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KEY FACTORS IN DEVELOPING TOURIST PEDESTRIAN ROUTES IN THE HISTORICAL CITY OF KHIVA

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Abstract

Optimizing pedestrian routes in historical cities is crucial for balancing heritage preservation and tourism accessibility. Despite growing interest in structured tourist pedestrian routes (TPRs), studies on pedestrian movement in heritage sites often lack quantitative analysis of efficiency and infrastructure deficiencies. This study addresses these gaps by analysing pedestrian flow dynamics in Khiva's historic centre using field observations, pedestrian flow modelling, and regression analysis. Results indicate that inadequate infrastructure, unprotected walkways, and insufficient safety measures hinder movement efficiency, especially at key intersections during peak evening hours. Regression analysis demonstrates that increased pedestrian density reduces mobility, emphasizing the need for simulation-based planning. Findings highlight the complexity of pedestrian behaviour and the importance of strategic urban design. This study provides recommendations for designated pedestrian corridors, improved safety features, and inclusive infrastructure, contributing to sustainable urban planning and tourism management while preserving cultural heritage in Uzbekistan's historical cities.

Keywords: Tourist Pedestrian Routes (TPR), urban planning, pedestrian flow modelling, historical city infrastructure, sustainable tourism development

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INTRODUCTION

Uzbekistan has prioritized the development of its tourism sector through a series of national policies and strategic frameworks. The Decree of the President of the Republic of Uzbekistan No. PF-5781 (2019) and the Resolution No. PQ-4755 (2020) emphasizes the expansion of tourism infrastructure while ensuring compliance with safety regulations (Kakhkharov et al., 2020). Additionally, the Central Asia Regional Economic Cooperation (CAREC) Tourism Strategy 2030 outlines long-term goals to position the region as a prominent tourism destination (*CAREC Tourism Strategy 2030*, 2020). Despite significant investments in Uzbekistan's tourism industry, research on optimizing pedestrian routes in historical cities remains limited (Dai et al., 2024). While cities like Samarkand and Bukhara have established tourist pedestrian routes (TPRs) 4, Khiva's unique urban fabric presents distinct challenges, including narrow streets, congestion hotspots, and inadequate pedestrian infrastructure. Islamic art and architecture, with their intricate geometric patterns and calligraphic inscriptions, play a vital role in defining the cultural and aesthetic identity of these historical cities, making their preservation crucial for both heritage conservation and tourism development (Baydoun et al., 2023, 2024; Dariyadi et al., 2022). Existing studies focus broadly on tourism development but lack detailed investigations into how pedestrian movement efficiency is affected by urban design constraints in historical areas (Baydoun et al., 2025). Addressing these gaps is essential for ensuring sustainable and accessible tourism experiences in Khiva (Jamshid, 2024). This study aims to analyse the key factors influencing the pedestrian movement in Khiva's historic centre, particularly within Ichan Qala. By employing field observations, pedestrian flow modelling, and regression analysis, the findings from this study will support policymakers in implementing evidence-based improvements for sustainable tourism management in Uzbekistan's historical cities. Previous studies on pedestrian flow in heritage cities have employed diverse methods, such as social force modelling (Helbing & Molnár, 1995), agent-based simulations (Johansson, 2009), and case studies in Asian heritage towns (Chen, Dong, & Zheng, 2018). Referring to these approaches strengthens the methodological basis for the present study.

METHODOLOGY

This study employs a mixed-methods approach, combining qualitative and quantitative techniques to analyse pedestrian movement efficiency in Khiva's historical centre. The research integrates a literature review, field observations, mathematical statistics, and correlation regression analysis to assess key factors influencing pedestrian mobility.

Data Collection

Pedestrian movement in Ichan Qala was tracked via visual observation and video analysis at six high-traffic intersections over three weeks. Footage provided data on density, speed, and movement, validated by manual counts at peak and off-peak hours.

Regression Analysis

A correlation regression analysis was performed to examine the relationship between pedestrian density and walking speed. The regression model considered variables such as time of day, infrastructure quality (e.g., sidewalk width, surface conditions), and pedestrian density per square meter. This approach allowed for a comprehensive assessment of how spatial and environmental factors influence pedestrian flow within Ichan Qala.

