Space Syntax & Regression Analysis: Evaluating the Impacts of Urban form and Socio-Economic on Walkability in some of the Neighborhoods Dora, Baghdad.

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Abstract
Even though it has been found that walking around a neighborhood has many benefits, including health benefits, these factors must be taken into account when planning. Walkability is hard to measure and can't be boiled down to a single number because it depends on both the cultural and social aspects of a community. Using space syntax theory, the layout of streets in different kinds of communities was looked at, and regression analysis was used to measure the socioeconomic factor. This study looks at the syntactical properties of the city's organized and unorganized (agricultural) areas in relation to people's walking patterns; examines the socioeconomic characteristics of the population; and looks into people's walking patterns and the variables that influence walkability in the study area. By conducting observations of the areas and interviews with residents. Some of the results of the research are the variation and difference in the variables that affect both areas of the analysis or field observation. The findings are then used to recommend approaches that planners, designers, and decision-makers could take to create transit- and pedestrian-oriented developments.

Keywords: *Space syntax, Walkability, Urban Planning, Linear Regression Analysis*

1. INTRODUCTION

The pedestrian lane is a crucial element in urban design. The regulation governs walkway construction in many nations, including New Zealand, Australia, India, the United States, and South Africa [1]. Unfortunately, in Iraq, there are no clear pedestrian standards or lanes designated for walking. Today, due to the random expansion in the unorganized areas (agricultural lands), the transfer of a very large number of families to live in them, and the neglect of many aspects, including sidewalks, pedestrian paths, and the distribution of land uses, absence of the municipality's role in directing and managing these areas. Complex networks can form and govern connections between two or more locations in the spatial structure, which is one of the most important characteristics [2]. Connectivity is calculated using the number of physically interconnected areas in a layout space [2, 3]. The quantity of space is calculated using the 'depth' concept of distance. The degree of interaction between nearby locations is determined by measuring connectedness.

One way of measuring street connectedness is Space Syntax. The basic premise of Space Syntax's thinking is connectedness [4]. Space Syntax is a topological approach to representing and quantifying the spatial layout of streets in urban settings and then building relations to understand how such spatial layouts affect people's movement [5, 6]. Researchers created Space Syntax to describe social behavior through measurement, and connectedness and integration are two of the most important parts [6]. The street's integration (or centrality) into a network is measured [7]. Streets can be represented as axial lines that adhere to straight lines of sight in the Space Syntax notion. Their topological relationships constitute the basis of many indicators [4].

In neighborhood research, space syntax approaches have been utilized to measure street connectivity [6]. Previous studies [8] indicated a positive association between the degree of street integration and pedestrian volume. Streets easily accessible from several lanes are better integrated, attracting more pedestrians [6]. The high connection indicates that a large number of people use the street. The accessibility and availability of direct routes to destinations are measured by network connectivity [9]. The Space Syntax methods comprehend the relationship between environmental attributes and pedestrian volumes in depth and demonstrate a positive and significant relationship between network connectivity and pedestrian activity [6, 8].

Street connectivity is critical for encouraging pedestrian use, particularly for walking activities [10]. The quantity of walking activity is consistently associated with roadway connectivity [11]. The density and directness of network links were examined using street connectivity. Better connectivity reduces travel lengths and increases time efficiency by shortening paths between origin and destination [9]. One of the most important components of sustainable cities is connectivity [6, 9]. When street networks are sustainable, the environment is more efficient and safer, and there are more ways and ways to get around [9].

This paper discusses pedestrian movement in the Dora district by comparing organized and unorganized (agricultural) neighborhoods in terms of connectivity and integration analysis. The software's maps were taken from Open Street Map (OSM) and recreated in AutoCad to create axial maps. Based on the Space Syntax, the Depthmap X software analyzed the axial maps to provide connectedness and integration. This paper will explain the effects of street patterns both from a design point of view and through the linear regression analysis of socio-economic variables and influences.

