

# Walking in the City: Using Machine Learning Algorithms to Evaluate Walkability in Public Open Space of Shiraz City\*

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## ABSTRACT

Many researchers have examined the urban structure to enhance social activities and walking to increase urban vitality and interactions. Hence, it is essential to consider those structures that increase the walking rate in public spaces of the city on the one hand, and enhance walking duration in the public space on the other hand, because it leads to a higher quality of life and health of citizens. The complicated nature of development and city structure patterns require use paying attention to various aspects to find the factors affecting the increase in citizen walking in various urban structures. Hence, the research method of this study uses questionnaires and machine learning through regression techniques. Machine learning technique allows researchers to investigate complex relationships between various variables. The purpose of this study is to examine the overt and covert relationships between various environmental factors affecting the citizens' walking in Shiraz Metropolis. The results indicate that the five factors have the highest effect on walking in urban spaces: individual privacy, improved access to public spaces, a public space free of garbage, high-quality architecture and connection between various elements, and enough opportunity for the movement of pedestrians. Surveillance factors such as police presence, more attention to the safety and security of individuals, and CCTV systems have the lowest effect. In general, these 16 factors affecting walkability help to predict the highest walking time in the day with approximately 92%. Urban planners, designers, and managers can use the results of this study to increase urban vitality and activities, especially walking.

**Keywords:** Machine Learning, Regression, Walkability, Public Open Space, Shiraz City.

\* This paper is derived from a Ph.D. The thesis by the first author titled "Determining the Spatial Structure of the Indigenous Pattern of Walkable Shiraz City Based on Space Syntax Approach" guided by the second author and advised by the third author in the Islamic Azad University of Isfahan (Khorasgan) Branch in 2022.

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## 1. INTRODUCTION

Sidewalks can be introduced as the factors that contribute to urban sustainable development. In terms of physical-functional values, sidewalks are important elements in attracting Iranian and foreign tourists (Pourahmad et al. 2012).

Too much attention to riding movement needs, lack of favorable spaces for pedestrians, and existing low-quality spaces have removed walking citizens from urban spaces. Such removal leads to the absence of vitality and happiness in the urban image due to non-attendance and a sense of belonging among citizens, which subsequently leads to lower public participation and security. Therefore, the importance of pedestrians and the customization of the urban environment for their presence in urban spaces are undeniable issues. This study aims to consider various walkability dimensions in the city and increased time and frequency of walkability to increase society's health and reduce environmental pollution (noise and air pollution) caused by automobiles. In this study, the researcher tends to answer this question: which factors can be used to increase the duration and frequency of walkability among various individuals of society in Shiraz?

## 2. BACKGROUND AND THEORETICAL FOUNDATIONS

### 2.1. Walkability in the City

The term "walkability" has been widely used in economic, social, and sustainable city studies. Most studies have focused on the walkable spaces in the urban open environment. Moreover, walkable places provide citizens with features required for vitality in urban centers. In terms of transportation, walking is the most stable transportation technique with the lowest effect on the environment (Frank et al. 2005; Abley and Turner 2011). However, there is no secure infrastructure for non-motorized transportation such as biking and walking, accessible and cost-effective public transportation service in most cities of developing countries (Moura, Cambra, and Gonçalves 2017). The concept of walkable open space is not in line with urban planning interests that do not pay attention to walking beyond the basic pedestrian paths. On the contrary, many authors take into account pedestrians as a goal for all urban open spaces (green spaces, public squares or courtyards, walkable passersby, and streets). People walk for different reasons, such as short movement, shopping, and going to work or school (Schmeidler 2008). According to national estimates in the US, almost 42% of adults walk during their leisure time, and 28% regularly walk for 10min regarding transportation goals (Kruger et al. 2008).

Urban planning researchers rarely paid attention to users' trips as an important research topic. However,

assessment of data related to the safety of pedestrians and accident prevention has led to considerable information in this field (Mayr et al. 2003), but limited information exists about this subject. Hence, the most important point is what encourages citizens to walk.

