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The Influence of Urban Design Performance on Walkability in Cultural Heritage Sites of Isfahan, Iran

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Abstract: This research explores the impact of urban design performance qualities on pedestrian behavior in a cultural heritage site designated by UNESCO. The study employs a multi-method approach, including a questionnaire survey, empirical observation of pedestrian activities, and empirical axial line and visibility graph analysis using the space syntax technique. The first part of the study involved a questionnaire formatted as a polling sheet to gather expert assessments of spatial performance measures. The second part used a pilot survey to capture the perspectives of end users regarding the study's objectives and their perceptions of the site. Pedestrian flow was observed using a technique called "gate counts", with observations recorded as video clips during specific morning and afternoon periods across three pedestrian zones. The study also examined the behavioral patterns of pedestrians, including their movement patterns. Finally, the ArcGIS 10.3.1 software was employed to evaluate the reliability of the results. The main finding of this research is that pedestrian behavior and walkability in the historical areas are significantly influenced by landmark integration, wayfinding behavior, and the socio-economic functions of heritage sites. This study highlights the importance of using cognitive and syntactic analysis, community engagement, and historical preservation to enhance walkability, accessibility, and social interaction in heritage contexts. In addition, it identifies the need for improvements in urban design to address inconsistencies between syntactic maps and actual pedestrian flow, emphasizing the role of imageability and the impact of environmental and aesthetic factors on pedestrian movement. This research provides valuable insights for urban designers and planners, environmental psychologists, architects, and policymakers by highlighting the key elements that make urban spaces walkable, aiming to enhance the quality of public spaces.

Keywords: urban design; walkability; pedestrian friendly; pedestrian movement patterns; place making; social interactions; cultural heritage site; space syntax

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1. Introduction

Walkability, as an attribute of the built environment, lies at the center of debates in urban studies regarding the creation of social and vibrant cities through a sustainable strategy for developing public spaces inclusively. It plays a pivotal role in influencing urban planning decisions for streets in the historic city center, guided by local government policies [1–5]. Walkability spans various disciplines, including its role as the most sustainable form of transportation [6], a recreational activity [7,8], a means of physical exercise for improving health and well-being [9,10], and a way to foster social interaction [11,12]. Currently, people are becoming less physically active, resulting in fewer

pedestrians in public spaces and city streets, consequently increasing the risk of obesity and related diseases [13–16]. This underscores the need to boost walking activities within local communities to enhance health, well-being, and overall quality of life.

Prior studies have indicated a positive relationship between the built environment and mental health [17–19], life satisfaction [20–24], walkable tourism [25–29], and physical activities, including walking [30–33]. Key characteristics of the surrounding environment that support and promote walkability include a comfortable space, a safe and secure physical infrastructure [34,35], connectivity and accessibility [36–38], land-use diversity [39–41], legibility [42–46], and green areas [47,48]. Research extensively shows that urban areas with greater pedestrian accessibility are more likely to boost social interactions and enhance the vibrancy of local communities [49–51]. Moreover, measuring the quality of the streets and their accessibility is associated to social well-beings and the perception of healthy places [24,52,53].

The relationship between walkability and urban design has generated significant attention in recent urban studies, emphasizing the need for pedestrian-friendly environments. Research has shown that urban design qualities such as imageability and transparency significantly influence walking behavior [54]. Additionally, the ongoing discourse on walkability highlights the importance of creating memorable and walkable environments [55]. Cutting-edge methods like space syntax have been employed to capture pedestrian movement patterns and urban form, providing new insights into the dynamic interplay between street networks and functional attractors [56]. Comparative studies have further underscored the impact of different urban forms on walkability, with mixed-use developments emerging as a key factor [57]. In addition to pedestrians' behaviors and perceptions, sustainable attributes of the physical environment, such as comfort and safety, serve as factors in assessing the walkability-friendliness of urban neighborhoods [58,59]. Overall, these findings underscore the critical role of thoughtful urban design in promoting walkability and enhancing the quality of urban life.

While the concept of walkability is widely discussed in developed countries in Europe and the USA, it has become a pressing issue in the rapidly evolving urban policy planning of developing countries like Iran. In historical cities such as Isfahan, authorities have traditionally emphasized the use of private cars, investing in streets and parking lots. Nevertheless, over the past decade, Isfahan, Iran's cultural heritage site reflecting the urban planning vision of the Safavid dynasty from 400 years ago, has been largely pedestrianized. This pedestrianization responds to various pedestrian challenges, including inadequate amenities on sidewalks and a lack of suitable pathways to enhance urban vitality, livability, social interaction, and walking incentives.

Nowadays, pedestrian mobility in Isfahan is being spurred by local urban policies and strategies that promote a mix of transportation options, including walking, cycling, and green means of public transportation, as part of an integrated network aimed at reducing the use of private vehicles. Given that walkability performance can be influenced by historical context, and this research is conducted within a cultural heritage site as a specific urban spatial component, this study yields original outcomes. Therefore, the primary unanswered research question remains: "What are the spatial characteristics of the site that could contribute to the enhancement of walkability and transform it into a walkable heritage site?"

This study employs Sondheim's matrix as a foundational framework to systematically analyze and integrate key urban design qualities, including social encounter, aesthetic appeal, cultural identity, and functionality. By leveraging this matrix, we aim to provide a structured and comprehensive evaluation of these elements within the context of pedestrianization in cultural heritage sites. Recognizing the significant social value of streets and public spaces, the objective is to assess the spatial quality of these pedestrian/cyclist streets and the historic square of Naghsh-e Jahan. To achieve this, qualitative and quantitative methods are employed, including a questionnaire (with statistical analysis using SPSS version 29), count gating, and space syntax analysis and GIS. These methods will aid in

evaluating the practicality and attractiveness of these transition spaces, thereby contributing to a comprehensive assessment of the current situation. However, it is worth noting that these spaces have faced inactivity due to interruptions in the historical site's identity and unforeseen inconveniences resulting from changing street use, which authorities are currently unaware of.

This study aims to understand people's perceptions of specific heritage environments. Beyond data collection, our research has the potential to assist in designing and planning urban social spaces. The proposed placemaking method allows for the prioritizing of parameters that are crucial for the physical development of historic sites, making them more walkable. In this regard, urban planners, stakeholders, city authorities, and UNESCO authorities overseeing cultural sites can benefit from the outcomes and recommendations. In the subsequent sections, the research outline will follow a structured presentation. It will be initiated with an overview of the materials and methods utilized, followed by the presentation of the results and a comprehensive discussion of their implications, and it will culminate with a summary of the key findings, conclusions, and their broader significance.

2. Materials and Methods

2.1. Questionnaire Survey

The methodology employed in this study was centered around the development of two questionnaires based on the Sondheim matrix and modeling templates. These questionnaires were designed to evaluate four categories of pedestrian-influencing variables: social encounters, aesthetics, functional qualities, and cultural identity. The primary focus of this research was the assessment of environmental quality and the interaction between users and their built environment within a cultural heritage site. The study adopted a mixed-methods approach, incorporating both quantitative and qualitative data collection techniques.

2.1.1. First Questionnaire: Expert Assessment

The initial questionnaire, designed in a polling sheet format, aimed to assess spatial performance measures. Experts were tasked with evaluating these measures in relation to block faces within the boundaries of Isfahan's historic site. The Likert scale was used to gather expert responses, with data subsequently converted into a continuous variable. This transformation involved assigning numerical values to each response category, ranging from "1" (indicating "strongly disagree") to "5" (indicating "strongly agree"). To determine the statistical significance of these expert evaluations, a single-sample *t*-test was conducted. This statistical test is employed to compare the mean of a single sample of scores to a hypothesized value. In this case, the hypothesized value was set as the midpoint of the Likert scale, which corresponds to "3".

2.1.2. Second Questionnaire: End-User Perspective

The second questionnaire was designed to capture the perceptions and experiences of end users, including mobile users, commuters, and pedestrians, within a studied historic site. This questionnaire focused on four key categories: social encounter, aesthetic appeal, cultural identity, and functionality, each of which included specific Likert-scale questions rated from 1 ("strongly disagree") to 5 ("strongly agree"). The questionnaire was pilot-tested with a small group of respondents to ensure clarity and relevance, and adjustments were made based on feedback before conducting the full survey.

The sample size for the survey was determined using gate counting data to ensure that a representative sample of 150 respondents was reached, based on Cochran's formula and Morgan's table. Data collection took place in person between 28 September and 11 October 2022, at various locations within the study area during both peak and off-peak pedestrian flow times. These locations were strategically chosen to cover a wide range of pedestrian experiences, including popular routes and quieter areas.

The survey questions covered the four key categories:

- Social Encounter: Respondents were asked to rate the extent to which the space was continuous, pedestrian-inclusive, and well-used, and whether it provided well-planned spaces for social interaction, shelter, and a sense of ownership.
- Aesthetic Appeal: Questions focused on the space's sense of place, character, human-scale design, and the effective use of color, texture, lighting, and space for both formal and informal entertainment.
- Cultural Identity: The survey explored how well the space promoted cultural identity and cognitive associations with the heritage site.
- Functionality: Respondents assessed the ease of access to the site, proximity to public transport, the balance of human and motor traffic, and the space's potential for both social and commercial activities.

The collected responses were used to compare end-user perceptions with expert evaluations of each block face, contributing to a comprehensive understanding of how well the site supported walkability from both a professional and public perspective. These data provided valuable insights into whether Isfahan's cultural heritage site was conducive to pedestrian activity and aligned with the needs and expectations of its users.

2.2. Pedestrian Flow Measurement Using Observation of Gate Counting

Pedestrian flows were quantified employing the "gate counts" technique. This method involves establishing a series of virtual lines (referred to as gates) at specific locations and tallying the number of pedestrians traversing pedestrianized zones. These counts were performed at two distinct intervals: morning (from 10:30 am to 2:30 pm) and afternoon (from 3:30 pm to 7:30 pm) on weekdays throughout the months of September and October 2022, which coincide with the end of summer in Iran and typically feature moderate temperatures.

To ascertain the ingress and egress of individuals within each street segment, video clips were recorded for a duration of two minutes over three days per gate. Gate selection was based on multiple criteria, encompassing foot traffic, the locations featuring the highest density of people (such as entrances to shopping malls or areas offering shading and shelter), historical and cultural landmarks, numerical values of syntactical analysis, and designated sitting zones. Notably, these streets represented key destinations within the cultural site of Isfahan, serving as focal points for visitor engagement.

2.3. Space Syntax Methodology

Space syntax is a graph-based methodology employed by urban designers to assess the spatial characteristics of urban spaces and analyze their impact on walkability patterns and social interactions [60]. The syntactical examination was conducted using the UCL Depthmap 10 software, developed by scholars at University College London. Depthmap is a professional software designed for the syntactical evaluation and identification of spaces, enabling the anticipation of social aspects in pedestrian movement patterns through analysis [61].

The urban plan of the study area was initially created using AutoCAD 2010 software, based on official city planning maps, historical maps, and satellite images as the primary sources for base-maps. These sources ensured the accuracy of spatial configurations and street layouts. Multiple drawings were prepared to focus on the specific case study areas, which were then combined into a cohesive projection. The drawn projections of the urban plan were imported into Depthmap for further analysis. This process allowed for the analysis of spatial configurations across different sections of the urban area, facilitating the analysis of walkability and connectivity.