2. METHODOLOGY

A series of discrete lines of possible free movement, known as axial lines, were employed to characterize the environment with the fewest axial lines in order to assess the relative flow rates of pedestrians in the research zone. Each street segment's integration was computed using the DepthMap X software [12]. Each segment within a 1.5-kilometer (0.9-mile) Euclidean radius of its center was given an integration score based on the integration of all other segment types within this distance. This buffer size equates to a 10-to 20-minute walkable area, similar to the size of local regions used in research on community environments and physical activity. To account for edge effects, it was enlarged from the typical one-kilometer radius [13]. The number of lines in an axial map directly associated with a single line is referred to as connectivity in space syntax. Lines with high connection ratings are used more frequently by traffic than lines with lower connectivity ratings.

To an extent, this notion makes walkability predictable. The concept of "depth" was created to aid in comprehending the graph structure. As a result, the depth of an axial line can be measured by counting the number of surrounding lines within a specified number of steps. As a result, both connectedness and depth are characterized topologically. A questionnaire was provided to the research region for all types of destinations to be researched. However, one of the constraints was the lack of response from the local community in completing the questionnaire.

As a result, in the research areas, random interviews were used to ask questions about distance by estimating walking ability (less than 400 meters, between 400 and 800 meters, from 800 meters to 1 km, from 1 to 1.5 km, more than 1.5 km), work, school/university, shopping, entertainment, sports, mosque/place of worship, and other. It evaluates the state of the walkways, the residential neighborhood's beauty, and the sensation of safety. They also requested demographic information such as age, gender, education level, occupation, salary, and car ownership.

With 60 interviews, neighbourhood residents in Doura explored socio-economic variables and household walking behavior in the research region. Several interviews were conducted in the research areas, knowing that a large number of residents refused to be interviewed, especially females. Where 30 interviews were conducted in the agricultural neighborhood of Al-Jazira (unorganized area) and 30 interviews in the Al-Jami'ya neighborhood (organized areas). The method utilizes data gathered from houses and people' socioeconomic and walking behavioral aspects to explain the variance of walkability in the research area. In order to complete the analysis, linear regression was used while working in the SPSS environment.

3. STUDY AREA

Dora is a large area south of Baghdad. It overlooks the western shore of the Tigris River. An area surrounded by dense palm groves. It has many important neighborhoods and residential and commercial complexes. It lies approximately 33.251389°N, 44.391944°E on the Greenwich meridian. The population is approximately 280 thousand (based on 2014 population statistics).

During the past decade, and due to the economic and political changes, there has been a tendency to change the type of agricultural land use and convert it illegally to residential areas in vast lands in most cities, including the Dora area in Baghdad, resulting in the irregular distribution and division of lands by contractors and real estate without taking into account the design criteria such as the network of streets, sidewalks, and green areas. The targeted areas in this research are legally organized areas and unorganized areas (agricultural lands) to study and assess the possibility of walking comparing these neighborhoods, and they are as follows and shown in Figure 1:

Al-Jazira neighborhoods (unorganized agricultural areas). Al-Jami'ya neighborhood (organized areas).

As a description, and generally, for the organized neighborhoods, the residential and commercial neighbourhoods are considered to have a main commercial street in the middle and a residential area around it. The unorganized neighborhoods are mostly residential areas, and the commercial areas are concentrated on the sides of the neighborhood. In general, it is a grid-patterned neighborhood.

Figure 1. Study area Al-Jazira neighborhoods (unorganized agricultural areas). Al-Jami'ya neighborhood (organized area) Source:author map ArcGIS.

4. DATA ANALYSIS AND INTERPRETATION

For the purpose of estimating the relative flow rate of pedestrians in a complex environment such as the locations that were chosen, the surrounding area needs to be conceptualized as a collection of separate lines of prospective, unimpeded movement that are referred to as axial lines. The model's objective is to produce an accurate representation of the metropolitan region using as few lines of movement as is practicable. The process of reducing an environment to its principal axes of movement can be carried out algorithmically if a base map of building footprints is used as the starting point. It clarifies the interpretation of the pivot map shown in Figure 2, as the organized regions are of higher integrity than the unorganized regions, showing the contrast of red color gradations. Connectivity is significantly lower in the unorganized (agricultural) areas and slightly higher in the organized areas. Walking behavior is supposed to be significantly promoted as a consequence of the analysis, but the axial map analysis revealed that some organized area have a low walkability influence.

