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Article

New approach to integrating disaster resilience into public open space planning and design

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Abstract: Public open spaces, such as squares, parks, and sports fields, serve as crucial hubs during and after disasters, fostering a sense of normalcy and community, promoting social cohesion, and facilitating community recovery. Additionally, they offer opportunities for promoting physical and mental well-being during such crises. This study aims to enhance the responsiveness of public open spaces to disasters by prioritizing disaster resilience in their planning and design. This study consists of two main stages. Firstly, a literature review is conducted to explore the current trends in research on public open space planning and design and the incorporation of disaster resilience. Results indicate that the primary focus of the current research on planning and designing public open spaces centers around sociocultural, psychological, environmental, and economic benefits. There is limited emphasis on integrating disaster resilience into public open space planning and design, leading to a lack of clear guidance for planners and architects. The emphasis on disaster resilience in public open space planning and design mainly began after 2010, with a notable increase observed in the last six years (2017–2023). This emphasis notably centers on climate change impacts, followed by floods, and then earthquakes. Secondly, drawing on the pivotal role of public open spaces during disasters, the importance of urban planning and design, and the existing gap in incorporating disaster resilience in current research on public open space planning and design, this study develops a novel framework for enhancing public open spaces' responsiveness to disasters through resilient urban planning and design, based on four main disaster resilience criteria: multifunctionality, efficiency, safety, and accessibility. The insights gleaned from this study offer invaluable guidance to planners, architects, and decision-makers, empowering them to develop public open spaces that can effectively respond to various circumstances, ultimately contributing to bolstering community resilience and sustainability.

Keywords: disaster; planning and design; preparedness; public open space; resilience; response; sustainability

1. Introduction

Since ancient times, cities have witnessed many disasters, such as floods, earthquakes, pandemics, among others. However, over the past few years, the number of risks in cities has escalated as a result of several factors, such as rapid urbanization and climate change, which have led to great losses in lives, property, and the economy of cities.

In this regard, public open spaces such as squares, parks, and sports fields, essential components of a city, play a significant function in responding to disasters and alleviating their effects. They act as safe refuges for individuals, groups of people, and communities, affected by disasters, potentially reducing human losses (Fan et al.,

2012; Félix et al., 2013; Kreimer, 1979). Public open spaces facilitate social cohesion and community recovery, offering opportunities to improve both physical and mental well-being. They serve as places for relaxation, meditation, mood improvement, and stress reduction, alleviating much of the psychological trauma experienced by those affected by the disaster (Masuda, 2014; Villagra et al., 2014). Moreover, public open spaces provide a sense of normalcy and community, enhancing community resilience. People can come together in these spaces, deriving strength and comfort from the shared experience of overcoming challenges (Masuda, 2014; Villagra et al., 2014). Additionally, public open spaces can serve as centers for the collection, distribution, and coordination of relief materials, medical aid, and rescue operations (Masuda, 2014; Villagra et al., 2014).

However, studies on past disaster events have revealed that public open spaces are not always adequately prepared to respond effectively to such occurrences. For instance, during the COVID-19 pandemic, various studies indicated a notable decrease in the utilization of public open spaces (Addas and Maghrabi, 2022; Grima et al., 2020; Xie et al., 2020). In response to the pandemic, several countries, including China, Venezuela, Iran, Chile, and Hungary, enforced complete bans on the utilization of public open spaces (Honey-Rosés et al., 2021), while others, such as Lithuania, Slovenia, and Croatia, permitted their use but under strict regulations, such as maintaining safe distances and avoiding crowds (Ugolini et al., 2020).

During past earthquakes, public open spaces have exhibited inadequate preparedness and response. For instance, during the 1906 San Francisco earthquake, although public open spaces played critical roles, the lack of basic services posed challenges for refugees. This included the absence of sanitation facilities and inadequate water sources in some public open spaces. Additionally, some affected individuals faced difficulties accessing public open spaces due to the far distance from their homes (Greely, 1906). Similarly, in the 2008 Wenchuan earthquake in China, public open spaces served as recovery centers, providing essential services and support to affected individuals and communities, including shelter, medical care, food distribution, and coordination of relief activities. However, the lack of a comprehensive disaster response plan and restricted access to public open spaces resulted in significant losses (You et al., 2009). Following the 2010 earthquake in Chile, temporary camps were established in various public areas. However, evacuees tended to favor public open spaces closer to routes to reestablish trade, causing congestion, while those farther away were underutilized (Allan et al., 2013).

The increase in disasters within cities, the pivotal role of public open spaces in responding to such crises and mitigating their impact, and the inadequate response of public open spaces to past disasters underscore the pressing need for this study. This work aims to integrate disaster resilience into the process of planning and designing public open spaces, thereby fostering the creation of disaster-resilient public open spaces capable of effectively responding to disasters while enhancing their everyday usability. The study's goal is achieved by addressing the following questions:

- Q1: What are the current trends in research on public open space planning and design and the integration of disaster resilience?
- Q2: How can public open space planning and design be enhanced to respond

effectively to disasters?

This study, on the one hand, focuses on the types of public open spaces that play significant roles in responding to various types of disasters, including parks, squares, and sports fields. On the other hand, due to the broad scope of disasters, the study focuses primarily on natural phenomena like earthquakes and biological events like pandemics, which have a significant impact on cities and people's lives. Additionally, public open spaces play a crucial role during these crises. Moreover, urban design and planning interventions are vital for enhancing the response to these disasters.

This study stands out due to its thorough exploration of current research focus on public open space planning and design and the incorporation of disaster resilience into these processes. In addition, this study provides unique guidelines for improving public open spaces' resilience to disasters and insights for future public open space planning and design by incorporating disaster resilience into the process of public open space planning and design. This holistic approach ensures that public open spaces remain functional and adaptable in both normal circumstances and during disasters.

The findings gleaned from this study serve as a valuable resource for planners, architects, and decision-makers, equipping them to develop public open spaces resilient to disasters. Ultimately, this contributes to the reduction of damage costs and human loss, as well as the enhancement of community resilience and sustainability.

The rest content of this paper is ordered as follows: The second section provides an overview of disasters and public open spaces, consisting of two parts. The first part explores the increase in disasters in cities, while the second part examines the importance of public open spaces during disasters. The third section identifies the materials and methods used in the study. The fourth section presents the results and discussion, divided into three parts. The first part presents and discusses the trends in current research on public open space planning and design and the integration of disaster resilience. The second part develops the criteria for disaster resilience that should be integrated into current public open space planning and design. The third part explores the future direction of public open space planning and design. The fifth section presents the conclusion of the study. The sixth section addresses the limitations of the study and provides recommendations for future research.

2. Disasters and public open spaces

2.1. The increase in disasters in cities

A city can be defined as a geographical entity encompassing a large population, amenities, infrastructure, modern facilities, and more. It represents an integrated economic and social system situated within a specific geographical location (Friedmann, 1986). Beyond the tangible aspects of a city, there are intangible elements that bind people together, such as cultures, subcultures, values, and traditions (Pelling, 2003). As Pelling (2003) explains, cities serve as the backbone of economic expansion, comprising an interconnected system interlinked with consumption, manufacturing, employment, and political and cultural realms.

However, cities are also susceptible to sudden stresses or shocks that can result in social, physical, or economic collapse (Büyüközkan et al., 2022). Consequently, cities have historically been exposed to risks, with many centuries-old cities

demonstrating resilience in the face of resource scarcity, natural hazards, and conflicts. Nevertheless, the 21st century presents additional challenges due to global pressures at the city level, leading to an escalation in disasters (ResilienceIndex, 2014). According to the Emergency Events Database (EM-DAT), there were 4212 disasters recorded during the period between 1980 and 1999, averaging 210 per year (Cred, 2020). These numbers rose to 7348 in the first twenty years of the 21st century (2000–2020), averaging 367 disasters annually. The annual count surged to 432 disaster events in 2021. Floods, storms, and earthquakes were among the most frequent disasters. However, the onset of the COVID-19 pandemic at the end of 2019 was particularly devastating, resulting in the deaths of over 7 million people and infecting more than 703 million people by the beginning of March 2024 (Meter, 2024).