Sample Selection Rationale

The study focused on high-traffic pedestrian zones in Ichan Qala, where movement bottlenecks and congestion are most evident. Site selection was based on historical significance, tourist footfall, and accessibility challenges. The chosen intersections include entry and exit points, key tourist attractions, and commercial zones to ensure a representative analysis of pedestrian mobility patterns.

Tourist Movement and activities

Survey data links pedestrian behavior to tourism trends. In Uzbekistan, 57.2% of tourists travel in groups, with higher rates among North American (85.0%), Asia-Pacific (81.0%), European (78.1%), and Middle Eastern (72.0%) visitors. Solo travel is more common among Central Asian (50.5%) and CIS (46.0%) tourists. Popular activities include shopping, museums, walking tours, and historical excursions, with Central Asians favoring shopping (39.7%) and walking tours (31.9%), while Europeans prefer museums (77.5%), excursions (60.6%), and historical tours (54.1%).

Regional Distribution

Tashkent remains the most visited destination in Uzbekistan, with 58.0% of tourists reporting overnight stays. Other major destinations include Samarkand (31.0%) and Bukhara (25.6%), while Khiva accounts for 13.3% of tourist visits 888. By incorporating these methodological refinements, the study provides a structured and data-driven approach to understanding pedestrian movement in Khiva, ensuring greater clarity in data collection, analysis, and site selection.

TOURIST ROUTES IN UZBEKISTAN

Tourist routes in Tashkent city

Tashkent blends modern and historical attractions, with most tourist sites in the Old City, which preserves the city's cultural heritage amid urbanization (Doniyorov & Karimov, 2024). Visitors explore its traditional homes, mosques, markets, and Soviet-era landmarks like the Tashkent TV Tower and Independence Square. Tour agencies offer excursions from \$30 to \$200, with options ranging from bus tours to walking tours focused on the Old City, while the metro connects key sites.

Tourist routes in Samarkand city

Samarkand, a top tourist destination, boasts rich history, unique architecture, and a favorable climate (Khamroev, 2024). Its layout evolved through various eras, from lush gardens and canals in ancient times to Timurid grandeur and Russian-influenced planning. The city features a radial-circular street pattern, with Abromovsky Boulevard once marking the old-new city divide. Restoration efforts since 1918 preserve landmarks like Gur-e-Amir and Registan, with pedestrian routes enhancing visitor experiences (Sukma & Telaumbanua, 2024).

Tourist routes in Bukhara city

Bukhara's historic center, anchored by the Poi-Kalyan complex and Toqi Zargaron trading dome, preserves its cultural identity (Bolikulovich, 2021). The Ulughbek and Abdulazizkhan madrasahs stand to the east, while Lab-i Hauz, with its octagonal pool, reflects medieval planning. Once dense with caravanserais and trading hubs, the city's layout evolved within narrow streets and domed corridors, though demolitions have altered its cohesiveness. Each Uzbek city possesses a distinct urban style, historical landmarks, and planning principles (Yakhyayev et al., 2024). While similarities exist, a closer study reveals fundamental differences. Khiva, for instance, has its own unique characteristics but faces greater challenges due to its compact layout and extreme climate. This research, therefore, focuses on solutions and proposals tailored to Khiva's specific conditions. Compared to Samarkand and Bukhara, Khiva's compact urban form and narrow alleys increase congestion risks, making it more vulnerable during peak tourist hours. This contrast underscores the need for solutions tailored specifically to Khiva's unique morphology.

ORGANIZING TOURIST PEDESTRIAN ROUTES BASED ON THE HISTORICAL DEVELOPMENT MORPHOLOGY OF KHIVA CITY

Khiva, known for its ancient walls and minarets, was named the Tourism Capital of the Islamic World for 2024 (Kuldashev & Karimov, 2024). Archaeological studies since the mid-20th century have uncovered deep historical layers in Ichan Qala, the city's historic core. Khiva expanded significantly during the Khorezmshahs period (12th–13th centuries) and became the Khiva Khanate's capital by the 17th century (Nematov, 2024). The late 19th and early 20th centuries introduced modern infrastructure, contrasting with the unchanged historic quarters. The city's radial-ring layout evolved from fortress walls, with restoration efforts preserving its heritage. Today, Khiva remains a cultural hub, hosting major events and celebrations (Sartori & Sartori, 2021).

