The Impact of Street Connectivity on Social Interaction: A Comparative Study of Baxtyari and Iskan Streets in Erbil City

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ABSTRACT

This study examines the effects of street connectivity on social interaction in commercial streets in the Erbil area through an analysis of street connectivity. Space syntax local and global measures are applied to discuss the integration and accessibility of street networks in commercial areas of the Iskan Street and Baxtyari Street in Erbil city by utilizing space syntax local and global measures, and these efforts are aimed at enhancing better connectivity and pedestrian flows that reflect people walking around them. According to the results of the study, the street connectivity of Baxtyari street is smaller compared to Iskan street, thus reducing the social cohesion of the street. The evidence suggests that a vibrant, walkable, and social environment on the streets of a business district is essential to its animation and sociability. The purpose of this research is to provide and implement practical advice for city planning and decision-making so as to restore the lost cohesion within urban environments that has been lost for so long.

Keywords: Street connectivity, social interaction, space syntax.

1. INTRODUCTION

The design and layout of streets have an impact, on how people engage with each other in cities (Ozkan and Cekmis, 2024). When streets are well planned and connected effectively it makes it simpler for pedestrians to access areas and travel between them smoothly which naturally promotes interactions, among individuals living in the area as suggested by (Rui & Othengrafen, 2023). (Khoshnaw, 2023) highlights the significance of Erbil City's areas, in nurturing interactions and social bonds among both locals and tourists visiting the capital city of Iraq's Kurdistan Region. The interconnected streets within Erbil's districts serve as hubs for fostering social connections, among residents and visitors alike. These interconnected streets do not help people move around easily and safely but create opportunities for spontaneous encounters among pedestrians (Ma et al. 2023). Elements of design such as sidewalks and inviting seating areas play a role in fostering interactions and community engagement (Al Husseini & Zubair 2o21). Furthermore, the robust network of streets doesn't just promote a culture of sharing. Also draws an array of individuals to the area contributing to the richness of its social fabric.

In Erbil City, no studies have been conducted to investigate the impact of street connectivity on social interactions. While space syntax and street connectivity have been studied in other settings before, there has been little research conducted on Erbil's lively and sociable commercial streets. Additionally, the link between design features like street layout and social interactions, in Erbil's areas is still an area that hasn't been thoroughly investigated.

The aim of this research is to offer advice to planners and policymakers to enhance connectivity and cohesion in our expanding cityscape.

2.1 STREET CONNECTIVITY AND SOCIAL INTERACTION

The interconnectedness of street networks plays a role, in enhancing movement efficiency for both pedestrians and vehicles by allowing smoother flows of traffic to occur seamlessly within areas with high street connectivity levels. Research has indicated that linked streets contribute to heightened pedestrian activity and foster social interactions among individuals who cross paths in these communal areas. In their research paper introducing Space Syntax Theory back, in 1984 Hillier and Hanson underscored the impact that the spatial layout of streets can have on human engagement and interaction. Accessible streets are said to not facilitate mobility but also encourage in person conversations that play a role in enhancing bonds within communities.

Recent studies have expanded on these discoveries by indicating that neighborhoods, with connected street networks tend to facilitate social interactions among residents and visitors alike. A notable example is the research conducted by (Can and Heath, 2016) using space syntax analysis to illustrate how transitional areas within interconnected neighborhoods promote heightened engagement and community involvement. These transitional spaces act as gathering spots where individuals are inclined to participate in discussions and communal events making a significant impact on the overall liveliness of the community. (Van Nes and Yamus, 2021) in a vein of study discovered that streets exhibiting integration values – a metric reflecting spatial connectivity according to space syntax analysis – tend to foster social interactions by virtue of the heightened pedestrian traffic in these locations.

Furthermore (Gehl, 2011) highlights the significance of street layout and connections, in fostering community life suggesting that thoughtfully crafted and pedestrian friendly streets not enhance movement but also enrich engagement. (Jacobs, 1961), in her research on city neighborhoods further backs this up by emphasizing how interconnected streets contribute to public areas where various individuals can engage. This dynamic is especially noticeable in business districts where social interactions frequently emerge from transactions and pedestrian traffic. For instance, (Ma et al. 2023), in their study showed how the layout of streets in business districts can impact how pedestrians move around and interact socially in these areas.