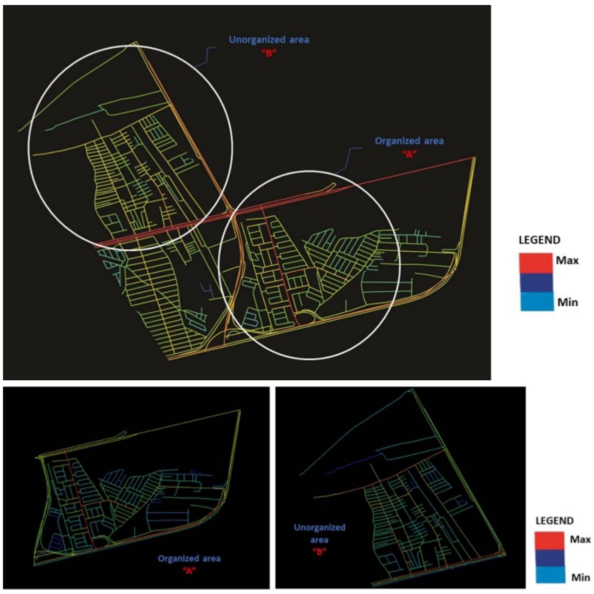

Figure 2. Axial map (Integration) of the pedestrian network for the organized region denoted with a 'A' and the disorganized area denoted with a 'B'; (The lines that have the most control are represented in red, the lines that have less control are displayed in blue, and the lines that have the least control are displayed in a sky blue color).

This could indicate that other intrinsic actors influenced the outcome. As a result, issues such as a person's socioeconomic status should be examined, as this may impact their walkability. The figure shows that the number of axial lines for the organized areas is greater than for the unorganized areas, although the result of the integration is somewhat close between the two areas. The results could also be explained in terms of to-centrality, utilizing the syntactic space idea of centrality and the logic of integration. The shape of the street network in the two areas is dominated by a longitudinal pattern, except for the Al-Jami'ya neighborhood (organized area), where the street pattern is more diffuse and directional. Thus, integration is higher on the main street and lower on the outskirts of the residential neighborhood. When looking at the axial map for angular integration from junction to junction, it can be seen that most of the roads in both organized and unstructured areas meet at an angle close to 90 degrees [12]. It has been discovered that this angular relationship plays a significant role in how residents orient themselves when deciding which route to take when traveling to a destination. Most regions with 90° and 180° junctions with long straight streets tend to influence people's walkability since residents can maintain linearity with the minimum angular deviation angles for road junctions. On the subject of route selection, this is consistent with Dalto [14] and Da'Achi [15].

The streets of the organized area tend to meander, and the number of streets depends on closed ends (cool de sac) somewhat, but they do not cause direct confusion to pedestrians because they are not dense and also because they are easy to understand. As for the unorganized area, most of the streets are in the form of a grid. It is also difficult to understand due to the lack of many irregularly fed streets, which confuses the loss level.

4.1 The study area's syntactical qualities:

Table 1 shows the syntactical properties of the examined neighborhoods for pedestrian networks. Compared to the organized and disorganized areas reveals that they have substantially different morphologies, where the organized area contains a grid with fewer streets and more curves than the unorganized area. This was not something that was anticipated due to the fact that the pedestrian networks in the unorganized region differed in terms of the number of axial lines. This suggests that there are no paths built for pedestrian usage on any street in the unorganized area, whereas in the organized areas, one can find bigger roads with pedestrian workways, and this was not something that was anticipated Table 1.

