significance, identified through frequent, periodic visits and observations of traffic flow, density, and peak times. Notably, Haifa Street and its intersections were observed to experience substantial movement during peak hours, specifically from 8:15 to 9:15 AM and 1:30 to 3:30 PM, (Figure 4).

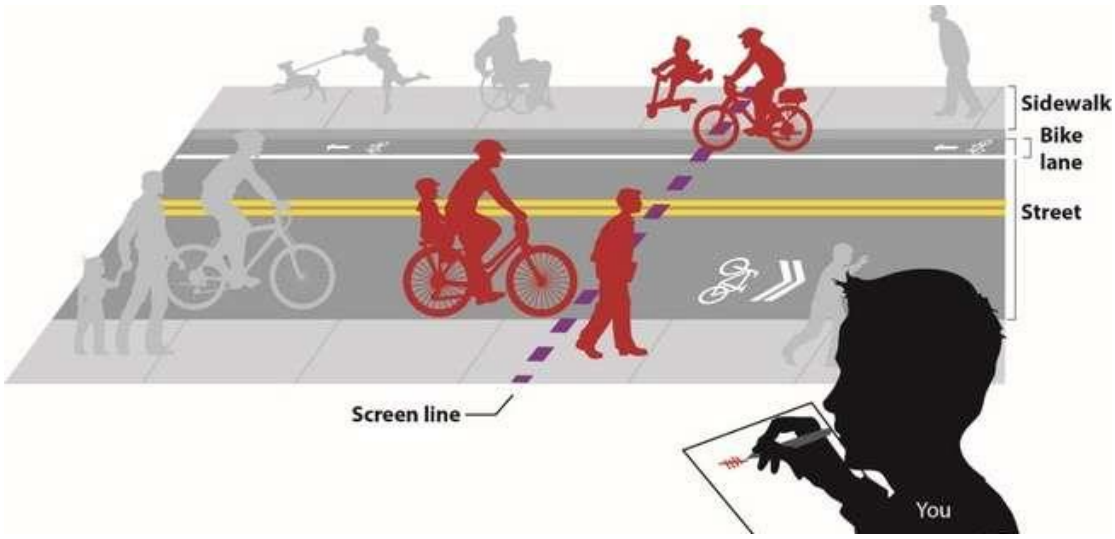


Fig. 4: The processes of counting the pedestrians flow in the selected stations. Source: Author

To facilitate data gathering, the researchers were assembled and dispatched to the predetermined stations, which were strategically located at intersections and streets known for their consistent traffic flow. The sites selected for this study included Ahmed Al-Waeli Square, Haifa Street, Al-Tala'i Square intersection, Martyrs' Square, King Faisal Square, and Bab Al-Mu'adham Bridge Street (Figure 5) Then, they observed and recorded pedestrian traffic, employing a manual way for counting pedestrians every 15 minutes and documenting the counts on prepared forms (Table A) This process was further supported by photographic and video recordings to ensure the accuracy of the collected data.

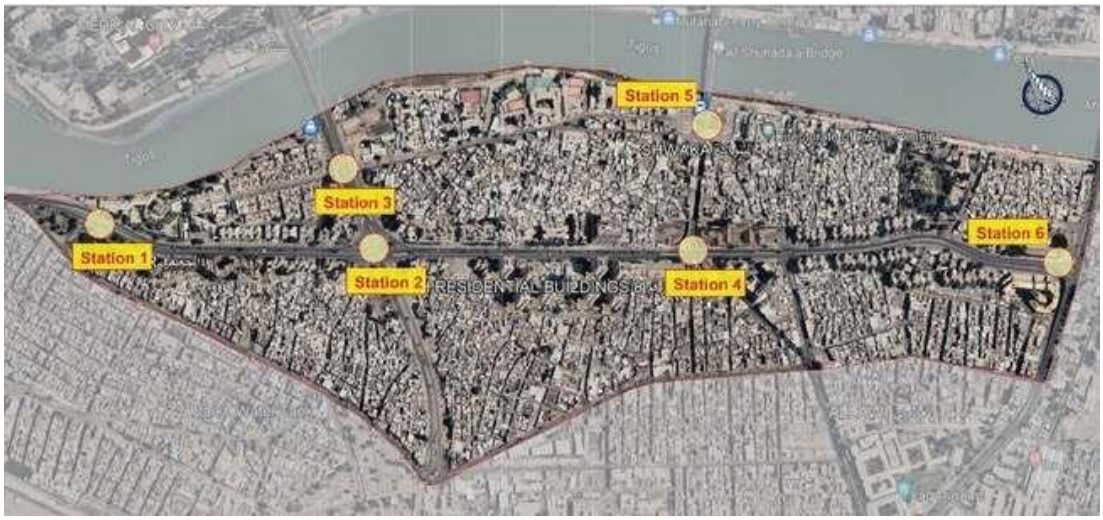


Fig. 5: The pedestrian survey in Alkarkh area including the 6 stations.
Source: Authors.