Given the objectives of this study, two fundamental values, integration and connectivity, were identified as pivotal in the space syntax analysis [62]. A higher degree of integration reflects how easily a space can be reached from all other spaces in the system, indicating its potential to support walkability. Increased connectivity measures the number of directly connected spaces to a given location, representing its local accessibility within

the spatial network [60,63]. For further clarity, integration refers to the degree to which a space is connected to all other spaces in the system, making it central in terms of walkability. Connectivity, on the other hand, measures the number of spaces immediately adjacent or linked to a given space, which reflects its local accessibility. These values are key to understanding how spatial configurations influence pedestrian movement patterns. Space syntax primarily focuses on the mobility patterns of individuals within the built environment, and these patterns are significantly correlated with the degree of integration derived from the spatial configuration analysis, with the potential to enhance walkability in urban public spaces [64].

2.4. Study Area

The study area is primarily situated in the middle of downtown Isfahan city in central Iran, covering approximately 57 hectares. This area is historically known as the "Garden of Naghsh-e Jahan" and dates back to the Safavid dynasty. It is centrally located within the tourist hub of Isfahan (Figure 1). The regeneration project for this area commenced in 2020 and finished 2022, resulting in the pedestrianization of two main streets, Sepah and Chahar Bagh, as well as the Naghsh-e Jahan square, which had been used by motor vehicles for the past 70 years. The transformation of this site into a more pedestrian-friendly space introduced challenges related to motor traffic, the sense of place, functionality, aesthetic aspects, and communication within the area. It is imperative not only to identify these issues but also to comprehend pedestrian flow and behavior. To facilitate a more comprehensive analysis of the site, it has been categorized into three zones, each reflecting its historical functions. It is worth noting that the pedestrian zone is a UNESCO-registered site and holds great significance for the end users. These three historical zones can be visualized on maps as a three-layered pedestrian network, encompassing walking streets, sidewalks, and pedestrian zones.

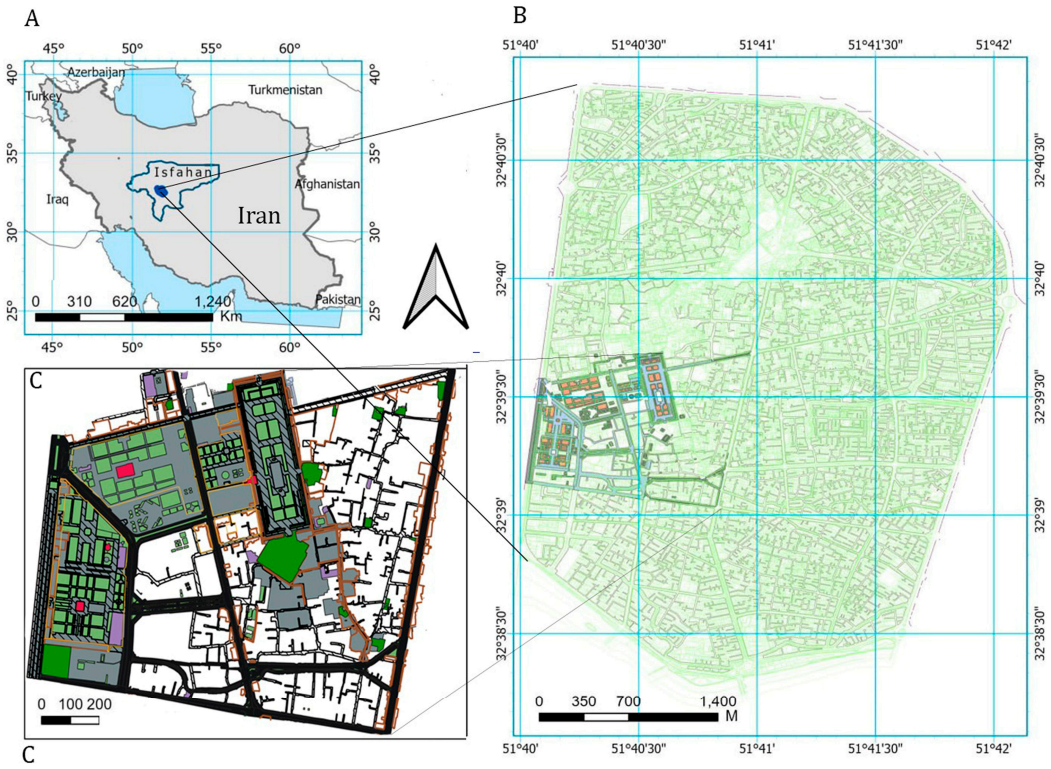


Figure 1. Hierarchical maps of the case study, showing the country, the focused district of the city, and the target cultural heritage site in Isfahan, Iran; (**A**) Country; (**B**) District 3 of Isfahan City; (**C**) Cultural Heritage Site of Isfahan Indicating in Gray Background (Source map: Iran National Cartographic Center and Municipality of Isfahan; incorporating authors' interventions).

Zone 1, Naghsh-e Jahan Square, boasts a rich history and covers around 9 hectares. It includes the Hafez entrance, Qeisarieh gate, and Sepah entrance. The square is a popular tourist destination and underwent construction in two phases in the 17th century. It features a geometric layout based on the golden ratio [65] and is surrounded by waterways and plane trees. Historic landmarks like Ali Qapo and the Shah Mosque add to its significance. The square experienced modifications to accommodate vehicles between 1930 and 1935. André Godard designed the central green space with a large rectangular pond. This zone encompasses gate numbers 1 to 20. Zone 2 encompasses Sepah Street, Ostandari Street, and Tohid Khane Park, along with a metro station at Darvaze-Dolat Square. Pedestrians can access Naghsh-e Jahan Square by walking 750 m along Sepah Street. Tohid Khane Park, located on the site of a historic palace, offers small gardens for picnicking. This zone comprises gate numbers 21 to 43. Zone 3, Chahar Bagh Street, is unique with its sidewalks, pedestrianized streets, and a central sitting area. It runs from Imam Hossein Square to Amadegah Street and is home to historic sites like Chahar Bagh School and the entrance to the Bazaar of Honnar. The study focused on the east side of Chahar Bagh, which is a cultural heritage site (Figure 2). This area also houses Hasht Behesht Park, named after a historic palace, and falls within gate numbers 45 to 77.

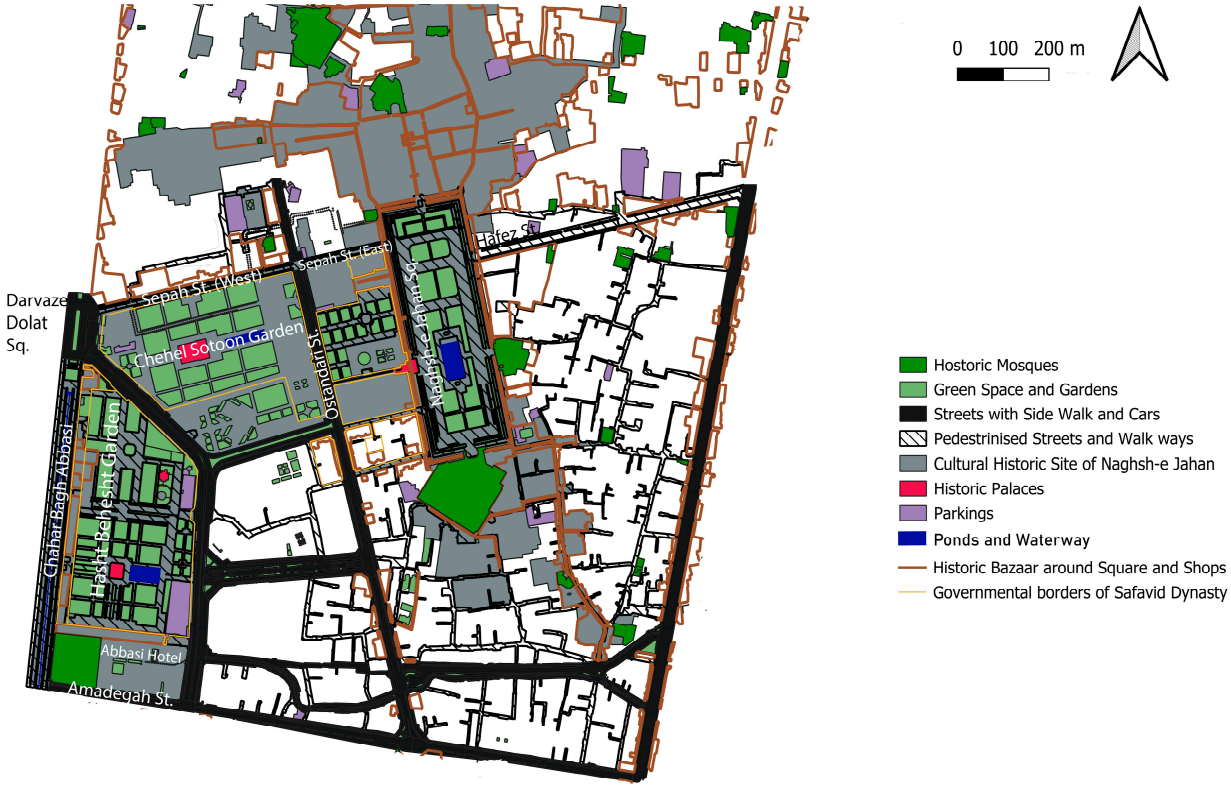


Figure 2. Land-use and pedestrian network in the cultural heritage site of Isfahan, Iran.

3. Results

3.1. Empirical Observations and Questionnaire Analysis

The survey data were analyzed by a panel of 29 experts, with balanced participation from both men and women. Most respondents were aged 20–39, making up 16 of the 28 responses, while 3 were over 70. Seventy-five percent held PhDs or higher qualifications, with 8 holding master's degrees and 6 being professors. In total, 12 respondents were familiar with the case study, 6 had prior travel experience related to it, and 3 expressed interest. In terms of cultural backgrounds, 12 experts were Iranian, 3 Italian, 2 American, and 2 Greek, with others representing diverse nationalities. The results were organized into four categories based on a theoretical framework for analysis and interpretation.

3.1.1. Social Encounter

Approximately 60% of respondents reported visiting the study site accompanied by friends or family. The survey analyzed pedestrian behavior, focusing on factors contributing to street vibrancy, such as passive activities (e.g., sitting), the availability of outdoor dining, motivations for staying, and duration of stay. The clustered bar chart demonstrates that the primary objective for most visitors was to maintain mental peace and well-being, indicating that cultural sites serve as stress relief, though this motivation varies by zone. The "Where_Contact_People" chart highlights that Chahar Bagh facilitated interpersonal communication, while Sepah showed lower engagement in sitting activities (Figure A1).

Environmental factors influencing social encounters were assessed through questionnaires. Shading and sheltering were identified as key contributors to the site's social dynamics, while the proximity to noise was a significant irritant, rated at 2.12 by experts. The illicit trade of motor vehicles and human involvement in transportation were found to cause stress, with experts rating it at 1.25. Table 1 details the number of motor vehicles associated with each gate. The presence of motorcycles in pedestrian areas significantly reduced the sense of safety, with 100% of respondents agreeing on their disruptive impact (Figure 3).

Table 1. The number of motor vehicles passing through gates.