Analysis of Khiva City's Historical Tourism Routes and Existing Tourist Pedestrian Routes (TPR)

Khiva's tourism infrastructure lags behind Samarkand and Bukhara, highlighting the need for improved pedestrian routes. Ichan Qala, surrounded by historic landmarks, lacks well-organized pathways, with safety concerns from vehicular encroachment, poor surfaces, and high curbs (Niri, n.d.). Limited accessibility, visual clutter from stalls and signage, and disorganized landscaping further hinder the experience. Enhancing pedestrian infrastructure through strategic planning will improve walkability, accessibility, and tourism appeal while preserving Khiva's historical charm (Saltarin-Molino et al., 2023). Figure 1 shows a few Touristic pedestrian areas in Khiva.



Figure 1: Touristic pedestrian areas in Khiva

MODELING PEDESTRIAN MOVEMENT IN HISTORICAL TOURIST CENTERS

Field studies measured pedestrian movement around Ichan Qala to model flow patterns. Given the complexity of pedestrian behavior, modeling optimizes routes and movement. The Level of Service (LOS) framework, widely used in transportation engineering, evaluates infrastructure performance, including sidewalks, waiting areas, and stairways, based on comfort and efficiency criteria. The LOS methodology categorizes the pedestrian movement environment into three primary elements: sidewalks, waiting areas, and stairways. Each of these elements is assigned a specific level of service based on numerical criteria and calculation methods that define pedestrian comfort and safety. The fundamental relationships between pedestrian flow parameters within the LOS framework can be described mathematically as follows:

$$P = \frac{V}{M}$$

where: P = pedestrian movement intensity (persons/m*min),
 V = average pedestrian flow speed (m/min),
 M = dynamic space per pedestrian (m²/person).

Additionally, pedestrian movement intensity can be expressed in terms of pedestrian density:

$$P = V \times D$$

where: D = pedestrian density (persons/m²).

A key parameter for assessing pedestrian comfort is the dynamic space available per individual, which directly influences the degree of freedom in movement. Empirical studies suggest that pedestrians naturally maintain a clearance of approximately 0.4 meters from any contact element. Consequently, the effective width of a pedestrian pathway is typically 0.8 meters less than its total width. The optimal pedestrian flow capacity is estimated at 1.65 m² per person.

In Tourist Pedestrian Routes (TPRs), sufficient pedestrian space must be ensured to accommodate:

- Walking at a comfortable pace without obstruction,
- Seamless movement of individuals with limited mobility or strollers,
- The avoidance of collisions with oncoming pedestrians,
- A safe and secure walking environment.

When designing TPRs, it is critical to account for peak pedestrian flow periods. A 15-minute interval is recommended for determining maximum pedestrian density and flow rates. Since pedestrian movement varies based on demographic factors such as age, flow composition, and travel purpose, the "average speed" parameter is utilized, typically measured in meters per minute. Globally, free movement speeds on horizontal pathways and descending stairs range between 48 m/min and 155 m/min. Speeds below 48 m/min indicate restricted movement, while speeds above 155 m/min are characteristic of running conditions. Research indicates that pedestrian speeds between 90–155 m/min are typical during emergencies or peak congestion periods. For ascending staircases, movement speeds range from 12 to 80 m/min, with high-activity scenarios occurring at 50–80 m/min. For general pedestrian network planning, an average movement speed of 4.2 km/h (70 m/min) is recommended.

The experimental analysis was conducted using a predefined methodology to obtain precise pedestrian movement data. The required width of pedestrian walkways can be determined using the following formula:

$$B = \frac{b_1 N_f k}{P}$$

where:

B = required pedestrian walkway width (m),

b_1 = standard width of a single-lane pedestrian walkway (0.75 m),

N_f = intensity level of two-way pedestrian movement (persons/hour),

k = coefficient for projected changes in pedestrian intensity (derived from urban development analysis),

P = standard capacity of a single pedestrian movement lane (persons/hour).