Table A: Recoding the survey data in the selected 6 stations of the examined area.
Source: Authors

Survey Type	**Movement Densities pedestrians' surveys in AlKarkh historic core**			
	Traffic Surveys Locations	***Total Pedestrians***	**Total Pedestrian (*Peak time*)**	
			A (8:15-9:15) am	**B (1:30-3:30) pm**
Pedestrian Survey	Station 1 (Ahmad Al-Waeli Park)	511	69	162
	Station 2 (Talaea Square)	834	209	245
	Station 3 (Bab Al-Moatham Bridge)	743	200	245
	Station 4 (Haifa street square)	1255	314	368
	Station 5 (Shuhada square)	5960	1733	1307
	Station 6 (King Faisal 1 square)	1719	379	395

The researchers conducted visits to the AlKarkh area's municipality to obtain detailed analysis of urban development projects. By dividing the region into a grid and utilizing satellite image, land use maps, and digital data, it was possible to update land use information comprehensively. This multifaceted approach allowed for a thorough examination of the area's urban layout and pedestrian traffic patterns, contributing valuable insights into the dynamics of movement within the study area. The investigation unfolds across five distinct steps:

- The initial step involved a precise mapping of AlKarkh's core street network, leveraging satellite imagery to capture an accurate spatial representation.
- Subsequent rigorous field investigations were conducted to verify the network's layout, focusing on integrated streets as highlighted in the schematic representations, shown in the Figure 5 and Table A. These explorations gathered empirical pedestrian flow data across various times, encapsulating both the hustle of weekdays and the calm of weekends. Figure 6 illustrates the modes and patterns of pedestrian and vehicular movement densities.
- Utilizing DepthmapX, an advanced tool developed by UCL, the fourth stage processed the axial map. This involved assigning color codes to streets based on their integration values – for this time we focused on the integration measurements – red for highly integrated streets and blue for those less (Figure 7). This color-coded

analysis facilitated a Spatial Syntactic Analysis (SSA) of AlKarkh area, employing the integration measure (HH) to gauge global movement patterns (Rn) (Figs 7 & 8).

- The research undertook the task of updating the land use map, combining existing municipal plans with comprehensive field observations to accurately chart the evolution of land use patterns (Figure 9).
- The concluding stage integrated the diverse maps and data points via graphic analysis, revealing the complex interrelations and patterns embedded within the data examined. Figure 10 was constructed by superimposing the urban layers of the analyzed data, resulting in a comprehensive composite map.

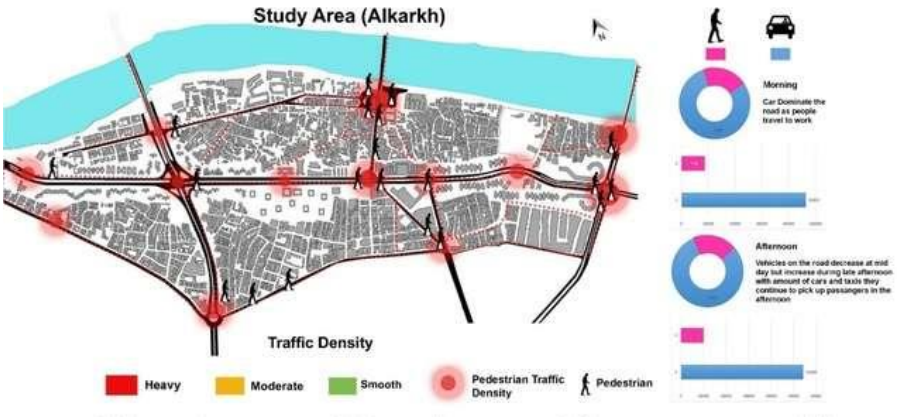


Fig. 6: Identifying the modes of car and pedestrian densities.
Source: Authors.

This comprehensive process was conducted with an acute awareness of the need to conserve and rejuvenate AlKarkh's venerable architecture and distinct ambiance, acknowledging its invaluable cultural legacy for posterity. This methodology not only promises to enhance our understanding of urban pedestrian movement but also underscores a commitment to safeguarding the historical and architectural essence of AlKarkh for future generations.

