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# Codification of The Conceptual Framework of River Valleys' Physical Resilience (Case Study: "Kan" River Valley, Tehran)

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**ABSTRACT:** The Urban River Valleys are not only the interface between the city and nature, but they are also essential spatial places that carry urban context, local life, and other environmental characteristics. As a result, the design of urban river Valleys is one of the most important strategies for promoting urban ecological systems, protecting socio-economic benefits, and increasing aesthetic values. This paper proposes the resilience concept to address the problem of natural hazards at the River Valleys while maintaining the environment's qualities. For this purpose, the focus is on applying the physical dimension of resiliency for presenting design qualities and indicators by studying the expected roles and qualities of urban rivers and the concept of resiliency. So at first, the Resilient Urban River Valleys Conceptual Framework has been codified, and dimensions, Components, and criteria of resilient River Valley design are proposed. In the next step, This Conceptual Framework is used to examine the quality of Tehran's Kan River Valley s Public Space using a SWOT matrix and develop design goals and strategies. Finally, this study stands on the notion that a place's resilience not only embraces formulating an immediate response to crises such as floods but also considers long-term mitigation and adaptation strategies and environmental qualities to face environmental challenges. In this perspective, reconnecting the community with the river through creating a favorable public space and using the natural potential of the rivers to confront the hazards is necessary.

**Keywords:** *Physical Resiliency, River Valley, Conceptual Framework, Kan River, Design Strategies.*

## INTRODUCTION

Over the past decade, increased industrialization, restructuring of land use, and building of huge transport networks and metropolitan areas have imposed many challenges in protecting the rivers from related problems such as water scarcity, pollution, solid waste, and biodiversity (Baris et al., 2010). Many River Valleys worldwide are in deteriorating urban condition due to various environmental, social, and economic factors (Hussein, 2014). also, some actions to confront flood impacts in some parts of the world have worsened the condition of the urban river Valleys. Limiting rivers to separated parks and green spaces along the passages and leaving them from the natural structures of the urban, reduction of water quality and biodiversity, intensifying the natural and social threats, and creating unpleasant and unsafe urban areas are some of the effects resulting from some of these measures made to tackle the flood.

So study of urban resilience provides a comprehensive analysis of the risk of natural disasters and the capacity of urban ecosystems to survive these disasters; It can be said that Urban resilience is a significant capacity to adjust to stress from hazards and to recover quickly from their impacts from catastrophe (Pendall et al., 2010). In the meantime, potential urban hazardous parts grab more focus in the Field of resiliency. Urban River Valleys are among these areas that are precious urban natural and public spaces while being among the most dangerous ones. These potential threats are the main reasons that in many developing countries, designing approaches have been operationalized in river fronts (such as channelizing or covering the rivers with concrete) that have led to the destruction of the natural identity of the rivers while enhancing the threats of natural and social hazard. The Field of riverfront design is increasingly embracing the

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concept of resilience, which suggests that it may soon become integral to river policy and programs. Consequently, understanding the role of resilience in rivers is a crucial aspect of the scientific method. However, differing opinions on how to apply resilience in policy and programs may potentially sideline river research from the policy-making process (Holling, 1973).

In Iran, after the flooding of Tajrish river in 1987, which caused 300 deaths (Ghahroudi Tali & Nezammahalleh, 2013) a trend appeared among the city administrators to canalize the rivers in order to control them. This trend led to appearance of homogeneous river parks with no specific water-related identity, while planners were oblivious to this fact that water should be the defining force that fundamentally shapes the character of each place it touches. Accordingly, in today's development pattern of Tehran city's natural areas, the reconstruction of urban River Valleys does not comply with the natural structure of the rivers and their role as a public space area. As a result, the final design does not fulfill the citizen's need for recreational activities in the natural environment. In Kan's river, for example, after the reconstruction of the River Valley, which contained channelizing the river with cement walls and construction of a park with no water-related identity, the majority of the respondents agreed that although the accessibility to the River Valley area has been enhanced after the construction, the design was not correspondent to other environmental qualities. Also, direct connection with the water and associated aesthetics, vital criteria of vivid urban River Valley, are seriously harmed after Kan's project. Apart from that, according to the site visit, the cement channel has increased the speed of runoffs and decreased the amount of native vegetation which are considered major reasons of flood in urban river Valleys.

Regarding these issues, this paper addresses the following questions:

- What is the definition and dimensions of resilience concept in face of urban River Valley s?
- What are the function and spatial qualities of River Valley in cities?
- What are the design qualities based on studying Global Experiences in the Field of resilience in river systems?
- What further design strategies can be recommended for the kan River Valley to become resilient?

So, This paper aims to present a conceptual framework of resilience the River Valley on the descriptive-Analytical method; This framework provides the possibility of examining the Ken River Valley and proposing a design strategy and qualities to achieve a resilient high-quality public space in the next step.

## Urban Resiliency; Dimensions and Characteristics

Etymologically, resilience derives from the Latin resilient, whose meaning is 'to spring back' and 'to rebound' but also, significantly enough, 'to withdraw.' This concept was first entered the systems theory by Holling (1973) and is defined as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Pizzo, 2015). Since then, numerous studies, particularly in the Field of ecology, have contributed to resilience thinking; From the beginning of the 1990s, the theory of urban resilience has been taken into urban development practice, and over the past decade, its use in policy and practice has increased (Scheffer, 2020); because the city as a complex system was becoming increasingly powerful while also becoming more and more fragile; any damage or failure in adaptation to new changes of sub-systems, could result in a fatal crisis even devastation of the entire city (Davoudi, 2012). So, based on an extensive review of literature from a wide range of disciplines, Davoudi (2012) distinguishes between three broad conceptualizations of resilience:

Engineering resilience concerns cities' capability to be sustainable and return to equilibrium or a steady state during an extreme event while reconfiguring their physical configuration. Engineering resilience that is related to the aims of this study, focuses on the Physical dimension, and involves resilience in Built Environment and Infrastructure, Land-Use, and urban Structure (Kong et al., 2022). Ecological resilience, however, emphasises persistence over stability. The idea of a stable equilibrium, "be it a pre-existing state to which a resilient system bounces back (in engineering) or a new state to which it bounces forth (in ecology)," is what engineering resilience and ecological resilience share in common (Lu & Wang, 2015). More recently, this perspective has been challenged by socio-ecological resilience (Davoudi et al. l., 2013); This approach views resilience as the capacity of complex social-ecological systems to alter, adapt, or transform in response to stressors and strains (Carpenter et al., 2005), as opposed to resilience being conceptualized as "a return to normalcy" (Pendall et al., 2010). As a result, rather of concentrating on long-term, small-scale changes, engineering and ecological resilience tend to focus on responses to unexpected and catastrophic threats. But socio-ecological resilience supports the idea that "people and nature are interdependent systems." (Folke et al., 2010). This perspective argues that people's decisions are the main reasons causing threats. For example, in the flooding case, the dense human construction across floodplains, getting the rivers' bed concreted over, getting the people indifferent to the situation of the rivers by lowering their sense of belongingness resulting from low-quality urban spaces around them all contribute to the vulnerability of the rivers to the environmental hazards.

