# ARCHITECTURAL SCIENCES AND SUSTAINABLE APPROACHES: URBAN RESILIENCE



Editors
Prof. Dr. Ömer ATABEYOĞLU
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*October 15, 2025*

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**Architectural Sciences and Sustainable Approaches: Urban Resilience**

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# PREFACE

Dear Professors and Colleagues,

We are pleased bring to life that Architectural Sciences and Sustainable Approaches: Urban Resilience, which was published as an e-book by IKSAD Publishing House with the editors Prof. Dr. Ömer ATABEYOĞLU and Prof. Dr. Ertan DÜZGÜNEŞ.

This book project, entitled “Architectural Sciences and Sustainable Approaches: Urban Resilience,” aims to address sustainability-oriented approaches to urban resilience from theoretical, methodological, and practical perspectives. The volume seeks to establish a multi-layered platform of discussion, ranging from the scale of individual buildings to the entirety of the urban fabric. Within this framework, it welcomes contributions from scholars and researchers working in architecture, urban design, landscape architecture, urban and regional planning, environmental engineering, and related disciplines.

With the valuable contributions of our chapter authors working in the professional disciplines of landscape architecture, architecture, city and regional planning, urban design and sustainability, we have completed Architectural Sciences and Sustainable Approaches: Urban Resilience book study has been completed with 24 book chapters. We would like to thank you,

our esteemed authors, for their contributions to the preparation of the book.

We would also like to thank the editorial board and IKSAD Publishing House. We wish to continue this process we have started in the coming years.

In addition, we would like to express our sincere appreciation to Prof. Dr. Atila GÜL, the book coordinator of IKSAD Publishing House, for his guidance and support throughout the publication process.

We hope that our book '***Architectural Sciences and Sustainable Approaches: Urban Resilience'*** will be helpful to the readers.

Best regards.

15.10.2025

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# From Vulnerability to Resilience: The Van Earthquake and Its Implications for Disaster-Informed Urban Planning

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## 1. Introduction

In an era of rapid urban expansion and increasing natural disaster frequency, the need to develop resilient cities is undeniable. Earthquakes, in particular, threaten densely populated areas, with the potential to cause widespread destruction and economic losses in the billions. For instance, the 1999 Marmara Earthquake resulted in approximately 17,000 fatalities and an estimated economic cost of 10–15 billion USD for Turkey (Erdik, 2000, Disaster and Emergency Management Presidency (AFAD) n.d.). Predicting or preventing the next major earthquake remains impossible.

Urban resilience plays a pivotal role in enhancing cities' capacity to cope with challenges arising from rapid urbanization and environmental change. Adapted from Holling's (1973) ecology-based resilience concept, it refers to a city's ability to anticipate, respond to, and recover from shocks and stresses (Meerow, Newell, & Stults, 2016, Ahern, 2011).

Recent major earthquakes in Turkey have underscored the critical need for urban resilience. The October 23, 2011 Van-Erciş and November 9, 2011 Van-Edremit earthquakes, in particular, highlighted the devastating impacts on urban areas. Data from the National Seismology Observation Network, operated by AFAD, indicate that the main shock on October 23 released energy equivalent to approximately 33.2 Hiroshima atomic bombs, and when aftershocks are included, the total energy released reached the equivalent of about 37 atomic bombs (Güney, 2012, AFAD 2012).

This article analyzes the Van earthquake within the framework of urban resilience. The resilience of physical and social systems is examined

through five key criteria: robustness, redundancy, resourcefulness, adaptability, and rapidity. The analysis focuses on pre-earthquake measures, the planning process, and post-earthquake interventions.

In the planning process of Van, the elements defined as the 4Rs by Bruneau et al. (2003) were analyzed. This analysis was integrated with the Key Dimensions and Characteristics of Urban Resilience identified by Ribeiro & Gonçalves (2019).

## 2. Research Methodology

A systematic process was applied to conduct a comprehensive literature review on urban resilience. This process consisted of three stages: (i) searching online databases, (ii) analyzing data related to the Van earthquake, and (iii) examining spatial planning decisions in terms of urban resilience criteria. Academic databases were used to systematically select the articles reviewed in this study.

