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Special Issue:

Resilience in Crisis

Dossier Editor

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Editorial

"Why has the world not collapsed?" inquire Holling et al. in the book "Panarchy: Understanding Transformations in Human and Natural Systems" (2002, pg. 15). Their interpretation from the human perspective unfolds as follows:

> *"Change and extreme transformations have been part of humanity's evolutionary history. People's adaptive capabilities have made it possible not only to persist passively, but to create and innovate when limits are reached".*

In the face of unprecedented challenges and disruptions, the human has demonstrated remarkable resilience throughout history. The ability to adapt, recover and develop in the face of adversity is a proof of the inherent strength of individuals and societies. As we navigate an era marked by global crises, ranging from health pandemics to environmental emergencies, the concept of resilience has taken center stage in both academic discourse and practical applications.

As the anniversary of the Kahramanmaras earthquakes approaches, our thoughts turn to the victims and those affected by this greatest tragedy. The impact of such disasters goes beyond the physical realm, leaving lasting scars on the lives and communities touched by the calamities. In honor of the resilience shown and the challenges faced, we pay tribute to those who endured the disaster and continue to rebuild. Their strength inspires collective efforts in disaster preparedness, response and recovery, and fosters a future where societies stand resilient in the face of adversity.

Consequently, this special issue of the Journal of Design for Resilience in Architecture & Planning is dedicated to the discussion on "Resilience in Crisis", investigating the multifaceted dimensions of resilience in the context of various challenges. Through rigorous research and insightful analysis, our authors examine how diverse fields contribute to our understanding of resilience.

Ilan Kelman, Victoria Pratt, Ayesha Ahmad, Amy Balderston, Catherine Baxendale, Ben Eaton, Sheila Ghelani, Samrawit Gougsa, Hsi-Nong Huang, Nqatyiswa Mendu,and Cecilia Vilela visually captures the collaborative efforts of Land Body Ecologies (LBE), a global transdisciplinary network situated in London. LBE, integrating science, art, and public engagement, focuses on understanding and addressing the persistent crisis of land trauma among land-dependent and Indigenous communities. Despite ongoing challenges, these communities demonstrate remarkable resilience. The perspective of Kelman et al. captures LBE's London-based work, offering glimpses into the arts-science-community space that serves as the epicenter for their global initiatives.

Louise K. Comfort, Süleyman Çelik and Burçak Başbuğ Erkan explore collective learning in areas affected by the February 6, 2023, Kahramanmaraş Earthquakes in Türkiye. Using a multi-methods approach, the study examines knowledge acquisition, information distribution, interpretation, and organizational memory. It underscores the importance of timely, accurate information and technology in decision-making during seismic events. Comfort et al. identify inaccurate information as a key obstacle to collective learning and emphasizes the need for alignment across diverse community groups and jurisdictional levels. The study offers insights for policymakers

and practitioners to translate collective learning into sustained measures for reducing future disaster risks, moving beyond resilience for sustainable risk reduction.

Sanja Mrksic Kovacevic and Frederic Bouder examine the slow digitalization in the Architecture, Engineering, and Construction (AEC) sector despite increased use of industrial robots and AI (Artificial Intelligence) tools. Highlighting factors like undervaluation by decision-makers and safety decisions amid uncertainty, Kovacevic and Bouder question how AI, especially AI algorithms, might impact uncertainties and act as a crisis prevention tool. Through 21 interviews with AEC professionals, the study suggests potential for wider AI use, contingent on addressing knowledge gaps. Kovacevic and Bouder underline that, while AI can prevent certain crises, its increased usage introduces new uncertainties, emphasizing the importance of proper implementation to avoid new risks.

Çağlar Göksu, Seda Kundak, Kerem Yavuz Arslanlı, Ahmet Atıl Aşıcı, Duygu Kalkanlı and Ali Yılmaz investigate resilience in the face of crises, examining the impacts of seismic events in Türkiye in 1999 and 2023 using Impact Chain analysis. The study traces the evolution of disaster management practices, highlighting advancements in risk management and resilience from 1999 Kocaeli earthquake to 2023 Kahramanmaraş earthquakes. Both events expose vulnerabilities in building design, emphasizing seismic shortcomings. The impact extends to critical infrastructure, affecting transportation, communication, and energy systems, with cascading effects on the socio-economic landscape. The study emphasizes the effectiveness of Impact Chain analysis in revealing complex causal relationships and facilitating communication among stakeholders. The research contributes to understanding disaster resilience, guiding subsequent research, policy formulation, and practical strategies for disaster preparedness and response.

Zeynep Deniz Yaman Galantini examines the impact of the COVID-19 epidemic on urban areas and questions the reasons why the pandemic persists, despite principles of "resilience" and "sustainability" in urban planning. The study aims to integrate these principles into urban planning processes, enhancing institutional capabilities for management and monitoring. Using conceptual analysis, it defines essential elements of the "post-pandemic" urban planning paradigm. Emphasizing the need for "sustainability" and "resilience," the study discusses the "pandemic city" and "post-pandemic city," concluding by exploring how these attributes contribute to the "post-pandemic urban planning" paradigm.

Aysun Aygün Oğur examines the impact of extreme heat on urban and rural areas, challenging the common focus on the economy, built environment, and daily human life. Through an extensive literature review, it explores the divergent resilience of these areas across economic, social, environmental, structural, and governmental factors. The research concludes that both settings have unique advantages and disadvantages, influencing their vulnerability and resilience levels. Aygün Oğur's work contributes to a comprehensive understanding of resilience studies related to extreme heat.

Seda Yurtcanlı Duymaz investigates earthquake-induced migration, as a significant challenge in Türkiye. Türkiye has experienced various forms of forced migration due to earthquakes, impacting physical security, human dignity, and societal structures. Yurtcanlı Duymaz 's study focuses on İstanbul, a high-risk area, assessing whether existing legislation aligns with international standards to effectively protect against environmental displacement and "build resilience in crisis". The study emphasizes the human rights approach and legal mechanisms in establishing resilience during crises, relying on content analysis of disaster plans, policy texts, and relevant legal provisions related to earthquake-induced migration scenarios in İstanbul.

Meltem Narter addresses the psychological impact of natural disasters, particularly earthquakes, emphasizing the need to define and discuss crises that follow. Resilience is crucial in coping with the aftermath, described as the ability to adapt to adverse conditions. Narter highlights the responsibility on both individuals and society to foster psychological resilience, advocating against leaving individuals alone to cope. Instead, she suggests mobilizing various resources, including emotional, mental, social, and artistic investments, to actively address the wounds caused by natural disasters and enhance individual and societal well-being.

Gülru Koca addresses challenges in Türkiye's rapid urbanization, emphasizing the need for urban sustainability to balance urban and rural development. With seismic risk in mind, she highlights the importance of preventing dense housing and uncontrolled migration in urban areas to mitigate earthquake-related issues. Strengthening connections between urban and rural areas, ensuring social and economic sustainability in rural areas, and

designing settlements away from fault lines are key measures. The study emphasizes using appropriate construction techniques, favoring traditional methods, and preserving architectural texture for earthquake-resistant and sustainable settlements in Türkiye.

Özcan Erdoğan and Rümeyza Kazancıoğlu emphasize the crucial role of hospitals in disaster situations, stressing the need for accessibility and operational readiness during various crises. To enhance resilience, hospitals are expected to identify and address both structural and non-structural risks. Social resilience through health services is achieved through organizational planning, human resource management, effective communication, and logistical and financial preparation. The ultimate goal is to guarantee uninterrupted patient care and supportive services, with measures in place for decontamination, patient evacuation, and overall hospital security when necessary.

As we struggle with the uncertainties of the present and future, understanding resilience is becoming not only an academic endeavor, but also an important pillar of promoting preparedness, response and recovery. The lessons learnt from the studies in this special issue have the potential to inform policies, interventions and practices that enhance resilience at individual, societal and global scales.

We are grateful to the researchers who contributed their expertise to this issue. May their work inspire further exploration and collaboration as we all strive to build a more resilient and sustainable future together.

Sincerely,

Following names that provided valuable contribution as referees of articles in this issue are:

Çağlar Akkaya, (Assoc. Prof. Dr.), Istanbul Technical University
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Cover photo: Image copyright ©Murat Germen, (February 2023). The image on the left is detail " View from Kurtulus Street to Sokullu Street in historic Antakya after the earthquake."

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DRArch's objectives are:

- to question how future building technologies are revolutionizing architectural design, city planning, urban design, landscape design, industrial design, interior design and education,

- to catalyze the processes that lean on interdisciplinary and collaborative design thinking, creating a resilient thinking culture,

- to improve the quality of built environment through encouraging greater sharing of academicians, analysts and specialists to share their experience and answer for issues in various areas, which distributes top-level work,

- to discover role of the designers and design disciplines -architecture, city planning, urban design, landscape design, industrial design, interior design, education and art in creating building and urban resilience,

- to retrofit the existing urban fabric to produce resilience appears and to support making and using technology within the building arts,

- to discuss academic issue about the digital life and its built-up environments, internet of space, digital in architecture, digital data in design, digital fabrication, software development in architecture, photogrammetry software, information technology in architecture, Archi-Walks, virtual design, cyber space, experiences through simulations, 3D technology in design, robotic construction, digital fabrication, parametric design and architecture, Building Information Management (BIM), extraterrestrial architecture, , artificial intelligence (AI) systems, Energy efficiency in buildings, digitization of human, the digitization of the construction, manufacturing, collaborative design, design integration, the accessibility of mobile devices and sensors, augmented reality apps, and GPS, emerging materials, new constructions techniques,

-to express new technology in architecture and planning for parametric urban design, real estate development and design, parametric smart planning (PSP), more human-centered products, sustainable development, sustainable cities, smart cities, vertical cities, urban morphology, urban aesthetics and townscape, urban structure and form, urban transformation, local and regional identity, design control and guidance, property development, practice and implementation.

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Editorial Team

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Photo Essay
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Land body ecologies: The London hub

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Abstract

This photo essay and accompanying text visualize and represent the work that was based in London, UK of a collective project called Land Body Ecologies (LBE), a global transdisciplinary network exploring the deep interconnections of mental health and ecosystem health. LBE's research and action work combined science, art, and public engagement to understand and redress the ongoing crisis of land trauma among land-dependent and Indigenous peoples who nonetheless display remarkable resilience. The research and action have been rooted within communities seeking resilience for their interlinked culture, environment, and land rights, so that they could comprehend, document, and overcome the crises and traumas endured when their land suffers. LBE's London-based work is presented through photos of the arts-science-community space that anchored the work around the world.

Keywords: eco-anxiety, eco-inspiration, hope, solastalgia, trauma

1. Background

This photo essay visualises and represents the work that was based in London, UK of a collective project called Land Body Ecologies (LBE), a global transdisciplinary network exploring the deep interconnections of mental health and ecosystem health. The work combined science, art, and public engagement to understand and redress the experiences of land trauma (Ahmad et al., 2022) among land-dependent and Indigenous peoples (Ahmad & Gosling, 2021). LBE's research and action have been rooted within communities addressing their interlinked culture, environment, and land rights issues. Through a variety of outcomes and outputs seeking and supporting continuing collaborative successes, it sought to comprehend, document, and overcome the traumas endured when the land suffers (Ahmad, 2022).

The key verbs are "comprehend, document, and overcome" rather than merely examine and suffer. As such, the activities depicted in the photo essay are specifically about tackling, addressing, and redressing "Resilience in Crisis". The importance of positive action is partly to take on board the severe critiques of resilience framings (Pugh, 2014; Reid, 2012) and crisis constructions (Hodder & Martin, 2009; McHugh et al., 2021) in order to move beyond their detriments for constructive outcomes. Another major part of this work is using different presentations, representations, and voices in order to work together to identify and solve the challenges (e.g., Van Auken et al., 2010; Wang & Burris, 1994).

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To achieve these goals, LBE asked and answered:

- How is the mental health of marginalized, land-dependent communities affected by changes in their ecosystems?
- To what extent does the definition of 'solastalgia' (adverse mental health impacts induced by environmental changes; Albrecht, 2005) encompass the lived experiences of marginalized, land-dependent communities?
- How do historical and contemporary violences faced by marginalized, land-dependent communities feature in their lived experience of solastalgia?

The LBE collaborative aimed to understand the traumas endured when the land suffers, focusing on the entanglement of psyche and environment paralleling the interlacing of physical, mental, emotional, community, and environmental healths.

LBE was initiated and led by Invisible Flock, an arts studio in Yorkshire, UK. In 2021, the Wellcome Trust, based in London, UK, accepted LBE for its Hub Award (grant number: 220767/Z/20/Z). This £1 million grant included a two-year residency until mid-2023 in part of the fifth floor of Wellcome Collection in Euston, London. The space, termed the London Hub for LBE, was anchored by Invisible Flock and Minority Rights Group International.

This photo essay documents the London Hub with the purpose of showing how it has become a living space, for working and creativity, as well as for the community and for art. It brings to life the experiences of LBE's team around the world while learning from and being inspired by those local to or visiting the London Hub.

2. Ethics

Ethics approval for the entire project was led by co-author Ayesha Ahmad, so that it was reviewed and granted by St George's University of London (number 2021.0230). Local ethics approvals were led by the other Hubs to be reviewed and granted locally in each location. All research and activities were conducted in line with guidance on the feedback of health-related findings in research (MRC & Wellcome Trust, 2014) and were closely monitored and commented on by the Wellcome Trust.

Part of the ethics process ensured full accreditation for all artistic outputs, while adopting an inclusive authorship ethos, as espoused by Castleden et al. (2010). This authorship ethos was put into practice for Gougsa et al. (2023) and is reflected in this piece about the London Hub, while still accrediting each photo to the photographer as part of the appropriate ethical process. In fact, the production of this article highlights our collaborative approach to accreditation, not just ensuring that all those involved receive due recognition, but also requiring authors to have been part of the lived experience of what the London Hub represents, by working from it, attending the events, and supporting the location as a community space for working, interacting, learning, and exchanging.

3. A Collaborative Space

The London Hub was used as a collaborative working and community space for LBE. The focus was exploring more widely health-related research and engagement through creative and innovative approaches (Gougsa et al., 2023). In addition to being the core working place for LBE's UK-based team members, it was used for project meetings, especially to welcome non-UK team members; it became an experimental and creative arts studio; Wellcome staff worked at desks interacting with and supporting LBE team members; project outputs such as podcasts were launched; open workshops were held to draw on the London community's creativity; and it served team members, such as Minority Rights Group International holding its annual meeting in 2023 and University College London staff holding research discussions. The space was set up to be welcoming and to encourage creativity, including through furniture permitting a flexible working environment

with lighting and objects from team members around the world (the other hubs) to inspire interaction and innovation.

The London Hub is one of six LBE hubs. The other team members have their own hubs in:

- Arctic (in Finland and Sweden) (Autti, 2022; Szpak & Ochwat, 2021).
- Bannerghatta (in India) (Clarke et al., 2021).
- Ban Nong Tao (in Thailand) (Szpak & Ochwat, 2021).
- Bwindi (in Uganda) (Mitchell, 2023).
- Mau Forest (in Kenya) (Redvers et al., 2020).

Each of these hubs and peoples, as evidenced in these citations, is struggling with their own crises, displays their own resiliences, and continually aiming to determine what form of resiliences can be applied to deal with the various forms of crises. In the Arctic Hub, the main river has been dammed, changing its flow, its sounds, its ecosystem, and its use for livelihoods—changing the river's being and connection to the land and people. Responses for resiliences include art, storytelling, advocacy, science, and adjusting livelihoods as best as feasible. In the Mau Forest hub, the people are being forcibly and illegally evicted from their land. Resiliences have involved taking the government of Kenya to court and winning in the African Court on Human and Peoples' Rights alongside international lobbying with Minority Rights Group International.

The backgrounds of the people involved in all this work are artists (including sound, video, and visual artists), communicators, conservationists, designers, Indigenous and land-dependent community and non-governmental organization representatives, researchers (with specialties including climate change, environmentalism, health, indigeneity, law, and rights), and technologists. Many of the team members use their profession for policy influence, action on the ground, and activism. Whereas this photo essay highlights the London Hub providing a collaborative, local-to-international space for dealing with "Resilience in Crisis" / "Resiliences in Crises", other publications document the other hubs' work in this regard (e.g., Autti, 2022; Gougsa et al., 2023).

4. Meaningfulness for Resilience and Crisis

The photo essay is divided into four sections, demonstrating how all the people involved come together for a collaborative space. The photos have been curated and ordered to be representative of the people of the London Hub, the shifting dynamic of the fifth floor of Wellcome Collection, and the variety of activities occurring there. As such, the images offer a balance of people, place, process, object, and action, illustrating how the Hub was used without being comprehensive across all uses, events, and interactions.

4.1. *The Hub's Space*

The space is an open plan working environment with one glassed-in office, one lockable storage room, and a kitchen. Different sections of the open-plan area are set up with different workspaces, including rows of desks that move vertically and horizontally, different-sized tables joined or separated, corners that individuals sequester, and couches creating a cloister like a living room or coffee conversation space. Some people typically use the same desk or location while others move around during the day and across different days. This variety is expressed in the photos, perhaps presenting various "resiliences" within a working environment while providing various modes of "crises" working, such as for impending deadlines or personnel problems.

Figure 1 The London Hub (photo: Ilan Kelman).

Figure 2 Starting to set up the London Hub (photo: Samrawit Gougsa).

Figure 3 Presenting Land Body Ecologies (photo: Ilan Kelman).

Figure 4 Presenting Land Body Ecologies (photo: Ilan Kelman).

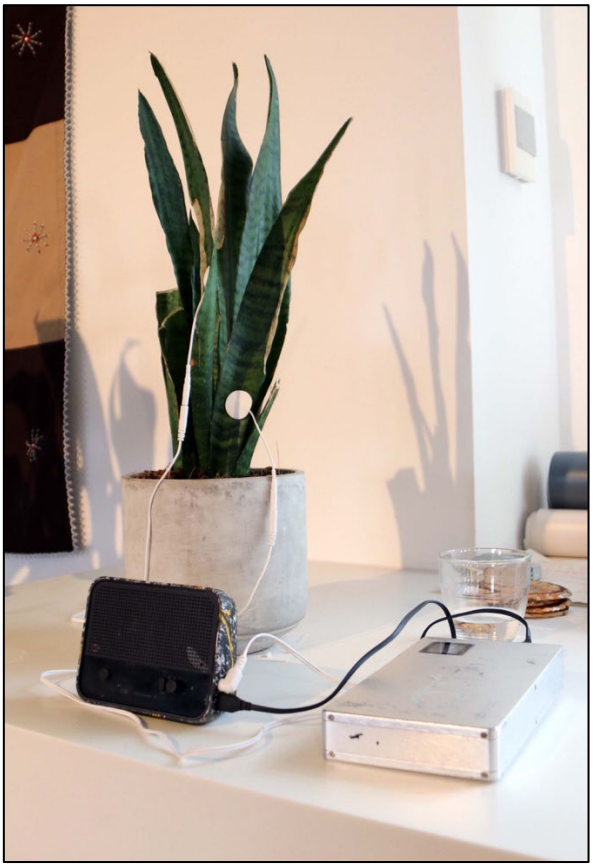

Figure 5 Listening to a Plant (photo: Ilan Kelman).

Figure 6 The London Hub (photo: Ilan Kelman).

4.2. *The Art Hub*

Art and cultural pieces from all the hubs are showcased, improving the working conversation and exchange environment aesthetically while reminding all of us why we are there and who we serve. Some pieces represent varying forms of crisis, some represent varying forms of hope, some represent both, and some represent neither, demonstrating the two concepts' vagueness, presence, and interlinkages. The photos display how some of the art is interactive and/or useable, such as a stool suitable for meetings and letters for spelling out feelings of the day.

Figure 7 Wood (photo: Ilan Kelman).

Figure 8 Constructing Art (photo: Victoria Pratt).

Figure 9 Bee Sculpture (photo: Cecilia Vilela).

Figure 10 Fungus (photo: Ilan Kelman).

Figure 11 Letters (photo: Ilan Kelman).

Figure 12 Insect (photo: Ilan Kelman).

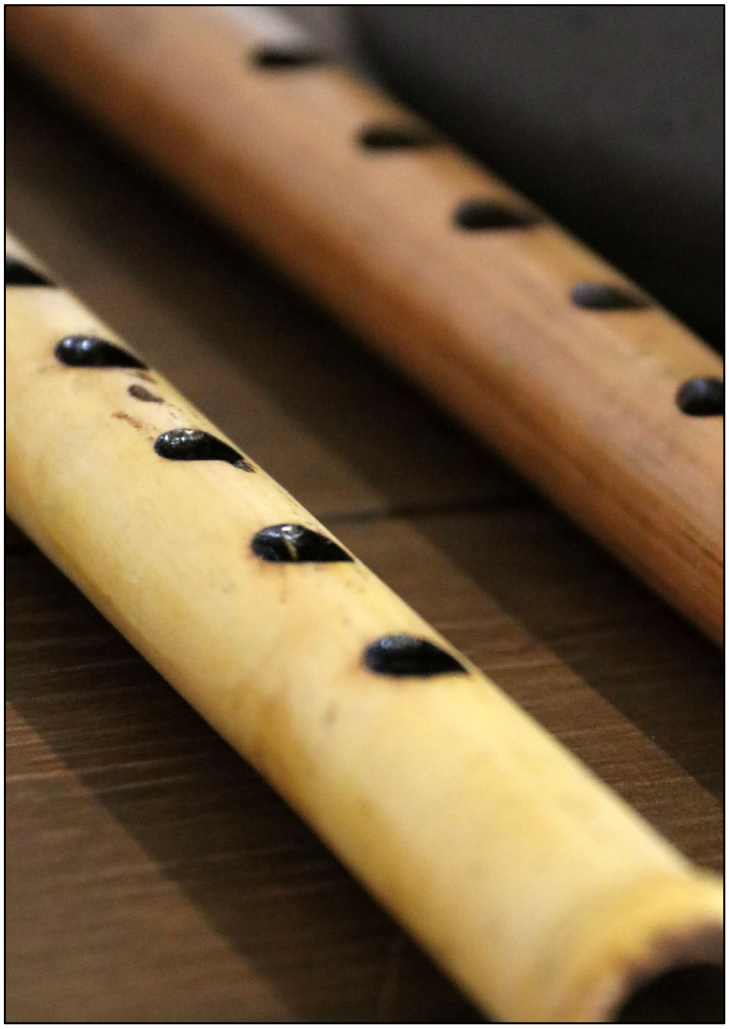

Figure 13 Flutes (photo: Ilan Kelman).

Figure 14 Stool Manufactured by Mischief Plastics (photo: Ilan Kelman).

4.3. *The Community Hub*

People from around the world joined the hub for meetings, presentations, events, displays, and a week-long festival in June 2023, all connected to and critiquing of "Resilience in Crisis" themes regarding land trauma, solastalgia, and action on them. The photos indicate different ways in which the space can be set up, depending on needs, such as rows of chairs for an annual meeting or ad hoc beanbags surrounding by screens for an immersive podcast listening experience. Other examples included academic talks, artistic speeches, clay molding, tarot card readings, and food and drink representing one of the other hubs.

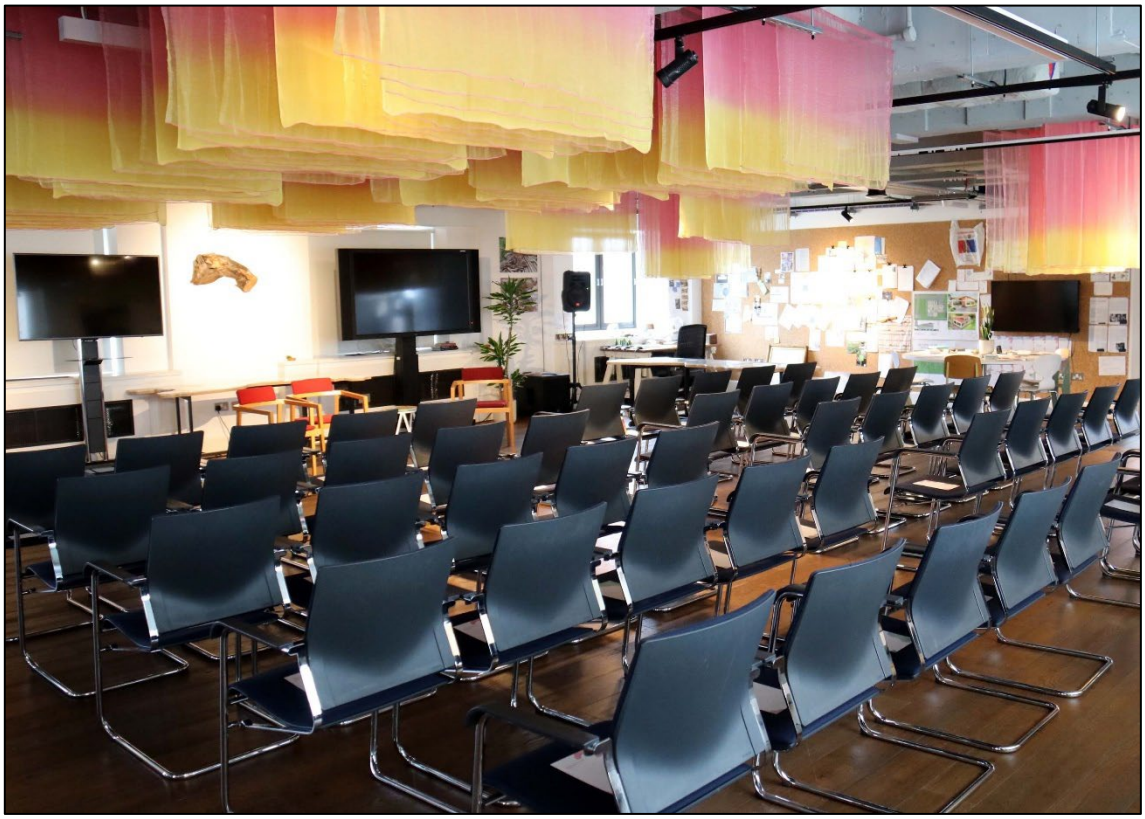

Figure 15 Readying for the community (photo: Ilan Kelman).

Figure 16 Welcoming People (photo: Ilan Kelman).

Figure 17 Readying for a Podcast (photo: Victoria Pratt).

Figure 18 Collaborating and Learning (photo: Ilan Kelman).

Figure 19 Inviting Exchange (photo: Ilan Kelman).

Figure 20 Food and Drink for a Podcast Launch (photo: Ilan Kelman).

Figure 21 Food and Drink for a Podcast Launch (photo: Ilan Kelman).

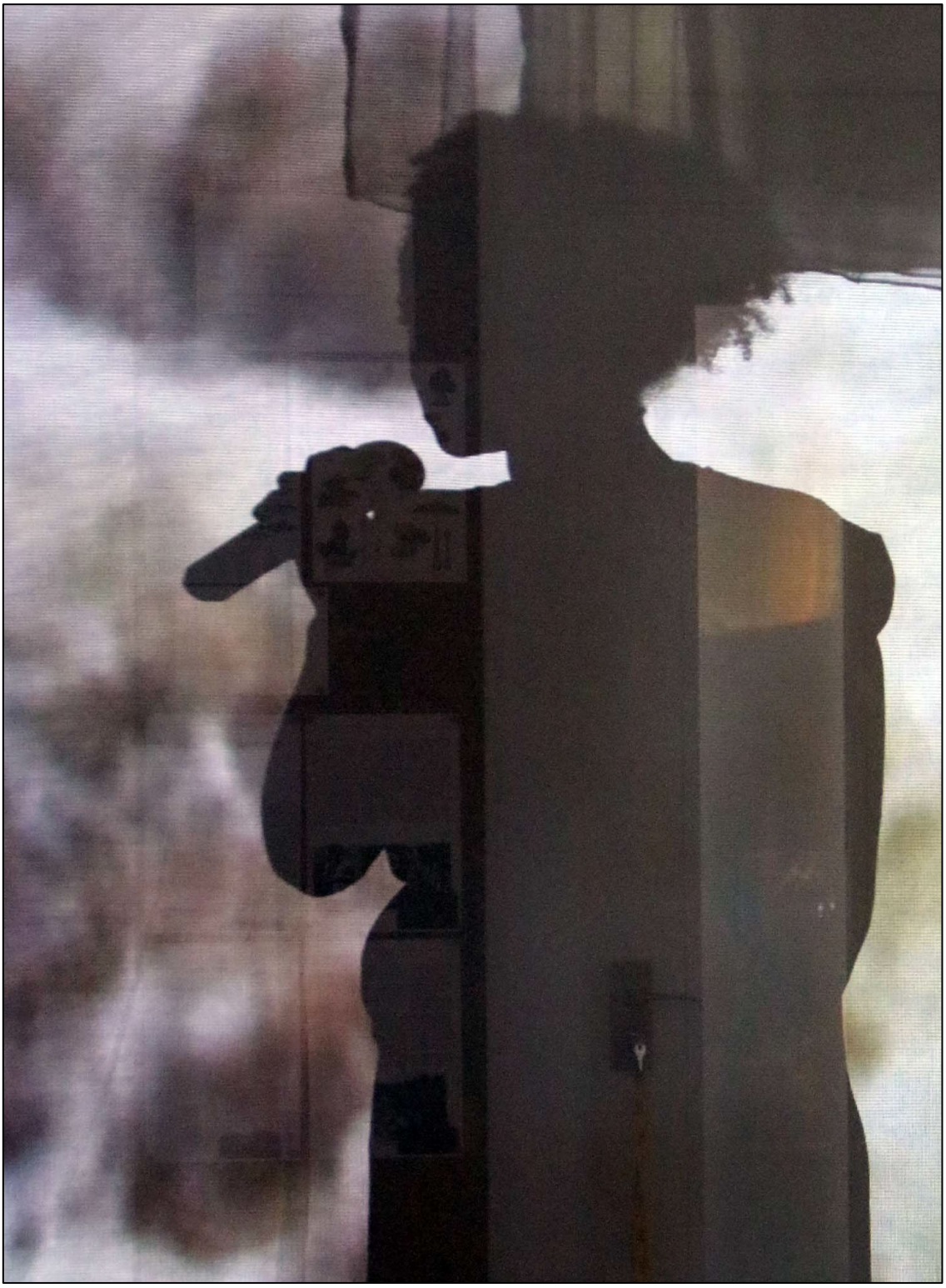

Figure 22 Launching a Podcast (photo: Ilan Kelman).

