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# GREEN INFRASTRUCTURE FOR PROTECTING SHIRAZ'S HISTORIC URBAN FABRIC FROM FLOODING

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**Abstract.** Shiraz, a city known for its rich historical urban fabric, faces increasing challenges posed by climate change and extreme weather events, particularly floods. The rapid urbanization and limited stormwater management infrastructure have exacerbated the vulnerability of the city's historic areas to flooding. Due to the registration of 360 km of Shiraz historical fabric in the national register in 2023, the importance of planning to safeguard this precious heritage has become twice as crucial. This study explores the potential of urban green spaces as a sustainable approach to mitigate flood impacts on Shiraz's historic urban fabric. Through a comprehensive analysis of flood patterns, urban green spaces, and historic buildings, this research aims to identify the most flood-prone areas and assess the effectiveness of existing green spaces in minimizing flood risks. The study also evaluates the role of vegetation and permeable surfaces in stormwater management to reduce floodwater runoff and its impact on historical structures. The findings reveal that strategically designed and maintained urban green spaces can act as natural flood buffers, helping to regulate water flow, reduce surface runoff, and minimize flood-induced damage to historic buildings. By integrating green spaces into urban planning, policymakers can enhance the city's resilience to floods and preserve the unique character and heritage of Shiraz's historic urban fabric. This study advocates for incorporating green infrastructure and sustainable stormwater management practices as integral to urban planning strategies. By embracing nature-based solutions, Shiraz can safeguard its historical treasures and foster a more sustainable and resilient urban environment for current and future generations. This research aimed to assess the implications of reducing urban green spaces, particularly in the green belt surrounding Shiraz's historic urban fabric and Snag-e-

Siah neighborhood, on the vulnerability of historical sites to flood damage and potential demolition. With the utilization of urban green spaces, flood damage to Shiraz's built heritage was investigated in this study using both quantitative and qualitative methods simultaneously. The study results showed that the reduction of urban green infrastructure significantly increased the damage caused by floods in the historical area of Shiraz.

**Keywords:** Built Heritage, Natural Disaster, Urban Green Space, Sustainable Flood Mitigation Strategy, Urban Flooding

**Introduction.** The preservation of built heritage holds a profound significance, not only for the well-being of the built environment but also for the essence of community, cultural identity, and the distinct character of a place. Over the 20th century, society has realized the importance of safeguarding natural and historical sites to uphold urban identity and maintain a continuous link between the past, present, and future. Disruption of this continuum can lead to feelings of displacement and loss, underscoring the vital role of preserving built heritage. Since 1995, Shiraz's historic urban fabric has been confronting an alarming destruction process, a trend that accelerated significantly by 2011. Over the past three decades, approximately 20 hectares of the city's total 360 hectares of built heritage have been irreversibly lost due to new urban development and construction, excluding new streets. Concurrently, the adverse effects of climate change have manifested in natural disasters, particularly urban flooding, wreaking havoc on familiar surroundings and emotional landmarks, especially within historical sites. In 2019, a devastating flood severely impacted Shiraz's neighborhoods, inflicting extensive damage on the city's urban fabric. In disaster response, the importance of built heritage sites is often relegated to a lower priority than other infrastructure aspects. While certain measures exist to mitigate the impact of natural disasters, both structurally and non-structurally, scant attention has been devoted to exploring the potential role of urban green spaces as a sustainable strategy for flood mitigation. Traditional hazard mitigation methods, such as rainwater retention tanks, previous paving, and pumping stations, have received primary focus in previous research. At the same time, adopting more sustainable approaches to preserve built heritage sites has been underinvested.

Therefore, this research endeavors to study the reduction of flood damage impacts with a specific focus on safeguarding Shiraz's built heritage through sustainable urban strategies, including integrating urban green spaces. The study addresses two fundamental questions: Firstly, how do urban green spaces in the historical context of Shiraz city effectively mitigate flood damage and reduce its impacts on the built heritage? Secondly, what is the role of urban green space area, as a substantial variable, in reducing water storm impacts in Shiraz's historic sites? An extensive literature review and remote mapping techniques have been employed to carry out this study comprehensively.

By examining the potential benefits of urban green spaces as a sustainable flood mitigation measure and investigating their impact on preserving built heritage, this research seeks to contribute valuable insights to urban planning and disaster resilience in Shiraz. Integrating these sustainable strategies may pave the way for the city's more resilient and culturally enriched future, aligning with the imperative goal of safeguarding its historical identity for generations to come.