Name of Zone	Gate Numbers	Number of Motor Vehicles Passing
Naghsh-e Jahan (Zone 1)	Hafez axis (Gate 2)	3 to 5 motor vehicles
	Northern axis (Gate 4 to 11)	7 to 10 motor vehicles
	Through green space (Gate 19)	2 motor vehicles
	Sepah entrance (Gate 20)	4 to 10 motor vehicles
Sepah (Zone 2)	Gate 21 to 26	10 to 13 motor vehicles
	Gate 30 to 36	2 to 6 motor vehicles
Chahar Bagh (Zone 3)	Chahar Bagh street (all gates)	0 to 1 motor vehicles

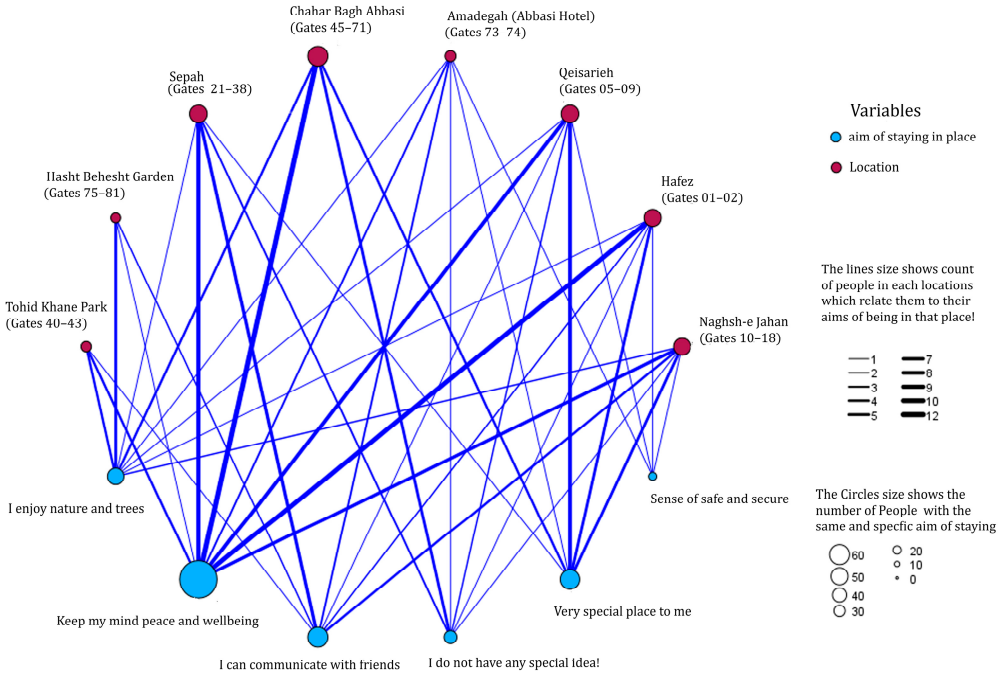


Figure 3. Relationship map between locations and aim of staying obtained from questionnaires.

Hafez Gate, serving as the eastern entrance to the square from Gate 2, stands out as one of the most heavily frequented gates within the site. Benches were situated on both the right and left sides of the Hafez entrance, adjacent to Gate 12. Surprisingly, these benches remained predominantly unoccupied. One primary factor contributing to this issue was the absence of adequate shading. As twilight descended and the temperature slightly decreased, all available seating spaces quickly reached full capacity. According to available records, an estimated average of 3 to 5 motor vehicles passed through Gate 2 every minute (Table 1). Consequently, the sense of shelter and comfort in this gate appeared scattered and insufficient to accommodate the needs of visitors (Figure 4).

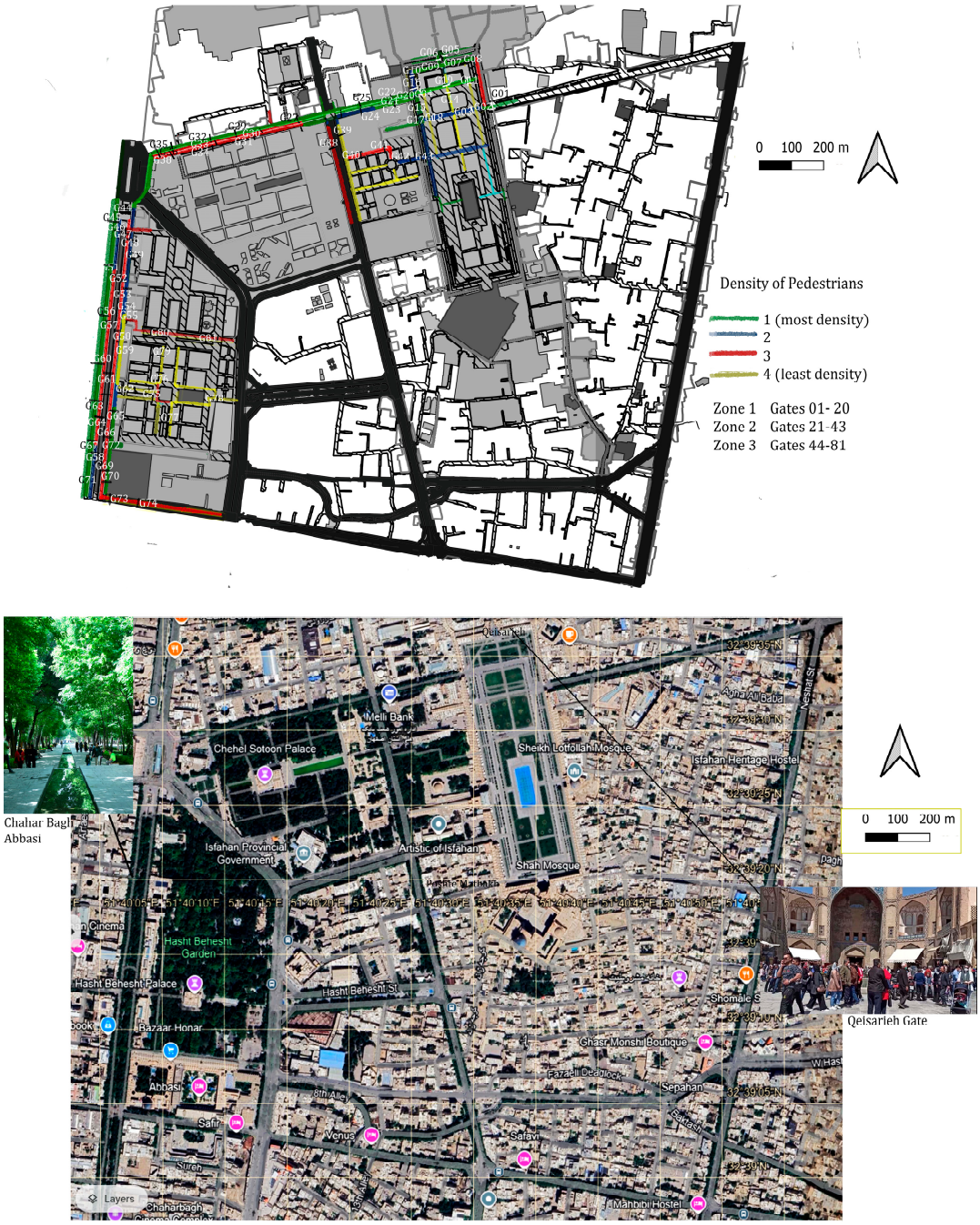


Figure 4. Pedestrian movement flow and density across various zones, accompanied by an orthophoto map for spatial reference (Source map: Municipality of Isfahan and Google Earth; incorporating authors' interventions).

This pedestrian street, the main route within the square, averaged 15 pedestrians per minute on its asphalt surface but lacked adequate shading. While benches were present, only three to four individuals used the seating near Gates 4 and 11. Gate 4 saw 7 to 10 motor vehicles per minute (Table 1), raising safety concerns. The eastern Sepah area faced an even higher vehicular influx, with 4 to 10 motor vehicles entering the square through Gate 20 per minute, exacerbating safety risks.

Survey responses show Qeisarieh Bazaar as the top choice for 62% of pedestrians visiting Naghsh-e Jahan. Gates 5 and 6 saw 25 to 35 pedestrians per minute, a flow deemed orderly and contributing to vitality with a rating of 3.65. Experts, however, suggested increasing spatial capacity for smoother movement, reflected in a rating of 2.17. Pedestrians at Qeisarieh Gate noted four main issues: lack of trees, offensive odors and uncleanliness of the pond, uneven ground stones, and notably, the presence of motorcycles near the pond. Retail workers parking motorcycles close to the pond significantly deterred people from staying in the area for long periods (Figure A2).

Gates 5 to 10 experienced the highest foot traffic within the square. Despite available benches in Zone 1 (G7 to G10), these remained unused due to inadequate shading and lack of social interaction opportunities. In the evenings and nights, individuals were observed sitting on benches from various directions. In traditional bazaars, cultural exchanges and interactions occurred during transactions, and some people utilized historical platforms near the Gate of Qeisarieh.

The sidewalk between Gates 14 and 15, near the Sepah entrance and Mesgaran Bazaar, offered the best shading in the square, accommodating the highest number of seated pedestrians. This area benefits from green elements and continuous shading due to its shop-lined setting. Traditionally, "Hose Khane" courtyards in bazaars served as social spaces for breaks, fostering community interactions. However, these spaces are no longer present in this case study, leaving only a few benches as resting options. Studies suggest that thoughtful architectural design can enhance social engagement, but this has not been addressed in the current layout.

Experts rated the square as ideal for cultural events (score: 1.67) and noted that vibrant social interactions could enhance enjoyment (score: 2.30). In the evenings, families occupied green spaces every 30 square meters, with about a quarter reporting social interactions during picnics. However, the walkways did not align with pedestrian patterns, requiring crossing lawns to reach the central pond. The lack of shading in Naghsh-e Jahan Square caused discomfort, with people primarily gathering under trees at Gates 19 and along the path between Gates 4 and 18.

The street leading to the square is essentially a connected roadway, particularly evident in the area from the eastern Sepah Gates 21 to Gate 24. Although 83% of the respondents expressed their support for pedestrianizing this route, there was an insufficiently defined space for seating and resting as of September 2022 (due to a construction project between Fall 2021 and Winter 2022). Subsequent research will provide further confirmation on this matter. Notably, between 2 and 6 motor vehicles were observed driving through the crowd between Gates 30 and 36. The junction of Sepah (Gate 27) serves as the central section of Sepah Street and experiences significant congestion.

According to experts, the high number of individuals in this area has made it uncomfortable, often resulting in chaotic conditions. The presence of currency dealers actively utilizing the space from 10:00 to 13:30 and 15:00 to 18:00 further exacerbates the issue. The population at this junction varies throughout the day, with counts decreasing to 80, 50, 20, and 16 at different times, specifically 12:00, 14:00, 17:00, and 18:00, respectively. Interestingly, as the number of wandering traders decreased, true pedestrian traffic found opportunities to move more freely, particularly in the afternoons. Dealers also positioned a significant number of motorcycles, exceeding 20, along the Ostandari sidewalk (Gate 38), akin to the situation at the pond in front of Qeisarieh. According to sources, the large population along Sepah Street has effectively formed an unofficial, distinct trading hub.

The sidewalk adjacent to retail and department stores in western Sepah received a high vibrancy rating of 2.21 from experts. Foot traffic was 60% to 100% higher here compared to the central street zone, based on gate count data. Pedestrians also noted concerns about the limited space for retail and galleries on these sidewalks. Gate 43 observed a high influx of around 20 individuals per minute, likely due to its location between the park and the square, adjacent to a bazaar and an art university, with a restroom nearby. Bench occupancy averaged 10 to 15 individuals per minute. However, parked vehicles and unpleasant restroom odors were consistent annoyances, limiting social interaction at this gate. In contrast, Gate 41's pond had a calming effect and promoted socializing. Visitors mainly consisted of families picnicking, preferring Naghsh-e Jahan Square over Tohid Khane for its appealing atmosphere (Figures 5 and A3).