Figure 23 The Listening Experience (photo: Ilan Kelman).

Figure 24 The Audio and Visual Experience (photo: Ilan Kelman).

4.4. *The Idea Hub*

The Hub's different spaces bring together different communities in different ways to generate different ideas, using research, art, conversation, interaction, and communities. The photos show individual and team laptop working, creating art, conducting science, greeting people, and socializing.

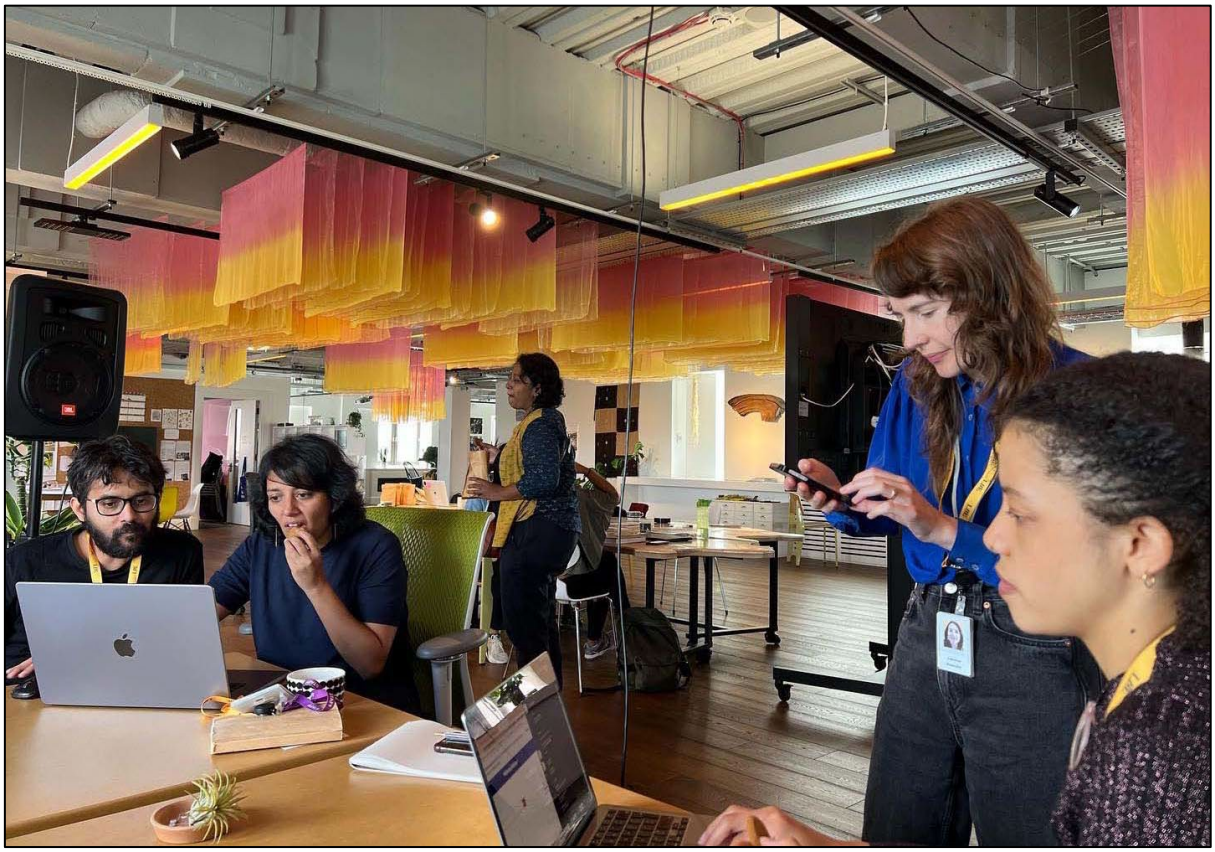

Figure 25 Developing Ideas (photo: Victoria Pratt).

Figure 26 Illustrating Ideas (photo: Ilan Kelman).

Figure 27 Building Ideas (photo: Ilan Kelman).

Figure 28 Presenting Ideas (photo: Victoria Pratt).

Figure 29 Implementing Ideas (photo: Victoria Pratt).

Figure 30 Technical Direction (photo: Ilan Kelman).

Figure 31 Creative Direction (photo: Ilan Kelman).

Figure 32 Creating Inspiration (photo: Ilan Kelman).

Figure 33 Using Inspiration (photo: Ilan Kelman).

Figure 34 Relaxing (photo: Ilan Kelman).

5. More Than Crisis and Resilience

These sections of the photo essay and the photos comprising them cannot be viewed linearly. As with resilience and crisis, they are not neatly compartmentalized as required by the structure of a photo essay and accompanying text in an academic journal. Instead, as The Hub does, they show how art, science, and community are mixed and melded, so the photo essay needs to be viewed in this way, despite its presentation.

This exchange and interaction aim to deliver balance. The violence and trauma to this planet, to the people on it, and to their land and environments are terrifyingly real. The hopes nonetheless remain inspiringly real. Across peoples, languages, cultures, continents, knowledges, and wisdoms, Land Body Ecologies is not the three autonomous concepts in its name, but is rather a single process and connection for bettering and healing (Ahmad et al., 2022; Gougsa et al., 2023). Rather than becoming mired in the indisputable solastalgia (Albrecht, 2005), with wider social and environmental devastation impacting people's mental health and well-being (Albrecht et al., 2007), The London Hub and the photos representing it aim to center support and pathways for moving forward by linking people who are going through challenging times based on local-to-global changes that they have not enacted.

They aim to help themselves overcome the difficulties, using local processes based in their peoples and environments, with others including *Buen Vivir* from Latin America (Caudillo-Félix, 2012) and *Falepili* from Tuvalu (Chambers, 1983). These processes acknowledge the negative vocabulary expressing horror, including climate grief, eco-grief, eco-anxiety, climate crisis, climate emergency, and climate catastrophe. They also acknowledge the cycle of destruction that this crisis-laden vocabulary imbues and foists (Hodder & Martin, 2009; McHugh et al., 2021) including adverse

impacts on mental and physical health and well-being. Land Body Ecologies has been working with knowledge-based alternatives for balance, moving beyond the ubiquitous doomerism to suggest evidence-based and action-based eco-inspiration, climate hope, and positive activities (e.g., Flores et al., 2022; Johnson-Jennings et al., 2020) including the Symbiocene which refers to nature and humanity obtaining mutual benefit by living together (Albrecht, 2020).

Despite the contradiction of being in the center of a megacity on the fifth floor of a large edifice, the London Hub hopes to epitomize and embolden exploration and implementation of conceptualizations such as the Symbiocene, Buen Vivir, and Falepili—and far beyond, notably drawing on the needs and offerings of the other hubs. Learning from each other and exchanging what is happening and what ought to be done, from teaching/learning to legal action, from academic papers and blogs to photo essays and performances, forms, melds, shapes, and extends Land Body Ecologies for the world.

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Resume

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Learning from stress: Transforming trauma into sustainable risk reduction

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Abstract

This study explores the collective learning process that evolved in the cities, towns, and districts damaged in the February 6, 2023, Kahramanmaraş earthquakes in Türkiye. Employing a multi-methods approach and a dataset comprising a review of relevant documents, semi-structured interviews, and field observations, we examine four fundamental stages of collective learning – knowledge acquisition, information distribution, interpretation, and organizational memory – in assessing the learning process in communities exposed to the devastation and trauma of the earthquakes. The study highlights the importance of adaptation, change, and collective growth as communities struggle to cope with the demands incurred by the disaster, and identifies factors that inhibit such growth in practice. In the aftermath of the Kahramanmaraş earthquakes, individuals and organizations sought to adapt their existing knowledge and practices to meet the challenges posed by recovery from this disaster and to build a consensual understanding of changes needed to achieve sustainable reduction of continuing seismic risk. The study underscores the vital Importance of timely and accurate Information In enabling Individuals and organizations to make informed decisions during and after the chaos engendered by the earthquakes. It highlights the pivotal role of technology in bridging communication gaps and facilitating the flow of critical information. The study concludes by identifying inaccurate information as the most harmful characteristic inhibiting collective learning, and by emphasizing the importance of aligning collective learning processes simultaneously among diverse groups within the community and across jurisdictional levels of operation. This study offers valuable insights into how to translate collective learning from traumatic events into sustained measures to reduce the risk of future disasters, going beyond resilience to achieve sustainable risk reduction. By understanding the factors that drive collective learning and the challenges that can arise, policymakers and practitioners can develop more effective strategies for supporting collective learning in the aftermath of extreme events.

Keywords: collective learning, knowledge acquisition, resilience, sustainable risk education, transforming trauma

1. Introduction

The extraordinary escalation in extreme events over the last decades reveals a serious gap in understanding how residents of heavily damaged communities cope with such events and rebuild their lives, presumably learning from the experience to enact changes that will prevent such

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destruction in the future. Nowhere is this gap more vividly apparent than in the response to the 6 February 2023 Kahramanmaraş Earthquakes that devastated a wide region of 11 provinces, 10 cities, multiple districts, and smaller villages, affecting 13 million residents in southern Türkiye, with the destruction spilling across the border into Syria (Çetin, Ilgaç, Can, & Çaker, 2023). Losses incurred from this event tallied more than 50,783 lives and 115,353 individuals injured in Türkiye, more than 8,000 lives in Syria (AFAD, 2023), and an estimated $103.6 billion in total costs for Türkiye alone (Turkey Presidential Strategy and Budget Directorate, 2023). Ironically, these events occurred only 24 years after the sobering sequence of earthquakes in 1999, August 17 in the Marmara Region and November 12 in Duzce. These events triggered an extensive revision of building codes, and led to the development of the Turkish National Disaster Plan (TAMP) and the Turkish Catastrophe Insurance Pool (TCIP) that was intended to protect Turkish citizens from losses in future events (Gülkan, 2001; Basbug Erkan & Yilmaz, 2015).

Presumably, the substantive steps implemented after the 1999 earthquakes demonstrated societal learning and informed actions taken to prevent future catastrophes in a nation of known seismic risk. Regrettably, those carefully constructed changes in building codes and policy following the 1999 earthquakes did not translate uniformly into practice, as in 2023, a total of 37,984 buildings collapsed completely, and more than 240,000 buildings were rendered unusable following the Kahramanmaraş earthquake sequence and aftershocks (AFAD, 2023; Çetin et al., 2023). Millions of residents in damaged cities, towns, and villages affected by the earthquakes were huddled into temporary rescue sites with inadequate facilities in housing, sanitation, access to clean water, and medical care, while an estimated 3.5 million people left the region (OCHA, 2023).

As the number, frequency, and severity of extreme events increases, the challenges to learning from such events and translating those insights into effective action become ever more difficult as the social, economic, physical, and technical systems that enable a community to function are increasingly interconnected and interdependent. In disaster-degraded conditions, as one system falters, it triggers failure in the next and the next, rippling dysfunction throughout the whole community and creating further stress for the residents. Stress is defined as the sense of being overwhelmed by external events, and loss of agency to manage the situation without support (Lindau, Almkvist, & Mohammed, 2016). For communities exposed to multiple hazards, the sequence of failure is compounded by cascading events, deepening the initial losses and weakening the communities' capacity for full recovery. This pattern is vividly illustrated in the chaotic response operations in the immediate days following, and the struggle for recovery from, the Kahramanmaraş Earthquakes that is still ongoing in southern Türkiye and northern Syria. *The question is whether, and if so, how, communities can learn collectively from the stress of extreme events and transform their communities through sustainable measures to reduce known risk.*

2. Theoretical Context

Learning from stress is not a new concept. The oft-cited maxim, '*That which does not kill me makes me stronger,'* attributed to Friedrich Nietzsche in 1888, has been touted as an antidote to the sense of loss and grief that overwhelms people affected by extreme events. Previous researchers have sought to explore the validity of this widely repeated maxim, but the studies have focused on individual response to stress. Findings, largely from psychologists, suggest that approximately 50% of those who experienced trauma reported positive learning outcomes (Tedeschi & Calhoun, 2004; Lindau, Almkvist, & Mohammed, 2016). Other researchers, in business, emergency response, and neuroscience, report that cognitive capacity drops under stress (Nelson & Winter, 1982; Klein, 1993; Arnsten, 2009). While this concept has been studied extensively, researchers report mixed findings regarding the capacity of individuals to function in stressful conditions or to recover from traumatic events, conditional upon previous experience and resources available for support (Calvo & Gutiérrez Garcia, 2016; Fink, 2016).

More difficult and little studied is whether communities that have collectively experienced major trauma can transform the mental, emotional, physical, and economic stress from the event

into a collective learning process that yields positive outcomes. There are many cases that document the negative impact of stress on cognitive performance when whole communities experience a traumatic event. For example, the Town of Paradise, California, USA was overwhelmed by wildfire in 2018 (Comfort et al., 2021); the cities of Golbasi, Antakya, and Samandagi, Türkiye were devastated by earthquakes in 2023 (Comfort, Celik, & Erkan, 2023); and the town of Lahaina, Maui, Hawaii, USA was destroyed by wildfire in August, 2023 (Bogel-Burroughs, Kovaleski, Huber, & Mellen, 2023). These events and the struggle to recover from them demonstrate that the impact of an extreme event escalates when the whole community experiences the trauma. The consequences of an extreme event fall differently on individuals, but collectively on the whole community. The challenge is to determine what strategies and conditions allow communities to transform trauma into a positive learning experience and act collectively to reduce future risk.

There are few known instances when collective learning has led to sustainable change after traumatic events. One example is the Helsinki Peace Agreement signed on August 15, 2005, after the deadly Indian Ocean Tsunami of 26 December 2004 to end the long-running conflict between the Indonesian Government and the Free Aceh Movement, approximately eight months after the earthquake and tsunami claimed more than 125,000 lives in Indonesia alone (Aspinall, 2005). A major rationale for the agreement, brokered by then-president of Finland, Martii Ahtisaari, was that both sides were exhausted from 30+ years of conflict and acknowledged that their shared experience of the heavy losses from the 2004 tsunami demonstrated that they had more substantive goals in common than differences that divided them (Comfort, 2019). A second instance was the end of apartheid in South Africa in 1994 after decades of internal conflict, loss, and trauma (Finnan, 2022). Rare as these cases are, they offer glimpses of successful transformation of trauma into collective learning processes that demonstrate the capacity for whole communities to recover from severely damaging events.

Yet, collective learning from stress is never certain. Other communities that experienced major trauma lose their resolve, resources, and capacity to envision constructive change, and spiral downward into ever greater dysfunction. For example, Haiti, after the devastating earthquake on January 12, 2010, has never fully recovered from that painful event and has slipped increasingly into social, economic, and political chaos in the following years (Comfort, 2019; Merino & Ware, 2021). Given the possibility of positive outcomes from traumatic events on a community-wide scale, but often deadly failure, this study explores three research questions. First, what conditions and characteristics of communities that have suffered collective trauma lead to collective learning, positive outcomes, and near-full recovery? Second, what conditions and characteristics inhibit collective learning and impair recovery after traumatic events, deepening dysfunction in the community? Third, how does collective learning from stress vary in dynamic contexts across jurisdictional scales? Exploring the consequences of stress and trauma on collective learning and increasing the capacity to act to reduce risk of future catastrophe are fundamental to creating sustainable communities in zones of recurring risk.

Multiple concepts and strategies have been advanced to suggest methods of coping with stress. Most depend on prior knowledge and recognition of risk from previous experience.

First, there is the classic assertion by Herbert Simon (1962), distinguished scholar of organizations and decision making, that ‘we can only create what we already know.’ With this statement, Simon acknowledged the essential role of information in framing strategies of action in uncertain contexts.

Second, Gary Klein (1993) and his colleagues built on Simon’s insight and developed a conceptual framework for decision making in urgent conditions termed ‘recognition-primed decision making.’ This framework held that actors facing novel, urgent conditions drew on previous experience to forge new strategies of action to fit immediate demands, but the framework applied more specifically to individual managers in urgent operations, not necessarily to a whole community.

A third approach, as researchers sought to comprehend the varied responses of communities to adverse events, is the effort to define and develop resilience. This concept, first articulated by Mary Douglas and Aaron Wildavsky (1982), acknowledged the impact of adverse events on both individuals and communities, but also noted the capacity of the actors to withstand harm and recover to their previous level of function. The concept of resilience has been widely adopted and refined by many researchers and organizations (Comfort et al., 2010; National Research Council, 2012; Davis, Mostafavi, & Wang, 2019). The basic approach is to build capacity to recover from adverse events generated by known risk through preparedness, planning, and modeling alternative strategies, so when a hazardous event occurs, the community is not surprised and can act to reduce risk, minimize losses, and recover quickly. While many efforts have been made to identify workable strategies to build resilience in communities exposed to risk (Davis, Mostafavi, & Wang, 2019; Ayyub, 2021), these concepts and methods do not always lead to action or change in fundamental behaviors to reduce risk.

A fourth approach, antifragility (Taleb, 2012), is likely the most relevant to the conditions of the Turkish communities affected by the 6 February 2023 earthquake sequence. This approach reflects a community that is aware of the risk to which it is exposed, and creates its social, physical, and economic institutions to anticipate uncertainty and build the resources to detect and reduce risk. It relies on new technologies to search and exchange information regarding risk and to develop agency for action among the residents of the community through simulations and 'serious games.' This approach includes the concept of post-traumatic growth (Tedeschi & Calhoun, 2004); that is, the positive outcome for people who have lived through traumatic experiences but have learned from those experiences how to transform risk into informed action to reduce the likelihood of future damaging events. This approach is being adapted in a current research project on wildfire risk reduction in northern California, USA, funded by the U.S. National Science Foundation's program on Smart and Connected Communities (Soga, 2022).

Translating any framework into action in the dynamic context of recovery from a major seismic event is difficult. Recovery operations involve multiple jurisdictions, organizations, and disciplines, each with different backgrounds, specific interests, goals, and capabilities. In practice, the actors cooperate at some times, other times not. Further, residents as well as public, private, and nonprofit agencies are operating in a degraded disaster environment without their usual means of support. Consequently, dynamic conditions create unique tensions for decision processes. As conditions change, actors need to remain *open* to incoming information and update their understanding of the operational context, but mobilizing response to changing conditions requires *control* over information critical to the operation and a clear logic of action (Hautz, Seidl, & Whittington, 2017). The degree of tension varies with the intensity of the event, severity of destruction, and capacity of the actors to adapt to the fluctuating rate of change in the operational context. Balancing openness with control to achieve an effective outcome depends on the flow of information within the larger complex, adaptive system that envelopes those organizations, agents, and community residents most directly involved in implementing the recovery processes. Information, then, becomes a primary resource for managing the continuing tension between the government agencies seeking to execute the recovery process and the residents of the community whose interests are most at stake.

In his review of learning from traumatic events, Huber (1991) identified four basic activities that characterize the learning process in individuals and organizations. These activities include knowledge acquisition, information distribution, information interpretation, and encoding new information into organizational memory. Would these same processes characterize a collective learning process for whole communities, and if so, could they be structured to enhance the possibility of positive outcomes for groups and communities that have experienced major trauma? This study will examine this question in reference to communities affected by the 6 February Kahramanmaraş Earthquakes in southern Türkiye.

3. Research Design Methods and Data

The research design for this study is an exploratory case study (Yin, 2016) of the potential for collective learning by communities that experienced the trauma of the 6 February Kahramanmaraş Earthquakes and, further, the possible effort to translate an emerging consensual understanding of seismic risk into sustainable measures to reduce the threat of future earthquakes. The study seeks to characterize the potential for collective learning from actual traumatic events and to create a sufficiently rigorous understanding of the process to serve as the basis for future systematic investigation. It included a field visit to Türkiye, March 4 – 12, 2023 for L. Comfort, with site visits in collaboration with Turkish colleagues, Suleyman Celik and Burcak Basbug Erkan, in Ankara, March 6-7, and with Suleyman Celik in the disaster-degraded region, March 8-10. On March 11, L. Comfort met with policy and engineering experts in Istanbul. In early May, 5-6, Burcak Basbug Erkan made a field visit to Sanliurfa.

We used three methods of data collection in conducting the study, First, we reviewed the relevant documents regarding the context of seismic risk in Türkiye, previous policies and changes in law and building codes made following the 1999 earthquakes, and current updates to policies and practices that were in force during the 6 February 2023 earthquakes. Second, we conducted 23 semi-structured interviews with experts in Türkiye from a range of disciplines – earthquake engineering, public administration and policy, psychology, urban planning, business management, and disaster management. Third, L. Comfort and S. Celik visited cities and towns in the heavily damaged provinces of Kahramanmaraş, Hatay, and Adiyaman, and observed directly the actual conditions of people who remained in these cities and towns approximately one month following the earthquakes, as they were struggling with recovery operations. We visited the provinces of Gaziantep, center and districts of Islahiye and Nurdagi; Kahramanmaraş center and Pazarcik district; Adiyaman and Golbasi district; and Hatay with the districts of Kirikhan, Defne, Antakya, and Samandagi. A later field site visit in May by B. Basbug Erkan included observations and interviews from Sanliurfa.

In preparation for the study, we developed an interview protocol for planned semi-structured interviews and submitted our research design and protocol to the University of California, Berkeley's Institutional Review Board, requesting an exempt review. We specified the unit of analysis for the study as the organization, and the unit of observation as individual experts and managers who had specific knowledge of the conditions, regulations, and context of seismic risk in Türkiye. The Berkeley IRB granted exempt review status for the study, which allowed us to create informal relationships with our interviewees so they could speak candidly about their operations, as no personal, identifying data were collected.

During these site visits, we conducted interviews with field personnel who were managing operations in these locations. We used a purposive sample, seeking managers of site operations and local officials, but also in Antakya, a local resident who served as the organizing leader for his neighborhood. We had remarkable access to local leaders, including governors and mayors, gained through academic contacts and professional relationships. The field visits often included tours of the facilities being used and observation of service delivery under disaster conditions.

In terms of analytical procedures, we transcribed the 23 interviews and coded them systematically, checking and cross-checking the content to identify major themes that were shared among the 23 respondents, and conversely, differences that were observed among managers representing different levels of government or between managers in public agencies and local community leaders. The analysis included an identification of areas for future study of social and policy issues.

4. Context of Recovery Operations

Briefly, the context in which the earthquakes occurred shaped the organizational response and the initial reactions of the affected communities. Two major earthquakes, M_w = 7.7 and M_w = 7.6,

occurred approximately six hours apart on the same day, February 6, 2023 in Kahramanmaraş, a province astride the East Anatolian Fault in southern Türkiye. The policies and practices designed to reduce earthquake risk following the 1999 earthquakes were presumably in practice. Yet, the destruction of homes, businesses, roads, communications, water, and electrical power infrastructure shattered the sense of safety in the region.

Given Türkiye's high seismicity, with 95% of the land area exposed to some degree of seismic risk, developing sustainable methods of managing risk is imperative for the country (Erdik et al., 2023). Fig. 1 below shows the extent of seismic risk throughout the whole country. Other characteristics were important in shaping the response to this traumatic event in 2023. Türkiye is a middle-income country, but high rates of inflation had been buffeting the economy for years, and citizens were uneasy about the falling value of the lira. The country was still reeling from the consequences of the July 2016 attempted coup and effort to take over the presidency, followed by the Administration's harsh measures to punish and jail anyone suspected of supporting the effort. Consequently, the society was fragmented with deep mistrust among different groups, lack of communication within and between organizations, and institutions hollowed out by loyalty tests to

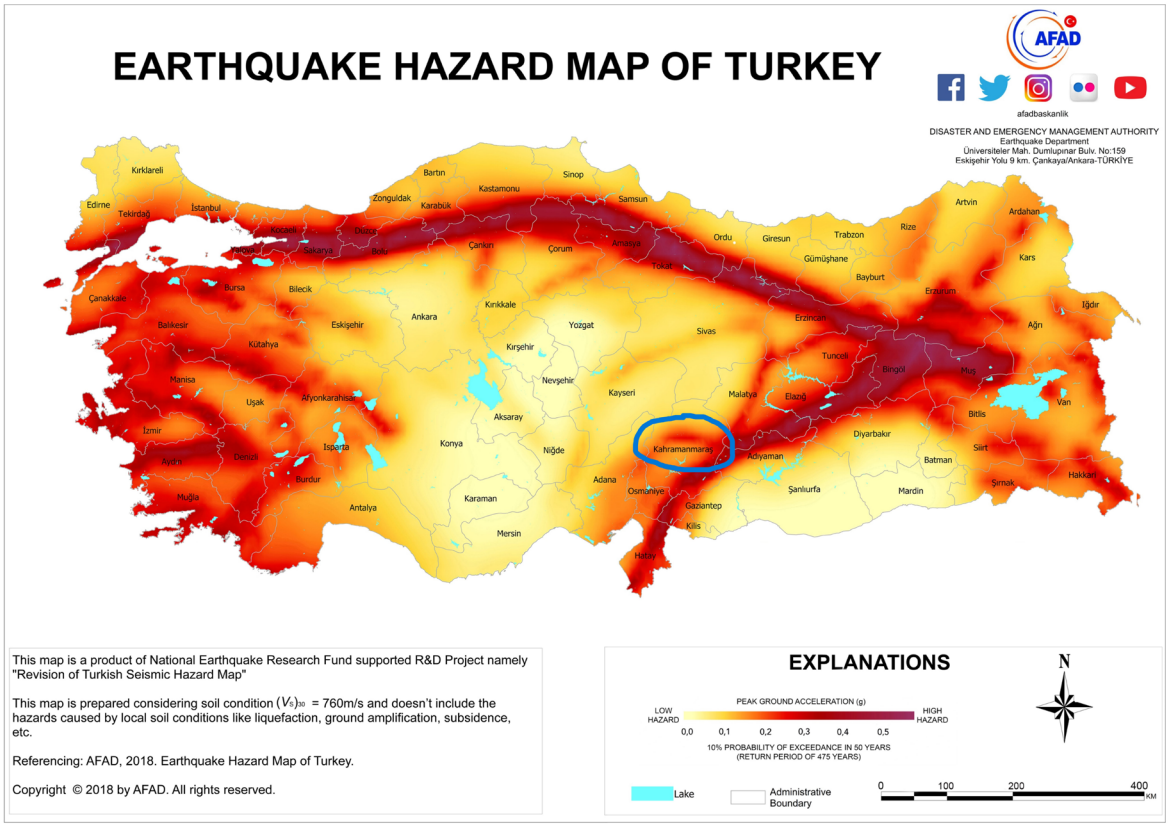

Figure 1 Revised Seismic Hazard Map of Turkey in use since 2018. The East Anatolian Fault is the dark red area slanting diagonally at the right, and the blue circle indicates the epicenters of the 6 February 2023 earthquakes. Source: (AFAD, https://www.afad.gov.tr/turkiye-deprem-tehlike-haritasi)

the current government (N. Karanci, personal communication, March 6, 2023). Further, 2023 was an election year in Türkiye, with the president, Recep Tayyip Erdogan, running for re-election, amid deep suspicion between the ruling party and the opposition party. This national event colored the response and recovery operations, as tensions were already high among citizens who were deeply polarized. In this context, recovery operations were initiated in the damaged communities with badly traumatized individuals sharing their grief and despair in collective trauma that affected whole communities.

5. Findings

Returning to the main research question of *whether communities can learn collectively from the stress of extreme events and transform their communities through sustainable measures to reduce known risk,* we find that this question breaks into two parts. First, clearly communities came together in substantive ways to help one another and adapted remarkably to survive in very difficult, harsh conditions, so the potential for collective learning is evident. The news media were filled with stories of residents from Istanbul, Ankara, and Erzincan mobilizing resources to support families needing assistance in the earthquake-damaged region. Nonprofit organizations reported a remarkable increase in volunteers from all over the country to support outreach efforts to traumatized communities (ANDA, personal communication, March 7, 2023).

The more difficult task is to transform this traumatic experience into sustainable measures to reduce known risk. In reviewing the findings from our field study, we used the four suggested categories in Huber's (1991) concept of post-traumatic growth in organizations as an analytical framework to examine this collective process for whole communities. Although our study was limited in both time and resources, we find some evidence relevant to the emergence of positive growth toward collaboration among different groups in rebuilding communities, but also barriers to this process.

5.1. Knowledge Acquisition

The first step toward developing a consensual understanding of seismic risk is gaining access to valid information about the seismicity of the region and of ongoing steps to reduce that risk. In this instance, the seismicity of the region was well-known among the scientists (Lund, 2023; Erdik et al., 2023), but the communication of that risk to residents of the community was not well developed. The shock of the earthquakes was documented and relayed via television and news accounts to the entire country, but the detailed assessment of how the risk affected the built infrastructure, why the buildings collapsed, and what measures residents could take to ensure safe reconstruction was not.

Further, it was difficult to determine which reports were valid and which were not. The government's control over information about the earthquakes and the recovery process was nearly complete. Independent journalists were not granted direct access to damaged earthquake sites, nor were their stories published in the widely circulated national newspapers. The massive destruction from the earthquakes was visible and documented extensively by research teams of national and international experts (Çetin, K. Ö., Bray, J. D., Frost, J. D et al., 2023; Çetin, K. Ö., Ilgaç, M., Can, G., & Çaker, E., 2023), but the actual account of how and why the scale of damage was so severe, given the measures taken after the 1999 earthquakes, was fractured among different groups in the society.

5.2. Information Distribution

Technologies to support communications were being rapidly adopted, and although statistics vary, cell phone penetration was estimated at 101% of households in Türkiye. Even in rural communities, cell phone use was high. Importantly, the use of WhatsApp groups became the dominant form of exchanging information about the earthquakes and the processes of recovery. For example, in Golbasi, as the school administrators were preparing to reopen the schools, they formed a WhatsApp group for the teachers and school administrators, a second WhatsApp group for the students and parents, and a third WhatsApp group for school administrators in different cities who were going through the same process of re-establishing their schools' operations and returning to functioning school buildings (School administrator, Golbasi, TR, March 10, 2023) . Many school buildings survived the earthquake as they were built relatively recently, but were still nonfunctional as they lacked electrical power, water, and sanitation.

