

## Original Article

Received: 2025/11/13  
Revised: 2026/02/01  
Accepted: 2026/02/10



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## HOW TO CITE THIS ARTICLE

Asgari Elham A. Sajadzadeh H. Samari A.B. Sohrabi N. The role of urban green infrastructure on social sustainability (Case study: old neighborhoods of Hamadan city). *Urban Economics and Planning* 7(8):4-23.

DOI: [10.22034/uep.2026.558042.1774](https://doi.org/10.22034/uep.2026.558042.1774)

## The role of urban green infrastructure on social sustainability (Case study: old neighborhoods of Hamadan city)

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### Abstract

Urban green infrastructure, as one of the main pillars of sustainable development, plays a fundamental role in improving the quality of life of citizens and achieving social sustainability. Despite the importance of this component, many Iranian cities, especially in old contexts, have faced challenges in recent decades, such as the reduction of local green spaces, erosion of canals and springs, and the decline of social interactions. The present study aims to analyze the role of urban green infrastructure in improving the social sustainability of historical neighborhoods in Hamedan. The research method is descriptive-analytical and applied in terms of purpose. A questionnaire was used to collect data, and the statistical population included residents of five old neighborhoods of Hamedan (Kalpa, Kebabian, Haji, Aghajani Beg, and Khatuniyeh). The sample size was determined as 385 people using the Cochran formula, and the data were subjected to factor analysis and structural equation modeling using SPSS and AMOS software. The results showed that there is a significant relationship between urban green infrastructure and dimensions of social sustainability, including neighborhood identity, sense of place, social presence, safety and security, social participation, and accessibility. Among these dimensions, "neighborhood identity" and "place attachment" have received the greatest impact from green infrastructure, while "social participation" has shown the least relationship. Accordingly, preserving and revitalizing natural elements such as springs, canals, and neighborhood lawns can be considered as an effective strategy for improving the quality of life and social sustainability of historic urban contexts.

### Keywords

historical neighborhoods of  
Hamedan  
neighborhood identity  
sense of place  
social sustainability  
Urban green infrastructure

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## 1. Introduction

Cities, as one of the most important development phenomena of the present century, play a decisive role in shaping the economic, social, and environmental structures of human societies. Today, more than 55% of the world's population lives in urban areas, and according to United Nations forecasts, this figure will reach more than 68% by 2050 (United Nations, 2012). This is an issue that has received less attention from an environmental and social perspective. Due to the increasing population of cities, numerous problems arise in areas related to humans that challenge the livability of cities (Norouzi & Bemanian, 2019). Although today efforts are being made to expand green spaces in cities, the development of these spaces in Iranian cities is based on increasing per capita income and in a rushed manner. In the current century, urban green infrastructures are developing significantly in environmental issues (Lak, 2017), as well as the abundance of forests and natural features that define the visual corridor. Along with the development of green spaces throughout the world (Hakimian & Lak, 2017), and the abundance of forests and natural features that define the visual corridor, green infrastructures provide ecosystem services that are equally necessary for human health. Their loss has significantly high costs for society (Mahmoudzadeh et al., 2019). Similarly, among the challenges facing governments in the current century are environmental issues and improper exploitation of natural resources, which are largely due to the lack of continuity and coordination in urban green infrastructures (Grunwald, 2018). In this regard, urban green infrastructure plays a vital role in the development and spatial organization of cities and is effective in improving the quality of the built environment. At a larger level, urban green infrastructure can be defined as a green landscape that provides a comprehensive framework for the interaction between the natural environment and the human-made environment (Jongman & Pungetti, 2004; Bennet & Mulongoy, 2006). The concept of "green infrastructure" has its roots in ideas and designs related to open and natural spaces, such as greenways, garden cities, and the landscape ecology school. Green infrastructure as a concept has generally developed over the past two decades. Green infrastructure usually refers to interconnected networks of green

spaces that can be found in urban landscapes and urban areas, or is defined as a system of urban and periurban green spaces. The multiple ecological, economic, and social benefits of green infrastructure enable planners to create multifunctional, innovative, and sustainable places while also promoting ecosystem and human health and well-being.

Given the special importance of urban green infrastructure in improving the quality of life and social sustainability, the present study aims to examine the role of urban green infrastructure in improving sustainability components in traditional neighborhoods of Hamadan, taking into account environmental sustainability factors and explaining the concept of urban green infrastructure. The old neighborhoods of Hamadan have faced numerous challenges in recent decades, including the reduction in the function of canals and fountains in these neighborhoods, and the conversion of some local green spaces to new uses, which in turn has led to a decrease in social interactions, a weakening of the sense of belonging, and a decline in citizen participation. However, a closer examination of the spatial and historical structure of the target neighborhoods shows that the presence of natural elements such as springs, canals, and lawns has played a fundamental role in strengthening social bonds, forming neighborhood interactions, and increasing the sense of place in the past. Indeed, the structure and morphology of traditional neighborhoods in Hamedan have been historically shaped by urban green infrastructure patterns. Over time, this pattern has successfully maintained and enhanced social sustainability, residential stability, and the quality of urban life in these areas. Consequently, conceptualizing these components not merely as physical-spatial elements, but also as active socio-cultural platforms, can pave the way for future sustainable urban planning. Accordingly, the main goal of this research is to investigate the impact of urban green infrastructure on the social sustainability of old neighborhoods in Hamadan. The main questions of the research are:

1. To what extent have environmental sustainability indicators influenced the formation of the traditional urban fabric?
2. To what extent does the structure of urban green infrastructure impact the social sustainability of traditional neighborhoods in Hamadan?