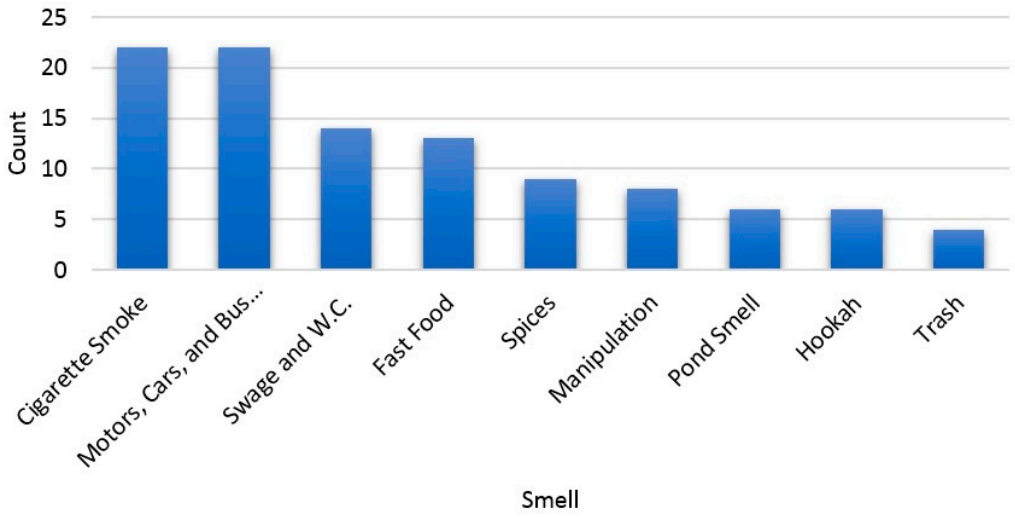


Figure 5. Ranking of off-putting smells in the cultural heritage site.

Chahar Bagh, pedestrianized two years before Sepah Street, features distinct characteristics like shaded trees, diverse retailers, and van cafés, creating a unique social environment compared to Zones 1 and 2. This area is well-regarded for fostering intimate conversations (rating of 2.52) and providing a sense of safety and orientation through its amenities. Experts rated Chahar Bagh as a welcoming space for friends and couples (2.28). Notably, Gate 66, near the café culture of Chahar Bagh, attracts significant foot traffic with café van patronage peaking in the evenings (7, 4, 12, and 24 people at 10:00 AM, 15:00, 17:00, and 19:00, respectively). Despite its pedestrian-friendly features (rating of 1.88), Chahar Bagh had only one café in 2022. The historic garden within Chahar Bagh School, housing an ancient tree from the Safavid era, remains inaccessible to the public (Figure 4).

Pedestrians in Chahar Bagh face challenges such as high foot traffic, narrow sidewalks during peak times, and insufficient amenities for the elderly. Video footage revealed a range of age groups engaging in social interactions at key gathering points. The scent of coffee was well-received, while food odors were notably disliked (Figure A4). Water features significantly increased bench seating usage by providing shading and shelter. Tourist numbers dropped when watercourses were not active (Table 2). Children also benefited from play areas around central ponds. In Hasht Behesht Park, 29% of respondents reported feeling insecure due to hooligans, negatively impacting social interactions. The primary odor nuisances were cigars, hookahs, and vehicle congestion near park entrances. The historical palace within the park appeared undervalued, and the area lacked a welcoming atmosphere. Notably, the highest concentration of visitors, especially the elderly, was found along the pathway with sports facilities at Gate 76.

Table 2. The effect of active and passive fountains on walkability and social gatherings.

Chahar Bagh	**Active Fountain in Terms of Flowing**			**Passive Fountain in Terms of Flowing**		
Time	**12:00**	**15:00**	**16:00**	**12:00**	**15:00**	**16:00**
Gate 47	11	13	14	4	6	2
Gate 61	17	14	11	4	6	0

3.1.2. Aesthetic Appeal

The investigation into aesthetics and architectural attractiveness evaluated human scale, imageability, color, and texture across various public spaces. A key finding is the preference for light green and turquoise colors, reflecting pedestrians' identity and cultural perspectives, which could inform future place-making strategies (Figure A4). Imageability, defined as the distinctive property of a location through color, texture, and memorability, showed that Tohid Khane Park was highly rated by both experts and the public for its imageability. This preference highlights the appeal of entering the square through a gate surrounded by lush greenery (Figure 6). Likewise, Figure 7 displays the photo-documentations of these recognizable entrances.

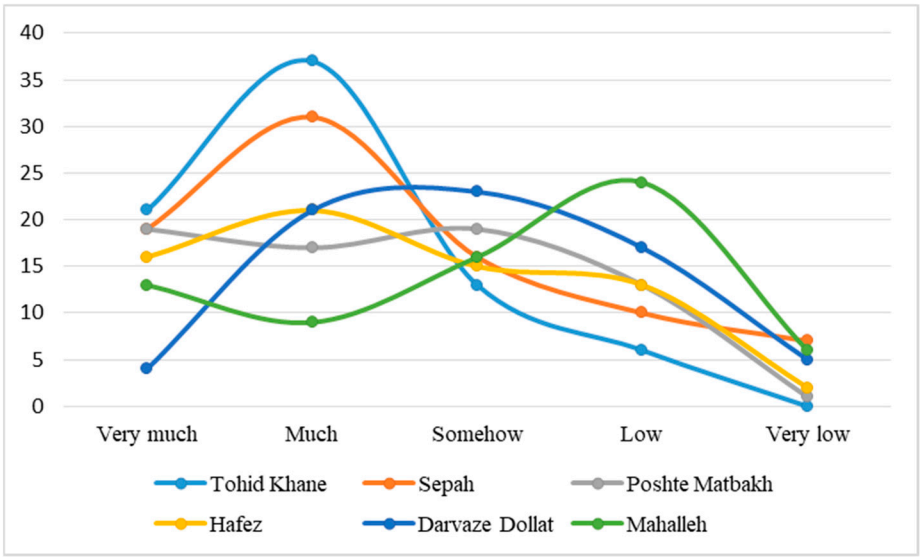


Figure 6. Pedestrians' viewpoint regarding the recognizable and memorable entrance.

Experts rated the imageability of Hafez Street at 2.79, indicating limited visual interest. The street, lined with old restaurants and fast-food outlets, generates substantial pedestrian traffic but competes with the historic site's appeal, scoring only 2.07 for cultural identity. Hafez Street, leading to the bazaar at Gate 2, suffers from cleanliness issues, with one-third of pedestrians highlighting this concern. Overall, Hafez Street is considered unsuitable as a walkable street due to its lack of visual interest and limited engagement beyond its view of the square.

The open space in front of Qeisarieh, with a rating of 2.17, was designed for free movement but suffers from poor footpath quality and uneven surfaces. Pedestrians noted issues such as substandard footpaths, motorbikes near the pond, a narrow bazaar gate entrance, and high crowd density, which disrupt the area's tranquility. Despite these problems, the Qeisarieh bazaar features distinctive characteristics, including a variety of merchants and architectural elements, contributing to its unique ambiance (rated 2.2, Table 3). Many also praised the exceptional view from the rooftop café overlooking the square.



Figure 7. Photo-documentation of the recognizable entrances (authors).

Scholars criticized East Sepah Street for its lack of visual distinctiveness, attributed to the rectangular buildings from the Raza Shah Pahlavi era, which received a low rating of 2.55. The high noise levels from the nearby Chehelsotoon garden further detract from the street's appeal. Pedestrians also rated Sepah Street poorly due to its unremarkable, outdated structures. Experts suggested that shops with large windows could enhance brand visibility. Overall, Sepah Street lacked appeal for pedestrians, who preferred a more engaging journey to the square, even if it meant a longer or less direct route.

Table 3. Inquiries regarding the imageability of Qeisarieh Gate (one-sample statistics).

Criteria	Mean	Std. Deviation	Std. Error Mean
High density of humans makes this environment uncomfortable.	3.3478	1.26522	0.26382
Shop stands and window designs encourage people to shop around.	2.2500	0.73721	0.15048
The size, texture, and articulation of outdoor physical elements (such as basins or flower stands) match human proportions.	2.5455	1.01076	0.21550
There should be sufficient space for pedestrians to sit and relax for their usual period of time.	2.1739	0.83406	0.17391

The sidewalks on Sepah Street, despite aligning with human-scale dimensions such as size, texture, and proportion, are insufficiently spacious relative to pedestrian volume. The preferred walking lane, as identified through gate counts and pedestrian feedback, is underwhelming due to limited views of Chehelsotoon, which experts rated poorly at 2.5. This lack of visual appeal diminishes the historical garden's influence. However, the experience of window shopping and passing through gates from 41 to 61 adds interest to the stroll along Sepah Street.

Chahar Bagh Street, like Sepah Street, features rectangular buildings without setbacks, impacting its imageability negatively. The new Hasht Behesht building, spanning Gate 55 to Gate 72, received poor ratings from both pedestrians and specialists, contributing unattractively to the street's architecture. Pedestrians inside the park also noted its lackluster appearance. Expert evaluations identified elements such as building colors, outdoor dining areas, and varied pavement textures (rated 2.61). The street's middle section, although not monotonous (rated 3.19), lacked historical diversity and trees, which were added 200 years after its establishment. During the day, pedestrian density was moderate (rated 2.33), but evenings saw high congestion, making the environment uncomfortable. Experts appreciated the street's attractiveness when amenities for passive activities were present.

3.1.3. Cultural Identity

Pedestrians were surveyed about their sense of belonging and historic identity (Table 4). The data revealed that Qeisarieh in Naghsh-e Jahan strongly conveyed historical identity, while Chahar Bagh elicited a higher sense of belonging. Chahar Bagh, inspired by Persian gardens, lacked effective integration of these historical elements. Respondents emphasized the importance of preserving historic buildings, trees, and pedestrian pathways, while businesses, lawns, and some ponds were deemed less valuable. A significant 63% of users preferred experiencing the pathway as a garden, rather than as a park. Additionally, 19% favored a blend of garden and park, and 17% supported developing the pathway as a park.

Table 4. Searching for a sense of place in the cultural site of Naghsh-e Jahan through a sense of belonging and a sense of being in a historic location.

Sense of Belonging	Percentage	Sense of Being in Historic Place	Percentage
Chahar Bagh	45%	Qeisarieh	78%
Qeisarieh	32%	Chahar Bagh	10%
Hahst Behesht	13%	Hasht Behesht	8%
Sepah	9%	Sepah and Tohid Khane	6%

Visitors at the Qeisarieh bazaar gate reported the strongest sense of being in a historical location, with 78% highlighting its evocative nature compared to other gates like Hasht Behesht Park, Sepah, and Chahar Bagh. Despite this, a strong sense of belonging was not universally felt. Historically, reverence for preserving buildings was less emphasized, though experts recognized the traditional bazaar's potential to evoke a strong sense of place (rated at 2.08). The sense of belonging was influenced by the scent of spices and the

traditional bazaar ambiance. Residents of Naghsh-e Jahan felt a strong identity, particularly when observing tourists interested in historical sites. While Qeisarieh and Naghsh-e Jahan had a high sense of place, Sepah and Chahar Bagh had lower scores, indicating that the historical expressiveness of monuments enhances the sense of place (Figure A5).

Table 4 indicates that Sepah Street lacks a strong sense of place, belonging, and historic significance. Historically a pathway to the square, it now feels narrow and uninspiring. People's sense of approaching a historic space is mainly driven by their awareness of Naghsh-e Jahan's proximity. The new retail establishments along Sepah Street have not fostered a sense of belonging among visitors. However, efforts to preserve the area's trees have been made.