Disaster managers also used WhatsApp as a main form of communication, as the groups could easily include personnel from government agencies at different jurisdictional levels – international, national, provincial, municipal, and district – as well as nonprofit organizations, large and small, and business organizations. WhatsApp groups became an easy and simple mode of connecting people around specific issues but did not connect people from different groups effectively. While these WA groups could build a shared understanding of the problem for specific issues, they did not easily translate the groups' perspective into an operational view of the whole system. The practice of forming WhatsApp groups for easy communication, commonly used, illustrates the impact of 'complex time. Different groups were often acting on their own assessment of needs without considering the impact of their actions on other groups in the same system, leading to misalignment in action among the set of groups in the communities, despite their common goal.

Other modes of information distribution, such as television, web pages, radio, and satellite phones, were available, but none encompassed the entire profile of the event, with updates at specific levels of detail. It became difficult for even the most dedicated community resident to follow the news regarding all aspects of the recovery process, and especially for those in towns, villages, and cities that were operating on different time scales. The distribution of information among the different groups, especially for a society of more than 85 million people, each of whom was affected, directly or indirectly, by this event, was complex. While key to the development of a consensual understanding of seismic risk, so essential to building commitment to reducing future seismic hazards, the modes of distribution and communication of information varied widely. This variation in modes of distributing information led to variation in practice at different scales of operation and misalignment in action among the scales of operations as local households, community groups, and public agencies sought recovery within the wider Turkish society. Fig. 2, below illustrates this misalignment as 'complex time' (Krakauer, 2020); that is, actions that are shaped by different perceptions of time at different levels of operation in a shared endeavor, such as disaster recovery.

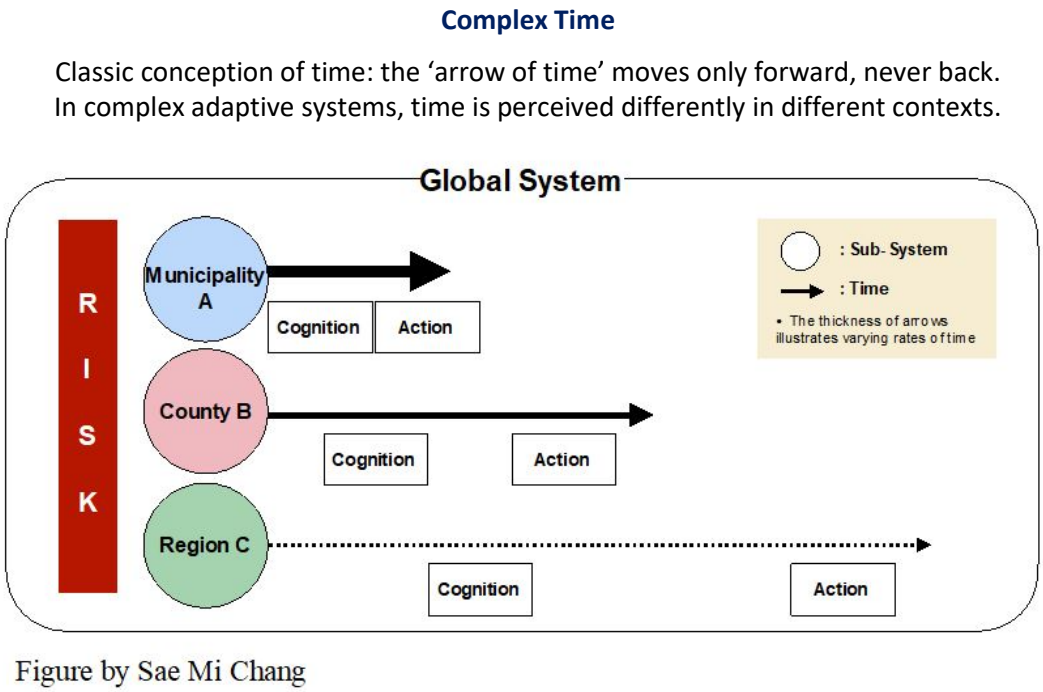

Figure 2 Complex Time

The concept of complex time illustrates the integral relationship between cognition and action and the essential role of information in enabling cognition in novel, stressful conditions (Comfort & Rhodes, 2022). For example, in the chaotic first three days following the earthquake, when communications were urgently needed to coordinate search and rescue operations, it took days for

the communications companies to bring mobile vans with equipment and technicians to the damaged areas to repair the shattered infrastructure to enable coordination among the multiple teams. The cell towers for communications transmission had been located on the roofs of buildings in cities and towns, so when the buildings collapsed under seismic shaking, the communications system also collapsed (Disaster operations director, personal communication, Kahramanmaraş, March 8, 2023). Ironically, the delay was caused in part because the communications infrastructure was destroyed by the earthquakes, and communications technicians outside the region had no way of knowing immediately the extent of destruction in the damaged communities (Disaster operations director, personal communication, Samandagi, March 9, 2023).

5.3. Interpretation

The third phase in Huber's framework for collective learning is likely the most difficult and most complex. To achieve a consensual model of a complex problem, such as recovery from a major disaster, the first two phases need to be sufficiently established to have a reasonably coherent profile of the whole operating system and its components, with sufficient understanding of the component parts and their respective roles. That is, the actors need to recognize their membership within the operating system and their specific roles in achieving the overall system's goal, sustainable recovery from the current disaster event in ways that reduce risk of future disaster events.

It is not clear that the interpretation of the events of the 6 February 2023 earthquakes has sufficiently reached a degree of consensus within the Turkish society to meet this standard. There is still discussion and disagreement about aspects of the recovery, with different views being reported at different scales of operation while the recovery process is still underway. Commentary from the Kahramanmaraş region reports that one casualty was found almost 10 months after the earthquake. Further, people still living in temporary shelters suffer from seasonal conditions such as heavy rainstorms, high winds, flash floods, and snow. A major issue in the area is the serious risk from asbestos. As the necessary precautions were not taken when removing the rubble at the initial stages of reconstruction, the Turkish Medical Association declared that the level of the asbestos in the region is three times higher than the level that is considered safe by the World Health Organization, likely leading to an increase in cancer cases in the future (Turkish Medical Association, 2023).

In the damaged cities, construction of new housing is proceeding, but are the building codes, revised again in 2018 (Turkish Building Earthquake Regulation, 2018), being followed? Is there sufficient knowledge and agreement among the building owners, contractors, and government agencies overseeing the construction process to ensure that not only the buildings will be built according to current codes, in force since 2019, but the supervision process specified under Law No. 4708 (Law on Construction Supervision, 2001) will also be followed? There is little information publicly available to document the construction process, but these are practical tests of a shared understanding of what is required to achieve sustainable recovery from a major disaster event.

In Huber's (1991: 102) discussion of achieving a common interpretation of new information about a shared event, he notes that an important factor is the degree of uniformity in the prior cognitive maps of participating groups or organizations. This factor relates directly to the vital effort to collect timely, valid information about the new event and to distribute that information broadly to all participating members. If the differences in cognitive maps are significant, it is likely necessary for some members or groups to "unlearn" existing beliefs that have blocked their acceptance and understanding of new information. For example, in a public statement made while on tour of the devastated earthquake region three days after the event, President Erdogan reportedly stated that it is "not possible to be prepared for such a disaster" (Druker, 2023). Such a statement, uttered by the President, would need to be unlearned by the millions who may have heard or seen it before they can accept agency for changing their existing practices to achieve sustainable risk reduction in zones prone to seismic risk. Creating a valid interpretation of the actual events is a vital but ongoing

process in a dynamic society, as leaders change, external conditions change, and new information supersedes previous accounts of actual events.

5.4. Organizational Memory

The fourth phase of Huber's framework for post-traumatic growth is encoding the new knowledge gained from the traumatic experience into organizational memory. Huber, in contrast to other researchers (Arnsten, 2009), does not assume that learning from trauma necessarily leads to change in behavior, but holds that it does lead to change in perspective about extreme events and understanding of the organization's role in relation to other actors. Applying this concept to the larger social construct of a community becomes a harder task. Communities vary in size, for example, Golbasi municipality and district, pre-earthquake, had approximately 150,000 residents; Antakya, pre-earthquake, was a municipality of approximately 400,000. Cities develop identities and do so in numerous ways. Some cities construct museums or memorials following extreme events to honor the dead and to acknowledge the sacrifices made that day so that others may live. The City of Kobe, Japan has created a museum to house artifacts from the Great Hanshin Earthquake of January 17, 1995, and grade school children make regular pilgrimages to the museum so they 'will never forget.' New York City has created a memorial to honor those who died in the tragedy of the 9/11 terrorist attack in September, 2001 to serve as a public reminder of the city's grief that day, but also of the collective response of the city and nation to recover from that shattering event.

Collective learning, however, is more than building a museum or a monument. In terms of achieving an actual shift in perception or, indeed, a change in behavior; the information held collectively in people's minds about a threat needs to change. This step can be facilitated by digital technologies that create archives of records and store visual artifacts that document the consequences of buildings constructed not according to code or inadequate siting of major facilities, like hospitals or schools, where they may be vulnerable to seismic movement.

Again, the concept of 'complex time' factors into the encoding of knowledge into collective memory. For the cities and districts that were most severely damaged, the events may be vividly encoded in digital archives and made accessible to public schools, universities, community organizations, and nonprofit organizations to serve as a continuing record of the event. The archives can then be freely accessible to members of the community, scientific and arts organizations that can review the records and develop innovative strategies to counter seismic risk. The archives essentially create 'time machines' that enable users to align their perspectives across jurisdictions and organizations to build a consensual understanding of risk that serves as the basis for sustainable change in managing a long-term hazard like seismic risk.

6. Conclusions

Returning to the major question posed for this study, "*can communities learn collectively from the stress of extreme events and transform their communities through sustainable measures to reduce known risk,"* findings from this preliminary field study of the 6 February 2023 Kahmaranmaraş Earthquakes are mixed. There is evidence of collective response, both in the damaged cities and villages and in the regions of the country outside the earthquake-stricken area, in which people spontaneously rallied to assist residents in the disaster-degraded areas and contributed their time and resources to provide support in the immediate post-earthquake period. But the review of actions taken for the recovery process are still underway in the earthquake-shattered provinces of southern Turkey, and it may be too soon to determine the eventual outcome of this process.

Reviewing the three sub-questions regarding collective learning from trauma in the specific context of the Kahramanmaraş Earthquakes, preliminary insights can be gained from this field study that indicate the potential for shaping collective learning from trauma. They are summarized below.

6.1. Characteristics that Lead to Collective Learning

An important insight underscored in the study is that learning relies on timely, valid information, and constructing a shared knowledge base of accurate information about the extreme event and ensuing trauma is the first step in developing a consensual understanding of the event, what happened and why. The second step is distributing this information widely over a reliable platform to build trust among the diverse audience of participants in the community. These steps may be done most effectively at the local level, with trusted leaders verifying the information and translating it into local terms. To engage in both steps, innovative but practical uses of information technology are critical. The adaptive use of WhatsApp to form communication groups after the earthquakes, as organizations and groups sought to re-establish connections and develop strategies for action to cope with the demands of recovery, illustrates the potential for enhancing learning processes. It demonstrates, again, that learning is social, and engaging people in shared communication processes contributes to an emerging consensus for the group.

6.2. Characteristics that Inhibit Collective Learning

The most damaging characteristic that inhibits collective learning is distorted information that is discovered to be false. This discovery destroys trust in not only the purveyor of that information but, more seriously, the whole public information collection and distribution process. The lack of trust leads to withdrawal from community activities, isolation, and angry denial of responsible action to support community goals.

This characteristic, regrettably, was evident in some communities where the residents believed they had been misled regarding the reliable construction of their buildings. Other factors that inhibit collective learning are lack of access to valid information and the resources that allow people to search for information while they are under stress from other needs.

6.3. Variance in Collective Learning in Dynamic Contexts

One of the most interesting but difficult aspects of collective learning is that learning occurs at different rates for different groups of residents in a community and at different rates at different jurisdictional levels of operation. This is a factor of complex perceptions of time. The discrepancies can be managed, but to do so, requires a small group of community leaders to articulate the goals for the whole system in ways that every participant can understand. Advances in information technology, appropriately developed for different regions and different levels of jurisdictional operation can be adapted to facilitate this vital process.

6.4. Toward Sustainable Risk Reduction

Based on these observations, we conclude that transformation of trauma into a learning process to reduce risk is a collective effort. No community can do it alone. Rather, it depends on the support, understanding, and guidelines set by the wider social and institutional context of the traumatic event. This means that investing additional resources -- financial, organizational, technical, intelligence, emotional -- is instrumental to enhancing the learning process and essential for holistic recovery of damaged communities. Further, collective learning will proceed at different rates for different groups within the traumatized community, so aligning the learning process among these groups is fundamental to achieving a consensual goal in a dynamic social environment.

In this critical task of building a consensual commitment to sustainable risk reduction, information technologies offer an important tool to accelerate learning and provide greater access, openness, and engagement for participation at different jurisdictional levels of operation. Greater investment in technologies that allow rapid, easy access to valid knowledge will facilitate the collective learning process essential to the transformation of trauma into positive outcomes. Investing in community outreach and building local social networks can reinforce the confidence that people working together can reimagine the built infrastructure in their communities to withstand seismic shaking. Innovative uses of simulations and modeling, enhanced by scientific

expertise, could present information about seismic risk to community residents in ways they can easily understand.

The Turkish society faces a critical set of choices in the cities, towns, and villages damaged by the Kahramanmaraş earthquake sequence of 6 February 2023. Recovery means not just reconstruction of buildings and bridges, but also creating the social connections and collective confidence to act that enable communities to transform trauma into sustainable risk reduction.

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Resume

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The use of AI algorithms in architecture, engineering and construction: A tool for crisis prevention? The uncertainty perspective

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Abstract

Within the Architecture, engineering and construction (AEC) sector we see movements toward greater use of industrial robots, machine learning, algorithms, and other artificial intelligence (AI) tools. Yet, the AEC industry, despite being one of the largest fields on a global scale, is known for being the slowest to digitalize and innovate. Factors such as unrecognizing the value of digitalization by the decision-makers and making safety-related decisions under high levels of uncertainty, appear to be critical in preventing successful large-scale digitalization. This situation raises multiple questions from a risk science perspective. How, among other things, might the expansion of AI and more specifically AI algorithms usage in the AEC field affect uncertainties, and could AI be considered a tool for preventing crises? To obtain responses to these questions, we conducted 21 semi-structured, in-depth interviews with AEC employees who are currently using AI and AI algorithms or will soon be doing so in their everyday work. Our findings show potential for wider use within the AEC field, subject to overcoming knowledge gaps. Moreover, although having the potential to reduce some uncertainties, the increased use of AI and AI algorithms appears to be introducing an entirely new set of uncertainties. As a result, although AI may effectively prevent certain crises and be regarded as crisis prevention tool, its inadequate implementation could potentially create new risks.

Keywords: AEC, AI, algorithm, crisis, uncertainty

1. Introduction

The Architecture, Engineering and Construction (AEC) sector has proven a great potential to widely employ robotics and Artificial Intelligence (AI) in the past twenty years (Emaminejad & Akhavian. 2022). For instance, industrial robots are used as one option for the deconstruction site automation (Lee & Brell-Cokcan, 2023). Machine learning has been implemented to automate the building design process, using Building Information Modelling (BIM) data, collected from different projects, and save time on the design process compared to traditional approaches (Zabin et al., 2022). Recourse to AI, and more specifically Big Data technology in the construction sector offers potential in areas such as resource and waste optimization, value added services, facility management, energy management & analytics (Bilal et al., 2016). In addition, Pan & Zhang (2021) also consider automation, risk mitigation, high efficiency, digitalization and computer vision as the main pluses of using AI in construction and engineering.

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Many of the AI current and potential applications in the AEC field are based on AI supported algorithms. Different AI algorithm supported robots can be of aid in relation to site inspections, assembly and material handling (Goly, 2023). Drones are used in multiple phases of construction projects, from the stage of land purchase to the post construction stage of the project with almost no risk and while providing real-time information (Mahajan, 2021). Data-driven mechanisms to empower construction machinery with intelligence rely on industrial data resources and AI algorithms, which carry potential in intelligent construction machinery (Zheng et al., 2023). Scheduling and optimization algorithms could be deployed to derive new strategies to address possible issues arising during an onsite construction project (Turner et al., 2021), and the rule checking algorithms for detecting required prevention methods for slab edge (Zhang et al., 2015). Nevertheless, it would be possible to use transportation route optimisation algorithms for project planning (Blanco et al., 2018).

The future of the AEC industry is influenced by two major developments (The World Economic Forum, 2016):

- Buildings are responsible for 30% of global greenhouse gas emissions, which is considered a call for urgent action. The United Kingdom government, for instance, has a 2025 target for 50% reduction in greenhouse gas emissions in the country's-built environment.
- The world's population is growing at a pace of 200 000 people per day. This, combined with lifestyle changes and expectations, suggests that the need for housing, transportation and other types of infrastructure will continue to increase significantly.

Therefore, it should come at no surprise that calls for digitalization are coming from many different corners. The Construction 2025 Industrial strategy report published in the UK in 2013 offers one such example. The report addressed technology advancements, use of BIM, as well as research and innovation needs (HM Government, 2013). On the EU level, the European Commission (2021) reports that in most EU Member states (16 out of 27), policies are in place to target the digitalisation of the construction sector. Many national governments have BIM requirements in place as part of their public procurement process.

Yet, while AEC is one of the largest economic sectors in the world, it is one of the slowest to digitize and innovate (Abioye et al., 2021; Blanco et al., 2018; McKinsey & Co., 2020; The World Economic Forum, 2016). As it seems decision-makers in the AEC field lack knowledge about the implementation of digitalization to generate value (Lavikka et al., 2018). It does not help that the AEC industry usually comprises small businesses (82.3%) which are known for being late technology adopters (Emaminejad & Akhavian, 2022). Several authors also identified challenges to the digitalization of the AEC sector. The main issues include data security, privacy, protection (big data) (Bilal et al., 2016), a lack of common data standards, data security and ownership (digital twins) (Shahzad et al., 2022).

When discussing the adoption of AI technology, a key element for the successful integration into organizations is the workers' "trust in AI technology" (Glikson & Woolley, 2020). Many times, however, this precondition is not met (Ibid,). Many organizations face the challenge of algorithmic aversion, in which people tend to place more trust into human interventions than algorithmic performance even when seeing an algorithm outperforming a counterpart human (Dietvorst et al., 2014). Employing AI algorithms demands accurate data for training, whereas collecting large datasets can be very costly and time-consuming for many construction companies (Regona et al., 2022). Moreover, only a limited number of people can interpret the data, leading to limited economies of scale, thus hindering digitalization and innovation (Regona et al., 2022). Finally, there is a question about whether the wider use of AI in the field could lead to different types of crises, such as unemployment resulting from automatization(Ford, 2013; Hughes, 2014).

2. Could AI Algorithms be seen as a Crisis Prevention Tool?

A very large share of construction works, up-stream or downstream of groundbreaking, involves making safety-related decisions under uncertainty (Tixier et al., 2017). Inaccurate location-awareness, blind spots, and unexpected environment disturbances are only a part of the many uncertainties present in the construction field operations (Zheng et al., 2023). In the context of AI use in AEC we witness more calls for improved risk analysis, such as in machine learning applications to BIM (Zabin et al., 2022). Therefore, it is of great importance to provide construction practitioners with tools to mitigate the adverse consequences of uncertainty on their safety-related decisions (Tixier et al., 2017).

According to risk research, there is a number of obstacles when implementing new technologies that could hinder the idea of employing AI algorithms as crisis prevention tools. Early on, Slovic (1987a) discussed what appears to be public's concerns towards risky technologies, and highlighted the importance of education in that context which would lead to a change in risk perceptions. We also witness great technological advancements, but despite these advancements on the technological side, too little progress has been achieved in improving the understanding of AI algorithms among different stakeholders (Bouder, 2020). In the AEC field, this would involve, for instance, developers, engineers, and all other relevant parties working on a project.

A crisis originally denoted "the turning point for better or worse in an acute disease or fever", and nowadays often addresses "a difficult or dangerous situation that needs serious attention" (Merriam-Webster, 2023). Crises in the AEC industry, considering its scale and specificities, are often systemic and severe. The cost of infrastructural projects is usually very high, which also leads to raising costs stemming from any kind of delay within the projects (Hällgren & Wilson, 2008). In addition, Slovic (1987b) when discussing complex industrial systems explains that impact of "unfortunate events" in such systems could ripple outward and cause substantial indirect costs exceeding the initial event. This analysis is reinforced by later research from Renn and Klinke (2004) about the unfolding of systemic risks. In addition, also out-of-the-field large-scale crises such as COVID-19 have an enormous impact on the whole AEC sector (King et al., 2021). We also know that if modelling to express risk is not done appropriately in crisis situations, it could result in extreme scenarios being given more weight than it should (Aven & Bouder, 2020).

However the whole idea of introducing digital technologies in construction comes with abundant promises to tackle known challenges of labour shortage, competitiveness, resource, energy efficiency and productivity (European Commission, 2021). Therefore, the aim of this paper is to investigate how the use of AI and AI algorithms may affect uncertainties in the AEC field, and can it be considered as a crisis prevention tool.

3. Method

To answer this inherently qualitative question, we opted for a research design involving semi-structured, in-depth interviews with the aim of investigating the prospectives of the AI use in AEC, especially the use of AI algorithms in the field. This research adopts a risk science perspective, which offers a solid framework to deepen ones understanding of how technologies may affect uncertainties and how greater resilience may be achieved (Logan et al., 2022). In this particular case the focus is on how employees face uncertainties on an everyday level, and how in this context AI may be used as a crisis prevention tool. We aimed for respondents currently employed in the AEC field, who either use some of the AI tools during their daily work or whose work would be influenced by the AI in the future. To narrow the focus down, we aimed for respondents working in AEC field in Europe. We wanted to better understand their understandings and opinions on the current use of AI algorithms in the field. We also want to grasp how the enhanced use of AI algorithms may influence the uncertainties that they face on the daily level. In particular, could key actors in this sector consider AI technology as a crisis prevention tool, and if so, what could be their thoughts on the prospects of the every-day use of AI within AEC.

After we identified the need for expert interviews the next step was to determine who should be the part of our target group. We decided to use as the main discrimination criterion whether a potential respondent works currently in the AEC field. This criterion ensured that target group members are in contact with the main trends in the industry, and that they are using, will be using or at least will be exposed to AI technology in their daily work. We did not discriminate based on their working positions in accordance with the feedback that we received from the pilot interviews: work positions may significantly vary across and within countries, sub-sectors and even among different companies.

The interview protocol was designed after a comprehensive literature review and following two pilot interviews with three respondents from the field. The final list of themes for the interviews consisted of the current state of AI integration in AEC, uncertainties, crisis, regulation, and prospect of AI use on every-day basis within AEC. Guest et al. (2006) suggest 12 interviews when the goal is to understand common perceptions and experiences of a relatively homogenous group. It could be argued whether our group was entirely homogenous since we did not have as inclusion/exclusion criteria a specific work position for the respondents. We therefore aimed for more than 12 interviews and finally reached 21 respondents to ensure robust sampling and data saturation concerning the scale of study.

We conducted the interviews in October 2023. The interviews were organized starting with the introduction describing the aim of the study. Eight open-ended questions were formulated to provide insights into respondents' perspectives of AI, and AI algorithms in the AEC field (see annex).

4. Results

We conducted 21 interviews with employees from the AEC sector across Europe. Considering the novelty of the topic and the feedback gained after the pilot interviews, reflecting substantial variations even across different companies and cities, we decided to keep the inclusion criteria for respondents on a rather simple level. This way, we were given the opportunity to delve deeper into the understanding of the current and possible future use of AI and AI algorithms in the AEC sector, while reflecting on uncertainties and crisis prevention. The work positions of the respondents encompass a range of roles, including BIM managers, architects, construction site leaders as well as academics engaged in research and lecturing within the field. The interviews focused on 1) their factual understanding and 2) their reflections based on own experiences and subjective viewpoints.

4.1. The Understanding of AI and AI Algorithms

The majority of respondents do not perceive algorithms as a unified concept, but rather understand them to be subject to diverse interpretations across various fields, within the AEC sector itself, across professions, working positions, and different projects. This raises potential challenges, and they highlighted an array of additional uncertainties. For instance:

"An AI algorithm is a model learning the history and predicting the future" (Respondent 2)

Still, most respondents were familiar with the use of AI and AI algorithms in the AEC sector. Examples included drone projects, detecting concrete cracks on dams, tablet with BIM being used by a construction worker, and predicting structural response. Nonetheless, the majority of the respondents had not yet used AI or AI algorithms or were ignorant about the fact that they had. The reason behind this is that, while respondents can easily perceive differences among different applications including nondigital and digital working environments, they appear to encounter more challenges in distinguishing between non-AI-supported software and AI-supported software. For some, the idea of AI remains ambiguous. For example, they associate AI primarily with autonomous driving vehicles and robot-like features, while mainly failing to take into account applications backed by machine learning. During the interviews, several respondents were uncertain about whether BIM, which they use in their daily practices, should be counted as an AI-supported software or not.

Those who were more familiar with the application of AI and AI algorithms in the AEC sector suggested that the design phase could benefit the most from their everyday use. This is because AI can be of assistance during the initial phases of projects and could continue to provide assistance throughout the entire project life cycle, which is normally a time-consuming process. Other respondents also pointed to the important help that AI can offer in areas such as geodesy, structural analysis, and modelling of bitumen quantities. However, we also see disagreements. A few respondents, for instance, explained that AI and AI algorithms could be effectively used by architects. Conversely, a few others completely opposed this idea, reflecting on the challenge of AI to mimic the unique style and individual expressions of architects.

Reflecting on whether the AI and AI algorithms could prevent system failure or potential crises, most respondents highlighted that this could go in both directions. While AI has the potential to prevent potential system failures, or accidents on construction sites, it can also lead to new types of failures, uncertainties, and even crises. The challenge with AI is that it could make some working positions obsolete, and it could even lead to severe employment crises. Also, as multiple respondents report, most projects include numerous stakeholders with many different interests, resulting in various changes throughout the project, making them highly dynamic and demanding. Currently, a lot of work seems to be done based on empirical experience. This could be concerning since, if AI takes over many of their working tasks, employees' prior working experience would not be enough for them to understand and follow the entire working process. Furthermore, as respondents argue this could lead to new types of crises.

Another challenge arises since AI-supported solutions often have an appealing interface and are very intuitive but can also provide inaccurate results due to one or more mistakes in parameters. For instance, a model that was familiar to one of the respondents and was supposed to conduct calculations and provide guidance to heavy machinery operators regarding excavation locations, turned out to be completely inaccurate after a longer period had passed. Due to its appealing interface, this error was only discovered later in the project compared to what would have been the case with older methods. The AEC sector is prone to uncertainties, as respondents state, and AI could amplify them further or generate new uncertainties.

4.2. Are AI Algorithms Good Enough?

Typically, projects within the AEC industry are lengthy, and their structure varies not only from country to country, but also between projects. The high sensitivity of input parameters presents a challenge that respondents frequently observe in today's software solutions used by the AEC sector. Elaborating further, a lot of software packages attempt to convey too many processes, resulting in poor outputs which puts an extreme weight on input parameters. This leads to severe oversights. In that context, one of the respondents described a situation that occurs frequently:

"I inserted all the correct parameters in the software, but the software gave me these bad results." (Respondent 7)

The respondent mentioned that this situation constantly occurred during the implementation of a new, arguably simpler, software used by his company. This, he explained, shows the importance of adequate education for using AI and AI algorithms in the field. Most other respondents reported similar difficulties. As they state, education is one of the major preconditions for successful implementation of AI in the AEC sector. If done correctly, the effectiveness of the algorithms themselves could be assessed better. Most projects involve many individuals, starting with architects, engineers in various positions, but also workers with limited formal education. Thus, it is challenging to enable a good balance and understanding of, for example, advanced, dynamic AI algorithms. This results in a situation where sometimes algorithms work well, yet the human factor is not good enough, which may create an impression that the algorithms are not good enough.

Other respondents also mentioned the challenge of conveying too many processes. Another major issue was the challenge of "one size-fits-all" solutions. For instance, one beam will be exposed to different influence (e.g. of wind, water, etc.), depending on many factors, which is, one respondent argued would challenging to take on board using AI. Another respondent also mentioned a specific issue linked to the digitalization of AI:

"When I see a house, I can recognize by the style used, that the house has been built in the 1930s. However, I see that the façade had been changed during the 2000s and the style does not fit the initial one. I can see that, by having a quick look at the house. Would AI be able to recognize it the same way? Those atypical situations and recognizing the fine details are problematic." (Respondent 15)

Most respondents depicted uncertainties as definitely being one of the key characteristics of AEC projects. They named so-called "model uncertainty", "person uncertainty (e.g. user, developer)", "parameter uncertainty" as a few examples. Uncertainties are especially present in cases of complex, long-term projects. Respondents see AI and AI algorithms as something that may contribute to the efficiency of their work, but on the other hand they argued that it could bring a new set of uncertainties. Therefore, they find it challenging to describe current AI algorithms as good enough to be used on an every-day basis.

In practice, an algorithm's quality is frequently biased towards its appearance. It seems, as the respondents report, that sometimes developers favour creating an appealing interface, rather than putting more weight on data. Visualisation may be highly relevant, but it is important not to forget that the robustness of data comes first. Moreover, this bias towards visual attractiveness may also create challenges on the user side, as errors may be concealed for a longer time compared to the less visually pleasant traditional formats.

Trial periods would play a critical role to see whether AI algorithms are good for purpose. The process should involve experienced engineers who would test their merits alongside classical methods. Additionally, smaller scale pilot projects would make a good start for pre-testing new AI algorithms, before introducing their use onto large scale projects of great significance. Several respondents were of the view that such testing of AI in real-life situations may prevent severe failures or the overlooking of tail uncertainties within more complex projects. Here AI algorithms could be indeed seen as crisis prevention tools. However, multiple respondents emphasized that trial periods will not be able to rule out uncertainties all together. Projects in the AEC field are complex and demanding. There are almost no two identical projects, thus uncertainty will always be present to some extent.

Additional challenge that may occur while using AI and AI algorithms in the field is the need to take into account specific circumstances. For instance, seismic parameters are needed in regions that are more prone to earthquakes. In this case the way forward is to devise dynamic AI algorithms that are flexible enough to follow changing requirements and parameters. For instance, in some countries, regulations define that objects must be constructed taking in consideration a 50 year probability of earthquake occurrence , whereas, hypothetically, no earthquake may occur in the next 300 years. A few of our respondents asked whether an AI algorithm would be able to capture such parameters in a correct and unambiguous manner.