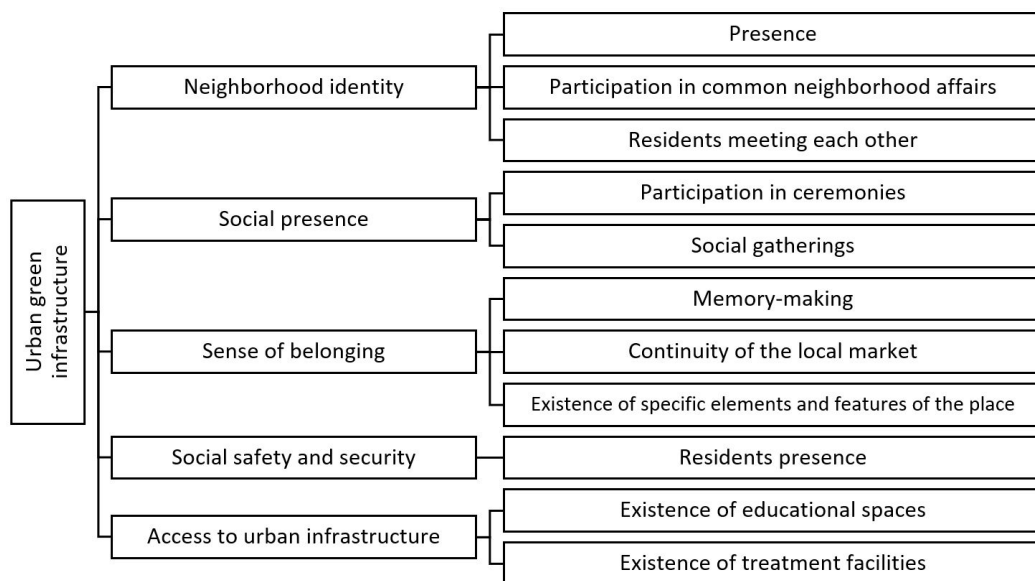


Figure 1. Conceptual research model

## 2. Research background

The term “green infrastructure” can be traced and analyzed in three historical periods, each of which shows its own characteristics and approaches in the development and management of urban green space. With the publication of works such as the sustainable development document in the United States and the influential article by Benedict and McMahon in 2002, the concept officially entered the scientific and policy literature. It gradually became popular in professional research and reports. The second phase (2005 to 2010) was dedicated to expanding the theoretical and practical discussions of this concept, so that at this time, the focus was on examining the benefits and functions of green infrastructure in regional development, strategic planning, and promoting urban sustainability. Finally, in the third phase (from 2010 to the present), the concept of green infrastructure was established in the scientific literature, and a relative consensus was formed regarding its definition, scope, and method of development. So the body of research became broader, and more precise empirical evidence was provided in support of its role in urban and regional planning (Mell, 2017).

The study and research in the field of urban infrastructure began in the second half of the 20th century and was mainly based on studies of the history of technology. During this period, the study of the multidimensional role of urban infrastructure during the Industrial Revolution and its impact on the

formation of modern society attracted the attention of researchers and experts in various fields, including history, sociology, architecture, ecology, and landscape architecture (Al-Hashemi et al., 2016). The history of the formation of the concept of urban green infrastructure can be seen by studying the theoretical foundations of urban design in some contemporary theories in this field. In new approaches to urban design, especially within the framework of the “transition to modern urbanism” movement, there has been an attempt to depict various types of urban environments, from the suburbs to the city center, as a continuous spectrum between completely natural and completely artificial spaces. In this view, the presence of natural elements in each part of this spectrum is different, and these differences lead to the formation of various types of green infrastructure in urban environments.

For example, in the central core of the city, the manifestation of green infrastructure can be observed in the form of urban parks, public open spaces, natural routes of intra-urban waterways, and seasonal valleys. In contrast, in peripheral areas and suburbs, this infrastructure often manifests itself in the form of protected areas, belts, green margins of passages, and natural spaces. This continuity and diversity in the manifestation of green infrastructure indicate the efforts of theorists to create a link between the built environment and the natural context in the process of urban development.

Dipeola et al., in a study titled “Factors determining residents’ preferences in urban green infrastructure in Nigeria”, aimed to investigate residents’ preferences for different forms of urban green infrastructure with green features, trees, water, and other factors affecting these in the Lagos metropolis of Nigeria. The results show that participants generally show a greater preference for urban green infrastructure with green features, including green corridors, lawns, sports fields, parks, and gardens, than others. The four main factors determining participants’ preferences for different forms of urban green infrastructure were environmental and health benefits, as well as respondents’ participation in green infrastructure activities in their neighborhoods. The study concluded that urban planners should focus on strategies that maximize the environmental and health benefits and quality of green infrastructure and enhance citizen participation in the development and management of urban green infrastructure in cities in Nigeria and other countries in sub-Saharan Africa (Dipeolu, A.A et al. 2020).

In a study titled “Advancing urban green infrastructure through integrated participatory planning”, Vano et al. aimed to use urban green infrastructure as a research lens to critically evaluate the planning process in Slovakia at the national, regional, and local levels, analyzing planning documents, interviewing green space actors, and evaluating local good practices. The results indicate weak instrumental support for urban green infrastructure planning, as well as other systemic and procedural barriers to the creation of green infrastructure (Vano, S, et al P., 2021).

In a study titled “Building an urban green network from the perspective of ecosystem services and ecological sensitivity”, Bai et al. have proposed the idea that an urban green network is identified and created from the perspective of ecosystem services and ecological sensitivity, and that it is also possible to identify poles through the assessment of ecosystem services and ecological sensitivity, with the aim of improving and protecting ecosystem sustainability and better guiding cities and villages towards green development (Bai, Y., Guo, R., 2021).

In a study titled “Green infrastructure and network cohesion,” Sluis et al. point to the unique role of ecological networks in the formation of the concept of urban green networks and consider the process of networking and its coherence to originate from landscape ecology (Sluis, T.V.D., 2021).

Feng Li et al., in a study titled “Urban environmental

Infrastructure: An Integrated Network for Ecosystem Services and Sustainable Urban Systems,” define “urban environmental infrastructure” and propose an integrated framework in which the infrastructure network changes despite changing ecosystem services and sustainable urban systems (Feng Li et al., 2017).

Tulisi, in a study titled “Urban green network design: defining green network from an urban planning perspective,” studies the urban green structure as a network and measures the performance of the green structure system by creating models (Tulisi,2017).

In a study titled “Effects of relationships between critical problems (key barriers) in sustainable renewal of old residential neighborhoods in China”, Zhu and his colleagues aimed to identify critical barriers to sustainable neighborhood renewal in China and explore their related interaction mechanisms. They investigated the barriers through library studies and interviews with experts. Then, they examined the relationships between barriers using a fuzzy method. The results revealed thirteen major barriers, and among them, the lack of effective support policies was considered the main reason for unsustainable neighborhood renewal. In addition, the lack of a private enterprise mechanism, unequal and ambiguous information among stakeholders, lack of public participation, low profit of the private sector, and immature laws and regulations were all proven to be important causes (Zhua, Sh et al. 2020).

In a study titled “Conceptualizing green infrastructure in desert cities” with the aim of searching for and operationally defining green infrastructure in mature discourses of water and city, as well as finding instances of green infrastructure in desert cities, using the qualitative content analysis method in texts related to green infrastructure and establishing the concept of infrastructure, and after analyzing the definitions, they concluded that green infrastructure in central Iranian desert cities is not only considered as a title for urban organs that are members of a natural and artificial ecological network, but also can be referred to as a scientific approach and a method of environmental design and planning that supports the best type of relationship between water and city form to support natural and artificial processes in water resource management in historical desert cities. In cities on the edge of the desert, green infrastructure exists as a multi-functional system that creates value for providing ecosystem services with the aim of sustainable resource management. This network includes a wide range of canals, gardens, streams,

urban spaces, and water-based natural and artificial architecture (Qadrian et al., 2014).

A study titled "Evaluation of spatio-temporal changes in urban green infrastructure based on spatial processes decision tree algorithm in Tehran" aimed to analyze spatio-temporal changes in the pattern of urban green infrastructure in Tehran affected by the spatial processes of the landscape. Using the decision tree algorithm method to identify spatial processes and landscape metrics in analyzing the impact of spatial processes on changes in the pattern of composition and distribution of green infrastructure, it was observed that the processes of "removal" and "fragmentation" respectively reduce the number and area of green and open lands in the combined pattern and also disrupt the spatial connection and continuity of these lands.