Database searches employed keywords such as "Urban resilience," "Resilient urban systems," "Resilient cities," "Resilience in cities," and "seismic resistance," along with related terms. For scientific articles, the review focused on the last 15 years (2010–2025), prioritizing relevance and selecting studies cited more than ten times. Technical documents were drawn from publications by relevant institutions on the Van earthquake, while spatial plans were obtained from the Ministry of Environment and Urbanization's website.

## 3. Urban Resilience and Its Conceptual Framework

The concept of resilience is widely applied across disciplines, from environmental studies to engineering, and from psychology to sociology and economics (Sharifi, & Yamagata, 2016). It generally encompasses

both strength and flexibility. According to the Merriam-Webster Dictionary, “resilience” refers to (i) the ability of an object to return to its original size and shape after deformation under stress, and (ii) the capacity to recover and adapt in the face of adversity or change. In the context of earthquake disasters, Comfort (1999, p. 21, cited in Bruneau et al., 2003) defines resilience as “the capacity to adapt existing resources and skills to new conditions and operational demands,” emphasizing the need for both pre-event and post-event strategies, including risk reduction, loss prevention, impact minimization, and recovery.

Urban resilience extends this concept to the city scale, referring to a city’s capacity to withstand, adapt to, and recover from shocks while maintaining its essential functions and overall well-being (Ribeiro & Gonçalves, 2019; Cao, 2023). Importantly, resilience is not only about adaptation; historical evidence suggests that strategies that appear effective in the short term can, over the long term, increase systemic vulnerability, demonstrating the concept’s complexity and multidimensionality (Chelleri, 2012). The rise of the “Resilient Cities” framework reflects this complexity, particularly in the context of urban adaptation to climate change, and has stimulated global collaboration in fields such as risk management, sustainability, and urban governance.

Community-based seismic resilience emphasizes the role of social units—including organizations and communities—in reducing hazards, limiting disaster impacts, and recovering in ways that minimize social disruption. Effective resilience requires both robust infrastructure capable of functioning during and after earthquakes, and well-coordinated emergency

response and recovery strategies to reduce fatalities, injuries, and economic losses (Bruneau et al., 2003).

Seismic resilience can be conceptualized through the four key attributes of the 4R framework—Robustness, Redundancy, Resourcefulness, and Rapidity—which collectively define urban resilience. **Robustness**, the capacity to maintain functionality under stress; **redundancy**, the ability to substitute functions in case of failure; **resourcefulness**, the capacity to identify problems, prioritize actions, and mobilize resources effectively; and **rapidity**, the ability to act promptly to limit losses and prevent future disruptions (Xie, 2023; Bruneau et al., 2003, Kapucu, Ge, Rott, & Isgandar, 2024) (Table 1).

**Table 1.** Key Components of Resilience;4R Framework (Bruneau et al., 2003)

| Component | Description |
|---|---|
| **Robustness** | Ability to withstand stress without loss of function. |
| **Redundancy** | Capacity to substitute functions during failure. |
| **Resourcefulness** | Ability to identify problems, prioritize, and mobilize resources. |
| **Rapidity** | Ability to act promptly to limit losses and prevent future disruptions. |

In addition, urban resilience can be examined across four interrelated dimensions: technical, organizational, social, and economic. The technical dimension captures the capacity of physical systems to maintain functionality under shocks, relying primarily on robustness and redundancy. The organizational dimension refers to the ability of institutions managing critical facilities and disaster tasks to coordinate, make decisions, and respond effectively, incorporating resourcefulness and rapidity. The social dimension reflects the degree of protection and support for communities and public administration units, emphasizing

community-based resilience and post-disaster recovery. Finally, the economic dimension addresses the city's capacity to reduce both direct and indirect economic losses through risk management and loss mitigation strategies (Ribeiro & Gonçalves, 2019) (Table 2).

**Table 2.** Key Dimensions and Characteristics of Urban Resilience (Ribeiro & Gonçalves, 2019)

| Dimension | Definition | Key Characteristics |
|---|---|---|
| **Technical** | Capacity of physical systems to function under shocks. | Robustness, Redundancy |
| **Organizational** | Capacity of organizations managing critical facilities and disaster tasks. | Resourcefulness, Rapidity, Decision-making ability |
| **Social** | Degree of protection for communities and public administration units. | Community-based resilience, Post-disaster recovery |
| **Economic** | Capacity to reduce direct and indirect economic losses. | Loss mitigation, Risk management |

Taken together, these components and dimensions provide a comprehensive framework for understanding, assessing, and enhancing urban resilience, particularly in earthquake-prone and rapidly urbanizing contexts.