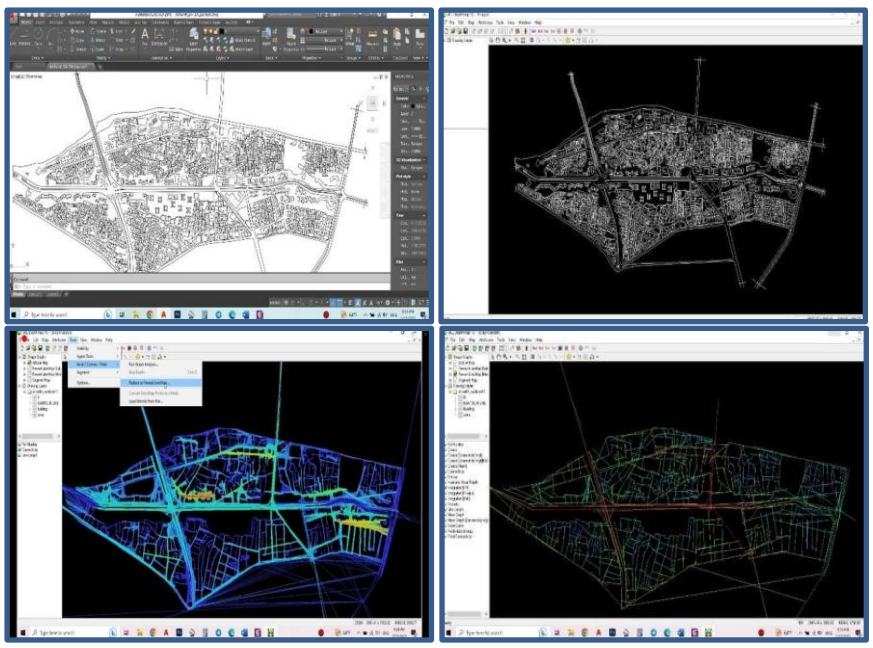


Fig. 7: Input and process data in depth map x.
Source: Authors.

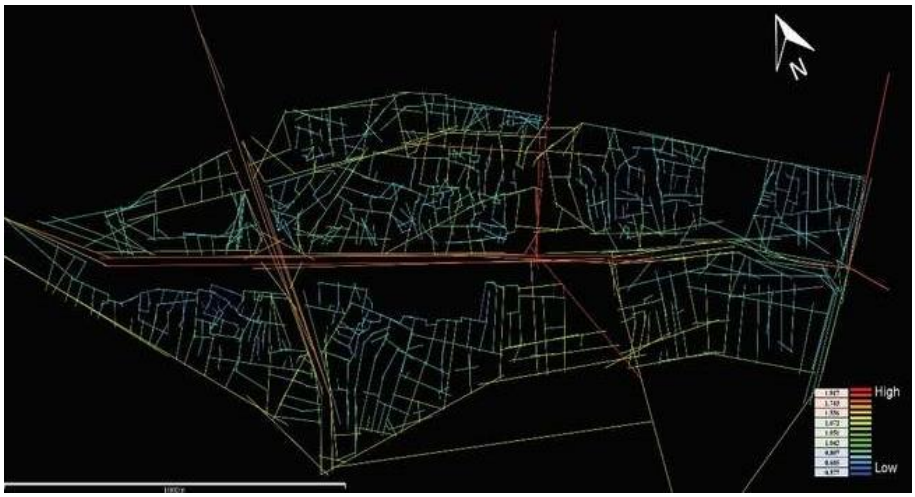


Fig. 8: Representation the Depth-Map showed the global values of integration (Rn-HH) in Alkarkh historic core.
Source: Drawn by author using the UCL Depth-Map software.

Fig. 9: The updated land use map of AlKarkh Historic Core.
Source: Author.