The result of this trend is the creation of an unbalanced distribution and a reduction in the continuity of green infrastructure in the landscape of Tehran (Naroui et al., 2014).

In another study titled "Landscape green networks: the role of articulation in the integration of green spaces in the landscape of contemporary Iranian cities," written by Sabunchi et al. (2018), point out that to investigate the internal and external coherence of the green network, it is necessary to use the landscape-based articulation strategy. Articulation, with an emphasis on the functional structure and identity role of the city's green structure, is a basis for regulating and organizing green spaces in relation to other urban structures and an effective factor in their quality. Articulation, by creating a single network of green spaces, leads to a better perception and understanding of citizens of the landscape and natural environment, and a basis for increasing the readability and identity of the city (Norouzi & Bemanian, 2019).

In a study titled "Analysis of the effect of urban green infrastructure on improving environmental sustainability components", the aim was to investigate the relationship between different classifications of urban green space, such as distance from green space, functional scope, and the relationship between different functions of the urban landscape, distance of green spaces from residential areas, their type of use, and the role of landscape elements on infrastructure, environmental, and service components as an approach for improving urban sustainability indicators and improving the livability of citizens. In this study, which was conducted with a descriptive-analytical approach and using a survey method, data were

collected through a questionnaire and analyzed using descriptive and inferential statistical methods. The results of data analysis in the SPSS software environment showed that the type of spatial structure of green spaces, their thematic function, and the distance from residential areas all have a direct and significant effect on changing environmental sustainability indicators at the city level (Norouzi & Bemanian, 2019).

In a study titled "Explanation of the intervention pattern in urban green infrastructures with the aim of creating ecological resilience," they found that, to date, urban green infrastructures and their role in urban design and planning have not been properly formulated. While it has been proven that the use of urban infrastructure is one of the important strategies for reducing and adapting to climate impacts, precise principles for the proper use of this infrastructure in cities have not been presented so far (Shirgir et al., 2019).

In a study titled "Analysis of the effect of urban green infrastructure on improving social and economic indicators of quality of life", the impact of different classifications of green spaces on social and economic factors affecting livability indicators was investigated and analyzed. Then, by collecting the data through a questionnaire and examining the relationship between landscape functions, landscape distance from residential environments, and landscape components on economic and social factors, it was concluded that improving livability in cities is an approach to achieving social and economic sustainability of green spaces and cities. In general, green spaces such as industrial parks or those parks located on the outskirts and at a great distance from the urban context play a small role in improving the social and economic livability indices of cities. In contrast, green spaces located in the vicinity of areas with diverse uses, especially those with commercial, recreational, or other similar functions, have shown the greatest impact on increasing livability indices in social and economic dimensions (Norouzi, 2019).

A review of the research background shows that most of the research presented in relation to the discussion of green infrastructures has focused more on the environmental and physical dimensions of urban contexts and has paid less attention to the role of urban green infrastructures in the social sustainability of neighborhoods. Also, most domestic studies have examined the amount of green space per capita and its relationship with social indicators, such as social

sustainability, and place attachment has been less studied. The present study focuses on old neighborhoods and the old urban context area, using advanced statistical methods (factor analysis and structural equation modeling in AMOS software). An objective examination of the role of green infrastructure in the city's old neighborhoods (lawns, neighborhoods, and canals) based on social sustainability criteria provides a model appropriate to Iranian culture and tradition in the historical contexts of old neighborhoods.

### 3. Theoretical foundations of research

#### 3.1. Urban green infrastructure

The green infrastructure movement has its roots in land studies and the interaction between humans and nature, which began more than 150 years ago. The roots of green infrastructure planning and design are related to ideas and actions taken to preserve nature through national and state parks, wildlife refuges, forests, rivers, wetlands, and wilderness protection. In essence, green infrastructure is a scientific approach that best uses land to support both natural and artificial processes that create natural landscapes and complement the infrastructure and recreational needs of citizens (Benedict & McMahon, 2002). The idea of forming and creating green infrastructure dates back to the early 1900s when Theodore first proposed the idea of a connected park (Eisenman, 2013). It continued in the form of topics and examples of open space with green roads, urban gardens, and landscape ecology (Hakimian & Lak, 2017). However, the first academic concept related to green infrastructure began in the early 1990s to 1995 in the works of people such as Little (1995), Ahern (1995), and Fabos (1995), focusing on the aspects of the physical connection of green spaces. This trend continued from 1995 to 2005 with an emphasis and focus on the different dimensions and aspects of this physical connection in the works of these people (Fábos & Rayan, 2006), until it entered the metamorphosis stage of this literature in 2005. In 2006, Benedict and McMahon (2006) took the concept of green infrastructure to a new level by emphasizing ecological aspects.

This development was welcomed by experts in the field, including Ahern (2007). Urban green infrastructure generally refers to a set of multi-purpose green spaces and facilities with diverse characteristics that support sustainable development. Green

infrastructure occurs in urban areas in four different forms: 1) green facilities (like, green roofs, parks and gardens, lawns and sports fields, and green corridors); 2) tree facilities (like, community forests, urban forests, and street trees); 3) water facilities (like, floodplains/wetlands, rivers, ponds, and lakes and springs); 4) other (like, open spaces, non-green parks, wildlife habitats, school playgrounds, and cemeteries) (Wolch, 2014; Adegun, 2018; Dipeolu & Ibem, 2020). Currently, most cities are building green spaces in the form of green infrastructure, which ultimately results in a fragmented and inefficient space. In addition, the uneven distribution of resources and the invasion of urban green spaces by species that are not compatible with the region's ecosystems not only reduce urban ecological services, but also destroy the balance and sustainability of the urban ecosystem.

Therefore, it is necessary to integrate urban green spaces to create a united network to improve ecosystem services, environmental services, and habitats for urban organisms, and ensure urban environmental security (Carmerona, 2012). According to Morris and Brown, green infrastructure can be transformed into the city's consensus areas, including identity creation, presence, and memory building. Moreover, at a higher horizon, its useful function can be used in the exploitation of cultural, social, and ecological applications. (Mahmoodzadeh et al., 2010). Green infrastructure brings many benefits in the fields of the environment, the economy, and the health of citizens. Among the spaces that are particularly evident in enjoying the benefits of green infrastructure are urban spaces and the suburbs of cities, where the presence of green space is limited and leads to wider environmental damage. The components of green infrastructure include a variety of natural, native ecosystems, and landscape types that create a system consisting of centers and connections between them: A\_ center: the origin or destination of wildlife and ecological processes. Such as large protected areas (national and state parks and wildlife habitats), protected native landscapes (large state lands and forests), agricultural lands (private farms, pastures), and regional and protected parks and public and small parks; B\_ connections: connecting elements connect centers and make green infrastructures come alive and work as a network, such as related landscapes (large natural protected areas), linear protected corridors (rivers and streams), green paths with recreational functions, and green or ecological belts.