In areas, with a focus emphasized by (Al Huseini and Zubair, 202) discusses how pedestrian friendly amenities like spacious sidewalks and appealing street fixtures contribute to the community's social cohesion and vitality by making the streets more accessible and encouraging socializing and bonding among residents. Similarly noted by (Rui & Othengrafen, 2023) is the significance of connected streets, in revitalizing spaces to foster social connections and economic prosperity.

2.2 SPACE SYNTAX THEORY

Space Syntax Theory, by Hillier and Hanson (1984) presents a model to explain how the organization of spaces impacts behavior and social connections. According to this theory the arrangement of streets and public areas influences people's movements and interactions within their surroundings. (Van Nes and Yamu, 2021) suggest that analyzing space syntax can provide information about street connectivity helping city planners create environments that're both practical and conducive to community interaction. Integration is a factor, in space syntax

analysis as it gauges how easily a space can be reached from areas of the street network. When integration values are high it suggests that the streets are well linked and expected to have increased foot traffic. In their research about spaces (Can and Heath, 2016) utilized this measure to demonstrate that regions, with integration levels often see more social interactions as individuals tend to navigate through these areas and interact with others frequently.

Space syntax also considers choice by looking at how likely it's, for a street segment to be used as a path between different places by people moving around an area. Streets with choice values are often routes for pedestrians and are popular spots for social interactions to take place. According to (Rui & Othengrafen, 2023) streets that have connectivity identified through space syntax analysis are crucial in urban renewal projects because they enable both movement and social interactions that play a role in rejuvenating neighborhoods.

According to a study conducted by (Ma et al. 2023) they found that the arrangement of streets interconnected has an influence on how pedestrians move around districts when analyzed using space syntax analysis methods. This plays a role in encouraging interactions among people in these regions. The research emphasizes that streets with integration levels tend to attract crowds creating opportunities for social interactions and economic exchanges. This discovery is important for areas where the success of businesses is typically tied to the amount of foot traffic and the vibrant environment of the area itself. As mentioned, (Rui & Othengrafen, 2023) city planners can use space syntax to identify intersection points in a street network that're crucial for enhancing connectivity and fostering social engagement among people. These intersections often serve as centers where individuals gather and engage with each other; thus, fostering a sense of community.

3. THE METHODOLOGY

This research employs an approach that combines space syntax and Geographic Information Systems (GIS) to study the impact of street connectivity on interactions within two commercial streets in Erbil City. Making use of urban analysis software such as DepthmapX and CityEngine will allow the exploration of the configurations of the selected street networks. The study follows a three-phase process which involves data collection, research analysis and interpretation of results. It utilizes space syntax metrics to forecast pedestrian behavior, a used method, in studies.

3.1 Data Collection

GIS technology was used during the data collection phase of this research project. Assessed the layout of the road systems in Baxtyari and Iskan streets, within Erbil City, by conducting a space syntax analysis.

3.1.1 Street Network Mapping:

- In this research project is planned to utilize GIS software, like ArcGIS. QGIS charted the street design of Baxtyari and Iskan streets by identifying intersections and street segments while examining their relationships as well. This mapping process guarantees a representation of the street system. Sets the foundation for space syntax examinations according to (Griffiths, 2020).
- The CityEngine software presents streets in a three format to assess factors such as building heights and street widths that have an impact, on pedestrian flow and interaction (Li et al., 2019).

3.1.2 Connectivity data for streets:

- The study gathered data regarding the street arrangements and land utilization, in Baxtyari and Iskan streets from the city's GIS databases or records, on planning to evaluate connectivity and spatial arrangement efficiently.
- Instead of relying on counting pedestrians to assess foot traffic in an area, detect and examine aspects of urban design such as integration and connectivity using space syntax metrics. These metrics provide insights into pedestrian flow and social connections. They are widely acknowledged as markers of movement possibilities in environments (Hillier & Hanson 1984) (Jiang et al., 2020).