The standard capacity of a single-lane pedestrian walkway varies based on its integration within the urban movement network and is given in Table 1. This study's findings contribute to a data-driven approach for optimizing pedestrian pathways in historical tourist centers, ensuring an efficient, accessible, and safe pedestrian environment within the Ichan Qala complex.

Table 1: The standard capacity of a single-lane pedestrian walkway

Elements of Pedestrian Communication Systems	The capacity of a single lane, persons/hour
If shops are located along the red lines	700
When separated from shops by green lines	700 - 800
Within green spaces	800 - 1000
Walking and pedestrian paths	600 - 700
Level intersections along the road	1200 - 1500

The authors propose a methodology for determining walkway widths to optimize pedestrian flow in urban planning. Using modelling techniques, the study analyses pedestrian movement in tourist areas, comparing empirical data with modelled flow. It assesses pedestrian conditions in historical centres, focusing on key sites in Khiva near essential services like hotels and restaurants. Additionally, the study considers existing tourist pedestrian pathways to ensure a comprehensive analysis as shown in Figure 2.

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 Key Factors in Developing Tourist Pedestrian Routes in The Historical City of Khiva

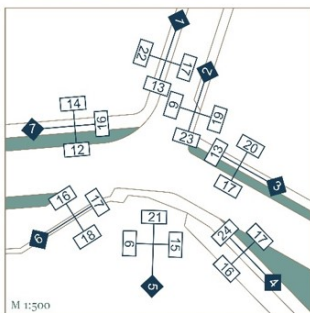


Figure 2: Points for Determining Pedestrian Movement Intensity

As of January 4, 2024, Khiva had 152 hotels (4,075 guests/day), with 440,300 foreign tourists in 2023, reflecting high pedestrian traffic. This study assesses pedestrian intensity, tourist dwell time, and accessibility to optimize walkways. Observations at six intersections found Mustaqillik and Zargarlar Streets busiest (468 pedestrians), with peak movement in the evening. Speed and density variations highlight the need for inclusive infrastructure. Figures 3–8 show pedestrian movement at key points. Figures 3, 4, 5, 6, 7, and 8 show the Pedestrian movement in point 1, 2, 3, 4, 5, and 6 respectively.

Unlike Samarkand and Bukhara, where broader streets reduce bottlenecks, Khiva's compact form amplifies congestion pressures during evening peaks.

Mustaqillik, Zargarlar va
R.Olloberganov street intersection



Direction	Pedestrian			Total
	Left	Straight	Right	
1	22	13	17	52
2	9	23	19	51
3	17	13	20	50
4	16	24	17	57
5	6	21	15	42
6	16	17	18	51
7	14	16	12	42

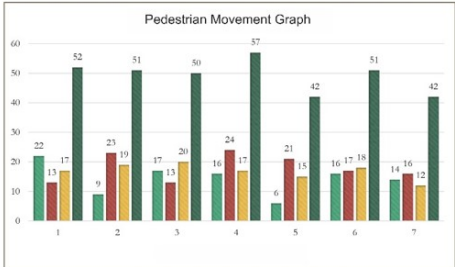
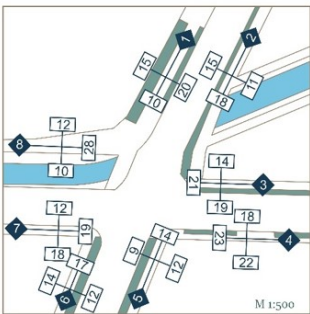


Figure 3: Pedestrian movement in point 1

Mustaqillik va Najmiddin Kubro
street intersection



Direction	Pedestrian			Total
	Left	Straight	Right	
1	15	10	20	45
2	15	18	11	44
3	14	21	19	54
4	18	23	22	63
5	12	14	9	35
6	14	17	12	43
7	12	19	18	49
8	12	28	10	50

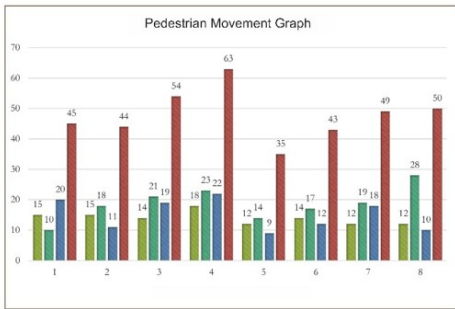
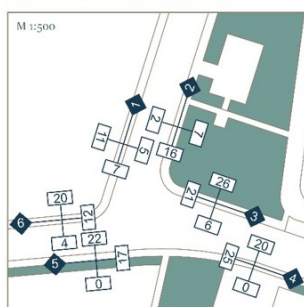


Figure 4: Pedestrian movement in points 2.