4.3. Regulatory Challenges

Most respondents see the necessity of regulating the AI-supported algorithms used in the AEC sector. Justification stems from lowering the already high level of risks and uncertainties in everyday working environments. Reflecting on the need for regulation, respondents raised the issue of how to best conduct regulatory compliance. Views diverged regarding how this goal should be met. Some highlighted the importance of introducing flexible regulation, while others emphasized the need for stricter governmental intervention.

Yet only few respondents were in favour of standardization. By that they meant Eurocode or ISO-type standards. Still, many recognized the practical limitations of regulation and standardization from the perspective of direct experience. People working on different AEC projects tend to rely to a large extent on the experience that they have acquired from past projects. Existing non-AI-related guidelines are often ignored in favour of experience. This could also pose a practical challenge for future AI regulation.

Instead of relying heavily on strict regulatory compliance, well-trained employees may be more effective at controlling AI implementation. One way of doing this would be to designate a responsible person holding a certain AI license. Different licences are widely used within the field today, so therefore, incorporating another set of licences could be recognized as a simple solution, understandable to the wide range of AEC employees.

A few critical concerns were raised that could pose additional challenges for the reinforcement of regulation. Those are the challenge with the liability issue of AI, ethical and moral concerns, and similar problems. A few highlighted EU Commission as the regulatory authority that could take responsibility on the European level.

4.4. Heading for the Future

All respondents agreed that AI is needed. The reasoning is that AI algorithms could help to simplify many procedures in the field that are currently time-consuming. They also identified trends in other fields and agreed that it is only a matter of time before they spill over to the AEC sector. Algorithms can be very positive, for instance, when using drones for inspection or construction site automation, that can remove the possibility of height fear among workers. The same is valid in the case of not easily approachable terrains.

One respondent formulated a key concern shared by the majority of respondents as follows:

"We have to be aware of the limitations, otherwise the use of AI algorithms can easily lead to new uncertainties, and crises. We have to keep in mind that the data is never perfect, so the results cannot be perfect either. Too much reliance on any software can be harmful, and counterproductive." (Respondent 2)

To name an example, one respondent suggested that it would be very salient to formulate an AI algorithm that helps create working schedules. Yet, while it seems an attractive idea may practical obstacles exist: work phases are very specific, and variability is high depending on the project, the construction site, the workers needed, the operation machines needed, and so on. The question is whether an algorithm could capture such levels of variability and complexity . While all respondents agreeing on this sector's need for AI and AI algorithms, differences were noticeable when it comes to the specifics. More experienced respondents were rather in favour of older ways of running projects. Their view was that AI would be confined to limited tasks such as eliminating redundant tasks. More junior respondents, on the other hand were in favour of larger digitalization and inclusion of AI. However, both groups emphasized that some specific strategic attention needs to precede the introduction of AI and AI algorithms into everyday practice.

Respondents disagreed about *when* AI and AI algorithms will start to be widely used in the AEC sector. A few respondents saw AI to as a longer-term prospect. The main reason, they argue, is resistance to changes. As one respondent explained:

"In the company where I work, we bought a software package that should be of great help for multiple projects we are working on. The investment was very significant, for both the software package and the support in the implementation process. However, eventually it was not used at all, because no one had time to get familiar with the software, and they simply kept doing things the way they have done before, to be able to respect the deadlines." (Respondent 13)

Respondents who saw AI as a shot term prospect also recognized that inertia and habits will delay change. This means that although there are guidelines on how certain projects should develop, people tend to rely on habits acquired in previous projects. The scientific approach in the field is often missing. What is very interesting that even in a same company among different departments there seems to be extreme differences, and different parts of the projects are done in completely different ways.

Education was singled out as the main issue, being even much more relevant than finances and delays needed for the implementation of different AI algorithms. This is especially the case in some basic projects that do not demand a highly skilled workforce. In addition, the challenge with the engineering jobs is that problems then to be solved in ad hoc, atypical ways. The "curve" of physical models is constantly evolving. One aspect from machine learning is how to construct the learning model, and a second aspect is the data side, to follow the real curve as close as possible. As a respondent put it:

"A premise of good control and good data is crucial. For simple structures it is easy to predict, but for the unknown or unknowns we cannot predict" (Respondent 4)

Different fields are included in the AEC projects, which amplify the challenges on how to best implement AI without bringing along a new set of uncertainties by using more dynamic AI algorithms. Therefore, many respondents were in favour of holding a very tight cooperation, good risk and uncertainty communication among engineers who use the AI algorithms and developers who develop them. This appears to be an ongoing challenge within the field when using some simpler software applications. This is amplified due to the specifics of different construction projects. Most respondents raised the need for enhanced risk and uncertainty communication among engineers and developers. Others also suggested to improve risk communication and uncertainty communication among risk analysts and non-engineering positions in the AEC sector.

Simplicity was also mentioned as a must. Introducing AI and algorithms should be done on an easy pace, and as a step-by-step process. Otherwise, the already existing uncertainties may only increase. During projects, there should be a good framework for providing feedback and learning from mistakes early on. The approach should be evidence-based.

A small minority of respondents showed a more sceptical attitude, asking fundamental questions about whether the implementation of AI and AI algorithms in everyday AEC practice is at all necessary. The reasoning behind this is that AI could introduce new uncertainties, leading to new crises. For instance, people may lose their jobs as the learning pace of AI and robots is much faster. This could lead to a loss of institutional memory and skills. Those AI-sceptics also highlighted that the public should be more informed on how these processes work.

5. Discussion

AI and AI algorithms in the AEC sector are generating great expectations as well as significant challenges. The complexities of the AEC sector have slowed developments in this area. Consequently. It remains one of the least digitalized sectors in the world. Respondents throughout all the questions emphasized the significant uncertainties that they already deal with on a regular basis at work. Their responses to the interview questions depict insecurities on how these uncertainties will be dealt with once AI is widely introduced in the field. This suggest that to date AI is unlikely to be of use as a crisis prevention remedy, and that future prospects in this respect are also unclear.

When addressing the understanding of algorithms, most respondents emphasized not seeing them as a unified concept. This aligns with earlier results of a similar study that focused on the application of AI algorithms into precision medicine (Mrksic Kovacevic & Bouder, 2022). However, interestingly enough, most respondents, showed ignorance in employing AI and AI algorithms in their daily work, explaining that the concept of AI appears to be ambiguous. Scholars have reported

similar challenges in different contexts. As White and Lidskog (2022) point out, AI is often used in a very broad manner, making its essence and limits difficult to define. Another relevant example may be found in the European Commission (2021) report on Digitalisation in the construction sector. There, many respondents were not able to provide an answer on the adoption rate of AI in their countries, which they assign to the AI's low visibility in the construction sector. When discussing the use of AI and AI algorithms, the respondents identified design as a phase which could benefit the most with their wider use. According to Baduge et al. (2022) researchers have been successfully using these tools within the architectural design phase. Some respondents also mentioned structural analysis as an example of success. Uncertainty was confirmed as one of the greatest challenges that the AEC sector faces on a daily basis. The respondents recognized the numerous uncertainties that they are facing. They rose a concern that the introduction of AI, especially if inadequately implemented could lead to a new set of uncertainties. An et al. (2021) find that lack of understanding about the inherent uncertainty leading different AI applications to face challenges and limitations in work. Darko et al. (2020) also describe uncertainty as one of the most frequently addressed issues in using AI (Darko et al., 2020). This study's respondents also described the challenging impact of specific rules and atypical situations. In view of previous examples this may lead AI implementation to create new sets of uncertainties, failures, and even lead to crisis. Tengberg and Hagentoft (2019), explain, for instance, using a Swedish construction industry example, that too often the introduction of new technical solutions results in failure, possibly leading to large-scale damages.

Respondents reflected on how to determine whether AI algorithms are good enough to be used in practice. When answering these questions, they typically showed optimism when it came to algorithms' role in aiding to lower the high uncertainties they face within their sector. Here they explained that if AI and AI algorithms are trained on smaller-scale projects, they could be of great aid even as crisis prevention tools, hindering severe failures. However, they also pointed to specific challenges. One is definitely the complexity of providing good training for AI algorithms, as there are almost no two identical projects in the field since each project carries its own set of specificities. Therefore, although they see them as potential remedies for some situations, respondents were concerned about the fact that algorithms could carry a whole new set of uncertainties on board. In such situation, Jiang et al. (2017) suggest the use of sophisticated algorithms to "learn" from big data and then employ the obtained knowledge to offer practical assist. Respondents also highlight the challenge of an appealing interface, which sometimes even in much simpler applications could be misleading. Also, the parameter importance and the challenge of the human factor, may lead to the understanding that the algorithm is not good enough, whereas the error could have been human.

There was wide support for some form of regulation when it comes to the use of AI and AI algorithms in the AEC sector. Respondents even highlighted options such as standardization and possible licenses, but some also mentioned the need for the European Commission to interfere. This wish may be met as the European Commission itself (2021) suggested an EU-level regulatory framework. Yet the main take home message was that regulation will not be a panacea. Existing guidelines, for instance, seem to play a lesser role than direct experience from past projects. Therefore, the importance of having a stronger regulatory requirement appeared as both needed and questioned. Respondents also expressed concerned about transferring too much burden to AI, which could generate many new uncertainties and cause potential crises instead of solving them.

When discussing the future, this study's results show that the introduction of AI and AI algorithms in the AEC field is a matter of time, but it seems that it is not yet imminent. This finding aligns well with observations made in the Digitalisation in the construction sector report (European Commission, 2021). The report concluded that while the EU construction sector is advancing in the uptake of digital technologies, AI still remains in the development stage and cannot yet be considered as market ready. Our respondents highlighted time and costs as highly relevant but did not see them as crucial factors for hindering AI implementation in the field. In their opinion, lack of

education within the field is one of the key elements, which is also consistent with the European Commission (2021) report. There, the cost of equipment and software, the lack of a skilled workforce, and a lack of awareness and understanding of digital technologies are the three main factors hindering the faster and broader digitalisation of the European construction sector. Early on, Slovic (1987a) highlighted the need of education in cases of opposition towards risky technologies. Recent AI literature has confirmed that similar mechanisms are at play in this field. The willingness to use AI depends on the knowledge a person has about the AI. The more knowledgeable are more prone in employing AI (Schwesig et al., 2023). Yet, AI education rest on a science-informed and evidence-based approach. While this approach was described as highly desirable, the remedies to meet this goal are often missing in practice. Additionally, our respondents highlighted the need to enhance the risk and uncertainty communication among developers and engineers working in the field, especially when using AI solutions. Interestingly, in another study that we conducted in the field of precision medicine (Mrksic Kovacevic & Bouder, 2022), risk and uncertainty communication were also highlighted as relevant, but there the role of regulators in it was also emphasized. In the present study, however, the role of regulators was seen as less crucial, and more weight was given to communication among developers and users. Interestingly, many respondents emphasized the need to include risk analysts or risk-educated professionals as an important role in risk and uncertainty communication. We also see multiple calls in the vast risk literature for more and better risk and uncertainty communication despite the complexity of the topic communicated (Löfstedt & Bouder, 2021). Finally, our respondents see the need for a step-by-step implementation process as extremely important, as otherwise we could face much larger uncertainties and even end up in crisis situations.

6. Conclusions

Our study shows the need for wider implementation of AI and AI algorithms in the AEC field. However, this comes with certain challenges. It seems that the use of AI would lead to lowering some known uncertainties, but if not implemented adequately it could bring on board some new ones. One of important challenges as our results implicate is ignorance in using AI and AI algorithms. Finally, AI and AI algorithms could be seen as a crisis prevention tools in certain situations, but again with insisting on AI implementation at any cost, this could backlash and induce new types of crises. A proper strategy for the AEC sector is therefore needed before introducing AI. This strategy should be risk-informed so to mitigate risks and prevent future crises from erupting.

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Resume

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Annex

The interview protocol

1. Are you familiar with the integration of artificial intelligence (AI) in the AEC field?
    a) If yes: Could you provide some specific examples?
    b) Do you currently incorporate AI solutions into your daily practices?
        a. If no: do you have plans to do so in the near future?
    c) Do you consider them to be contributing to failure & crisis prevention?
2. How would you define an AI algorithm in this context? Do you think that there are different interpretations of algorithms in the AEC context?
3. How can we assess whether the implementation of AI, and AI algorithms improves the outcomes of AEC projects? Do you believe they are helping in failure and crises prevention?
4. How should we evaluate whether an algorithm is good enough to be used in practice?
5. The AEC field deals with uncertainties on many levels. In your opinion what will be the effect of algorithm use on uncertainties? And what led you to this opinion?
6. Can you identify specific areas within the AEC field where AI applications could be particularly advanced?
7. Are you aware of any examples of algorithms that have been regulated by a formal regulatory body? If yes, can you provide an example? If no, do you think that they should be regulated and by whom?
8. What is the most important thing that needs to be done to move the use of AI algorithms into everyday AEC? Are we heading this way?

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A comparative impact chain analysis of 1999 Kocaeli and 2023 Kahramanmaraş earthquakes

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Abstract

Resilience in the face of crises is crucial for minimizing the impact of disasters and enabling rapid recovery. This study delves into the interlinked consequences of two seismic events that significantly impacted Türkiye in 1999 and 2023. Using an impact chain analysis, the aim is to provide a thorough understanding of the extensive effects on structures, infrastructure, and socio-economic dynamics. The research also examines the evolution of disaster management practices from the 1999 Kocaeli Earthquake to the more recent seismic events in 2023, highlighting advancements in risk management and resilience. Both seismic events revealed vulnerabilities in the construction of buildings, emphasizing seismic shortcomings that led to widespread damage. Earthquakes exert a profound impact on critical infrastructure, affecting transportation, communication, and energy systems, with cascading effects that extend to the broader socio-economic landscape. The effectiveness of the methodology, particularly, the impact chain analysis, is emphasized as it reveals complex causal relationships. Visual representations support effective communication and collaboration among stakeholders, offering a holistic perspective on systemic risks. In conclusion, this study contributes to understand disaster resilience and provides a foundation for subsequent research, policy formulation, and pragmatic strategies for disaster preparedness and response.

Keywords: cascading effect, disaster, earthquake, impact chain, resilience, systemic risk

1. Introduction

Resilience during a crisis involves the crucial qualities of a system to withstand and recover from adverse conditions. In times of crisis, a resilient structure, capable of enduring disasters while maintaining its functions, not only reduces the risk of severe damage but also plays a crucial role in expediting the restoration of normalcy. Moreover, their ability to facilitate timely recovery lessens the environmental burden, aligning with the sustainable use of resources, as the demand for repair and reconstruction resources is reduced. As this study delves into understanding the root causes of disasters and initiatives promoting resilience in crisis, it becomes evident that these interconnected

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efforts pave the way for a more comprehensive and sustainable approach to manage and mitigate the impacts of events. The evaluation of disasters based on their consequences provides a comprehensive perspective on the direct and indirect impacts, fostering a comparison that serves as valuable lessons for the future.

In recent decades, there has been a notable shift towards understanding the root causes of disasters, with initiatives like the FORIN Project (FORIN 2011; Oliver-Smith et al., 2019). This approach goes beyond merely comparing consequences; it delves into uncovering repetitive cause and consequence relationship in various case studies. Additionally, organizations like Eurac (Pittore, 2023) have pioneered methodologies such as impact chain (IC) analysis to explain the causal relationships of climate change at different levels which are also applicable to other disaster events.

In this study, two devastating earthquakes occurred on 1999 and 2023 in Türkiye, respectively, were examined through IC method. The first event took place on August 17th, 1999, at 03:02 (local time) with a magnitude of M_w 7.4 along the North Anatolian Fault (NAF), with an epicenter located in the vicinity of Gölcük, Kocaeli. Henceforth, it will be referred to as the 1999 Kocaeli Earthquake. The second case involves a series of three consecutive earthquakes with magnitudes of 7.7, 7.6, and 6.4 on February 2023 in Türkiye. The initial earthquake originated in Kahramanmaraş-Pazarcık, followed by subsequent earthquakes in Kahramanmaraş-Elbistan and Hatay-Yayladagi (AFAD, 2023). Thereafter, it will be referred to as the 2023 Kahramanmaraş Earthquakes. The geographical settings of two seismic events are presented in Figure 1. As seen in the figure, 1999 Kocaeli Earthquake occured on the Marmara Region while Kahramanmaraş Earthquakes occurred on Southeast Anatolian Region of Türkiye.

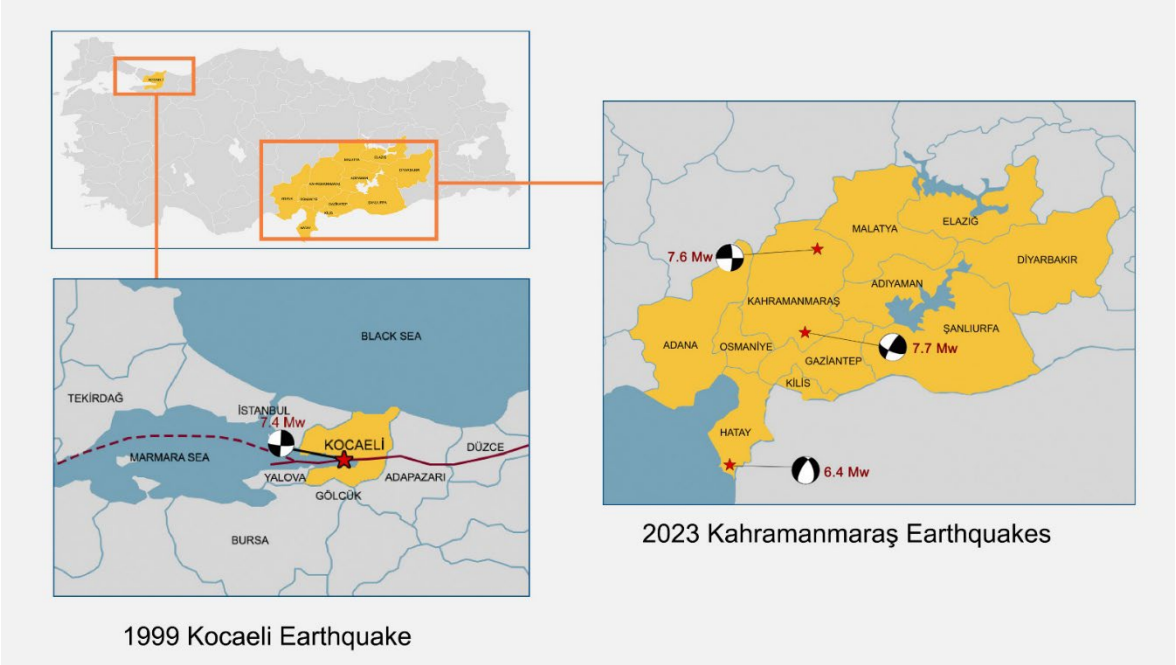

Figure 1 Geographical settings of considered seismic events.

So far, the consequences of earthquakes have been evaluated with some studies focusing on the structural deficiencies exposed during seismic events, while others delve into the social or economic aftermath. However, all this time after 1999 Kocaeli Earthquake, which occurred over 20 years ago, scholarly efforts have predominantly been discipline-specific, neglecting the need for a comprehensive examination, and there has been notably a lack of holistic evaluation integrating all the facets. Therefore, this study aims to bridge this gap by conducting a pioneering evaluation of the interconnected and far-reaching consequences of two devastating earthquakes that occurred in 1999 and 2023. Specifically, a perspective rooted in IC analysis was employed to examine not only the identified interaction types among various components but also to provide a thorough analysis of latent components and their impacts throughout the system. The goal is to offer a

detailed understanding of the broader implications of earthquakes, thereby, contributing to a more comprehensive and informed approach to disaster evaluation.

2. A Review of 1999 Kocaeli and 2023 Kahramanmaraş Earthquakes

The Erzincan earthquake in 1939 and the Kocaeli Earthquake in 1999 were the major devastating disasters to ever strike Türkiye until the earthquakes occurred in February 2023. The lack of organization and coordination, as well as losses, in the 1999 Kocaeli Earthquake led the paradigm shifted from disaster management to risk management. The year 2000 can be considered as a new insight in construction and planning implementations. This is due to the fact that the significant losses suffered during the 1999 Kocaeli Earthquake triggered advancements in construction practices and inspection systems. Chronologically, the Turkish Catastrophe Insurance Pool (TCIP) was settled in 2000. The Building Inspection Law (2001), enacted in 2001 and initially applied in 19 pilot provinces, including the cities of Gaziantep and Hatay which experienced earthquakes in February 2023, was later expanded to encompass the entire country in 2011. The deformed bars and ready-mixed concrete have become widespread due to advancements in manufacturing technologies and the availability of technical guidelines. Subsequent to these developments, revisions were made to Türkiye's primary reinforced concrete design and construction code, known as TS500 (2000). The Disaster and Emergency Management Authority (AFAD) was established in 2009 while Türkiye’s National Disaster Response Plan and the Urban Transformation Law were both settled in 2012 to enhance the capacity in coping with disasters.

Global observations subsequent to earthquakes, combined with numerous experimental and analytical investigations, lead to updating of seismic codes in the country. These updates involve the incorporation of innovative design principles aimed at accurately evaluating seismic hazards, structural response, and overall resilience. The concept of ductility was introduced at both member and structural levels in 1975, followed by the integration of capacity design principles and critical seismic design details in 1998. In 2007, seismic assessment and retrofitting requirements for existing buildings were added to the code (Ilki & Celep, 2012). More recently, the Türkiye Building Earthquake Code was revised in 2018 (TBEC, 2018). Although seismic codes have been improved for the well-being of structural design and construction since the mid-1900s, amnesty laws and regulations have encouraged the unplanned development due to construction of low quality and vulnerable buildings by non-professionals. The Slum Law no. 775 enacted in 1966, aimed to rehabilitate such areas and took measure in prevention of un-planned development in the future. However, slumisation could not be prevented and another amnesty was enacted in 1976. In 1983, slums built until 1981 were legalized. The 1984 amnesty law reduced the implementation difficulties in the previous laws, provided the right to obtain title deeds, and allowed squatters to build up to 4 storeys on their own land (Sönmez, 1996). Within the new millenium, some amendments were made to the articles of related laws as amnesty. Finally, in 2018, a comprehensive amnesty law was enacted (Figure 2).

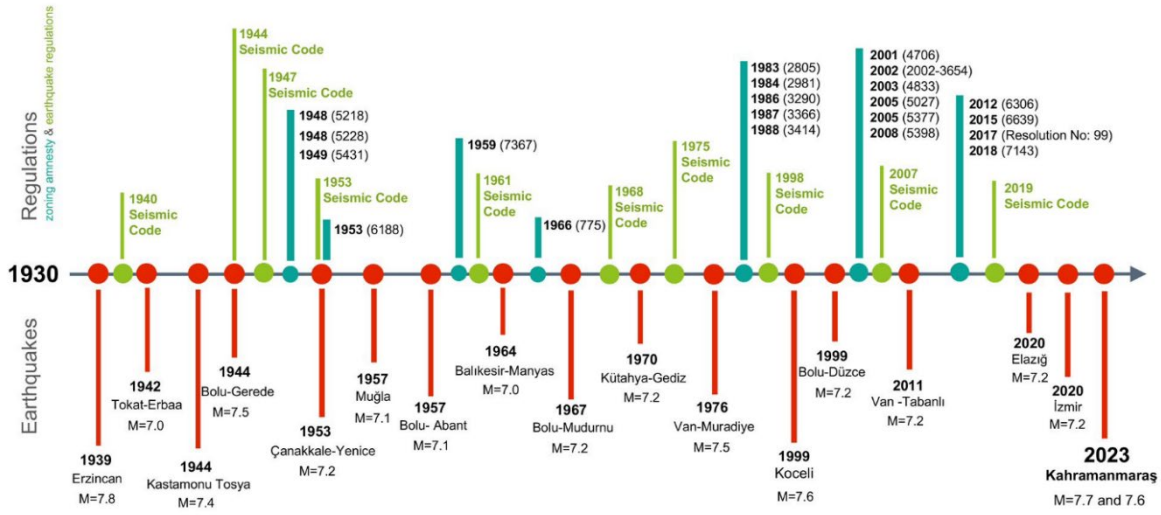

Figure 2 Timeline of earthquakes larger than M_W 7.0 and regulations.

2.1. *Performance of Structures*

At 03:02 a.m. (local time), on August 17, 1999, a M_w 7.4 earthquake occurred on the NAF, which is right-lateral strike-slip fault, in northwestern Türkiye. The hypocenter was located at a depth of 17 km at Kocaeli, 90 km east of Istanbul. Approximately 110 km of the NAF ruptured, with a maximum horizontal offset of 5.5 m and a maximum vertical offset of more than 2.3 m (Sezen et al., 2000). The majority of the destruction resulting from the 1999 Kocaeli Earthquake was centered within a 20 km radius of Gölcük, with significant impact: 18.373 casualties, 48.901 injuries, and approximately 365.000 housing and business units were damaged (TBMM, 2010). The destructive impact resulted in collapses and damage to various structures such as ports, cranes, and pipe systems, exhibiting a spectrum of damage from minor displacements to complete collapses (Altinok, 2001).

On the other hand, seismic activities in February 2023 resulted in a fault rupture spanning over 300 km along the left-lateral East Anatolian Fault. The earthquakes caused a displacement of approximately 3 to 5 meters on the fault. Near the epicenter in Kahramanmaraş-Pazarcık, peak ground acceleration values reached remarkable levels, as high as 2g (AFAD, 2023). These seismic events impacted 11 provinces in Türkiye, namely Kahramanmaraş, Adıyaman, Hatay, Osmaniye, Gaziantep, Kilis, Şanlıurfa, Diyarbakır, Malatya, Adana, and Elazığ, and affected over 14 million people. The devastation caused extensive collapses and damage to various structures, including buildings, bridges, airports, tunnels, hydraulic facilities, lifelines, and network systems. Over 90,000 reinforced concrete structures sustained severe damage, resulting in more than 50,000 casualties (MoEUCC, 2023; SBO, 2023). The region exhibited extensive damage across numerous structures, as illustrated in Figure 3.

Figure 3 A view from the earthquake-hit area, Hatay, Türkiye.

Reconnaissance studies conducted in the affected regions (either in Kocaeli or around Kahramanmaraş) have consistently identified that the inadequate seismic performance of numerous structures primarily stems from their failure to comply with seismic design codes (Sezen et al., 2000; Scawthorn, 2000; Binici et al., 2023; Avcil et al., 2023). Key vulnerabilities include soft-storey buildings, irregular structures, insufficient reinforcement detailing, corrosion of reinforcement, insufficient splice lengths, unconfined lap splices and poor material quality. In numerous structures, strong beams paired with weak columns. In several instances, poorly designed infill walls restricted column height, leading to shear failures, known as short column. Transverse reinforcement was widely spaced with 90-degree hooks, lacking cross ties, thus failing to maintain sufficient ductility. Ground failures, such as liquefaction-induced soil movements and differential settlements, were widespread in certain areas. Similar damage patterns were observed in previous seismic events as well (Celep et al., 2011; Tapan et al., 2013; Gürbüz et al., 2023).

Beyond the extensive damages to buildings, the 2023 Kahramanmaraş Earthquakes had a significant impact on critical infrastructure systems, including bridges, viaducts, tunnels, railways, roadways, airports, and energy infrastructure, such as coal and gas power plants, electrical distribution and transmission networks, liquified petroleum gas terminals, as well as water and wastewater systems (EERI, 2023). It is essential to highlight that these lifelines, comprising vital facilities and structures, play a pivotal role in meeting the fundamental needs of communities as experienced in 1999 Kocaeli Earthquake. Furthermore, breakdowns in communication systems, including base stations (Figure 4a), were notable. These complex challenges posed significant obstacles to recovery and response efforts in the aftermath of the earthquakes.

After earthquakes, a critical challenge that frequently emerges is the occurrence of fires (Figure 4b). Seismic activity has the potential to disrupt gas and electrical systems, leading to leakages and short circuits, consequently sparking fires in vulnerable areas. Moreover, the collapse of buildings and infrastructure can impede firefighting efforts, intensifying the difficulty of extinguishing the fires. In the aftermath of earthquakes, the seismic performance of buildings may deteriorate due to both the structural damage from the initial earthquake and subsequent fires, amplifying the risks and challenges faced in these situations (Demir et al., 2020a; 2020b; 2022).

Figure 4a Damaged base station due to collapse of the building (photo from Kahramanmaraş).

Figure 4b Fire following earthquake (photo from Nurdağı, Gaziantep).

2.2. *Economic Outline of the 1999 Kocaeli and 2023 Kahramanmaraş Earthquakes*

The economic effects of earthquakes can be estimated through various approaches. The World Bank (1999) identifies three key aspects: direct costs (physical damage to assets), indirect costs (output losses, lost earnings, and emergency relief expenses), and secondary effects (short to medium-term consequences on overall economic performance, fiscal accounts, balance of payments, poverty rates, and government policies). Kundak (2010) offers a different perspective, categorizing economic losses as stock costs from immediate losses (e.g., building collapse), stock and flow costs from business activity losses or from infrastructure damage.

The affected region by the 1999 Kocaeli Earthquake hosts Türkiye's heavy industry, including petrochemicals, car manufacturing, paper, chemicals and cement (Durukal & Erdik, 2008). The General Directorate of Disaster Affairs of Türkiye calculated overall economic damage amounted to roughly 10 billion USD, equivalent to approximately 4% of the Gross Domestic Product (GDP) in 1999. On the other hand, Durukal and Erdik (2008) estimated the total cost around 16 billion USD, which accounts for 7% of the GDP in 1999. In the damage report published by the Turkish Earthquake Foundation, direct losses were estimated to be over 5 billion USD (Özmen, 2000). Therefore, the expected indirect losses were either equal or greater than the direct losses due to 1999 Kocaeli Earthquake.

The economic context of the 2023 Kahramanmaraş Earthquakes is notable. The affected region, comprising 11 provinces, accounted for 9.8% of GDP in 2021, contributing approximately 79 billion USD to the national income. However, the per capita national income in these provinces falls below the national average, with an average per capita GDP of 5.924 USD in 2021. Despite this, the region played a significant role in national economic growth, contributing 0.98 points to the 11.4% growth recorded in 2021. In terms of exports, the region held an 8.6% share in 2022, with Gaziantep standing out with a 4.4% share. The 11 provinces collectively represented 6.7% of the 2022 imports, with Gaziantep and Hatay leading with shares of 2.3% and 2.1%, respectively.