On the other hand, objective studies have used the measured objective data to measure walking mentally and qualitatively based on the relevant factors or variables constructed for the walking (Khatami et al. 2022). Liman defined walking as "the quality of walking conditions, including some factors such as walking facilities, safety, comfort, and convenience of walking" (Litman 2003). In contrast, Adam argued that this definition has not specified the tangible and intangible factors of walkability (Asam 2014). Therefore, this question is designed: which subjective variables must be considered in the evaluation of walking?

Pikora and colleagues concluded that the audit method highlights the topics that are important in the walking related to destinations' presentation order, personal safety, and attractive spaces (Pikora et al. 2002). The hierarchy of walking needs by Alfonzo is another measurement model that determines the relative importance of walking factors (Fig. 1.) (Alfonzo 2005). This model explains that walking decisions are related to the extent to which public open space can satisfy the users' needs. The most underlying factors in this case include feasibility followed by accessibility, comfort, safety, and pleasure (based on the importance rate order).

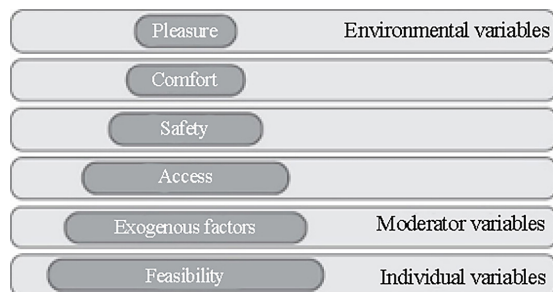


Fig. 1. Walking Behavior Hierarchy (Badland et al. 2010)

This model depicts that users walk longer when more needs are satisfied. Some needs may be more outstanding on the walking reason. For instance, pleasure may play a more important role in recreational walking decisions rather than walking in distance for transportation. The potential of various environmental features for various walking behaviors has been reflected in the model. Yung et al. agreed that the perception of the walking environment is affected by the physical specifications of walking, and this perception determines the overall walking behavior. They identified these factors classified into eight groups, including imageability, legibility,

human scale, transparency, connectivity, complexity, and cohesion (Yung, Conejos, and Chan 2016). They suggested understanding the walking phenomenon by using objective or subjective criteria. Mehta integrated the perceptual factors of the conceptual model with an ecological model of walking behavior, which has synthesized the walking needs hierarchy of Alfonzo to create a holistic and comprehensive model for Main Street (Mehta 2008).

### 2.2. Factors Affecting Walking

Various studies have shown that mixed land use would usually increase walking in public open spaces. For example, a comprehensive study conducted on walking and built environment by Silenz and Handi (2008) that indicated overlapping criteria of different land uses, distances between walkable destinations, and land use composition would affect walking (Aghajani and Pendar 2021). Forsyth et al. (2007) studied the overwalking criterion and concluded that only the social land use (e.g., for shopping centers and parks) is correlated with higher walking. Moreover, four key features can be identified in public open space: access and connections, comfort and image, uses and activities, and being social. Finally, it should be emphasized that high quality of design is not sufficient for creating walkable and livable spaces. It is important to provide physical, social, economic, and environmental solutions for the improvement of walkability and livability in the public open space (Forsyth et al. 2007). On the other hand, Mohamed (2013) argued that the lack of public open space in the main areas of the city would create a challenge for improvement (Mohamed 2013), while there is not enough land use for social activities in the cities of Shiraz. However, open space activities in Iran play a vital role in encouraging people to walk in the city center, so this case requires attention from managers, designers, researchers, and urban planners.

### 2.3. Evaluation of Walkability and Machine Learning

Many studies have been done on the use of machine learning in different scientific and industrial fields. These studies have examined the impact of various variables on the prediction of an objective function based on different methods (Affi et al. 2018; Valikhan Anarki et al. 2020). Various studies measure the quality of urban design related to walking using participatory techniques, such as field studies or surveys and questionnaires based on statistical methods. However, it is not easy to evaluate some factors, such as clean sidewalks, green streets, and safety perception due to the reliability and removal of some data. Therefore, new methods must be examined to fill the gap in which, quantitative empirical studies have developed systematic measurement tools to study walkability at street level. This study uses machine learning and its associated method to anticipate the factors affecting

the duration and frequency of walkability in different urban areas based on the factors affecting it.