**Analysis of the Recent Research and Publications.** Shiraz, a city steeped in rich history, civilization, culture, art, and architecture, has witnessed considerable destruction within its historic urban fabric in recent years due to ill-advised strategies and negligence. These valuable historical areas are imperative to safeguard the city's cultural heritage and protect it from potential risks and damages. However, like many other urban centers, Shiraz faces environmental challenges from global warming and climate change. Altered precipitation patterns, particularly urban flooding, threaten the city's built heritage.

A comprehensive approach encompassing structural and non-structural methods is essential to preserve Shiraz's historic sites. By implementing effective flood prevention, mitigation, and recovery strategies, the city can significantly reduce the impact of urban flooding on its precious

built heritage. Notably, current studies advocate adopting sustainable flood mitigation techniques as a promising solution.

The inadequacies of conventional piped drainage systems in managing stormwater runoff are exacerbated by urban development. Therefore, the importance of optimizing green infrastructure configurations to harmonize with the urban hydrological cycle, facilitating better control of urban flooding has been highlighted in recent studies; Integrating green infrastructure, which is found in various types, effectively attenuates the impact of urban runoff, retaining water within urban ecosystems so that there was an impressive reduction of total runoff by 15% and peak flow by 8% in Bejing [1]. As sustainable hazard mitigation strategies, urban green spaces significantly reduce long-term flood damage risks in cities. Despite substantial investments in various hazard mitigation programs, urban green spaces have often been overlooked; therefore, prioritizing urban green space as a type of green infrastructure can foster the development of disaster-resilient communities [2]. Moreover, to decrease flood risk and offer environmental advantages, previous studies used a geographic-information-based model to assess the benefits of reducing flood damage, compare them to costs, and create cost-effective nonstructural flood damage mitigation strategies applicable to flood-prone communities [3].

Various planning and governance challenges associated with managing green infrastructure landscapes are often situated far from downstream flood-prone areas and may extend across different administrative jurisdictions. Addressing these challenges requires collaborative efforts among diverse stakeholders across boundaries; spatial and river basin management plans can offer valuable examples of planning processes that can aid in this context. Additionally, integrating green infrastructure landscapes into a comprehensive response is essential, encompassing various spatial scales. However, it is noted that green infrastructure measures have not received sufficient attention in policy, practice, and research compared to other approaches. In this way, it is necessary to explore green infrastructure landscapes in different locations further and their potential to address diverse climate change adaptation functions beyond flood risk management [4]. Regarding this context, some guidelines have been released for enhancing flood resilience through urban green space spatial planning. By introducing green spaces in strategic locations, flooding probabilities decreased by up to 50%, depending on the area's green space coverage and flood-prone characteristics. Green spaces intercept water, promote infiltration, and slow down rainwater flow, reducing runoff by 16% and peak outflow by about 25% in forested areas. In addition, the area of green spaces, physical attributes, and environmental variables collectively influence flooding probabilities. From all the related variables, the green space area exhibited the highest impact on reducing flooding probabilities (Table 1). Consequently, urban areas with limited green spaces face heightened risks of flooding and damage to built heritage (Table 2) [5].

This research aims to build upon the insights provided by Lui, Tyler, Kousky, Carter, and Kim, seeking to explore the potential benefits of implementing sustainable flood mitigation strategies, with a particular focus on urban green spaces, to safeguard Shiraz's invaluable built heritage. By examining the effectiveness of green infrastructure in flood reduction and disaster resilience, this study aspires to contribute meaningful recommendations for preserving Shiraz's historical identity and cultural legacy for future generations.

Table 1 Variables' Analysis in 4 Flooded Area Types of Seoul, 2023, Authors

| Area Type 1 in Seoul, Korea | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | Presence of FRMI | Green Space Area | Detached Housing Area | Mixed-Land Use Area | Land Use | Slope | TWI | Soil Drainage | Max. Hourly Precipitation (mm) |
| Minimum Value | | | | | | ► | | | |
| Average Value | | | | | | | ► | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Maximum Value | ► | ► | ► | ► | | | | ► | |
| Area Type 2 in Seoul, Korea | | | | | | | | | |
| Minimum Value | | | | ► | ► | | ► | ► | |
| Average Value | | | ► | | | | | | |
| Maximum Value | | ► | | | | ► | | | ► |
| Area Type 3 in Seoul, Korea | | | | | | | | | |
| Minimum Value | | | | | | ► | | | |
| Average Value | | | ► | ► | | | ► | | |
| Maximum Value | | ► | | | | | | ► | ► |
| Area Type 4 in Seoul, Korea | | | | | | | | | |
| Minimum Value | | | | | | | ► | | |
| Average Value | | | | | | ► | | | |
| Maximum Value | | ► | | | | | | ► | ► |

