

Using Urban Spaces to Enhance City Resilience: A Framework for Planning and Design

Sally el-Derawy*, Abbas el-Zafarany, Noha Abd el-Aziz

Department of Urban Design, Faculty of Urban & Regional Planning, Cairo University, Egypt

Received October 13, 2024; Revised January 21, 2025; Accepted February 8, 2025

Cite This Paper in the Following Citation Styles

(a): [1] Sally El-Derawy, Abbas El-Zafarany, Noha Abd El-Aziz, "Using Urban Spaces to Enhance City Resilience: A Framework for Planning and Design," *Civil Engineering and Architecture*, Vol. 13, No. 3, pp. 2134 - 2152, 2025. DOI: 10.13189/cea.2025.130347.

(b): Sally El-Derawy, Abbas El-Zafarany, Noha Abd El-Aziz (2025). *Using Urban Spaces to Enhance City Resilience: A Framework for Planning and Design*. *Civil Engineering and Architecture*, 13(3), 2134 - 2152. DOI: 10.13189/cea.2025.130347.

Copyright©2025 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract Cities face various types of risks; some are natural such as floods, extreme heat, and earthquakes, others are urban risks such as fires, crime, and riots. Urban spaces can be creatively utilized to protect the city and increase its resilience. In some cases, urban spaces can be a "safe refuge" for the city residents. Such a concept is an untapped opportunity which has not been applied in the local context and there is not much literature about it. This research aims to help the designers and urban planners to make the right decisions about urban spaces enabling them to improve the Egyptian city's resilience. A framework for planning and designing urban spaces is created based on the concepts of resilient cities, disaster risk reduction approach, and some international case studies. The framework is verified using Delphi technique for testing and prioritizing the framework principles. The main result (the framework) includes the planning and design principles and the procedures applied to find them. For example, an open space can be a refuge from earthquakes, where people can escape dilapidated buildings. The safe dimensions of space are related to the height of the surrounding buildings. Additionally, a set of principles has been developed for each type of natural disaster. This framework highlights some of the conflicts that can occur in a recommendation that solves one problem and increases the risk of another, such as encouraging wind movement to withstand heat waves which conflicts with using windbreaks to reduce exposure to sandstorms. The framework integrates diverse principles of planning and design in urban spaces in order to mitigate several risks. The principles of the framework are classified into a group

of sub-categories, and then arranged based on the relative importance index and the number of responses of design principles to disasters.

Keywords Resilient City, Disaster Risk Reduction, Urban Spaces, Safe Refuge Sites

1. Introduction

Disaster risks are increasing around the world. This can be attributed to the city's inability to mitigate these risks, the weakness of its infrastructure, the weak management of emergency services, and the lack of awareness. As the population increases, the need to the city's resilience increases, especially in the developing countries. The Egyptian cities are exposed to major natural hazards such as floods, earthquakes, sandstorms, sand dunes, extreme heat, and epidemics. These disasters have been studied as the main reason behind such substantial human and financial damages. However, the impact of sand dunes has not been thoroughly studied, as the solutions to this problem often lie outside the urban areas and are not directly reflected within the city spaces, which is the primary focus of the study. Additionally, there is a necessity to increase the city's resilience which can be defined as "increasing the ability of the city's systems to confront disaster risks with the least number of losses, and quickly regaining its ability to carry out its normal functions and activities after the disaster" [1-3]. Enhancing

resilience also helps achieving sustainable development, as stated in the eleventh goal of the United Nations Sustainable Development Goals 2015-2030 [4]. The lack of frameworks focusing on urban resilience in local context emphasizes the importance of focusing on one of the urban tools, such as planning and designing urban spaces to help the city mitigate the natural risks.

2. Disaster Management Approaches

Disaster management approaches have been developed to focus on three temporal phases of disaster management, which are pre-disaster preparedness, response during the disaster, and post-disaster recovery. Each timeframe contains a set of procedures as shown in (Figure 1). The purpose is to reduce the increasing rate of disaster losses and improve preparedness to respond rapidly to disasters so that countries can recover better after a disaster strike [5-8]. Planners and engineers can intervene in the preparation phase before disasters helping the city mitigate the risks

through effective planning and design strategies.

Some of the global community resilience assessment frameworks which have emerged recently focus on assessing the resilience of the coastal areas, the buildings, and the spaces. The most famous framework is City Resilience Framework 2015 (CRF) of The Rockefeller Foundation, whose goal is to strengthen risk management organization in all sectors and invest in disaster risk reduction measures that enhance resilience [9]. By analyzing some of these lists, general procedures for addressing disasters, which must be implemented before a disaster, are deduced and summarized in 4 main dimensions as shown in (Figure 2). There are strategic dimensions; such as effective leadership and management, social dimensions; including community awareness of risks and training citizens to protect themselves in emergency cases, economic dimensions; such as the investment sustainability to enable the city to maintain its infrastructure, and urban dimensions, which focus on the effective management and maintenance of vital facilities and the integration of transportation networks with information and communications technology.

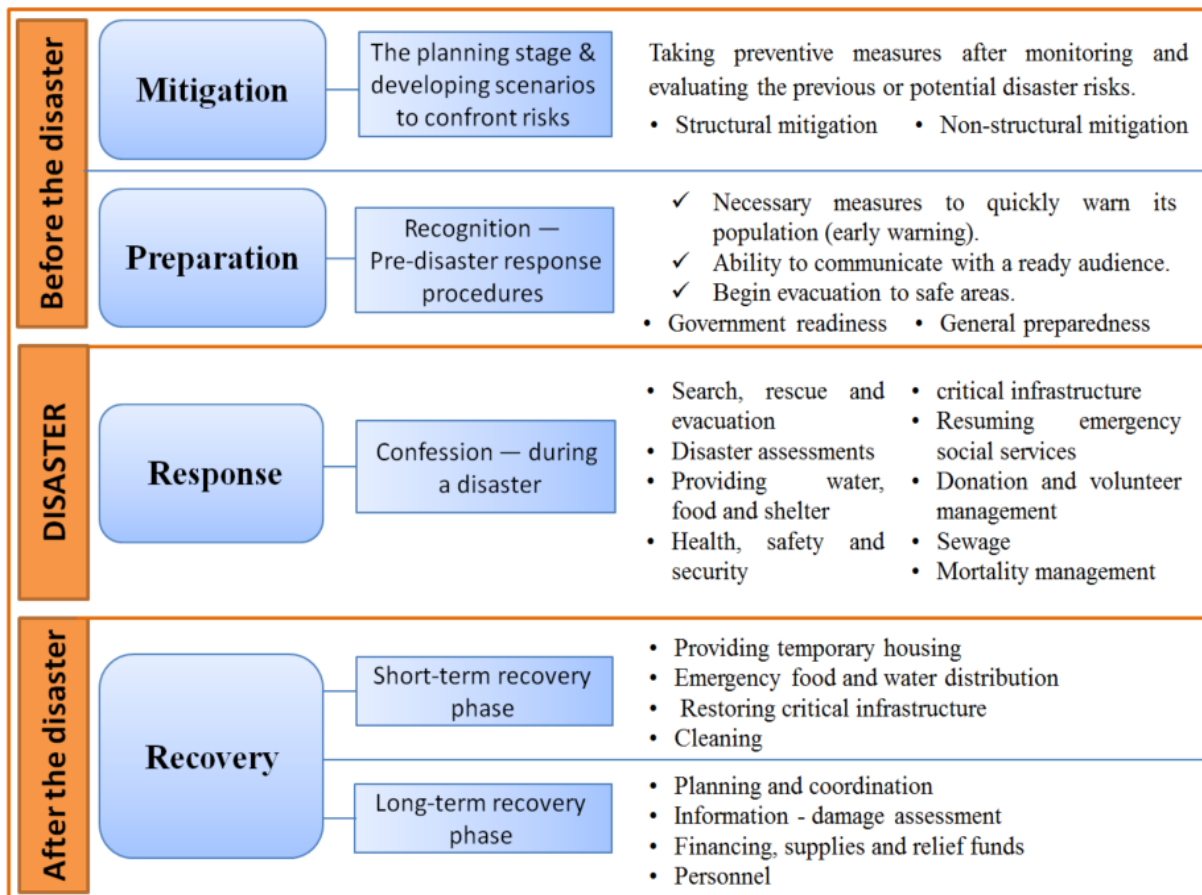


Figure 1. The procedures of the three temporal phases of disaster management. Source: Adapted by the researcher based on [6]