Various organizations and public offices have presented divergent economic impact assessments following the 2023 Kahramanmaraş Earthquakes. TURKONFED (2023) suggests an economic cost of 84 billion USD, equivalent to 10.3% of the 2021 GDP. Strategy and Budget Office of Presidency of Türkiye (2023) emphasizes housing damage as the primary economic burden, accounting for 54.9% (1,073.9 billion TRY; 56.9 billion USD), followed by public infrastructure and service buildings at 12.9 billion USD. Private sector damage, excluding housing, was estimated at 11.8 billion USD, covering various industries and sectors. Taking into account insurance sector losses, tradespersons' revenue losses, and macroeconomic impacts, the total financial burden was estimated at 2 trillion TRY (103.6 billion USD), equal to 9% of the 2023 GDP forecast. According to BETAM (2023), the total financial burden ranges from 77.4 to 104.8 billion USD, representing 8.6% to 11.6% of the GDP forecast for 2023.

In the year preceding the earthquake, the 11 provinces collectively exported 11.1 billion USD between February and July 2022. However, after the earthquakes in 2023, total exports during the same months declined to 8.9 billion USD, marking a 20% decrease. Gaziantep, the leading exporter in the region, witnessed a decline of nearly 0.5 billion USD but displayed signs of recovery. In contrast, Hatay and Kahramanmaraş did not show similar signs of improvement. According to the TEPAV Employment Watch May 2023 Bulletin (TEPAV, 2023), the employment declined in the 11 provinces amounted to 374.5 thousand jobs, equivalent to around 1% of total employment, in the first five months of 2023. This decline varied across provinces, reaching 30% in Malatya, Kahramanmaraş, and Hatay due to life losses and migration. Elazığ, Kilis, Gaziantep, and Şanlıurfa experienced a 10% decline, while other affected provinces like Kilis, Adana, Diyarbakır, and Osmaniye saw a 5% decrease in employment (Figure 5).

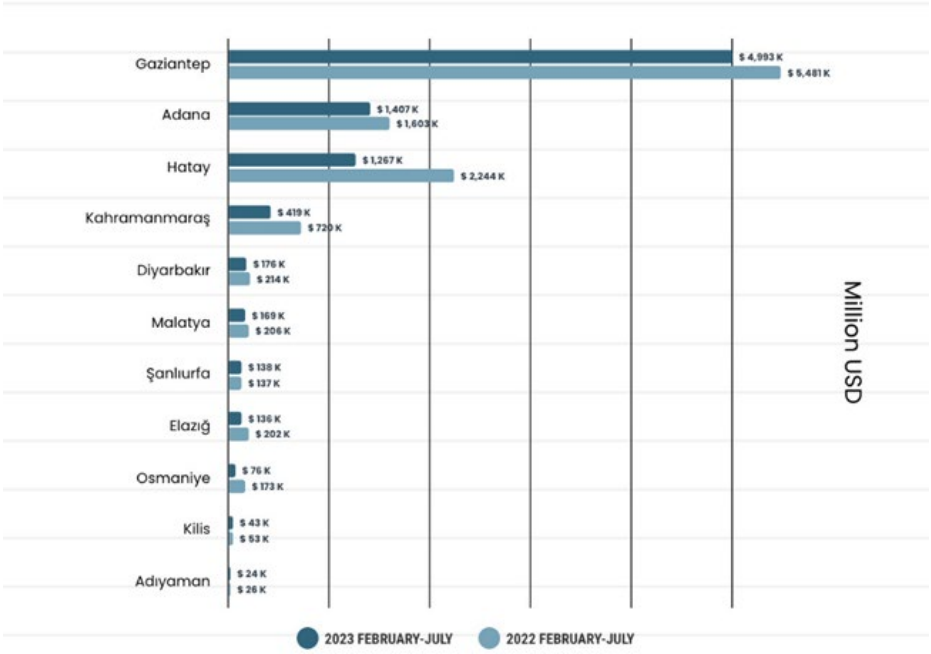

Figure 5 Provincial exports before and after the 2023 Kahramanmaraş Earthquakes (Turkstat, 2023).

3. Methodology: Impact Chain and Forensic Analysis

The components of risk and their interactions present complex systems which are able to cause chaotic situations once facing severe hazards. Consequently, delineation of these components within their specific features, particularly for risk assessment, provides a wider perspective to better understand the causal relationship among them which can either amplify or mitigate the adverse impacts of hazards. Hereby, the forensic investigation of disasters project (FORIN 2011; Oliver-Smith et al. 2019) launched an innovative perspective on risk assessment. For instance, organizations such as Forensic Architecture aim to identify the social, economic, political, environmental, and cultural factors that influence the root causes of events by using spatial techniques and technologies (Weizman et al., 2010). Similarly, the Forensic Investigations of Disasters (FORIN 2011; Oliver-Smith et al., 2019) project embraces a comprehensive causal typology that recognizes the intricate interplay of human agency and natural processes in disaster risk.

Impact Chain is a collaborative framework developed by Eurac Research in partnership with various stakeholders, originally designed for climate risk assessments in the European Alps and later applied to Germany's national climate risk and vulnerability study (Pittore et al., 2023). This framework presents intricate cause-and-effect relationships behind specific climate risks within a defined context. It categorizes factors and processes into hazard, vulnerability, or exposure components, emphasizing participatory development that integrates local data, knowledge, and past experiences. They are graphical models that depict the causal relationships between climate hazards, exposure, vulnerability, and risk outcomes in a specific context (e.g., region, sector, system) (PARATUS Project, 2023). The visual representations of complex climate interactions enable effective communication and collaboration among stakeholders, ensuring a holistic understanding of climate change impacts and risks (Zebisch et al., 2022). They evolve from current climate risk scenarios to embrace future projections, considering shifts in climate, exposure (e.g., urbanization), and vulnerabilities (e.g., an aging population).

Although initially employed to delineate complex systems on the focus of climate change, the IC method extends its applicability to synthesize the causal relationships based on different hazards and their potential impacts. Likewise to its utilization in climate change studies, the IC method applied to hazard and risk evaluation yields outcomes from a collaborative and participatory process, engaging both experts and stakeholders. This collaborative effort forms the foundation for

a robust risk assessment, aligning with the fundamental components of risks, namely hazard, exposure, and vulnerability. These assessments illustrate how different hazards can trigger cascading impacts across diverse exposed subsystems (United Nations Office for Disaster Risk Reduction, 2019). Moreover, the IC method provides a comprehensive perspective on how risks spread through systems, contributing to an enhanced comprehension of systemic risks. Impact chains also help to discuss potential risk reduction measures in the early stages of the risk assessment process by highlighting vulnerabilities, identifying adaptation gaps and explaining risk mechanisms. Thus, the IC method emerges as a valuable tool not only in climate change studies but also in broader hazard and risk evaluation scenarios.

4. Discussion

In this section, based on the background presented previously, the 1999 Kocaeli and Kahramanmaraş Earthquakes are reviewed through the perspective of IC approach. To deploy the IC analysis on these events, a comprehensive dataset encompassing losses, detailed information about damaged structures (buildings, infrastructure, etc.), scientific findings, and operational reports were thoroughly collected. To conduct IC analysis effectively, a software platform is required to facilitate efficient visualization, along with a database capable of managing structured data updates. Among several available options, the KUMU and MIRO software tools have been employed for IC analysis due to their user-friendly interfaces, offering advantages in data representation (Kumu 2011; Miro, 2011). They facilitate ease of comprehension while accurately capturing the complexity inherent in the system. The IC analysis of 1999 Kocaeli and 2023 Kahramanmaraş Earthquakes are presented in Figures 6 and 7, respectively.

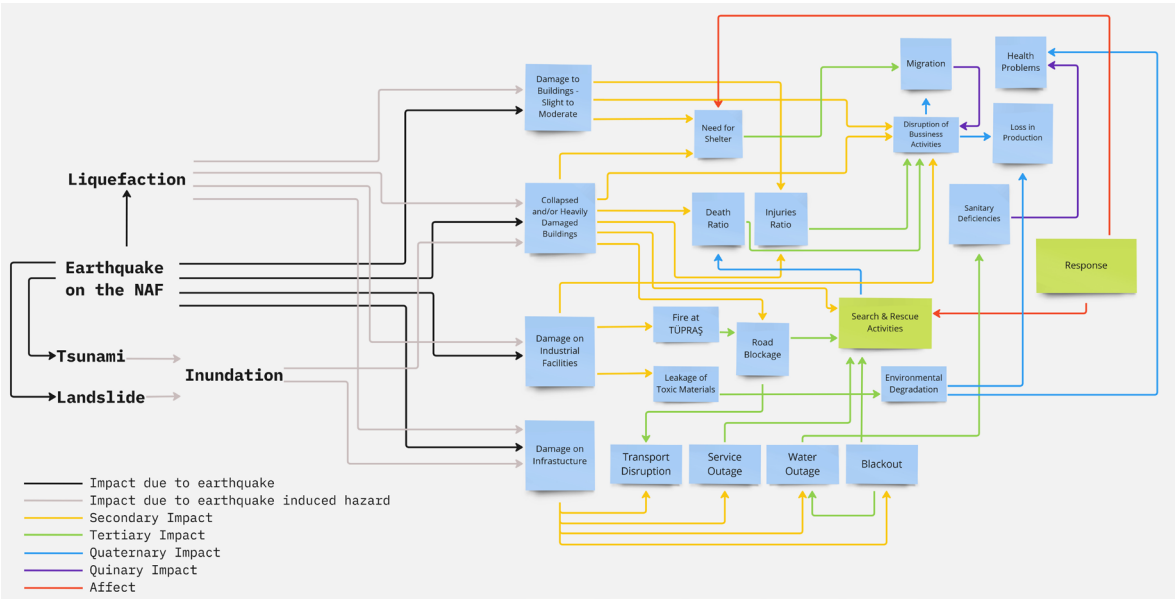

Figure 6 Visualization of impact chain for 1999 Kocaeli Earthquake.

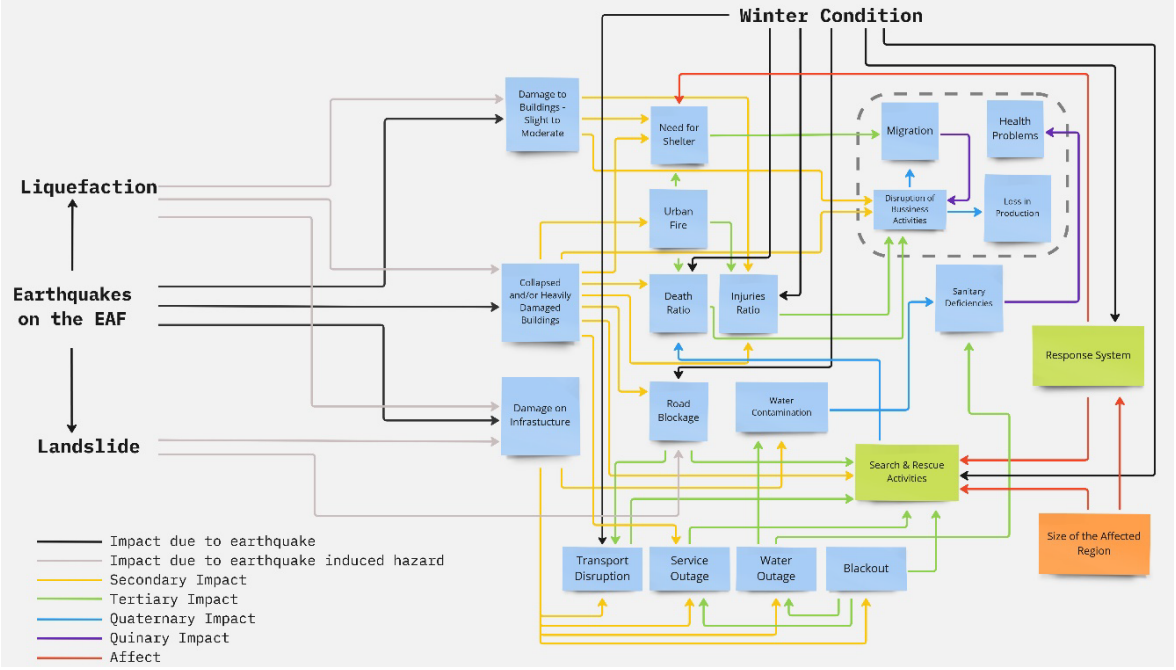

Figure 7 Visualization of impact chain for 2023 Kahramanmaraş Earthquakes.

The diagrams produced to illustrate the IC process of both earthquakes outline the sequence of each impact on the response system. Black arrows depict the immediate and direct effects of earthquakes, while gray arrows define the impacts resulting from earthquake-induced hazards. Orange arrows represent secondary impacts stemming from physical failures in the urban system. Likewise, green, blue and purple arrows show consecutive impacts. Red arrows are associated with the response process, signifying an "affect" on specific situations and notions. Thereby, green boxes refer to interventions to ease the adverse consequences of these calamities.

It's important to highlight that the temporal characteristics of both earthquakes were comparable, with the 1999 Kocaeli Earthquake occurring at 03:02 (local time) and the first earthquake taking place at 04:17 (local time) for 2023 Kahramanmaraş Earthquakes. When assessing the magnitude of these earthquakes, both are classified as devastating, falling into the category of seismic activity with a M_w exceeding 7.0. However, the challenging situation during the 2023 Kahramanmaraş Earthquakes was further exacerbated by adverse winter conditions.

When comparing the earthquake-induced hazards in both cases, it is observed that liquefaction caused settlement in the field land zone and water saturated area. On the other hand, inundation occurred after the 1999 Kocaeli Earthquake due to a local landslide through the Izmit Bay and tsunami triggered by the earthquake (Altinok, 2001). Whereas aftermath of 2023 Kahramanmaraş Earthquakes, landslides were observed mostly at mountainous areas where the roads were either physically damaged or blocked by rockfall.

As aforementioned, due to the persistency of the repetitive inadequate implementation practices in structural systems of buildings, both earthquakes led to total collapse on significant number of buildings, causing an increase in casualties. Furthermore, the increased ratio of uninhabitable residential buildings was led to a notable demand for immediate temporary and then permanent shelters.

In both instances, significant disruptions to infrastructural facilities were evident albeit with some nuances. The damage on transportation system can be examined based on physical and functional failures. Physical failures result from the deformation of transportation modes and blockages due to various reasons. Functional failures pertain to the overburdening of transportation infrastructure due to high demand, also known as traffic. Since the viaducts and tunnels of the main highway (known as TEM) were not completed in 1999, the direct highway connection between Istanbul and Ankara was only provided by the Bolu Mountain pass (known as

D100). During the 1999 Kocaeli Earthquake, two expressways traveling from Istanbul to Ankara remained undamaged; however, some connections, such as bridges, collapsed, impeding traffic flow in the transit circulation. For instance, at the Sakarya crossing of the TEM highway, a part of the road was out of use due to ground subsidence and bridge collapses. Within the inner city, collapsed buildings obstructed the passage of emergency vehicles and private cars. Additionally, a large fire at the TÜPRAŞ Oil Refinery hindered traffic flow in the surrounding area. Furthermore, heavy and accelerated traffic from/to the affected area caused congestions, as observed during the 2023 Kahramanmaraş Earthquakes as well. The performance of the transportation system aftermath of the 2023 Kahramanmaraş Earthquakes can be considered deficient due to large cracks and subsidence on transit roads, blockages from collapsed buildings, and large rocks resulting from local landslides. Moreover, heavy snow made accessibility more difficult in several areas. In certain zones, rails were bent in an 'S' shape, a phenomenon also observed as a consequence of the 1999 Kocaeli Earthquake. Regarding the performance of transportation modes, damages to maritime transport following the 1999 Kocaeli Earthquake and air transport after 2023 Kahramanmaraş Earthquakes were highlighted. In the case of the 1999 Kocaeli Earthquake, the epicenter was located at Gölcük in the İzmit Bay, where several ports and docks were situated for logistics and passenger transportation. However, either due to liquefaction in the area or a lack of anchorage at the docks, sea transportation infrastructure sustained notable damages, making them unusable for evacuation and the delivery of necessary goods. Likewise, 2023 Kahramanmaraş Earthquakes caused lateral crack on runway at the Hatay Airport. Given that Hatay was the most severely impacted region among the provinces affected by the 2023 Kahramanmaraş Earthquakes, the destruction of the airport hindered immediate response efforts.

The failures and malfunctions of other infrastructural facilities, including water, sewerage, electricity, natural gas, and communication systems, had cascading impacts primarily on search and rescue activities and the living conditions of earthquake survivors. The breakage of pipe systems in both earthquakes resulted in interference with water and sewerage systems, leading to sanitary problems for earthquake survivors and response and recovery teams. A notable difference in the IC of infrastructural deficiencies when comparing the 1999 and 2023 earthquakes is evident in the realm of communication. In 1999, mobile phone coverage and usage in Türkiye were limited. According to TÜBITAK-BILGEM (2001), the number of mobile phone users was around 8 million, constituting approximately 12% of the country's population. In contrast, landline analogue phones were still prevalent for communication. Therefore, despite widespread destruction during the 1999 Kocaeli Earthquake, analogue lines worked properly and remained unaffected by the blackout. From the 1999 through 2023, while landline analogue phone subscriptions decreased from 33% to 13% according to the population, mobile subscriptions increased from 12% to 105% (BTK, 2023). Consequently, communication system has become more dependent on the functioning of mobile infrastructure system. During 2023 Kahramanmaraş Earthquakes, base stations which had been installed on the tops of buildings suffered damage due to the collapse of these structures (Figure 4a). Furthermore, prolonged power outages led to the depletion of mobile phone batteries and the incapacitation of standing base stations, hindering communication. Recognizing the widespread use of mobile communication, it's clear that it has made sharing information easier, even in challenging situations, such as identifying the location of victims under debris, when it's functioning properly. However, it's important to note that along with its benefits, it also facilitates the dissemination of misinformation and the spread of provocative news.

When natural hazards strike large settlements, it is nearly inevitable that they trigger technological accidents, commonly referred to as NaTech (natural hazards triggering technological accidents). Such incidents occurred in both earthquakes. During the 1999 Kocaeli Earthquake, which took place near Türkiye's most industrialized region, several industrial facilities sustained damage, leading to environmental degradation due to the leakage of toxic materials. It should be noted that the most immediate consequences of earthquakes can be described but it is always challenging to comprehend the latent impacts. For instance, details concerning environmental degradation following the 1999 Kocaeli Earthquake and its subsequent effects on public health only

became apparent three to five years after the seismic event (Dündar & Altundağ, 2002; Dündar & Pala, 2003; Cruz et al., 2004; Steinberg & Cruz, 2004). As a long-term consequence, it has been observed that the health of individuals exposed to toxic substances was adversely affected (Girgin, 2011). Furthermore, the most notable accident was the fire at the Tüpraş Oil Refinery. Similarly, in the 2023 Kahramanmaraş Earthquakes, urban fires were observed in some parts of inner cities. Additionally, a fire broke out at the Iskenderun Port in the dock zone, highlighting the multifaceted challenges associated with technological accidents triggered by seismic events.

Prior to the 2023 Kahramanmaraş Earthquakes, the 1939 Erzincan Earthquake held the highest fatality toll, with the 1999 Kocaeli Earthquake ranking the second. The substantial increase in casualties during the 2023 Kahramanmaraş Earthquakes can be attributed not only to the magnitude of the earthquakes but also to the vulnerability of the building stock. Additionally, harsh winter conditions and shortcomings in search and rescue operations contributed to the increase in life losses. Unlike the 1999 Kocaeli Earthquake, which occurred in August, allowing disaster victims to meet their sheltering needs in open areas and tents, the 2023 Kahramanmaraş Earthquakes in February presented challenges. The tents dispatched to the region provided limited protection, and the construction of temporary shelters took a considerable amount of time. Nevertheless, in both earthquakes, temporary migrations occurred as the demand for shelter could not be fully met. Furthermore, since many sectors were damaged, disrupting trade, disaster victims migrated due to difficulties in meeting their daily needs. As a consequence of migration, even businesses that survived the earthquake without damage suffered, they struggled to find both employees and customers.

When comparing the response systems of both earthquakes, it is worthy to note that, during the 1999 Kocaeli Earthquake period, disaster and risk management practices were not well established, briefly, a formalized response “system” was absent. Furthermore, there was no comprehensive management system in place to be implemented after such a significant disaster. Therefore, voluntary efforts played a crucial role in search and rescue activities following the 1999 Kocaeli Earthquake. However, from 1999 to 2023, several new adjustments have been made in the disaster response system, including the Disaster Response Plan of Türkiye established by AFAD (2013). During the 2023 Kahramanmaraş Earthquakes, the primary reasons for deficiencies in the implementation of the response plan were the size of the earthquake-hit region (11 provinces) and severe winter conditions. Moreover, inadequate personnel and equipment, along with a lack of organization, posed additional challenges in field operations. In addition to bottlenecks in search and rescue activities, there were logistic problems in providing shelter for the disaster victims after the earthquake.

5. Conclusion

Resilience in a crisis involves anticipating, mitigating, and preparing for probable risks, ensuring systems (hereby urban systems) maintain their integrity and functionality. Therefore, evaluating disasters based on consequences offers valuable lessons for the future by providing a comprehensive perspective on direct and indirect impacts. Hence, this study highlights the importance of causal relationship of cascading effects of disasters through a holistic approach. The comparative analysis of the 1999 Kocaeli and 2023 Kahramanmaraş Earthquakes reveals the evolution in Türkiye's risk mitigation strategies.

Notably, the 1999 Kocaeli Earthquake prompted significant changes in construction practices, legislation, and the establishment of disaster response mechanisms, expected to improve resilience. On the other hand, both earthquakes revealed seismic deficiencies of the buildings leading to extensive damage. The impact on critical infrastructure, including transportation, communication, and energy systems, highlights the cascading effects of earthquakes on communities. Lessons from the breakdowns in communication systems post-2023 Kahramanmaraş Earthquakes emphasize the growing dependence on mobile infrastructure and the need for resilient communication strategies. The overview of economic losses, export declines, and

employment shifts provides valuable insights for future risk mitigation and recovery planning. The employed IC methodology reveals the complex causal relationships between hazards, exposure, vulnerability, and risk outcomes. The visual representations aid in communication and collaboration among stakeholders, offering a comprehensive perspective on systemic risks.

In conclusion, this study contributes to the broader understanding of disaster resilience by offering insights into the interconnected consequences of earthquakes. The findings provide a foundation for future research, policy development, and practical strategies to enhance disaster preparedness and response, ultimately fostering a more resilient society in the face of events.

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Resume

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Ali Yilmaz, a Ph.D. Candidate at Istanbul Technical University, is a proficient urban and regional planner specializing in urban design and spatial data analysis. His academic background includes a Master's in Urban Design (2022) and a Bachelor's in Urban and Regional Planning (2018). With a blend of academic and practical experiences in urban planning, including serving as research assistant in ITU, Ali exhibits an understanding of urban development dynamics.

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Reinterpreting "Sustainability" and "Resilience" in the post-pandemic urban planning paradigm

Zeynep Deniz Yaman Galantini*

Abstract

In the past three years, there has been no crisis more "unexpected" than the COVID-19 epidemic, which was deemed as pandemic by WHO on March 11, 2020. Indeed, urban planning must play a significant role in resolving the pandemic dilemma. So, given that pandemics are natural disasters and environmental factors are their primary cause, how is it possible we are still experiencing this outbreak even though "resilience" and "sustainability" principles are ingrained in urban planning paradigms? Accordingly, it is essential to grasp how to incorporate "sustainability" and "resilience" ideas into urban planning processes and to develop the institutional capability to manage and monitor these procedures. Therefore, the purpose of the study is to clarify how sustainability and resilience principles might help to define the essential elements of the "post-pandemic" urban planning paradigm through conceptual analysis and a thorough assessment as the methodology. The first section discusses the necessity of the two most relevant concepts of urban planning paradigms; "sustainability" and "resilience" to tackle with pandemics, followed by the discussion of the "pandemic city" and "post-pandemic city" concepts. Finally, the last chapter explores how the attributes of resilience and sustainability can contribute to "post-pandemic urban planning" paradigm.

Keywords: Resilience, sustainability, pandemic city, post-pandemic city, post-pandemic urban planning

1. Introduction

One of the most "unexpected" crises of the 21st century, the COVID-19 outbreak on March 11, 2020, was recognized as a pandemic by the World Health Organization. As Ali et al. (2022) stated, urban and planning thinkers and practitioners were reminded of the baggage that planning carried when it came to the history of infectious disease in cities when the global pandemic was declared, and the shifting rhythms and constrained spatial patterns of urban life became empirical and chiefly experimental almost overnight. Since the emergence of what Gandy (2006), as cited by Ali et al. (2022), called the bacteriological city at the beginning of the 20th century, planning theory and practice have likely been preoccupied with the health of urban living. After all, starting in the 19th century, the initial attempts to bring order to architectural and social settings through zoning, parks, slum removal, and other measures were made to clean up the excesses of the industrial metropolis. However, especially when health crises were urban phenomena, as it was during the 2003 global SARS epidemic, academics and professionals looked closely at urban planning to assess the specific intersections of planning practice with disease outbreaks and interventions (Ali et al., 2022).

Surely, it is challenging to get to an agreement on how urban planning techniques can manage the COVID-19 pandemic. To accomplish it with the least amount of harm, it should be managed in all of its dimensions. At this time, one of the key axes of the struggle process should be developing

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the most "resilient" urban systems and addressing the social and urban requirements coming from this unanticipated pandemic in the most sustainable manner possible. As Yaman-Galantini (2021) emphasized, today it is understood that unexpected changes are especially related to environmental problems, that is to say, because of ignoring the environmental dimension in urban development decisions. Unexpected problems such as climate change are created because of this ignorance. Given the uncertainty and complexity that come along with modern urban processes, a static planning approach is currently even less effective to address the negative consequences of the pandemic. Therefore, more complicated methods to urban planning are now required in circumstances where the future appears to be increasingly unclear due to unanticipated developments, not only to minimize global hazards, including pandemics, but also to manage the changes brought about by risks (Figure 1). This means that goals and tactics of urban planning paradigms must alter since we are in an extraordinary period of global interconnectedness and transition.

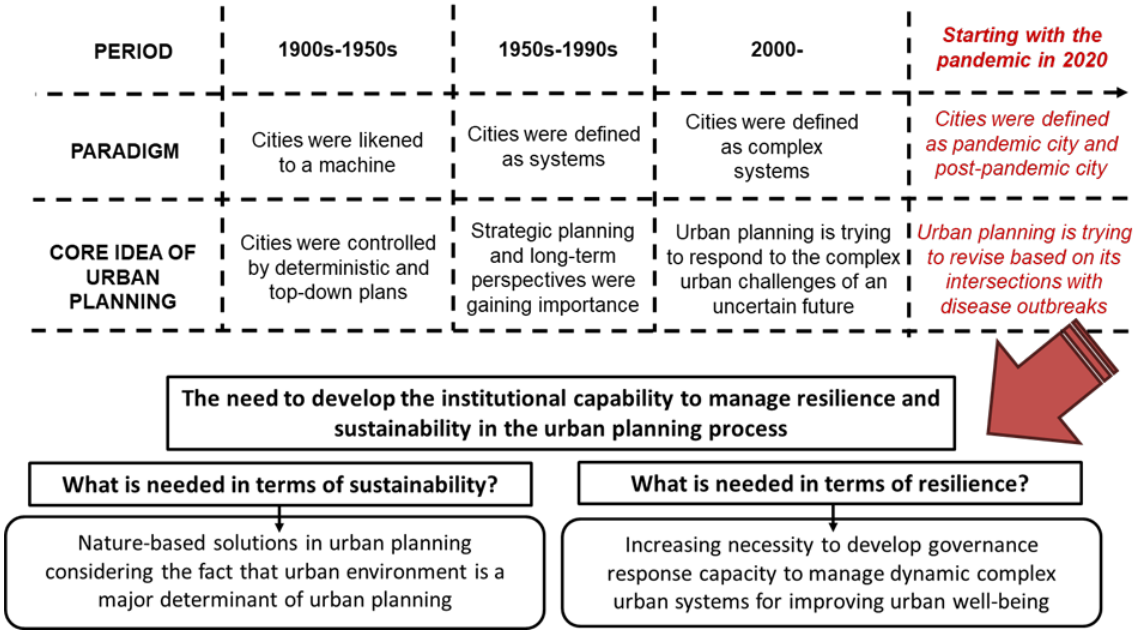

Figure 1 Transformation in Urban Planning Paradigms with the COVID-19 Pandemic (Developed from Yaman-Galantini (2019))

Since its first discussions in 1970s, sustainability-based planning paradigms have been searching for the "ideal city" and meanwhile in the 2000s, there has been an evolution of new ideas in the definitions of urban sustainability (Yaman-Galantini, 2021). The underlying principle is the necessity of cities to be in a harmony with nature. As Newton and Bai (2008) also argue that, since resources become more limited for development in the 21st century in important areas like water, oil and gas, food, and some building/manufacturing materials, the pursuit of transition toward sustainability gets dominant in sustainability science, which studies interactions among complex systems.

In this context, significant issues are raised: How can we develop governance response capacity to successfully manage the challenges of this complexity? Are natural disasters genuinely unexpected if humanity attempts to dominate nature? As a result, developing readiness for the unexpected assumes basic relevance in resilience-based urban planning. The concepts of sustainability and resilience take on essential significance in modern urban planning due to this setting. To counteract the pandemics, it is vital to identify how these notions might be promoted based on their characteristics.

The next part focuses on the basic characteristics of the pandemic city and the post-pandemic city. Following the brief discussion of the literature's inclusion of those notions, the subject of how

sustainability and resilience attributes should be determined in urban planning within these concepts' framework will be addressed.

2. Pandemic City and Post-Pandemic City

According to Ali et al. (2022), it wasn't difficult to predict the importance of cities as the source of a potential pandemic before 2020, considering the particular significance of changing urban political ecologies and pathologies of demographic, infrastructural, and governance change. Cities, in particular, become the actual hubs of societal change. The increasing tendency to work from home and the closing of restaurants and other entertainment venues pushed for a re-evaluation of daily life, with a shift in emphasis on housing, children, the elderly, and the neighborhood (Ali et al., 2022).

With the increase in the transmission rate of the COVID-19 pandemic and the start of the quarantine around the world, the relationship between pandemic and space has started to be widely discussed. The definition of space has changed, and there have been many disputes about what people expect from space. Various studies have been carried out on this change in space and on which prominent concepts urban planning should be developed in the pandemic city.