### 3. MATERIALS AND METHODS

This study uses a hybrid method to measure various dimensions of walkability, discover the walkable spaces in Shiraz, and investigate the physical and psychological factors through a questionnaire. Finally, these factors are analyzed based on the new machine learning algorithms to assess the factors affecting the duration of stay in the space and frequency of coming to that space. In this study, 12 places were selected for field and questionnaire surveys through the observation method. The questionnaire was then distributed in the considered spaces to examine the factors affecting walking duration and frequency in a day. It is worth noting that only 360 questionnaires out of 420 distributed questionnaires were collected as reliable questionnaires, and the rest of them were deleted. This questionnaire has been examined based on the previous studies and opinions of relevant experts to confirm its validity and reliability. After the considered factors are obtained in the next phase of the study based on Fig 2., the variables affecting the objective functions of the study are then examined. It means that the effective and restrictive factors of study that are related to the topic are kept and the rest factors are deleted. The case study of the site is then introduced using the observation method, and the places in which variables must be examined are taken into account. The artificial intelligence (AI) network is then used to predict the duration of visiting places and the frequency of visits.

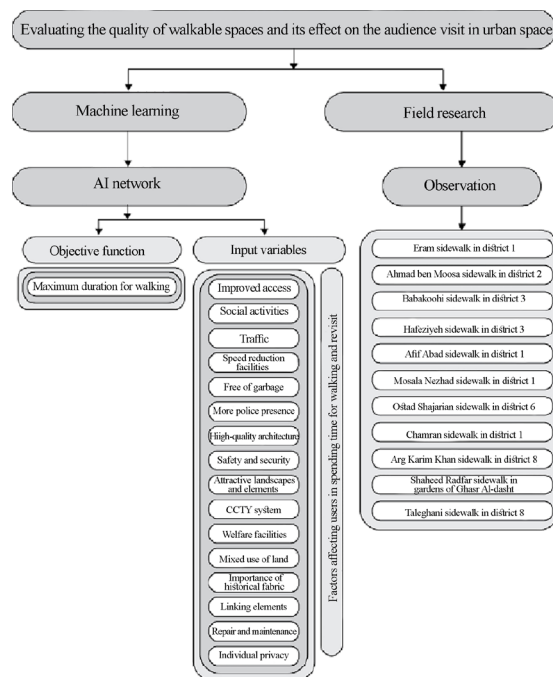


Fig. 2. Framework of Study for Predicting duration of Presence in the Space based on the Effective and Restrictive Factors

### 3.1. Studied Area

Assessment of walkability structures and their effects on the mind and psyche of people requires enough knowledge about walkable environments and spaces, which is obtained through observation. This study focuses on Shiraz as one of the largest metropolises in Iran.

A holistic study of the target society is impossible in significant survey research; therefore, a representative sample must be employed.

Studies can use more accurate statistical solutions, such as a sample size guide based on the confidence level of 95% so that no difference more than  $\pm 5$  is seen in 95 cases out of 100 survey iterations (Saunders et al. 2009).

In total, 520 questionnaires were distributed to users within four studied scopes (130 questionnaires for each field), and reliable responses were collected, with confidence is about 80%. This study accepted the recommendation of Payne and McMorris (1975) that consider a sample size of 479 adequate for the required accuracy and reliability of populations larger than 100000 (Payne 1967).

### 3.2. Observation

The qualitative observation method was the first

instrument used for data collection in the field study. Observation was done by spending 30 minutes on 20 selected case studies.

In this study, observation was done in 11 districts of Shiraz. The boundaries of each case study are defined clearly by the streets or surrounding buildings. These cases comprise all types of walkable public spaces. Machine learning methods that can be used in predicting the objective function of this study must be examined after the field survey.

### 3.3. Designing Questionnaire

Data collection in this study is done through questionnaire distribution and field surveys. For this purpose, a questionnaire was designed to examine effective factors based on Table 1. The researcher-made questionnaire was prepared for these factors using the studies conducted on walkability and walking duration. The opinions of experts and scholars were used to confirm the validity of questions, 16 questionnaires were distributed and Cronbach's alpha was determined for reliability of them.