based on above, urban resilience is identified by four core characteristics: preparedness, persistence, adaptability, and transformability. These characteristics are typically used to describe the diverse and interrelated abilities of urban ecosystems across phases of resilience (before, during, and after an event) (Jabareen, 2013; Sharifi & Yamagata, 2014; Ribeiro & Gonçalves, 2019; Tong, 2021; Kong et al., 2022). Monitoring the value of these characteristics can reflect a system's level of resilience and inform actions to enhance its resilience:

- ***Preparedness*** is humans' capacity for foresight and intentionality and their search for ways to enhance their ability to anticipate and plan (Kong et al., 2022). So preparedness is essential to facilitate the decision-making process before disasters; because the inherent uncertainties of the hazards require a learning-based approach to both accumulations of knowledge and identification of vulnerabilities and also the opportunities. Some of these attempts exemplify in studies undertaken to understand the extent and severity of the hazards (such as analyzing fluvial flood risks and the capacity of flood barriers and drainage systems to withstand them) or Identifying the potential of the place to prepare for the hazards (for example improvement of the green infrastructure, terracing the floodwalls of the river). Besides the detailed statistical data, past experiences in terms of lessons learned or peoples, play an essential role in this process. In this perspective, people would

not be considered as the factors that can be affected by the disasters or not; instead, they have an active role as participants in a place resiliency by finding new and ways of reducing uncertainty. In this regard, social learning and Preparing the local societies to endure the stress emerged from the catastrophes can be obtained through intensifying social justice, a sense of belonging, responsibility, collective memory, or personal narrative (Davoudi et al., 2013; Ribeiro & Gonçalves, 2019). Many of these factors can be achieved from the processes in which social potential opportunities and vulnerabilities are detected such as activities that can be done by the local governments or NGO s to participate and empower the local people.

- ***Persistence*** is concerned with the cities' physical infrastructure and utility ability to withstand a given level of stress, endure its impacts, and cope with it to a certain extent while not being degraded by its effects or losing function, particularly during and shortly after a disaster (Sharifi & Yamagata, 2014; Ribeiro & Gonçalves, 2019). This characteristic reflects the inherent strength of urban ecosystems' ability to sustain fundamental functions, such as robustness, diversity, and redundancy. It can be referred to as 'Actions taken in response to an event to limit the impact of the event, for example, restricting non-essential water use during a drought, or providing emergency accommodation for people displaced by an extreme weather event.
- ***Adaptation*** is "the flexibility to seize opportunities and the capacity to initiate informed, deliberate, long-term changes in the system in responding to changing conditions to maintain desired functions" (Jabareen, 2013; Tong, 2021). Adaptability lies in both flexibility and resourcefulness; Flexibility draws attention on the significance of the connections between critical sectors (such as transport networks and also social networks between people and institutions) and the significance of cooperation between various levels of governance in post-disaster recovery. Maintaining these links that facilitate flows of ideas and resources is one way of increasing the adaptability of socio-ecological systems. Resourcefulness refers to efficiency, rapidity, and diversity. Diversity refers to different species types and their different functional role (Gunderson, 2009). Planners contend that mixed-use developments, diversity in spatial planning have a better chance of avoiding blight. For example, not clustering important activities in the flood sensitive areas.
- ***Transformability*** is "the capacity to become a different kind of system, to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable" (Tong, 2021; Kong et al., 2022). Transformability considers framing omega phase of the adaptive cycle (when the system experiences a 'regime shift' and crosses thresholds leading to unpredictable trajectories) as a window of opportunity with potentials to transform socio-ecological processes towards radically different and more desirable paths. In other words, it is achieved by fundamental changes in infrastructures, functions and relationships.

These characteristics suggest that the cities can become more or less resilient depending on their social learning capacity (being prepared) for enhancing their chances of resisting disturbances (being persistent and robust), absorbing disturbances without crossing a threshold into an undesirable and possibly irreversible trajectory (being flexible and adaptable), and moving towards a more desirable trajectory (being innovative and transformative). This definition lays a theoretical foundation for enhancing the capacity of urban ecosystems to survive, adapt to, and grow from changes and uncertainty.

In the following, based on the aims of the research, the principles and criteria governing the physical dimension related to Engineering resilience will be examined and its relationship with the design of riverbanks will be verified.

## Characteristics of the Physical Resilience

Physical resilience to improve the quality of the environment and stability against risks in the physical dimension, in addition to providing shelters for the injured after the crisis, the principles for designing the body before the crisis and danger are discussed (Feliciotti et al., 2016; Parizi et al., 2022). So, The physical dimension of resilience is defined as optimizing the quality of the environment for the stability of communities against natural disasters by considering the social, economic, and cultural capacities of the local community. In this dimension, it pays attention to the following:

- How the infrastructure works
- Access to critical facilities, including water, electricity, gas, and waste management lines
- Access to health and health services
- How the emergency function of the city body works in the event of crises
- How to connect residential areas
- The possibility of using public facilities and providing support measures for water and food supply
- quality of open spaces
- The physical condition of buildings (resistance, quality and building age, ownership, construction technology, and materials, building height, massing and occupation level, building density)
- Access and movement system (permeability, evacuation, and repetition of risks)
- Land Uses compatibility (Lak, 2013; Parizi et al., 2021, 2022).

But, despite the importance of this dimension in urban resiliency, there is currently no agreement in the literature on a unified list of proxies encompassing all aspects of the physical dimension of engineering resilience; a multidisciplinary review of the literature show that the characteristics agreed upon by researchers and frequently mentioned in the literature are diversity, connectivity, redundancy, robustness, modularity, adaptability, multi-functionality, and efficiency, as shown in Figure1 (Allan & Bryant, 2011; Anderies, 2014; Feliciotti et al., 2016; Parizi et al., 2021, 2022):

- ***Diversity*** is a core concept in physical resilience. Systems with greater diversity are better equipped to adapt to change and maintain some degree of stability, which increases their capacity for creativity. Diversity thus refers to the inclusion of several physical components in various shapes and functions, which allows the system to adapt to a broad variety of varied and occasionally unanticipated circumstances. The variety of urban land uses, communication systems, and open and green areas, for instance, may all assist the physical structure of the city deal with natural risks.
- ***Connectivity*** refers to the ease of access to different urban spaces and the appropriate hierarchy between them. Both high and low

connections can be advantageous for resilience: the first promote information dissemination and recovery after disturbance, while the second slows the spread of disturbance and allows for the retention of localized memory. Furthermore, because greater connectivity increases the points of contact and exchange between elements of the urban fabric, the structure of connections between them is frequently even more important than their nature in determining how people move around and where and how intensely activities occur. For this reason, connectedness is crucial to urban permeability. To escape and offer help during disasters and afterward, adequate access and communication are required.