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Tinchlik and Qodir Yoqubov

Street intersection



Direction	Pedestrian			Total
	Left	Straight	Right	
1	11	7	5	23
2	2	16	7	25
3	6	21	26	53
4	0	25	20	45
5	22	17	0	39
6	20	12	4	36

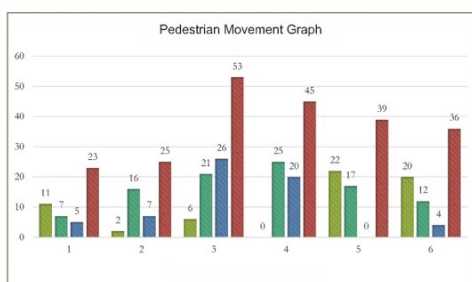
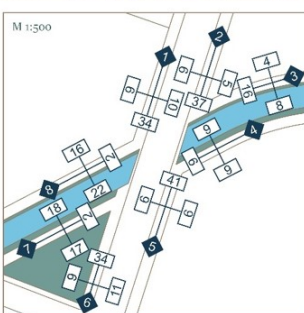


Figure 5: Pedestrian movement in point 3.

Zargarlik Street



Direction	Pedestrian			Total
	Left	Straight	Right	
1	10	34	6	50
2	5	37	6	48
3	8	16	4	28
4	9	6	9	24
5	6	41	6	53
6	9	34	11	54
7	18	2	17	37
8	22	2	16	40

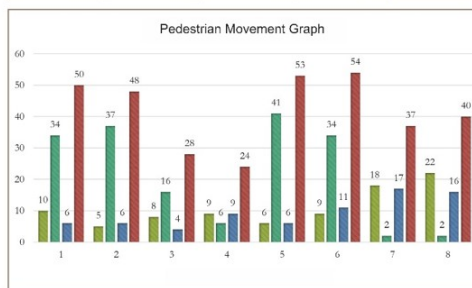
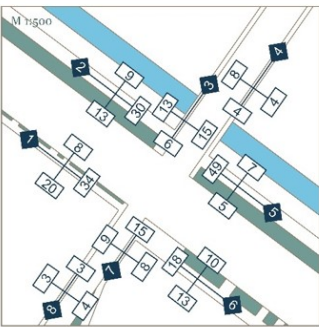


Figure 6: Pedestrian movement in point 4

Amir Temur and Feruz
Street intersection



Direction	Pedestrian			Total
	Left	Straight	Right	
1	8	34	20	62
2	9	30	13	52
3	15	6	13	34
4	4	4	8	16
5	5	49	7	61
6	13	18	10	41
7	9	15	8	32
8	3	3	4	10

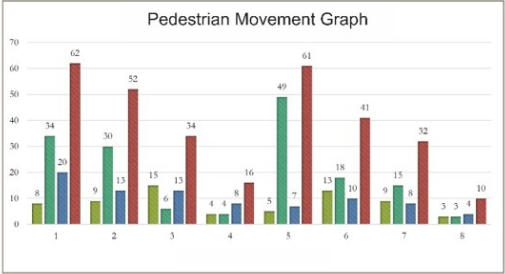


Figure 7: Pedestrian movement in point 5

Polvon Qori and Q. Otayev
Street intersection



Direction	Pedestrian			Total
	Left	Straight	Right	
1	8	34	20	62
2	13	20	14	47
3	15	36	11	62
4	24	30	16	70