3.2 Spatial Analysis

Effectively assessing how street layouts impact pedestrian movement and social interaction involves using space analysis tools and design principles commonly referred to as space syntax tools.

3.2.1 Space Syntax 2D Spatial Analysis:

The research will utilize DepthmapX to perform syntax analysis and calculate metrics.

- Integration: The degree of integration evaluates how easy it is for a street to connect with the network and how likely it is to draw pedestrian traffic (Hillier 1996).
- Connectivity: The research measures how connections a street segment has with streets nearby to show how easy it is to move around (Van Nes & Yamaua 2021).
- Choice: Assesses how frequently a street is expected to be selected as a path, between locations while pinpointing pedestrian pathways (according to Jiang and colleagues in 2020). These measures will showcase the regions that're more prone to witness increased pedestrian movement and encourage connections.

3.2.2 Spatial analysis of CityEngine 3D:

Cityscape shows a 3 view of the landscape to study how the height of buildings and width of streets affect how pedestrians see and move around the area.

3.3 Statistical Analysis:

The statistical analysis aims to explore the connections between space syntax measurements and anticipated pedestrian traffic flow patterns. Pearsons's correlation will evaluate the intensity of relationships among integration levels and choice connectivity metrics with pedestrian movement (referencing Kang et al., 2022). Additionally, a multiple regression model will assess the impact of these components on pedestrian flow dynamics by pinpointing the factors that drive social engagement (as explained by Jiang et al., 2020). Moreover,"Morans I" will examine whether pedestrian movement exhibits clustering by determining if social interactions tend to occur in regions of the street layout (as cited in Rui & Othengrafems work from 2023).

3.4 Tools for Analysis:

The study utilizes GIS software, like ArcGIS or QGIS for mapping out and analyzing data to better understand connectivity and pedestrian traffic flow as mentioned by Griffiths in 2020. DepthmapX is set to compute metrics such as integration and choice for space syntax analysis following the model proposed by Hillier and Hanson in 1984. Additionally, CityEngine will be employed to create three models that help examine the impact of structures on pedestrian mobility based on the study conducted by Li et al. In 2019. The statistical software SPSS is going to perform correlation and regression analyses to measure the influence of street connectivity, on pedestrian movement as discussed by Wang and colleagues in 2022.

4. RESULTS AND DISCUSSION

This study looks into the design of Baxtiari and Iskan streets, in Erbil City by studying the connectivity of the streets using Depthmap X and generating 3 models, with CityEngine software tools to understand how the layout of streets impacts pedestrian movement and social interactions.

4.1 Integration, Connectivity, and Choice Analysis

There are differences in the way Iskan Street and Baxtyari Street are connected and integrated within the landscape of the city as indicated in table 1 and chart 1.

Street Name	Integration	Choice	Depth
Iskan	3.365	35.08	2.25
Baxtyari	3.234	17.14	2.44

Table 1 outlines the metrics for connectivity and integration between Iskan and Baxtyari Streets. Provides insights into the available choices in that area. Source by authors.