For instance, Jasiński (2022) addressed the characteristics of the pandemic city as density and space, mobility, and public transportation and public versus virtual space. According to him, curfews, and social isolation requirements were among the public health measures implemented by the government during the COVID-19 pandemic, restricting both mobility and civil liberties. However, travel restrictions, industry closures, and a decrease in public transportation emissions caused by the pandemic improved the air quality in cities all around the world. People started to commute by walking, bicycling, or driving their own cars, changing their daily routines. Cities have started implementing sustainable transportation options, such as restricting car access and enlarging bicycle and pedestrian lanes, to improve their urban environments. With public health guidance including social distance, more outdoor space, and safer streets principles, the crisis may mark the beginning of responsible, environmentally friendly urban transportation (Jasiński, 2022). Similarly, Martinez and Short (2021) explains that COVID-19 has resulted in a drop in traffic and a move away from car-dependent communities. As a result, urban public spaces were reimagined, with certain streets turning into pedestrian-only zones. City officials are encouraging walking and bicycling while decreasing traffic and using public transportation. Public transportation has also been impacted by the pandemic, with demand drastically falling as a result of work-from-home policies. Passengers are less likely to use public transportation due to the health advice and an increase in time spent in close proximity to other people (Martinez & Short, 2021).

However, some urbanist dogmas were called into question by the COVID-19 pandemic. Jane Jacobs, one of the leading figures of the modern urban movement, praised the advantages of vibrant street life and high building density, but also noted that dense population concentration was a prerequisite for the development of urban diversity. Large private spaces are now a luxury only for the privileged. There is a decline in public spaces and social activities (Jasiński, 2022). Martinez and Short (2021) also analyzed that urban public places, which are essential for fostering intimacy on a social and psychological level, have been forced to closure because of the pandemic.

In all civilizations, there is an important interaction between the characteristics of urban environments and the behavior of urbanite. People with high incomes are protected from other potential sources of infection by their private gardens, roof terraces, etc. While families living in apartment blocks could only see outside world through windows or at most from their balconies, wealthy people with their own private houses, and gardens did not have to experience the harsh and claustrophobic effects of repeated restrictions. A quarter of the world's urban population, living in low-quality housing, often without access to clean drinking water and basic amenities, faced the most severe impacts of the pandemic (Jasiński, 2022).

Moreover, Jasiński (2022) points out that the role of information technology in pandemic has increased as digital space becomes a platform for sharing information and enabling human interactions. The pandemic has provided momentum for smart city development, telemedicine, online commerce, and education, as well as surveillance systems. It offered an opportunity to develop resilient city planning and efficient disaster risk management. However, it also presented an opportunity to strengthen electronic surveillance and control over population.

Besides the spatial challenges cities face with the pandemic, in their work “Everyday urbanisms in the pandemic city: a feminist comparative study of the gendered experiences of COVID-19 in Southern cities” Razavi et al. (2022) detected that with the COVID-19 pandemic, changes in spatial-temporal ordering have exacerbated racial and gendered exclusions, as seen in women's daily life. In addition, a lack of mobility as well as the various features of production and social reproduction have increased the amount of aggression, and stress on mental health. On the other hand, throughout the pandemic, social reproduction solidarities that support both the old and new care circuits have become stronger (Razavi et al., 2022).

Last but not least, Sokol (2021) conducted a study on the effects of the pandemic on cities through a scenario in which the coronavirus does not lose its effect and the pandemic does not end. In this kind of scenario, coronavirus will continue to have a serious health concern in the pandemic city. Further economic and financial harm will result from the ongoing health crisis, with serious joblessness, homelessness, and housing markets. However, not everyone in society will experience the economic and financial suffering equally. There is reason to think that some societal segments will be affected more severely than others, which will lead to an increase in social polarization. Spatial and social polarization will coexist in these cities, both inside and between them. Simply, some cities and regions within cities will perform far better than others. Uneven social and economic consequences will further polarize politics. The political landscape will become more disjointed and unpredictable, with extremist movements becoming more mainstream. For example, it will be impossible to reach the crucial consensus on how to address the climate disaster in the face of such political polarization. The environmental problems will worsen as a result. It is not doubtful that law and order will collapse in the face of escalating environmental disasters which will be exacerbated by the economic, financial, social, and political crisis. It will also become harder to implement any public health precautions to stop the virus from spreading as law and order in cities crumbles. The pandemic will only spread faster as a result, and the crisis's many facets will only get worse. There will surely be attempts to put technology solutions into place when faced with such a vital circumstance. These solutions, though, will simply exacerbate polarization in urban areas. Some people may benefit from an expanding array of innovative online services and technology-enabled solutions, while others will be completely cut off from these services and experience: causing social and economic marginalization. This scenario excludes the existence of post-pandemic cities. Instead, the pandemic will last forever, with cities serving as its epicenters. Devastating effects will result from the vicious circle's continuation (Sokol, 2021).

To summarize the main arguments;

- Planning of lower density settlements or increased interest in the countryside rather than the city,
- Advocating the need to adopt planning approaches that include natural conservation concerns,
- The emptying of office buildings as many companies supports working from home,
- Increasing lack of mobility,
- Developing and diversifying the definition of home and private space,
- Preferring private cars as being safe even though public transport is encouraged,
- Increasing racial and gendered exclusions,
- Deeping the gap between rich and poor,
- Increasing social solidarities,

– Providing food and other needs through the internet, leaving shopping centers or other commercial areas unqualified have become the characteristics of the global pandemic city. The traits of the pandemic city can also be summed more extensively in Figure 2.

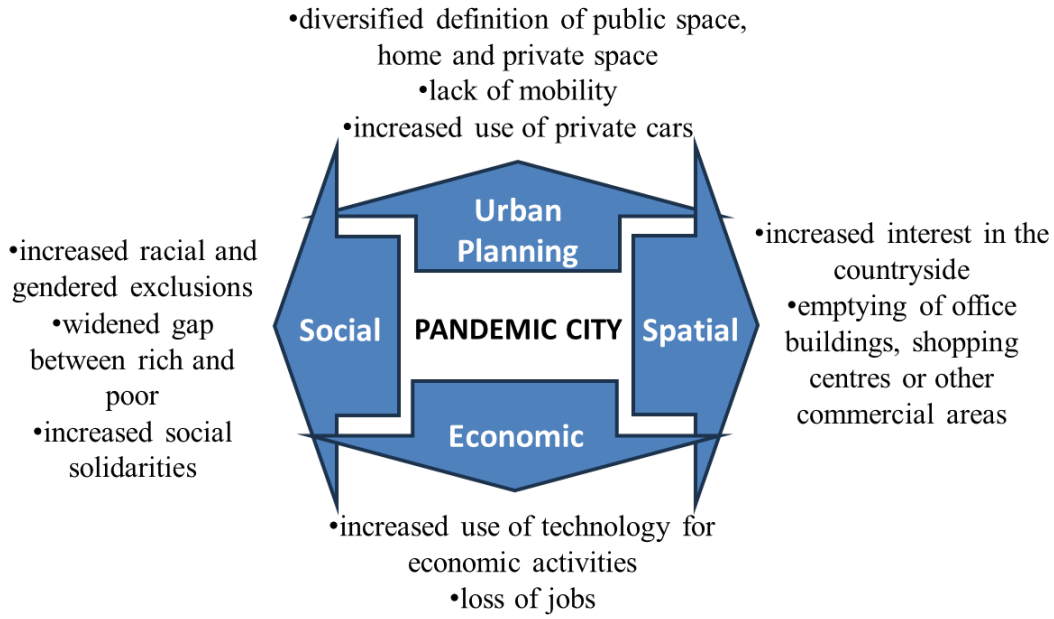

Figure 2 Pandemic City (Own Source)

In this context, although the Covid-19 pandemic has contributed to the significance of natural conservation with small-scale positive progresses such as the increase in the importance of urban public spaces and air quality in many cities, it should be determined what is not sustainable and resilient in the pandemic city and to establish the essential urban planning policies to eliminate the vulnerabilities. For this reason, discussions continue on how the "post-pandemic city" should be.

At this point the term post-pandemic city refers to urban regions that have successfully navigated or will successfully manage the adverse effects of the pandemic by meeting sustainability and resilience standards. Alternatively, it involves cities that can develop the ability to withstand and adapt. Drawing lessons from the past, utilizing governance capacity, and strengthening current capabilities by adjusting them to the changing conditions of the present day should be the main goals while planning the post-pandemic city. All elements identified in the pandemic city that are not sustainable and resilient must be compensated. In order to meet this, while the importance of ecological protection concerns in urban planning paradigms has increased, at the same time, new urban concepts such as 15-minute city or 20-minute city have started to be discussed.

Mölders and Levin-Keitel (2021) emphasized the growing evidence supporting the necessity of creating sustainable cities after the COVID-19 pandemic. While Sharifi and Reza Khavarian-Garmsir (2020) conducted a comprehensive study of 140 published articles that examined the impacts of the pandemic on cities and identified key lessons for urban planning, design, and management. Their findings revealed a heavy focus on improving air and water quality, also shedding light on the disproportionate impact of the pandemic on vulnerable and marginalized communities. Covering various aspects such as environmental quality (air quality, environmental factors, urban water cycle), socio-economic impacts, management, and governance (including smart cities), transport and urban design (Bharule et al., n.d.), which provide valuable insights into the sectors that should be prioritized in post-pandemic urban planning guidelines.

Just to give an example, the pandemic has brought attention to the need for equitable living conditions in cities that consider both space quantities and spatial qualities for all citizens (Mölders & Levin-Keitel, 2021). It may be necessary to reduce density and reevaluate public areas in the post pandemic metropolis. Since lower income groups could rely more on urban public places for social

meetings, this redesign may have redistributive effects (Martinez & Short, 2021). Sector-based divisions of urban planning organizations allow for the use of urban planning instruments as well as existing normative aims to address current crisis-related difficulties. By establishing a connection between the current situation and the desired outcomes, transformational knowledge highlights the significance of the transformational process. With different approaches offering insights into weaknesses, threats, strengths, and opportunities for different ways of taking decisions that lead to more and better transformative knowledge, there is an increasing demand for a more collaborative approach to building more livable cities (Mölders & Levin-Keitel, 2021).

Relatedly, Balducci (2022) points out the diversity that we have steadily lost since Jane Jacobs' denunciation in 1960, the containment of spatial inequality that has not been addressed, the quality of the environment sacrificed in favor of efficiency, the re-appropriation of public space for people, the breaking of the rigid relationship between form and function of buildings and other structures. These are just a few of the issues that must now be on the agenda for cities and require thought, strategy, and courage. Sewage systems, building codes, or straightforward reconstructions won't be sufficient this time.

It would be unrealistic to say that human beings are in control of the changes that result from their interventions in nature in order to develop and progress. However, through a comprehensive system planning approach, it is possible to develop the capacity to adapt to out-of-control developments and ultimately restore balance. For this, in addition to sustainability, resilience needs to be found at the joint of the balanced interaction with spatial and social dynamics and governance capacity in the post-pandemic urban planning paradigms. The existence of a balance between the protection and utilization of the natural environment in the spatial perspective, the consideration of natural thresholds in urban development decisions on the basis of the concept of sustainability aside from ensuring socio-economic and social equality will enable the creation of resilience with a holistic approach. So, it should be emphasized that the development of sustainability and resilience capacity essentially depends on the urban planning stakeholders and the relations among them. This is because a clear definition of the stakeholders and the relationship between them is the basis for the creation of tools such as urban plans, strategies and laws that will improve sustainability and resilience through common sense and cooperation, as well as ensuring social resilience. Therefore, prominent post-pandemic urban planning approaches can be summarized in Figure 3.

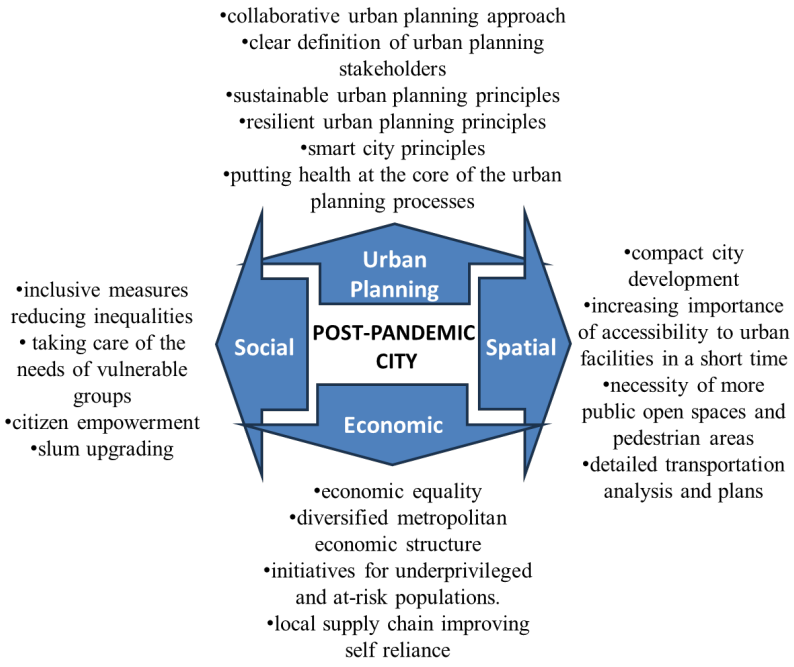

Figure 3 Post-Pandemic City (Own Source)

The important point here is to determine which qualities of sustainability and resilience needed to be highlighted while shaping the post-pandemic city. The next section clarifies this issue.

3. Attributes of Sustainability and Resilience in Post-Pandemic Urban Planning Paradigm

At the very beginning of the study, it was asked "how is it possible we are still experiencing this outbreak even though "resilience" and "sustainability" principles are ingrained in urban planning paradigms?". The COVID-19 pandemic has shown that not only a change in urban planning practices is necessary, but also it is inevitable that this required change in urban planning approaches must be continuous in order to secure human health. Then, in the post-pandemic period, the competitive advantages of cities should include indicators such as sensitivity to environmental thresholds, robustness of resilience capacity, and adoption of healthy city principles. Again, important lessons learnt from nature and the events of the recent past are essential for cities to cope with future threats. Thus, it is vital for cities to learn to manage uncertainty through anticipatory planning strategies, implementing sustainability-based policies, and developing adaptive capacity to cope with shocks. To form the basis for the determination of these indicators, which should be evaluated on a city-specific basis, it is of great importance to reconsider the concepts of sustainability and resilience, which are two dominant concepts in the current urban planning literature.

When we analyze the literature, we see that the idea of providing the mentioned dynamic structure in urban planning has been discussed since the 2000s. For example, in the e-discussion "The Future of Sustainability: Have Your Say!" organized by IUCN in 2006, 460 registered participants from over 70 countries discussed new models that see ecosystems as the cornerstone of economy and society or life support systems instead of the traditional three-pillar sustainable development model. They emphasized the significance of moving beyond abstract ideas and assisting actual communities in implementing sustainable development on the ground, noting how the idea of sustainable development had been misappropriated and politicized. The discussions addressed to advancements in sustainability sciences, fresh insights into cultural diversity, and calls for improved communication between scientists and the general public in the 21st century (Jeanrenaud, 2007).

Likewise, according to the Australian case study conducted by Newton and Bai (2008), it is essential to adopt a modified decision-making process that deviates from the traditional sustainability strategy in order to create an ecologically sustainable future. While acknowledging that many important components of society are not concentrated around economic activity, this new perspective recognizes that the economy is a crucial component of society. In essence, it illustrates how completely dependent human civilization is on the limitations set by the natural environment of our world. As a result, it is crucial to include ecological factors in all facets of social and economic planning (Figure 4).

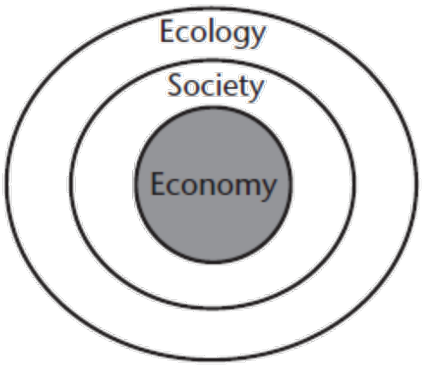

Figure 4 Framework for Ecological Sustainability in Decision-Making; Adapted from Newton and Bai (2008) quoting Lowe (1996)

Hence, as Newton and Bai (2008) recommended, an appropriate framework must be conceptualized to make the transition to more sustainable cities. Since Brundtland (1987),

sustainability has become a new and potent driving force, influencing how the government, business, and community view urban development. In terms of how future urban systems are planned, developed, and operated, it is the area where considerable shifts are needed. This means that, it is essential to develop more exact models, metaphors, and metrics that effectively portray the interaction between human actions and the environment to lay the groundwork for sustainability. In addition, strengthening governance competence necessitates a dedication to ongoing improvement. As a result, society as a whole needs to adopt this culture of effective management.

According to Orr (2002), to guarantee the fair transfer of wealth through generations, governments must be influenced by a morally upright and well-organized public. An informed populace can also actively engage in political decision-making and take ownership of how those decisions are carried out. Governments can increase social resilience by putting resilience strategies in place to deal with unforeseen shocks where a culture of active engagement in building sustainable cities develops. Once again, Orr (2002) highlights that the continuation of society depends on a sequence of public decisions that require for strong state institutions and politically active, informed citizens.

It is crucial to create a better connection between resilience and sustainability at this turning point, where the commitment for constant change in urban planning strategies is clear. The COVID-19 pandemic has highlighted how crucial it is to think about resilience and sustainability as related ideas when constructing cities. By uniting these two fields, we may create an urban development strategy that not only protects human health but also strengthens our capacity to withstand and respond to new challenges. In any case, it is already impossible to resist developing a new agenda for this new era, that is centered on how to maintain sustainability while ignoring uncertainty and complexity. Today the main characteristics of sustainability which are the provision of needs, development and inter and intra-generational equity-justice in terms of resource maintenance should be updated based on non-linearity. Therefore, as Yaman-Galantini and Tezer (2018) suggested, sustainability should be updated and upgraded based on today's needs, developments and equity approaches considering resilience perspective.

The main challenge is to achieve sustainability requirements while offering uncertainty responses. Therefore, in an evolutionary system with ongoing development, it is impossible to name any ideal state, stable equilibrium, or optimal development route. Therefore, it can be deduced that the fundamental characteristics of resilience should refer to a continual process

of learning, adapting, and changing in order to give the principal appraisal of sustainability. According to Novotny et al. (2010), this requirement gives sustainability its dynamism or in other words, makes it an inherently moving target that accounts for a process of continuous development.

To underline what it relates to, resilience is defined as a city's potential to manage, adapt, cope with unexpected changes/crises and develop capacity against the unexpected. According to Brand and Jax (2007), it is a comprehensive notion that describes a socio-ecological system's capacity to handle uncertainty and unanticipated changes as well as its ability to manage, adapt, and control change. Servillo and Reimer (2013) define resilience as the capacity to return to normality in the face of threats resulting from change. Alternatively, it refers to a complex socio-ecological system's capacity to alter, adapt, and transform rather than a return to normalcy. In terms of the principle of the strongest survives, Davoudi (2012) describes it as an evolutionary strategy. She contends that systems' nature can change over time without the intervention of an outside force or a genuinely dangerous threat.

Integrating resilience into urban planning demands considering three key viewpoints, building on the idea of continual learning and adaptation. These viewpoints operate as fundamental concepts for successfully integrating resilience into planning procedures. Accepting these viewpoints will help us promote a smoother and more efficient shift to resilience-based planning.

They are also fundamental for the groundwork for a more flexible and adaptable strategy for sustainable development. Besides, they make use of the concept's evolutionary meaning to better manage change and enhance cities' capacity for quick recovery.

In their SPARK project, where they suggested a resilience-based strategic planning approach, Dos Santos and Partidário (2011) recognized innovation, continuous learning, and stakeholder communication as critical factors for the planning process to have the capacity to manage change. According to Davoudi et al. (2013), who utilized the definition of evolutionary resilience for the London climate change adaptation strategy, adaptation to climate change is a continual process including social and organizational learning. However, Lu and Stead (2013) identified six significant obstacles to enhance Rotterdam's resilience to climate change while also fending off external threats and returning to normalcy. Goals must be set, initiative must be made, public activities must be prioritized, trends and potential hazards must be considered, and failures must be learned from. The examples show how resilience's dynamic character -derived from its evolutionary definition and the objective of defining a system that is ready for unexpected changes- can offer a process in contemporary urban planning practices, help us create awareness against uncertainties by adding a new perspective to planning.

In this context, the main strategy for fighting the pandemic should be to use urban resilience as a major idea in achieving governance success. Lebel et al. (2006) identified three characteristics that are necessary for resilient governance in their study, "Governance and the capacity to manage resilience in regional social-ecological systems": Participation, multifaceted institutions with multiple levels, and accountable authorities make up the first three. In order for the society to have faith in the management, to mobilize, and to be aware of living/acting collectively, it is crucial to assure involvement in planning procedures in the context of the battle against the pandemic. The combined efforts of all players are necessary for society to fight the pandemic in a resilient manner.

The ability to produce greater information flow, cooperation, coordination, and social solidarity depends on the participation of more stakeholders from various scales. We must learn to live together, as the pandemic's most crucial lesson is to remind us. According to Mulligan et al. (2016), social coherence, inclusiveness, and solidarity all contribute to social resilience. Having a responsible authority is obviously necessary for managing the procedure effectively and getting responses quickly. The ability of vulnerable groups in society to adapt can be managed in this way. The role of local governments in this process is significant too. Eliminating the issues affecting public health services and the complaints of people who have experienced financial losses are critical priorities.

Making spatial plans with pandemics and other potential disasters in mind is a crucial part of the urban resilience viewpoint in the fight against the pandemic. Urban planning is critical to developing emergency action plans for dealing with catastrophes, calculating the likelihood that hazards would be faced, figuring out what to do in these circumstances, and eliminating or lessening the risks that may result from them. A planning system that permits the improvement of physical environmental conditions can be a key element in reducing the occurrence and spread of diseases, according to the theory that pandemics are particularly caused by environmental problems. People are in constant communication with one another because they can continue to live as a community. Infectious diseases spread swiftly from one infected individual to another. The pandemic thus demonstrates a geographical spread.

According to this perspective, pandemics have both social and spatial elements. The pandemic spreads more quickly as the more mobile the population is. By this time, it is clear once more how crucial planning scale is to the fight against the pandemic. According to Wilbanks (2009), when defining society, it is important to consider how geographic scale affects sustainability and resilience. The "think globally, act locally!" philosophy, one of the cornerstones of sustainability, emphasizes that the key to winning the societal and international battle against the pandemic is to

successfully implement local solutions. Coincidentally, the idea of urban resilience does one of the most significant contributions to the creation of spatial plans in the neighborhood scale.

Resilience plans might differ greatly at the neighborhood level depending on the type and intensity of the vulnerabilities that are present. A customized approach to resilience development is possible by having a thorough understanding of the particular difficulties that various areas encounter. Infrastructure quality, environmental dangers, and socioeconomic conditions are only a few of the variables that affect how vulnerable and adaptable a community is. Urban planners can construct context-specific solutions that improve resilience and build more resilient and inclusive communities by identifying these variables. Additionally, working on this local scale may be simpler to provide the additional funding, support, or accessibility required to achieve resilience standards. For instance, while access to a broader variety of resources might be feasible at the macro scale, it might be possible to make decisions more quickly due to simplified decision-making processes at micro scale. Therefore, by removing the risks experienced at the local scale, urban resilience can be attained more quickly. Also, the neighborhood scale is important because it's a scale where social organization and solidarity can be achieved more quickly, as well as by making common public areas and services easily accessible and preventing people from moving around excessively and crowding the streets to meet their needs during the pandemic. For this purpose, it is necessary to re-evaluate urban planning standards, to change the area requirements and accessibility distances required by the services in accordance with the population, and to carefully plan areas that may serve a purpose other than their current use (e.g., health service area, accommodation area, storage area, etc.).

It is also essential to take social factors into account while evaluating spatial issues. Spatial planning should deliberate the connections between physical locations and social interactions in the context of the current pandemic. Effective resilience practices can be improved by knowing how spatial arrangements affect social dynamics. Urban planners may develop environments that improve both the physical and social resilience of communities by supporting accessible and inclusive public places, encouraging community engagement, and planning neighborhoods that encourage social connections. Through the integration of spatial and social factors, this integrated approach ensures a comprehensive understanding of urban resilience. Likewise, as Rönkkö et al. (2022) expressed, for cities to be pandemic-proof, the socio-cultural component of resilience is essential because it enables people to adapt both collectively and individually amid severe health crises. In order to retain coherence when experiencing social isolation, resilience-building techniques should consider psychological resilience. The pandemic has brought attention to socio-spatial imbalances, as well as the value of family and community assistance, particularly for the urban poor residing in slums and informal settlements (Rönkkö et al. 2022).

The ability of all societal groups to work together will guarantee the prevention of the pandemic's further spread. It is critical to adopt planning strategies that effectively combine society and space to perform this, in addition to taking spatial considerations into account while planning cities. The process of integrating resilience into urban planning also includes establishing and executing spatial design principles that support social resilience. Therefore, it is essential to plan the built and natural environments in a way that highlights the community's assets. For instance, Carpenter (2013) claimed that neighborhoods with walkable and mixed usage see an increase in social capital and sense of belonging. According to Berkes and Ross (2013), a strong urban plan that emphasizes social phenomena like social values and beliefs, knowledge, skills and learning, social networks, a diverse and innovative economy, human-space connection (also known as belonging), collaborative governance, and the ability to accept change can create the foundation for social resilience.

Lastly, in Figure 5, the proposed intersections between sustainability, resilience and governance and their prominent attributes in the post-pandemic urban planning paradigm are summarized. The important point is that when planning post-pandemic cities, planning practices should have the aim of capacity building to support an equitable and fair development through;

- Providing basic needs and stability in the city even in the most difficult times,
- Being able to continuously improve its knowledge and technical infrastructure against all possible threats,
- Identifying governance tools that will take responsibility for ensuring intergenerational justice to access basic resources and,
- Prioritizing ecological concerns in planning processes.

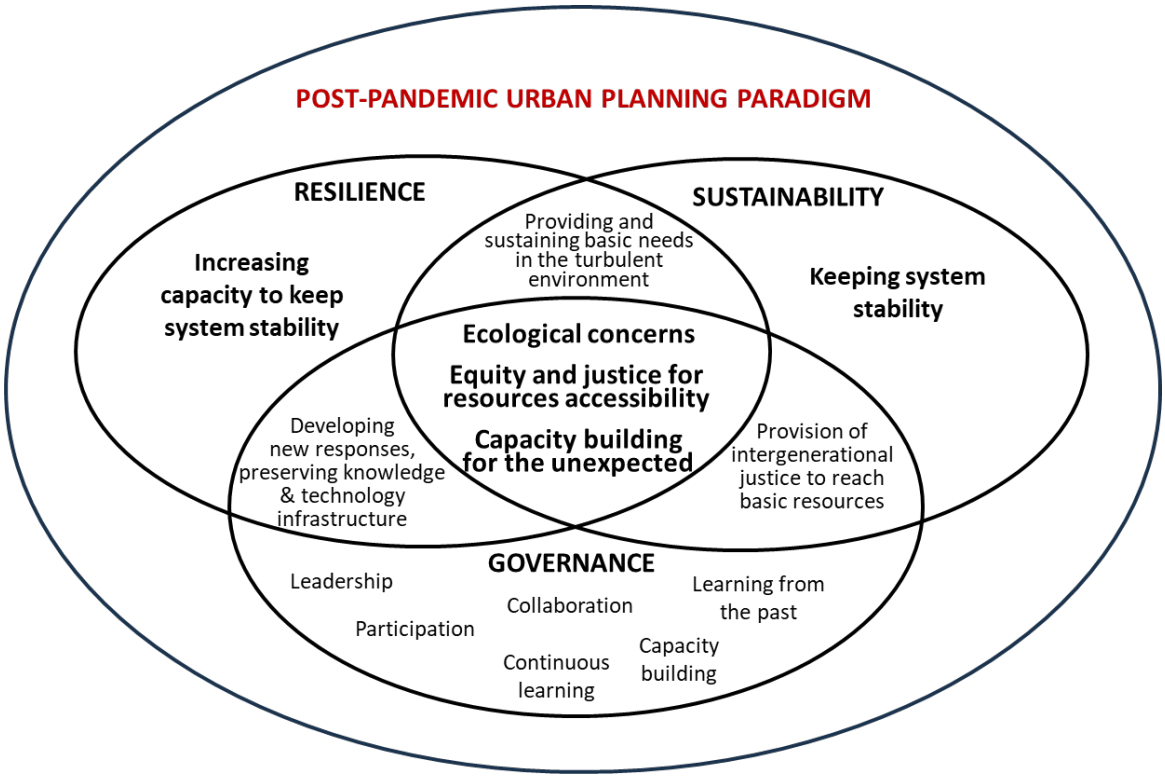

Figure 5 Key Components of Post-Pandemic Urban Planning Paradigm (Own Source)

To sum up, when we look back, we see that the concept of sustainability and resilience have been known for years, expressed on national and international platforms, and reminds us of the priorities necessary to solve chronic problems. The governance capacity and basic spatial strategies described within the scope of sustainability and resilience criteria in combating the pandemic are not new definitions. However, this recent perspective, with its emphasis on the possibility of the devastating impacts of unexpected changes at any time, gives us a comprehensive top heading idea arguing that these issues should be refocused today.

4. Conclusion

In conclusion, the COVID-19 pandemic has damaged our ability to live in urban environments that have been developed over many generations and it has exposed the weaknesses of cities. There is no denying the importance of historical learning for contemporary cultures. Even though cities have historically faced a variety of difficulties, including wars and pandemics, it will be more central to be more prepared for disasters in the future. Simply repeating past errors would cost more in the long run.

We must admit that the uncontrolled and continual growth of cities runs counter to the natural processes that are essential to human welfare. To attain urban sustainability and resilience or build the essential capacity to successfully handle upcoming crises, our existing understanding of policy and governance is insufficient. Therefore, using what we've learned from handling the unexpected pandemic we recently experienced, we need to make bold decisions that combine livability with the capacity to adapt to the unknowable.