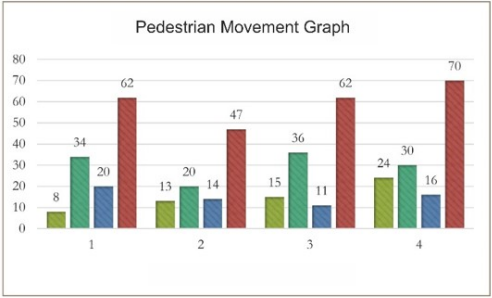


Figure 8: Pedestrian movement in point 6

The analysis of pedestrian movement in Khiva revealed distinct trends in age distribution across different times and locations as shown in Figures 9, 10, 11, 12, 13, and 14. Individuals aged 20–40 dominate pedestrian flow (32%–45%), followed by those aged 10–20 (27%–37%). Children under 10 and adults over 40 make up 10%–23%. These trends emphasize the need to tailor tourist pedestrian routes to younger and middle-aged visitors.

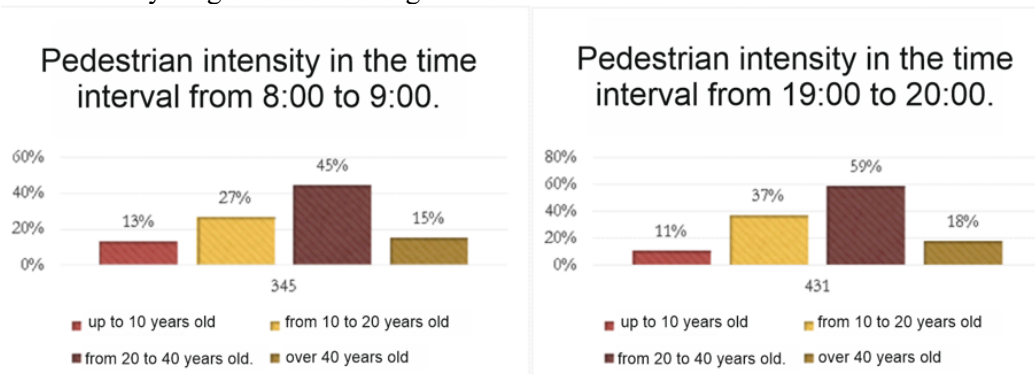


Figure 9: Pedestrian intensity at the intersection of Mustaqillik, Zargarlar, and R. Olloberganov streets



Figure 10: Pedestrian intensity at the intersection of Mustaqillik and Najmiddin Kubro streets

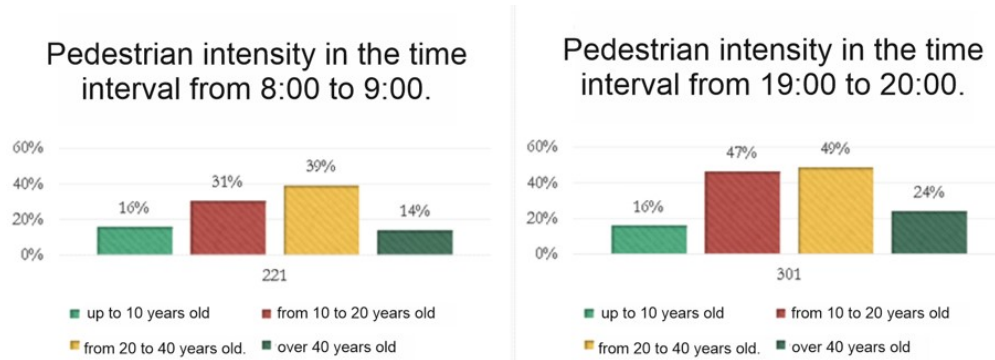


Figure 11: Pedestrian intensity at the intersection of Tinchlik and Qodir Yoqubov streets.



Figure 12: Pedestrian intensity on Zargarlik Street and the traffic section along the canal.