- ***Redundancy***, which serves as an insurance mechanism against change, damage, or failure, is the presence of numerous components or channels "performing the same, similar, or backup functions." A redundant system has a decreased chance of stalling because, in the event that one or more components fail, redundancy assures continuity by making backups available. The degree of internal variability within each functional group is what provides the system the buffer capacity to employ alternate resources or pathways when the primary ones are gone, thus redundancy is not just about duplicating functions. Redundancy is a structural characteristic of the urban form that is independent of any specific future scenario, yet it can aid in a system's survival in the case of catastrophic occurrences. Therefore, redundancy makes sure that systemic disruptions are kept to a minimum when the danger and its consequences affect a number of urban physical components.
- ***Robustness*** is one of the critical characteristics of urban physical resilience. The capacity of the urban physical structure to endure earthquake pressures greatly rises when buildings and other urban physical components are strong.
- ***Modularity*** in the urban physical system refers to the way that smaller parts of the urban physical system work together to form bigger ones. As a result, even if one or more of the components' functions are lost or interfered with, the overall urban system will still work. Modularity is, therefore, essential for resilience. Each module or sub-system is protected from over-connectivity by its relative autonomy; this allows it to try new ideas without interfering with other modules and fail without significantly impacting others, which promotes stability. At the same time, the interdependence of the modules fosters adaptability by enabling the diffusion of innovation and information.
- ***Adaptability*** enables the physical system to cope flexibly with disruptions and subsequent changes. A flexible urban physical system also possesses the potential to learn from past mistakes.
- ***Multi-functionality*** of the urban system indicates that some of the urban physical components can be used for multiple purposes. For instance, during unfavorable circumstances, temporary shelters might be built in open and natural areas.
- ***Efficiency*** in resilience is controversial. According to a number of writers, efficiency is often gained at the sacrifice of modularity, connection, redundancy, diversity, and overall resilience. This is the case when efficiency is considered in the context of a short-term viewpoint that aims to minimize issues by streamlining procedures and maximizing results on a single scale. Actually, there is no optimal state in complex systems because of scale interdependency, which causes maximization of one process or element to have unpredictably non-linear effects on others. In fact, efficiency in complex systems doesn't result from a process of simplification; rather, it calls for an increase in structural complexity at every scale. Efficiency in the urban form has to do with the hierarchical organization of various urban components and demands that the same degree of complexity be guaranteed at all scales. For instance, having convenient access to a variety of medical and fire services, varied urban uses, mixed densities, etc. may improve reaction times and speed up recovery times, which increases efficiency.

Figure 1 shows urban resilience dimensions and characteristics.

## The Function and Spatial Qualities of River Valley in Cities

The term of River Valley can be defined as a part of a town that is next to an area of water such as a river or the sea (Amola, 2009). the River Valleys are the convergence point of land and water which are dynamic resources of unique history, identity, and environmental qualities in the cities and would be the places where people are connected to nature, and they could be used for relaxation, leisure and enjoying the nature (Kim et al., 2014). So nowadays it has become the consideration of many cities that, in order to create a better public realm at the waterfront areas, envision some qualities to create a network of well-connected, multi-use public spaces that fit the community's shared goals (Mostafa, 2017). To determine their expected environmental qualities, first, their role and function in the city must be studied. At this point, Table 1 shows the main functions of urban

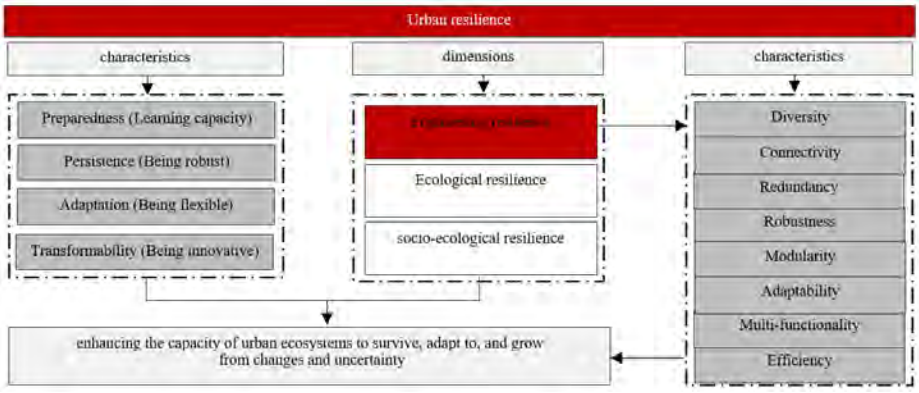



Fig. 1: Urban resilience dimensions and characteristics

River Valleys that would be attributed to the three main dimensions of Physical-functional, Perception-Aesthetical, and Ecological based on the Golkar "sustainable place" model (Golkar, 2001).

Based on tab, in addition to the structural and economic roles in cities, the River Valleys fulfill part of the society's biological needs and improve the citizens' living standards. Therefore, their most important role is to provide the necessary ground for human connection with nature and human activities, which can be provided through spatial qualities related to the three dimensions of sustainable place (Figure 2):

- ***Physical-functional qualities***: The Physical-functional qualities, related to the land use, access, structure and physical form of the River Valleys, embark on good connectivity and accessibility