Table 2 Flood Probability Estimation Based on the Area of the Urban Green Spaces in 4 Flooded Area Types of Seoul, 2023, Authors

| Description | Average of Green Space Area Ratio Within a 100m Radius in Seoul, Korea | Flood Probability |
|---|---|---|
| Flooded Area Type 1 | %2.26 | High |
| Flooded Area Type 2 | %22.48 | Low |
| Flooded Area Type 3 | %2.81 | High |
| Flooded Area Type 4 | %6.23 | Medium |

| Legend | |
|---|---|
| Average of Green Space Area | Flood Probability |
| S > %19.43 | Low (Non-Flooded) |
| %4.49 < S < %19.43 | Medium |
| S < %4.49 | High (Flooded) |

**Materials and Methods.** With the benefit of urban green spaces, flood damage to Shiraz's built heritage was investigated in this study using both quantitative and qualitative methods simultaneously. Initially, the current study explored various destructive causes of Shiraz's historic urban fabric, and one of the most significant factors, urban flooding caused by climate change and human intervention, was identified to get deeper due to a couple of urban floods that happened in Shiraz over the last forty years. Because of the vulnerability of the historical sites and environmental concerns in Shiraz, urban green space was specifically chosen as a sustainable approach to minimize the effects of flood damage and preserve Shiraz's historical sites.

In this manner, firstly, the maximum hourly precipitation, which was secondary data, for the Shiraz urban flood in 2019 was specified as 75mm in the Shiraz historic urban area; Second, the area of urban green spaces was estimated by less than 2%, which was the primary data, in this district to determine the flood probability level based on a map of Shiraz's historical urban fabric in 2022. Finally, it was discovered that Shiraz's historical urban context had a slope between %1.32 and %7.35 based on topographic and geological maps. This study found the secondary data through literature reviews, whereas the primary data were estimated through remote mapping and analysis.

Additionally, using a qualitative approach, the effects of various factors, such as soil perviousness rate, runoff rate, water flow arrival time, and energy, were examined in Shiraz's historical sites. Due to the need to compare statistics among similar past experiences in Shiraz and to examine the beneficial effects of urban green spaces to lessen the damage caused by urban flooding in Shiraz's historic urban area, this study used both methods concurrently. In the current study, an observation instrument was effectively used to collect data.

**Statement of the Problem.** Shiraz has a long history of gardens' role in the configuration and growth of its urban landscape [6]. The city's developmental process can be categorized into four distinct phases – the first being dominated by greenery and a few buildings, followed by a parallel development of gardens and buildings. During this phase, both natural and built heritages grew at similar rates. However, the third period saw a decrease in greenery development due to new urban development like street construction [7], leading to the destruction of historical areas and a shift towards built heritages dominating natural ones in present times [Fig. 1]. In Shiraz, the lack of communication between green structures and historical sites has arisen due to three primary factors: the destruction of greenery, the abandonment of historic urban fabric, and the construction of new urban developments without proper consideration for the vulnerability of historical sites (Fig. 1).