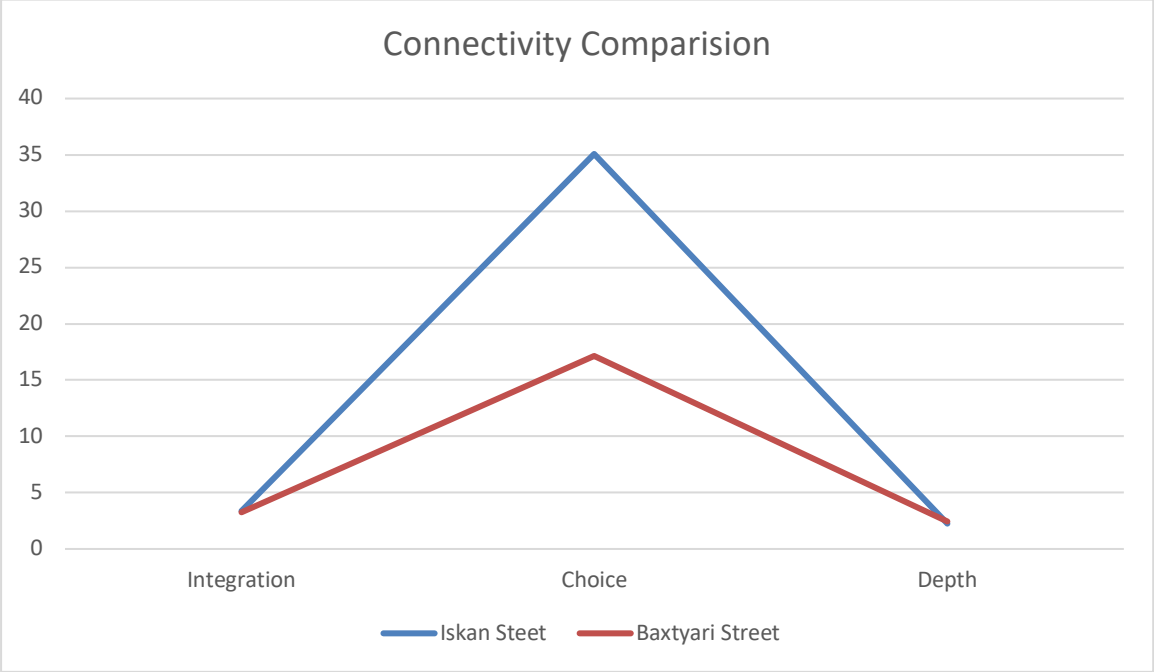