Ribeiro and Gonçalves (2019), building on Bruneau's criteria, evaluated resilience across five dimensions, including a natural dimension. Urban resilience is not limited to the four core components; it can also be assessed through these five dimensions: the natural dimension, which considers environmental factors and ecosystem resilience; the economic dimension, encompassing the sustainability of economic systems and their flexibility in the face of crises; the social dimension, reflecting communities' capacity to withstand crises through solidarity, social capital, and social networks; the physical dimension, addressing the resilience of infrastructure, buildings, and transportation systems; and the institutional

dimension, covering governance, policy, planning mechanisms, and their role in crisis management. Within this framework, urban resilience is a multidimensional and dynamic concept aimed at producing holistic and sustainable solutions to the challenges cities face (Xie, 2023). It represents the ability of a city or urban community to withstand various risks, crises, and unexpected disruptions.

Several opportunities and challenges have been identified in the field of urban resilience. To capitalize on these opportunities and address the challenges, it is essential to integrate diverse experiences within and across cities and to foster collaboration among scientists, the public, and authorities. Such collaboration should aim to produce knowledge that is scientifically reliable, contextually relevant, socially robust, and practically applicable (Ribeiro & Gonçalves, 2019). Moreover, by generating clear operational definitions, measurable criteria, and concrete baseline data, conceptual ambiguities, local-level disconnects, and coordination gaps can be mitigated, while facilitating the integration of different types of knowledge (Table 3).

**Table 3.** Opportunities and Challenges in Urban Resilience (Ribeiro & Gonçalves, 2019)

| Opportunities | Challenges |
|---|---|
| Integration of diverse experiences (within and across cities) | Conceptual ambiguity in different contexts |
| Collaboration among scientists, the public, and authorities | Lack of operational definitions |
| Production of knowledge that is applicable, contextually relevant, and socially robust | Local-level disconnects and coordination gaps |
| Development of clear criteria and concrete baseline data | Need for integration of different types of knowledge |

Indeed, the urban resilience approach requires not only reducing disaster risks but also establishing social resilience mechanisms that enable effective response during crises and rapid recovery after disasters (Meerow et al., 2016). Consequently, resilience in urban areas aims not only to mitigate the impacts of potential disasters but also to strengthen communities through crisis experiences. This perspective, as illustrated by cases such as the Van earthquake, positions disaster risk management as a fundamental component of sustainable urban development (Cutter et al., 2008).

## 4. Characteristics and Spatial Vulnerabilities of the 2011 Van Earthquake

Van Province provides a relevant case study for applying these concepts. Historically, the region has experienced avalanches, landslides, earthquakes, rockfalls, floods, and rising lake levels (Ministry of Environment and Forestry, 2011). Among these, earthquakes are the most frequent and destructive, causing the greatest human and material losses. The province lies within first- and second-degree earthquake zones, with the city center in the second-degree zone, intersected by significant fault lines.

The region's fragile soil and settlements' limited resilience exacerbate seismic impacts. Earthquakes recur approximately every 30–35 years, and accumulated stress along fault lines, combined with loose soil and shallow groundwater, further increases damage potential. Additionally, interactions among multiple fault zones heighten regional vulnerability (Ministry of Environment, Urbanization and Climate Change, 2017- In 2021, "Climate Change" was added, making this the ministry's current

official name). Strengthening disaster risk reduction and preparedness is therefore essential. The most destructive earthquakes in Van occurred in 1930, 1976, and 2011, each registering a magnitude of 7.2.