**Table 1. Classifying Items of the Questionnaire based on the Dimensions Affecting the Walking Duration**

Q.	Specification	References
Q1	Maximum Walking Duration	(McPoil and Cornwall 1996; Bruijn et al. 2009; Suzuki et al. 1990)
Q2	Improved Access to Public Spaces	(Nicholson et al. 2006; Abbott and Detheridge 2009)
Q3	Social Activities	(Carrasco and Miller 2006; Kelly et al. 2017; Huang et al. 2022)
Q4	Preventing Traffic in the City Center	(Cohen and Dalyot 2020; Jacobsen, Racioppi, and Rutter 2009)
Q5	Having Facilities for Crossing Streets and Reducing Traffic Speed	(Gitelman et al. 2012; Huang and Cynecki 2000; Pau and Angius 2001)
Q6	Fre of Garbage	(Fantozzi et al. 2020; Hollman et al. 2007)
Q7	More Police Presence	(Arellana et al. 2020; Lee and Contreras 2021)
Q8	High-Quality Architecture	(Refaat and Kafafy 2014; Al-Hagla 2009)
Q9	Greater attention to the Personal Safety and Security of Individuals	(Foster and Giles-Corti 2008; Jiang et al. 2018)
Q10	Having Attractive Landscapes and Elements and Soft Landscaping	(Sarimin and Ibrahim 2018)
Q11	CCTV System	(Shach-Pinsly and Ganor 2021)
Q12	Welfare and Comfortable Facilities such as Public WCs	(Xia, Li, and Chen 2018; Khan 2020)
Q13	Creating more Business Activities and mixed-Use	(Zagow 2022; Jamal et al. 2017; Cannon et al. 2013)
Q14	Individual Privacy	(Hernández et al. 2019)
Q15	Importance of Historical Fabric	(Caselli et al. 2021; Mansouri and Ujang 2017)

Q.	Specification	References
Q16	Linking Different Elements and Enough Opportunity for Pedestrians' Movement	(Shay et al. 2003)
Q17	Periodic Repair and Maintenance of Buildings and Streets	(Thabet 2021; Zuniga-Teran et al. 2017)

## 4. DISCUSSION AND RESULTS

### 4.1. Results of Observation

The field observation method was used in this study to examine spaces with high walkability in Shiraz City. The researcher who has lived many years in this city has conducted an environmental assessment without any predetermined interferences. These spaces include the Ahmad ben Moosa sidewalk in District

2, Arg Karim Khan sidewalk in District 8, Afif Abad sidewalk in District 1, Ostad Shajarian sidewalk in District 6, Babakoochi sidewalk in district 3, Mosala Nezhad sidewalk in district 1, Taleghani sidewalk in district 8, Hafeziyeh sidewalk in district 3, Chamran sidewalk in district 1, Eram sidewalk in district 1, and Shaheed Radfar sidewalk in garden fabric of Ghasr Al-Dasht in district 6. This sidewalk and its location have been depicted in Fig 3.

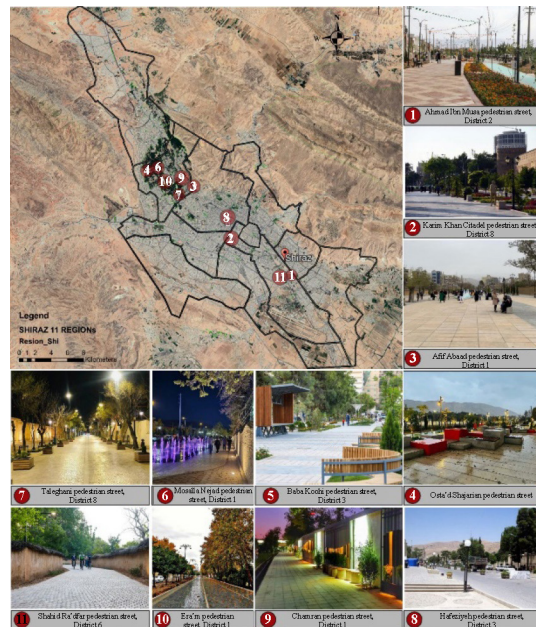


Fig. 3. Eleven Districts with High Walkability in Shiraz City

### 4.2. Results of Regression Analysis

Analysis of the main component was selected due to its common application for extracting a factor from social data. The main component has been analyzed in this study as a ranking method for reducing the dimensions of datasets. This makes it possible to compare studied fields by creating key explanatory keys. Three tests were used to assess data suitability