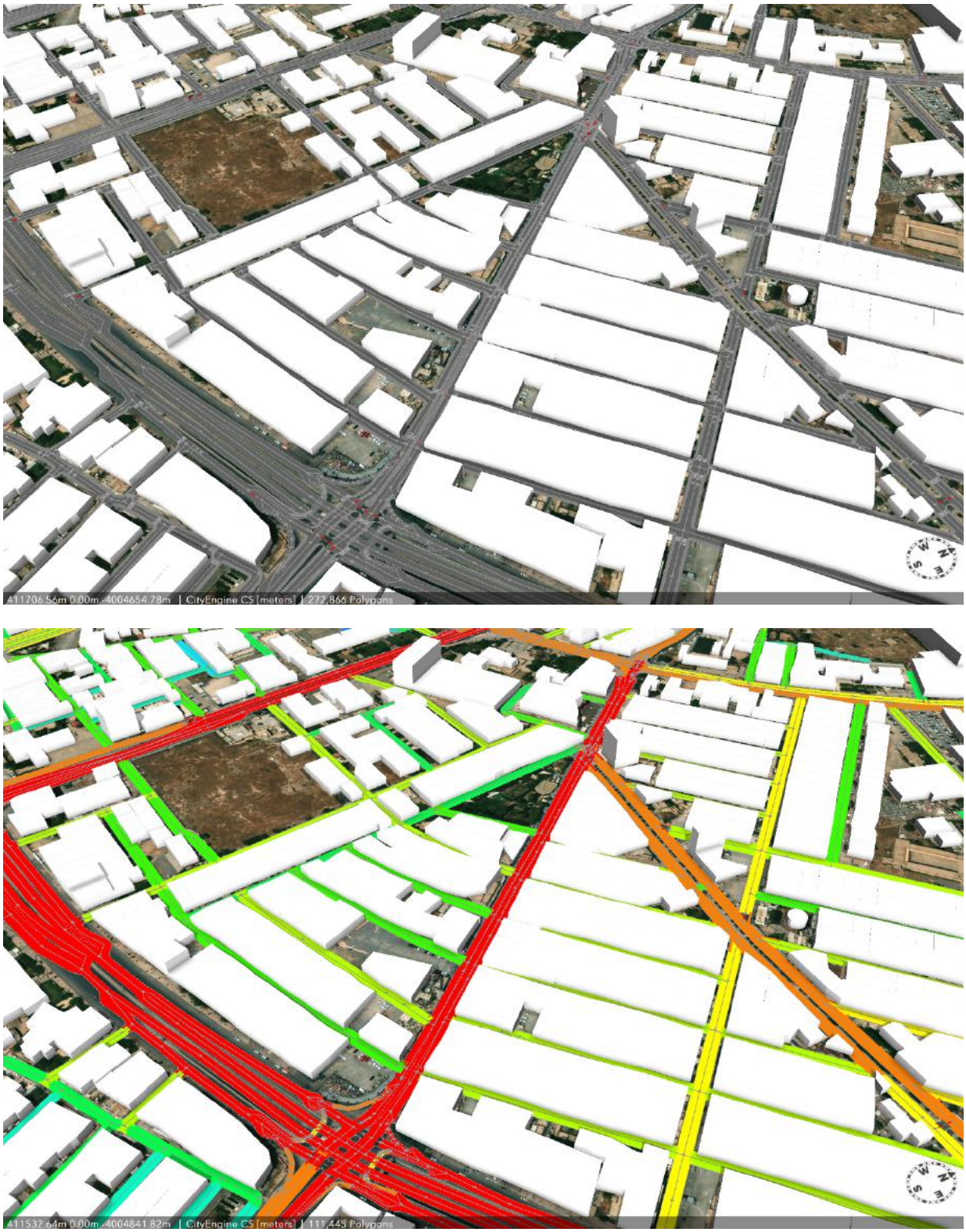