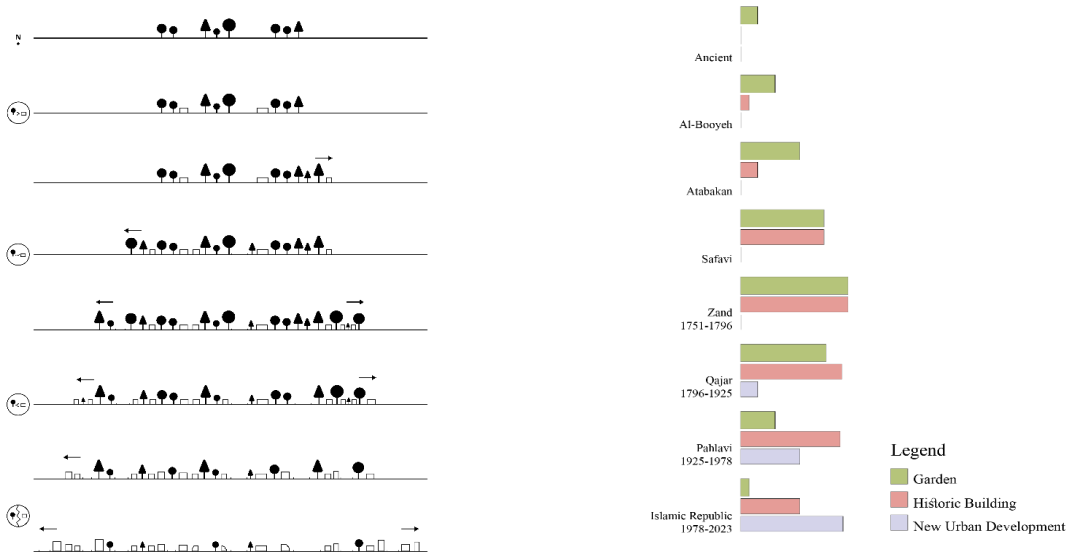


Fig. 1 Urban Structure Development from Beginning to the Present in Shiraz, 2023, Authors

In the academic context, climate change, caused by global warming, poses a significant challenge as it has various detrimental effects on cities and people. In recent years, there has been a noteworthy shift in precipitation patterns due to climate change, putting certain urban areas, particularly historical sites, at risk of urban floods and subsequent extensive damage [3]. Over the past four decades, Shiraz has experienced three major urban floods in 1986, 2001, and 2019 [Table 3] due to extreme precipitation events. These floods resulted in water overflow in river streams and caused severe destruction to several parts of Shiraz's urban infrastructure. Furthermore, based on forecasts from the national meteorological organization, Shiraz was expected to face serious flood risks in the spring of 2020 and the summer of 2022 (Fig. 2). According to the maps (Fig. 2), it can be seen which part of Shiraz's built heritage is at flood risk more, in 2020 and 2022. Moreover, This highlights that Shiraz is considered one of the flood-prone cities in Iran due to factors such as climate conditions, precipitation behavior, morphological and geological factors [Table 4], as well as human interventions like street and building construction, changes in land use, construction near riverside areas, and destruction of urban green spaces [8].

The historic urban fabric of Shiraz is particularly vulnerable to destruction during floods due to its delicate structure. For instance, in the case of Shiraz's urban flood in 2019, the maximum hourly precipitation rate in the northeast of the city (Quran Gateway) was approximately 75mm (Table 3). Hence, in this condition, much rainwater entered the Khoshk river stream below the Quran Gateway and northeast Shiraz's historic urban fabric (Fig. 3). Afterward, due to the small width of the Khoshk River catchment, impervious surfaces resulting from inappropriate urban development alongside the Khoshk River stream, and lack of urban green spaces, as a green belt around the historical sites (Fig. 13) To minimize the water flow speed and volume, an excess amount of water flow entered Shiraz's historical urban area so that some historical sites, such as Zand Blv. and Vakil Bazar, due to the gentle slope of the land, were flooded, and consequently, some historical assets were posed to damage significantly (Fig. 3) [8].

Table 3 Maximum Hourly Precipitation in Flooded Areas of Shiraz During Urban Flood in 2019, 2023, Authors

| Shiraz's Flood in 2019 | |
|---|---|
| Direction | Hourly Precipitation Rate |
| Northwest | 150mm |
| Southeast (Historic Urban Fabric) | 75mm |
| Northeast (Quran Gateway) | 75 mm |

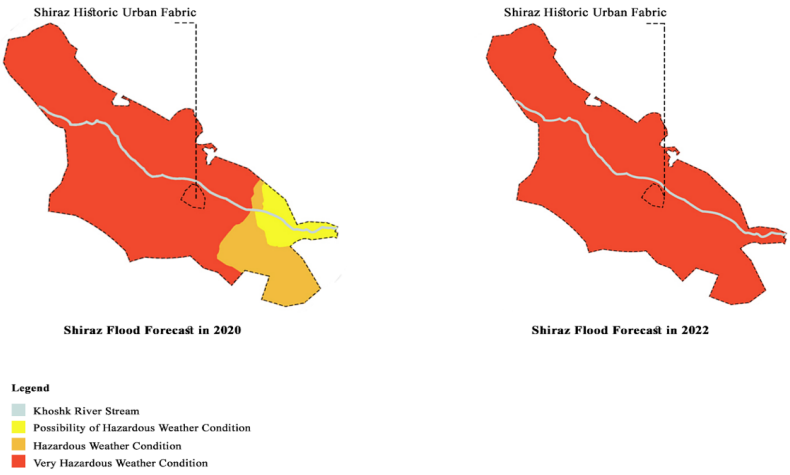


Fig. 2 Shiraz Flood Forecast Maps in 2020 and 2022, 2023, Authors

Table 4 Flood Probability Analysis in Shiraz Based on the Morphological and Geological Variables, 2023, Authors