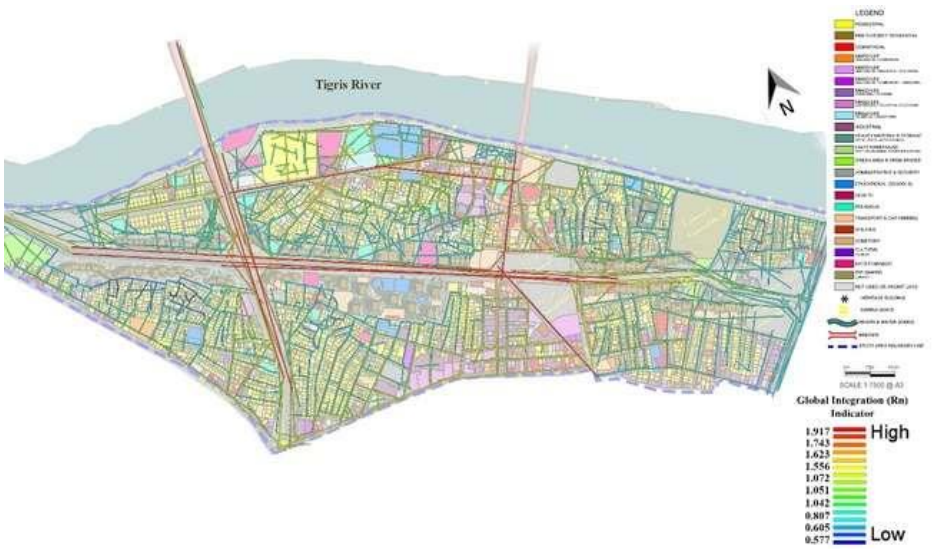


Fig. 10: DepthMap Global integration Rn and their relationships with land use around the study area.
Source: Author

Findings and the Discussion

The investigation into the historical area of Alkarkh using space syntax techniques has revealed critical insights into the dynamics of urban movement. A notable finding is the high integration value of Haifa Street, the area's most prominent thoroughfare. Its status as the widest and longest street, coupled with its extensive connections to other streets, underlines the significant influence of street networks on urban movement densities. The pedestrian and traffic surveys conducted at key locations, including Ahmad Al-Waeli Park, Talaea Square, Bab Al-Moatham Bridge, Haifa Street square, Shuhada Square, and King Faisal 1 Square, have provided quantitative evidence of these dynamics. For instance, Haifa Street square recorded the highest pedestrian counts during peak times, with 314 pedestrians in the morning (8:15-9:15 AM) and 368 in the afternoon (1:30-3:30 PM), highlighting its role as a major urban artery (Figure 11).

In the traditional market areas such as Alshawaka and Bab Alseef, characterized by their narrow, meandering streets and compact urban structure, a high level of integration was observed. These areas, fostering social and commercial interactions, illustrate the intricate relationship between urban design and community dynamics. However, these findings also bring to the fore the complexities faced by urban planners in conserving the historical essence of such areas while meeting contemporary urban needs. The pedestrian surveys underscore this with the significant movement recorded at Shuhada Square, where the total count reached 5960 pedestrians, with peak times showing 1733 in the morning and 1307 in the afternoon, reflecting the area's vibrancy and its challenge in balancing modernity with historical preservation. As described in the Table A.

Contrastingly, residential zones, typified by their organic layout prioritizing privacy and seclusion, exhibited the lowest integration values. This aspect of the urban fabric, emphasizing isolation, is clearly reflected in the spatial analysis. Further analyses utilizing the local integration axial map, based on a radius R3, revealed a stark difference within residential interiors compared to global integration metrics. There is a discernible gradient in the integration index, transitioning from higher values in the bustling public streets to lower values in the quieter, residential sectors (Figure 11,12).

Fig. 11: an old traditional market, Al-Samaatcha Market for a fish salesman,
Source: Authors.
Fig. 12: Global integration Rn and their relationships with land use around the study area.
Focus on the traditional markets.
Source: Author.

Comprehensively, the study shows that both the primary and secondary streets, often associated with commercial activities or public spaces, exhibited high integration values. This observation underscores a strong correlation between street network design and urban functionality. These findings are invaluable for urban designers and planners, offering deeper

insights into the nexus between street network properties and movement densities. It underscores the importance of thoughtful urban design that promotes efficient movement while facilitating social and commercial engagement. However, the unique challenge in historical areas like Alkarkh lies in striking a balance between modern urban needs and the preservation of cultural heritage. This necessitates innovative and adaptive design strategies to navigate the complexities of historical urban fabric (Figure 13).

Fig. 13: Depth Map Axil line map - Local integration (R3) indicator for the historical Alkarkh.
Source: map generated by Author- UCL Depth Map software.