Several factors contribute to the increase in disasters in urban areas, with urbanization serving as a major catalyst. By 2007, more than half of the planet's population resided in cities, a figure that reached 54% by 2014 (Zhang, 2016). Projections suggest that the urban population could expand by as much as 72% by 2050 (Zhang, 2016). Human migration and the increasing expansion of urban populations present considerable challenges to the natural and built environments of urban areas. As per the United Nations International Strategy for Disaster Reduction (UNISDR) (UNISDR, 2012), rapid urbanization poses several challenges, such as increased pressure on land and services, inadequate capacities and uncertain mandates for Disaster Risk Reduction (DRR), resource mismanagement, settlement in hazard-prone regions, inconsistent emergency services, and ecosystem degradation.

Climate change represents another major factor amplifying disasters in cities through complex interactions with risk and vulnerability components. For instance, climate change has altered precipitation patterns, resulting in some regions experiencing more severe and frequent rainfall while others face drought (Dore, 2005). These changes affect agricultural output, food security, and water availability. Areas experiencing heavy precipitation witness more frequent and severe flooding, leading to significant losses in lives and property. Furthermore, climate change has heightened the frequency and intensity of forest fires, rendering forests more susceptible to blazes (Hore et al., 2018). Additionally, climate change has impacted the dispersion of ailment vectors such as ticks, mosquitoes, and fleas, contributing to the spread of diseases like dengue fever, malaria, and Lyme disease. Rising temperatures have also increased the prevalence of heat-related illnesses and allergies (Costello et al., 2009).

2.2. The vital role of public open spaces in disaster response

Public open spaces serve as the arena where people interact, express their values, and sense their identity, encompassing both perceptual and functional dimensions. Within the city, public open spaces play a pivotal function in shaping its morphology and performance, serving as the canvas upon which the city's identity is revealed and the conduit through which its internal dynamics are accommodated. Moreover, public open spaces assume a critical role during extraordinary events. They provide a semblance of normalcy and community amidst and following a disaster, fostering social cohesion and facilitating community recovery. Public open spaces also offer opportunities to promote physical and mental well-being during such exceptional

circumstances.

During disasters, public open spaces such as squares, parks, and sports fields serve as ideal locations for safely and efficiently evacuating affected individuals. For example, after the 2004 Indian Ocean tsunami (Yamada et al., 2006) and the 2012 Hurricane Sandy in New York City (News, 2012), public open spaces were utilized as safe refuges for evacuees, providing shelters and distributing relief goods.

In health disasters such as the COVID-19 outbreak, public open spaces play a vital role in delivering fundamental services. Public open spaces such as sports fields and squares served as sites for pandemic testing, vaccination clinics, and the treatment of affected individuals (**Figure 1**).

Figure 1. Using public open space for medical purposes during the COVID-19 pandemic (Chongqing, China, 2022).

Public open spaces also contribute to relief efforts during disasters. After Hurricane Katrina, parks and sports fields served as distribution depots for relief goods (Subaiya et al., 2014). Similarly, following the Haiti 2010 earthquake, soccer fields and parks were utilized as landing sites for helicopters distributing relief supplies (Migration, 2021). Moreover, public open spaces serve as central locations for volunteers to coordinate their operations (Rahill et al., 2014).

In addition to their practical roles, public open spaces offer important psychological benefits. They provide social support and a sense of community for affected individuals, helping to reduce stress and enhance psychological resilience. For example, sports fields and parks served as gathering areas for affected individuals after the Grenfell Tower fire in London in 2017 (Macey, 2018). During the COVID-19 pandemic, accessing public open spaces has been shown to significantly improve people's health and reduce the negative impacts of the pandemic (Soga et al., 2021).

3. Materials and methods

This study consists of two primary stages. Initially, a comprehensive literature review was conducted to explore current trends in public open space planning and design, with a particular emphasis on integrating disaster resilience. The search encompassed three databases: Google Scholar, Web of Science, and Scopus, focusing solely on English-language documents published up to 2023. The literature review was organized into several steps (**Figure 2**).

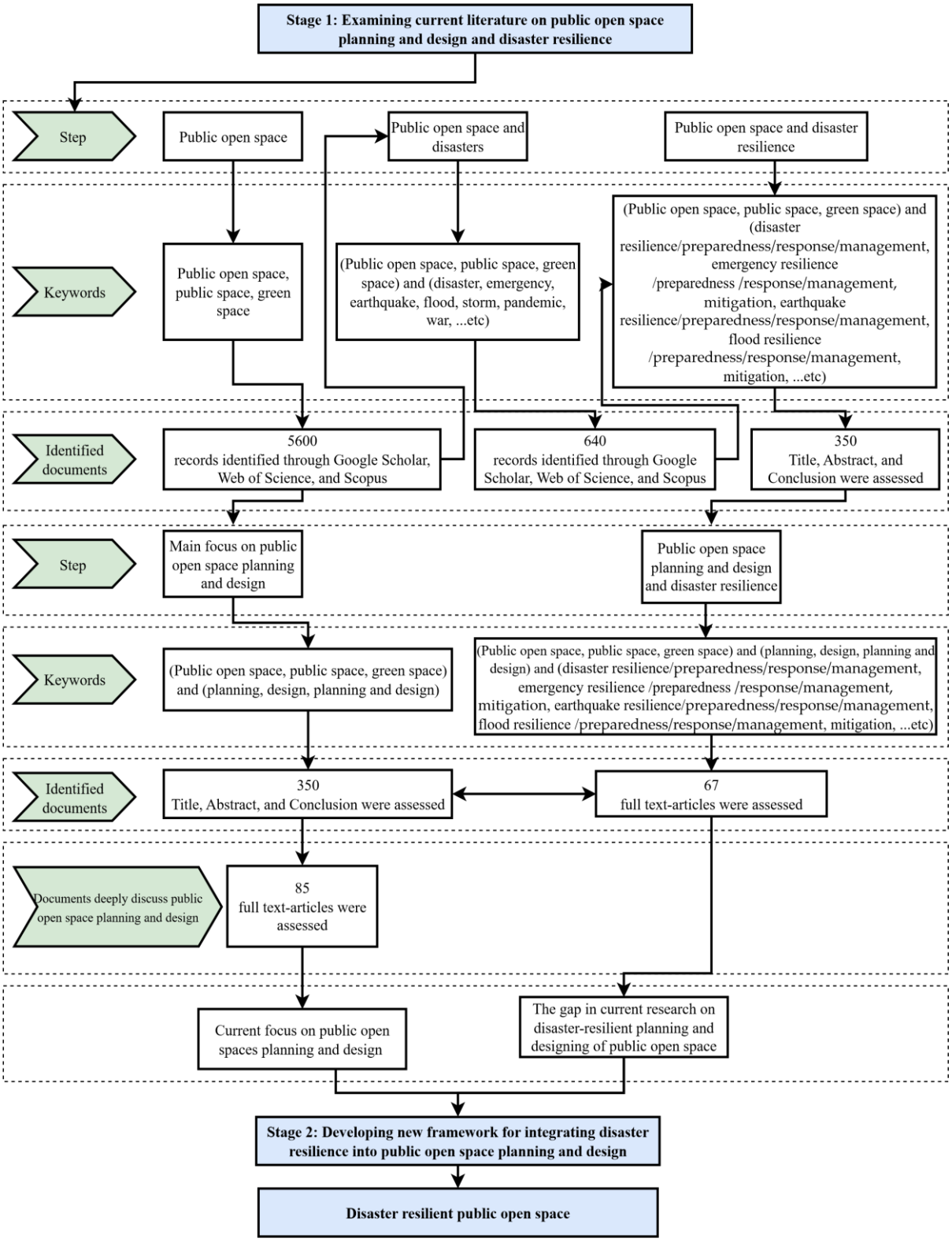

Figure 2. Methodology of the study.

Initially, a broad search on public open space yielded 5600 documents. Subsequently, two additional searches were conducted to delve into literature specifically related to public open space planning and design, and public open space and disaster resilience, resulting in 350 and 640 documents, respectively.

From the subset of 350 documents on public open space planning and design, 85

were selected for their in-depth discussions on the topic. Similarly, from the 640 documents related to public open space and disasters, an additional search focusing on public open space and disaster resilience identified 350 relevant documents. From this subset, 67 articles were chosen for their relevance to disaster resilience and public open space planning and design. These documents underwent careful examination to explore the potential of integrating disaster resilience into current research on public open space planning and design.

In the second stage of the study, a comprehensive framework was developed based on the insights gleaned from the literature review. These insights were derived from the pivotal role of public open spaces during disasters, the importance of urban planning and design, and the existing gap in incorporating disaster resilience in current research on public open space planning and design. This framework aims to establish disaster-resilient public open spaces capable of functioning effectively both in normal circumstances and during disasters.