| Morphological and Geological Factor Role in Shiraz's Urban Flood Probability | | | | |
|---|---|---|---|---|
| Location | Soil Type | Soil Perviousness rate based on the soil type | Slope | Flood Probability |
| Northwest | Carbonate Units | High | %50 | Low |
| Northeast | Marnie Units | Low | %14.28-%30.43 | High |
| Southeast (Historic Urban Fabric) | Alluvial Sediments | Low to average | %1.32-%7.35 | Medium to high |

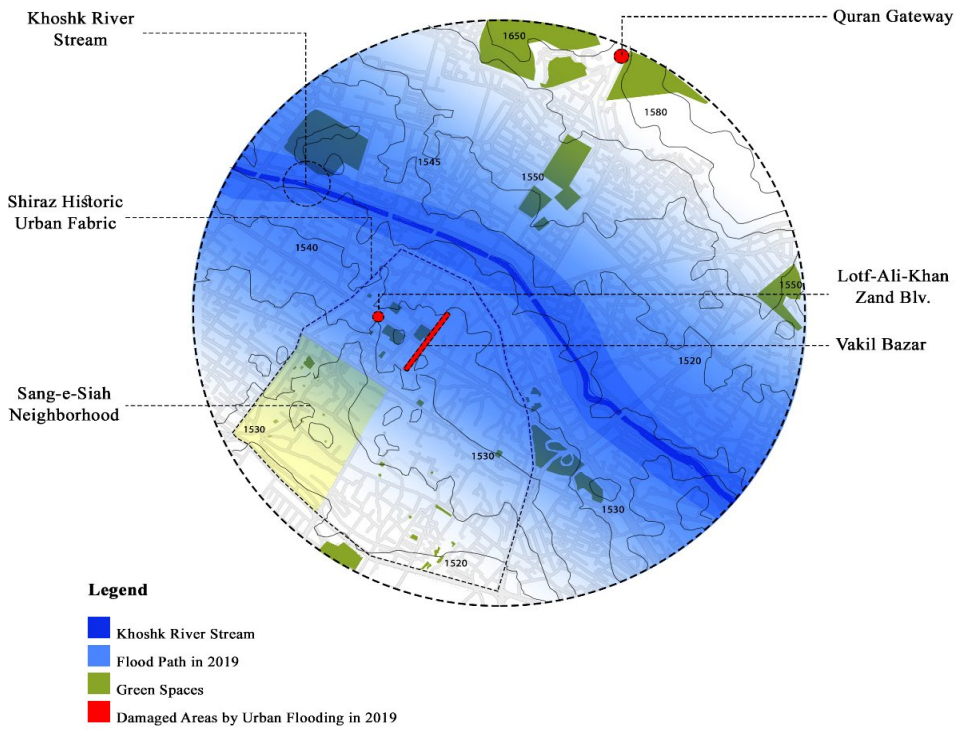


Fig. 3 Flooded Areas in Shiraz Historic Urban Area in 2019, 2023, Authors

There are two conventional approaches to mitigating hazards in urban areas: structural measures (engineering methods) and non-structural measures (administrative methods) [2]. While both of these approaches can reduce flood losses in cities, there is a need for further investigation into more sustainable flood mitigation strategies. These strategies should simultaneously be cost-effective, environmentally friendly, and sustainable [2]. Regarding Shiraz's historic urban fabric, many urban green spaces and gardens have been destroyed over the years without considering their important role as one of the most effective sustainable flood mitigation strategies for preserving built heritage.