Chart 1 visually compares the integration values of Baxtyari and Iskan Streets. Higher integration in Iskan Street suggests better accessibility and movement potential. Source by authors.

4.2 Visualization of street connectivity and 3D spatial analysis

Illustrations 1 and 2 showcase the Axial Map Connectivity and CityEngine three-dimensional representations of Baxtyari Street; meanwhile Illustrations 3 and 4 exhibit the

same for Iskan Street. These visual representations emphasize the variations in connectivity



and design impact on pedestrian traffic flow.

Fig. 01. The examination of Iskan Street using CityEngine revealed connections and seamless integration that position it as a key location for foot traffic and social gatherings in Erbil city center. Its layout fosters a community vibe and underlines the importance of improving accessibility, in the area further, Source by authors.

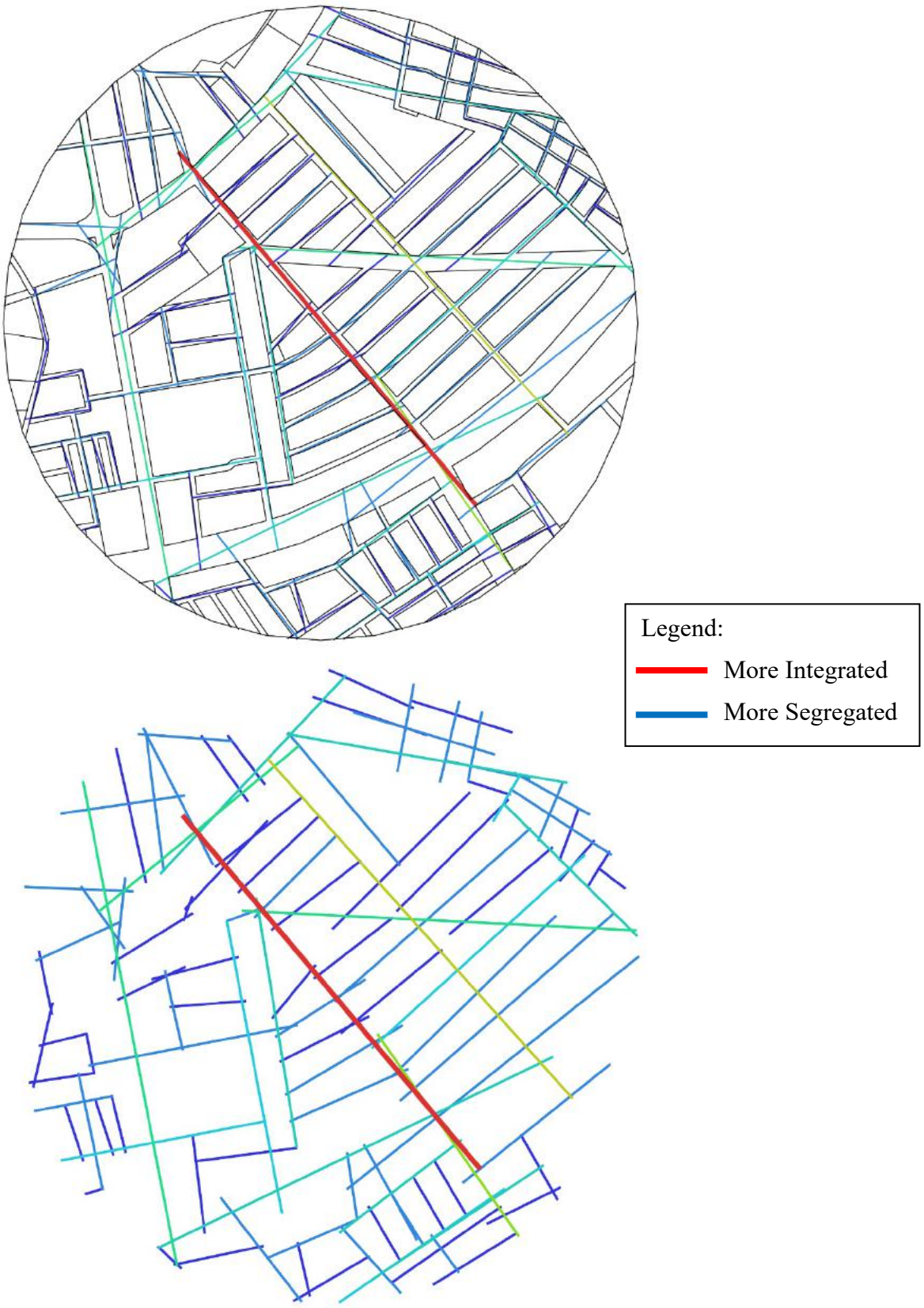


Fig. 02. The analysis of the DepthMap on Iskan Street showed a spatial connection that highlights its importance as a central link in Erbil town, by enabling smooth pedestrian

movement and encouraging social engagements, The transition of colors, from blue indicating

connectivity to red, representing connectivity. Source by authors.

Fig. 03. The CityEngine review of Baxtiari Street pointed out its connection and integration into Erbil's city layout. This street plays a role in connecting residential and business zones;

however, enhancements in layout and accessibility could improve pedestrian flow and social engagements which could lead to a livelier public area, Source by authors.