4. Results and discussion

4.1. Trends in research on public open space planning and design and disaster resilience

4.1.1. Main focus of current research on public open space planning and design

Among 350 published works that have been found in connection with public open space planning and design, 85 works were assessed deeply in this study. The choice of these works is based on their deep emphasis on public open space planning and design. Results show that public open spaces constitute a fundamental aspect of any city, and there has been a noticeable shift towards prioritizing their planning and design in the last three decades. According to Thompson (2002), the main objective of public open spaces is to preserve and enhance natural resources while facilitating recreational activities. Carmona (2010, 2019) extends this perspective from a sociocultural angle, emphasizing that exterior public open spaces breathe life into urban areas by providing opportunities for movement, wildlife habitats, and hosting special events. Public open spaces in urban areas, as noted by Mehta (2014), serve as venues for celebrating cultural diversity, enjoying the outdoors, and fostering community cohesion and communication. Adding to this, Woolley (2006) highlights the prominent social benefits of urban public open spaces, providing places for social interaction, engagement in activities, and event participation. Additionally, public open spaces offer residents a respite from stress and an opportunity to appreciate tranquility and peace (Chiesura, 2004). Consequently, there is an increasing recognition of the importance of inclusive design, which aims to cater to diverse groups, including individuals with disabilities, seniors, children, and ethnic minorities.

In addition to the sociocultural and psychological advantages, attractive large public open spaces have been shown to increase the likelihood of walking and engaging in other forms of physical activities, which have positive impacts on people's health (Douglas et al., 2017; Koohsari et al., 2015). Furthermore, contemporary designers and planners are keen to integrate greenery into public open spaces due to its visual appeal and the environmental benefits it offers to the area. According to

Chiesura (2004) and Sturiale and Scuderi (2019), urban parks and green spaces contribute to environmental purification by filtering water and air, reducing wind and noise, and stabilizing the microclimate. Moreover, urban parks and green areas are recognized as vital components of climate change adaptation because they provide natural cooling effects and help reduce surface runoff of rainwater (Peng et al., 2021; Selmi et al., 2016).

Moreover, current planning and design considerations for public open spaces extend to encompass their economic advantages for governments and inhabitants. For example, the emphasis on historical, recreational, and aesthetic aspects of a city's public open spaces can bolster the tourism sector, thereby creating more job prospects and increasing the city's income (Carmona, 2019). Furthermore, the presence of natural and recreational features enhances property values, leading to higher tax revenues (Chiesura, 2004). Within this context, Tajima (2003) elucidates that public open spaces contribute significantly to the comprehensive advancement of a region and its urban layout. On one hand, inhabitants are more inclined to reside near public open spaces when they have easy access to them. On the other hand, this increased residential proximity incentivizes investment in improving the public open spaces' quality, thereby attracting more people to use and enjoy them (**Table 1**).

Table 1. Summary of the focus on current research on public open space planning and design.

Aspect	Focus of research
Sociocultural benefits	Enhancing community cohesion and communication.
	Providing opportunities for social interaction and engagement.
	Hosting special events and celebrating cultural diversity.
Psychological benefits	Offering residents a respite from stress and promoting tranquility.
	Promoting physical activity and positive impacts on health.
Environmental benefits	Integrating greenery for visual appeal and environmental purification.
	Climate change adaptation.
Economic benefits	Boosting the tourism sector and creating job prospects.
	Increasing property values and tax revenues.
	Contributing to the comprehensive advancement of urban regions.

4.1.2. Current research on disaster resilience in public open space planning and design

1) Current research on public open space and disaster resilience

After conducting a survey of the literature, 640 documents were found on the topic of public open space and disasters. Among these 640 documents, 350 indicated resilience to disasters in public open spaces, while the other publications only acknowledge the significance of public open spaces during disasters. The chosen papers were meticulously classified based on the types of disasters explored and the period of their publication.

The results show that the predominant focus of research on public open space and disaster resilience pertains to climate-related issues, with a significant portion dedicated to studying urban heat islands (8%), floods (18%), and the impacts of

climate change (40%). The impacts of climate change category encompass a broad spectrum of topics, including heat waves, stormwater management, air pollution, drought, erosion, landslides, and water pollution. While floods and urban heat islands may be inherently related to climate change, they were treated separately if not explicitly linked within the documents.

7% of the literature focused on earthquakes, while 1.5% focused on pandemics. 20.5% of the literature was dedicated to general hazards without specific disaster scenarios, while 5% of the analyzed studies focused on man-made incidents such as terrorism and wars, as well as some other natural disasters not mentioned above, like hurricanes, tsunamis, droughts, windstorms, and fires (**Figure 3**).

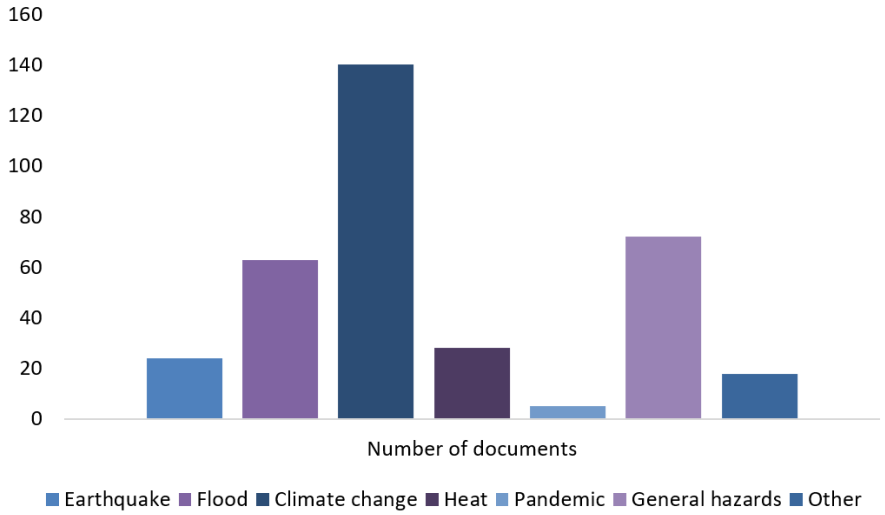

Figure 3. Distribution of disaster types addressed in the literature on public open space and disaster resilience.

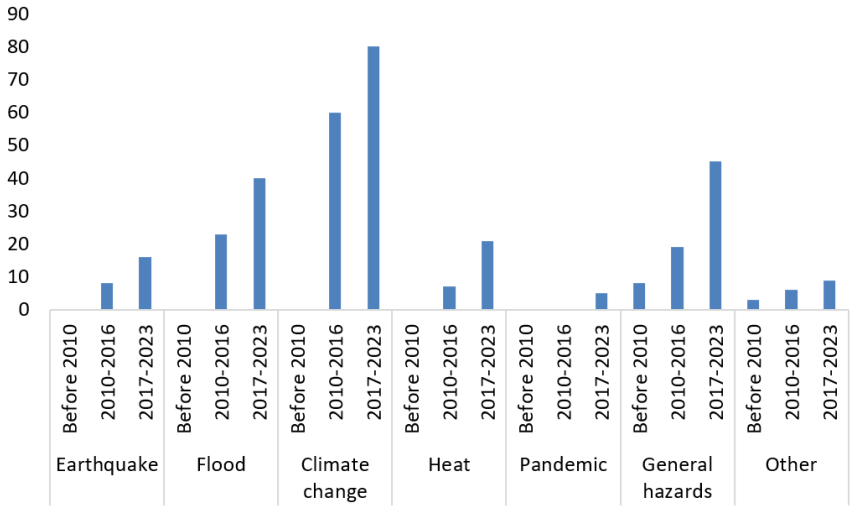

Figure 4. Temporal distribution of studies on public open space and disaster resilience.

Regarding the publication timeline, the majority of the selected documents were published within the last six years (2017–2023). Predating 2010, the focus of most studies primarily revolved around general hazards or some man-made and other natural disasters that are classified in this study under the category of other. Research

specifically addressing individual disaster types such as earthquakes, floods, and urban heat islands became more prevalent after 2010. Research on public open space resilience to pandemics mainly emerged since 2020, following the onset of the COVID-19 pandemic (**Figure 4**). These results indicate the increasing recognition of the significance of open spaces in disaster resilience and underscore the pressing need for further exploration and inquiry in this emerging field.