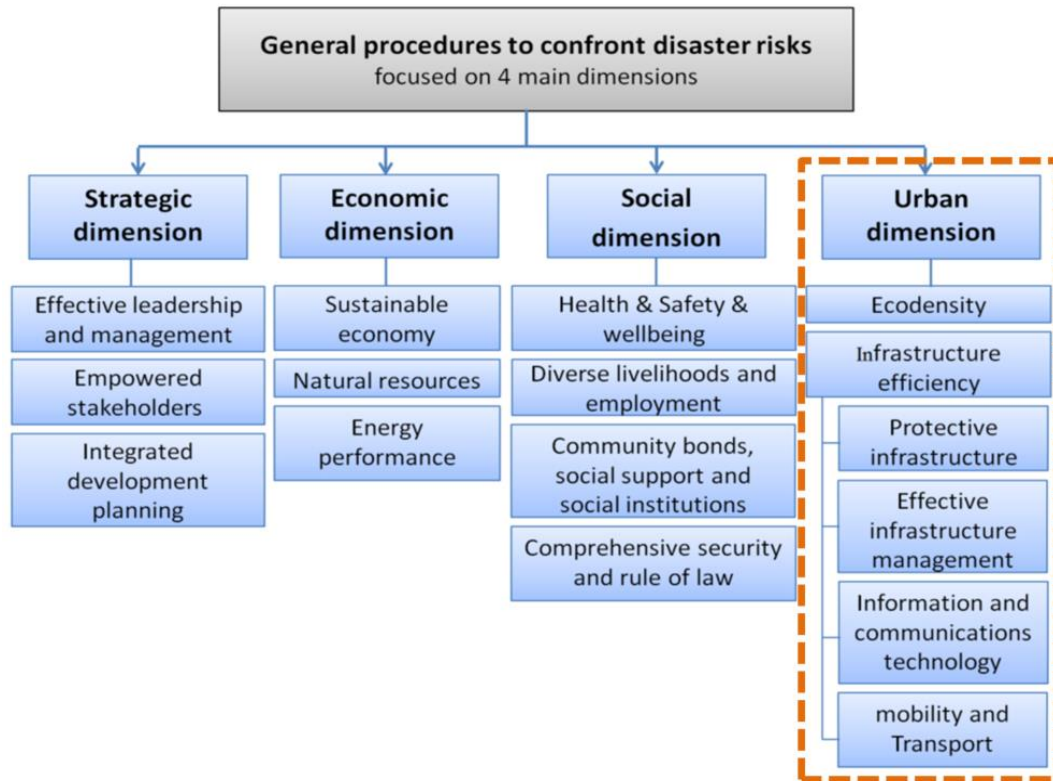


Figure 2. The general procedures for disaster risk management in the preparedness phase. Source: Adapted by the researcher based on [10-14]

It is noted that these lists have largely focused on the administrative and organizational measures to withstand disaster risks in the preparation phase. They also touched on some structured mitigation measures within the urban dimension, such as the mobility of basic needs and services, choosing safe sites to avoid risks, and developing slums. However, it **overlooked employing the rest of the various planning and urban design tools** that can help the city withstand natural risks. Although there are international examples of urban spaces that help the city adapt to natural risks, there is no clear framework for using urban spaces in the local context to help the city in this respect. Hence, the research question is: How can urban spaces get prepared to help the Egyptian cities confront natural hazards and save the lives of residents, especially during disasters? This is achieved by creating a framework of principles for planning and designing urban spaces to increase the resilience of the Egyptian cities to withstand these risks. This paper aims to help designers and urban planners to make righteous decisions to use urban spaces to improve the city's resilience. Public urban spaces, as defined by UN-Habitat [15, 16], include squares, pocket parks, playgrounds, parks, and a network of roads and corridors.

3. Forming the Framework

The framework consists of three Pillars using the

deductive approach as shown in (Figure 3).

3.1. The First Pillar: Assisting Urban Design in the Mitigation Phase

The first pillar depends on disaster preparedness by studying the theoretical methods to protect cities from the risks of the five aforementioned disasters. It aims to deduce the design principles for urban spaces that enhance the city's resilience using examples of spaces around the world. The study investigates some of these principles that adapt to such risks. For example, one way to deal with urban flood at the city level is identifying the areas designated for water flooding and the areas protected from the water flowing [17], e.g., the case of Zollhlen Square within the network of spaces in Copenhagen city [18]. In this pillar, a good connection of the pedestrian path to safe refuge areas from earthquakes, floods, sandstorms, or epidemics is provided to link them together with public transport stations, taking into account time, comfort, and safety. Planning circuits of active safe pedestrian and cycling paths linking neighborhoods and four parks in Montreal City, Canada provides a good example of this connection. The goal is to go out to urban spaces and practice walking and cycling to increase physical activity, raise immunity, and reduce cases of depression during curfew periods [19].

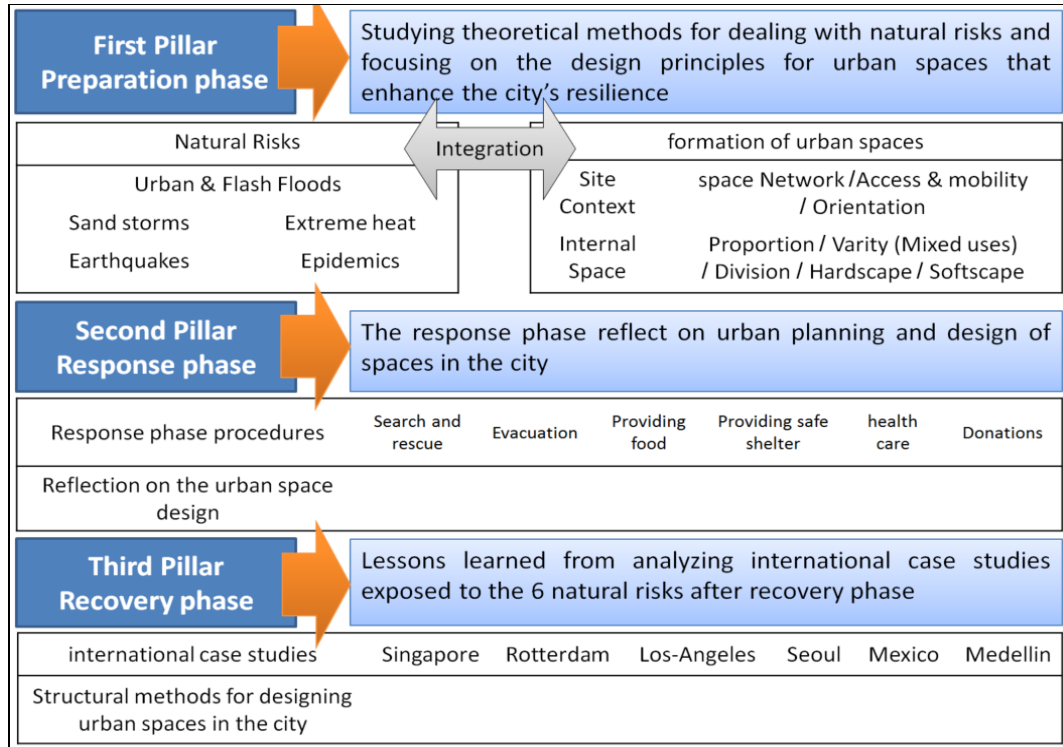


Figure 3. Pillars of the framework. Source: Adapted by the researcher based on [5]; [20-22]

The use of permeable pavements is one of the basic principles in the interior design of urban spaces. It helps the city to reduce surface runoff resulting from heavy rains. It has also been successfully tested in urban spaces and pedestrian paths in the Arkadien Winnenden neighborhood in Germany [23] and Derbyshire Street Pocket Park in London [24]. In addition, rain gardens have been used to retain rainwater and recharge groundwater such as the rain gardens in Portland, Oregon [25] and the permanent rain gardens in Waltham Forest neighborhood in London [26].

3.2. The Second Pillar: The Response Phase Reflection on Urban Design

The second pillar depends on studying the response and containment measures that were implemented at the time of the event. Reflection of these procedures on the appropriate urban planning and design of spaces in the city prepares the space to help the community carry out response procedures effortlessly. These procedures are search, rescue and evacuation in addition to providing water, food, shelter, health, emergency social services, etc. [6].

Deploying search and rescue teams, distributing food to those affected and facilitating evacuations are reflected in designing straight emergency movement corridors to enable the entry of urgent service vehicles (ambulance, firefighting, rescue and relief) to carry out evacuation efforts and transport emergency supplies in the right time. It is necessary to take into account a good design for pedestrian escape paths by using ramps that help people

with special needs reach safe places, with quality paving, crossing areas, and directional signs for the safety of residents. Some other response actions are reflected on identifying safe spaces, then designing and repurposing safe areas according to the type of disaster. For example, large spaces are designed to allow camping after an earthquake, while adding community needs such as water sources like Rokko Kaze No Sate Koen Park in Japan [27], central cooking facilities, and public toilets.

3.3. The Third Pillar: Lessons Learned from Post-Recovery Case Studies

The third pillar depends on the lessons learned from analyzing the international case studies exposed to natural risks after the recovery phase, then identifying the structural methods for designing urban spaces to help the city's resilience.

The cities of Singapore [28], Rotterdam [29], Los-Angeles [30], Seoul [31], Mexico [32], and Medellin [33] are chosen to join the 100 Resilient Cities Network launched by the Rockefeller Foundation, owing to their exposure to natural hazards which is targeted for the present study. In this respect, some socio-cultural characteristics are similar to the Egyptian situation, such as the interest in family ties, hospitality and friendliness as in the Mexican culture and Rotterdam [29], and the ties between members of society such as friendship, brotherhood and cooperation in Medellin and Los Angeles. The people of Mexico [34] and Seoul generally enjoy good morals such as politeness, respect and patience. They are

generous in compliments, loyalty and honoring deceased relatives every holiday. Los Angeles [30] is a city of culture, arts and creativity that attracts large numbers of visitors, and its community has the same welcoming qualities of Egypt. Seoul's [35] population density is similar to the Egyptian cities and is characterized by an ancient history and vibrant historical sites that residents cherish. Additionally, it gives women the right to work, inherit and share property, the right to freedom in marriage and divorce, and the participation in senior positions. Medellin [32] has a cultural heritage as it contains many local markets for handicrafts and crafts in addition to diverse customs and traditions such as festivals and celebrations. Finally, Singapore [28, 36] is characterized by participatory planning and design to enhance ownership and social cohesion, and interest in improving the quality of life for residents, promoting participation and volunteer work, and building a strong community support system for the elderly. Common spaces and platforms are also developed to enhance community interactions and build social cohesion to reduce the disadvantages of ethnic diversity.