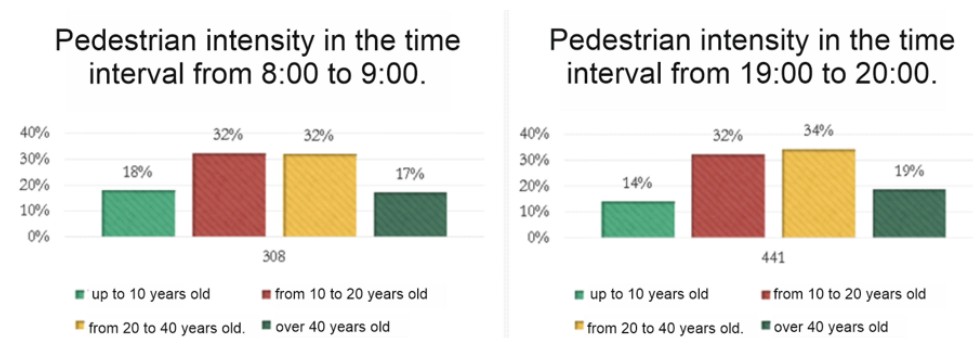


Figure 13: Pedestrian intensity at the intersection of Amir Temur and Feruz streets.

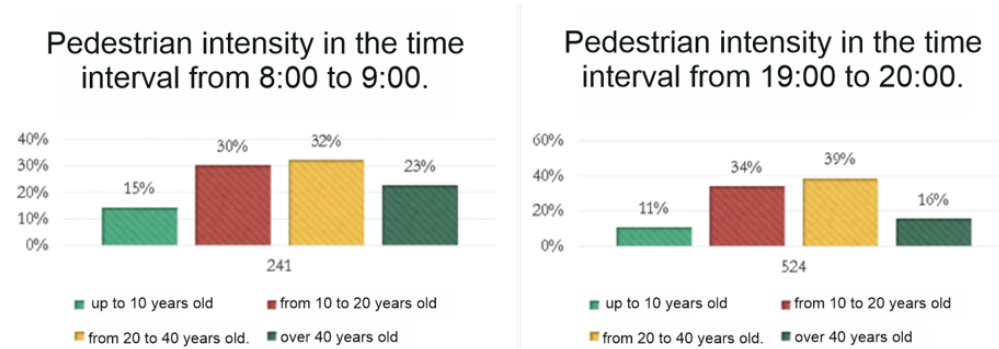


Figure 14: Pedestrian intensity at the intersection of Polvon Qori and Q. Otayev streets.

This study examined the movement patterns and composition of pedestrian flows across different age groups. Experimental findings indicate that individuals aged 20 to 40 comprised 39% of the total pedestrian flow as shown in Figure 15. The analysis also revealed that a pedestrian's free movement speed unimpeded by interactions with others follows a normal distribution and declines as flow intensity increases. Given that age significantly impacts walking speed, these findings provide a basis for future research on the relationship between pedestrian density and movement dynamics.

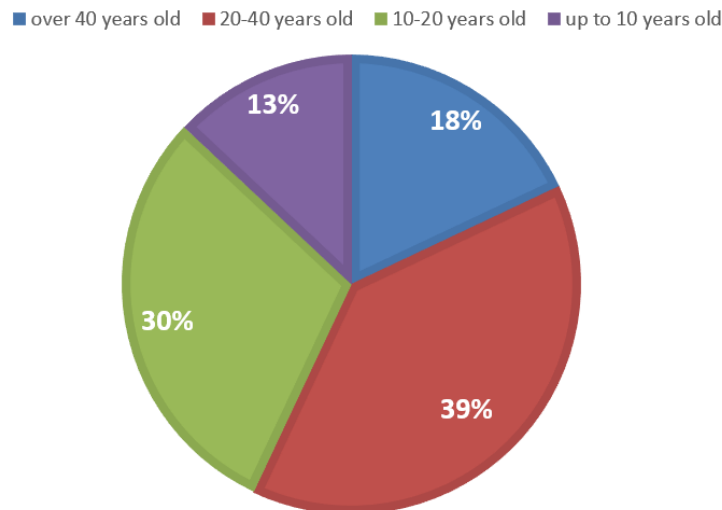


Figure 15: Overall age distribution of pedestrian composition.

MODEL OF THE RELATIONSHIP BETWEEN PEDESTRIAN FLOW SPEED AND PEDESTRIAN DENSITY

Understanding the relationship between pedestrian flow speed and density is essential for effective crowd management in high-traffic environments. Using regression analysis, a predictive model was developed based on experimental data. The pedestrian speed (V) was analyzed in relation to pedestrian density (D), applying the least squares method for parameter estimation. Table 2 shows the number of pedestrians, their age, and speed.