2) Current research on public open space planning and design and disaster resilience

Research on public open spaces and disaster resilience reveals that out of the 350 documents focusing on this topic (as discussed in part 4.1.2.1), only 67 articles address the planning and design in ensuring disaster resilience in public open spaces. These articles mostly focus on climate change impacts, floods, and earthquakes, accounting for 42%, 22%, and 18% of the total, respectively. The remaining 18% encompass studies on disasters in general and other types of disasters not mentioned above (**Figure 5**). The emphasis on disaster resilience in public open space planning and design mainly began after 2010, with a notable increase observed in the last six years (2017–2023) (**Figure 6**). However, despite the notable growth of literature on disaster resilience in the planning and design of public open spaces, this growth is slow and limited compared to the other components of a city, such as buildings and infrastructure. Moreover, the current literature often lacks clear practical guidance on planning and designing resilient public open spaces to respond to disasters and mitigate their effects. Instead, it emphasizes the importance of ensuring public open spaces are resilient to disasters and advocates for modifications in public open space design and planning. This gap may stem from a misunderstanding of the role of form and space in urban system dynamics. Additionally, the various definitions of the resilience concept and the persistent confusion between notions of sustainability and resilience could further exacerbate this situation.

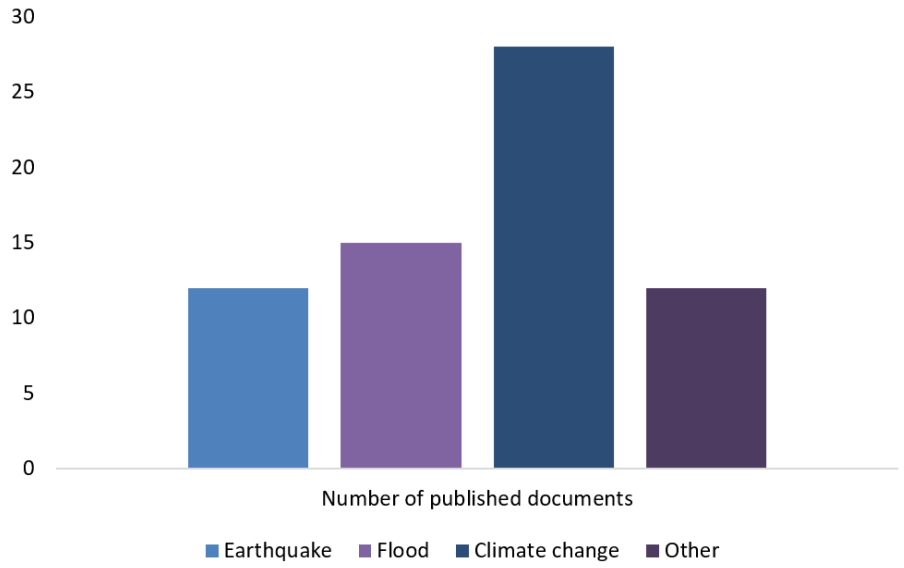

Figure 5. Distribution of disaster types addressed in the literature on public open space planning and design and disaster resilience.

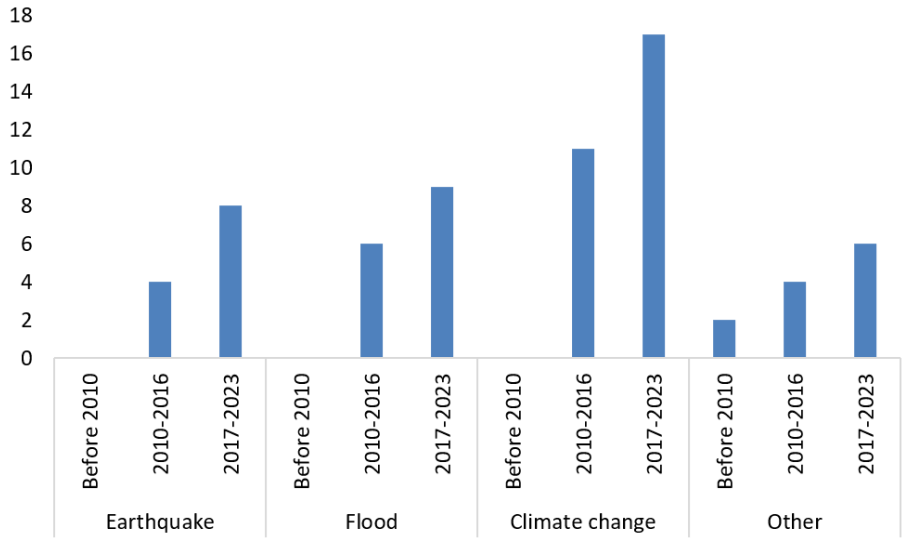

Figure 6. Temporal distribution of studies on public open space planning and design and disaster resilience.

In this regard, this study posits that integrating resilience criteria into the current emphasis on public open space planning and design is essential for ensuring their effective response to disasters. Resilience holds various interpretations in academia, contingent upon the aspect or domain investigating the concept (Marasco et al., 2022). In the realm of disaster prevention, resilience typically denotes the capacity to withstand, absorb, and recover from disasters (Timmermann, 1981). In recent times, the "disaster resilience" concept has gained increasing prominence in urban contexts (Sharifi, 2020). The "disaster-resilient city" notion has similarly gained traction and is now prevalent in many institutional policy documents and disaster management studies (Alawi et al., 2023).

Within this context, urban planning and design hold significant potential to play a vital role in the establishment of resilient disaster cities and serve as important instruments in mitigating the devastating consequences of disasters while bolstering community resilience. Urban planning and design possess the capability to integrate multidimensional features aimed at reducing the impact of disasters. Numerous recent studies have underscored the importance of this role (Allan et al., 2013; Covatta and Ikalović, 2022; Hossain, 2014; Villagra-Islas and Alves, 2016). Furthermore, recent international agreements such as the Hyogo Framework for Action (2005) (UNISDR, 2005), the Sendai Framework for Disaster Risk Reduction (2015) (UNISDR, 2015), and the 2030 Agenda for Sustainable Development (2015) (Nations, 2015) have emphasized the significance of integrating resilience-building and disaster risk reduction into urban design and planning processes.

4.2. Criteria for disaster resilience in public open spaces

The literature in Section 2.1 indicates that disasters in cities are increasing. Additionally, the literature in Section 2.2 on the role of public open spaces during past disasters shows that these spaces play a crucial role in responding to and mitigating the effects of disasters. However, the results in Section 4.1 show that the current focus on planning and designing public open spaces is primarily to ensure sociocultural,

psychological, environmental, and economic benefits, with limited attention given to integrating disaster resilience. This lack of focus on integrating disaster resilience in the planning and designing of public open spaces fails to provide clear guidance for planners and designers. Consequently, this section aims to provide clear guidance for planners and designers to integrate disaster resilience into the process of public open space planning and design by developing four main criteria. These criteria ensure the effectiveness of public open spaces' response, both in normal situations and during disasters.

4.2.1. Multifunctionality

Functionality indicates the capability to fulfill a specific duty or role. The interpretation of functionality is subjective and relies on the context in which the medium, whether it be a space, activity, object, or process, is considered capable of carrying out its function toward any given objective. Multifunctionality, in this context, is a criterion of space, activity, or artifact that involves fulfilling or having multiple functions and providing several purposes or goals, or outputs at once. It is also possible to view multifunctionality as a value that helps with the resolution of numerous issues or the acquisition of several advantages. But it's not a value until it's connected to a specific goal or purpose (Živković et al., 2019). In the realm of urban planning and design, the multifunctionality of public open spaces indicates the usage of public open space (park, square, sports field, etc.) to provide multiple functions and be used for a wide range of activities, like recreation, play, movement, education, landscaping, agriculture, wildlife habitat setting, and community development (Waters and Smith, 2002).

Multifunctionality in public open spaces plays an essential role in enhancing their responsiveness to disasters. Multifunctionality promotes a culture of adaptability and helps to establish more resilient communities (León and March, 2014). From the multifunctionality perspective, public open spaces are capable of providing multiple functions and fulfilling a range of demands at once. They can effectively respond to disasters while also providing various sociocultural, psychological, environmental, and economic benefits. Therefore, it is imperative to incorporate multifunctionality into public open space planning and design to enhance and expand disaster preparedness.

In this context, public open spaces should satisfy the everyday requirements of inhabitants and deal with unexpected events. Public open spaces' responsiveness to disasters is more efficient if incorporated into everyday life (Mazereeuw and Yarina, 2017).