Accordingly, a green infrastructure network is a type of interconnected network of green spaces that protects the values and functions of natural ecosystems (Hakimian & Lak, 2016). Instead of being a profit-making goal, green infrastructure should achieve the following goals: 1- enriching the sense of place: green infrastructure as a spatial framework (elements of the mental landscape) for citizens' orientation; 2- linking public interest and benefit: green infrastructure as part of national and collective wealth that is created by collective efforts and must be under continuous maintenance; 3- improving ecological performance: green infrastructure as a system intertwined with ecological systems and the natural environment. Green infrastructure focuses on immediate social needs to transform artificial or urban environments into better places with high social sustainability and higher resilience. Urban green infrastructure itself is a kind of social ecological system, which is the result of interactions of various elements, especially humans. The components of urban green infrastructure can be considered a combination of open and closed spaces and a mixture of natural plant habitats, which are of high ecological, social, and economic importance. As a result, appropriate design in these spaces can have significant impacts on daily life, and resilient design is one of the most appropriate principles and relationships for designing such spaces (Oliver, 2014). Types of green infrastructure include green roofs, permeable green surfaces, green paths and streets, urban forests, and public parks (Demuzere, 2014).

### 3.2. Social sustainability

Social sustainability is one of the dimensions of sustainable development that has been historically discussed later than other dimensions and has received less attention, especially in the area of urban neighborhoods. This is while, according to sociologists, not paying attention to the social dimensions of development has had painful consequences for various societies, including its manifestations at the international level, such as civil unrest. One of the major challenges for governments in the current century is environmental issues and inappropriate exploitation of the environment, which is largely rooted in the lack of continuity and synergy in urban green infrastructure networks (Grunwald, 2018). In this context, urban green infrastructure plays an important role in shaping and developing human-generated space. At a larger level, urban green infrastructure can be defined as a green landscape or

network that enhances the connectivity of natural elements at an urban scale (Jongman & Pungetti, 2004; Bennet & Mulongoy, 2006). Major attention to urban green infrastructure has been evident at international levels in recent years, and research emphasizes the development of green space and the protection of natural features in the urban landscape (Hakimian & Lak, 2017). In addition to defining visual boundaries, these infrastructures shape the abundance and distribution of natural elements such as forests and wetlands in the urban landscape. Just as artificial infrastructures such as roads, water, and electricity networks are essential to modern societies, green infrastructures are also an integral part of urban sustainability mechanisms.

On the other hand, social sustainability can be understood as the ability of a society to maintain and strengthen institutions and mechanisms that provide the basis for creating collective well-being, continuing social participation, and maintaining the stability of social elements. In other words, this concept refers to a set of interpersonal interactions, cooperation between formal and informal institutions at the local level, and the existence of social trust and solidarity that ultimately leads to the formation of a common identity and a sense of belonging to a place (Meshkin, 2013; Dempsey, 2012). Despite the fundamental position of this dimension of sustainability, the theoretical and empirical literature regarding its precise definition, measurability, and indicators has not yet reached full coherence. Researchers and policymakers, each with different conceptual and specialized approaches, have presented distinct perceptions and definitions of social sustainability (Colantonio, 2012).

In recent decades, significant changes in urban lifestyles have transformed the social and physical structure of neighborhoods. In such circumstances, the sustainable development approach, as a theoretical framework for responding to the growing challenges of cities, has once again placed the concept of "neighborhood" at the focus of attention of planners and researchers. The neighborhood, as the smallest social and spatial unit of the city, has a valuable capacity to improve the quality of urban life and strengthen social dynamics. Utilizing internal resources, social capital, and potential capabilities in neighborhoods can provide a platform for solving urban problems and improving livability. In the Iranian context, the category of neighborhood-based development is associated with considering specific

cultural, social, and physical conditions. Therefore, combining new local management models with deep-rooted traditions of neighborhood life is considered a critical priority on the path to achieving urban sustainability. Given that social sustainability is one of the fundamental pillars of sustainable development, its realization and strengthening at the neighborhood scale requires the promotion of effective environmental qualities. When the neighborhood environment has characteristics that facilitate and encourage social interactions, the ground is prepared for the formation of social cohesion and sustainability. In other words, focusing on environmental quality and promoting the vitality and efficiency of urban spaces is a determining factor in the continuity of urban life and strengthening the foundations of social sustainability (Razmjoo, 2015). The prerequisite for the formation of social sustainability in neighborhoods is the creation of qualities that lead to a quantitative and qualitative increase in collective actions and social interactions among residents. The criteria for social sustainability in urban neighborhoods can be expressed as follows: activity, which includes the diversity of activities, vitality, accessibility, and local markets; identity, encompassing memorable places, local mosques, local elements, and urban landmarks; security, involving management and maintenance, monitoring, privacy, and access; and spatial justice, which ensures access to educational, service, sports, and cultural centers. Physical spatial coherence includes: hierarchy, continuity and integration, and class density (Jenks and Jones: 2010, Axelsson et al:2013).

### 3.3. The link between green networks and social sustainability

Social sustainability means establishing justice in access to urban resources, promoting participation and social interactions, and strengthening collective identity (Campbell, 1996). Green space networks provide a suitable platform for the formation of social capital and intergenerational interactions by providing meeting places, recreation, and socio-cultural activities (Wolch, Byrne & Newell, 2014). This link is established through several key dimensions:

**Spatial justice:** Fair distribution of green networks in different neighborhoods prevents the concentration of services in privileged areas and the deprivation of other groups (Lutfi, 2017).

**Social capital:** Public green spaces act as focal points for social interactions and the creation of social bonds, which leads to a strengthening of a sense of belonging

and civic participation (Kuo, 1998).

**Mental and physical health:** Equal access to green networks facilitates stress reduction and increased physical activity, which results in improved quality of life and reduced health costs at the societal level (Maas et al., 2006).

## 4. Research method

The present study is applied in terms of purpose and descriptive-analytical in terms of nature and method. In this study, an attempt has been made to measure and analyze the role of urban green infrastructure in the social sustainability of historical neighborhoods in Hamadan city by using statistical methods and structural modeling. The statistical population of the study includes all residents of five historical neighborhoods in Hamadan city, which are: Kalpa, Kababian, Haji, Aghajani Beg, and Khatuniyeh. These neighborhoods were selected as representative examples of the traditional fabric of Hamedan due to their historical background, the presence of natural elements such as canals and springs, and the continuity of human settlement over time. For this purpose, the concept of urban green infrastructure and its relationship with social sustainability were first examined, and by studying the records and referring to reliable scientific sources, the literature on the subject was compiled, and basic information and theoretical foundations were completed. The quantitative and qualitative data needed for analysis, review, and comment on the research criteria were obtained through questionnaires distributed among residents and people in business located in the aforementioned neighborhoods.

### 4.1 Statistical population and sample size

In order to determine the sample size, the Cochran formula was used. Considering the population of residents of these neighborhoods and a 95% confidence level, the sample size was estimated to be 385 people. The samples were selected from among the resident households by a simple random method, and questionnaires were distributed among them.