Main material and results. Climate change, resulting from global warming, is considered a major concern for cities in the present era, as it presents numerous challenges. One of these challenges includes natural disasters like floods that can damage cities, particularly vulnerable and sensitive areas like historical urban fabrics. Flooding is an extreme weather event that can occur for various reasons, and its impact depends on several factors in historical urban areas, such as the presence of urban green spaces. American Research has found that a yard tree can intercept 760 gallons (3455 liters) of rainfall in its crown, reducing polluted stormwater runoff and flooding [9]. Different types of green infrastructures have the most co-benefits to natural disaster mitigation. Parks and wetlands, as urban green spaces, are ideal for maintaining levels and supporting habitats. These huge urban green spaces can help reduce the severity of natural disasters such as floods by controlling and preventing erosion [10]. The presence of vegetation, as a sustainable flood mitigation strategy, in historic urban areas has a positive effect on flood damage reduction; vegetation can reduce peak flood waves and delay their arrival time by providing resistance to water flow and causing energy dissipation [11]. Additionally, vegetation acts as a natural barrier that slows down water flow and allows it to be absorbed by soil rather than remaining in the area and damaging the historical buildings [12] (fig. 4). Accordingly, there are three main ways in which vast green spaces and vegetation in the urban or pre-urban environment can contribute to flood alleviation: by delaying the downstream passage of flood flows, reducing the volume of runoff through interception, and promoting rainfall infiltration into the soil [9].

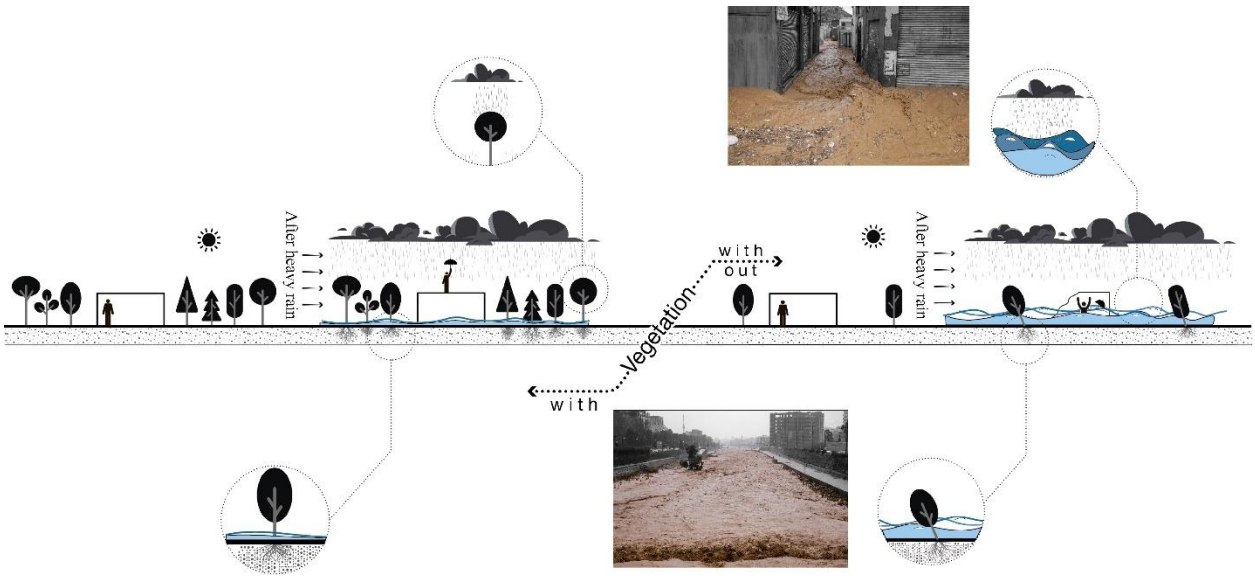


Fig. 4 Flood Damage Diagram Based on the Vegetation Cover, 2023, Authors

**The Most Effective Urban Green Space Type in Mitigating Flood Damage in Shiraz**

Urban green spaces are integral components within the city's structure, possessing distinct characteristics. These structures comprise diverse types, including trees, parks, gardens, lawns, shrubs, greenery roadsides, cemetery landscapes, central courtyard Houses, groundcovers, tomb landscapes (Table 5) [13], and agricultural lands in Shiraz. Each type plays a unique role in the organization and definition of the urban environment while simultaneously promoting the city's image [14]. They also serve as habitats for urban wildlife and indirectly protect historic areas within the city fabric with special features. In the context of sustainable flood mitigation, certain types of urban green spaces are more efficient than others, depending on the area's scale. For example, agricultural lands and pastures are effective at the urban fabric scale, while parks, gardens, lawns, cemeteries, and tomb landscapes are suitable at the neighborhood scale. At the single-building scale, shrubs, roadside greeneries, and central courtyards are appropriate for reducing flood damage to preserve Shiraz's built heritage. Despite the loss of significant portions of green spaces in Shiraz's historical urban fabric in recent times, there still exist some green areas that are intrinsically linked with historical sites because Shiraz's historical urban fabric was designed as a city garden where the presence of green spaces and historical buildings were interdependent.