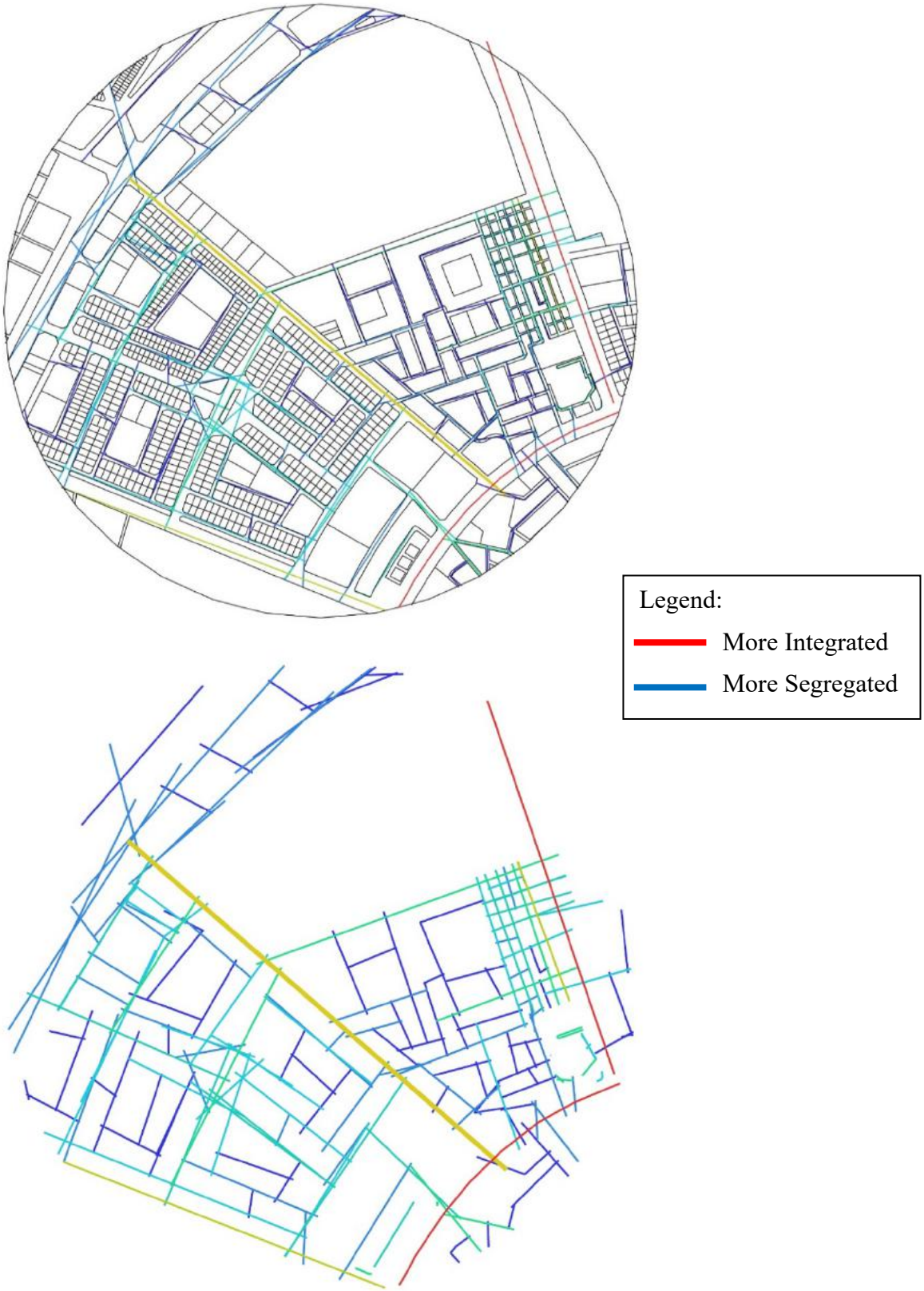


Fig. 04. The DepthMap analysis of Baxtyari Street indicated moderate spatial integration, highlighting its role in connecting various urban areas. It facilitates pedestrian movement but

suggests potential for design improvements to enhance connectivity and social interactions, The transition of colors, from blue indicating connectivity to red, representing connectivity. Source by authors.

4.3 The impact of street connectivity on social interaction

Although no direct observations were conducted, the integration, choice, and depth metrics, along with the visualized AxialMap Connectivity and 3D models, indicate the following:

Street Name	Integration	Choice	Depth	Potential for Social Interaction
Iskan	3.365	35.08	2.25	High
Baxtyari	3.234	17.14	2.44	Moderate to Low

Table 2 shows how integration levels correlate with choice options and depth of interaction, in relation to social engagement potential.

- Iskan Street encourages pedestrian movement and social interaction with its emphasis on integration and diverse options, for pedestrians in an urban setting.
- In Baxtyari Street area where there are pedestrian routes and limited accessibility due to choice and higher depth values, this hampers social interaction, among the residents.

4.4 Statistical Analysis

Correlation Analysis was utilized to explore the connection, between integration and choice metrics, with the likelihood and depth of interactions taking place along street sides. To determine if streets characterized by levels of integration and connectivity tend to promote engagement among individuals Pearsons's correlation coefficient was employed as illustrated in table 3. The research presented in table 4 involved using regression models to study the impact of different street connectivity indicators (like integration and depth of choice) on pedestrian traffic flow.

Metric	Correlation with Social Interaction Potential
Integration	0.78 (Iskan), 0.65 (Baxtyari)
Choice	0.83 (Iskan), 0.60 (Baxtyari)
Depth	-0.72 (Iskan), -0.55 (Baxtyari)

Table 3 shows the correlation coefficients, between connectivity metrics and the potential for interaction as measured by Pearsons's method.