before using factor analysis. Also, Cronbach's alpha coefficient ( $\alpha$ ) was used to test the reliability of research variables. In addition to sample size and number of variables, correlation of some variables is necessary. Regression analysis is not suitable when there is a low correlation between variables. In this study, Cronbach's alpha coefficient greater than 0.5 would be the proper coefficient in regression analysis.

Table 2. Correlation between Variables

	Duration	Access	Public Open Space	Traffic	Speed Reduction	Clean Space	Police Surveillance	High-Quality Architecture	Security	Attractive Landscapes	CCTV System	Welfare Facilities	Business Activities	Privacy	Historical Places	Connecting Elements	Protection
Duration	1.0	0.7	0.5	0.4	0.6	0.6	0.4	0.7	0.5	0.5	0.4	0.7	0.6	0.6	0.5	0.7	0.6
Access	0.7	1.0	0.6	0.3	0.6	0.6	0.2	0.7	0.5	0.5	0.3	0.5	0.4	0.6	0.3	0.6	0.6
Public Open Space	0.5	0.6	1.0	0.5	0.7	0.4	0.5	0.6	0.3	0.3	0.3	0.5	0.3	0.4	0.1	0.4	0.4
Traffic	0.4	0.3	0.5	1.0	0.6	0.3	0.4	0.3	0.2	0.3	0.5	0.4	0.3	0.2	0.2	0.2	0.2
Speed Reduction	0.6	0.6	0.7	0.6	1.0	0.6	0.6	0.7	0.4	0.4	0.4	0.6	0.4	0.4	0.3	0.6	0.5
Clean Space	0.6	0.6	0.4	0.3	0.6	1.0	0.4	0.8	0.6	0.4	0.3	0.5	0.4	0.5	0.5	0.7	0.7
Police Surveillance	0.4	0.2	0.5	0.4	0.6	0.4	1.0	0.4	0.2	0.3	0.5	0.4	0.4	0.2	0.4	0.1	0.2
High-Quality Architecture	0.7	0.7	0.6	0.3	0.7	0.8	0.4	1.0	0.6	0.4	0.3	0.5	0.5	0.5	0.5	0.7	0.7
Security	0.5	0.5	0.3	0.2	0.4	0.6	0.2	0.6	1.0	0.3	0.1	0.3	0.4	0.4	0.3	0.6	0.6
Attractive Landscapes	0.5	0.5	0.3	0.3	0.4	0.4	0.3	0.4	0.3	1.0	0.4	0.5	0.3	0.5	0.3	0.4	0.3
CCTV System	0.4	0.3	0.3	0.5	0.4	0.3	0.5	0.3	0.1	0.4	1.0	0.6	0.5	0.3	0.5	0.2	0.2
Welfare Facilities	0.7	0.5	0.5	0.4	0.6	0.5	0.4	0.5	0.3	0.5	0.6	1.0	0.5	0.5	0.4	0.5	0.5
Business Activities	0.6	0.4	0.3	0.3	0.4	0.4	0.4	0.5	0.4	0.3	0.5	0.5	1.0	0.5	0.6	0.4	0.4
Privacy	0.6	0.6	0.4	0.2	0.4	0.5	0.2	0.5	0.4	0.5	0.3	0.5	0.5	1.0	0.4	0.7	0.6
Historical Places	0.5	0.3	0.1	0.2	0.3	0.5	0.4	0.5	0.3	0.3	0.5	0.4	0.6	0.4	1.0	0.4	0.4
Connecting Elements	0.7	0.6	0.4	0.2	0.6	0.7	0.1	0.7	0.6	0.4	0.2	0.5	0.4	0.7	0.4	1.0	0.8
Protection	0.6	0.6	0.4	0.2	0.5	0.7	0.2	0.7	0.6	0.3	0.2	0.5	0.4	0.6	0.4	0.8	1.0

Table 2 indicates the rate of correlation between variables. The highest correlation rate exists between each variable and itself, shown with 1 indicating diagonal values of Table 4. The important point is seen in the correlation between variables and objective function, shown by How-Long in the table.