### 4.2 Information gathering

In this study, the questionnaire was researcher-made. The questions were designed using the theoretical foundations of the research and previous models to cover the indicators related to the research variables. The questionnaire consists of two main parts: the first

part is dedicated to the demographic characteristics of the respondents (gender, age, education, and residence history). The second part includes items on the dimensions of social sustainability (neighborhood identity, sense of place, social participation, social security, presence, and access to green infrastructure). The questionnaire items were designed based on a five-point Likert scale (from completely disagree to completely agree). Then, the parameters obtained in the field of sustainability and urban green infrastructure were converted into quantitative parameters and analyzed using SPSS software, which included different age and gender groups with different levels of education and jobs in the neighborhood. 60% of the respondents to the questionnaire were men, and 40% were women. Moreover, in terms of education, the respondents included: 25% freelance, 20% employees, 18% government, 18% market, 25% local people in business, and 12% other jobs. In terms of education, the respondents included: 8% cycle, 23% diploma, 21% post-diploma, 26% bachelor's, 20% master's, and 2% doctorate. Also, 70% of the respondents were married, and 30% were single.

To ensure the content validity of the questionnaire, the opinions of experts and specialists in the field of urban planning and urban sociology were applied, and the necessary amendments were made in the form of an initial review. Cronbach's alpha was also applied to measure the reliability of the instrument. The alpha value for the entire questionnaire was calculated to be 0.86, which indicates the appropriate reliability of the measurement instrument.

It has been carried out at two levels: descriptive and inferential. In the descriptive part, statistical indicators such as mean, standard deviation, frequency distribution, and percentage were used. In the inferential part, confirmatory factor analysis (CFA) and structural equation modeling (SEM) were used to examine the structure of relationships between variables using Amos software. Additionally, SPSS version 26 software was used for preliminary analyses and data reliability. Cronbach's test can be used to examine the reliability of the research, and by placing the information obtained in the Cronbach's formula, we have reached a percentage of 94.7%, which indicates that the closer the percentage obtained is to 100%, the greater the reliability of the questionnaire. In this article, to extract indicators and develop a conceptual research model, a systematic review method was used. First, domestic and foreign scientific research articles related to the concepts of "urban

green infrastructure" and "social sustainability" were reviewed from reputable scientific databases such as SID, Science Direct, etc.

After refining the sources and selecting relevant studies, the most frequent indicators and components confirmed by previous research were extracted. In the next stage, the extracted indicators were categorized based on conceptual overlap and theoretical convergence and were grouped into the main dimensions of social sustainability, including: neighborhood identity; sense of place belonging; social participation; social safety and security; and presence and access to green infrastructure. Finally, based on these dimensions, a conceptual model of the research was designed in which urban green infrastructure was considered as an independent variable and social sustainability as a dependent variable.

Based on the extracted conceptual model, a questionnaire was designed in which each dimension of social sustainability was considered as a latent variable, and a set of observable items was developed to measure each variable. For each dimension, it is as follows: Neighborhood identity - Sense of place belonging - Social participation - Social safety and security: - Presence - Access to green infrastructure. They were designed based on a five-point Likert scale (from completely disagree = 1 to completely agree = 5). The resulting data, after coding, were converted into quantitative variables and used for statistical analyses.

In the first step, in order to identify the factor structure of the variables and reduce the data, exploratory factor analysis (EFA) was performed using SPSS software. Before performing the factor analysis, the data adequacy was checked with the KMO test and Bartlett test, which confirmed the suitability of the data for factor analysis.

Next, the number of factors was determined using a scree plot. Based on this chart, the breakpoint of the curve was observed. After this point, the slope of the curve decreased significantly, and the changes in the eigenvalues became insignificant; therefore, the factors before the breakpoint were considered as significant factors.

## 5. Discussion and research findings

### 5.1 Study area

The samples studied in this research are the neighborhoods of Kalpa, Aghajani Beig, Khatunieh,

Kababian, and Haji, which are considered traditional neighborhoods of Hamedan and have a historical background.

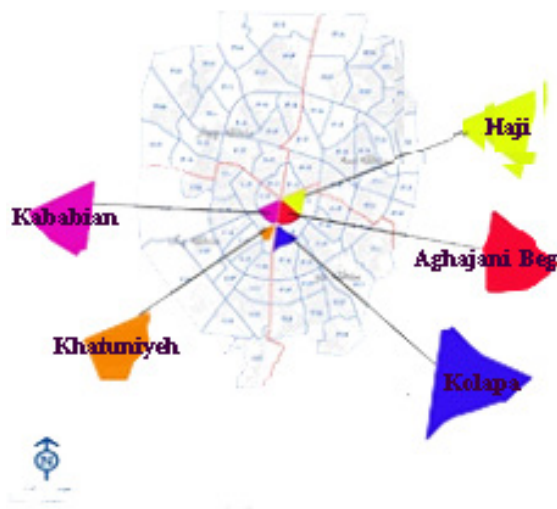


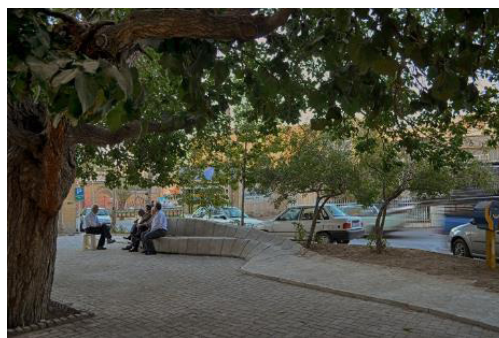
Figure 2. Location map of Aghajani Beg, Haji, Kolapa, Khatuniyeh, and Kababian neighborhoods in Hamedan city

The neighborhoods studied in this study are considered to be among the old neighborhoods of Hamedan city. Given that traditional neighborhoods in Hamedan typically developed around natural features—such as rivers, aqueducts, or green areas—and centered around a focal green space known as the “neighborhood lawn” (often featuring a single tree), they serve as a highly suitable case study for this investigation. In fact, the nature of the formation of the aforementioned

neighborhoods is based on the same green infrastructure in the neighborhood, which is the reason for the creation of social places in the first place, and then a solid reason for the continued survival and social sustainability of the neighborhoods. They have maintained their spatial identity over the years, and these neighborhoods are usually known as the neighborhood lawn.



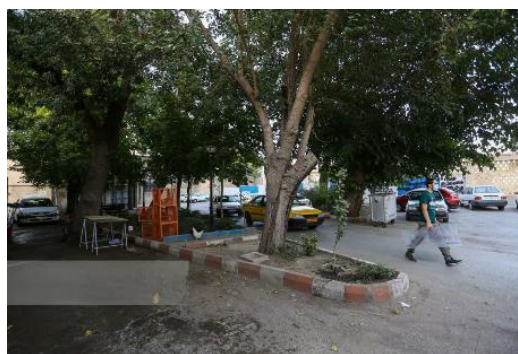
Haji neighborhood lawn



Kolapa neighborhood lawn



Khatunieh neighborhood lawn



Kababian neighborhood lawn

Figure 3. Image of the lawns of the studied neighborhoods

**Table 1. Demographic characteristics of respondents**

Variable	Percentage
Gender (male) 60%	60%
Gender (female) 40%	40%
Marital status (married) 70%	70%
Marital status (single) 30%	30%
Education (diploma and less) 31%	31%
Education (post-diploma) 21%	21%
Education (bachelor's degree) 26%	26%
Education (master's degree and above) 22%	22%

### 5.2. Analysis of findings

The main indicators examined in this study include 7 criteria: identity, presence, attachment to place (sense of belonging), social safety and security, social participation, and accessibility. All of their sub-indices

(items) examine the role of green infrastructure on the aforementioned criteria. According to the table presented, all sub-indices (items) examine the relationship between the aforementioned variables in relation to the green infrastructure of neighborhoods.