We can rethink and reshape cities that are more equipped to face the problems that lie ahead by adopting a more holistic approach. This necessitates re-examining our methods for urban development, encouraging sustainable expansion, and emphasizing resilience in urban planning and governance. Additionally, it calls for increasing stakeholder cooperation and knowledge exchange, utilizing the potential of technology and innovation, and contemplating the social, economic, and environmental elements of urban life. By doing this, we may work to build cities that are more sustainable, inclusive, and supportive of the well-being and prosperity of their citizens as well as more robust to upcoming crises. We can build cities that are better prepared to navigate the challenges of an uncertain future by taking lessons from the past and utilizing our combined experience.

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Resume

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Uneven resilience of urban and rural areas to heatwaves

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Abstract

Extreme heat represents one of the most challenging climate change impacts of the Anthropocene, exerting influence not only on the economy and built environment but also on daily human life, posing threats to health. Within the existing literature, heatwaves and extreme heat phenomena have predominantly been examined at the urban scale, emphasizing the vulnerabilities inherent in urban areas. Conversely, rural areas are often highlighted for their advantages related to the natural environment. However, a broader perspective reveals that rural areas have their unique vulnerabilities that warrant careful consideration. This paper seeks to comparatively assess the vulnerabilities of urban and rural areas. Through an extensive literature review, the paper explores the divergent resilience of urban and rural areas across economic, social, environmental, structural, and governmental factors. The study concludes that both rural and urban areas exhibit distinct advantages and disadvantages, influencing their levels of vulnerability and resilience. This research is instrumental in providing a comprehensive outlook on resilience studies related to extreme heat.

Keywords: extreme heat, urban areas, rural areas, vulnerability

1. Introduction

Climate change is one of the most challenging problems of the Anthropocene. The changing climate due to the effects of greenhouse gases accumulating in the atmosphere has irreversible impacts on both the built and natural environment. Melting of glaciers, change in precipitation regime, sea level rise, increase in average global temperatures bring problems such as more frequent and severe extreme weather events, droughts, floods, coastal floods, ecosystem degradation, decrease in biodiversity, and directly or indirectly affect areas such as energy, food, water, health, and economy (IPCC, 2018). In the United Nations Framework Convention on Climate Change (1992; 7), climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". The inception of anthropogenic influences on the global climate can be traced back to the Industrial Revolution, which has shaped today's human activities encompassing production-consumption dynamics, alterations in land use, dependence on fossil fuels, and the extensive practice of deforestation (IPCC 2014; 2023). Today, "anthropogenic climate change" triggered by human activities has caused global average temperatures to increase by 1.10C compared to the pre-industrialization period. This increase has led to the effects of climate change being observed with increasing severity and frequency all over the world. Projections show that if no action is taken, these temperatures could rise by up to 40C, with 1.50C being a critical threshold that should not be exceeded (IPCC 2018; 2023).

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One of the most critical human-induced impacts of climate change is the increase in heat waves and extreme heat stress. According to the latest assessment report published by the IPCC (2021), the duration, intensity and frequency of heat waves are "highly likely" to increase in the future. Prolonged exposure to heat waves is associated with health problems and fatalities (Kinney et al., 2008; Gasparrini et al., 2015). As a matter of fact, the measurement of the highest average temperatures in history in July 6th 2023 as 17.230C is an indication that the effects of climate change are already being observed today. In July 2023, 147 deaths were recorded in 5 states of the USA due to heat stress, while 60,000 people were recorded to have lost their lives in Europe due to increasing temperatures in the summer of 2022 (Niranjan, 2023; Rannard, 2023). Considering all these, it is clear that rising temperatures pose a deadly threat and this issue should be addressed as a priority.

Climate risk, which is referred to as "extreme/severe heat", "heat stress", "heat waves" in the literature, has negative consequences in many areas such as societies, health, economy and daily life. The decrease in outdoor thermal comfort due to increasing temperatures, even to the extent of threatening health, can directly affect people's daily lives by reducing the time spent outdoors and changing outdoor activities (Sharifi & Boland, 2017). Extreme heat should not only be evaluated in terms of its relationship with health, but should be considered from a broader perspective. Projections show that heat waves will have significant impacts on the built environment, natural environment and social life and economy (Zuo et al., 2015).

In the literature, numerous studies have concentrated on examining the impacts of heatwaves on urban areas. The emphasis on urban areas stems from their highly-dense populations and elevated temperatures compared to the surrounding natural areas (called as “urban heat island” effect). Consequently, it is widely acknowledged that urban areas exhibit heightened vulnerability to heatwaves. Nevertheless, resilience to extreme heat is not solely contingent upon exposure; it is concurrently influenced by social characteristics within society, including factors such as age, education, health condition, and social isolation (Li et al., 2017). Moreover, the living conditions, accessibility to services and mitigation tools and connection to the information services have important influence on the resilience of the communities (Lal et al., 2011). Cutter et al. (2012) identified the most vulnerable groups to climate change as the elderly, children, migrants and low-income households. It is known that heat waves affect the elderly, young children, individuals with social and physical limitations, low-income groups without access to cooling technologies such as air conditioners, immigrants, minorities, chronic patients more (Reid et al., 2009; Rebetez et al., 2009; Mueller et al., 2017; Bayar & Aygün Oğur, 2023; Kim et al., 2023). Therefore, the potential vulnerabilities linked to the characteristics of the settlements need to be identified.

Grounded in this perspective, the primary purpose of this study is to elucidate the distinct vulnerabilities associated with heatwaves in both urban and rural settings. Defining vulnerability as a component of resilience, the investigation undertakes a comparative analysis of rural and urban areas, evaluating them across a spectrum of factors to discern their respective strengths and weaknesses. Informed by a comprehensive literature review, the study scrutinizes these factors under five overarching categories: Economic, Social, Environmental, Structural Factors and Governance. The research aims to answer the following questions; “To what extend do urban and rural areas differ in vulnerability to heatwaves?” and “How economic, social, environmental, structural and governmental factors affect rural and urban area’s vulnerability to heatwaves?”

2. Vulnerability as a Function of Resilience

Studies have shown that different geographies and social groups experience varying levels of impact from climate change (Javadinejad et al., 2019) which is strongly related to the vulnerability and resilience levels. Resilience is a widely employed term spanning various disciplines to characterize the capacity of a system to withstand shocks or stressors. Cambridge Dictionary defines resilience as "the quality of being able to return quickly to a previous good condition after problems" (Resilience, 2023). The concept was initially introduced in ecology by Holling (1973) to

delineate the ecological system's capability to absorb disturbances and sustain its functionality. Subsequently, it permeated other disciplines, including psychology, economics, engineering, urban science, and climate change.

In a broader context, resilience is construed as the system's ability to confront change and perpetuate development. This system may encompass an economy, a city, a natural area, or an individual (Applegath, 2012). The definition encourages innovative thinking to overcome and renew following disruptive crises or shocks (Stockholm Resilience Centre, 2011). Climate change resilience specifically addresses a system's competence in absorbing climate variability (Trohanis et al., 2009). Resilience has become a ubiquitous concept in contemporary research, finding application in studies of political, physical, and natural systems.

Upon scrutinizing the definition of resilience, it becomes evident that the discourse revolves around the concept of an unpredictable shock or crisis. Presently, society grapples with pervasive uncertainty across various domains, encompassing the realms of the economic crisis, climate, and natural disasters. The repercussions of these uncertainties have the potential to yield profound and detrimental consequences for the global system. Specifically, these consequences may occur as economic downturns, environmental degradation, escalation of natural disasters that lead human suffering, mass migration, displacement, epidemics, etc. Indeed, the concept of resilience proffers a strategic framework that involves proactive preparedness to contend with and mitigate the impact of such uncertainties. Resilience is concerned not only with responding to the challenges encountered but also with shaping them (Davoudi, 2012).

Vulnerability constitutes a pivotal concept pertinent to the resilience exhibited by a system in the face of climate change. The association between vulnerability and resilience within the climate change context is typified by an inverse correlation. According to the Intergovernmental Panel on Climate Change (IPCC) in 2007, vulnerability is defined as the extent to which a system is susceptible to and incapable of managing adverse effects arising from climate change, encompassing both climate variability and extremes. Vulnerability is contingent upon the inherent characteristics, magnitude, and rate of exposure to climate change and variability, as well as the sensitivity and adaptive capacity inherent to the system. As articulated by this definition and the preceding discourse on resilience, an escalation in system’s vulnerability results in a decrease in resilience, and vice versa. Research indicates discernible variations in the exposure of diverse social groups across distinct geographical locations to disparate levels and types of climate variables. Furthermore, disparities exist in the vulnerabilities inherent to each region and social group. Therefore, each community, settlement or region will experience different level of severity in the impacts of climate change (Javadinejad et al., 2019).

The vulnerability definition provided by the IPCC (2007) encompasses three pivotal key terms essential for comprehending the assessment of vulnerability. These key terms—namely, exposure, sensitivity, and adaptive capacity—serve as foundational components in the evaluation of vulnerability. Exposure denotes the magnitude of climate variability within a given region. Sensitivity is elucidated as the extent to which a constructed, natural, or human system is directly or indirectly influenced by alterations in climate conditions, encompassing variables such as temperature and precipitation, or specific impacts resulting from climate change, such as sea level rise and elevated water temperature. Adaptive capacity is defined as the capability of constructed, natural, and human systems to accommodate alterations in climate, inclusive of both climate variability and extremes, with minimal potential damage or cost. In a general sense, systems exhibiting elevated adaptive capacity are more adept at managing the impacts of climate change (ICLEI, 2007).

This study investigates the vulnerability of both rural and urban areas within the aforementioned conceptual frameworks. The examination involves a comprehensive analysis and

comparison of the exposure, vulnerability, and adaptive capacities specific to heatwaves in both rural and urban contexts. The study further conducts a comparative evaluation of the respective advantages and disadvantages inherent in each settlement type. Such an assessment provides valuable insights into the impediments and potential avenues for enhancing resilience in response to heatwaves.

3. Urban and Rural Vulnerability to Heatwaves

Given the distinct adaptive capacities, risk management experiences, and infrastructural disparities between rural and urban areas, a comprehensive understanding of their respective resilience assumes paramount significance. Variances in resilience levels across diverse living areas and lifestyles are anticipated, influenced by a multitude of factors. Identifying these discrepancies becomes imperative to formulate viable and effective strategies for augmenting resilience capacity. The meaningful pursuit of resilience initiatives for each settlement necessitates tailored, context-specific assessments, accounting for the unique attributes of the locality, community, and way of life. Identifying local resources and inherent resilience factors becomes pivotal for the formulation of pertinent strategies (Javadinejad et al., 2019).

Urbanization, as a human activity, not only contributes to climate change but also introduces substantial risks through the concentration of infrastructure, economic endeavors, populations, and construction within cities (Tuğaç, 2022). The combination of inadequate infrastructure, high-density settlements, and urban inequalities heightens the vulnerability of marginalized groups to the impacts of climate change (Yenneti et al., 2016). Existing literature consistently underscores the heightened severity of temperature-related effects within urban environments. Cities and urbanization occupy a central position in climate change studies, as urbanization is identified as a contributing factor to climate change, while simultaneously exacerbating climate risks due to the concentration of economic activities, sizable population cohorts, infrastructure investments, and socio-cultural activities within urban settings (Aygün Oğur & Baycan, 2022). Insufficient infrastructure, unregulated construction, and socio-spatial disparities in urban areas exacerbate their susceptibility to the impacts of climate change. The process of urbanization contributes to a reduction in ecosystem services, alterations in land use, the diminishment of natural areas, and an expansion of built-up spaces within urban and surrounding regions. Consequently, this amplifies the vulnerability of cities to climate-related risks and the escalating occurrence and intensity of heatwaves. In cities deemed vulnerable, both critical infrastructures and inhabitants confront substantial risks (Lapola et al., 2019). The transformation of land cover resulting from urbanization has further modified the microclimate of urban environments (Pappalardo et al., 2023).

Furthermore, an additional rationale for the emphasis on studying extreme heat within urban contexts is attributed to the phenomenon known as the "Urban Heat Island" (UHI) effect, a factor contributing to heightened heat stress. The UHI, characterized by elevated temperatures in urban areas compared to their surrounding natural and rural counterparts, is intricately linked to the structural attributes and settlement patterns of cities. Its manifestation is primarily associated with the widespread use of heat-absorbing materials such as asphalt and concrete, a scarcity of green spaces, and the prevalence of high-density construction (Venter et al., 2021; Xi et al., 2023). The urban canyon effect, engendered by densely constructed and tall buildings, particularly during summer periods, impedes natural air circulation. Additionally, the presence of spaces that absorb and retain heat throughout both day and night exacerbate the adverse effects of rising temperatures (Oke, 1973; Hatvani-Kovacs & Boland, 2015). The concept of urban heat encompasses the cumulative impact of the urban heat island and heatwaves (Wang et al., 2022).

Although the Urban Heat Island (UHI) effect takes significant attention in studies examining the temperature-related impacts of climate change within urban areas (Hatvani-Kovacs & Boland, 2015), it is essential to acknowledge that rural areas are equally susceptible to climate change. While discussions regarding the impact of temperature rise on urban areas commonly assert that urban locales are more vulnerable than their rural counterparts due to inherent structural

characteristics (De Sherbinin et al., 2007; Mora et al., 2017), it is noteworthy that divergent perspectives exist within the literature. Fischer et al. (2012) posit that both rural and urban areas undergo a comparable escalation in heat stress under a scenario involving a doubling of CO2 levels.

In addition to experiencing commensurate levels of stress, the vulnerabilities associated with the socio-economic and demographic structures of individuals residing in rural areas underscore the imperative for research attention equivalent to that given to urban areas. The population residing in rural settings exhibits cultural and economic dependencies on natural resources, coupled with a dearth of diverse services. In comparison to urban counterparts, the services available in rural areas, marked by limited quality and accessibility, constitute a factor amplifying vulnerability in these regions (Lal et al., 2011). Although the literature on this subject is limited, it does address the vulnerabilities inherent in rural areas. Notably, the prevalence of elderly individuals, who are more susceptible to heat stress in rural environments, forming the majority of the population, coupled with constrained access to health services and the concentration of lower socio-economic groups in these areas, are delineated as factors exacerbating vulnerability (Benmarhnia et al., 2015; Burkart et al.Cassi, 2014; CDKN, 2018). In this context, a critique has emerged within the literature, challenging studies concentrating on urban areas that remain confined to the health-rising temperatures-built environment nexus (Madrigano et al., 2015; Sarofim et al., 2016). It can be deduced from this analysis that a singular consideration of heat risk based solely on exposure offers a constrained viewpoint. When the distinctive vulnerabilities inherent in the social structure and service distribution are considered, urban and rural areas manifest divergent susceptibilities (Li et al., 2017). Building upon this insight, the present research diverges from a sole concentration on urban areas and extends its scope to encompass broader terrains, explicitly incorporating rural areas. Such an expansive approach is deemed essential to comprehensively scrutinize the ramifications of extreme heat in both urban and rural contexts, aiming to unveil the underlying factors contributing to these distinct impacts. Contrary to prevailing perceptions, elevated temperatures pose an equivalent, if not greater, risk to human health in rural areas compared to urban areas. The research landscape on heat vulnerability has predominantly centered on urban locales, with the urban heat island effect identified as a contributor to heat-related mortality in such settings (Li et al., 2017). This effect has fostered the presumption that urban residents face a higher vulnerability to heat compared to their rural counterparts. Nevertheless, a body of research contradicts this assumption.

Rural areas exhibit a vulnerability to climate change comparable to that of urban areas. The populations residing in these rural areas are characterized by a cultural and economic reliance on natural resources, coupled with a deficiency in various essential services (Krannich et al., 2014; Hemson et al., 2004). The anticipated consequences of climate change in these regions are poised to significantly impact the quality of life and health of the rural populations. Notably, when contrasted with urban counterparts, the provision of services in rural areas, marked by limited quality and accessibility, emerges as a factor amplifying the vulnerability of these regions. Additionally, demographic and economic conditions further compound the susceptibility of rural areas to climate change. Communities in rural settings, often endowed with fewer resources and alternatives, are predisposed to experiencing more pronounced impacts as a result of climate change (Lal et al., 2011; Altıntaş & Hovardaoğlu, 2022).

Building upon this review, the classification of categories for scrutinizing the disparities in vulnerability between rural and urban areas to heatwaves can be delineated into five primary domains, each with associated subcategories: Economic Factors; (Economic Activities), Social Factors; (Demographics and Socio-economic Factors, Community Dynamics), Environmental Factors; (Natural Environment, Air Quality), Structural Factors; (Building Design and Materials, Connectivity, Infrastructure and Technology, Health Care Access and Services), Governance; (Policy and Governance). This categorization provides a comprehensive framework for systematically examining the multifaceted dimensions of vulnerability in both rural and urban contexts, facilitating

a nuanced understanding of the factors influencing susceptibility to heatwaves within these distinct settings.

3.1. Economic Factors

Economic activities in both rural and urban areas can contribute to increased vulnerability to heatwaves through various mechanisms. This factor presents how the economic activities in urban and rural areas have influence on exposure, sensitivity and adaptive capacity for heatwaves.

3.1.1. Economic Activities

Economic activities within urban areas are inherently linked to the Urban Heat Island (UHI) effect, a phenomenon driven by heat-generating processes as in industries or manufacturing (He et al., 2020; Li et al., 2020). The UHI effect manifests as elevated temperatures within urban regions relative to their surrounding rural counterparts (Phelan et al., 2015). This localized warming effect results in heightened exposure to heat for the inhabitants, exacerbating the thermal conditions within urban environments. On the other hand, rural landscapes undergo transformation pressures associated with economic development, notably exemplified by activities like deforestation. These alterations impose stress on the microclimate of rural areas over the medium to long term. The gradual loss of natural habitat heightens the susceptibility of rural regions to increased heat exposure (Wolff et al., 2018).

Another crucial aspect involves the economic activities upon which people in settlements depend. In rural areas, a predominant portion of the population engages in agricultural production. This circumstance not only exposes them to heightened temperatures during fieldwork (Frimpong et al., 2020), with limited recourse for mitigation, but also renders agricultural productivity in rural locales particularly susceptible to the impacts of extreme heat (El Khayat et al., 2022; De Lima et al., 2021). The adverse effects on agricultural output extend beyond the immediate challenges faced by laborers, holding broader economic implications that reverberate through the livelihoods of farmers and the overall economic stability of rural communities. Furthermore, the combination of extreme heat and insufficient precipitation triggering water scarcity affect both human consumption and agricultural irrigation (Taft, 2015). The restricted availability of clean water for human use not only poses health risks but also complicates the daily lives of rural communities. It poses health challenges for urban inhabitants as well (Rijsberman, 2006). The complex interdependence among agricultural production, local economies, and food security underscores the vulnerability of rural areas to the extreme heat. This vulnerability assumes heightened significance in regions where agriculture constitutes a primary source of sustenance and income. Heatwaves exert adverse effects on outdoor workers within urban locales, with the impacts being magnified by the Urban Heat Island (UHI) effect (Moda et a., 2019). Nevertheless, despite these challenges, urban areas benefit the advantage of diverse range of economic activities, in contrast to rural areas.

3.2. Social Factors

Today, over 50% of the global population resides in urban areas, and projections indicate that this proportion is anticipated to surpass 65% by the year 2050 (UN, 2018). Notably, cities, already hosting a substantial population, continue to experience growth, primarily fueled by rural-urban migration. The phenomenon of shrinking rural settlements poses a challenge for both rural and urban regions in the face of climate change. Moreover, the demographic structure, cultural norms, and social dynamics within rural and urban settings differ, thereby influencing the vulnerability of respective groups.

3.2.1. Demographic and Socio-economic Factors

Urban areas exhibit diverse populations in terms of socio-economic conditions, age, ethnicity, and race. The vulnerable demographic, comprising the elderly, low-income groups, and individuals with pre-existing health conditions, who are more susceptible to heatwaves, is prominent in urban areas (Macintyre et al., 2018). On the other hand, rural populations are characterized by lower socio-economic status and a higher proportion of older individuals, factors collectively contributing

to heightened vulnerability to heat-related illnesses and fatalities (Haskins, 2018). These conditions may limit the capacity to afford essential resources, including cooling systems, suitable housing, or healthcare services, particularly during periods of extreme heat. Rural areas often have a higher concentration of elderly individuals, inherently more susceptible to the adverse effects of extreme heat, necessitating additional care and support during such events (Rebetez et al., 2009).

3.2.2. Community Dynamics

Despite the assumption of high social connectedness in densely populated urban areas, urban residents, especially the vulnerable minorities (Tigges et al., 1998) may experience social isolation, thereby intensifying the impact of heat stress. This phenomenon is especially relevant for individuals lacking robust social networks or support systems. In contrast, rural communities often exhibit stronger social networks, fostering cooperation and mutual support during challenging periods, such as heatwaves. This enhanced social cohesion plays a pivotal role in helping individuals cope with the adversities posed by extreme temperatures. The interconnectedness within rural social structures often results in a communal response to heat-related challenges, providing a support system that extends beyond individual capacities. The strength of these social networks in rural areas not only contributes to the resilience of the community but also underscores the importance of considering social dynamics as a vital component in comprehensive strategies for mitigating the impacts of heatwaves (Cassidy & Barnes, 2012).

Furthermore, rural communities often possess traditional knowledge and practices that contribute to adaptive strategies in dealing with heat stress. This is particularly evident in agricultural practices, where longstanding local expertise is leveraged to navigate extreme weather conditions. The incorporation of such traditional knowledge into contemporary adaptive measures not only enhances the ability of rural populations to withstand heat stress but also highlights the importance of acknowledging and integrating indigenous practices in broader climate resilience initiatives (Fischer et al., 2021).

3.3. Environmental Factors

In general, rural areas are located in geographically distinct environments characterized by higher elevations and more extensive vegetation or forest cover compared to urban areas. These geographical features significantly influence precipitation patterns and temperatures. The higher elevation and augmented vegetation in rural areas foster a more favorable climate for precipitation. The conjunction of elevated terrain and increased vegetation cover in rural areas leads to decreased temperatures and cleaner air. The existence of forests and vegetation additionally affects local microclimates, offering shade and promoting cooling (Zeleňáková et al., 2015). Consequently, rural regions typically encounter lower temperatures and higher air quality in contrast to their urban counterparts. This factor compares the environmental factors that affect vulnerability in both settlements.

3.3.1. Natural Environment

Urban environments, characterized by dense infrastructure and minimal green spaces, face specific challenges during heatwaves. The scarcity of vegetation, parks, and green areas limits the presence of natural cooling mechanisms, including shade and evapotranspiration. Vegetation, green areas, and natural corridors are crucial sources of a cooling effect. The deficient greenery in urban locales results in a decreased capacity for natural cooling, ventilation, contributing to elevated temperatures, particularly evident during heatwaves (Oke, 1982; Ge et al., 2020; Okumuş & Terzi, 2021; Mueller et al., 2017; He et al., 2020; Yin et al., 2018; Yang & Li, 2015).

Rural areas have a distinctive natural environment characterized by abundant green spaces, encompassing diverse features such as forests, fields, and expansive landscapes. Unlike urban areas, rural settlements are less densely built, a characteristic that plays a pivotal role in cooling the environment. The natural features of rural areas, varying across geographies, contribute significantly to temperature regulation. The presence of green and blue structures together, including water bodies like lakes, rivers, and ponds, enhances the cooling effect. These bodies of

water act as heat sinks, absorbing and dissipating excess heat, thereby influencing the surrounding air temperature. The natural cooling systems in rural areas offer multifaceted benefits, extending beyond temperature moderation. Dense vegetation, including forests, fields, and natural landscapes, contributes to cooler microclimates through the shading effect. The combination of green spaces, water bodies, and open layouts collectively creates a more comfortable and thermally regulated environment in rural areas, enhancing overall resilience to the impacts of elevated temperatures (Li et al., 2015; Wu & Zhang, 2019).

3.3.2. Air Quality

Urban areas frequently contend with elevated levels of air pollution, a factor that can exacerbate heat stress and contribute to respiratory issues, particularly during extreme heat events (Cohen et al., 2004). The confluence of increased temperatures and heightened air pollution poses significant health risks for urban residents (Jacob, & Winner, 2009; Brugha & Grigg, 2014). Elevated levels of pollutants, such as particulate matter and ground-level ozone, intensify the physiological impact of extreme heat, compromising respiratory function and exacerbating heat-related health concerns (Kalisa et al., 2018; Kinney, 2008).

In the context of air quality during heatwaves, rural areas are characterized by inherently lower levels of pollution compared to their urban counterparts. This disparity arises from a combination of factors that collectively contribute to a more favorable air quality profile in rural regions. One key determinant is the diminished concentration of industrial activities in rural settings, leading to a reduction in emissions associated with manufacturing processes. Furthermore, the lower prevalence of vehicular traffic in rural areas results in reduced emissions from transportation, particularly notable for urban air quality challenges. Moreover, the expansive natural landscapes and green spaces characteristic of rural areas play a pivotal role in mitigating air pollution during heatwaves. The presence of extensive vegetation serves as a natural filter, capturing pollutants and promoting improved air quality. This symbiotic relationship between rural landscapes and air quality underscores the ecological benefits offered by the rural environment, especially during periods of heightened temperatures (Tecer, & Tagil, 2014; Majra, 2011).

However, in contrast to urban areas, rural regions frequently contend with a scarcity of air quality monitoring stations and a relatively limited regulatory framework. Moreover, even they have the regulatory framework, rural authorities are not as experienced as urban ones (Ing et al., 2001). This discrepancy poses challenges in promptly identifying and effectively addressing air quality issues, particularly when exacerbated by the intensifying conditions of heatwaves. The consequence of this limited monitoring infrastructure is a reduced capacity to systematically track variations in air quality, hindering the timely detection of emerging issues related to heatwaves. Identifying pollution sources and understanding the dynamics of air quality during heatwaves becomes intricate without a well-established monitoring infrastructure (Beattie et al., 2002).

3.4. Structural Factors

The land use within and around settlements, including materials and construction density, is intricately linked to the microclimate impacts that may induce either cooling or heating effects during heatwaves. Rural and urban areas exhibit distinct construction patterns, with urban areas experiencing the Urban Heat Island (UHI) effect due to dense built-up areas and specific materials used. Conversely, rural areas tend to derive more benefits from ecological services (Nuruzzaman, 2015). This structural contrast extends to services and infrastructure, presenting different patterns in urban and rural areas, influencing the capacity for mitigation and adaptation to heatwaves, as well as flexibility, accessibility and information access in health-related emergencies. These variations contribute to divergent vulnerabilities between rural and urban areas, a topic explored within this factor (Kapucu et al., 2013).

3.4.1. Building Design and Materials

Traditional rural architecture often demonstrates a thoughtful integration of design elements aimed at harnessing natural cooling strategies. These considerations are rooted in the use of local

materials, specific architectural features, and ventilation strategies tailored to the climatic conditions of rural environments (Yao et al., 2020). Traditional rural architecture frequently relies on locally sourced materials with high thermal mass. These materials possess the ability to contribute to temperature moderation. Examples include adobe, stone, or rammed earth construction, which, due to their thermal properties, help in maintaining a more stable indoor temperature (Gou et al., 15Benmarhnia15; Beckett et al., 2018).

Certain rural housing structures may exhibit vulnerabilities to extreme temperatures due to factors such as inadequate insulation and a lack of modern cooling systems. These limitations can render these homes more susceptible to the adverse impacts of climatic extremes, particularly during periods of extreme heat. Many traditional or older rural homes might lack proper insulation, which is crucial for regulating indoor temperatures. During extreme heat, insufficient insulation can lead to higher indoor temperatures, making these homes less resilient to temperature extremes (CDKN, 2018; Klok & Kluck, 2018).

The absence of modern cooling systems, such as air conditioning or efficient ventilation mechanisms, in some rural housing further compounds the vulnerability to extreme temperatures. Cooling systems play a pivotal role in maintaining comfortable indoor environments during heatwaves. Without these systems, residents may face challenges in mitigating the impact of elevated temperatures, leading to potential health risks. Rural communities often face challenges in accessing electricity, and the affordability of cooling technologies becomes a critical concern. This energy poverty intensifies the susceptibility of rural residents to the adverse effects of extreme heat (CDKN, 2018).

Urban areas exhibit higher concentrations of buildings, roads, and other heat-absorbing infrastructure, contributing to elevated temperatures in comparison to the surrounding rural areas (Oke, 1973). Urban environments feature extensive impervious surfaces such as asphalt and concrete, which have high thermal mass and absorb solar radiation. These surfaces store heat during the day and release it at night, contributing to elevated nighttime temperatures. The increased prevalence of impervious surfaces intensifies the UHI effect. Urbanization often results in the reduction of green spaces, such as parks and vegetation, which play a crucial role in cooling through evapotranspiration (Mueller et al., 2017). The diminished presence of greenery decreases the overall capacity of the urban area to dissipate heat, further amplifying the UHI effect (Lapola et al., 2019). The density and height of buildings in urban areas influence the UHI effect. Tall structures create canyons that trap heat, restricting air circulation and exacerbating temperature extremes (Yin et al., 2018). The UHI effect alters the local microclimate, leading to temperature differentials between urban and rural surroundings (Ge et al., 2020; Okumuş & Terzi, 2021). This can impact weather patterns, precipitation, and overall climatic conditions in the urban area, influencing the resilience of the environment to extreme heat events.

3.4.2. Connectivity

The limited availability of public transportation and access to essential services in rural areas accentuates the impact of heat stress, particularly for individuals who face challenges in reaching cooling centers or accessing emergency aid. Rural areas often experience limited public transportation options, and the reliance on personal vehicles becomes more pronounced (Kamruzzaman & Hine, 2011). This poses challenges for individuals who do not own vehicles or face mobility issues. The lack of convenient transportation exacerbates the isolation of certain segments of the population during heatwaves. The isolation of rural communities poses significant challenges to their resilience during extreme heat events, impacting access to information, resources, and support networks. The lack of connectivity in rural areas can hinder the timely dissemination of early warnings and crucial information related to heat stress, exacerbating the vulnerabilities of these communities (Putzer er al., 2012). This lack of information can impede the ability of residents to proactively prepare for and respond to heat-related challenges. Rural communities may face challenges in accessing vital resources needed to cope with extreme heat, such as emergency supplies, medical assistance, and cooling facilities. Connectivity issues can hinder the efficient

coordination and distribution of these resources, further amplifying the vulnerability of rural populations during heatwaves. The lack of connectivity disproportionately affects vulnerable groups within rural communities, including the elderly, individuals with pre-existing health conditions, and those with limited mobility. These individuals may be more dependent on external support networks and services, making them particularly susceptible to the adverse effects of heat stress in the absence of reliable communication channels (Gutierrez & LePrevost, 2016).