The lessons learned from Singapore city are presented as an example to identify the planning and design of urban spaces to help the city adapt to such risks. Singapore city is exposed to stormwater runoff due to large areas of impermeable roads, extreme heat, and epidemics. Greening the city and planting a large number of trees have helped the city control of stormwater runoff. Moreover, trees help reduce temperatures in the city through transpiration and shade provision. Singapore has also focused on expanding the network of green spaces. The Park Connector Network, a linear green corridor (Figure 4), and the Rochor River, a rainwater channel (Figure 5), connect separate pocket parks and open spaces with walking and cycling paths [28]; [37-39]. This network features cool breezes along scenic roads, rivers and canals that connect to Singapore's major parks to reduce heat stress and also increase immunity during periods of epidemics.



Figure 4. Park Connector Network [39]



Figure 5. Rochor Canal [38]

The proposed framework is built on the basis of the previous three pillars. It is divided into 5 parts based on the natural disasters to which the Egyptian cities are exposed. The parts of the framework present the principles of planning and design of urban spaces to enhance the city's resilience against the risks of urban and flash floods, earthquakes, sand storms, extreme heat, and epidemics separately as shown in (Table 1). Each risk is reflected differently in the space design, as indicated in the first pillar. Some principles are also deduced in the framework by reflecting the practices of the response phase on the planning and design of the road network and the urban spaces in the city to facilitate their use during the disasters, as indicated in the second pillar. Similarly, some principles are deduced from the adaptation of urban spaces in the cities (selected case studies) whose spaces are analyzed to determine how to face risks, as indicated in the third pillar.

Table 1. The proposed framework

Principles of planning and designing urban spaces to enhance the city's resilience against:	
A. Flash & Urban floods [17]; [23 - 26]; [28, 29, 31]; [40 - 43]	
Urban planning	- Direct the movement of surface water in specific paths through periodic maintenance of flood channels.
	- Determine the locations of flood zones and safety zones to avoid the flow of surface water.
	- Establish ground reservoirs to receive the flood water, and use it in agriculture and landscaping in squares.
	- Make a green street plan by creating a network of spaces to collect surface water from high areas to low areas.
	- Plan flood channels as urban linear parks.
Urban design	- Design the transverse and longitudinal inclinations of the roads to collect water from high to low places.
	- Design the road level higher than the valley floor, or lower the levels of roads to avoid facing the flood.
	- Use permeable pavements.

Table 1 continued

		- Use rain gardens in large unused areas and stormwater planters in narrow spaces to reduce surface runoff.
		- Use bioswales on road islands, parking lots, and spaces to enhance groundwater recharge by the infiltration
		- Locate dry detention ponds when landscaping near a rainwater source to collect and retain it.
		- Design wet retention ponds as part of landscape elements for spaces and gardens.
B. Earthquakes [17, 27, 32, 33, 44, 45]		
Urban planning		- Plan and design evacuation routes to be taken as escape routes and ensure quicker and safer access to spaces.
		- Choose locations of safe refuge, during an earthquake, away from buildings or slopes that may fall or collapse.
		- Identify earthquake survival kit storage locations with safe evacuation routes and spaces.
		- Utilize the city's road infrastructure to grow vegetable gardens (such as planting road islands) for food security.
Urban design		- Design straight emergency roads to enable the movement of urgent service vehicles and handle evacuation efforts.
		- Ensure good connection of the pedestrian path to safe refuge areas and link them to public transport stations
		- Design the dimensions of safe urban spaces as they are linked to the heights of the surrounding buildings.
		- Plant slopes with plants to protect and maintain the soil from the danger of sliding in areas with sharp slopes.
		- Ensure that the safe assembly site contains some necessary services and facilities, such as: a source of potable water, a source for charging mobile phones, a reserve stock of food supplies, and public toilets.
		- Provide good design for the escape paths by using ramps that help people with special needs reach safe places.
		- Pave corridors in residential areas with rough-textured materials to reduce cases of slipping during escape.
		- Design the seats to fit in cooking pits or toilets if the spaces are used as shelter sites.
		- Regulate the directions of car traffic to a one-way system.
C. Sand storms [17]; [46 - 48]		
Urban design		- Use buffer zone evergreen belts in several rows to repel sandstorms and create protected areas.
		- Reduce the lengths of roads and corridors by using attached housing units.
		- Plant trees to direct the movement of dust storms away from urban spaces and movement paths.
		- Stabilize sand on both sides of the road by inserting rows of trees and plants to provide protection against dust.
		- Direct the space entrances and arcades away from sandstorms to avoid high air speeds.
		- Utilize water features like ponds and waterfalls which are effective in capturing dust.
		- Use climbing plants and grass which help trap dust and stabilize the air.
		- Employ the safe dimensions of the space with a maximum of 1/4 to provide good protection from sandstorms.
		- Orient the long axis of the space and the roads perpendicular to the direction of the sandstorms.
		- Expand the space entrances facing the sandstorms provided that the space entrances do not exceed 25% of its perimeter.
	- Install short advertising banners on paths and roads so that it does not cause risks to pedestrian and car traffic.	
D. Extreme heat [17, 28, 30, 49, 50]		
Urban planning		- Create public parks at the city level to disrupt the urban fabric.
		- Increase public transportation linked to the pedestrian and cycling network.
		- Determine the locations of urban spaces and gardens in integration with the urban distribution.
		- Promote mixing uses to facilitate the process of daily transportation and reduce energy consumption.
		- Provide an environmentally friendly means of transportation to connect parking areas and residential areas.
		- Reduce the lengths of pedestrian paths by using attached housing units to protect from the direct sunlight.
Urban design		- Shade pedestrian paths, urban spaces, and sidewalks adjacent to buildings in various ways.
		- Connect pedestrian paths and urban spaces to corridors and green areas.
		- Use oblique orientation 45° of the main streets to obtain the desired air from the north-west direction.

Table 1 continued

	- Use water surfaces and cultivated land (soil covers) that disperse solar radiation.
E. Epidemics [17, 22, 28, 32, 51, 52]	
Urban design	- Plan a network of vibrant, multi-use spaces of the city to encourage the community to go out into open areas.
	- Allocate bike lanes to promote physical activity and thus strengthen the immune system.
	- Use perennial trees to improve air quality, as they are an essential element for the physical and mental health.
	- Orient public spaces along their longitudinal axes perpendicular to the direction of the prevailing winds.
	- Orient the main streets parallel to the direction of the prevailing winds to form main lanes for air movement.
	- Distribute shrubs in urban spaces and gardens by separating parallel pedestrian paths to create a safe distance.
	- Design directional signs that contain symbols to direct pedestrians to instructions that promote social distance.
	- Design a grid of squares drawn on the ground of urban spaces with a minimum of 1.8 meters of safe distance.
	- Use fountains as they symbolize the source of life and internal balance.

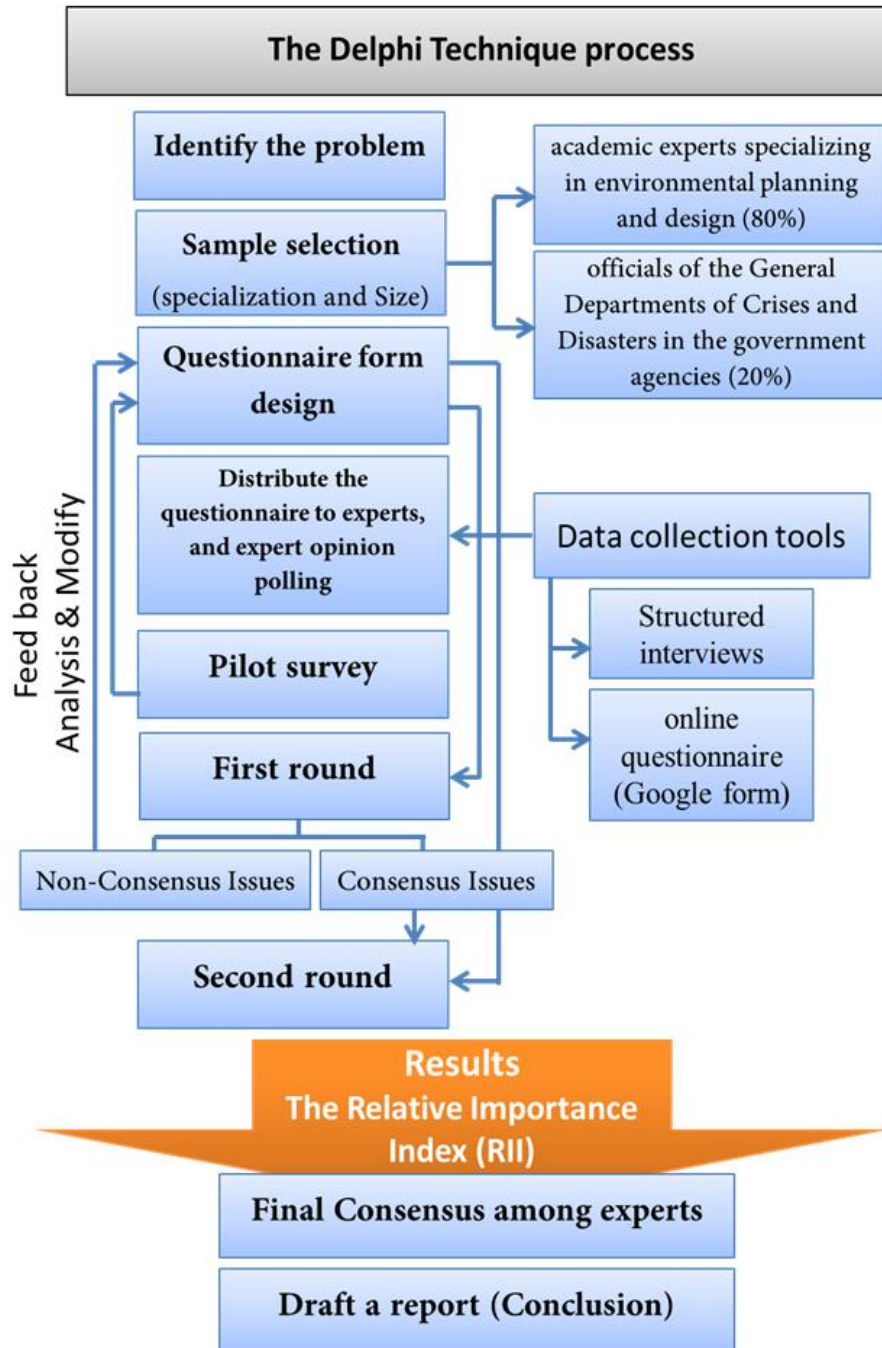
This framework will be used to conduct the questionnaire to test the importance of each principle by calculating a relative importance index based on the analysis of expert responses. This will be explained in detail as follows:

4. Testing the Framework: The Delphi Technique Process

The accuracy of the proposed framework for preparing urban spaces to enhance the city’s resilience against natural hazards is tested using the Delphi technique, which is defined as “an organized means of communication between a selected group of experts and specialists in a specific field to propose appropriate solutions to a specific problem

without the need for meeting or confrontation among themselves” [53].

This technique is selected for three reasons. First, it does not depend on its members meeting face to face, as it is difficult to gather experts in one meeting at the same time. Second, it avoids some opinions dominating others. Third, it gives the expert the opportunity to revisit his previous estimates more than once. Finally, this method depends on the opinions of the majority of experts having a greater degree of validity. It is not based solely on individual opinion. It is the appropriate technique for finding points of consensus among experts by drafting a series of questionnaires to collect data, analyzing their opinions, and testing the degree of importance of each principle of the proposed framework. The Delphi technique process is illustrated as shown in Figure (6).



Source: Adapted by the researcher based on [54]

Figure 6. The Delphi Technique Process.

4.1. Identifying the Problem

The problem revolves around the information collected to form a proposed framework for planning and designing urban spaces to help cities face their risks through international examples and theoretical studies needs to be tested for credibility. This is done by seeking the opinions of experts specialized in this field from academics, practitioners, and the government sector using the Delphi technique for the possibility of using the modified principles for designing urban spaces in the Egyptian case.

4.2. Sample Selection

Qualified experts with relevant backgrounds and experience in the target issue of space design and natural hazards are selected from various governmental agencies such as the National Center for Housing and Building Research, New City Centers, Egyptian city governorates, and the Urban Planning Authority. This group of workers, consultants, and heads of the General Departments of Crises and Disasters from these governmental agencies in

addition to a number of academic experts, professors of urban and environmental planning and design are selected as a sample. It is recommended by some literature that researchers should have at least ten to fifteen experts participating in a Delphi study, while others suggest 20 to 30 experts participating in each round [54,55]. It is also advised that the most appropriate members of the target groups should be identified and selected through a nomination process. If the sample size is very large, it allows for avoiding one of the drawbacks of the Delphi technique such as low response rates [53, 56].

4.3. A questionnaire form design

A list of questions is designed to collect data, which aims to know the opinion of experts on the extent to which each principle contributes to life saving during a disaster. The contents of the questionnaire are classified into three main parts in the two rounds as follows:

1. Primary data: This is specific to experts and consists of name, position, and specialization.
2. A closed question: It depends on providing basic information and data on the research topic to the experts and asking them to determine the degree of importance of the framework principles for planning and design of urban spaces. Table 1 is used in formulating this question. Using a 5-Point Likert Scale as one of the tools used to classify data [57], the respondents' attitudes are measured, where 1 represents "strongly disagree", 2 represents "disagree", 3 represents "neutral", 4 represents "agree", and 5 represents "strongly agree".
3. An open question: This part is specific to the experts' comments with the freedom of opinion to put their different perceptions around it and state the underlying facts with which they support their choices. It is formulated as follows: Based on your Excellency's experience, are there other suggestions that can be formulated within the proposed framework which are not included in this questionnaire?

4.4. Data Collection Tools and Expert Opinion Polling

A pilot survey is conducted to test the clarity of the initial questionnaire wording, followed by two rounds using data collection tools such as structured interviews in addition to an online questionnaire to test the accuracy of proposed framework as follows:

4.4.1. Pilot Survey

The formulated questionnaire is presented to four academic experts for an initial pilot survey through personal interviews to obtain their opinion on the formulation of the questions and the ease of understanding the written principles.

4.4.2. The First Round

The questionnaire forms are distributed to a number of academic experts specializing in environmental planning and design, a number of officials of the general departments of crises and disasters, and a number of project consultants in the aforementioned government agencies, through two data collection tools that are divided into the following two sections:

1. Structured interviews are conducted with each of the 10 experts separately from the aforementioned government agencies. This tool of collecting data is used as the experts are not personally known. They are identified through a nomination process for other individual experts, for example, the head of the New Sphinx City Center is nominated by the Director of the General Administration of Crises and Disasters in Giza Governorate to be contacted, sequentially requesting their opinion. The purpose of the questionnaire is explained to them and the purposed principles are presented to them in a smooth manner, so that each expert can give an evaluation with the appropriate rating from strongly agree to strongly disagree, and explain their viewpoints on their choices, whether positive or negative. Then, they are asked about the open question to provide their suggestions and recommendations.
2. An online questionnaire, a Google form, is sent to a number of academic experts. This tool of collecting data is used due to the previous personal connection with the experts and the ease of contacting and sending the questionnaire form online to the largest number of experts in no time. Similar to the interviews, the experts responded and gave an evaluation for each principle in the closed question, in addition to giving opinions and suggestions in the open question.

4.4.3. The Second Round

The aim of this round is to further refine the revised framework after deleting and adding the principles of urban space design. Based on the experts' recommendations in the first round, a revised questionnaire is reformulated and distributed to the experts a second time using only the online questionnaire tool at this stage for easier communication with all the experts encountered in the first round.

5. Results

All answers to the closed question in the two rounds are transcribed with the help of Microsoft Excel. The Relative Importance Index (RII) aims to review the framework and obtain a high degree of accuracy for the proposed principle. RII is calculated according to (1), where its value ranges from 0 to 1, and is calculated as: W is the weight given to

each factor by experts which ranges from 1 to 5 according to 5-Point Likert scale. W is calculated for each factor such as $W=5*n5$ for factor 1, $4*n4$ for factor 2, and so on. A is the highest weight, i.e. 5 in this case and N is the total number of experts, i.e. 54 in the first round. Table 2 shows an example of the first 5 questions in the first round and an analysis of the number of experts responding as 5, which represents Strongly Agree, and the number of experts responding as 4, 3, 2, and 1 to calculate RII.

$$RII = \Sigma W / (A*N) = (5n5 + 4n4 + 3n3 + 2n2 + 1n1) / 5*N \quad [57] \quad (1)$$

Five important levels are transformed from RII values: high ($0.8 \leq RII \leq 1$), high-medium ($0.6 \leq RII < 0.8$), medium ($0.4 \leq RII < 0.6$), medium-low ($0.2 \leq RII < 0.4$) and low ($0 \leq RII < 0.2$). Below, the opinions of experts is presented and discussed in the two rounds.

Table 2. The relative importance index results according to the equation.

	A	B	C	D	E
SA (5)	41	30	32	21	26
A (4)	6	15	15	20	21
N (3)	3	6	4	9	3
D (2)	2	2	3	2	3
SD (1)	2	1	0	2	1
RII	0.90	0.86	0.88	0.81	0.85

5.1. Pilot Survey Results

The wording of some sentences in the questionnaire is modified to be shorter and simpler and to clarify the meaning directly based on the guidance of the experts in the pilot survey. Table 3 Shows examples of expert recommendation on the first form.

Table 3. Examples of expert recommendation on the first form

The questionnaire form that is presented to the experts in the pilot survey	Expert recommendation	The result
<p>Orient public spaces along their longitudinal axes in the direction (northeast-southwest) so that they do not face direct solar radiation.</p> <p>Use Oblique orientation 45° of the main streets facing east and west and rectangular in a direction parallel to the prevailing winds (northwest and southeast) to form main lanes and tunnels for wind movement that permeate the urban mass. It also achieves the exchange of shadows and radiation around the road network (the fabric of perpendicular streets is exposed to the highest solar radiation).</p>	Combine items and rephrase them shorter	Use Oblique orientation 45° of the main streets and the longitudinal axes of public spaces with the east-west direction to obtain the desired air from the north-west direction and to achieve the exchange of shadows and radiation around the road network.
<p>The safe dimensions of the space and their relationship to the height of the surrounding buildings to provide good protection against sandstorms are achieved: $a/h^2 \leq 20$, where (a) = the interior area of space, (h) = the average height of the walls of the space, and this percentage ensures protection unless the openings face the wind. (Good for buildings ≥ 4 floors).</p>	Calculate the proportion of the equation, and rephrase the sentence in a simpler way	Employ the safe dimensions of the space with a maximum of 1/4 to provide good protection from sandstorms, as shallow spaces allow the wind to fall into them exposing the surrounding buildings to the effects of sand.