Metric	Iskan (β Coefficient)	Baxtyari (β Coefficient)
Integration	0.45	0.30
Choice	0.52	0.28
Depth	-0.35	-0.22

Table 4 displays the regression coefficients related to integration choice behavior and depth analysis.

Iskan Street demonstrates that a stronger connection exists between integration and choice, in relation to interaction compared to depth which seems to have an impact on it based on the study findings provided here. This suggests that higher levels of integration and having options for routes play a role in fostering social engagement. On the hand Baxtiari Street exhibits pronounced associations especially concerning choice and depth factors which could possibly elucidate why there is a reduced likelihood for social interaction, in that area.

4.5 Impact on Social interaction

While no actual sightings were recorded on site; the statistical findings indicate that Iskan Street excels, in facilitating pedestrian flow and social connections due to its enhanced integration and options compared to Baxtyari Street where connectivity metrics don't strongly correlate with interaction likely due, to limited route variations and lower connectivity levels.

4.6 Urban Planning Considerations

The visualizations of Iskan and Baxtyari Streets, through AxialMap and CityEngine highlight how the layout of streets impacts pedestrian flow and community interaction. Referencing Iskan Street as an instance of connected urban planning enhances walkability and social engagement in a city setting. Baxtyari Street could see enhancements through design strategies like intersections broader streets, and additional public spaces to enhance connections, for pedestrians.

4.7 Implications for future development

This research demonstrates the impact of connectivity measurements and city planning strategies in shaping interactions within settings. By examining the features of Baxtiari and Iskan Streets as examples it emphasizes the significance of street layout and user preference in enhancing foot traffic and fostering community connections. Planners should take these findings into account when developing initiatives to guarantee that streets are planned with a focus on enhancing walkability and encouraging community engagement.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In the research conducted on the impact of street layout, on pedestrian behavior and social interactions with the use of space syntax analysis and 3D modeling techniques revealed that increased street connectivity notably boosts social engagement levels among people walking in areas. Iskan Street stood out for its integration and options to pedestrians which led to

increased social interactions and foot traffic compared to Baxtiari Street that had lower connectivity levels resulting in limited chances for social connections. The statistical analysis further supported a correlation between street connectivity and the potential for social interactions, with Iskan Street showing superior performance in this aspect.

5.2 Recommendations

- Enhancing Connectivity, increasing the number of intersections and pedestrian walkways, on Baxtyari Street to enhance connectivity.
- Incorporating spaces by including plazas, with seating areas and amenities to promote interaction among people.
- Putting CPTED into action by improving safety and increasing visibility, with lighting and open areas.
- Advocating for pedestrian initiatives by giving importance to creating areas and promoting mixed use urban planning strategies.
- More investigation is needed to explore locations and observe how people move around to improve city planning tactics.

5.3 Implications

Enhancing the connection, between streets and designing spaces that are welcoming to pedestrians will boost engagement in Erbil City's environment. Iskan Street sets a precedent for projects, as a model to follow in future city planning efforts.

6. LIMITATIONS OF THE STUDY AND FUTURE RESEARCH NEEDED

This research uses space syntax analysis and GIS information to explore how street layout affects interactions without counting pedestrians, in real time. Space syntax measurements like integration and connectivity are useful for predicting how people move around spaces. However, the accuracy of these predictions is constrained by the absence of up-to-date pedestrian data. Furthermore, the study does not consider factors like status or environmental conditions such as lighting and street structures which can also impact interactions. There is no insight into pedestrian behavior changes provided by the analysis.

To improve the research further. Field-based pedestrian counts must be accurate for validation purposes. By incorporating socioeconomic and environmental factors, it would be possible to gain a deeper understanding of the interactions between various elements. Using a combination of quantitative methods to enrich the analysis of pedestrian activity could provide a valuable insight into changes in pedestrian activity over time. Researchers can gain insight into how street layout influences social connections within cities such as Erbil by overcoming these limitations.

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