Table 1: function of River valley in cities

| | criteria | Indicator | Reference |
|---|---|---|---|
| physical-Functional | Food supply | Fertility of the surrounding area | (Fachrudin & Lubis, 2016; Fan et al., 2016) |
| | | Irrigation of lands | |
| | | Source of fresh water | |
| | Form of the city | Impact on locating and Spatial formation of cities | (Wang et al., 2008) |
| | | combination of natural and human environments | (Fan et al., 2016) |
| | | City development control | (Viles &, Rosier, 2001; Wang et al., 2008) |
| | Socio-economic | Economic Importance and Financial Investment | (Toronto Sustainability Framework, 2005) |
| | | City Branding | (Toronto Sustainability Framework, 2005) |
| | | Reinforcement and expansion of tourism | (Golkar, 2001; Toronto Sustainability Framework, 2005) |
| | | Renovation and improvement of communication in the landscape | (Wang et al., 2008; Kim et al., 2014) |
| | | Recreational opportunities | (Little, 1995; Ahern, 1995; Griffin, 2005; European Greenways Association, 2005; Turner, 2006; Rukiah & Zainora, 2012) |
| | | Creation of active social fields | (Griffin, 2005; Toronto Sustainability Framework, 2005) |
| | | Increase in land price besides greenways. | (Griffin, 2005) |
| | | Physical security | (Griffin, 2005) |
| | | Cultural and historical corridors | (Fábos & Ryan, 2004; Toronto Sustainability Framework, 2005) |
| | | Economic Importance and Financial Investment | (Ahern,1995) |
| Perception-Aesthetical | Providing citizens' needs for green spaces and natural amenities | Linkage of the people and nature in the city | (Rukiah & Zainora, 2012) |
| | | Cheerfulness and stress relief | (Hoyle, 2001) |
| | the vitality of the city | Dynamic and active edges (impact on legibility) | (Baris et al., 2010; Kim et al., 2014; Kim et al., 2014) |
| | | Facilitating social relationships | (Hoyle, 2001) |
| | Visual Impact | Rich aesthetic values | (Viles &, Rosier, 2001; Greenways Association, 2005; Turner, 2006) |
| Ecological | Ecological benefits for the city | Ecological benefits for the city | (Viles &, Rosier, 2001) |
| | | | (Little,1995; Ahern,1995; Fábos & Ryan, 2004; Greenways Association, 2005) |
| | | | (Hoyle, 2001) |
| | | | (Ahern,1995; European Greenways Association, 2005; Fábos & Ryan, 2004; Turner, 2006) |
| | | | (Kim et al., 2014) |

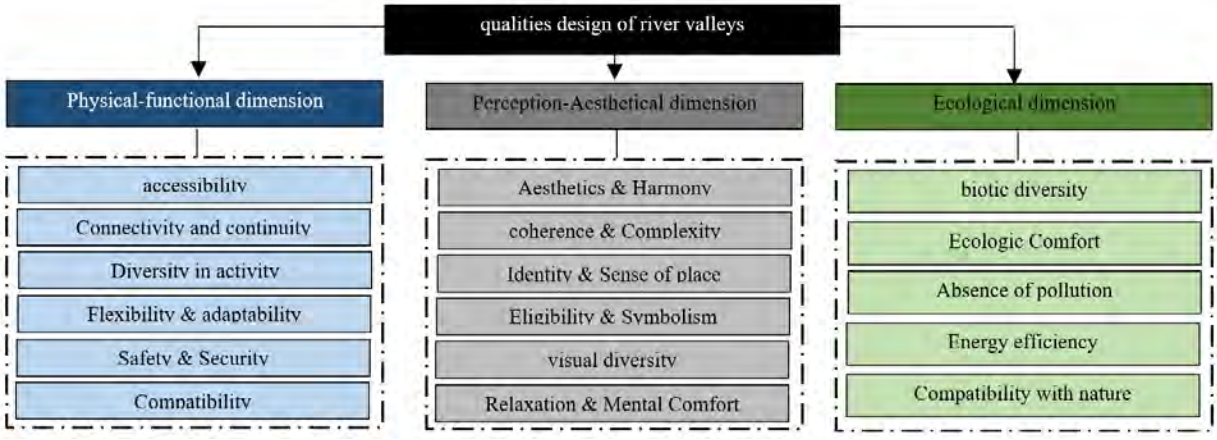



Fig. 2: qualities design of river valleys based on three dimensions of sustainable place

for all users especially pedestrians, diversity in activity and land use, flexibility and adaptability, providing safe, secure, and vital public space as well as leisure activities for the users (Pakzad, 2012; Hussein, 2014; Urban Waterfront Manifesto, 2016; lak, 2013). It is important to consider that the River Valley must not restrict the connection of the people with the river and also water associated activities while providing the users with a safe and vital urban space.

- **Perception-Aesthetical qualities:** River valleys, as urban edges, are one of the most important elements of the city's structure and remain as a sign and indicator of a part of urban areas in citizens' minds; the urban axes that are created in connection with this natural corridor in the cities play a significant role in the identity of the city to the extent that the special characteristics know some of these cities of these axes (Pakzad, 2012; Alehashemi et al., 2015). Also, the Perception-Aesthetical qualities of River Valleys consider the role of rivers landscape in providing natural visual Aesthetics such as harmony, complexity, and visual diversity (Pakzad, 2012; Pourjafar & Rastandeh, 2009; Lak, 2013) besides affecting the perception of the people such as legibility, identity, relaxation, and Mental Comfort. It is important to consider that these perceptions must be water identity-based to have a successful design.
- ***Ecological qualities***: The energy and environmental benefits of the river valleys are highlighted by their ecological features. Rivers, which are distinguished by distinctive natural habitats, considerably lessen the effects of urban heat islands and enhance biological processes. Rivers in metropolitan areas, however, have lost their ability to operate as rivers as a result of urbanization and industrialisation since they have been covered with concrete and asphalt. The government should therefore adopt environmentally friendly river improvement techniques to improve the surrounding landscape, recover the fundamental functions of rivers, such as the function of self-purification, preserve biotic diversity, and restore the waterway and return the environment to its original ecological state. (Ministry of Environment in Korea & Korea Environment Corporation, 2011).

## Studying Global Experiences in the Field of resilience in River Systems

### Brattleboro's Lower Whetstone Brook Corridor (2017)

Brattleboro, Vermont, was founded due to the confluence of Whetstone Brook, a tributary of the Connecticut River. The city has experienced floods from the Whetstone throughout its history. Most recently, a significant flood from Tropical Storm Irene in 2011 submerged portions of the Whetstone corridor. Since that disaster, Brattleboro has launched several efforts to lessen the effects of flooding and develop plans, guidelines, and activities that will lead to a more resilient downtown. The U.S. Environmental Protection Agency (EPA) provided technical support to the municipality in 2016 as part of its "Making a Visible Difference (MVD) in Communities" project. The town has the following particular objectives for the project:

- Use green infrastructure to catch and filter storm water to preserve water quality.
- Use green infrastructure to catch and filter storm water to preserve water quality.
- Locate potential sites for infill construction and redevelopment.
- Establish a link between locals and tourists to Whetstone Brook by creating several public areas for pleasure.