5.2. The First Round Results

Based on the survey and compilation of expert evaluation on the framework, the total number of expert respondents is **54 experts** in this round, divided into 10 experts from government agencies and 44 academic experts. The percentage of high importance level is 57% of the total number of principles presented in this round (72 principles), while the rest occupied a high-medium importance level. The questionnaire is reformulated based on the experts' objection to the way the principles are presented, divided into five parts according to the types of risks to which these Egyptian cities are exposed. Some principles can be duplicated and removed.

The principles can be classified based on the sub-elements of urban space planning, which are the distribution of the spaces network, accessibility and orientation, and the sub-elements of urban space design, which are the division of space, proportion, and landscape elements. Thus, the duplicate principles and principles that are disputed by the experts can be removed and the proposed principles can be added, so that the modified questionnaire can be used in the second round.

5.3. The Second Round Result

Based on compilation of expert evaluation on the modified framework, the total number of expert respondents is **48 experts** in this round, divided into 9 experts from government agencies and 39 academic experts. The percentage of high importance level is 78% of total number of principles presented in this round (42 principles), and the rest took a high-medium importance level. It is noted that the experts agreed on the principles of space planning and design at this stage and no major changes occurred in the framework. Therefore, there is no need for conducting a third round. Finally, the opinions of experts in the two rounds are discussed below.

6. Discussion

6.1. Discussion of the First Round

Based on the previous survey and compilation of expert evaluation on the framework, it is found that some experts **strongly agreed** on some of the principles presented in the first round, as their relative importance index reached 0.9 or more which means high important level, such as directing the movement of surface water in specific paths, using evergreen belts to repel sandstorms, and planting trees to direct the movement of sandstorms away from urban spaces that are resorted during storms. Some experts **strongly disagreed** with some principles and their relative importance index does not exceed 0.7 which means a high-medium important level, such as limiting pedestrian movement to a one-way system in gardens due to the

difficulty of implementing it with the local community and designing seats to fit cooking pits or toilets in case of using spaces as shelter sites during earthquakes as they can be misused by the local community. Moreover, growing vegetable gardens in public areas (RII 0.67) is inappropriate as they are constantly picked. There must be a specific body to protect them like the Agriculture Directorate, and to harvest them like the General Authority for Cleanliness and Beautification. **The experts' opinions on the proposed principles dealing with the five natural disaster groups are listed as follows:**

A. Principles for dealing with flash and urban floods: Some experts object to lowering road levels to avoid facing floods, which exposes these tunnels to the risk of water accumulation. Thus, electrical suction devices are required, such as the Haram and Orouba Tunnels, especially when there are no drains for water infiltration. Others agree not to use these roads during the crisis and to use them as tunnels for the movement of water to reach its natural drain (RII 0.81). There are also contradictory opinions of some experts on exploiting flood streams as urban parks. Some of them find it difficult to apply them in Egypt due to the nature of the rocky ground. In contrast, other experts believe that if a budget that covers construction costs is available, it can be implemented in Egypt. Therefore, RII (0.81) is not affected.

B. Principles for dealing with earthquakes: Experts believe that the use of rough materials on floors during earthquakes (RII 0.79) conflicts with smooth movement to facilitate the escape process, taking into account the presence of children and cyclists that do not fit with this type of paving. Some experts, including specialists in disaster and crisis management, considered that storing earthquake survival kits in safe spaces and paths (RII 0.79) is susceptible of theft. According to the experts, an earthquake survival kit is a bag that should be with every family, especially in cities that are constantly exposed to earthquakes or wars (in Gaza, dry dates are added), and in Egypt it is called relief supplies (it consists of mattresses, blankets, and shelter tents). Additionally, a room is allocated for them inside the government buildings. Some experts suggest locating survival equipment stores in the spaces used during emergencies at known vital points.

C. Principles for dealing with sandstorms: Some experts state that using grass (RII 0.81) requires a lot of water, and climbing plants (RII 0.81) are difficult to grow and maintain and they attract insects if neglected. Some experts suggest installing sensors on lighting poles to sense danger an appropriate period of time before the disaster.

D. Principles for dealing with extreme heat: Although the level of importance of the use of attached housing units is high-medium (RII 0.76), many experts disagree because they increase thermal stress within the building and reduce air penetration between them. They emphasize that there must be a setback for the building of 2.5 to 5 meters for the possibility of immediate response in case of fires and easy maintenance of gas or electricity. A

few experts also object to the mixed uses (RII 0.83) being unsafe and noisy, as the residential area has its own privacy which enables children to play in the street. Moreover, there must be a walking distance of 5 minutes to reach all daily services. Some experts suggest the possibility of using the arcades (RII 0.76), provided that environmental raw materials are used in their construction. Some experts agree that providing a friendly means of transportation, increasing means of public transportation, and regulating movement directions is not the decision of the urban planner or designer but their role is only to design the movement path for this means of transportation, such as allocating an emergency path in tunnels.

E. Principles for dealing with epidemics: The importance level of encouraging going out to public spaces is high (RII 0.87). However, some experts are not enthusiastic about psychological treatment for cases of depression during curfew periods in epidemics. They refuse going out to public spaces and parks, and using fountains as they do not support the internal balance of society (RII 0.68). Rehabilitation takes place after epidemics. Some experts suggested that the multiple uses of space lead to crowding and are not appropriate in epidemics. Thus, expanding the size of spaces and integrating with the network of parks and green areas is best during epidemics. However, the experts' opinion is excluded by using granite in garden furnishing elements such as benches, as it has the advantages of being easily disinfected, especially during epidemics. However, granite absorbs heat and releases it with difficulty which causes an increase in the temperature of the seats exposed to sunlight and causes danger to humans.

The results of the expert opinions in the first round indicate that all principles are of high to high-medium importance. However, the framework is refined by removing certain principles and incorporating others, and reformulating the framework by classifying the principles based on the sub-criteria for planning and designing urban spaces, in line with the recommendations of experts in the first round, such as orientation, accessibility, and proportions. Then, the revised framework is used in re-conducting the questionnaire and calculating the RII in the same way as before. The results of the second round are discussed below.

6.2. Discussion of the Second Round

Expert evaluations are collected in the second round, showing the similarity between the principles agreed upon by the experts in the two rounds. The experts do not object to the framework principles in this round, but some experts added two more principles. The first is the importance of distributing elements of emergency signage and way finding plans for evacuation and escape operations. In addition, a site warning system is applied in the response phase. This system indicates safe paths and spaces or dangerous areas that are closed during periods of danger.

This can be done using an information sign at the entrances to spaces explaining in colors safe places and dangerous places to guide the community and facilitate movement, instead of designing signposts to direct pedestrians to instructions that only promote social distancing during epidemics (RII 0.78). The second is the experts' emphasis on the importance of organizational procedures in the preparation stage such as continuous maintenance programs for public spaces and refuge sites, training programs for volunteer teams, community awareness and educational programs, and proactive simulation and forecasting models. These procedures have been focused in the frameworks for evaluating resilient cities, as mentioned in the literature review. Therefore, the focus is on the urban procedures of the proposed framework, which is integrated with other regulatory frameworks.

Finally, some experts classify the principles of urban planning and design according to the type of society's behavior toward risks during a disaster. This behavior stems from a sense of danger and panic with earthquakes, floods, and sandstorms. This requires a design that is balanced with operations of escape, rescue, emergency, and safe refuge. There is another behavior that is not linked to a sense of danger, such as the society behavior with high extreme heat or epidemics. This type requires a balanced design, with individuals walking at an appropriate temperature, fresh air, staying away from crowded places, and resorting to parks and gardens. This classification explains the slight increase in the relative importance index in the principles in which the response to the risks of earthquakes, floods, and storms is more frequent than the risks of extreme heat and epidemics.

7. Conclusions

The set of principles that could be added to the framework is identified after discussing the controversial elements with experts from the first round, namely, survival equipment stores are located in the spaces used during emergencies at known vital points to secure it against theft. In addition, modern surveillance cameras are distributed and installed on lighting poles within urban spaces to increase the security of stores in times other than disaster. Another principle can be added to the framework, which is the use of benches, pergolas, and other environmentally friendly furnishing elements in urban spaces that are easy to disinfect, maintain, and reduce heat stress. Moreover, various facilities are used on the borders of space in a way that does not exceed the required rates in application of the mixed uses idea to reduce crowding during periods of epidemics. Sensors are installed on lighting poles to sense danger an appropriate period of time before the disaster enabling people to resort to safe areas (Site Warning System). Another principle is added from the second round, which is the distribution of emergency signage for evacuation and escape operations elements in

roads and public spaces throughout the city.