Pedestrians on Chahar Bagh Street reported a strong sense of belonging, with 45% of participants expressing this feeling (Table 4). They preferred Chahar Bagh over other sites like Qeisarieh and Hasht Behesht due to its cultural integration and historical identity (rated 2.08 and 2.25, respectively). Despite this, recreational objectives were less emphasized. The street's cultural elements and historical significance contributed to this sense of belonging, though there were criticisms about the design and functionality of shops. Children occasionally played in the water, but overall, pedestrians favored green, tranquil environments. The centrally shaded lane provided recreational opportunities for both adults and children.

Chahar Bagh has effectively fostered a strong sense of belonging, enhanced by its symbolic features and role as a historical corridor within Persian gardens. It is a key hub for pedestrians, with Chehelsotoon Garden emerging as the most favored destination. The garden's impressive identity and the role of water in creating a connection were highlighted. Data showed a preference for café visits over picnicking, which improved social interaction and underscored Chahar Bagh's unique character within the café culture (rated 1.92). Walking, a cultural preference (rated 2.00), was promoted in Chahar Bagh and Naghsh-e Jahan, contributing to stress reduction and a more welcoming atmosphere. Conversely, Hasht Behesht did not evoke a sense of specialness despite housing the historical Hasht Behesht palace.

3.1.4. Functionality

Key factors affecting the quality of the location include design functionality, connectivity, mobility, public transportation, vehicle traffic, and pedestrian safety. Effective management of both human and motorized traffic, optimizing mixed-use areas, and proximity to residential zones are crucial. Transportation to Naghsh-e Jahan primarily involves driving and taxis. Streets like Ostandari and Bagh Goldaste, though lacking bus services, show potential for regeneration into walkable areas with better integration into the surrounding environment. Despite their current use as driveways, these streets are well-connected to main hubs.

Qeisarieh, at Gates 5 and 6, is the most frequented spot in Naghsh-e Jahan, attracting 64% of pedestrians. It is a key shopping hub, with 58% of respondents identifying it as a primary destination. Its popularity stems from its central location and accessibility from Sepah Street, extending to the Hafez entrance. Visitors come for shopping, recreation, and a traditional atmosphere. However, safety concerns arise from motorcycle congestion, which has led to dissatisfaction among all respondents. Visits to Qeisarieh include shopping (29%), shopping and recreation (29%), work (19%), and exploration (14%) (Figure A6).

The diversification of retail options in Naghsh-e Jahan may be a contributing factor that increased people's inclination for walking, as indicated by the experts' opinion rating of 2.33. This diversity resulted in a distinct character in Naghsh-e Jahan compared to the Sepah gates. Notably, Gate 20 experienced significant crowding, with an average of 20–30 people passing through per minute, leading to substantial pedestrian flows along the axis. In the historic cultural site of Naghsh-e Jahan, pedestrians expressed that their points of interest and public transportation stations were within a walkable distance. Those who utilized the subway and walked to Sheikh Lotfollah and Hafez on the east

side of the square reported that distance was not a problem for them (approximately 1200 m). However, it is noteworthy that only 25% of respondents used the subway as their mode of transportation (see Figure 8), and all respondents were under 70 years old. Consequently, the pedestrianization of streets leading to the square did not impede access to public transportation. Isfahan, unfortunately, did not benefit significantly from an efficient subway system, as it remained limited to one line as of 2023. While other public transportation, mainly buses, remained efficient, the predominant use of cars and taxis led to additional challenges.

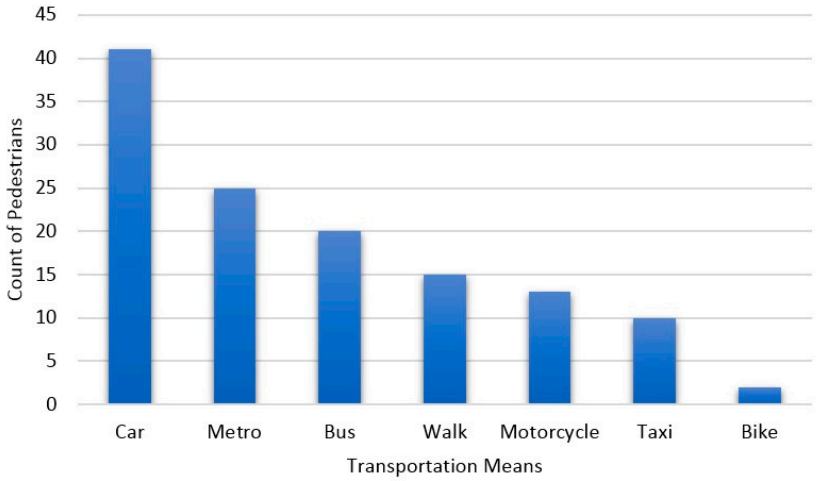


Figure 8. The means of transportation employed to reach the cultural site.

The historical buildings in Naghsh-e Jahan contribute to its uniqueness and sense of place, with landmarks such as the Shah Mosque, Sheikh Lotfollah, Aali Qapou Palace, and Qeisarieh enhancing its historical significance. In contrast, Chahar Bagh has fostered a strong sense of belonging through its cultural elements, such as water features and shaded trees, though these elements have not been fully realized. Despite the growth of green spaces in Naghsh-e Jahan, the central area has not effectively developed a sense of place, with 82% of respondents noting a lack of attachment to this space. The facilities added to the square have not seamlessly integrated with the historical context, with issues such as poorly executed paving patterns and obstructive tree placements reported by 21% of pedestrians.

During the summer, the square experiences a surge in visitors, who engage in picnicking as a means of cultural unity. However, challenges such as insufficient seating and shaded areas during the day, along with poor nighttime illumination, persist. The Azan, a religious ritual, is culturally accepted and considered a significant amenity, with 52% of respondents agreeing that its presence within the square is acceptable. In general, while Naghsh-e Jahan's historical structures and Chahar Bagh's cultural elements provide a sense of place, practical issues such as integration, maintenance, and amenities still need addressing to enhance the overall user experience.

Before pedestrianization, Sepah and Chahar Bagh Streets primarily served as shopping areas. Post-pedestrianization, pedestrians continued to frequent the sides of these streets where shops and passage galleries are located (see Figure 4). Approximately 57% of pedestrians identified the 750 m stretch of Sepah Street as their main route to Naghsh-e Jahan. Sepah East, a high-traffic thoroughfare, is used for shopping, access to the square, currency dealings, and banking. Pedestrians employ various transportation modes, including the metro, motor vehicles, and walking from adjacent areas. However, Sepah Street suffers from unclear functional designation, with structures failing to clearly indicate their purpose—whether for shopping, transit, or leisure. Additionally, unofficial trading activities alongside official buildings, such as banks, contribute to functional confusion and density issues. Despite these challenges, such activities are seen as integral, with even historical elements like Melli Bank retaining pedestrian significance.

Experts have criticized the decision to designate Sepah Junction at the intersection of Ostandari and Hakim Streets as a shared space, deeming it a detrimental choice that has compromised the area's identity. With 57% of visitors traversing Ostandari or Sepah, the high volume of taxis at the beginning of Ostandari has exacerbated traffic congestion and disrupted pedestrian movement. In contrast, Chehelsotoon Garden, a notable Persian garden adjacent to Sepah and Ostandari, has significant potential to enhance the appeal of these streets. Despite its limited public access, the garden could contribute to making the surrounding areas more engaging for pedestrians.

Chahar Bagh was primarily used for walking and recreation, with 60% of individuals walking and 16% engaging in recreational activities. Preferences indicated a stronger inclination toward visiting Chahar Bagh (51%) compared to Chehelsotoon (41%). This suggests distinct visitation preferences, with 40% of people visiting both the square and Chahar Bagh in a single trip. Historically, Chahar Bagh and the square (Meidan Naghsh-e Jahan) functioned separately, with no direct connection between them. Additionally, pedestrians from Siose-pol bridge, connecting the city's north and south sides, used this historical route, which is accessible by metro due to two stations along it. Parking lots adjacent to Chahar Bagh further underscore its connectivity beyond the subway.

Regrettably, according to the obtained data, Hasht Behesht Park was not a central hub frequently visited by individuals. Despite its considerable potential to be an outstanding garden comparable to Chehelsotoon, the park did not attract a substantial number of visitors. Notably, Hasht Behesht Park had good connectivity with other key hubs such as Chahar Bagh, Sepah, and even Ostandari; however, the utilization of this park by the public was limited. Access to Hasht Behesht was predominantly achieved by car or bus, with individuals either parking in lots along Baghe Goldaste Street or utilizing bus transportation.

Based on the results of the statistical analysis, both experts and end-users consistently identified "social encounter" as the most important value of walkability within cultural heritage sites. Experts emphasized environmental factors such as shading, sheltering, and noise reduction to foster social interactions, highlighting the importance of green elements, historical architectural design, and the elimination of disruptive elements like motorcycles. For them, functionality was also highly important, particularly in terms of pedestrian safety, connectivity, and enhancing urban vitality. While experts considered aesthetic appeal moderately important, favoring historical architecture and memorable visual elements, they were moderately to highly focused on cultural identity.

End-users similarly placed a high importance on social encounters, associating them with mental peace and stress relief, particularly in shaded areas with seating. Although they appreciated aesthetic appeal, their emphasis leaned towards practical aspects like cleanliness and maintenance, with a strong preference for visually distinct sites that provided serene environments. Cultural identity was highly valued by end-users, particularly in historically rich areas, where they felt a sense of belonging. However, their concern for functionality, while present, was more moderate, centering around ease of access and comfort. Despite these differences in emphasis, the analysis revealed no statistically significant difference in the factors influencing walkability between the two groups. This suggests that while experts may prioritize functionality and safety more, and end-users might focus more on cultural identity and mental well-being, both groups share similar overall perceptions of the key factors that enhance walkability in cultural heritage sites.

3.2. Space Syntax Analysis

Syntactical analysis in this study was carried out based on one of the most prominent analytical approaches, namely axial analysis (Figure 9). The results obtained from the morphological analysis of space syntax revealed a wide variety of configurational attributes within different streets of the study area. According to the aforementioned findings, three well-known environments are renowned for their societal attractions and tourist destinations, which may enhance walkability in these spaces. Thus, the streets and

roadways leading to these tourist hubs and attractions may warrant consideration. These outstanding tourist hubs in syntactical analysis are Naqsh-e Jahan Square, Hasht Behesht, and Chehel Sotun.