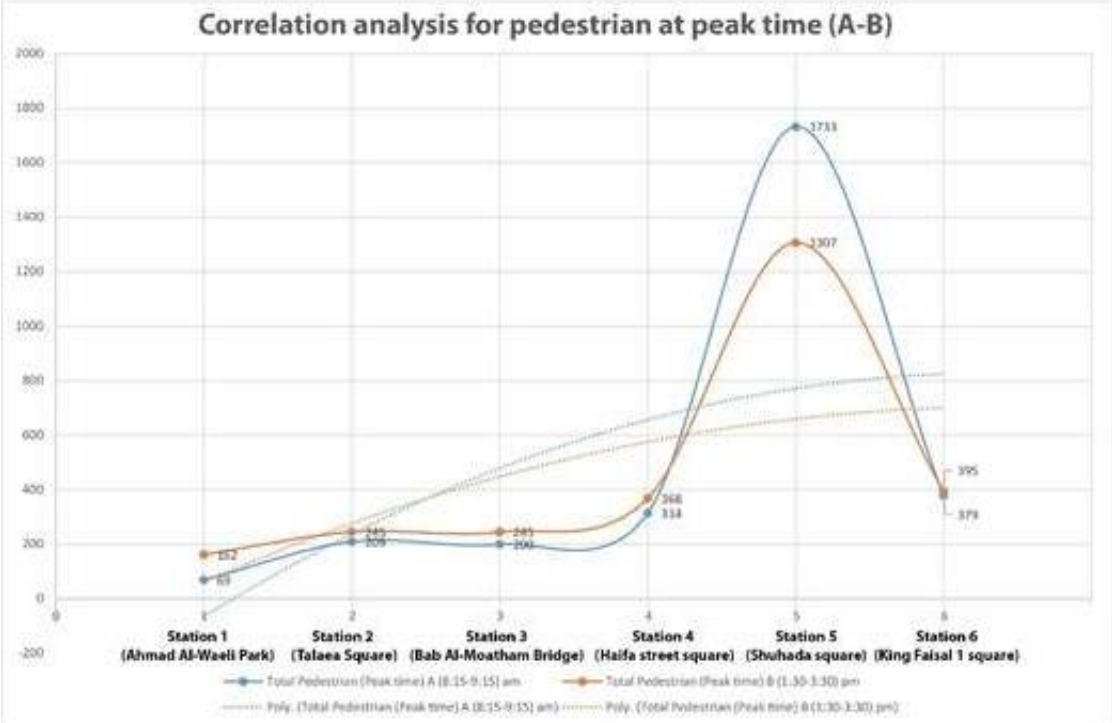


Fig. 14: Correlation analysis for pedestrian at peak time (A-B)
Source: Authors

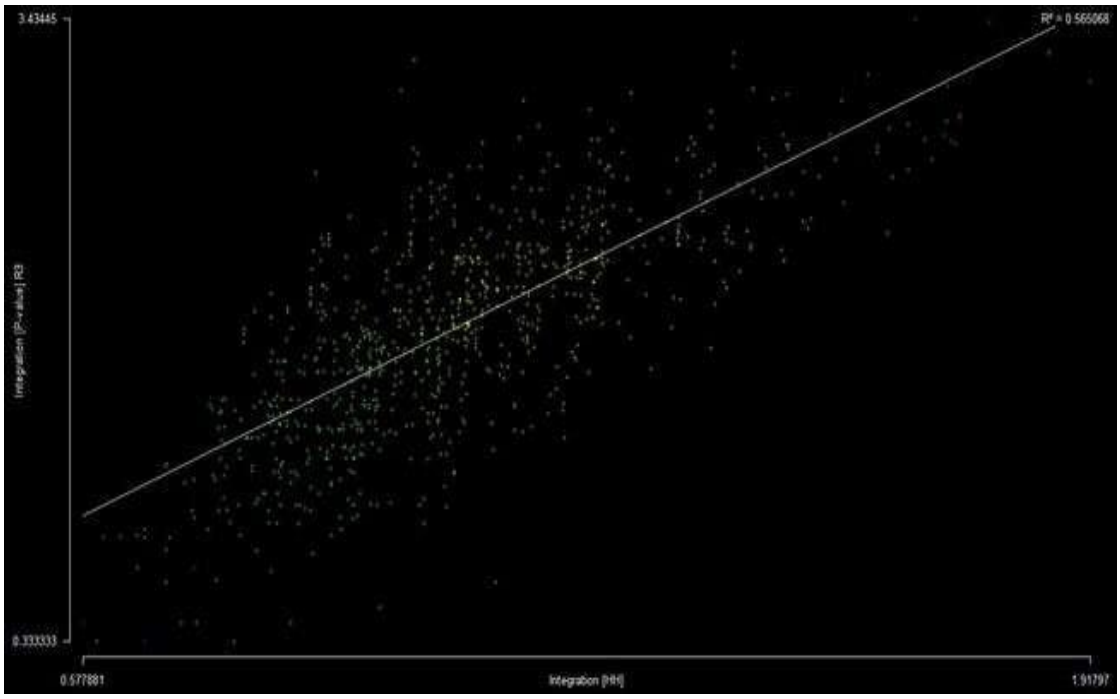


Fig. 15: A correlation analysis between the integration measures used the Rn and R3.
Source: map generated by Author- UCL DepthmapX software.