On the other hand, the regression is more suitable for prediction when there is less relationship between independent variables. On the other hand, a strong correlation must exist between the independent variables (that include 16 variables) and the dependent variable.

Table 3. General Dimensions of Variables Regarding the Answers given by Different Groups

	Duration	Access	Public Open Space	Traffic	Speed Reduction	Clean Space	Police Surveillance	High-Quality Architecture	Security	Attractive Landscapes	CCTV System	Welfare Facilities	Business Activities	Privacy	Historical Places	Connecting Elements	Protection
N	479	479	479	479	479	479	479	479	479	479	479	479	479	479	479	479	479
Mean	68	3.6	3.7	3.9	3.9	3.8	3.9	3.9	4.2	4.1	3.7	4.0	3.6	3.9	3.4	3.5	3.7
std	33	1.3	1.2	1.2	1.1	1.3	1.1	1.3	1.2	0.9	1.3	1.2	1.2	0.9	1.3	1.2	1.3
Min	10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	Duration	Access	Public Open Space	Traffic	Speed Reduction	Clean Space	Police Surveillance	High-Quality Architecture	Security	Attractive Landscapes	CCTV System	Welfare Facilities	Business Activities	Privacy	Historical Places	Connecting Elements	Protection
25%	40	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3
50%	60	4	4	4	4	4	4	4	5	4	4	4	4	4	3	3	4
75%	100	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Max	120	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Since 479 members gave accurate and acceptable answers to the questions and data dispersion is an important variable considering whether they are distributed around the mean value, the std value must be measured. According to data from Table 3, the higher standard deviation of independent

variables of study equals 1. Therefore, more data are close to the mean value of research. According to the upper quartiles and most data of the study, these data strongly agree that the considered factors affect walkability.

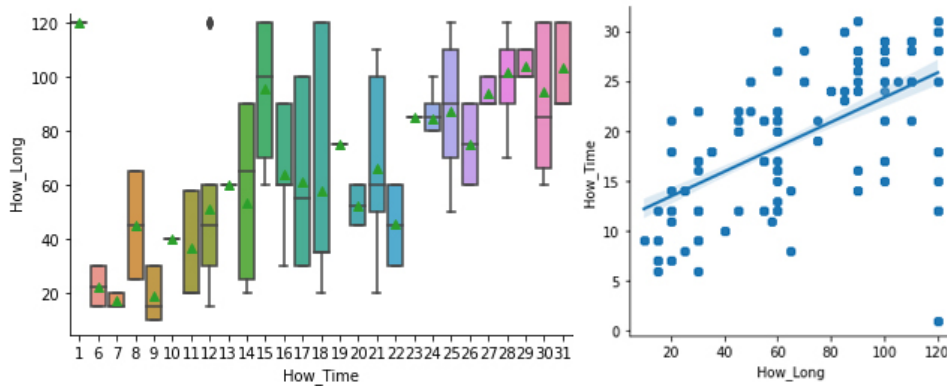


Fig. 4. The Relationship between Walking Duration in the Day and Walking Frequency in the Month

According to Fig 4, most individuals walk more at the end of the month between the 25th and 30th,

while walking hours vary between 25 minutes and 120 minutes in the middle of the month.