Based on goals, design methodologies show how to construct ecologically and culturally sensitive, flood-resistant landscapes that satisfy Brattleboro's aims and concerns. This plan for the corridor may be executed gradually over time and might lead to enhancements in the Whetstone Brook's water quality as well as the health and wellness of its citizens and tourists. suggested

design possibilities (Figure 3):

- transforming the parking lot into a park in order to reduce the amount of impervious surface and increase the quantity of water that can be stored during major storm occurrences Removal of some vertical channel walls along the brook and replacement with terracing elements to increase flood storage.
- renovation of the area by adding tiered outdoor seating that overlooks the creek and makes the most of this superb resource.
- The establishment of pedestrian and bicycle lanes on both sides of the brook that link the communities, provide options for walking and bicycling enjoyment, and permit close proximity to the Whetstone Brook.
- The development of a mixed-use community on currently idle industrial property.
- Construction of an effective stormwater management and flood storage facility on a 12-acre location upstream of the city.

The extensive use of green infrastructure for storm water management (Design for Resilience in Brattleboro's Lower Whetstone Brook Corridor, 2017).

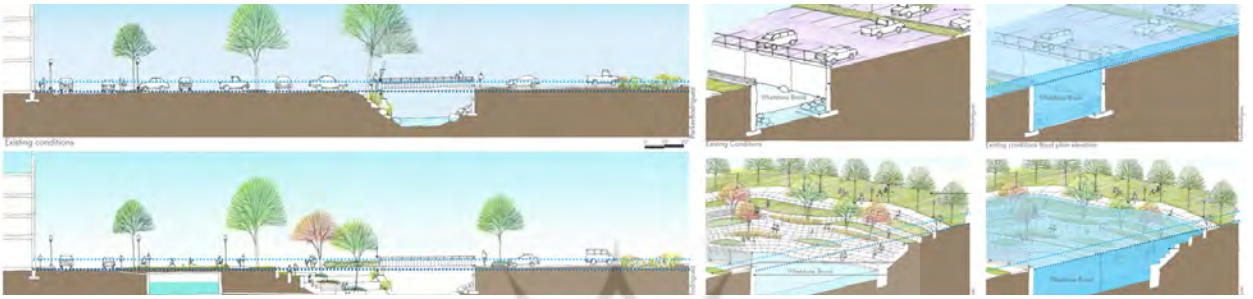


Fig. 3: Brattleboro's Corridor, before and after pictures (Design for Resilience in Brattleboro's Lower Whetstone Brook Corridor, 2017)

**Yanwieizhou Park Project (2014)**

For many years, Yanweizhou was an undeveloped natural riparian wetland. they were situated where the Jinhua River and the two rivers meet. Beyond its tail, an organically structured opera building has already been built, eradicating riparian wetlands. The three rivers, each measuring more than 100 meters in width, once separated the region's heavily inhabited villages. Due to accessibility issues, nearby cultural venues and nearby green spaces were underutilized. Sand quarries broke up or ruined the remaining 50 acres of riparian wetland. Poplar and Chinese wingnut trees filled the existing swamp, creating a home for local birds. As a result, the project draws attention to:

- Provide facilities to the congested urban core's inhabitants while preserving the riparian environment's last surviving area.
- Determine the appropriate flood management strategy (allowing the park to flood or preventing it with a tall, concrete retaining wall).
- Create a unified landscape by fusing the current structure with the surroundings.
- Reunite the divided metropolis with the riparian ecosystem to enhance community and cultural identity (Figure 4):

Based on goals, the following design strategies are proposed:

- Adaptive strategies to protect the remaining ecosystems, such as plants and topography that can withstand monsoon floods;


Fig. 4: Yanweizhou Park, before and after pictures (Yanwieizhou park project, n d)

- Water-resilient topography and planting design: Resilient spaces are made to meet the demand for brief, intensive usage by the opera house audience, but they may also be used on a daily basis by those looking for quiet, shaded areas. The interplay of the river currents, human movement, and the gravitational pull of things creates a dynamic concord. This is accomplished with the help of meandering vegetated terraces, curving benches, serpentine bridges, curvilinear walks, and circular bio-swales and planting beds..
- A resilient pedestrian bridge linking the city with the outdoors: A robust system of walkways and bridges was created to accommodate the shifting water currents and traffic movements. The trails and bridges unite the city with nature and the past and future (Yanwieizhou park, n d).

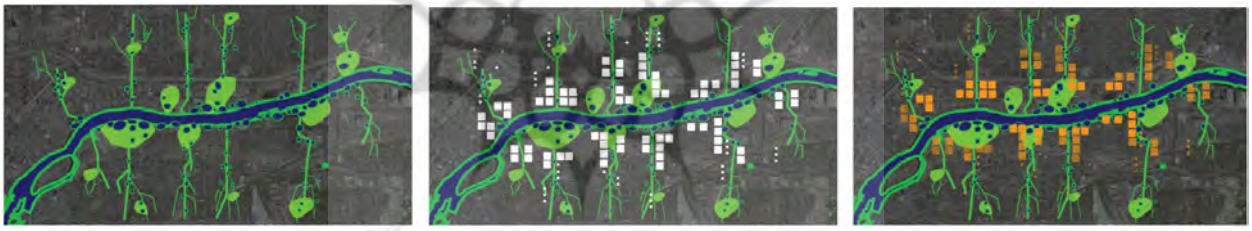
**Minneapolis Riverfront Project (2012)**

The Mississippi River has fueled Minneapolis' growth ever since it was established. The upper riverbank needs to be rediscovered and redesigned, whereas the lower riverfront of the city has achieved great success. This area has difficulties due to a declining industrial base and extensive infrastructure that separates the river from the nearby neighborhoods. As a result, the project's methodology honors the Resilient River by acknowledging the healing potential of nature and the significance of the River in Minneapolis residents' daily lives. The goal is to support the riverfront's recovery as a vital natural site and a location for employment and habitation. Whereas the river has served as a justification for segregating communities and populations, the initiative seeks to provide a space where people may interact. The design team suggested three tactics to deal with these goals (Figure 5):

- Create an ecological infrastructure: A powerful network of city parks is based on nature's strength and adaptability. The project identifies natural assets, such as green infrastructures for urban agriculture, sustainable stormwater management, and sustainable mobility, to create an ecological network that protects and improves important natural and cultural processes.
- The city may be reoriented around the natural resources of the river, juxtaposing it with schools and homes, employment and research, and art and commerce, as green infrastructure expands. These will enhance social fairness, cultural identity, and economic stability.

Maintain the vision across time: The city's municipal authorities realized that while the city's land usage and architecture would change over time, its core landscape components would not. The planning and design process investigates optimum growth over fifty years based on those fundamentals (the resilient river, n d).

Figure 6 demonstrates the design qualities of resilient river valleys based on studying related global experiences.