Table 2: The number of pedestrians, their age, and speed.

No.	X1-intensity (number of pedestrians).	X2-composition (age)	V-speed (m/s)
1	25	5	0,7
2	67	15	1,7
3	118	25	1,6
4	91	35	1,4
5	40	45	0,9
6	29	55	0,8
7	13	65	0,5

For multiple regression analysis, pedestrian speed was modeled as:

$$Y(X) = 0.69 + 0.009X1 - 0.005X2$$

where X1 represents pedestrian intensity (number of pedestrians), and X2 represents age composition. The model was validated with an unbiased error of 6.9%, confirming its reliability.

A second regression model was developed to represent the relationship between pedestrian speed and density. Table 3 shows the Pedestrian speed (V) and pedestrian density (D).

Table 3: Pedestrian speed (V) and pedestrian density (D).

No.	D (Density)	V (Speed)
1	0,1	0,8
2	0,3	0,7
3	0,5	0,67
4	1	0,65
5	1,5	0,6
6	1,8	0,55
7	2	0,5

$$Y(X) = 0.768 - 0.126D$$

with a multiple correlation coefficient $R=0.957R$, indicating a strong predictive capability. The model's statistical significance was verified using the t-test and variance analysis. The results demonstrate that pedestrian speed decreases as density increases, aligning with established pedestrian flow theories as shown in Figure 16.

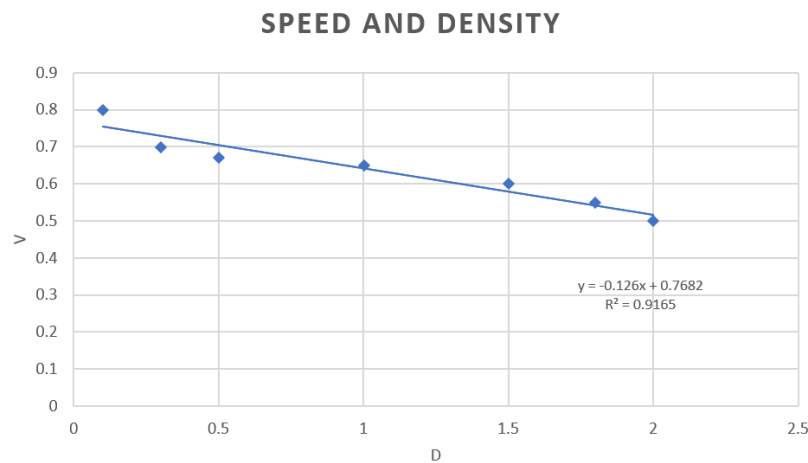


Figure 16: Model of the relationship between pedestrian flow speed and pedestrian density

The findings are shaped by Khiva's specific morphology and may not directly apply to other historical cities with different urban forms or seasonal conditions. Future studies should test the models in diverse contexts to improve transferability.

While this study identifies key infrastructure needs, future work should include schematic sketches or diagrams of pedestrian corridors and safety measures to better communicate design proposals to policymakers.

CONCLUSION

This study analyzes pedestrian dynamics in Uzbekistan's key tourist destinations. Surveys show 57.2% of tourists travel in groups, primarily for shopping. Tashkent attracts 58% of visitors, followed by Samarkand (31%), Bukhara (25%), and Khiva (13.3%). While Tashkent blends historical and modern sites, Samarkand follows a structured Tourist Pedestrian Route, and Bukhara has defined corridors around Lab-i Hauz. In contrast, Khiva faces pedestrian safety issues, poor inclusivity, and disorganized circulation. An empirical study in Dishan Qala recorded the highest foot traffic (468 pedestrians) at the Mustaqillik-Zargarlar intersection, mainly in the evening. A mathematical model was developed to optimize pedestrian flow. Future research should integrate smart

mobility tools, such as real-time pedestrian monitoring and IoT-based design features, to improve safety and accessibility in Khiva while preserving its heritage fabric.

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