### 4.1. The 2011 Van Earthquake and Disaster Management Process

The 2011 Van Earthquake occurred on Sunday, October 23, at 13:40 local time, with its epicenter in Tabanlı Village, Central District, registering a magnitude of 7.2 (M). While post-disaster management efforts were ongoing, a second earthquake struck on Wednesday, November 9, at 21:20, with a magnitude of 5.6 (M) and its epicenter in the Edremit District. Following these events, an average of 180 aftershocks per day was reported over the subsequent month (Erdik, Kamer, Demircioğlu, & Şeşetyan, 2012)

The earthquakes resulted in 644 fatalities and 1,966 injuries. Damage assessments were conducted on 187,000 buildings, of which approximately 49,000 were identified as damaged. Among the assessed structures, 76.4% of residential buildings, 78.9% of workplaces, and 82.3% of barns were damaged. Overall, these assessments covered 77% of the total building stock, underscoring the vulnerability of local structures and their insufficient resilience to seismic events (METU, 2012; Yıldız Technical University, 2011).

Expert-led search and rescue operations began within the first thirty minutes following the earthquakes. Emergency needs—including temporary shelter, healthcare, and food support—were provided via road and air transport. Tent settlements were established to address multiple humanitarian requirements, including shelter, health services, education, psychological support, social spaces, sanitation, and security. These

temporary settlements were later replaced by container-based housing complexes. The post-earthquake response provided critical lessons for enhancing regional resilience. Reconstruction efforts included the construction of permanent housing and the development of planned living areas. Site selection studies were conducted to identify safe locations for new housing, and comprehensive planning was completed to ensure secure living environments for earthquake survivors ((METU, 2012; AFAD, 2014). Overall, urban resilience in Van demonstrates that effective disaster risk management not only mitigates the impacts of earthquakes but also strengthens communities through crisis experiences, positioning resilience as a fundamental component of sustainable urban development (Meerow et al., 2016; Cutter et al., 2008).

**4.2. Planning Studies in Van Province**

Urban planning is an effective tool for disaster risk management, helping to prevent potential losses. In Van, planning efforts can be evaluated through the lenses of vulnerability and resilience. Prior to the 2011 Van earthquake, the 1996 zoning plan identified the city's population as 353,419. The urban fabric was dispersed, scattered, and sprawling, with a gross density of 53 people/ha and undeveloped areas in the city center (Van Büyükşehir Belediyesi 2016). Before the implementation of the 1996 plan, approximately 2,000 amendments were made, mainly increasing building heights, reducing green areas, and expanding residential zones, which disrupted the integrity of the plan (ÇŞB, 2013a). These changes intensified central urban density and strained infrastructure below planned standards (DAKA, 2014). Unregulated or unauthorized constructions, inconsistent building heights, and the unequal distribution of public facilities increased

the city's vulnerability. Green areas were limited (2.15 m² per capita), and playgrounds were insufficient relative to population density. Overall, the 1996 plan was inadequate in providing public spaces, contributing to Van's disaster vulnerability (ÇŞB, 2013a).

**4.3. 1/100,000 Muş-Bitlis-Van Environmental Master Plan (EMP)**

The 1/100,000 scale Environmental Master Plan for the Muş-Bitlis-Van area, approved on April 1, 2011, aimed to prevent rural-to-urban migration, support balanced and sustainable regional development, control unplanned settlements, preserve ecological balance, promote agriculture and livestock, and protect natural and cultural assets (ÇŞB2019, April 5).

Residential areas for the projected 2035 population were proposed mainly on vacant urban plots and surrounding dry farmland. Northern areas were designated for industry and included the university. The plan also suggested specialized zones in the city center, such as fairgrounds, festival areas, technoparks, and storage/development areas for Van OSB (ÇŞB2019, April 5). Compliance with building regulations for disaster-prone areas, including the Earthquake-Resistant Buildings Regulation, was stipulated (Figure 1)