**Table 2. Indicators examined in the research**

Variables	Items
Identity	Optimal use of environmental green elements, existence of old trees, existence of canals, geometric shape of environmental space, and climatic and natural factors
Presence	Activity diversity, climatic comfort and convenience, social happiness and vitality, enclosed green space, diversity of vegetation, face-to-face encounters, use in different time periods, peace and comfort, flexibility of environmental green elements, mental health, diversity of garden and green space form, and vegetation.
Attachment to place	Sense of pride and boasting, collective memories, level of belonging of residents, and behavioral patterns of residents
Social safety and security	Children's safety, sense of security, safety and security of women and children, nightlife, and strangeness
Social participation in the neighborhood	Conducting meetings and decisions, raising awareness and education, conducting rituals, social relations, intimacy, and social interactions
Accessibility	Range of access to green infrastructure, access and permeability of green space, easy access for children, and safe access

The analysis process of the collected data was carried out using SPSS software and based on the Pearson correlation test. The results of these analyses are presented and explained in Table 2. According to the data in Table 3, the correlation coefficient of the data can be examined as follows: the correlation coefficients are mostly positive, and this indicates the existence of a significant relationship between the components examined. According to the obtained correlation coefficients, the identity components in relation to the green infrastructure of the neighborhoods have a significant relationship with the components of presence, safety and accessibility with correlation

coefficients of 0.51, 0.17 and 0.31, respectively; This means that just as the presence of green infrastructure in neighborhoods is effective in creating neighborhood identity, it also plays an effective and positive role in creating safety, presence, and accessibility. Moreover, green infrastructure factors in the presence component have the greatest impact on the identity components of 0.51, attachment to place 0.70, and safety 0.23 in relation to green infrastructure in neighborhoods. In the context of components related to attachment to place - green infrastructure, the effective correlation coefficients for the two presence components are 0.70 and 0.18 for accessibility. The safety-green

infrastructure component has the highest correlation coefficients with the identity-green infrastructure components of 0.17, presence-green infrastructure of 0.23, and access-green infrastructure of 0.54. The social participation-green infrastructure component does not correlate with any of the other components. Moreover, the access-green infrastructure component

has the highest correlation with the identity-green infrastructure component, with a correlation coefficient of 0.31, with the attachment to place-green infrastructure component, with a coefficient of 0.18, and with the safety-green infrastructure component, with a coefficient of 0.54.

**Table 3. Pearson analysis of data**

		Correlations						
		Qualities	Identity	Presence	Attachment	Safety	Participate	Accessibility
Identity	Pearson correlation		1	0.51	0.00	0.17	0.10	3.31
	Significance level of the test		0.00	0.00	0.00	0.00	0.00	0.00
	Sample size		152	87	111	128	96	93
Presence	Pearson correlation	0.51	1	1.70	2.32	0.00**	0.00	
	Significance level of the test	0.00	0.00	0.00	0.00	0.00	0.00	
	Sample size	87	113	84	111	66	61	
Attachment	Pearson correlation	0.00	1.70	1	0.00**	0.200*	0.18	
	Significance level of the test	0.017	0.00		0.009	0.028	0.00	
	Sample size	111	84	148	127	101	95	
Safety	Pearson correlation	0.17	3.23	*00.00	1	0.00**	2.54	
	Significance level of the test	0.00	0.00	0.009		0.03	0.00	
	Sample size	128	111	127	171	100	99	
Participate	Pearson correlation	0.00**	0.00**	0.00**	0.00**	1	0.00	
	Significance level of the test	0.00	0.011	0.028	0.003		0.088	
	Sample size	96	66	101	100	123	83	
Accessibility	Pearson correlation	3.31	0.00	0.18	2.54	0.00	1	
	Significance level of the test	0.00	0.00	0.00	0.00	0.088		
	Sample size	93	61	95	99	83	122	

\*. The correlation is significant at the 0.05 level (two domains)

\*\* . The correlation is significant at the 0.01 level (two domains).

In addition, the perceived importance of the questionnaire items was evaluated by analyzing their descriptive statistics. In Table 3, the interpretation expresses the mean and standard deviation of the statistical population in response to the raised items.

As can be seen, the mean of most questions is between the numbers 3 and 4, and the standard deviation of the items varies between the numbers 0 and 1. In fact, these numbers express the importance of the items.

Table 4. Mean and standard deviation of data.

	Item	Mean	Standard deviation
Identity	Environmental green elements - natural identity of space and neighborhood vitality	3.00	0.00
	Old trees and grass - neighborhood identity	4.04	10.00
	Canals - springs - physical identity	4.00	0.00
	Geometric shape of the living space and identity	3.00	10.00
	Climatic and natural factors, and spatial and physical identity	2.00	10.00
Presence	Green space and the possibility of hosting events	3.00	1.007
	Neighborhood green space - activity diversity	4.00	1.022
	Environmental elements - climate comfort	4.00	10.00
	Size of green space - presence	4.00	0.00
	Green space - social happiness and vitality	4.00	0.00
	Neighborhood lawns - promoting vitality	3.00	0.00
	Enclosure of green infrastructure space - presence	3.00	0.00
	Variety of vegetation - presence	3.00	10.00
	Neighborhood lawns - face-to-face encounters	3.00	10.00
	Possibility of using green space - different time periods	2.00	10.00
	Flexibility of environmental green elements - presence	3.00	0.00
	Existence of environmental green elements - comfort and convenience	3.00	0.00
	Green infrastructure - sense of calm	4.08	0.00
	Environmental elements - mental health	3.00	10.00
	Variety of green infrastructure forms - presence	2.00	10.00
Sense of belonging	Vegetation - neighborhood sustainability	3.00	10.00
	Green infrastructure - sense of pride and boasting	2.00	10.00
	Belonging to environmental elements	2.00	10.00
	Role of environmental elements - collective memories	2.00	10.00
	Sense of pride and boasting - neighborhood green space	3.00	0.00
Sense of belonging (attachment to place)	Lawn and green space - behavioral pattern	3.08	10.00
	Neighborhood lawns - children's sense of safety	4.04	0.00
	Green infrastructure - sense of security	4.00	0.00
	Green infrastructure - movement security and crossing safety	4.00	0.00
	Green infrastructure - women and children use	3.00	10.00
	Public monitoring of green infrastructure - improving neighborhood safety	3.08	10.00
	Green infrastructure - nightlife security	4.00	0.00
Neighborhood green infrastructure - neighborhood alienation	3.00	10.00	