Some design elements can be removed from the proposed framework from the first round, such as limiting the movement of pedestrians or cars to a one-way system, designing seats to fit cooking pits or toilets in case the spaces are used as shelter sites, using fountains for internal balance during epidemics, and the use of attached housing units, and planting vegetable gardens in public spaces. Finally, experts object to paving the corridors in residential areas with rough-textured materials that interfere with smooth movement to facilitate the escape process. Another principle is removed from the proposed framework in the second round, which is the design of directional signs that contain symbols and instructions that promote social distancing, which are added at the city level for evacuation and escape operations.

Some principles are added or deleted from the proposed framework in the two rounds, and urban planning and design principles are classified into subcategories to avoid duplication of principles in disaster groups that are modified based on the recommendations of experts in the first round. Urban planning is everything related to the general location and is divided into space network, access and mobility, and orientation. As for the urban design, it is represented in the design of the internal elements of the space, and is divided into proportion, division of the space, and landscape. The principles are arranged in a descending order based on the RII in the second round for each group of subcategories to determine the extent to which each principle contributed to life saving during a disaster, and based on the number of responses of design principles to disasters, as some principles can respond to more than one disaster, as is shown in (Table 4).

Table 4. The framework of planning and design principles of urban spaces to enhance the Egyptian cities resilience

The principles		Floods	Earthquakes	Sand storms	Extreme heat	Epidemics	No. of responses	RII	
Site context (Urban planning)	Space Network	Plan a network of spaces, gardens, and vital paths within the city in integration with the urban distribution, reduce heat stress, help in managing and collecting rainwater and floods, and can be used by the residents as a resort during disasters.	√	√	√	√	√	5	0.93
		Design the locations of spaces higher than the water flow level in the city so that they can be taken as safe refuge spaces for residents.	√					1	0.92
		Choose gardens and open green areas locations that are accessible for safe refuge, away from structures and slopes that may collapse.		√		√	√	3	0.90
		Use evergreen buffer zone in several rows to repel sand-storms away from spaces, roads and paths, thus creating shelter belts (L) that depend on the height of the barrier (H) where $L = 5.5H$.			√	√		2	0.85
		Design locations of spaces lower than the water flow level in the city to be rain gardens to retain rainwater and reduce surface runoff.	√					1	0.85
		Plan flood channels as urban linear parks in addition to safe areas from water flow	√					1	0.85
	Access & mobility	Provide good connection of the pedestrian and bicycle path to safe refuge areas by using ramps that help people with special needs (sick, elderly) in easy access.	√	√	√		√	4	0.91
		Design straight emergency roads to enable the movement of urgent service vehicles, handle evacuation efforts, and transport emergency supplies.	√	√	√			3	0.88
		Choose escape and evacuation routes away from the path of landslide debris and collapsing roadsides and buildings to ensure the safest access to safe spaces.		√				1	0.87
		Design the transverse and longitudinal inclinations of the road and pedestrian network to collect surface water in low-lying areas.	√					1	0.85
		Stabilize sand on both sides of the road by inserting rows of trees to prevent road collapse during earthquakes, provide protection against dust, and provide shading for paths to improve climatic conditions during periods of heat stress.		√	√	√		3	0.82
		Identify mass transit stations linked to the pedestrian and cycling network to reduce private car traffic, lessen emissions, and facilitate access to urban spaces.				√		1	0.80
		Use bioswales on road islands leading to urban spaces, or stormwater planters to collect surface water and use it to irrigate trees.	√					1	0.79
Change the width of straight paths or create bends of routes that reduce the effects of sand-laden air flowing.			√			1	0.71		

Table 4 continued

Orientation	Direct the movement of surface water along specific paths (natural and artificial) through cleansing and periodic maintenance of flood streams.	√					1	0.85	
	Direct the main roads and paths parallel to the desired wind direction and perpendicular to sandstorm direction to improve the climatic conditions of the pedestrian environment during epidemics, heat stress, and sandstorms.			√	√	√	3	0.78	
	Orient the longitudinal axes of the public spaces perpendicular to the northwest direction to obtain the desired air during periods of heat stress, renew the air, and prevent the spread of viruses.				√	√	2	0.78	
	Direct the space approaches away from sandstorms to avoid high air speeds.			√			1	0.78	
Internal space (Urban design)	Division of space	Divide the space into areas far from structures that may collapse during an earthquake, which is often the central space for social interactions and is the most suitable for resorting, and unsafe areas, which are close to the walls of the space.		√				1	0.87
		Divide the space into flood zones designated for water flooding and safety zones that are higher than the surface water flow level and are most suitable for resorting.	√					1	0.84
		Divide the space by distributing the various services on the borders of the space in a way that does not exceed the required rates in application of the mixed uses idea, where the middle space is left for social interactions to reduce energy consumption resulting from daily transportation to service areas thus lessen thermal emissions, determine user density, and reduce crowding and spread of epidemics.				√	√	2	0.82
		Divide the space into shaded areas that are most suitable for use during periods of heat stress, and areas exposed to solar radiation that are most suitable in the winter.				√		1	0.82
	Proportion	Design the proportion of urban spaces to be greater than 1:4 for safety during earthquakes so that they can serve as points for gathering and safe refuge.		√				1	0.83
		Design the proportion of urban spaces that are safe from sand-storms at a maximum ratio of 1:4. The shallow spaces allow the wind to blow through them.			√			1	0.80
		Design the space entrances not to exceed 25% of its perimeter to avoid sandstorms			√			1	0.75
	Hard scape & Soft scape	Plant trees in order to: 1- Shade some places in urban spaces to maintain the degree of humidity and reduce heat stress. 2- Direct the movement of sandstorms away from the urban spaces. 3- Absorb rainwater, reduce surface runoff, and recharge groundwater after tree roots absorb sediments and pollutants. 4- Stabilize slopes to protect the soil from sliding during earthquakes. 5- Improve the quality of air in urban spaces during periods of epidemics.	√	√	√	√	√	5	0.90
		Distribute of emergency signage and way finding for evacuation and escape operations elements in roads and public spaces throughout the city. (added)	√	√	√		√	4	-
		Use environmental and permeable materials in paving spaces and movement corridors (for a rain permeability, dust retention, and heat emission reduction)	√		√	√		3	0.89
Add some necessary services and facilities in the safe urban spaces, such as: a source of potable water, an outlet for charging mobile phones, and public toilets.		√	√				2	0.88	
Stabilize the slope by removing unstable sediments in the vertically inclined section, grade the edge of the slope to prevent soil collapse, and fill the areas at the foot of the slope to stabilize it during earthquakes.			√				1	0.87	
Use water elements such as retention ponds and fountains in urban spaces and gardens to disperse solar radiation, reduce air temperature during periods of heat stress, retain rainwater, and trap dust.		√		√	√		3	0.85	
Locate survival equipment stores in the spaces used during emergencies at known vital points to secure it against theft.		√	√	√			3	0.83	
Use stormwater planters in urban spaces to collect surface water and use it to irrigate trees.		√					1	0.83	
Install sensors on lighting poles to sense danger an appropriate period of time before the disaster enabling people to resort to safe areas (Site Warning system).		√	√	√			3	0.82	
Use short advertising banners in urban spaces or attach them well to buildings so that they do not fall or pose risks to pedestrian and car traffic during severe storms.				√			1	0.82	
Design a subsurface storage to store rainwater in urban spaces, using riser pipes or curb cuts, with pre-treatment of water so as not to quickly clog the storage system.		√					1	0.82	
Locate dry detention ponds in urban spaces near the source of rainwater.		√					1	0.82	

Table 4 continued

Hard scape & Soft scape	Distribute modern monitoring cameras and install them on lighting poles within urban spaces to protect survival equipment stores against theft.	√	√	√			3	0.81
	Use benches, pergolas and other environmentally friendly furnishing elements in urban spaces landscaping (which are easy to disinfect and maintain in addition to their ability in reducing heat stress)				√	√	2	0.80
	Use of dust-retaining surfaces in urban spaces, such as climbing plants, so dust particles are deposited when they collide with the surfaces of building while paying attention to their regular maintenance.			√			1	0.80
	Distribute shrubs in urban spaces, gardens, and parks by separating parallel pedestrian paths to create safe physical distance between individuals.					√	1	0.78
	Take advantage of the dust trapping property of grass to reduce the concentration of dust in the air.			√			1	0.76
	Design a grid of squares drawn on the ground of urban spaces with a minimum of 1.8 meters of safe distance between users to help them navigate the area.					√	1	0.71

There is a general consensus among experts that urban spaces can help the Egyptian cities withstand its natural hazards and thus increase the city's resilience. The framework contains principles that deal with the risks of floods, earthquakes, and sandstorms, which experts have agreed upon and have given a high level of importance in saving lives. It is necessary to form a network of urban spaces at the city level and identify the locations of safe and unsafe urban spaces at risk as shown in (Figure 7). These spaces are well connected to a movement network used for escape and are supported by an emergency road for easy access of relief and rescue vehicles to the population, which could be used as a bicycle path during a disaster as shown in (Figure 8). They are also supported by public transportation stops in addition to the distribution of indicative signs for evacuation and escape operations, at the city level, at the entrances of spaces to facilitate the movement and direction of the community during the crisis. The framework is supported by various urban design principles, such as determining the proportions of space that are safe from earthquakes or sandstorms, designing roads to drain water from high to low areas and supplying them with stormwater planters, rain gardens, and bioswales so that they can be used for irrigation. Moreover, trees can be used to direct sandstorms away from safe areas. Survival equipment stores are distributed in safe areas and vital roads. Finally, integrating this network with parks and green spaces helps residents resort to them during crises.