Table 1. Summary attribute of the axial map.

		minimum	*maximum*	*average*
Organized area	*Connectivity*	1	6	3.500
	Integration	121.056	338.617	229.837
	Mean depth	2456.300	6870.720	4663.510
	Node count	912	912	912
Unorganized area	*Connectivity*	1	8	4.500
	Integration	107.735	314.579	211.157
	Mean depth	1388.910	4055.520	2722.215
	Node count	661	661	661

Table 1 shows the syntactical properties of the examined neighborhoods for pedestrian networks. Comparisons of the organized and disorganized areas demonstrate that they have quite different morphologies, with the organized area having more axial lines than the unorganized area. This was expected since the networks in the unorganized region differ in axial lines, indicating that there are no pedestrian paths on any of the unstructured area's streets, whereas the organized area has broader roadways with pedestrian workways Figure 2 and Table 1.

The comparison makes it clear that the communities have significantly different levels of global and local integration in terms of their attributes. The grid in the unorganized area has a shallower depth of 1388.910 and considerably fewer disconnected streets than the grid in the organized area has (2456.300), which indicates greater global integration values. This further illustrates that the street design pattern of the unorganized area is more porous and enables simpler syntactic accessibility between streets than that of the organized area. These findings show that the two regions have quite different approaches to the spatial arrangement of their respective environments. On the other hand, it appears that those living in the organized region walk a greater distance to areas of utility than those living in the unorganized sector. This is the typical expectation that comes from the impact of the street. If the layout of the street has no effect on the way people walk, then it is reasonable to assume that there are other components of this behavior that need to be investigated in order to have a better understanding of it.

4.2 Investigating the socioeconomic influences on walking behavior

The socioeconomic details of the sampled subjects are displayed in Table 2. More than two-thirds of the final sample—76.6 % of the organized area's participants and 70 % of the unorganized area—were men. Both organized and unorganized areas have their workforce employed outside of their native region. People in the organized region made more money each day than those in the unorganized area; 60 percent of the organized region's residents made more than 800 thousand dinars per day, compared to 43.3% of the unorganized area residents. The rate of car ownership, which is greater in the organized region (73%), may be related to the average linear distance walked each day.

When the walking destination was taken into account, it was shown that people make 40 percent more leisure trips in the organized area than in the unorganized area, where only 26.6 percent of people make such journeys. The percentage of participants who walked to the mosques was likewise greater in the organized area (33.3%) than in the unorganized area (13.4%), as shown in the following table. Here are 16 variables for the regression model as dependent and independent variables, as follows: walkability desire, age, gender, household income, car ownership, health status, the distance you walk, district type, pavement status evaluation, green space evaluation, sense of safety evaluation, shopping trip, working trip, leisure trip, sports trip, mosque or church trip. Tables 3 and 4 show the linear regression results for organized and unorganized areas. It reflects the degree to which aspects of walkability might vary from one another.

Table 2. Percentage values for the sampled participants' socio-economic characteristics.

Variables	Classes	60 Intreviews	
		Organized Area	Unorganized Area
Age:	*15 - 44*	73.0%	83.3%
	< 45 year	27.0%	16.7%
Gender	*Male%*	76.6%	70.0%
	Female%	23.4%	30.0%
Household Income	*> 799th Dinar*	40.0%	60.0%
	800 - 1 Milion	30.0%	23.3%
	1.1 Milion <	30.0%	16.7%
Car Ownership	---	73.0%	33.3%
Distance you walk (m)	*>800 m*	23.3%	23.3%
	801 m - 1 km	30.0%	60.0%
	1.1 km -1.4 km	40.0%	10.0%
	1.5 km <	6.7%	6.7%
Walking Activties	*Shopping*	33.3%	30.0%
	Mosque/Church	33.3%	13.3%
	leisure trips	23.4%	16.7%
	Sport Trip	16.7%	10.0%

The model outcome for the organized area shows a very good predictor between walkability desire (dependent variables) and other independent variables; the R-squared value (0.699) indicates that the model explains 69.9% of the variance in independent variables, and F(30) = 19.875, p< 0.001, which indicates that some of the independent variables can play a significant role in shaping walkability desire. But about the variables, many of them are not significant as following: Age, Gender, Household Income, Car ownership, District type, pavement status evaluation, green space evaluation, shopping trip, working trip, leisure trip, sports trip, and p-value results respectively (0.590, 0.910, 0.956, 0.948, 0.512, 0.552, 0.702, 0.589, 0.662, 0.411, 0.085, 0.813, 0.194), three good significant independent variables, health status, sense of safety evaluation, and mosque/church trip, show signs of a very good predictor with a significant p-value less than 0.005 that effects on rates of walkability in the area.