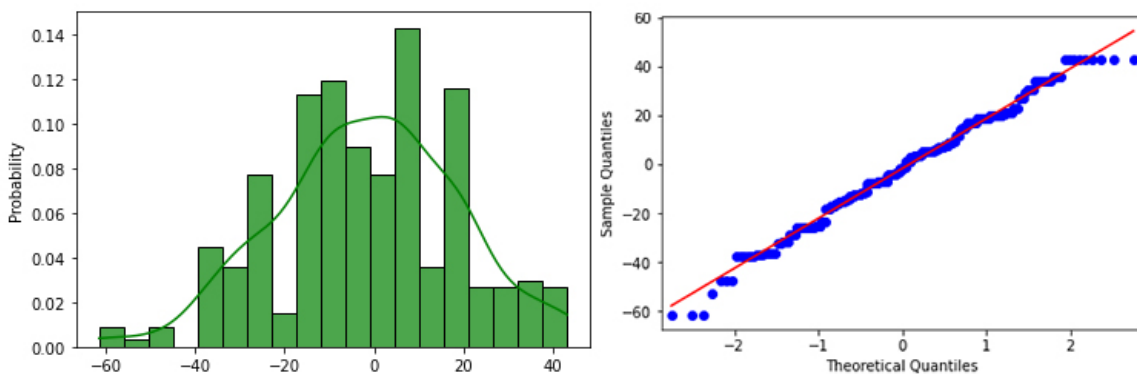


Fig. 5. Histogram Graph of Residuals and Dispersion

Fig 5 depicts the residual data and data normality in two histogram and data dispersion graphs. The closer the distribution of residuals to normal distribution, the more fit the model will be. Following these two

graphs, it is anticipated that data have a distribution that is highly close to normal distribution, so the predicted and real values are close to each other.

**Table 4. OLS Regression Analysis**

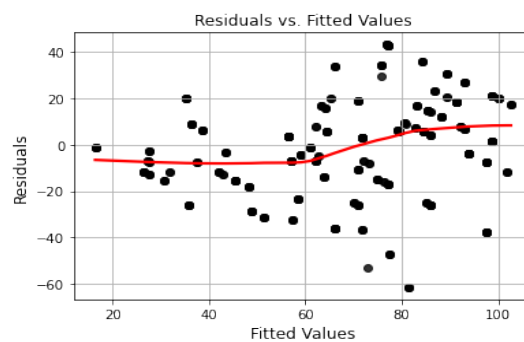
OLS Regression Results						
Dep. Variable	How_Long	R-squared (Uncentered)			0.926	
Model	OLS	Adj. R-squared (Uncentered)			0.922	
Method	Least Squares	F-statistic			248.2	
Date	Sun, 21 Aug 2022	Prob (F-statistic)			3.32e-169	
Time	13:12:07	Log-Likelihood			-1486.6	
No. Observations	335	AIC			3005.	
Df Residuals	319	BIC			3066.	
Df Model	16					
Variable	coef	std err	t	P> t	[0.025	0.975]
Access	7.5687	1.537	4.924	0	4.545	10.593
Public Open Space	-0.0748	1.6	-0.047	0.963	-3.223	3.073
Traffic	1.8633	1.344	1.386	0.167	-0.782	4.508
Speed Reduction	-2.3133	2.022	-1.144	0.253	-6.291	1.664
Clean Space	1.4748	2.047	0.721	0.472	-2.552	5.502
Police Surveillance	-1.0058	1.514	-0.665	0.507	-3.984	1.972
High-Quality Architecture	-0.013	2.146	-0.006	0.995	-4.236	4.21
Security	-2.5579	1.307	-1.957	0.051	-5.13	0.014
Attractive Landscape	-0.5252	1.517	-0.346	0.729	-3.51	2.46
CCTV Systems	-0.8742	1.334	-0.655	0.513	-3.499	1.751
Welfare Facilities	5.7111	1.501	3.805	0	2.758	8.664
Business Activities	2.4759	1.391	1.78	0.076	-0.26	5.212
Privacy	-3.853	2.022	-1.906	0.058	-7.831	0.125
Historical Spaces	4.4183	1.254	3.523	0	1.951	6.886
Connecting Spaces	7.2509	1.88	3.858	0	3.553	10.949
Protection	0.2109	1.685	0.125	0.9	-3.103	3.525
Omnibus	1.408	Durbin-Watson:		1.972		
Prob (Omnibus)	0.495	Jarque-Bera (JB):		1.407		
Skew	-0.156	Prob(JB):		0.495		
Kurtosis	2.945	Cond. No.		37		

[1] R2 is measured without centrality because the model does not have a single constant

[2] standard errors assume that the covariance matrix of errors has been determined accurately.