The framework also contains principles for dealing with the risks of extreme heat and epidemics, which depend on creating an environment suitable for pedestrian movement with clean renewable air by staying away from crowded places and resorting to parks and gardens, taking into account the appropriate orientation of spaces and roads.

This increases air movement within the city, and determines appropriate rates for the intensity of activities in the network of vital spaces, roads, and pedestrian paths at the city and the urban space levels. This is supported with various urban design principles such as division of space into shaded and unshaded areas, planting trees, using paving and environmental furnishing elements, using water elements, and using shrubs to support the idea of social distancing.

There are some principles presented in the framework that could conflict with each other if the city is exposed to a number of risks at the same time, such as encouraging air movement from desired winds in the city spaces to reduce heat waves, while using windbreaks to reduce exposure to sand storms, especially from the west or northwest which are unexpected directions for sandstorms. This is solved by adding the aforementioned principle in Table 3 by installing sensors on lighting poles to sense danger an appropriate period of time before the sand-storm blows from unexpected directions enabling people to resort to indoor spaces. In case the sandstorm blows from southwest, the space facing favorable winds can be made safe from sand deposits by planting rows of trees in the southwestern part to direct dusty winds away. The proportions of spaces safe from sand storms 1/4 also conflict with the proportions of spaces safe from earthquakes, as they must be far from structures that may collapse. This can be solved by identifying spaces safe from sand storms with a specific ratio of 1/4, and identifying other spaces with a ratio greater than 1/4, which could be a network of parks that integrates with urban spaces to be safe from earthquakes and also to be suitable for epidemics.



Figure 7. Urban space as a safe refuge. Source: The researcher.



Figure 8. Movement network design. Source: The researcher.

There are some principles presented in the framework that help adapt to several disasters together, such as planting trees which help adapt to five disastrous occasions, for shading to reduce thermal stress on pedestrians, absorbing rainwater, directing dust storms away from urban spaces, stabilizing roadsides and slopes during the earthquake, and helping to increase rates of Oxygen in the air and its renewal against epidemic risks. Additionally, environmental materials can be used for paving as they do not cause an increase in thermal stress and are permeable to surface water in the event of urban flood. Planning a network of spaces, gardens, and a vital multi-use path for pedestrian movement within the city in integration with the urban distribution can serve as areas of safe refuge from earthquakes, sandstorms, and floods allowing residents to easily access them during periods of the epidemic. It also

reduces extreme heat waves and helps in managing and collecting rainwater and floods. In addition, it is necessary to provide good connection of pedestrian and bike paths with spaces and green areas for safe refuge during disasters of earthquakes, floods, epidemics, and sandstorms, with the design of slopes that help people with special needs in easy access. Finally, it is necessary to direct the main roads and pedestrian paths parallel to the desired wind direction and perpendicular to the sandstorms direction to form main air movement lanes that permeate the urban mass, improve the climatic conditions of the pedestrian environment during epidemics and periods of heat stress, and reduce their effects as a conduit for sandstorms so that they are not a source of nuisance to pedestrians.

The uniqueness of the Egyptian case appears in preparing urban spaces to adapt to natural hazards and

allow for residents lifesaving, taking into account the culture of society and the possibility of the urban space returning to its natural state in short term. This, in return, helps to achieve the concept of resilience. Nonetheless, there is a great necessity for identifying the location of survival tool stores in vital spaces and roads that contain activities generating high traffic frequencies and to secure them most of the time. Additionally, there is a dire need for raising community awareness of the importance of using these stores only during disasters to help save lives. These stores contain survival tools from sandstorms, earthquakes, and floods such as first aid kits, dust masks, potable water, a reserve stock of food, a flashlight, a whistle, and a battery-operated radio. Furthermore, it is highly required to design a network of linear parks parallel to the road that integrates with public parks to suit the high population density within the city's urban areas, reduce heat stress in the city, and create a healthy environment that could be suitable for pedestrians during epidemics.

The specificity of the Egyptian case appears in the necessity of designing straight bicycle paths to be used as emergency paths during disasters. Additionally, these paths allow the movement of emergency service vehicles (ambulance, firefighting, rescue and relief) in order to bear evacuation efforts and the transport of emergency supplies. It is significantly important to place signposts along the road lane to alert drivers not to overtake and raise awareness within the local community of the importance of evacuating these paths, especially in times of disasters. Finally, installing sensors on lighting poles in open spaces, gardens, and roads is highly required in the Egyptian case to sense the danger an appropriate period of time before sandstorms blowing from unexpected directions, as was previously urged in the Mediterranean coastal cities, which enables locals to resort to indoor places.

This framework helps to increase the resilience of the Egyptian cities from the urban perspective in light of the presence of a society aware of the ways to deal with disaster. This can be achieved through raising awareness and education of the local community. Therefore, providing training programs for samples of the community, performing proactive simulation models to reach safe areas without crowding, and raising the community's interest in preserving spaces and gardens help to increase the resilience of the Egyptian city. Finally, urbanism is considered as a mirror of its own community.

Acknowledgements

I extend my deepest gratitude to my supervisors, Dr. Abbas el-Zafarany and Dr. Noha Abd-elaziz, for their invaluable guidance and feedback during my research. I also wish to thank all those who offered their support and advice when it was most needed.

REFERENCES

- [1] D. R. Godschalk, "Urban hazard mitigation: Creating resilient cities," *Natural Hazards Review*, vol. 4, no. 3, pp. 136–143, 2003, doi: 10.1061.
- [2] "What is the meaning of resilient city?," *CCRNedu*, Available: <https://www.uccrn.education/what-is-the-meaning-of-resilient-city/> (accessed Sep. 14, 2023).
- [3] D. I. Alvarado, "Urban resilience: Building sustainable and future-proof cities," *ZIGURAT*, Available: <https://www.e-zigurat.com/en/blog/urban-resilience-sustainable-cities/> (accessed Jul. 18, 2023).
- [4] United Nations, "Make cities and human settlements inclusive, safe, resilient and sustainable," in *The 2030 Agenda and the Sustainable Development Goals: An Opportunity for Latin America and the Caribbean, LC/G.2681-P/Rev.3*, Santiago, 2018, pp. 51–53.
- [5] J. A. Lapus, T. C. Sangil, and V. J. Tobin, "The Philippine disaster risk management system," in *Disaster Risk Reduction Resource Manual, DepED Philippines, UNICEF Philippines*, 2008, pp. 60–102.
- [6] D. P. Coppola, "Mitigation - Preparedness - Response - Recovery," in *Introduction to International Disaster Management, 3rd ed.*, Elsevier, 2015, pp. 209–422.
- [7] OneNYC, "Vision 4: Our Resilient City," in *One New York: The Plan for a Strong and Just City, NYC Government*, 2013, pp. 214–251.
- [8] United Nations, "United Nations Disaster Assessment and Coordination: UNDAC Field Handbook," 7th ed., OCHA, 2018, pp. 1–18.
- [9] UNISDR, "Sendai Framework for Disaster Risk Reduction 2015–2030," 1st ed., United Nations, 2015, pp. 9–27.
- [10] The Rockefeller Foundation, Arup International Development, "City Resilience Framework: 100 Resilient Cities," *ARUP*, 2014, updated 2015, pp. 1–21.
- [11] S. A. Alshehri, "A Proposed Framework for Resilience to Biological Disasters: The Case of MERS-CoV Threat in a Transient Mass Gathering Event," *PhD Thesis*, Cardiff University, 2016.
- [12] UNDP Empowered lives. Resilient nations, Humanitarian Aid and Civil Protection, "Community-Based Resilience Analysis (CoBRA), Conceptual Framework and Methodology," *Version 1, UNDP Drylands Development Centre*, 2018, pp. 1–16.
- [13] Sharif, "A critical review of selected tools for assessing community resilience," *Ecological Indicators*, vol. 69, pp. 629–647, 2016, doi: 10.1016/j.ecolind.2016.05.023.
- [14] J. C. Applegath and Fraic, "Future proofing cities: Strategies to help cities develop capacities to absorb future shocks and stresses toolkit," *Scribd*, 2012.
- [15] J. Gonzales et al., "Conceptual framework for public open spaces," in *Public Open Space Resilience Framework: An Assessment Framework of Public Open Space and Its Functions as They Relate to Resilience, UIC*, 2019, pp. 22–29.
- [16] "The Essex Design Guide: Design details," 3rd ed., *EPOA*