Public open spaces should include free areas that can be utilized for recovery and physical activities during disasters (Turer Baskaya, 2015). These spaces can be used for celebrations and activities in normal times. Moreover, the inclusion of smart furniture in public open spaces makes it easier to manage and change its usage pattern as needed (Shaleh et al., 2022). In addition, public open spaces must be well-equipped with essential aspects like water, public sanitation, and electricity, as their importance has been underscored by past disasters experiences (Villagra-Islas and Alves, 2016). Furthermore, a strong link to nature is crucial in public open spaces to meet users' preferences and support their recovery from the psychological effects of a disaster

(Turer Baskaya, 2015) (**Table 2**).

Table 2. Multifunctionality aspects for disaster resilient public open spaces.

Aspect	Importance
Integration into everyday life.	Enhances the daily use of public open spaces during normal times and increases their responsiveness to disasters.
Abundant free spaces.	Provides multiple options for utilizing public open spaces for recovery during disasters, as well as serving as places for activities and gatherings during normal times.
Smart furniture integration.	Attracts users during normal times and facilitates mood adjustment during disasters based on users' needs.
Essential amenities.	Amenities such as water, public sanitation, and electricity are vital for supporting individuals during disasters and meeting users' needs during normal times.
Connection to nature.	Crucial for satisfying user preferences during normal times and aiding in psychological recovery from the effects of disasters.

4.2.2. Efficiency

Public open space effectiveness indicates the ability of public open space to furnish sufficient uses. The current focus on efficiency in public open spaces is on the ability of public open spaces to provide options for social activities and make public open spaces attractive destinations for visitors (Jalaladdini and Oktay, 2012). In addition to reflecting the needs and beliefs of the communities and showing the place's identity (El-Husseiny, 2012). According to Bell et al. (2007), elements affecting public open space effectiveness are government policy priorities including social inclusion, public concerns such as economic values and the flow of people between spaces. Contrarily, some social scientists have raised concerns about class-based exclusion, emphasizing that public open spaces cannot be fully understood without considering the social context and their development within modern capitalist society (Stanley et al., 2012). According to El-Husseiny and Kesseiba (2012), effective public open spaces should be both structured and structuring. Structured refers to the physical layout and design, while structuring denotes their capacity to shape social interactions and community dynamics. Therefore, it is crucial to determine the necessary indicators for a public open space network, which can lead to enhanced urban models. These indicators are capable of influencing people's activities while also being influenced by the behaviors and values of the surrounding community.

However, the current focus does not address the efficiency of public open spaces in disasters. The public open spaces' efficiency in disasters means the ability of those spaces to continue to perform their functions during those difficult times effectively and sufficiently for all users. The existence of efficient public open spaces helps to respond and recover quickly from disasters and reduce their losses. On the other hand, the absence of efficiency in public open spaces leads to the inability to meet the needs of those affected by disasters, which leads to exacerbating the effects of the disaster and increasing its losses.

The sufficient usable size of public open space is the major factor in ensuring the efficiency of public open space during disasters. Ensuring sufficient usable size of public open spaces promotes community engagement and resilience during disasters. Consequently, such public open spaces can serve as venues for individuals to securely congregate, offer mutual support, and recuperate from the impacts of a disaster (**Table**

3).

Table 3. Efficiency aspect for disaster resilient public open spaces.

Aspect	Importance
Sufficient usable size	Crucial for effective responsiveness to disasters; it ensures that all people affected by the disaster have the required space to recover from the disaster's effects. Additionally, it plays a role in providing sufficient space for users' needs during normal times.

Efficiency can be measured by determining the usable size of public open spaces and determining the surface required for each user based on the norms required according to the type of disaster and comparing it to the number of residents of the area to determine the ability of these public open spaces to meet the requirements of users during the disaster effectively and safely.

4.2.3. Safety

Safety is frequently identified as the primary concern in public open spaces. There is a greater emphasis on safety now than ever before, and as a result, policies and regulations that address these concerns have dominated public open space planning and design. However, the current focus of integrating safety principles in public open spaces is to provide a sense of security against injury and crime during daily use in normal times (Mehta, 2014). The current focus on public open space safety is to ensure that those areas are clear, reading, legible, well-maintained, and clean (Ghavampour, 2014; McGlynn et al., 2013). In addition to the availability of features that enhance the sense of safety for users and improve the use of public open spaces like appropriate lighting units (Cutt et al., 2008; Lloyd et al., 2008; Tucker et al., 2007), security men, monitoring stations, escort cameras (Zavadskas et al., 2019), and the presence of emergency stations (Gallerani et al., 2017).

Ensuring safety in disasters is a fundamental aspect of planning and constructing public open spaces for disaster response, taking into account that not all public open spaces are appropriate for disaster response. To achieve the effective response of public open spaces to disasters, they must adhere to safety principles: Assure safety inside the space, reduce the disaster effects, and prevent secondary risks that may happen due to some types of disasters. Public open spaces must be devoid of external physical hazards and provide a stable environment for users during disasters, enhancing their physical and mental well-being.

Safety must be ensured within the public open space. This includes implementing safety regulations and strategies that protect the users' well-being during disasters. These measures encompass providing basic medical facilities, controlling access (Ghavampour, 2014; McGlynn et al., 2013), monitoring stations, surveillance cameras (Zavadskas et al., 2019), and providing emergency stations (Gallerani et al., 2017). Public open space's location suitability is a fundamental aspect of ensuring safety during disasters. Public open spaces should be situated in areas that are shielded from the direct effects of disasters and the potential secondary hazards resulting from disasters, including risks like building collapse (Song et al., 2019), proximity to flood sources (Chen et al., 2018), terrain topography (Liu, 2022), and proximity to explosion sources such as factories and gas stations (Soltani et al., 2014) (**Table 4**).

Table 4. Safety aspects for disaster resilient public open spaces.

Aspect	Importance
Safety within the public open space (such as controlling access, surveillance cameras, and monitoring stations).	Protects users' well-being during disasters and provides a sense of security for users in normal times.
Location suitability (such as building collapse, proximity to flood sources and explosion sources, and terrain topography).	Protects users from the direct effects of disasters and the potential secondary hazards resulting from disasters and provides a stable environment for users' physical and mental well-being.
Basic medical and emergency facilities (emergency stations).	Provides basic and fast assistance in case of abnormal occurrences in public open spaces, whether during disasters or normal times, enhancing users' safety and well-being.

4.2.4. Accessibility

Accessibility is a term that reflects the ease and distance of reaching a particular location. It is usually defined as a measure of the proximity between two locations (Chang and Liao, 2015; Nicholls, 2001; Yin and Xu, 2009). According to Sendi and Goličnik Marušić (2012), the current focus on accessibility to public open spaces is on three levels: visual, physical, and symbolic. Visual access is achieved by promoting transparency and a visible connection between individuals and the places they intend to visit. Physical access refers to the linkage and connection between public open space and its surrounding environment without obstacles. Symbolic access is achieved through notable landmarks, distinct signage, landscape elements, suggestive features, etc. (Sendi and Goličnik Marušić, 2012).

The disaster resilience of an access network is identified as the capability of the access network system to keep the performance or minimize the effect after a disturbance. In addition, the system should be capable to bounce back from setbacks or adjust to new circumstances (Aghababaei et al., 2021; Mason and Brabhaharan, 2021; Zhang et al., 2015). In this regard, the access network to public open spaces must be efficient before, during, and after a disaster. On the one hand, the availability of a resilient access network attracts users to visit public open spaces and perform their daily activities, thus improving the city's sustainability. On the other hand, it ensures safe and efficient reach to public open spaces during disasters. While the unavailability of a resilient access system to public open spaces will reduce their use in normal times and make it difficult to use public open spaces during disasters, resulting in increasing losses from disasters.

Linking public open spaces with vehicle roads and active transport (pedestrian paths and bicycle lanes) (Organization, 2022) is a leading factor in determining accessibility to public open spaces. Access networks to public open spaces must ensure equity, quality, and sufficiency to avoid disturbance, delay, and congestion during disasters, especially in densely populated areas. In addition, the proximity of public open spaces to healthcare facilities, security, and fire stations (Gall, 2004; Tai et al., 2010) is a critical factor in ensuring an effective response to disasters. Another significant factor in evaluating the accessibility of public open spaces is their proximity to homes (Logan and Guikema, 2020) (**Table 5**).

Table 5. Accessibility aspects for disaster resilient public open spaces.