Build an ecological infrastructure | Reorient urbanism to the river | Curate the vision through time

Fig. 5: three strategies proposed by the Minneapolis Riverfront project (the resilient river, n d)

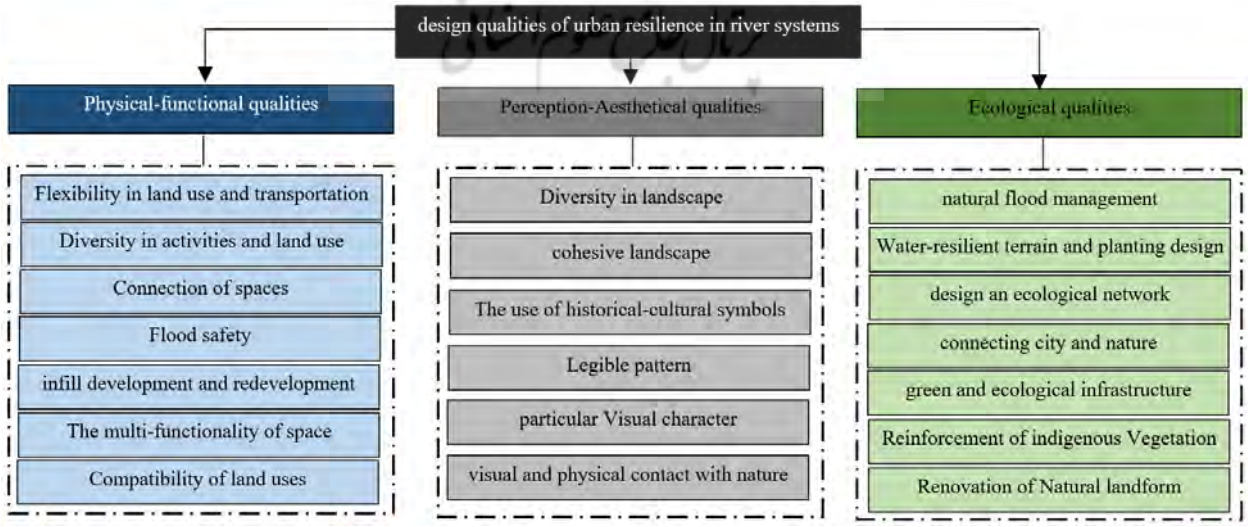



Fig. 6: design qualities of urban resilience in river systems in global experiences

**Resilient Urban River Valleys Conceptual Framework**

The purpose of resilient urban design is to increase flexibility in the three main components of the city, including "physical form," "city function and flows" (movement of people, information, transportation), and "services and infrastructures." To realize the essential dimension of resilient river valleys design, After reviewing the dimensions and characteristics of urban resiliency, function and spatial qualities of River Valleys and related global experiences, qualities for resilient-based river valley design are proposed in the form of a conceptual framework based on four dimensions of a sustainable place (Table 2).

Table 2: Resilient Urban River Valleys Conceptual Framewor

| dimension | Component | criteria | Component | criteria | Component | criteria |
|---|---|---|---|---|---|---|
| Physical-functional | Access network | Connectivity<br>Physical Permeability<br>Flexibility<br>Hierarchical communicationLegible structure<br>Fluid flows<br>Substitutability<br>Redundancy<br>Safety | Land use and activity | Mixed-use<br>Compatibility<br>Flexibility<br>Adaptability<br>Diversity<br>Decentralization<br>Transformability<br>Multi-functionality<br>Safe placement<br>Connectivity<br>Infill development | Public space structure | legible structure<br>Modularity<br>Connectivity<br>Flexibility<br>Multi-functionality<br>Safety<br>Robustness<br>Naturalism<br>Redundancy |
| Perception-Aesthetical | visual landscape | Diversity<br>Cohesiveness<br>Decentralization<br>Regularity<br>Robustness<br>Visual Permeability<br>Safety | mental landscape | legibility<br>sense of place | | |
| Ecological | Naturalism | Natural drainage<br>natural hazard safety<br>vulnerability<br>ecological infrastructure<br>indigenousness | efficiency | Energy efficiency<br>recycling technology | | |

## MATERIALS AND METHODS

**The Study Area**

The Alborz mountain range and rivers have created a special geographic and topographic location for Tehran. In 1347, the rigid approach of the Tehran Urban Development Plan neglected rivers' structural role in urban development and the provision of citizens' needs and transformed the rivers into surface water discharges, sewage, and dangerous urban areas. In the meantime, the Ken River was chosen as the city's tourism axis, and its regeneration programs were developed by one of Tehran's famous Consulting Engineer companies. Following this, in the summer of 2012, the Javanmardan Park on the river bank of Kan went into operation between Hemat Highway Bridge and Hakim Highway. Today, after more than five years of exploitation of the Javanmardan park, transformation of this project to one of the weakest projects in Tehran is being questioned (Figure 7).

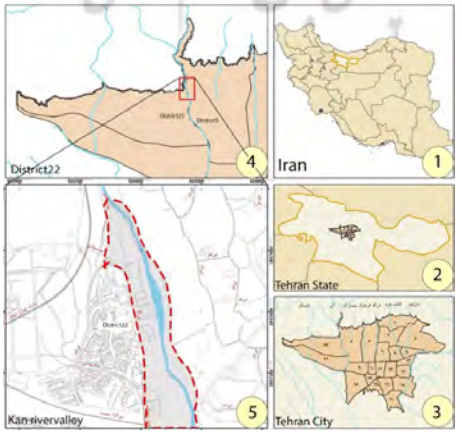



Fig. 7: Kan rivervalley's location

The designer's lack of understanding of the natural form and the landscape values of the riverside can be considered an important factor for the inability of the proposed design to meet the objectives of the master plan.

However, the failure of this project was not merely a failure of a design project but led to the disappearance of the natural and structural identity of the Kan river as one of the most important elements of the Tehran city. Despite accepting this failure by the authorities in this project, the continuation of the project is being carried out on sites in northern Hemmat (the proposed case study of this paper) and southern Hakim, which will slowly destroy the possibility of revitalizing the kan river as the largest riverside of Tehran. In addition, the continuity of channelizing the river with concrete materials and also neglecting the river's special environmental qualities will severely increase the vulnerability. To prevent future environmental deterioration and improve the area's aesthetic appeal, this research aims to produce a design suited to the natural identity, robust, and sensitive to human requirements.

### Research Methodology

The research methodology for this paper is based on theoretical and analytical studies. This research is divided into two parts: The first part of the study is based on a theoretical and practical literature review to design the conceptual framework of resilient river valleys. After providing this conceptual framework, in the second part of the research, conducted in the form of a field study, strategies to achieve resilience in the Kan river valley were identified based on SWOT analysis and the following steps:

- To support the resilient river valley plans, the SWOT matrix was used in this stage to assess threats, opportunities, weaknesses, and strengths (Table 3). This matrix compares opportunities, threats, strengths, and weaknesses based on information gathered from site visits and the conceptual framework established in the previous section.
- In these steps, strategies were Provided for developing the resilient river valley of Kan. Based on the SWOT Matrix, a variety of strategies were presented. Three different groups of diverse strategies were created using the SWOT matrix (Table 4).