- Essex Planning Officers Association*, 2018, pp. 191-203.
- [17] WHO European Region, "Findings: urban preparedness and resilience by type of event," in *Urban Planning, Design and Management Approaches to Building Resilience – An Evidence Review, First Report on Protecting Environments and Health by Building Urban Resilience*, Copenhagen: WHO Regional Office for Europe, Licence: CC BY-NC-SA 3.0 IGO., 2022, pp. 6-20.
- [18] H. Larsen, "Zollhallen Plaza," *Landezine: Landscape Architecture Platform*, 2015.
- [19] "COVID-19: Montréal to offer safe active transportation circuit this summer," *Ville de Montréal*. Available: http://ville.montreal.qc.ca/portal/page?_pageid=5977,43117560&_dad=portal&_schema=PORTAL&id=32662 (Accessed Aug.19, 2020).
- [20] J. Ruskin, "Areawide Design Guidelines," in *Designing Public Spaces: Energized Public Spaces Design Guidelines, Montgomery Parks: M-NCPPC*, 2018, pp. 14-31.
- [21] Fairfax County - OCR, "ch3: Open Space," in *Urban Design Guidelines for Fairfax County: Commercial Revitalization Districts and Areas*, vol. 1, pp. 3-2:3-11, 2018.
- [22] 100RC member cities, "Resilient Cities, Resilient Lives: Learning from the 100RC Network," *The Rockefeller Foundation- 100RC*, 2019, pp. 18-19.
- [23] H. Larsen, "Arkadien Winnenden," *Landezine: Landscape Architecture Platform*. Available: <https://landezine.com/arkadien-winnenden-by-henning-larsen/> (accessed Apr. 3, 2013).
- [24] Interreg, "Derbyshire Street Pocket Park, London Borough of Tower Hamlets," *Susdrain*. Available: https://www.susdrain.org/casestudies/case_studies/derbyshire_street_pocket_park_london.html (accessed 2020).
- [25] C. Stewart, "Make a rain garden: Garden Design," *Garden Drum*. Available: <https://gardendrum.com/2012/09/10/make-a-rain-garden/> (accessed Sep. 10, 2012).
- [26] "SuDS Planters: London's Residential Flood Solution," *Meristem Design*. Available: <https://www.meristemdesign.co.uk/news/tag/Rain+Garden> (accessed Feb. 26, 2025).
- [27] M. Bryant, P. Allan, "Open space innovation in earthquake-affected cities," in *Approaches to Disaster Management - Examining the Implications of Hazards, Emergencies and Disasters*, (ISBN978-953-51-1093-4) *Intechopen*, pp. 183-204, 2013, doi: 10.5772/55465.
- [28] L. Wei Da, T. G. Hong, "A Resilient Singapore," *Centre for Liveable Cities (CLC) - Singapore, 100 Resilient Cities (100RC) - The Rockefeller Foundation* (ISBN 978-981-11-7811-5) 2018.
- [29] Resilient Rotterdam team, "Resilient Rotterdam Strategy 2022-2027: From Risks to Resilience," *The Municipality of Rotterdam*, 2022, pp. 1-95.
- [30] 100RC, "Ch.3: Prepared And Responsive City" in *Resilient Los Angeles, Eric Garcetti, 100RC*, 2018, pp. 86-125.
- [31] Seoul Metropolitan Government, "Resilient Seoul: A Strategy for Urban Resilience 2019," *100RC*, 2019, pp. 38-66.
- [32] CDMX Resilience Office, "CDMX Resilience Strategy: Adaptive, Inclusive and Equitable Transformation," *1st ed., Ciudad de Mexico (CDMX), 100RC*, 2016, pp. 1- 185.
- [33] Resilient Medellín Team, "Resilient Medellín: A Strategy for Our Future," *Alcaldía de Medellín - Cuenta con Vos, 100RC*, 2018, pp. 1-67. Available: https://resilientcitiesnet.org/downloadable_resources/Network/Medellin-Resilience-Strategy-English.pdf
- [34] S. Morales, "Exploring the Mexican cultural identity: A journey through history, art, and traditions," *Derecho en Sociedad*, vol. 18, no. 2, pp. 193-203, 2024. Available: <https://www.researchgate.net/publication/384948069>, doi: 10.63058/des.
- [35] Seoul team, "Captivated by Seoul - City of History, Nature, Culture, and Solidarity," *Seoul Metropolitan Government, Publication No. 51-6110000-002826-01, ISBN 979-11-6599-851-6*, 2022, pp. 1-184. Available: https://english.seoul.go.kr/wp-content/uploads/2023/05/Captivated_by_Seoul.pdf
- [36] National Heritage Board, "Our SG Heritage Plan 2.0," *MCCY*, 2023, pp. 1-72. Available: <https://www.nhb.gov.sg/-/media/nhb/files/resources/our-sg-heritage-plan-2/nhb-hp2-publication.pdf>
- [37] National Parks Board, "Urban Tree Care: Understand the Challenges That Urban Trees Face, and Discover What It Takes to Care for an Urban Forest," *TreesSG*. Available: <https://www.nparks.gov.sg/treesg/learn/benefits-of-trees#> (accessed 2023)
- [38] H. Larsen, "Rochor Canal," *Landezine: Landscape Architecture Platform*. Available: <https://landezine.com/rochor-canal-by-henning-larsen/> (accessed Jan. 14, 2016).
- [39] Park Connector Network (PCN), "Know Our Recreational Connectivity," *A Singapore Government Agency Website*. Available: <https://pcn.nparks.gov.sg/aboutrecreationalconnectivity/> (accessed 2022).
- [40] H. Larsen, "Copenhagen Strategic Flood Masterplan," *Landezine: Landscape Architecture Platform*. Available: <https://landezine.com/copenhagen-strategic-flood-masterplan-by-henning-larsen/> (accessed May 29, 2015).
- [41] De Urbanisten, "Climate Proof ZoHo District: A work in progress," *issuu*. Available: https://issuu.com/jesus_martin_hurtado/docs/urbanisten_climate_adaptive_zoho_lr (accessed Jan. 31, 2017).
- [42] D. Y. YING BIAN, "Sponge City: Stormwater Management in Landscape Design," (*Translated by Zhangxu*), *Turenscape Design Firm, AECOM Sasaki SWA*, ISBN 13: 9787553761701, 2013, pp. 1-406.
- [43] City of Camas, "Stormwater Sewer System Operations & Maintenance Manual," *Washington State*, 2022, pp. 1-46. Available: https://www.cityofcamas.us/sites/default/files/fileattachments/community_development/page/9505/stmsewerom2022_new.pdf
- [44] H. Karay, C. H. Choe, "Earthquakes: Guidelines on Preparing, Responding and Recovering," *IFRC (International Federation of Red Cross and Red Crescent Societies, Geneva)*, 2012, pp. 1-73. Available: www.ifrc.org

- [45] M. Alawi, D. Chu, S. Hammad, "Resilience of public open spaces to earthquakes: A case study of Chongqing, China, *Sustainability*, vol. 15, no. 2, pp. 1-20, 2023, doi: 10.3390/su15021092.
- [46] H. Mirghani, "Resisting the negative effects of sand and dust through city planning and building design," Symposium on Urban Development in Desert Areas and Construction Problems, Ministry of Public Works and Housing, Riyadh, Saudi Arabia, vol. 1, pp. 731-721, 2002.
- [47] M. El-Essawi, "The Economics of Environmental Design (A Model for Economic Environmental Design and Its Impact on Buildings)", *PhD thesis*, Faculty of Engineering, Dept. of Architectural Engineering, Cairo University, 2007.
- [48] S. S. Koohestani, "Urban open space adaptation in case of dust storms: A CFD simulation," *2nd International Conference on Future of Urban Public Spaces, Tehran, Iran*, vol. 1, no. 1, pp. 75-85, 2022.
- [49] S. Y. Bashandi and K. Z. El-Adly, "Introduction to Sustainable Urban Design and Shaping the Urbanization of Desert Communities - Study of Traditional Oasis Communities in the Western Desert of Egypt," Symposium on Urban Development in Desert Areas and Construction Problems, *Ministry of Public Works and Housing, Riyadh, Saudi Arabia*, vol. 1, pp. 386-373, 2002.
- [50] F. Sommese, "Nature-based solutions as climate change adaptation measures: Lessons and best-practices from European cities," in *Proceedings of the 11th International Conference of Ar.Tec. (Scientific Society of Architectural Engineering)*, *Civil Engineering*, 2024, pp. 678-691, doi: 10.1007/978-3-031-71863-2_42.
- [51] UN-Habitat (United Nations Human Settlements Programme), "Cities in the Face of COVID-19: The Role of Population Size, Density and Urban Form," in *Cities and Pandemics: Towards a More Just, Green and Healthy Future*, *Shutterstock*, 2021, pp. 18-46.
- [52] L. Diana, A. Gigliola, and F. Sommese, "New green spaces for urban areas: A resilient opportunity for urban health," in *Resilience vs Pandemics: Innovations in Public Places and Buildings, Urban Sustainability*, 2024, pp. 37-54, doi: 10.1007/978-981-99-8672-9_3.
- [53] C. Hsu and B. A. Sandford, "The Delphi technique: Making sense of consensus," *Practical Assessment: Research, and Evaluation*, vol. 12, no. 10, pp. 1-8, 2007, doi: 10.7275/pdz9-th90.
- [54] T. Sablatzky, "Methods moment: The Delphi method," *Hypothesis*, vol. 34, no. 1, pp. 1-6, 2022, doi: 10.18060/26224.
- [55] Kozak and A. Frączkiewicz, "Practical application of the Delphi method to identify key factors of social change implementation," *Silesian University of Technology Publishing House*, vol. 177, pp. 339-350, 2023, doi: 10.29119/1641-3466.2023.177.19.
- [56] G. J. Skulmoski, F. T. Hartman, and J. Krahn, "The Delphi method for graduate research," *Journal of Information Technology Education*, vol. 6, pp. 1-21, 2007, doi: 10.28945/199.
- [57] P. O. Akadiri, P. O. Olomolaiye, "Development of sustainable assessment criteria for building materials selection," *Engineering, Construction and Architectural Management*, vol. 19, no. 6, pp. 666-687, 2012, doi: 10.1108/09699981211277568.