	Item	Mean	Standard deviation
Neighborhood social participation	Green infrastructure - holding neighborhood meetings and decision-making	3.00	0.00
	Green infrastructure - improving awareness and educating residents	2.00	0.00
	Green infrastructure - ritual ceremonies	2.00	10.00
	Green infrastructure - improving social trust	3.00	0.00
	Green infrastructure - social relationships and intimacy	3.00	0.00
	Green infrastructure - social interactions	4.00	0.00
Accessibility	Range of access to green infrastructure	3.00	0.00
	Access to green infrastructure - neighborhood scale	2.00	0.00
	Access to green infrastructure - improving the quality of neighborhood space	3.00	0.00
	Accessibility and permeability of green infrastructure	2.00	0.00
	Easy access to green space - children	2.00	0.00
	Safe access - children	1.00	0.00

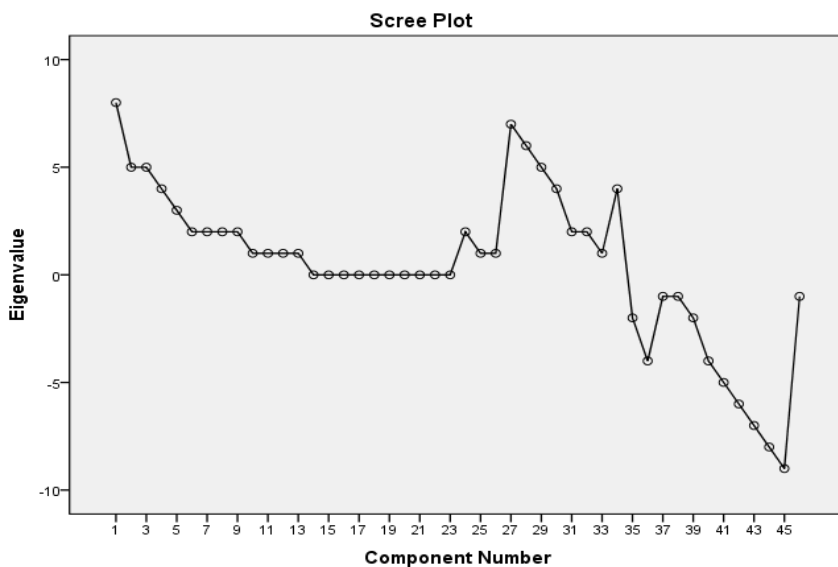


Figure 4. Scree plot

The scree plot shown in Figure 4 examines the extent of the relationship between the items presented and environmental green infrastructure. According to the scree plot, it can be seen that among the factors mentioned, the first factor, which is a subset of the identity variable, has the greatest relationship with urban green infrastructure, meaning that urban green infrastructure has the greatest positive impact on creating urban and neighborhood identity. In relation to the research conducted, among the related factors of social sustainability, urban green infrastructure has the greatest relationship with the identity variable. Therefore, the higher the quality of environmental

green infrastructure, the greater the identification with space. Another variable that is most affected by environmental green infrastructure is the variable of attachment to place (sense of belonging). In fact, the existence of green environmental infrastructure (neighborhood lawns and single trees) is effective in creating and promoting a sense of place among neighborhood residents. The existence of green environmental infrastructure also increases social safety and security. In the field of social participation, it can be stated that green environmental infrastructure does not have a significant impact on increasing the level of social participation.

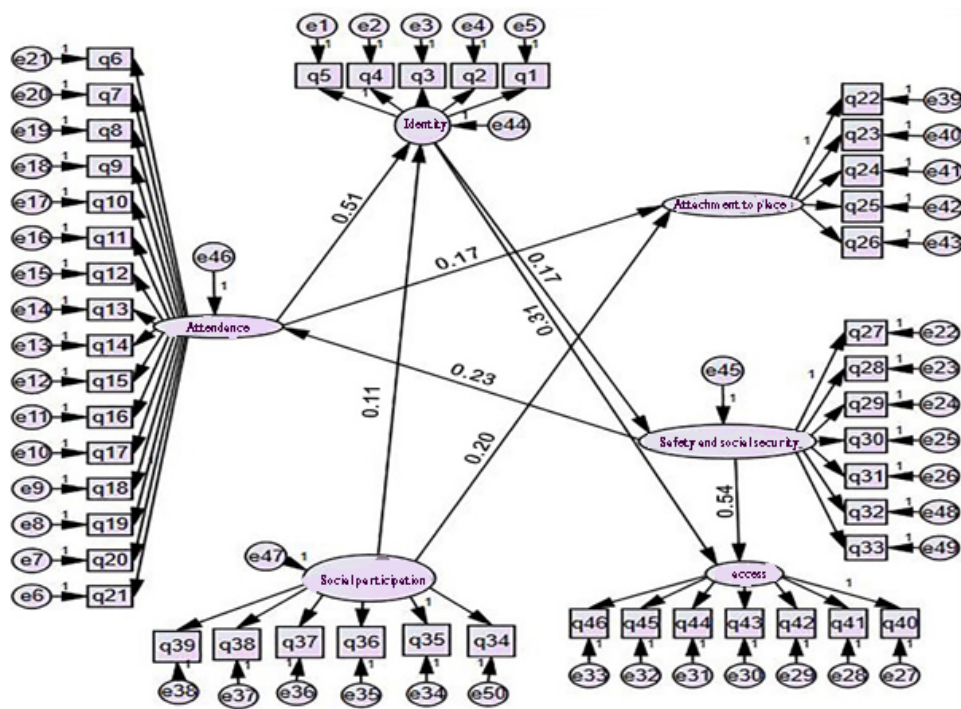


Figure 5. AMOS data analysis

After proving the impact of green infrastructure on the social sustainability of neighborhoods, the next step was to examine the degree of influence and impact of sustainability factors on each other in terms of environmental green infrastructure using AMOS software. The results of data analysis can be presented

according to Figure 5, as is clear. The components of presence - identity have the greatest influence and impact on each other. Moreover, the lowest level of influence is related to the component of social participation.

Table 5. Correlation coefficients between dimensions of social sustainability and green infrastructure

Variable	Identity	Presence	Spatial belonging	Safety and security	Social participation	Accessibility
Identity	1	0.51**	0.31*	0.17*	0.1	0.31**
Presence	0.51**	1	0.70**	0.23**	0.11*	0.28**
Spatial belonging	0.31*	0.70**	1	0.20*	0.18*	0.18*
Safety and security	0.17*	0.23**	0.20*	1	0.19*	0.54**
Social participation	0.1	0.11*	0.18*	0.19*	1	0.14
Accessibility	0.31**	0.28**	0.18*	0.54**	0.14	1

The highest correlation was observed between “presence” and “spatial belonging” (0.70), indicating that access and diverse use of green space have the greatest impact on creating a sense of belonging to the neighborhood. “Safety and security” also have a strong relationship with “accessibility” (0.54). Social participation had the least relationship with other variables.

infrastructure in old neighborhoods of Hamedan had the greatest impact on identity and place belonging, and this is consistent with the results of the study by Norouzi and Bemanian (2019). Compared to the study by Shirgiri et al. (2019), the focus of this study is on social dimensions (not just ecological), and its innovation is in emphasizing the role of identity and sense of belonging in the social sustainability of traditional neighborhoods.