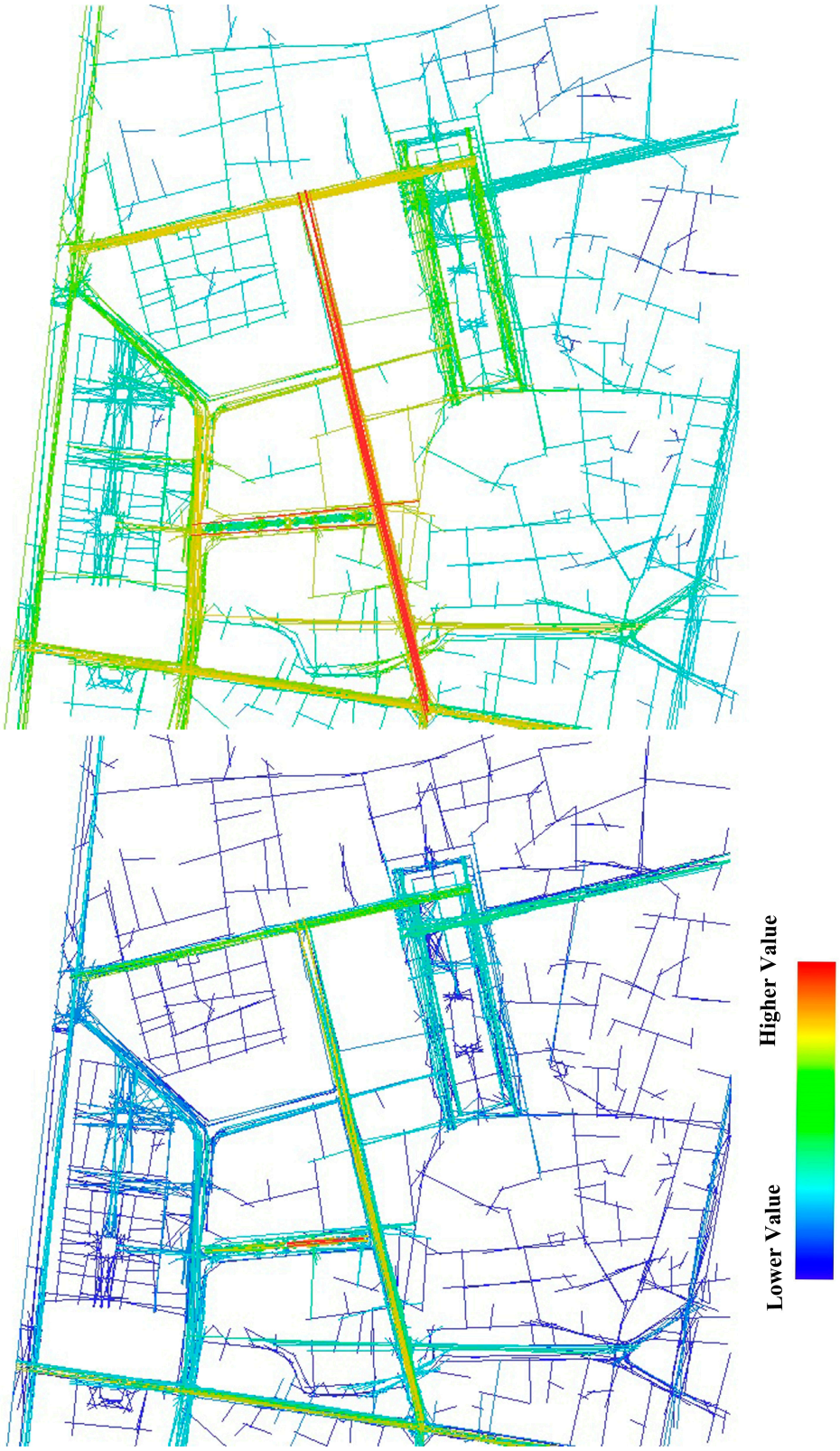


Figure 9. Integration (**upside**) and connectivity (**downside**) graphs of the study area based on space syntax analysis.

Regarding the syntactical characteristics, it should be noted that Ostandari Street is the most integrated space based on configurational attributes, with an integration value of 5.02. Following that, Hasht Behesht Street has an integration value of 4.69, and Sepah Street has an integration value of 4.11. While Hasht Behesht Street is identified as the most connected street with a connectivity value of 351, Ostandari Street comes next with a connectivity value of 256, and Sepah street with a connectivity value of 207; together, these are considered the most accessible spaces in the study area. It should be noted that Chahar Bagh pedestrian avenue, with an integration value of 3.38 and a connection value of 90, has a lower value of configurational attributes based on space syntax analysis (Figure 9).

According to the findings, centrality, wider streets, specific design paradigms, and layout details, such as the pattern of Chahar Bagh in urban design, may enhance integration and connectivity values in the spatial configuration of cities. However, the identified streets are not exclusively designed for pedestrians; they also serve as connectors to the main environments, potentially increasing sociability and walkability. Therefore, the intention is to delve into the morphological characteristics of these main sociable spaces to gauge their walkability potentials. Based on the obtained findings, Ostandari Street, located in the vicinity of Naqsh-e Jahan Square, possesses the most integrated space, facilitating accessibility to this socio-cultural plaza. On the other hand, the most connected street within the study area is Hasht Behesht Street, leading to Hasht Behesht Garden and mansion.

Another street connecting Naqsh-e Jahan Square with Chehel Sotun is Sepah Street, identified as the third integrated and connected street in the study area. To discern the walkability potential of sociable pedestrian areas, each of these walkable areas was subjected to analytical approaches in space syntax. In this step, alongside conducting axial analysis, Visibility Graph Analysis (VGA) was performed. The results of the morphological analysis indicated that Naqsh-e Jahan Square is the most accessible and connectable public milieu, and Chehel Sotun Garden is identified as the most integrated space with the ability to promote walkability (Table 5). The results obtained from the numerical outcomes of the syntactical analysis, as shown in Table 6, verify this finding and are consistent across both axial and VGA analyses.

Table 5. Syntactical graphs of the public spaces in the study area based on both axial and VGA analyses.

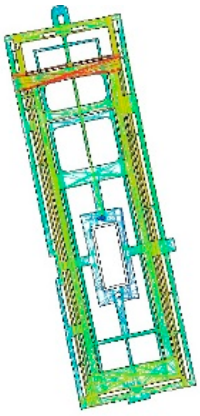
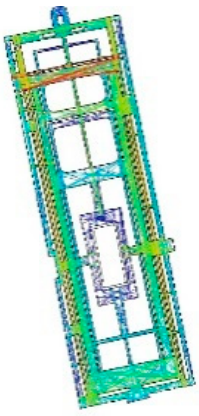
Walkable Gardens	Integration	Connectivity
Naqsh-e Jahan (Axial)		

Table 5. *Cont.*

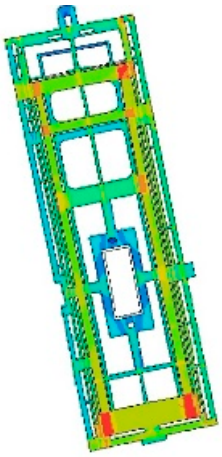
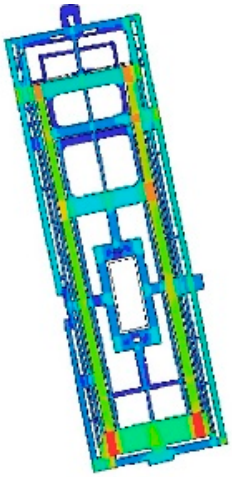
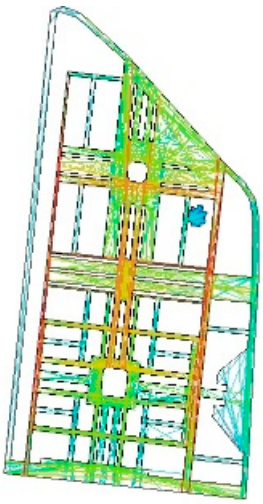
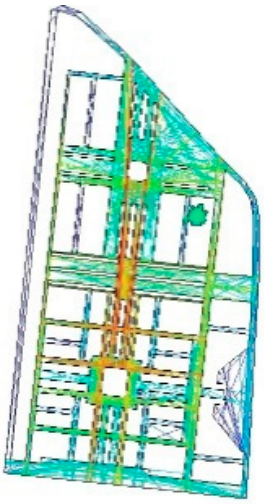
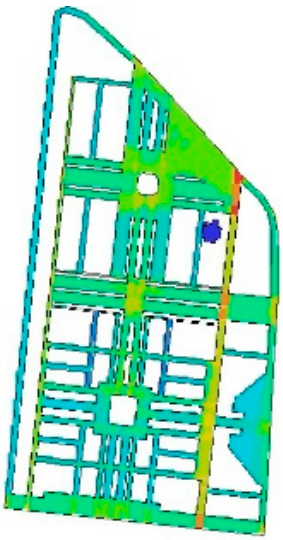
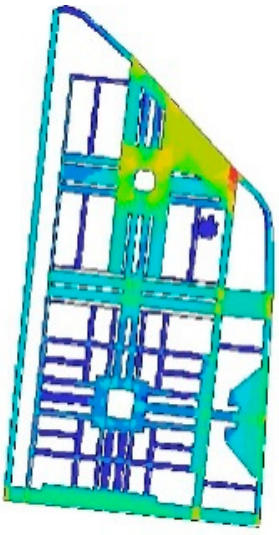
Walkable Gardens	Integration	Connectivity
Naqsh-e Jahan (VGA)		
Hasht Behesht (Axial)		
Hasht Behesht (VGA)		

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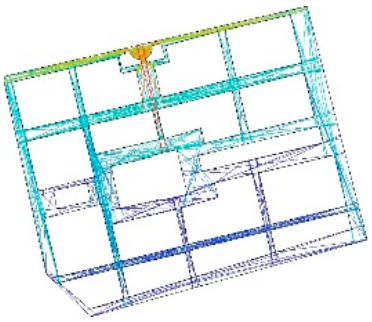
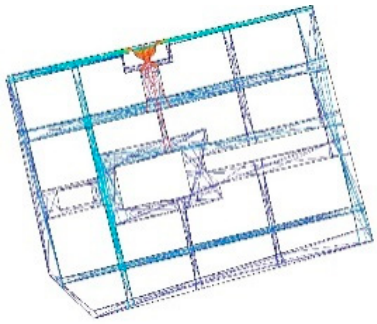
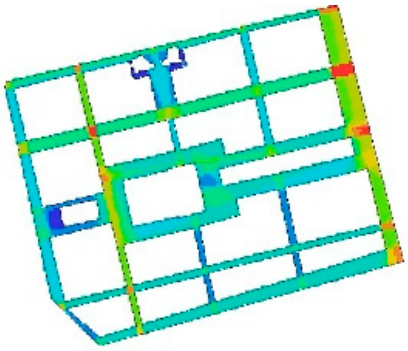
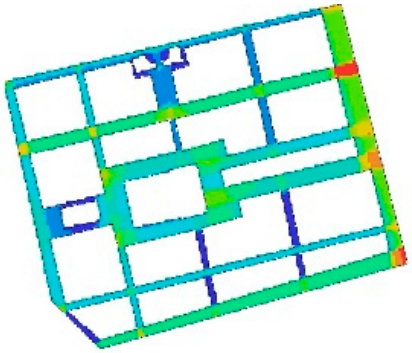
Walkable Gardens	Integration	Connectivity
Chehel Sotun (Axial)		
Chehel Sotun (VGA)		

Table 6. The numerical values for integration and connectivity for the gardens of Isfahan in both axial and VGA analyses.

Gardens	Analysis Type	Max Integration	Mean Integration	Max Connectivity	Mean Connectivity
Naqsh-e Jahan	Axial	9.73	4.2	517	265
	VGA	9.87	6.34	2144	1078
Hasht Behesht	Axial	7.07	4.46	387	197
	VGA	9.92	6.04	1387	699
Chehel Sotun	Axial	11.48	6.88	445	230
	VGA	10.51	6.94	1360	683

4. Discussion

4.1. Interpretation of the Results

The findings from this study underscore the complex interplay between pedestrian behavior, urban design, and heritage conservation within the context of historic cities. The pedestrianization project in Naghsh-e Jahan Square and Sepah Street in Isfahan revealed a significant relationship between pedestrian flow and spatial legibility, with landmarks such as Naghsh-e Jahan Square acting as critical nodes that guide movement and wayfinding behavior. The syntactic analysis combined with real-time gate counting confirmed that spatial integration directly influences the flow of pedestrians. However, minor discrepancies between the observed pedestrian counts and the syntactic predictions suggest that additional factors, such as the presence of physical obstructions or the aesthetic quality of streetscapes, play a role in shaping pedestrian behavior.