Conclusion

The core of this investigation into the intricate dynamics between street network characteristics and urban movement patterns sheds light on the influential role these configurations play in shaping the flow of city life. The research highlights a significant link between the physical dimensions of streets—namely, their width and length—and their capacity to integrate within the urban grid, facilitating connectivity and accessibility.

Within the dense, winding streets of traditional market zones, a remarkable level of integration was noted, underscoring the integral relationship between urban form and the vibrant life it supports. The correlation results in figure 14,15 showed the correlation of integration Rn with increasing R values from RH until it reaches R3, that gave strong positive correlation. The higher the values of the radius (R) and the number of steps, the higher the correlation coefficient, which represents the integration values in the analysis of the road network. It was observed that as the R values increased, the movement density of pedestrians increased, as in Figures 14, 15, The trend line represents the correct values for the analysis, the more representative the correct data. This proves the validity and accuracy of the analysis process of the urban street network.

These findings pose a sophisticated challenge for urban planners: to navigate the delicate balance between nurturing lively public spaces and preserving the rich historic urban fabric that defines them.

In contrast, the secluded, organically arranged residential areas revealed a propensity towards lower integration, mirroring the varied spatial demands and preferences that coexist within the urban mosaic.

This study serves as a clarion call to urban designers and planners, urging a deliberate and considered approach to the design of street networks. The objective is to forge urban environments that are not just functional and navigable, but also resilient and adaptive. Specifically, in the realm of historic urban cores, the challenge intensifies, demanding a sensitive balance between accommodating contemporary urban necessities and conserving the invaluable legacy of cultural history. To achieve this, the deployment of forward-thinking, flexible design methodologies becomes paramount, aimed at crafting urban spaces that facilitate movement and foster community, all while celebrating the distinctive cultural identity inherent to each locale.

Recommendations

- Urban designers and planners should incorporate detailed spatial analysis into the planning and development process. By understanding the nuances of pedestrian movement and its correlation with street network properties, urban designers and planners can create more accessible and navigable urban spaces.
- Encourage the development of mixed-use areas that blend residential, commercial, and recreational spaces. This strategy can increase pedestrian density, promoting a lively urban atmosphere and reducing the reliance on vehicular transportation.
- Engage a wide range of stakeholders, including local communities, in the design and planning process. Collaborative approaches can lead to more holistic and culturally sensitive urban development projects that reflect the needs and identities of their inhabitants.

Research Limitations

- One limitation of the study is its focus solely on pedestrian densities, ignoring the impact of vehicular traffic on urban movement patterns. Including vehicle flow could provide a more comprehensive understanding of overall urban dynamics.
- The research did not employ other analytical tools such as Urban Network Analysis (UNA), which could offer additional insights into the complexity of urban networks and their influence on movement patterns.
- The study did not consider the effects of environmental factors (e.g., weather conditions, air quality, shaded paths, and sidewalks' widths) on pedestrian and vehicular movement. These elements can significantly influence urban dynamics and should be considered in future research to gain a fuller picture of urban mobility.

References

Al Hashimi, H. & Alobaydi, D. (2023) Measuring spatial properties of historic urban networks. In AIP Conference Proceedings. Vol. 2651, No. 1. AIP Publishing.

Albabely, S. & Alobaydi, D. (2023) Impact of Urban Form on Movement Densities: The Case of Street Networks in AlKarkh, Baghdad, Iraq. ISVS e-journal, 10(7), pp.147-163.

Albayati, R. & Alobaydi, D. (2023) Urban Dynamics in Historic Marketplaces: A Network Analysis of Traditional Bazaars in Baghdad, Iraq. ISVS ejournal, 10(12), pp.583-596.