Also, the T-Test for the three significant variables is greater than 2, which increases the hypothesis of a relationship between dependent and independent variables. Table 3 represents the results of the multi-linear regression analysis.

Table 3. A summary of the organized area's linear regression model results.

Organized Area				
Dependent Varible	R	R^2	F	Sig.
Walkability desire	0.843	0.669	19.875	0.000
Significant Independent Variable	t-test		P-Value (Sig.)	
Health status	-6.80		0.000	
Sense of safety evaluation	3.36		0.002	
Mosque/Church trip	4.31		0.000	

The unorganized area did the same linear regression model with the same variables. The results show that the model has a very good predictor from the R-squared value (0.744), which means that the model explains 69.9% of the variance in independent variables and F(30) = 25.182, p<0.02, and the effects of car ownership, health status, and shopping trip have significant values less than 0.04. The other independent variables have weak significant p-values > 0.02 and don't affect the dependent variables (walkability desire).

Additionally, the T-Test for the three significant variables is greater than 2, which strengthens the explanation that the dependent and independent variables are related. The results of the T-test demonstrate that the desire for walkability has a strong positive link with visits to mosques and churches, assessments of one's sense of safety, and a strong inverse relationship with one's health. The outcomes of the multi-linear regression analysis are shown in Table 4.

Table 4. A summary of the unorganized area's linear regression model results.

Unorganized Area				
Dependent Varible	R	R^2	F	Sig.
Walkability desire	0.863	0.744	25.182	0.000
Significant Independent Variable	t-test		P-Value (Sig.)	
Car ownership	5.306		0.000	
Health status	-2.279		0.031	
Shopping trip	8.230		0.000	

Although the R-squared value is good and high for both models, several variables were not addressed in the statistical analysis. Therefore, it can be justified that neither socioeconomic nor urban form variables can predict how individuals will walk. Consideration should be given to taking samples with a larger number, focusing on both types of variables to study and predict neighborhood walkability.

5. DISCUSSION

The results showed that street network measures correlated with walking frequency in both localities. The organized area has streets with good street integration, high connectedness, and a predisposition for pedestrian strolling, as shown by the axial map. Although there is a low likelihood of people strolling in the disorganized region, which was also found to be the case by the axial map analysis, the area did exhibit streets that were less interconnected and were characterized by modernization. This suggests that there may have been additional, not considered in the analysis, factors influencing this result. As discovered in earlier studies, these elements were connected to people's socioeconomic traits. [16, 17].

It was also identified that the organized area has a population that consists of people with middle to high income groups, good pavement conditions, a higher sense of safety, more green space, and a larger number of people who own cars; In addition, because of the urban form's excellent land-use mix, residents may walk further distances to amenities such as shops, markets, and utilities that are close to their residences. This was found to be the case. In contrast to the new unorganized area, which has a high population, a low and middle income, fewer car ownership numbers, and no pavements at all, the organized area has a moderate sense of safety; the green space or landscapes are not clear; the urban form is more residential with most utilities not too close; and so on. This result provided support for a study that was conducted across multiple countries to investigate the general pattern of activity-supportive neighborhood environment design for the purpose of reducing the amount of time that adults spend each day on sedentary and utilitarian walking excursions [16]. Therefore, it is possible to say that the organized area has a tendency to promote more walking as opposed to the use of cars [18].

Additionally, it was discovered that the walking destination significantly impacts a location's walkability, with a large percentage of residents in the organized region making more trips for leisure each day (23.4%) than only 16.7% in the unorganized area. This is undoubtedly caused by the organized area's having more recreational facilities, such as parks, than the unorganized area.