The wayfinding behavior exhibited by pedestrians highlighted the influence of both cognitive mapping and environmental cues. Visitors demonstrated a clear awareness of landmarks and destinations, particularly Naghsh-e Jahan Square, which was frequently

chosen as the primary goal of their visit. The cognitive maps formed by pedestrians aligned with the syntactic analysis in some aspects but also diverged in others, indicating that wayfinding is not solely dependent on spatial integration but also on other factors such as spatial memories and reference frames. Pedestrians' strong sense of place, facilitated by the square's historic and cultural significance, reinforced their navigation decisions. However, the lack of legibility at certain entrances, particularly from Hafez and Sepah, affected the overall aesthetic and functional experience, suggesting a need for urban design interventions that enhance imageability and visual coherence.

Social behavior in these pedestrianized areas further illustrated the importance of well-designed public spaces that support social interactions. The data showed that people often visited the square in groups, engaging in social activities such as sitting, resting, and shopping. However, the presence of narrow gates, street vendors, and motor vehicles in certain areas, particularly in Sepah and Qeisarieh Bazaar, impeded the free flow of pedestrians and created congestion. The study suggests that expanding social spaces around key entrances, providing more shaded resting areas, and reducing vehicle intrusion could enhance both pedestrian comfort and social cohesion.

Aesthetic appeal emerged as a critical factor influencing walkability, with Naghsh-e Jahan Square and Chahar Bagh being perceived as more visually pleasing than other parts of the city. Nevertheless, areas such as eastern Sepah, characterized by low imageability and a lack of social cohesion, experienced lower pedestrian satisfaction. The study highlights that while accessibility remains a priority for pedestrians, improving the aesthetic qualities of streetscapes through thoughtful design interventions, such as adding trees and enhancing landscaping, can significantly elevate the pedestrian experience.

The study underscores the importance of cultural identity in pedestrian behavior and urban design. Naghsh-e Jahan Square and Chahar Bagh, as historical landmarks, are central to cultural identity and heritage. The findings suggest that preserving and enhancing these spaces' historical and cultural elements is crucial for maintaining their significance. The adaptation of historical areas, such as the transformation of Chahar Bagh into a pedestrian-friendly space, aligns with preserving cultural identity while accommodating modern needs.

Finally, the functionality of urban spaces played a key role in shaping pedestrian behavior. The results indicated that areas with higher functionality, such as Chahar Bagh, benefited from well-maintained pathways, minimal vehicle intrusion, and a continuous flow of pedestrians. In contrast, locations like Hasht Behesht Park, which suffered from poor infrastructure and a lack of perceived safety, were underutilized by pedestrians. The study points to the need for targeted improvements in these areas, such as enhanced security measures, better lighting, and more accessible pathways, to create a more walkable and enjoyable environment for all users.

In sum, we elaborate on how spatial integration influences pedestrian flow by guiding movement patterns and wayfinding behavior. For instance, higher integration levels make it easier for pedestrians to navigate the space, enhancing both their comfort and social cohesion. Furthermore, physical obstructions such as street vendors and motor vehicles were observed to impede pedestrian movement in areas like Sepah and Qeisarieh Bazaar, confirming that these obstacles disrupt pedestrian flow, particularly in more congested zones. This is supported by both the syntactical analysis and real-time gate counts, which revealed discrepancies between expected pedestrian movement and observed behavior in areas with obstructions. To enhance clarity, we propose mapping these findings by pinpointing specific locations where interventions, such as expanding social spaces or providing shaded resting areas, would be most beneficial. For example, addressing vehicle intrusion near key entrances and improving the infrastructure in underutilized areas like Hasht Behesht Park could significantly boost pedestrian activity, as evidenced by both the space syntax analysis and gate count discrepancies.

4.2. Contribution of the Study

This study makes a novel contribution to the intersection of urban planning, environmental psychology, and social epidemiology by providing a comprehensive analysis of pedestrian behavior before and after the 2022 pedestrianization project in the cultural heritage site of Isfahan. The research advances the understanding of walkability in heritage sites by employing dynamic real-time data, including gate counting, syntactical analysis, and cognitive mapping, to assess pedestrian behavior and the spatial qualities of the urban environment. Unlike previous studies focused on Middle Eastern historical cities, which have often been limited in scope and methodology [66,67], this study integrates both quantitative and qualitative data to create a multidimensional perspective on pedestrianization, walkability, and wayfinding.

The use of real-time data, particularly gate counting, and syntactical analysis through GIS, presents a novel methodological approach for evaluating urban walkability in heritage sites. This approach addresses a gap in the existing literature [68], which has been dominated by traditional, less dynamic methods of assessing pedestrian flow and spatial configuration. The reliability of gate counting in this study is evidenced by its significant correlation with syntactical analysis maps. Although previous studies have demonstrated a significant correlation between connectivity values and urban mobility [69], minor inconsistencies between the observed pedestrian flows and syntactical predictions in this study underscore the complexity of walkability assessments, especially in heritage contexts. These discrepancies highlight the nuanced influence of historical urban layouts on pedestrian behavior, offering new insights that can inform future pedestrianization projects in similar historical settings.

One of the unique contributions of this study is its exploration of cognitive mapping and wayfinding behavior in a historic urban landscape. While previous research has recognized the role of landmarks, spatial memories, and reference frames in wayfinding [70,71], this study advances the field by examining how these factors influence real-time pedestrian decisions in a heritage context. The findings suggest that pedestrians demonstrate strong synchronous social wayfinding behavior, with clear objectives and spatial awareness driven by the recognition of significant landmarks, such as Naghsh-e Jahan Square and Chahar Bagh. This supports the idea that spatial legibility and the presence of key landmarks play a critical role in shaping pedestrian behavior and enhancing the walkability of heritage sites [72].

The study's examination of pedestrian preferences further contributes to the literature by revealing how aesthetic and functional elements influence walkability and social behavior. For instance, while Sepah Street showed the highest pedestrian flow, it suffered from low imageability and poor social cohesion, as previously highlighted by Ameli [73]. This finding contrasts with areas like Chahar Bagh, where a more pleasant walking experience, facilitated by trees and better-designed urban spaces, improved pedestrian satisfaction. The study also draws attention to the role of socio-economic factors in influencing pedestrian flow, as evidenced by the dominance of Qeisarieh Bazaar as a hub for social encounters despite its low integration scores in syntactical analysis [74,75]. This duality between spatial predictions and real-world behavior underlines the importance of combining objective and subjective data in urban studies.

In addition, this research addresses a significant gap in the understanding of the relationship between pedestrianization and social interaction in historical urban settings. Previous studies have largely focused on modern urban spaces, overlooking the unique social dynamics that occur in historical cities [76]. The current study demonstrates that social walking, often occurring in groups, is a vital aspect of pedestrian behavior in heritage sites, reinforcing the notion that walkability is not solely determined by physical infrastructure but also by the social and cultural context [77]. This insight is critical for future urban planning efforts aimed at enhancing walkability and social cohesion in cultural heritage sites.

Moreover, this study contributes to the growing body of literature on the ecological and environmental aspects of urban design in historical contexts. While previous research has emphasized the importance of conserving natural regimes and integrating ecological diversity into urban planning [78,79], this study extends these discussions by examining the landscape features of historical areas like Chahar Bagh and Naghsh-e Jahan. It underscores the need for better integration of green spaces and urban ecology into pedestrianization projects, particularly in areas that have undergone significant urbanization without adequate consideration of environmental issues. This focus on the interaction between hard and soft landscape elements provides a more holistic view of walkability, suggesting that successful pedestrianization in heritage sites requires not only infrastructural improvements but also attention to environmental sustainability.

Finally, the study highlights the critical role of safety and security in determining the walkability of heritage sites. While Hasht Behesht Park demonstrated lower pedestrian flow compared to other areas, the primary factor was a pervasive sense of insecurity. This finding aligns with previous studies on the importance of perceived safety in promoting walkability [58,80,81], suggesting that future interventions in historical urban areas must prioritize the creation of safe, well-lit, and socially vibrant spaces to enhance pedestrian experience and social interactions.

In sum, this study offers several contributions to the field of urban planning and walkability in historical cities. By combining real-time data, cognitive mapping, and syntactical analysis, it provides a dynamic, multi-faceted assessment of pedestrian behavior that accounts for both the physical and social dimensions of urban space. The findings not only advance theoretical understandings of walkability in heritage contexts but also offer practical implications for urban planners seeking to foster sustainable, pedestrian-friendly environments in historic urban areas.

4.3. Implications for Policy and Planning

Urban planners should emphasize enhancing the spatial legibility and cognitive mapping of pedestrians by improving wayfinding aids, such as landmarks and signage. These interventions could make historic areas more accessible and user-friendly, promoting heritage tourism while preserving cultural identity. Moreover, the findings suggest that enhancing sidewalk design and reducing congestion in critical areas, such as near major landmarks, can improve the overall walkability and visitor experience.

Strategically redesigning the main entrances to heritage areas could enhance visitor experiences and improve accessibility. Policy initiatives should focus on pedestrianizing key streets, such as Qeisarieh Gate, while providing adequate spaces for resting and socializing. The study suggests that improving entrance designs, enhancing aesthetic appeal, and ensuring better connectivity to public transportation would support more sustainable and enjoyable pedestrian experiences.

Urban planning policies should focus on enhancing public spaces within historic markets by expanding pedestrian zones, organizing vendor layouts, and improving seating and shade. By fostering social interactions in these spaces, local economies could be boosted, supporting both heritage conservation and community well-being. These interventions would also mitigate congestion and encourage a more vibrant, pedestrian-friendly environment.

Policymakers should integrate urban ecology into the planning of heritage sites by incorporating more green spaces, trees, and natural habitats. This would not only enhance walkability but also contribute to the conservation of historical landscapes. Restoring the ecological elements of places like Chahar Bagh could improve biodiversity while making these areas more appealing and functional for both locals and tourists.

Urban design interventions should prioritize reducing vehicular access and enhancing pedestrian amenities in heritage zones. Planners could implement policies that limit parking within historic cores and develop multi-story parking on the peripheries, thereby preserving the walkable character of the area. This would foster social interactions and enhance the cultural experience of heritage sites.

To improve safety and walkability in historical parks like Hasht Behesht, policy interventions should include enhanced lighting, better surveillance, and a diversity of amenities that promote both active and passive uses of the space. These improvements could transform the park into a safer, more attractive destination for both locals and tourists, supporting urban sustainability goals.

5. Conclusions

This research aims to understand the influence of urban design performance on pedestrian walkability behavior within a cultural heritage site in Isfahan. The study reveals that landmark integration, wayfinding behavior, and the socio-economic functions of heritage areas play a significant role in shaping pedestrian movement and enhancing walkability. The research highlights the value of cognitive and syntactic analysis, community engagement, and historical preservation in promoting accessibility and social interaction in heritage contexts. Importantly, the study identifies the need for urban design improvements to address discrepancies between syntactic predictions and actual pedestrian behavior. This work offers valuable insights for urban designers, planners, environmental psychologists, and policymakers, emphasizing the importance of integrating environmental and aesthetic considerations into urban spaces to foster sociable and walkable public areas.