Table 4 indicates the OLS (Ordinary least squares) analysis of two important parts of R-squared and Adj. R-squared that shows the data prediction based on the regression formula. According to this table, R-squared equals 92%. For instance, the standard error of access

and public open space in the regression model equals 7.5687 and -0.0748, respectively. Therefore, the model can predict access with higher accuracy rather than public open space.



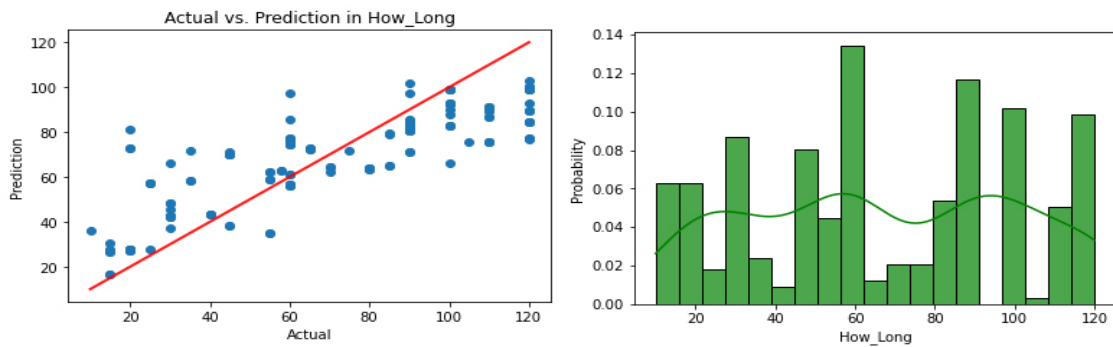
**Fig. 6. Dispersion of Residuals vs. Fitted Values**

**Table 5. The Sum of Squared Errors in the LM Test Method**

	The Mean Value of Outliers	Med	SD	Dispersion of Outliers	Minimum Outlier	Maximum Outlier
LM_t-test	16.285599	14.77566	12.14072	14.56009	0.935539	61.46017

According to the final graphs depicted in Fig 6, residuals vs. fitted data have been almost linearly distributed around the red line. As shown in this figure and data reported in Table 5, the objective function can be predicted around the axis with a relatively low error. However, the author emphasizes that research variables and their effect on the walkability

in the urban fabric is a complicated case that requires multidimensional and psychological investigations. Fig 7 depicts the predicted and actual data. According to this figure, a linear relationship exists between objective function prediction in this study that is walkability duration regarding its effective factor and its actual value.



**Fig. 7. Assessment of Predicted and Actual Data**

## 5. CONCLUSION AND RECOMMENDATIONS

According to the factors affecting walkability, among the research factors, 16 factors have significant effects on walkability but are not sufficient for increasing the walking duration for different goals by citizens. Hence, the productivity of some factors must be increased in the city to enhance the walkability duration.

According to the factors affecting walkability, individual privacy, improved access to public spaces, free of garbage, high-quality architecture and connection between various elements, and enough opportunity for pedestrians' movement have the highest effect on increasing walkability. Therefore, open urban spaces can be converted into walkable spaces by improving these elements. In the next step, the qualitative spatial and identity dimensions must

be considered. Some of these factors include paying attention to historical fabric, periodic repair and maintenance of buildings and streets, having attractive landscapes and elements and soft landscaping, creating more business activities, creating mixed function, and finally having the facilities for crossing through streets and reducing traffic speed in these fabrics.

In general, research results show that the factors affecting walkability can be used to increase the average walking duration of each person in the urban space. On the other hand, further studies must be conducted on walkability due to the complex nature of humans in the urban space and the effect of the environment on the citizens' behaviors. Other researchers must develop more studies focusing on urban structures and behavioral simulations.

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### **CONFLICT OF INTEREST**

The authors have no conflicts of interest to declare.

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The authors state that they have directly participated in the stages of conducting research and writing the article.

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