In addition to this, it was found that organized areas had a larger prevalence of walking for health and sport than disorganized areas did, with 16.7 percent of the people testifying that they walked for these reasons, whereas only 10 percent of the people in the unorganized area did so. The findings of the model indicate that the possession of a car is an accurate predictor of the walkability of both sites, particularly with regard to unorganized area explanations of walkability. Age and wealth were shown to be very poor predictors of walkability in both of the neighborhoods that were examined. These characteristics contributed to the diversity in walking behavior that was observed between the two locations that were researched. This points to a connection between the total amount of walkability in the districts and the number of people who own cars.

An explanation of the rationale behind walking in organized and unorganized areas may be found in the practical destination where mosques and churches are located. Trips and shopping trips have a very good positive relationship; t-test values (4.311, 8.230). Car ownership also provides a good explanation with a positive t-test value (5.306) of the variance of walking in the unorganized area. The sense of safety evaluation has a moderate positive t-test value (3.359) to explain the reason for walking in an organized area. The health status of the residents in both areas has a negative explanation of the reason for walking, with a very good t-test value (-6.798) in the organized area and an accepted t-test value (-2.279) to explain the walking habits in the unorganized area.

Finally, despite the results of both analyses (Axial map and regression analysis), it wasn't easy to interpret. The direct observations of the residents of both neighborhoods showed that age, gender, and car ownership have a significant role in influencing walking as a means of transportation in both neighborhoods, as well as not forgetting the impact of the weather on residents' walkability.

Utilitarian destinations should also be established close to people's homes, and a potential workplace should also be designed close to a certain threshold of the population in neighborhoods. As a result, and in general, the findings of the study point to the necessity for planners to encourage walking as a mode of transportation by putting an emphasis on the creation of functional mixed-land uses. In other words, planners need to encourage walking as a mode of transportation. It is important that the placement of utilities be close to where people live so that it is convenient for them to walk there. In contrast to traditional stereotypes, which are based on assumptions made in the absence of statistical backing and input from the public, urban planners should take into account a variety of factors that explain the walkability of certain places that are specific to that design. Because these designs may influence people's decisions about whether or not to walk to a walking destination, improving the aesthetics of a neighborhood is also an essential factor in making walking more pleasurable, creating a sense of safety in a neighborhood, and possibly increasing the amount of walking done for recreational purposes. Ensure that pedestrians traveling to destinations such as stores, local services, schools, mosques, or churches have access to paths that are both expedient and safe. The availability of sidewalks, tree cover, and other forms of urban form characteristics must present a warning or danger signal for pedestrian activity. This is true even when conditions vary slightly from neighborhood to neighborhood. Street crossings should be the major attention of designers because they frequently act as the final physical and psychological walking barrier and cause trip delays for pedestrians. In addition, street crossings should be designed so that they are accessible to those with disabilities.

However, since none of those mentioned above are legally enforceable, the state and municipal authorities must incorporate these activities into the legal system to give them teeth. For instance, walking plans should be created to address a more walkable city's environmental, social, and health advantages. In addition, it is a good idea to take into consideration the Transport Action Plan for Transport and Public Health Policy, which utilizes a "whole street approach" that is founded on Healthy Street Indicators in order to make streets that are more conducive to walking.

This plan was developed in order to make streets more pleasant for walking. This approach should take four important actions into consideration: designing and planning for walking, integrating walking with public transit, developing a culture that is open to change, and creating pedestrian-friendly streets and managing them. In addition, it ought to strengthen the political will to put this idea into action by establishing a special task force to maximize a multimodal transportation system, coordinating shared services between public transportation and various forms of transportation, and encouraging active travel. These are all things that should be done.

6. CONCLUSION

With other forms of pedestrian activity, walking has become a worldwide and multi-disciplinary challenge for governments. However, one's mental fortitude is just as important as one's physical abilities regarding walking.

The results show that walkers place convenience above all other pedestrian environment factors when choosing a route to a walkable destination. It was also discovered that the route's central infrastructure development offers safe, direct links to well-known landmarks.

During the design process, it was important to consider the interplay between walkability, neighborhood connectivity, land use planning, and social accessibility. Each proposed move to increase walkability should have some legal underpinning, as was emphasized repeatedly. Putting a transportation action plan into motion could be one option for achieving this objective.

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