The study faced challenges due to certain limitations. Firstly, the data utilized were not easily accessible. The information was collected during a period marked by heightened sensitivity and fear, coinciding with unrest in Iran. During this time, respondents were less inclined to participate in surveys. Nevertheless, individuals demonstrated courage in responding to queries related to security and safety. Hence, it becomes imperative to encourage a more diverse pool of respondents to ensure a comprehensive dataset as an outlook for future studies. Secondly, the maps presented by the municipality exhibited a variety of approaches in conceptualizing and operationalizing urban maps. The lack of uniformity among maps generated by syntactic analysis made it challenging to make direct comparisons with gate counting maps, and some minor details were obscured. As a result, the discussion of the selected part was based on the real-world observations rather than relying solely on the maps.

In conclusion, this study suggests that enhancing the legibility and identity of the space can be achieved by preserving and promoting historical monuments, vernacular elements, and socio-economic centers, such as traditional bazaars, which have an overwhelming impact on the creation of cognitive maps for pedestrians. This can help visitors to navigate the space more easily and appreciate its cultural and aesthetic values. Furthermore, footfall on the side of the street with shops was much higher all over the site. While this behavior may be cultural, it is recommended to encourage mixed-use development that can create a diverse and vibrant urban environment on both sides. For instance, preserving and promoting historical gardens like Chehel Sotoon, identified by the VGA as the most integrated space to promote walkability, or connecting a safer environment in Hasht Behesht Park by regenerating it in line with Persian gardens, can have a substantial impact on the creation of cognitive senses for pedestrians. This, in turn, can help visitors to navigate the space more easily and appreciate its cultural and aesthetic values. Additionally, the accessibility of crowded communities to Sepah Street should be reconsidered. It should be designated as a pedestrian-only zone, and during specific hours, shopkeepers should be free for delivery. Enabling individuals to choose a new path to arrive at Naghsh-e Jahan based on their preferences and emotions introduces unpredictability in people's movement patterns. This also creates a more personal, small-scale ambiance, turning the pedestrianized historic cultural zone into an old city.

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Institutional Review Board Statement: This research was conducted according to the guidelines of the Declaration of Helsinki. Ethical review and approval at any stage were waived for this study, due to the reason that no sensitive/personal information (e.g., names, contact details, codes, etc.) were sought/gathered during data collection or at any stage of this research. This research study and the questions asked were limited to context-based questions to generate knowledge about the role of urban design performance qualities on walkability in cultural heritage sites.

Data Availability Statement: The data that support the findings of this study are available upon reasonable request from the first author. Restrictions may apply to the availability of data due to privacy or ethical considerations.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

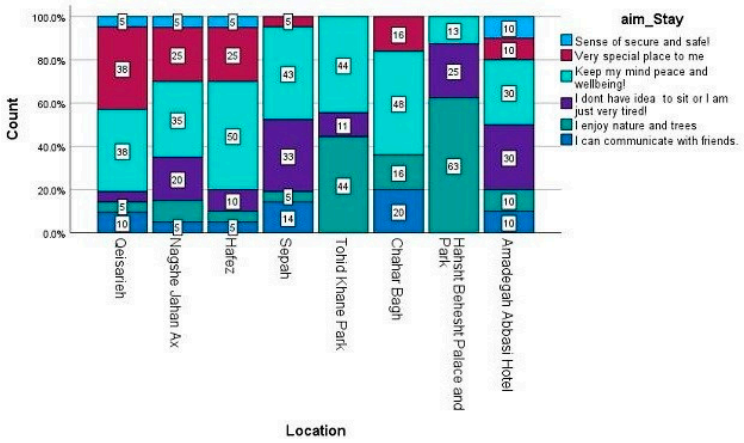


Figure A1. Aim of pedestrians to stay or sit in various locations of the studied cultural heritage site.

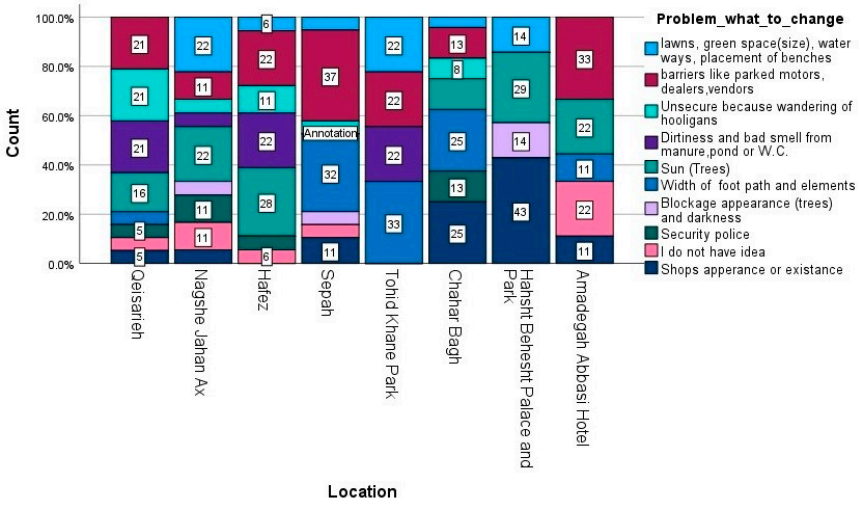


Figure A2. Problems in various locations of the heritage site based on the opinions of pedestrians.

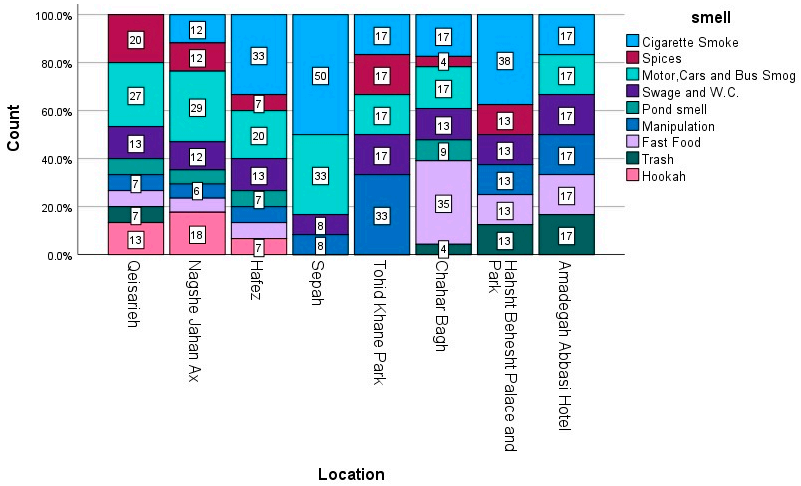


Figure A3. The worst smells in the cultural heritage site in terms of zones and their location.

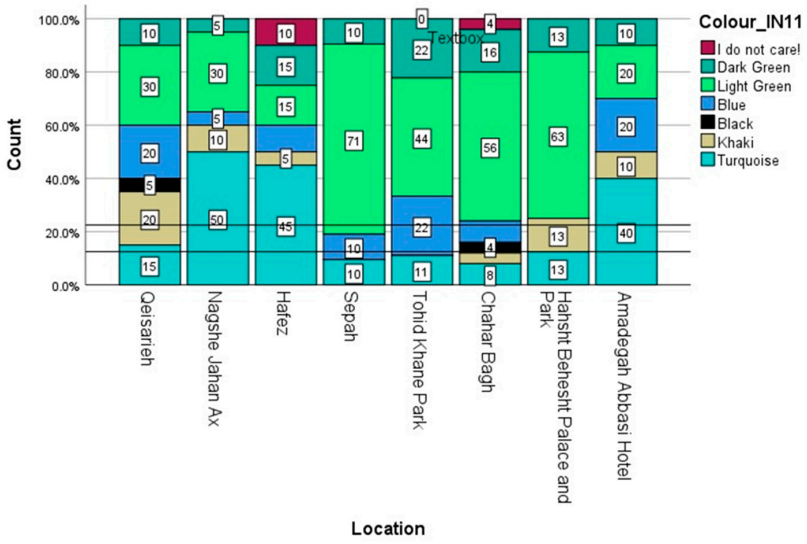


Figure A4. Preferred colors for different locations based on the viewpoint of pedestrians.

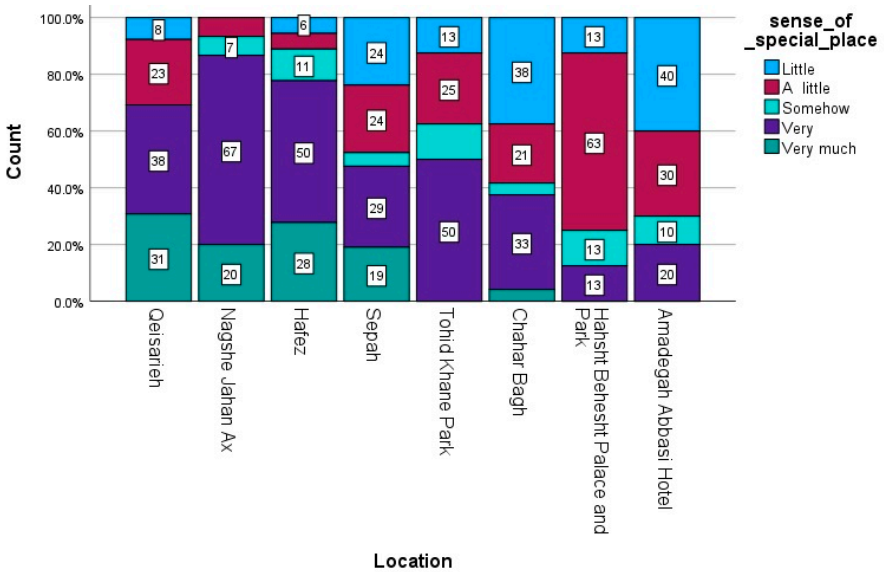


Figure A5. The sense of place among visitors in different locations.

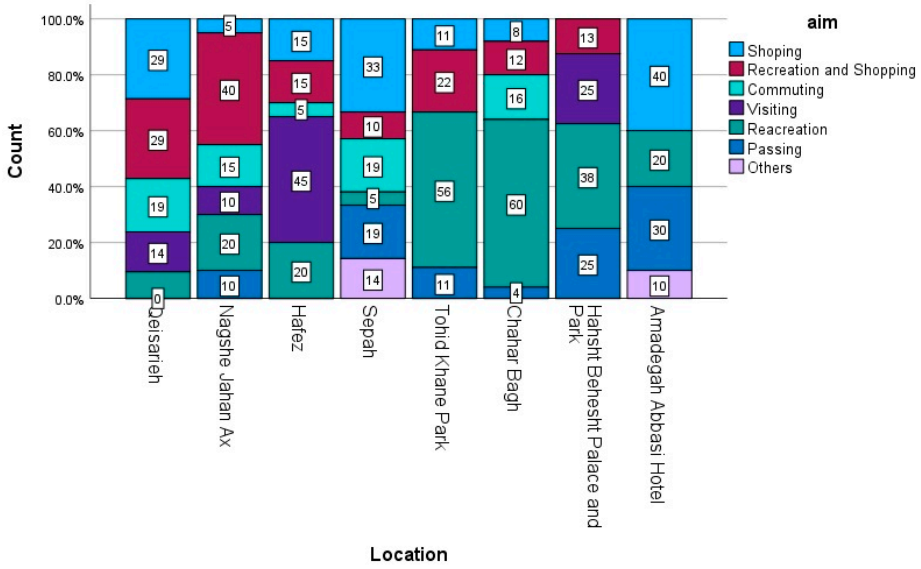


Figure A6. Purposes of visiting in various locations.

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