Aspect	Importance
Linking with vehicle roads.	Important for fast evacuation and to avoid disturbance, delay, and congestion during disasters.
Appropriate active transport network (pedestrian paths and cycling lanes).	Attracts users during normal times and provides safe and efficient evacuation during disasters, particularly crucial during events such as earthquakes when vehicular roads may be damaged or unusable, and during pandemics when individuals may avoid using public transportation due to the risk of infection.
Proximity to homes.	Ensures fast and safe access to public open spaces within a reasonable time. Additionally, it encourages individuals to visit public open spaces during normal times and enjoy their advantages.
Proximity to service facilities (healthcare centers, security, and fire stations).	Ensures fast and effective assistance for users' needs and problems in public open spaces, whether during disasters or normal times.

4.3. Future public open spaces planning and design

As outlined in part 2.1, the incidence of disasters is on the rise, placing increasing pressure on engineers, urban planners, architects, and authorities to enhance cities' resilience to disasters. There is an urgent imperative to prioritize the establishment of resilient cities capable of withstanding the impact of disasters, alongside conducting further research into methods for assessing urban resilience to disasters, enhancing governance structures, and integrating physical design and planning into urban environments. Within this framework, cities with accessible, adaptable, and well-utilized public open spaces exhibit higher resilience to disasters. Consequently, cities must strengthen the resilience of public open spaces and reevaluate financial and legislative frameworks to foster the creation of resilient cities.

This study underscores the importance for architects, urban planners, and policymakers to expand their focus beyond the typical priorities of ensuring sociocultural, psychological, environmental, and economic benefits. Prioritizing disaster resilience is crucial. Public open spaces must be planned and designed to function effectively both in ordinary circumstances and during disasters by integrating the current priorities with resilience to disasters (**Figure 7**).

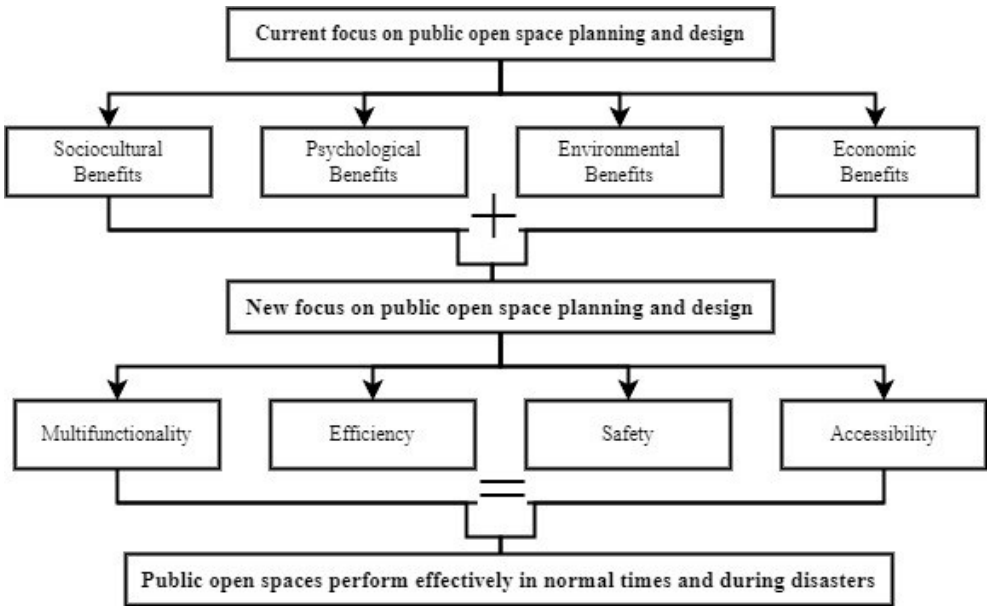

Figure 7. Framework for planning and designing disaster resilient public open spaces.

Furthermore, engaging the local community in the process of planning and design is essential. This engagement facilitates a deeper understanding of their requirements and desires, which can be utilized to tailor public open spaces appropriately. Such community participation nurtures a sense of ownership and encourages responsible utilization, particularly during disasters.

5. Conclusion

This study focuses on integrating disaster resilience into public open space planning and design. Initially, a literature review survey was conducted to assess the current focus of research on public open space planning and design and the integration of disaster resilience in these processes. Results indicate that out of 640 documents found on the topic of public open spaces and disasters, 350 addressed resilience to disasters in public open spaces, while the remaining publications merely acknowledged the significance of public open spaces during disasters. Among the 350 documents focusing on disaster resilience and public open space, only 67 articles discussed planning and design strategies to ensure disaster resilience, with a majority published during the last six years (2017–2023) and a notable emphasis on climate change impacts, floods, and earthquakes. However, it was found that studies indicating the integration of disaster resilience in the planning and designing of public open spaces often lack clear guidance for planners and designers. The current focus on planning and designing public open spaces primarily revolves around ensuring sociocultural, psychological, environmental, and economic benefits.

Secondly, the study established a theoretical framework for enhancing public open spaces' responsiveness to disasters through resilient urban planning and design. The study developed four main resilience criteria that can be integrated into the process of public open space planning and design to ensure the effectiveness of public open spaces in all situations, whether in normal situations or during disasters. These criteria include: (1) multifunctionality, encompassing everyday use, free spaces, smart furniture, essential amenities, and connection to nature; (2) efficiency, ensuring the availability of sufficient usable size in public open spaces; (3) Safety, covering safety measures within the public open space (such as controlling access, surveillance cameras, and monitoring stations), location suitability (e.g., susceptibility to building collapse, proximity to flood and explosion sources, and terrain topography), and provision of basic medical and emergency facilities (e.g., emergency stations); (4) Accessibility, involving the linkage of public open spaces with vehicle roads, the presence of appropriate active transport networks (e.g., pedestrian paths and cycling lanes), proximity to homes, and proximity to service facilities (e.g., healthcare centers, security, and fire stations).

6. Limitations and recommendations for future studies

Despite the significance of this work, there are several limitations. Although the literature survey covers various types of disasters—natural, man-made, and biological—the framework developed in this study primarily focuses on disasters that have a significant impact on cities and people's lives. Specifically, the study framework emphasizes disasters where public open spaces play a crucial role and

where urban design and planning interventions are essential for enhancing response efforts. These include natural phenomena such as earthquakes and biological events like pandemics. Additionally, due to the diverse nature of public open spaces, the study primarily focuses on those that play significant roles in responding to various types of disasters, such as parks, squares, and sports fields.

On the other hand, the disaster resilience criteria developed in this study are general, and the considerations of each criterion may vary from one disaster to another. Moreover, the degree of importance of each factor can also vary between disasters. Furthermore, the study develops only a theoretical framework without practical testing. Therefore, future research should concentrate on applying these criteria in different contexts to evaluate and enhance disaster resilience in public open spaces. Additionally, this study represents an initial step toward integrating disaster resilience into the process of planning and designing public open spaces. Therefore, it is imperative that future studies delve deeper into this topic through additional investigations.

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References

Addas, A., & Maghrabi, A. (2022). How did the COVID-19 pandemic impact urban green spaces? A multi-scale assessment of Jeddah megacity (Saudi Arabia). Urban Forestry & Urban Greening, 69, 127493. https://doi.org/10.1016/j.ufug.2022.127493

Aghababaei, M. T., Costello, S. B., & Ranjitkar, P. (2021). Measures to evaluate post-disaster trip resilience on road networks. Journal of Transport Geography, 95, 103154. https://doi.org/10.1016/j.jtrangeo.2021.103154

Alawi, M., Chu, D., & Hammad, S. (2023). Resilience of Public Open Spaces to Earthquakes: A Case Study of Chongqing, China. Sustainability, 15(2), 1092. https://doi.org/10.3390/su15021092

Allan, P., Bryant, M., Wirsching, C., et al. (2013). The Influence of Urban Morphology on the Resilience of Cities Following an Earthquake. Journal of Urban Design, 18(2), 242–262. https://doi.org/10.1080/13574809.2013.772881

Bell, S., Montarzino, A., & Travlou, P. (2007). Mapping research priorities for green and public urban space in the UK. Urban Forestry & Urban Greening, 6(2), 103–115. https://doi.org/10.1016/j.ufug.2007.03.005

Büyüközkan, G., Ilıcak, Ö., & Feyzioğlu, O. (2022). A review of urban resilience literature. Sustainable Cities and Society, 77, 103579. https://doi.org/10.1016/j.scs.2021.103579

Carmona, M. (2010). Public places urban spaces: The dimensions of urban design. Routledge.