Albayati, R. & Alobaydi, D. (2023) Conservation of Urban Heritage Landscapes: Lessons from Souq AlSaffarin in Baghdad, Iraq. *ISVS e-journal*, Vol. 10. Issue 4. pp.101-121

Al-Hasani, M.K. (2021) The transformation of the urban landscape in the old city of Baghdad between 1854-2009 (Doctoral dissertation, BTU Cottbus-Senftenberg).

Alobaydi, D. and Rashid, M. (2015) Evolving syntactic structures of Baghdad. In Proceedings of the 10th international space syntax symposium.

Alobaydi, D., Al-Mosawe, H., Lateef, I.M. & Albayati, A.H. (2020) Impact of urban morphological changes on traffic performance of Jadriyah intersection. Cogent Engineering, 7(1), pp.1772946.

Alobaydi, D., Al-Saaidy, H.J. & Al-Askary, A.A. (2023) Impact of Reach Centralities on Urban Accessibility and Connectivity: Insights from Iraq.

Alobaydi, D.M. (2017) A study of the urban morphological processes of Baghdad: Implications and guidelines for urban design and planning in middle eastern cities. Kansas, US: Faculty of the University of Kansas.

Alsaffar, N.H. & Alobaydi, D. (2023) March. Studying street configurations and land-uses in the downtown of Baghdad. In AIP Conference Proceedings (Vol. 2651, No. 1). AIP Publishing.

Auld, J. & Mohammadian, A. K. (2012) Urban transportation systems: Choices for communities. John Wiley & Sons.

Basee, D.H. & Abdulla, Z.R. (2022) Transformation of urban morphology, vulnerability and resilience: Haifa Street Area, as a case study. Ain Shams Engineering Journal, 13(4), pp.101718.

Berghauser Pont, M., Stavroulaki, G. and Marcus, L. (2019) Development of urban types based on network centrality, built density and their impact on pedestrian movement. Environment and Planning B: Urban analytics and city science, 46(8), pp.1549-1564.
Boeing, G., (2019) Urban spatial order: Street network orientation, configuration, and entropy. Applied Network Science, 4(1), pp.1-19.
Ewing, R., & Cervero, R. (2010) Travel and the built environment: A meta-analysis. Journal of the American Planning Association, 76(3), 265-294.
Farhan, S.L., Alobaydi, D., Anton, D. & Nasar, Z. (2022) Analysing the master plan development and urban heritage of Najaf City in Iraq. Journal of Cultural Heritage Management and Sustainable Development.
Givoni, M. & Rietveld, P. (2007) The access journey to the railway station and its role in passengers' satisfaction with rail travel. Transport policy, 14(5), 357-365.
Gomez-Lobo, A. & Contreras, D. (2014) Urban sprawl, land use and travel behavior in Santiago de Chile. Transport Policy, 35, pp. 344-354.
Hakim, B.S. (2013) Arabic Islamic cities rev: Building and planning principles. UK: Routledge.
Hanson, J. (1989) Order and structure in urban design: the plans for the rebuilding of London after the Great Fire of 1666. Ekistics, pp.22-42.
Hanson, J. (2000) Urban transformations: a history of design ideas. Urban design international, Vol.5, pp.97-122.
Hasgül, E. (2015) Space as configuration: Patterns of space and culture. Proceedings of the ARCHTHEO.
Hassan, S.A. (2023) Using Space Syntax Approach to Describe Movement Densities in Historical Urban Fabric: A Case Study of AlKarkh Historic Core, Baghdad, Iraq (Doctoral dissertation, University of Baghdad).
Hillier, B. and Hanson, J (1989). The social logic of space. Cambridge university press.
Hillier, B. and Hanson, J. (1998) Space syntax as a research programme B. Hillier and J. Hanson. Urban Morphology, Vol. 2(2).
Hillier, B. (1989 The architecture of the urban object. Ekistics, pp.5-21.
Hillier, B. (1996 Cities as movement economies. Urban design international, 1, pp.41-60.
Hillier, B. (2005) The art of place and the science of space. World Architecture, 185, pp.96-102.
Hillier, B., (2007). Space is the machine: a configurational theory of architecture. Space Syntax.
Hillier, B. (2009) Spatial sustainability in cities: Organic patterns and sustainable forms. Royal Institute of Technology (KTH).
Hillier, B. (2013) The now and future of Space Syntax: From structures and models to theory. In Proceedings of the Ninth International Space Syntax Symposium Seoul.
Hillier, B., Penn, A., Hanson, J., Grajewski, T. & Xu, J. (1993) Natural movement: or, configuration and attraction in urban pedestrian movement. Environment and Planning B: planning and design, 20(1), pp.29-66.
Jacobs, J., (1961). Jane jacobs. The Death and Life of Great American Cities, 21(1), pp.13-25.
Kanani, S. and Zandi, H., (2011). A study of the damages to historical monuments due to climatic factors and air pollution and offering solutions. International Journal of Humanities and Social Sciences, 5(8), pp.1018-1021.
Karim, M. & Khattak, A. J. (2017) Built environment and pedestrian behavior: An observational study of sidewalk and street-crossing behavior in the central business district of Rawalpindi, Pakistan. Journal of Transport & Health, 5, 163-174.
Karimi, K. (2012) A configurational approach to analytical urban design: 'Space syntax' methodology. Urban Design International, 17(4), pp.297-318.
Kubat, A.S., Ozer, O. & Ozbil, A. (2013) November. Defining a strategical framework for urban pedestrianization projects. In The Ninth International Space Syntax Symposium.
López-Baeza, J. (2023) Street-Scale Logistic Hubs for Enhancing Urban Vitality and Public Space Usage.