## RESULTS AND DISCUSSIONS

### Developing SWOT Matrix

The kan river valley is rich in natural and archaeological attractions for local and international visitors. With a focus on the conceptual framework formalized in the last stage of the research, the goal of the development of the Kan River Valley is to increase the river valley's resilience against hazards in addition to user happiness. This study discovered possibilities, risks, strengths, and weaknesses that can greatly impact the design of the kan river valley development plans using expert viewpoints (Table 3).

Table 3: SWOT Matrix

| | Strength | weakness | opportunity | threat |
|---|---|---|---|---|
| Physical-functional dimension | • Access to other parts of Tehran due to its proximity to Hemmat highway<br>• The presence of an elementary school, neighborhood hall, and hangouts consisting of a cinema, bank, and mosque., near the area<br>• adjacent to Fire Stations | • Difficult access to the eastern shore<br>• Absence of an active walking network<br>• Lack of security and vitality in most parts of the site due to the construction equipment<br>•illegal residential part on the eastern side<br>• The narrow width of some Street for emergency vehicles and fire engines<br>• Lack of responsiveness of the space to the needs of different social groups<br>• Lack of equipped service centers in the region (lack of services)<br>• Lack of coverage of public vehicles such as subway and taxi | • The possibility of converting the riverside paths into equipped green paths<br>• Converting the residential land use into mixed-use with commercial use on the first floor<br>• The presence of barren lands near the site<br>• The opportunity to increase security by attracting people to the site and social monitoring<br>• Connecting and integrating the Public space and pedestrians with linear green spaces | •spreading Illegal settlement<br>•Reducing people's visit to the site by continuing the construction contrary to the natural identity<br>•Abandoning the border in the form of unused and unidentified green lands if the project goals are not met<br>•The immediate conversion open space into a parking lot<br>•Turning the surrounding environment into an unsafe and anonymous constructing area if the environmental qualities are not improved. |
| Perception-Aesthetical dimension | • The existence of the functional signs (cinema, mosque, and restaurant)<br>• Strategic view of Alborz mountains<br>• River valley as a visual indicator element<br>• Various and influential topography in the landscape in the northern parts<br>•Favorable view of the lush eastern gardens<br>• Attractive wide view from Hemmat bridge | • incomprehensible spatial hierarchy<br>• illegible entrances of the complex<br>• unhuman scale and inducing a feeling of being lost in space<br>• Lack of multiplicity of functional nodes and identifiable signs<br>• Visual disturbance in the skyline due to new construction<br>• Lack of proper view to the outside on the west side due to the concrete wall<br>• Uniform landscaping without visual appeal<br>• Obstruction of visibility to the south by Hammet highway<br>• Inappropriate visibility on the eastern side due to illegal residents | • Possibility of connecting the site to the peripheral part by creating green axes from the western and eastern gardens and parks<br>• Possibility of clarifying the walls of the axes leading to the river to create a visual connection<br>• Possibility of Transforming the river valley into one of the main elements of Tehran's ossification and organizing the peripheral part | • The spread of large scale masses on the coast of the river<br>• Obstruction of the visual axes with irregular construction |

continue of Table 3: SWOT Matrix

| | Strength | weakness | opportunity | threat |
|---|---|---|---|---|
| Ecological dimension | • fertile and permeable soil<br>• Natural vegetation and hand planting<br>• large-scale gardens and green areas in the north and west of the site<br>• Favorable weather and increasing residential attractions | • The destruction of the natural base of the river and Native vegetation<br>• Indiscriminate construction and lack of attention to the river's exclusion<br>•Wall construction with concrete blocks instead of using natural materials<br>• water volume decrease in months of the year<br>• garbage and construction debris in the river bed<br>• unstable slopes and erosion of the river valley walls<br>• Destruction of the microclimate due to the gradual destruction of native flora and fauna<br>• Paving with impermeable and hard materials<br>• Reducing agriculture by selling lands for new developments east of the site | • Possibility of developing the site in neighboring contexts<br>• Possibility of Creating green corridors and connecting the river with the fabric open and unbuilt space<br>• Possibility of using native and natural materials in landscaping<br>• Existence of open and unbuilt space required for landscaping | • water pollution and sewage spilling by Indiscriminate development<br>• Fragmentation and destruction of green areas with the continuation of construction in gardens<br>• Reducing resilience against floods by continuing to transform the bed into a concrete channel<br>• migration and complete destruction of animal and plant species due to the prolongation of construction operations<br>• Increasing impervious surfaces by developing stone floor coverings and asphalt in the area to create a parking lot<br>• The possibility of collapse of unstable eastern walls |

**Developing Strategies Based on SWOT Matrix**

Table 4 depicts the strategies developed based on the SWOT matrix and concepts related to the conceptual framework.

Table 4: Resilient Urban Riverfronts goals and strategies

| dimension | goals | strategies |
|---|---|---|
| Physical-functional | Access network | • appropriate hierarchy of communication networks to provide access and speed<br>• alternative access to respond in case of crisis<br>• Convenient connection to the city's public transportation network<br>• walking trails that link with public transportation<br>• connection of the site to the vicinity using green corridors<br>• Improved accessibility and connectivity by avoiding large buildings on the edges<br>• main and secondary entrances in different parts of the site<br>• legible connection between spaces<br>• Terracing the site in order to access water in different seasons and with the rise and fall of the water level |
| | Land-use and activity | • Functional diversity by creating mixed uses and 24-hour activities<br>• activity centers in the vicinity of public transport stations and connecting them to the site<br>• Provision of parking lot next to the site<br>• Multi-functional space for different conditions by increasing open and green spaces<br>• alternative functions and activities of land use to prevent the cessation of activities during the crisis<br>• Removing incompatible land use and activity<br>• activity continuity by soft boundaries between them<br>• Removing and prohibiting unauthorized constructions and informal settlements in the riparian zone |
| | public spaces Structure | • diversity and redundancy of space for the initial settlement after the crises<br>• Non-separation of micro-spaces of the site and vicinity<br>• necessary facilities for the presence of different social groups<br>• Removal of movement barriers<br>• comfort and safety in flooring, slope and width of paths<br>• robustness of physical elements of the urban landscape<br>• Stabilizing the soil and preventing it from falling in places where citizens pass or gather<br>• Increasing the safety and robustness of furniture and physical components<br>• Securing the site facilities<br>• redundancy and dispersion of active and lively nodes along the route<br>• flexibility in the physical components of the area such as fixed and immovable furniture |