Carmona, M. (2019). Principles for public space design, planning to do better. Urban Design International, 24, 47–59. https://doi.org/10.1057/s41289-018-0070-3

Chang, H. S., & Liao, C. H. (2015). Planning emergency shelter locations based on evacuation behavior. Natural Hazards, 76(3), 1551–1571. https://doi.org/10.1007/s11069-014-1557-x

Chen, W., Zhai, G., Ren, C., et al. (2018). Urban Resources Selection and Allocation for Emergency Shelters: In a Multi-Hazard Environment. International Journal of Environmental Research and Public Health, 15(6), 1261. https://doi.org/10.3390/ijerph15061261

Chiesura, A. (2004). The role of urban parks for the sustainable city. Landscape and Urban Planning, 68(1), 129–138.

https://doi.org/10.1016/j.landurbplan.2003.08.003

Costello, A., Abbas, M., Allen, A., et al. (2009). Managing the health effects of climate change: lancet and University College London Institute for Global Health Commission. The Lancet, 373(9676), 1693–1733. https://doi.org/https://doi.org/10.1016/S0140-6736(09)60935-1 https://doi.org/10.1016/S0140-6736(09)60935-1

Covatta, A., & Ikalović, V. (2022). Urban Resilience: A Study of Leftover Spaces and Play in Dense City Fabric. Sustainability, 14(20), 13514. https://doi.org/10.3390/su142013514

Cred, U. (2020). Human Cost of Disasters. In: An Overview of the last 20 years: 2000–2019. UNDRR.

Cutt, H. E., Giles-Corti, B., Wood, L. J., et al. (2008). Barriers and motivators for owners walking their dog: results from qualitative research. Health Promotion Journal of Australia, 19(2), 118–124. https://doi.org/10.1071/he08118

Dore, M. H. I. (2005). Climate change and changes in global precipitation patterns: What do we know? Environment International, 31(8), 1167–1181. https://doi.org/10.1016/j.envint.2005.03.004

El-Husseiny, M. A., & Kesseiba, K. (2012). Challenges of Social Sustainability in Neo-liberal Cairo: Re- Questioning the Role of Public Space. Procedia—Social and Behavioral Sciences, 68, 790–803. https://doi.org/10.1016/j.sbspro.2012.12.267

Fan, L. (2012). Patterns and its disaster shelter of urban green space: Empirical evidence from Jiaozuo city, China. African Journal of Agricultural Reseearch, 7(7). https://doi.org/10.5897/ajar11.1661

Félix, D., Branco, J. M., & Feio, A. (2013). Temporary housing after disasters: A state of the art survey. Habitat International, 40, 136–141. https://doi.org/10.1016/j.habitatint.2013.03.006

Friedmann, J. (1986). The World City Hypothesis. Development and Change, 17(1), 69–83. https://doi.org/10.1111/j.1467-7660.1986.tb00231.x

Gall, M. (2004). Where to Go? Strategic Modelling of Access to Emergency Shelters in Mozambique. Disasters, 28(1), 82–97. https://doi.org/10.1111/j.0361-3666.2004.00244.x

Gallerani, D. G., Besenyi, G. M., Wilhelm Stanis, S. A., et al. (2017). "We actually care and we want to make the parks better": A qualitative study of youth experiences and perceptions after conducting park audits. Preventive Medicine, 95, S109–S114. https://doi.org/10.1016/j.ypmed.2016.08.043

Ghavampour, E. (2014). The contribution of natural design elements to the sustained use of public space in a city centre. Victoria University of Wellington.

Giles-Corti, B., Broomhall, M. H., Knuiman, M., et al. (2005). Increasing walking: how important is distance to, attractiveness, and size of public open space? American journal of preventive medicine, 28(2), 169-176.

Gill, S. E., Handley, J. F., Ennos, A. R., & Pauleit, S. (2007). Adapting cities for climate change: the role of the green infrastructure. Built environment, 33(1), 115-133. https://doi.org/https://doi.org/10.2148/benv.33.1.115

Greely, A. W. (1906). Earthquake in California, April 18, 1906: Special Report of Maj. Gen. Adolphus W. Greely, U.S.A., Commanding the Pacifc Division. Available online: https://oac.cdlib.org/view?docId=hb1t1n98g0&brand=oac4&doc.view=entire_text (accessed on 23 May 2024).

Grima, N., Corcoran, W., Hill-James, C., et al. (2020). The importance of urban natural areas and urban ecosystem services during the COVID-19 pandemic. PLOS ONE, 15(12), e0243344. https://doi.org/10.1371/journal.pone.0243344

Honey-Rosés, J., Anguelovski, I., Chireh, V. K., et al. (2021). The impact of COVID-19 on public space: an early review of the emerging questions—design, perceptions and inequities. Cities & Health, 5(sup1), S263–S279. https://doi.org/10.1080/23748834.2020.1780074

Hore, K., Kelman, I., Mercer, J., & Gaillard, J. (2018). Climate change and disasters. In: Handbook of Disaster Research. Springer International Publishing.

Hossain, N. (2014). Street'as accessible open space network in earthquake recovery planning in unplanned urban areas. Asian Journal of Humanities and Social Sciences, 2(4), 103–115. https://ajhss.org/pdfs/Vol2Issue4/9.pdf

Jalaladdini, S., & Oktay, D. (2012). Urban Public Spaces and Vitality: A Socio-Spatial Analysis in the Streets of Cypriot Towns. Procedia—Social and Behavioral Sciences, 35, 664–674. https://doi.org/10.1016/j.sbspro.2012.02.135

Jose, R., Holman, E. A., & Silver, R. C. (2019). Community organizations and mental health after the 2013 Boston Marathon bombings. Social Science & Medicine, 222, 367–376. https://doi.org/10.1016/j.socscimed.2018.08.019

Kreimer, A. (1979). Emergency, temporary and permanent housing after disasters in developing countries. Ekistics, 361–365.

León, J., & March, A. (2014). Urban morphology as a tool for supporting tsunami rapid resilience: A case study of Talcahuano, Chile. Habitat International, 43, 250–262. https://doi.org/10.1016/j.habitatint.2014.04.006

Liu, K. (2022). GIS-based MCDM framework combined with coupled multi-hazard assessment for site selection of post-

earthquake emergency medical service facilities in Wenchuan, China. International Journal of Disaster Risk Reduction, 73, 102873. https://doi.org/10.1016/j.ijdrr.2022.102873

Lloyd, K., Burden, J., & Kiewa, J. (2008). Young Girls and Urban Parks: Planning for Transition Through Adolescence. Journal of Park and Recreation Administration, 26(3).

Logan, T. M., & Guikema, S. D. (2020). Reframing Resilience: Equitable Access to Essential Services. Risk Analysis, 40(8), 1538–1553. https://doi.org/10.1111/risa.13492

Macey, J. S. T. (2018). Lessons for the Grenfell Tower Fire Disaster Recovery: Learning from previous disasters. Available online: https://www.jsna.info/sites/default/files/Annex%202%20Learning%20from%20previous%20disasters.pdf (accessed on 23 May 2024).

Marasco, S., Kammouh, O., & Cimellaro, G. P. (2022). Disaster resilience quantification of communities: A risk-based approach. International Journal of Disaster Risk Reduction, 70, 102778. https://doi.org/10.1016/j.ijdrr.2021.102778

Mason, D., & Brabhaharan, P. (2021). Characterisation of transport resilience and measures to enhance resilience in the recovery after the 2016 Kaikōura earthquake. Bulletin of the New Zealand Society for Earthquake Engineering, 54(2), 69–81. https://doi.org/10.5459/bnzsee.54.2.69-81

Masuda, N. (2014). Disaster refuge and relief urban park system in Japan. Landscape Architecture Frontiers, 2(4), 52–61.

Mazereeuw, M., & Yarina, E. (2017). Emergency Preparedness Hub: Designing Decentralized Systems for Disaster Resilience. Journal of Architectural Education, 71(1), 65–72. https://doi.org/10.1080/10464883.2017.1260928

McGlynn, S., Smith, G., Alcock, A., et al. (2013). Responsive environments. Routledge.

Mehta, V. (2013). Evaluating Public Space. Journal of Urban Design, 19(1), 53–88. https://doi.org/10.1080/13574809.2013.854698

Meter, W. (2024). COVID-19 coronavirus pandemic. Available online: https://www.worldometers.info/coronavirus/ (accessed on 23 May 2024).