Mueller, N., Rojas-Rueda, D. & Basagaña, X. (2018) Urban green and blue spaces and the trajectories of walking and cycling for transportation in Barcelona. Environmental Research, 161, 248-258.
Özer, Ö. & Kubat, A.S. (2014) Walkability: Perceived and measured qualities in action. A| Z ITU Journal of the Faculty of Architecture, 11(2), pp.101-117.
Penn, A., Hillier, B., Banister, D. & Xu, J. (1998) Configurational modelling of urban movement networks. Environment and Planning B: planning and design, 25(1), pp.59-84.
Peponis, J. & Wineman, J. (2002) Spatial structure of environment and behavior.
Peponis, J., Ross, C. & Rashid, M. (1997) The structure of urban space, movement and co-presence: The case of Atlanta. Geoforum, 28(3-4), pp.341-358.
Peralta, M.L. &Lima, M. (2019) Evaluation of the effects of dispersed urban growth on transportation systems in the eastern area of Panama City.
Pieri, C. (2005) Baghdad 1921-1958. Reflections on history as a" strategy of vigilance". In Bulletin of the Royal Inter-Faith Studies (Vol. 8, No. 1-2, pp. 69-93). Al-Nashra.
Pieri, C. (2008) Urbanism in Bagdad before the planning: A codification between the fates of the arbitrary and urgent needs (1920-1950). DC PAPERS, revista de crítica y teoría de la arquitectura, (1), pp.266-271.
Pieri, C. (2016) Sites of Conflict: Baghdad's Suspended Modernities versus a Fragmented Reality. In Urban Design in the Arab World (pp. 199-212). Routledge.
Pyla, P. (2008) Back to the future: Doxiadis's plans for Baghdad. Journal of Planning History, 7(1), pp.3-19.
Quttainah, M. A. (2016) The impact of public space design on pedestrian movement patterns: A case study of Cairo, Egypt. Cities, 51, 38-47.
Rashid, M. & Bindajam, A.A.A. (2015) Space, movement and heritage planning of the historic cities in Islamic societies: Learning from the Old City of Jeddah, Saudi Arabia. urban design International, 20, pp.107-129.
Rashid, M. & Bindajam, A.A.A. (2015) Space, movement and heritage planning of the historic cities in Islamic societies: Learning from the Old City of Jeddah, Saudi Arabia. urban design International, 20, pp.107-129.
Rashid, M. & Shateh, H. (2012) The dialectics of functional and historical morphology in the evolution of a city: the case of the Stone Town of Zanzibar. The Journal of Architecture, 17(6), pp.889-924.
Rashid, M. (2019) Space syntax: A network-based configurational approach to studying urban morphology. The mathematics of urban morphology, pp.199-251.
Tsitman, T.O., Proshunina, K.A. & Kudryavtseva, S.P. (2018) November. Formation of pedestrian street network system planning structure of historical part of city of Astrakhan. In IOP Conference Series: Materials Science and Engineering (Vol. 451, No. 1, pp. 012154). IOP Publishing.
Valença, G., Moura, F. & Morais de Sá, A. (2023) Where is it complex to reallocate road space? Environment and Planning B: Urban Analytics and City Science, pp.23998083231217770.
Wang, Y., Qiu, W., Jiang, Q., Li, W., Ji, T. & Dong, L. (2023) Drivers or pedestrians, whose dynamic perceptions are more effective to explain street vitality? A case study in Guangzhou. Remote Sensing, 15(3), pp.568.