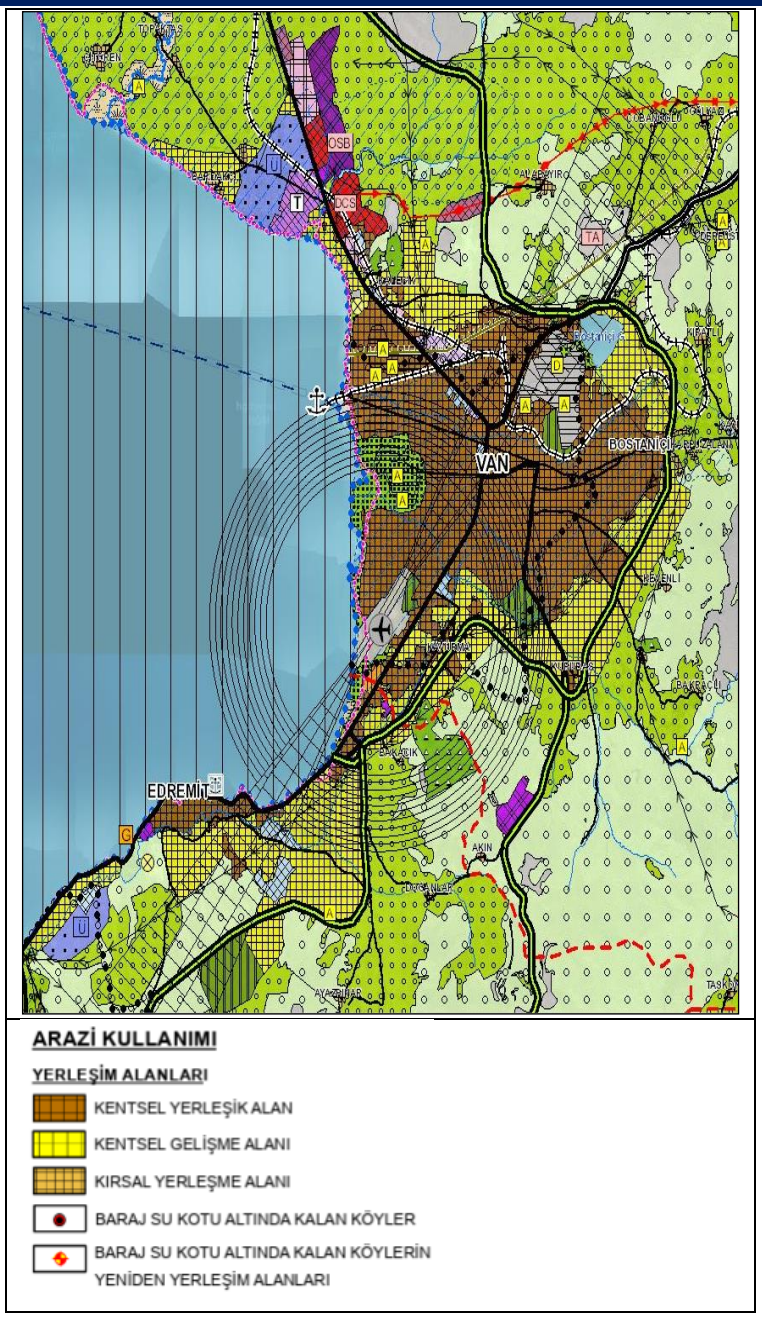



**Figure 1.** 1/100,000 Scale Environmental Plan (EP) of the Muş-Bitlis-Van Planning Region (www.csb.gov.tr)

### 4.4. 1/5,000 Scale Master Development Plan (MP)

The 1/5,000 MP was divided into three phases: Central, North, and South. The city developed between Erek Mountain and Lake Van, with the main road bisecting the city and commercial/public areas concentrated around it. Key facilities like the airport, industrial sites, university, and OSB were located in the north. The plan targeted a 2035 population of 700,000, with development directed toward southern and undeveloped areas to manage density. Bostaniçi and Edremit districts were planned with low- to medium-density areas to accommodate population growth safely. Transportation infrastructure lacked a comprehensive intra-city system, and parking shortages were identified as a major issue. Preferred commercial areas were positioned between the CBD and residential zones, with ground-floor commercial use along main axes.

Parks, squares, recreational areas, and green belts along rivers and energy lines were included. Social infrastructure was intended to be evenly distributed, and new housing developments adhered to detached zoning regulations, with population densities classified from sparse to high (Van Büyükşehir Belediyesi 2019).

### 4.5. 1/1,000 Scale Implementation Development Plan (UİP)

Under the 1/5,000 MP, the CBD was designated as the densest area, with building regulations B-5, B-6, and B-7 applied. Ground floors along main roads were allocated for commercial use (Van Büyükşehir Belediyesi 2019). Detached and semi-detached buildings were present in the city center, with density decreasing toward the periphery. Northern industrial zones lacked green buffers separating them from residential areas, increasing vulnerability. Although green areas were planned in the west, insufficient connectivity reduced overall urban resilience.