Migration, T. I. O. F. (2021). IOM Provides Emergency Help to Thousands of Haitians Affected by Earthquake. Available online: https://www.iom.int/news/iom-provides-emergency-help-thousands-haitians-affected-earthquake (accessed on 23 May 2024).

Nations, U. (2015). The 2030 Agenda for Sustainable Development. United Nations.

News, N. J. L. (2012). Hurricane Sandy evacuees moved to Oceanport tent city. Available online: https://www.nj.com/monmouth/2012/11/hurricane_sandy_evacuees_moved_to_oceanport_tent_city.html (accessed on 23 May 2024).

Nicholls, S. (2001). Measuring the accessibility and equity of public parks: a case study using GIS. Managing Leisure, 6(4), 201–219. https://doi.org/10.1080/13606710110084651

Organization, W. H. (2022). Moving around during the COVID-19 Outbreak. Available online: https://who.canto.global/v/coronavirus/s/MFSQ0?viewIndex=1&column=document&id=94covo1rdl4snc0dvh3f7uc956 (accessed on 23 May 2024).

Pelling, M. (2003). The Vulnerability of Cities: Social resilience and natural disaster. Earthscan, 212.

Rahill, G. J., Ganapati, N. E., Clérismé, J. C., et al. (2014). Shelter recovery in urban Haiti after the earthquake: The dual role of social capital. Disasters, 38(s1). https://doi.org/10.1111/disa.12051

ResilienceIndex, C. (2014). City resilience framework. The Rockefeller Foundation and ARUP.

Sendi, R., & Goličnik Marušić, B. (2012). Neighbourhood Design. International Encyclopedia of Housing and Home. Elsevier.

Shaleh, A., Asyifa, N., & Abhistha, T. (2022). The Role of Multi-Function Furniture in the Pandemic Era. International Journal of Design, 2, 1–6.

Sharifi, A. (2020). Urban Resilience Assessment: Mapping Knowledge Structure and Trends. Sustainability, 12(15), 5918. https://doi.org/10.3390/su12155918

Soga, M., Evans, M. J., Tsuchiya, K., et al. (2021). A room with a green view: The importance of nearby nature for mental health during the COVID-19 pandemic. Ecological Applications, 31(2). https://doi.org/10.1002/eap.2248

Soltani, A., Ardalan, A., Darvishi Boloorani, A., et al. (2014). Site Selection Criteria for Sheltering after Earthquakes: A Systematic Review. PLoS Currents.

Song, Y., Xie, K., & Su, W. (2019). Mechanism and strategies of post-earthquake evacuation based on cellular automata model. International Journal of Disaster Risk Reduction, 34, 220–231. https://doi.org/10.1016/j.ijdrr.2018.11.020

Stanley, B. W., Stark, B. L., Johnston, K. L., et al. (2012). Urban Open Spaces in Historical Perspective: A Transdisciplinary

Typology and Analysis. Urban Geography, 33(8), 1089–1117. https://doi.org/10.2747/0272-3638.33.8.1089

Subaiya, S., Moussavi, C., Velasquez, A., et al. (2014). A Rapid Needs Assessment of the Rockaway Peninsula in New York City After Hurricane Sandy and the Relationship of Socioeconomic Status to Recovery. American Journal of Public Health, 104(4), 632–638. https://doi.org/10.2105/ajph.2013.301668

Tai, C. A., Lee, Y. L., & Ching-Yuan Lin. (2010). Earthquake disaster prevention area planning considering residents' demand. In: Proceedings of the 2010 2nd International Conference on Advanced Computer Control.

Tajima, K. (2003). New Estimates of the Demand for Urban Green Space: Implications for Valuing the Environmental Benefits of Boston's Big Dig Project. Journal of Urban Affairs, 25(5), 641–655. https://doi.org/10.1111/j.1467-9906.2003.00006.x

Thompson, C. W. (2002). Urban open space in the 21st century. Landscape and urban planning, 60(2), 59–72.

Timmermann, P. (1981). Vulnerability, resilience and the collapse of society. Environmental Monograph, 1, 1–42.

Tucker, P., Gilliland, J., & Irwin, J. D. (2007). Splashpads, Swings, and Shade. Canadian Journal of Public Health, 98(3), 198–202. https://doi.org/10.1007/bf03403712

Turer Baskaya, F. A. (2015). Disaster sensitive landscape planning for the coastal megacity of Istanbul. Journal of Coastal Conservation, 19(5), 729–742. https://doi.org/10.1007/s11852-014-0365-5

Ugolini, F., Massetti, L., Calaza-Martínez, P., et al. (2020). Effects of the COVID-19 pandemic on the use and perceptions of urban green space: An international exploratory study. Urban Forestry & Urban Greening, 56, 126888. https://doi.org/10.1016/j.ufug.2020.126888

UNISDR. (2005). Hyogo framework for action 2005–2015. In: Encyclopedia of Earth Sciences Series. Springer. pp. 508–516.

UNISDR. (2012). How To Make Cities More Resilient—A Handbook for Local Government Leaders-A contribution to the Global Campaign 2010-2015—Making Cities Resilient—My City is Getting Ready! The United Nations Office for Disaster Risk Reduction Geneva.

UNISDR. (2015). Sendai framework for disaster risk reduction 2015–2030. In: United Nations Int Strateg Disaster Reduct. United Nations.

Vargas-Moreno, J., Meece, B., & Emperador, S. (2014). A framework for using open green spaces for climate change adaptation and resilience in Barranquilla. In: Proceedings of the Resilient Cities 2014 Congress, 5th Global Forum on Urban Resilience and Adaptation; Bonn, Germany.

Villagra, P., Rojas, C., Ohno, R., et al. (2014). A GIS-base exploration of the relationships between open space systems and urban form for the adaptive capacity of cities after an earthquake: The cases of two Chilean cities. Applied Geography, 48, 64–78. https://doi.org/10.1016/j.apgeog.2014.01.010

Villagra-Islas, P., & Alves, S. (2016). Open space and their attributes, uses and restorative qualities in an earthquake emergency scenario: The case of Concepción, Chile. Urban Forestry & Urban Greening, 19, 56–67. https://doi.org/10.1016/j.ufug.2016.06.017

Waters, T., & Smith, M. (2002). The planning and management of urban open space in Scotland: A case study based on the development of Dundee's Public Open Space Strategy. SNH Review.

Woolley, H. (2006). Freedom of the city: Contemporary issues and policy influences on children and young people's use of public open space in England. Children's Geographies, 4(1), 45–59. https://doi.org/10.1080/14733280600577368

Xie, J., Luo, S., Furuya, K., et al. (2020). Urban Parks as Green Buffers During the COVID-19 Pandemic. Sustainability, 12(17), 6751. https://doi.org/10.3390/su12176751

Yamada, S., Gunatilake, R. P., Roytman, T. M., et al. (2006). The Sri Lanka Tsunami Experience. Disaster Management & Response, 4(2), 38–48. https://doi.org/10.1016/j.dmr.2006.01.001

Yin, H., & Xu, J. (2009). Measuring the Accessibility of Parks: A Case Study in Shanghai, China. 2009 Sixth International Conference on Fuzzy Systems and Knowledge Discovery. https://doi.org/10.1109/fskd.2009.583

You, C., Chen, X., & Yao, L. (2009). How China responded to the May 2008 earthquake during the emergency and rescue period. Journal of Public Health Policy, 30(4), 379–394. https://doi.org/10.1057/jphp.2009.30

Zavadskas, E. K., Bausys, R., & Mazonaviciute, I. (2019). Safety evaluation methodology of urban public parks by multi-criteria decision making. Landscape and Urban Planning, 189, 372–381. https://doi.org/10.1016/j.landurbplan.2019.05.014

Zhang, X. Q. (2016). The trends, promises and challenges of urbanisation in the world. Habitat International, 54, 241–252. https://doi.org/10.1016/j.habitatint.2015.11.018

Zhang, X., Miller-Hooks, E., & Denny, K. (2015). Assessing the role of network topology in transportation network resilience. Journal of Transport Geography, 46, 35–45. https://doi.org/10.1016/j.jtrangeo.2015.05.006

Zivkovic, J., Lalovic, K., Milojevic, M., et al. (2019). Multifunctional public open spaces for sustainable cities: Concept and application. Facta Universitatis—Series: Architecture and Civil Engineering, 17(2), 205–219. https://doi.org/10.2298/fuace190327012z