The findings of the study showed that green

## 6. Conclusion and suggestions

This study investigated the relationship between the quality of urban green infrastructure (parks, lawns, and single trees) and the social sustainability factors of traditional neighborhoods (identity, presence, attachment to place, social participation, social safety and security, and accessibility). Considering the importance of green space in old neighborhoods and the various uses of green spaces in their neighborhoods by residents of old neighborhoods, it is necessary to know how a green space affects the social issues of its users and can meet the areas of social sustainability. identity, presence, attachment to place, social participation, social safety and security, and accessibility—to support the social sustainability of neighborhoods. Additionally, each of these factors includes a range of questionnaire items and related sub-factors. Specifically, the identity factor comprises the range of questions and sub-criteria)q1- q5), where q1 relates to the optimal use of urban green infrastructure, q2 to the presence of old trees, q3 to the presence of canals and springs, q4 to the geometric shape of the green infrastructure, and q5 to the role of climatic factors in neighborhood identity. Among the five sub-criteria mentioned, q3 (the presence of canals and springs) has the greatest impact on identity and green infrastructure, with an impact percentage of 37%. The presence criterion includes the range of questions: q6 occurrence, q7 activity diversity, q8 climatic comfort, q9 size (area and number) of green space, q10 social happiness and vitality, q11 vitality, q12 spatial confinement, q13 diversity of vegetation, q14 face-to-face interaction, q15 possibility of using the space in different time periods, q16 flexibility of green elements, q17 sense of comfort and convenience, q18 inducing a sense of peace, q19 mental health of neighborhood residents, q20 diversity of space and garden forms, and q21 neighborhood sustainability. Among these, q9—size (area and number) of green space—with a 61% impact on neighborhood sustainability, is the most important option within the range of presence criteria. In fact, the greater the number of neighborhood green spaces at different scales, the greater the presence of residents is provided, and as a result, the social sustainability of neighborhoods is expanded. In the topic of attachment to place, 5 sub-criteria were examined, including: q22 sense of pride in the neighborhood, q23 residents' attachment to the neighborhood's environmental elements, q24 creation of collective memories, q25 sense of pride in the neighborhood's environmental

elements, and q26 behavioral pattern. Finally, two sub-criteria, q22 sense of pride and boasting of residents towards the neighborhood, and q24 role of canals, fountains, and green infrastructure in creating collective memories, were jointly selected with an impact percentage of 20% as the most influential criteria in the topic of attachment to place. Regarding the social safety and security criteria, the options examined include: q27 children's sense of safety, q28 residents' sense of safety, q29 traffic safety and crossing safety, q30 women's and children's safety, q31 public surveillance and neighborhood safety, q32 nightlife safety, q33 neighborhood strangeness. Moreover, option q28 residents' sense of safety was selected with a 44% impact on social sustainability. This point states that to the extent that the green space of neighborhoods (green infrastructure) is considered, to the same extent, the sense of security is created among the residents of the neighborhood. In relation to social participation, several factors were examined: q34 holding neighborhood meetings, q35 raising awareness and education, q36 holding ritual ceremonies, q37 social trust of residents, q38 emotional relationships and intimacy of residents, and q39 social interactions. Moreover, factor q39 (social interactions), with a 49% impact on social sustainability, was found to be superior to other factors. Finally, the quality of access was evaluated by examining: q40 access radius, q41 access scale, q42 easy access for residents, q43 accessibility and permeability of space, q44 easy access for people with mobility problems, q45 easy access for children, and q46 safe access for children. Among these, factor q42 (easy access for residents) was identified as the most important element in the area of accessibility, with a 26% impact on sustainability components.

In the present research, we have reached the conclusion that to have a sustainable social space, we need a standard design that is of high quality and appropriate to the needs of the local people. In fact, the evaluation of the above-mentioned items can be used to better understand the green infrastructure and social needs of the residents of the neighborhoods for use in future plans and programs, so that the indicators of social sustainability increase in the minds of the residents and citizens feel highly satisfied with their living environment. Based on the analyses carried out, it can be stated that types of urban green infrastructures, including single trees, neighborhood lawns, and parks, have a significant impact on different types of sustainability components. In fact, not only

are sustainability components influential in urban green infrastructure, but these two factors also complement one another; the evolution and improvement of each factor fundamentally influences the evolution of the other. Moreover, the more attention is paid to urban green infrastructure in urban neighborhoods, the greater the social quality of the neighborhood will be. In fact, green infrastructure can simultaneously improve traffic management in neighborhoods, address issues of identity and belonging of neighborhood residents, and also improve social safety and security. The general results of the analyses can be expressed as follows:

### 6.1. Suggestions

The present study was conducted with the aim of explaining the role of green infrastructure in promoting social sustainability of traditional neighborhoods in Hamedan city. The results showed that green infrastructure, as one of the basic components of the spatial structure of traditional neighborhoods, plays a significant role in strengthening social identity, increasing social interactions, and promoting residents' sense of security and place belonging. The findings indicate that the quality, diversity, and layout of neighborhood green spaces, more than their quantity, are influential factors in shaping social sustainability, and easy and fair access to these spaces creates the basis for increasing social presence and vitality.

Furthermore, the integrated connection between green spaces and the local road network helps strengthen the social cohesion of neighborhoods by improving environmental quality and facilitating daily interactions. The results of the study also emphasize the importance of the role of green infrastructure in activating public spaces, which can lead to the promotion of security and social sustainability of neighborhoods through increased social monitoring. Overall, it can be concluded that an integrated approach based on the targeted development of green infrastructure, considering the physical and social characteristics of traditional neighborhoods, can be considered by urban planners and designers as an effective strategy in promoting social sustainability in Hamedan.

### 6.2. Research limitations

The current study faced several limitations that should be considered when interpreting the results. These constraints include:

Reliance on historical elements (canals, springs, and old trees):

- limited access to these elements in certain areas or changing natural conditions, such as drought and environmental degradation;

- challenges related to the preservation and maintenance of historical elements within urban spaces.

Dependence on natural elements to foster a sense of pride:

- variations in cultural and historical factors that differ across neighborhoods;

- uncertainty regarding the impact of these elements on social identity due to the diverse perspectives of residents.

Enhancing security through green spaces:

- the dependence of security on external variables, including lighting, surveillance, and social activities;

- the need for coherence between the design of green spaces and other urban measures to effectively promote security.

The link between green infrastructure and social sustainability:

- the varying impact of each component based on specific local conditions.

The aforementioned points indicate that barriers to implementing the proposed strategies exist, requiring multi-stakeholder approaches and local participation for overall success.

### Authors' Contributions

All authors of the article have contributed equally in the stages of drafting and publishing the article.

### Acknowledgments

The authors would like to express their gratitude to all participants in the interviews. They would also like to express their gratitude to the esteemed reviewers of this study.

### Conflict of Interest

There is no conflict of interest between the authors and all participants in the interviews conducted, as well as between the authors of the article, for the compilation and all stages leading to its publication. No financial source or material or moral support was provided to the authors of the article, and the authors' financial resources funded all stages of research, compilation, writing, and publication.

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