Table 5 Classification of Urban Green Spaces in Shiraz, 2023, Authors

| Figure Number | Green Space Type | Location | Image |
|---|---|---|---|
| Fig. 5 | Park | Valiasr Park |  |

| | | | |
|---|---|---|---|
| Fig. 6 | Garden | Narenjestan-e-Ghavam Garden |  |
| Fig. 7 | Lawn | Karim-Khan Arg |  |
| Fig. 8 | Roadside Greenery | Karim-Khan Arg |  |
| Fig. 9 | Sidewalk Greenery | Karim-Khan Arg |  |
| Fig. 10 | Cemetery Landscape | Dar-al-Salam Cemetery |  |
| Fig. 11 | Central Courtyard | Forough-al-Molk House |  |

| | | | |
|---|---|---|---|
| Fig. 12 | Tomb Landscape | Sheikh-Roozbahan Tomb |  |
| | | | |

**Urban Green Space Cut Downs in Shiraz's Historic Urban Area and the Flood Damage Increase**

Over the years, Shiraz has experienced multiple floods including the last severe one in 2019 that caused significant damage to both old and new urban areas as well as to the people. Regarding analyzing urban green spaces' area as a sustainable flood mitigation approach to preserve built heritage, this research focuses on two urban scales, including Shiraz's historic urban fabric, the Sang-e-Siah neighborhood.

According to the urban green belt around the Shiraz historical urban fabric in 1947, 1956, 1986, and 2022, there is a significant decrease in the green belt surrounding Shiraz's historic urban fabric, especially on its east side (fig. 13); this reduction in large-scale urban green spaces has led to an increased possibility of demolition of Shiraz's historical urban fabric during possible floods. This is because water flow cannot be controlled from entering historical sites due to the lack of green belts around them.

Flood impacts on the built heritage could be classified into three categories including structural damage, such as cracks and collapse, and non-threatening damage, such as moisture-induced issues like mold and biodegradation. Damages caused by urban floods showcase the vulnerability of certain materials and building types; also, they depend on various factors such as floodwater depth, flow rate, exposure time, pollutants, building materials, and dying speed. In the classification of damages, buildings made of earthen materials, such as adobe and daub, are especially vulnerable to long exposure to water. Physical degradation and anomalies in structures occur due to moisture, wooden structural elements, swelling with humidity, causing cracks in the mud mortar, and exposing the wood to weather effects, shortening its lifespan. Brick walls can also suffer damage from salt leaching due to high groundwater levels [15], moreover, significant changes in the mechanical characteristics of some materials, namely brick and natural stone, endanger built heritage considerably [16]. Regarding the Shiraz built heritage, due to flood direction building earthen materials, gentle slope, impervious surfaces, low density of urban green spaces (Table 6), Area type A in Sang-e-Siah neighborhood (fig. 14), is substantially subjected to long exposure to water, thereby, built heritage is highly vulnerable to destruction, especially in the southern part of the area, in the case of urban flooding.


Fig. 13 Analysis of the Urban Green Belt Condition around Shiraz Historic Context, 2023, Authors


Fig. 14 Area Type A in the Sang-e-Siah Neighborhood, 2023, Authors

Table 6 Vulnerability to the Flood Damage in Area Type A (Sang-e-Siah Neighborhood), 2023, Authors

| Area Type A in the Sang-e-Siah Neighborhood | |
|---|---|
| Flood Variables | Description |
| Historic Building Materials | Brick – Wood – Adobe |
| Soil Perviousness | Low to Medium (According to Table 4) |
| Slope | Low (According to Table 4) |
| Flood Direction | Northeast to the Southwest |
| Area of Urban Green Spaces | %6.12 |
| Historical buildings, located in Area type A, are highly vulnerable to structural (cracks and collapse) and moisture-induced destruction during and after urban floods. | |

**Conclusions.** The research outcomes shed light on the urgent need to reduce flood damage in Shiraz's historic urban fabric and the importance of safeguarding the city's built heritage. The study has brought attention to the vulnerability of historical sites to the escalating risks of urban flooding, posing a significant threat to Shiraz's cultural and historical identity. Recent severe floods have underscored the critical need for effective and sustainable flood mitigation strategies to protect the invaluable built heritage of the city.