continue of Table 4: Resilient Urban Riverfronts goals and strategies

| dimension | goals | strategies |
|---|---|---|
| Perception-Aesthetical | Visual landscape | • visual permeability and Removal of visual barriers<br>• visual-spatial diversity<br>• visibility of spaces and activities<br>•strategic and broad visions to the city to facilitate orientation<br>• Visual corridors to the waterfront<br>• lighting of the path<br>• diverse sub-spaces while maintaining the integrity of the spaces<br>• multi-functional furniture for different behaviors<br>• Avoiding imposing too much and inflexible urban furniture<br>• low-density development in the vicinity of the site<br>• human-scaled by avoiding large and disproportionate areas with human physical capabilities |
| | Mental landscape | • legible network of consecutive perceptions of signs and elements of the mental landscape for rescue and safe escape in case of crisis<br>• sense of belongingness by intensifying water-associated identity<br>• Preservation of natural and historical identity |
| Ecological | Naturalism | • Adaptation of access to the natural form of the land<br>• native biodiversity by identifying native plants<br>• natural landscape of the river<br>• connection between ecological elements and other elements of spatial structure<br>• green spaces connection and definition of new ecological axes<br>• Converting barren lands into green areas<br>• Removing concrete from the riverbed, which causes the loss of vegetation and erosion of the riverbed, and replacing it with natural materials.<br>• Limiting the density of high-rise building construction on the banks of the river<br>• Avoid artificial landscaping that contradicts the natural mood of the river |
| | efficiency | • Revival of the lost topography by demolishing the concrete wall and strengthening the edges in a stepped manner with proper drainage and vegetation<br>• Maintaining the natural winding of the river and avoiding straightening the paths<br>• flowing and underground water resources preservation by creating drainage beds and wetlands that are fed by floods<br>• Compliance with qualitative and quantitative river exclusion<br>• The possibility of draining and distributing water through alternative routes during floods<br>• Creating multi-function green spaces by revitalizing adjacent abandoned lands<br>• Converting land prone to danger into green space |

## CONCLUSION

The main purpose of this paper was to study some major resilience-related criteria that can be used to develop an integrated conceptual framework in urban River Valley design. The resiliency concept, defined as the capacity to adjust to stress from hazards and to recover quickly from the impacts of a catastrophe, has changed in its meaning and application through time from an engineering-based approach to a socio-ecological perspective. This paper stands on this notion that resiliency of the River Valley area does not only embraces formulating immediate and physical solutions (Engineering resilience approach), rather it has to consider resiliency which emphasizes people's social learning and also the ability of the site to transform to a desirable state after the crisis. But, this research concentrated on an engineering-based approach and argues that to evaluate the functional, Perception-Aesthetical and Ecological dimensions of urban River Valleys and generate a qualitative public space, the resiliency concept can provide a comprehensive design solution for urban designers.

To operate resiliency in urban river valley design, this paper proposed some components and criteria based on reviewing the literature of (1) dimensions and characteristics of urban resiliency, (2) function and spatial qualities of River Valleys in cities, (3) and design qualities of urban resilience in river systems in global experiences. Since the purpose of this paper concentrated on the effects and components of the Engineering resilience dimension in urban resiliency, all the studies related to physical and spatial concepts are based on three dimensions of sustainable place. After the literature review, the conceptual framework that presents resilience-based qualities in design which can operate as a strong tool to evaluate resiliency in urban design practice generated. This framework proposed some criteria in three dimensions and related components; in the Physical-Functional dimension, Access Network, Land-use and Activity, and Public Spaces Structure components; in the Perception-Aesthetical dimension, Visual and Mental landscape components; in the Ecological dimension, Naturalism, and Efficiency components. This framework provides the possibility to investigate and analyze the Ken River Valley using the SWAT technique. The results of the SWOT technique are shown in:

• Physical-functional dimension

the site has good connectivity through major roads with the rest of the city. However, the network does not create access to the river's body. The lack of amenities, mixed land-use, and proper walk paths also has led to an unattractive and unsafe space for the visitors, showing low-level flexibility with conditions of hazards. Hence, the citizens have not accepted that the northern part of the Kan river has not been well integrated with the city's urban fabric. The dominant land use in this

area is low-density residential, which contributes to creating soft edges that do not provide the users with vital urban space that fulfills their needs.

• Perception-Aesthetical dimension

Since the northern part of the Kan has not provided access to water for its users, it has not successfully created water-associated aesthetical values. Also, not providing proper visuals and areas with legible roads and signs can cause serious problems during hazards since the users cannot find the proper direction. This area's sense of belongingness and identity are relatively low, leading to low states of Sens of responsibility, respectively. It is obvious that intensifying local participation is essential to use the capacity of the people's creativity and participation for a resilient river valley in the Kan area. Also, the natural landscape has been widely neglected by established parking and construction areas, contributing to an unpleasant landscape for the users.

• Ecological dimension

Based on the surveys conducted on the site, Water quality in the Kan river is impaired by bacteria due to the recent construction of the site. The green cover largely corresponds to the east side of the river, where the private gardens and informal settlements are located. Many parts of the river and green corridors are disconnected due to sporadic channelization and construction. There are not any natural infrastructures to prevent floods. Also, there is a significant increase in impervious surfaces (e.g., rooftops, driveways, and roads) near the river body, exacerbating the flooding potential in Kan riverside during the storm as the stormwater can't sink into the ground. Thus these surfaces limit the water volume capacity during storm events. The sporadic vegetation alongside the river roughly helps slow runoff and minimize erosion. These river edges are characterized by riprap armoring combined with concrete walls to hold the steep embankments and prevent erosion, especially on the west side of the Kan, which has led to the lack of public access to the river-body, which remains hidden within the thick walls.

Based on the results, strategies to achieve resilience in kan river valley are proposed in the next step. Table 4 is the final output of this research and is presented in the form of resilient-based design goals and strategies and shows this study stands on the notion that the resilience of a place not only embraces formulating an immediate response to crises such as floods but also considers long-term mitigation and adaptation strategies and environmental qualities to face environmental challenges. In this perspective, reconnecting the community with the river through creating a favorable public space and using the natural potential of the rivers to confront the hazards is necessary.

## AUTHOR CONTRIBUTIONS

P. Alipour Kouhi and S.Alikaei performed the literature review and experimental design, analyzed and interpreted the data, and prepared the manuscript text and edition. S. Nouri performed the experiments and literature review, compiled the data, and prepared the manuscript.

## CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication or falsification, double publication and, or submission, and redundancy, have been completely witnessed by the authors.

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