The research has emphasized the significance of considering the urban green space area in flood mitigation planning, particularly within Shiraz's historic urban fabric. By strategically

locating and optimizing green spaces, the city can effectively attenuate floodwaters, delay peak flow, and facilitate water absorption into the soil, thus minimizing damage to historical buildings and streets during urban flooding.

The study has drawn attention to the concerning trend of decreasing green spaces in Shiraz's historical urban fabric over the years, particularly evident in the green belt surrounding the city's historical core. The research findings have illuminated the undeniable vulnerability of Shiraz's historic urban fabric to flood damage, as evidenced by the 2019 urban flood. The intensity of precipitation, with a maximum hourly rate of around 75mm in the northeast part of the city near the Quran Gateway, resulted in a substantial influx of rainwater into the Khoshk river stream, situated below the Quran Gateway and northeast of the historic urban fabric.

Unfortunately, several factors hindered the effective management of floodwaters, leading to significant devastation in the historical area. The Khoshk River catchment's narrow width and impervious surfaces resulting from poorly planned urban development alongside the Khoshk River stream exacerbated the flooding. Moreover, the alarming decline of urban green spaces from 27% in 1947 to a mere 2% in 2022 severely affected the area's capacity to mitigate the water's impact by absorbing and slowing its flow into the historical sites.

As a result, key locations such as Zand Boulevard and Vakil Bazaar succumbed to excessive water flow, amplifying the vulnerability of historical assets and causing substantial damage. The gentle slope of the land, ranging from approximately 1.32% to 7.35%, further worsened the situation, underlining the urgency for implementing sustainable flood mitigation strategies. Integrating urban green spaces into flood management plans emerges as a crucial solution to safeguard and preserve Shiraz's invaluable historic urban fabric from potential future flood events.

The decline of greenery in these areas has escalated the risk of flood-induced demolition and destruction of Shiraz's valuable heritage sites. Therefore, effective preservation and expansion of urban green spaces are critical for enhancing the city's resilience against the escalating impacts of climate change and natural disasters.

The research has underscored the imperative of adopting proactive and sustainable flood mitigation measures, specifically focusing on incorporating urban green spaces. This emphasis is vital in protecting Shiraz's historic identity, cultural heritage, and the well-being of its communities for generations to come. By addressing the research problem and achieving its objectives, the research contributes to the broader field of urban planning and disaster resilience, paving the way for Shiraz's more resilient and culturally enriched future.

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# ЗЕЛЕНА ІНФРАСТРУКТУРА ДЛЯ ЗАХИСТУ ІСТОРИЧНОЇ МІСЬКОЇ ТКАНИНИ ШИРАЗА ВІД ПІДТОПЛЕННЯ

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**Анотація.** Шираз, місто, відоме своєю багатою історичною урбаністичною тканиною, стикається зі зростаючими викликами, спричиненими зміною клімату та екстремальними погодними явищами, зокрема, повенями. Швидка урбанізація та обмежена інфраструктура управління зливовими водами посилили вразливість історичних районів міста до повеней. У зв'язку з внесенням 360 км історичної тканини Шираза до національного реєстру у 2023 році, важливість планування для збереження цієї дорогоцінної спадщини зростає вдвічі. Дослідження також оцінює роль рослинності та проникних поверхонь в управлінні зливовими водами для зменшення стоку паводкових вод та їхнього впливу на історичні споруди. Результати дослідження показують, що стратегічно спроектовані та доглянуті міські зелені насадження можуть діяти як природні буфери проти повеней, допомагаючи регулювати водний потік, зменшувати поверхневий стік і мінімізувати спричинені повенями пошкодження історичних будівель. Інтегруючи зелені насадження в міське планування, політики можуть підвищити стійкість міста до повеней і зберегти унікальний характер і спадщину історичної міської тканини Шираза. Це дослідження мало на меті оцінити наслідки скорочення міських зелених насаджень, особливо в зеленому поясі, що оточує історичну міську тканину Шираза і район Снаг-і-Сіах, на вразливість історичних об'єктів до повеней і потенційного знесення. У цьому дослідженні з використанням міських зелених насаджень вивчалася шкода від повеней для будівельної спадщини Шираза з використанням як кількісних, так і якісних методів одночасно. Результати дослідження показали, що скорочення міської зеленої інфраструктури значно збільшило збитки, спричинені повенями в історичному ареалі Шираза.

**Ключові слова:** архітектурна спадщина, стихійне лихо, міські зелені насадження, стратегія сталого пом'якшення наслідків повеней, підтоплення міст.