Urban areas, on the other hand, characterized by high connectivity and accessible services. Although there might be uneven distribution of public transportation services (Ricciardi et al., 2015) and information dissemination, they have advantage of stronger infrastructure compared to rural areas.

3.4.3. Infrastructure and Technology

Energy poverty in rural communities presents a formidable challenge (Kaygusuz, 2010), limiting access to reliable cooling systems and exacerbating the impact of extreme heat indoors. This issue is further compounded by inefficient and aged housing, collectively magnifying the vulnerabilities of rural residents during periods of elevated temperatures. The limitations on solutions for heat mitigation are evident in the predominant focus on strategies tailored to urban areas, resulting in the under-prioritization of solutions suitable for rural contexts. This imbalance in emphasis has significant implications for the effectiveness and appropriateness of heat mitigation efforts, as certain solutions designed for urban environments may not be readily applicable or effective in rural areas. Certain heat mitigation solutions which may be effective in densely populated urban areas, encounter limitations when applied to rural settings. The lower population density in rural areas diminishes the feasibility and efficiency of certain mitigation efforts, leading to challenges in providing widespread relief during heatwaves (Nicholas Institute, 2023).

3.4.4. Health Care Access and Services

In the event of a heatwave, access to emergency aid and medical services is paramount. The limited availability of these services in rural areas can delay or impede timely responses to heat-related emergencies (Pristaš et al., 2009). Residents facing health issues aggravated by heat may experience heightened vulnerability due to delays in accessing essential medical support. This lack of access to medical care presents a multifaceted challenge, making it more difficult for rural residents to manage chronic conditions and receive necessary care, especially during periods of crisis (Nicholas Institute, 2023). The ongoing trend of rural health facility closures has intensified the health disparities experienced by rural populations (Xu et al., 2019). Rural residents face heightened challenges in accessing timely medical assistance and preventive services, leaving them more vulnerable to the health impacts of extreme heat (Gohlke et al., nd).

Although health service is more accessible in physical terms in urban areas, the socio-economic disparities among social groups (low income) in urban areas create economic barriers in access to health service (Pristaš et al., 2009). The inequalities in urban areas heightens the vulnerabilities in urban areas during heatwaves and emergency situations. The vulnerable groups may lack of consistent treatment in the pre-existing health issues that will be more dangerous in extreme heat situations.

3.5. Governance

The resilience of urban and rural communities to extreme heat events is intricately linked to local governance and policies. The formulation and implementation of policies in areas such as land use planning, building codes, and emergency response strategies play a pivotal role in shaping how communities prepare for and respond to heat stress.

3.5.1. Policy and Governance

Effective policies encourage collaboration across various sectors, including agriculture, health, and infrastructure. Multi-sectoral approaches promote a holistic understanding of the interconnected challenges posed by extreme heat and facilitate coordinated efforts to enhance

resilience. Policies that incentivize collaboration and information sharing among different sectors contribute to a comprehensive and integrated approach to heat stress management. The influence of local governance and policies on urban and rural resilience to extreme heat is profound. Well-designed and implemented policies provide the framework for creating adaptive, sustainable, and community-centric solutions. By addressing the unique challenges of urban and rural areas, these policies play a crucial role in building the capacity of communities to withstand and thrive in the face of increasing heat stress (Martin et al., 2018).

4. Evaluation

Rural and urban areas exhibit distinct advantages and disadvantages concerning climate change, specifically in the context of heatwaves. Table 1 provides a comprehensive summary of the factors influencing the resilience and vulnerabilities of rural and urban areas. The outlined categories encapsulate the nuanced examination conducted within this research.

The literature review reveals that urban areas face challenges during heatwaves due to heat-generating economic activities, leading to elevated temperatures and posing risks to outdoor workers. On the other hand, urban areas benefit from economic diversity, providing adaptive advantages. Rural areas leverage natural landscapes, yet economic development poses a threat, altering land use. A significant concern arises from the dominance of the agricultural sector in rural areas, making them highly susceptible to climatic variations. Consequently, rural citizens experience economic stress, compounded by heat exposure during hot summer days. The limited range of economic activities in rural areas serves as an impediment to effective adaptation strategies.

Urban areas exhibit a diverse population in terms of age, gender, race, and socio-economic status, resulting in the concentration of various vulnerabilities. Additionally, the anonymity prevalent in urban settings may lead to the isolation of individuals from their communities. Consequently, a thorough examination of the urban social structure is crucial. Rural areas predominantly house socio-economically disadvantaged or elderly populations. Despite these disadvantages, rural areas benefit from stronger social networks and traditional shared knowledge on coping mechanisms during stressful situations.

In the realm of environmental factors, rural areas hold evident advantages attributed to their natural landscapes and their harmonious integration with the environment. Rural settings facilitate the efficient utilization of ecosystem services, providing benefits such as natural cooling and air purification. Conversely, in urban areas characterized by dense urbanization and industrialization, reaping the benefits of ecosystem services becomes challenging, hindering the potential for cooling and air cleaning.

While the Urban Heat Island (UHI) poses a formidable challenge to urban areas during heatwaves, they boast a robust advantage in terms of strong connectivity. This connectivity facilitates swift access to health services, efficient dissemination of information, and the implementation of early warning systems. Additionally, the enhanced infrastructure and widespread adoption of technology contribute to the effectiveness of adaptation and mitigation actions, ensuring their accessibility to the entire population. In contrast, rural areas, despite potentially leveraging traditional materials and housing styles for climate adaptation, encounter challenges. These areas often grapple with poor connectivity, inadequate infrastructure, and limited technology integration. The absence of robust infrastructure becomes particularly problematic during emergencies, impacting the overall response capacity. Furthermore, accessing health services emerges as a critical challenge in rural areas, especially during periods of heightened heatwaves.

Finally, local governments play a crucial role in shaping climate change adaptation and mitigation actions. It is imperative that these strategies extend beyond the confines of urban settlements and encompass the surrounding rural areas. Adopting an expansive perspective is paramount, considering the diverse vulnerabilities and advantages inherent in both rural and urban

areas. A comprehensive approach that addresses the specificities of each locality is essential for developing effective and inclusive climate resilience measures.

Table 1 The vulnerabilities of rural and urban settlements.

Categories	Sub-categories	Urban Areas	Rural Areas
Economic Factors	Economic Activities	(-) Heat-generating activities (-) Heightened risk for outside workers due to UHI (+) Diversity in economic activities	(-) Landscape changes/deforestation due to economic development (-) Dependency on agricultural production and field work
Social Factors	Demographics and Socio-economic Factors	(-) High concentration of vulnerable populations	(-) Socio-economically disadvantage population (-) Elderly population
	Community Dynamics	(-) Isolation	(+) Stronger social network (+) Traditional knowledge
Environment. Factors	Natural Environment	(-) Lack of green areas and ecosystem services	(+) Green areas and waterbodies (+) Geographic location advantage
	Air Quality	(-) Lack of natural ventilation (-) Dense industrial activities	(+) Natural ventilation (+) Diminished industrial activities (-) Limited monitoring infrastructure
Structural Factors	Building Design and Materials	(-) Urban Heat Island (-) High density of built-up area (-) Heat-keeper materials	(+) Traditional methods and materials (-) Lack of proper isolation and modern cooling system
	Connectivity	(+) Developed transportation network (+) Disseminating information	(-) Poor public transportation (-) Isolation (-) Access to information
	Infrastructure and Technology	(+) Tailored mitigation and adaptation technologies	(-) Energy poverty (-) Unsuitable mitigation policies
	Health Care Access and Services	(+) Economic inequalities	(-) Limited availability (-) Isolation
Governance	Policy and Governance	Local government policy and strategies	Local government policy and strategies

5. Conclusion

Addressing the challenges posed by climate change, particularly those related to extreme heat, necessitates a comprehensive approach that encompasses various types of settlements, economic activities, social groups, and the environment. This study specifically examines rural and urban settlements, considering their economic, social, environmental, structural, and governmental factors. The findings indicate that rural areas possess advantages, particularly in terms of environmental factors and, to some extent, social dynamics. However, these areas exhibit greater vulnerability in terms of infrastructure, connectivity, and economic activities. Urban areas, characterized by diverse contexts, exhibit both vulnerabilities and advantages across all factors. The paper challenges the prevailing notion in the literature that urban areas are more vulnerable, emphasizing significant vulnerabilities in rural areas. To ensure a resilient future, equal importance should be given to both urban and rural areas, necessitating the development of a comprehensive framework that addresses the unique characteristics and challenges of each.

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Resume

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Building resilience to the expected Marmara earthquake: Preparing for post-disaster population mobility in Istanbul

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Abstract

Along with other causes of migration, earthquakes have displaced millions of people worldwide over the last few decades, forcing them to move to other settlements within the country. As an "earthquake country", Turkey, where approximately 70% of its territory is located in the seismic zone, has faced a variety of environmentally forced migration that refers to a variety of demographic movements like evacuation, flight, displacement, resettlement, as well as forced migration. Disasters and disaster-related forced migrations as an aspect of survival anxiety have severe and irreversible consequences for the existence of physical security, human dignity, health, livelihoods, shelter, and social, economic, and cultural structures and processes of societies or their subunits. Therefore, disasters and disaster-induced migration, which can be defined as a process of significant vulnerability, are considered widespread and severe threats to the enjoyment and realisation of fundamental rights. Earthquake-related forced migration phenomenon is a widespread and high-risk factor, and this risk corresponds to a closer and more destructive possibility for the province of Istanbul. Therefore becomes vital to take preventive measures to mitigate the possible destructive effects as well as to eliminate the risks as much as possible. This study aims to determine whether relevant legislation is adequate to provide an effective and sufficient protection mechanism for environmental displacement that may occur in Istanbul after a significant earthquake for the purpose of “building resilience in crisis” in the view of international standards. Thus, it also emphasises the importance of the human rights approach and legal mechanisms in establishing resilience during crises. This study has been prepared by content analysing the disaster and emergency preparedness plans, policy texts, and relevant legal and regulatory provisions related to understanding and managing the earthquake-induced migration scenario in Istanbul.

Keywords: environmental forced migration, migration scenarios, Rights-Based Approach, protection obligation, Expected Marmara Earthquake

1. Introduction

According to the Risk Management Index (INFORM), which has been modelling and measuring disaster risk since 2012, Turkey is a high-risk country (index score 5.0) in terms of overall disaster risk assessment and a very high-risk country (index score 9.3) in terms of disaster-induced forced migration risk, which is assessed as one of the subcomponents of risk (INFORM, 2018). Earthquakes are the most significant hazards posing a high risk to Turkey.

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As an "earthquake country", with approximately 70% of its land area in the earthquake zone (AFAD, Turkey Earthquake Hazard Map), Turkey has been confronted with several environmentally induced migrations. Thirty thousand people were displaced in Gölcük after the 1999 Marmara earthquake (Südaş, 2004). The forced migration movement caused by the Van-Erciş and Van-Edremit earthquakes in 2011 affected 425,000 people (AFAD et al.; Deniz et al., 2017; Açıkalın, 2017); 30,000 people were forced to leave their permanent homes after the Elazığ-Sivrice and Bingöl earthquakes in 2020 (IDMC, 2020). Most recently, in February 2023, the Kahramanmaraş and Hatay earthquakes triggered the largest disaster-induced migration ever recorded in Turkey (TC Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı, 2023, p. 25).

These experiences of forced migration in the recent past show that after the expected Marmara earthquake, disaster-related migration is an imminent, serious, honest, and significant risk factor for Istanbul due to its population, settlement, and housing characteristics. First, Istanbul is the most populous city in Turkey, a megacity facing a significant earthquake risk. According to the Address Based Registration System, 15.84 million people live in Istanbul, and the metropolitan area has a population of almost 20 million.

Second, in the earthquake scenarios/loss estimates, 45% of the buildings in Istanbul are estimated to be at risk (IBB, 2019; İSTAMP 2021). Furthermore, urban transformation envisaged in the context of resilient urban policies will be implemented as parcel-based transformation (Kuyucu, 2018, p.277). This increases the population density in the area without considering local capacity, social facilities, and infrastructure (Bektaş, 2022, p.126; Duman & Zaman, 2021).

In terms of crisis resilience, one of the indicators of local and social capacity is the adequacy and accessibility of emergency assembly areas. Assessments of the power of emergency assembly areas, based on population and high-risk building data, show that the number of public disaster parks and assembly areas that spatially ensure continuity of life and access to basic vital needs after an earthquake is insufficient (Marangoz & Enginöz, 2021, p.39). Even in the optimistic earthquake scenario (AFAD RED, 2022), it is estimated that approximately 3 million citizens will need temporary shelters. The scale of expected destruction, the inadequacy of local coping capacity, and a potentially chaotic environment indicate that a significant earthquake could trigger a severe, mass, and irregular population movement in Istanbul. Therefore, it can be stated that the current earthquake risks for Istanbul continue to increase (Erdik, 1999, p.55).

This study aims firstly to conceptualise earthquake-induced population movements in the theoretical framework (1.) to identify the preventive protection obligations of the State in this management process (2.). Second, the legislation and preparations of the public authority in Istanbul for the population mobility caused by the possible Marmara earthquake answer the question of to what extent the State could fulfil its protection obligation (3.). The data required for this analysis were obtained in two stages. In the first stage, the strategic plans, activity reports, policy texts, and relevant legislation of the highest general-level public policy actors were subjected to a content analysis. Subsequently, in-depth interviews were conducted with bureaucrats, politicians, professionals, and civil society representatives working in the disaster and migration management units at the local level.

2. Earthquakes Causing Forced Migration

Environmental living conditions are the most critical factors in human settlement decisions. It is a constant phenomenon that people leave their permanent residences in the face of the sudden or gradual deterioration of vital environmental conditions. Disasters occupy an essential place among the factors that affect vital and livelihood conditions. International organisations that monitor human mobility in the world, such as the International Organization for Migration (IOM), Internal Displacement Monitoring Center (IDMC), United Nations High Commissioner for Refugees

(UNHCR), and Norwegian Refugee Council (NRC) have shown a significant increase in forced human mobility in recent decades. In particular, earthquakes that suddenly trigger large mass movements are substantial in the disaster-induced forced migration phenomenon (Forst, 2010; Terminski, 2012; Gray et al., 2014; Thiri, 2017; Açıkalın, 2017; Sağıroğlu et al., 2023). In the last two decades, approximately 10 million people have been forced to migrate following major earthquakes in different parts of the world.

Relevant studies show that the presence of a real, severe, and imminent threat of natural and human origin; direct exposure to the destructive effects of a disaster that creates physical hazards in the dwelling, rendering the home uninhabitable; social vulnerability and social dynamics are strongly linked to the phenomenon of population mobility in the context of disasters (Warner & Laczko, 2008, p.248; Aldrich, 2012, p.54, 74; Gray et al., 2014; Thiri, 2017, p.213; Açıkalın, 2017, p.60, 120). In times of disaster, all environmental, social, economic, demographic, geographical, and political factors influence the decision to migrate (Warner & Afifi, 2009: p. 9). Among these heterogeneous factors (Cournil & Mazzega, 2006, p.418), environmental conditions tend to be compelling and repulsive factors, oriented towards survival anxiety, rather than attractive factors, expressing improvement in socio-economic conditions and prosperity (El Hinnawi, 1985, p.4; Myers, 1993, p. 752; McLeman & Smit, 2006, p.33; Adamo, 2009, p.16; Hugo, 2011, p.261). For this reason, human mobility triggered by survival concerns arising from disasters, that can be defined as environmentally problematic (Yurtcanlı Duymaz, 2021, p.73 et seq.), can be conceptualised as 'survival migration' (Betts, 2013), 'crisis migration' (Martin and others, 2004), 'environmentally induced displacement' (Adamo, 2009) or 'environmentally forced migration' (Yurtcanlı Duymaz, 2021). Forced migration due to disasters refers to a variety of demographic movements such as evacuation, flight, displacement, and resettlement, as well as forced migration (Oliver-Smith, 2006). Because of data limitations, disaster-related population mobility studies have analysed all types of movement in a single migration datum (Hauer et al., 2020, p.1438).

Therefore, disaster-induced population movement involves an element of necessity. The element of "necessity" can be defined as "the involuntary (subjective criterion) abandonment of the place of residence due to the lack of favourable conditions to ensure the continuity of life or to satisfy vital needs" in a safe manner or due to the existence of a serious and real risk in this regard (objective criterion) with the urge to survive (subjective measure)" (Yurtcanlı Duymaz, 2021, p.77). This "necessity" is a continuum ranging from planned mobilisation to the last resort of flight (Hugo, 1996, p.107).

Earthquakes, a phenomenon that suddenly triggers a fear of survival, affect the livelihoods and living conditions in the affected area. Individuals, families, and communities must leave their places to survive. Therefore, earthquake-related population mobility tends to be collective and irregular. However, the timing, direction, duration, and subjects of this mobility exhibit variations and differences in each specific case.

The term "migration decision" in a time of crisis means both a decision to move and a location decision. Despite the destructive power of natural disasters, the deterioration of living conditions during sudden catastrophes such as earthquakes is mainly a local phenomenon. Furthermore, individuals, families, and communities facing sudden disasters have comparably less time to make migration decisions (Curtis et al., 2015, p. 1273). Therefore, the population affected by a sudden disaster tends to move within the borders of the country in which they live. The masses tend to migrate to the outskirts of the city where they live, to a neighbouring town, or to another region of the country with an urge to survive (Smith & McCarty, 1996, p.271; Paul, 2005, p.379; Warner & Afifi, 2009, p.72; Curtis et al., 2015, p.1273). Disaster-induced migration is, therefore, not a phenomenon limited to the mobility of those leaving the disaster area. In other words, those who do not leave the disaster area and continue to struggle to survive during and after the crisis but cannot live in their permanent residence are also included in the disaster-induced forced migration movement (Renaud et al., 2011, p.14, 15; Millan, 2015, p.56. For an opposite view, see Ferris, 2014, p.5.). At this point, there should be no other reasonable settlement alternative in the country of

origin for out-of-country migration to be considered within the scope of forced migration (Mayer, 2017, p. 31).

In addition to the frequency and severity of earthquakes, individual adaptive capacity, (Perry et al., 1981; Açıkalın, 2017, p.301), socioeconomic status (Stallings, 1984, p.12), capability to access essential public services (Ambrosetti & Petrillo, 2016, p.87), and dependency factors such as family relationships, social relationships, livelihood opportunities, asset status, etc. (Houts et al., 1988), home ownership and long-term residence (Smith & McCarty, 1996, p. 268), hometown ties (Ambrosetti & Petrillo, 2016, p. 84) and the affiliation (Orhan & Keskinok, 2019, p.366) of the affected populations and their preferences between two separate migration systems - evacuation and migration - (Hauer et al., 2020, p.1438) add to the diversity of manifestations of disaster-related forced migration.

Although it has a destructive power, in sudden catastrophes such as earthquakes, vital conditions deteriorate to the extent that they can be repaired. For this reason, the masses tend to migrate temporarily (Renaud et al., 2011, p.14). However, the length of the post-earthquake recovery period and distance can make population mobility permanent. (Smith & McCarty, 1996, p.267). The research has shown that those with greater individual capacity and social capital tend to migrate permanently. By contrast, those who do not have these personal and social capacities are forced to move within the short-distance evacuation system offered by the State (Hauer et al., 2020, p.1453).

On the other hand, post-earthquake migration has processual significance beyond the acute response (Oliver-Smith, 2019; Spitzer et al., 2020; Hauer et al., 2020). Disruption of the energy supply in the earthquake zone, lack of safe access to necessities such as food-water-housing, or the emergence of situations that trigger epidemic risks such as water pollution can lead to the continuation of forced migration mobility after a disaster. After an emergency and acute situation, the availability of vital livelihoods and economic losses may indicate processuality. Furthermore, post-earthquake adaptation problems can trigger new migratory movements.

Table 1 The possible effects of the phenomenon of destructive earthquakes on the mobility of the population can be illustrated in the following scenario (Yurtcanlı Duymaz & Duymaz, 2022: 40)

Pre-disaster period	Planned evacuation of high-risk residential areas by the governments of the countries
Rapid-onset disaster period	As a result of - Destruction or severe damage to the permanent dwelling, - Failure of essential infrastructure services, - Failure to meet basic needs such as water, food, and shelter in a safe, adequate, affordable, non-discriminatory, and impartial manner, - The emergence of secondary disasters such as epidemics, - Long-term loss of livelihoods and employment opportunities, - the development of armed conflicts over vital essential resources, Etc. Living spaces become virtually and safely uninhabitable after a disaster. In times of crisis, mobility occurs in two ways: - Individuals, families, and groups of individuals leave their permanent residence as far as possible or - Mass evacuation with the intervention of public authorities.
Recovery period	Finding a durable solution for IDPs: - Return home, - Local integration, - Relocation within the country

In other words, earthquake-related displacement has a meaning beyond acute mobility. It is necessary to evaluate the relationship between disasters and displacement as a holistic process (Yurtcanlı Duymaz, 2021, p.308). In this context, it is essential to express the State's obligations regarding disaster-induced forced migration using a processual approach.

3. State Protection Obligation in the case of Disaster-Related Forced Migration

The link between disasters and forced migration is a reality recognised by the international community, and this reality has been defined as the greatest humanitarian crisis of the 21st century (Sendai Framework for Disaster Risk Reduction 2015-2030; UN Agenda for Humanity, 2016; 2030 Sustainable Development Goals, 2016; Nansen Initiative, 2015). Regardless of when it occurs and where it originates, a disaster affects the living conditions and livelihoods of children-adults-elderly, women-men, disabled-not disabled, minorities-majorities, citizens-foreigners, black-white, rich-poor, believers-non-believers, regardless of political-apolitical distinctions. Disasters have severe and irreversible consequences for the existence of physical security, human dignity, health, livelihoods, shelter, social, economic, and cultural structures and processes of societies or their sub-units (Fritz, 1961, p.655). Disaster-induced displacement triggered by this destructive impact on fundamental rights and vital needs appears to be an aspect of survival anxiety. Disaster-induced displacement is, therefore, an extension of the right to life (Prieur, 2016, p.131; Cournil, 2006, p.1047-1048).

On the other hand, disaster-induced forced migration is one of the indirect and secondary effects of disasters, as it causes permanent economic, social, personal, and property losses. Displaced by disasters may lose all their assets, face safety and health risks, and risk losing their identity, social networks, and culture (Oliver-Smith, 1999). Vulnerable groups with specific protection needs may suffer significantly different and more severe losses (Enarson & Chakrabarti, 2009; Mehta, 2009). This displacement is thus a situation that further exacerbates existing vulnerabilities (IASC, 2011; Sendai Framework 2015-2030) and increases the tendency towards impoverishment (Cernea, 1999). In this context, disaster-induced forced migration is directly referred to as a secondary disaster, as it triggers individual and social destruction and trauma (Oliver-Smith, 2019, p.10). Earthquakes are a primary type of disaster that bring out this secondary disaster effect (Forst, 2010; Ambrosetti & Petrillo, 2016; Thiri, 2017).

Therefore, disasters and disaster-induced migration, which can be defined as a process of significant vulnerability, are considered widespread and severe threats to the enjoyment and realisation of fundamental rights (Kalin, 2005; HRC, 2011; Lavieille, 2012, p.372; CADHOM, 2013; Millan, 2015, p.56; UN International Law Commission, 2016; Mcdermott, 2018, p. 85-87; Yurtcanlı Duymaz, 2021, p.157 et seq.). In other words, this threat to fundamental rights raises the necessity of the State's obligation to protect the security of life and property of individuals (ECHR, Öneryıldız/Türkiye, 30/11/2004, §71; ECHR, Budayeva et al./Russia, 20/03/2008, §128, 130; ECHR, Kolyadenko et al./Russia, 28/02/2012, §158), which is the most fundamental raison d'être of the State in all circumstances (Locke, 1970; Dias & Crawford, 2013, p.142). In this context, the State has a 'duty to protect', which can be expressed as the prevention of disaster risks and the minimisation of damage resulting from disasters.

The State has both negative and positive obligations concerning disasters and disaster-induced displacements, which are widespread and high-risk factors. Negative duty requires the State not to engage in interventions that impede the building and development of individual and institutional capacities to identify the risk of disaster-induced displacement and to reduce and respond to related vulnerabilities. In this context, the existence of situations that impede the right of individuals to be informed about the risk of disaster-induced displacement and the management of the displacement process, or the existence of restrictive practices against organised struggle, which is critical in building resilience in the crisis process, can be considered issues that constitute a violation of the negative obligation.

The positive obligation (for an explanation of the theory of positive obligation, see Boyar, 2013) imposes a duty on the competent authorities to take "substantive and procedural" (ECHR, Öneryıldız/Türkiye, § 89-118; ECHR, Budayeva et al./Russia, § 131) Positive steps to ensure favourable and adequate protection. In the legal dimension, the State has broad discretion to determine "reasonable" methods and means to fulfil its positive obligation. However, for the

chosen instrument to be considered "reasonable", it must be capable of providing adequate, favourable, and effective protection against concrete dangers and risks. As part of soft law (Cournil, 2009, p. 7), The "Guiding Principles on Internally Displaced Persons" (Kalin, 2005), which have been in force since 1998, can be selected as the primary reference standard for identifying rights-based, objective criteria for 'adequacy'. In addition, international policy, and practice recommendations (IASC, 2011) aimed at identifying disaster-related migration risks, assessing needs, and identifying and disseminating good practices in risk and crisis management can also be considered as supporting resources. Finally, the UN Sendai Framework for Action 2015-2030, which deals with positive obligations in the context of the preparatory phase, sets out priorities for action in a political context. In this context, the phenomenon of positive obligation is embodied in a range of activities: from identifying and understanding disaster-related migration risks to assessing them; from establishing the necessary legal and administrative framework to building the organisation that will implement it; from defining emergency and response policies to researching and planning the relevant steps; and from supporting social awareness and implementation through exercises and training to establishing participatory and collaborative migration process management that can be further replicated.

Table 2 Human rights-based requirements of disaster displacement process management in light of the Guiding Principles and the Sendai Framework

Before displacement	During Displacement	After Displacement
Preventing the risk of displacement: - Principle of non-arbitrary relocation - Principle of last resort Preparing for the risk of displacement - Understanding the risk - Collaborative and holistic planning - Investing in risk reduction for resilience	The principle of non-coercion: - Evacuation procedures - In temporary accommodation procedures The principle of security of basic needs without discrimination: - Adequate standard of living - The right to humanitarian assistance - Positive discrimination in favour of disadvantaged groups	Achieving a durable solution: - No space and time constraints (long-term safety and security) - Willingness - Conscious choice - Access to information - Participation and oversight mechanisms - Right to an effective remedy

The performance and priorities of competent authorities, who have the duty and responsibility to realise individual, social, and institutional resilience, are crucial for the damaging effects of earthquakes. For the purpose of “building resilience in crisis”, it has become necessary to answer whether the preparations and relevant legislation are adequate to provide an effective and sufficient protection mechanism for environmental displacement that may occur in Istanbul after a significant earthquake.

4. Preparing for Disaster Related Forced Migration Risk in Istanbul After a Possible Major Earthquake

For a long time, Turkish disaster management focused only on crisis management, and relevant legislation prioritised crisis management concerns. In other words, the Republic of Turkey has limited its disaster protection obligations to crisis management. Although a fundamental law on crisis management has been in force since 1959 (Law No. 7269 on Measures Relating to Disasters Affecting Public Life and Relief Assistance), each crisis requires the adoption of a new legal act. In other words, the legislation on disaster process management and planning is not in a holistic structure and is a set of fragmented and complex rules (Azimli Çilingir, 2019, p.210; Genç, 2021, p.151, etc.). Following the Marmara earthquakes in 1999, the Republic of Turkey adopted a preventive approach to disaster management and gave it a legal and political form (Genç, 2021, p. 279). On 24 February 2022, in addition to 7269, the Regulation on Disaster and Emergency

Response Services established the legal framework[1]. The presidential decree enacted the final version of Turkey's Emergency Management Plan (TAMP)[2]. Therefore, the framework for the obligation to provide effective and adequate protection in terms of resilience in a crisis is offered by disaster and emergency preparedness plans, and legal and regulatory provisions.

The TAMP, prepared under the coordination and guidance of the AFAD and expressing the preparatory phase of disaster management at the national level, has adopted a clustering approach and a multi-level governance model (Marks & Hooghe, 2004) in crisis management. It defines the distribution of tasks related to disaster and emergency planning and management at the national level with 26 working groups and assigned responsibilities at the ministry level. The TAMP has also been a reference source for defining roles and duties at the provincial level. The TAMP and the Provincial Disaster Response Plans include “mass and irregular population movements” and “the need for evacuation and settlement” among the main assumptions to be considered during earthquakes. This provision can be described as a very ‘limited’ but first severe step by Turkish disaster management towards addressing the risk of earthquake-induced migration.

The public authorities' view of the relationship between disasters and migration is limited because the risk of displacement caused by disasters is assessed and dealt with using the concept of “evacuation”. The term “evacuation” means an acute and temporary displacement as an emergency solution (AFAD, Glossary of Disaster Management Terms; Article 15(11) of the Regulation on Disaster and Emergency Response Services of 24.02.2022). However, an analysis of national legislation shows that it does not provide for long-term or permanent displacement in the face of disasters, where reconstruction and return may take time, and location decisions may be shaped by human and social capital connections. In accordance with the TAMP, the Istanbul Provincial Disaster Response Plan (ISTAMP) handles the risk of disaster-related forced migration limited to acute mobility.

The Evacuation, Settlement and Planning Working Group conducted studies to understand, assess, and manage the risk of displacement in Istanbul following a possible major earthquake. Concrete steps in evacuation planning could only be taken after 2020 when the Istanbul Provincial Gendarmerie Command was designated as the leading solution partner of the working group. Previously, this planning authority was given to the Istanbul Provincial Directorate of Migration Management, whose expertise, experience, and staff were limited to protecting foreigners and regularising foreign migration. On the one hand, this authorisation gave the impression that forced migration after the earthquake was not considered a real risk factor for citizens. It also led to the conclusion that the criteria of "professionalism" and "expertise" were not included among the indicators measuring the success of planning. The Istanbul Provincial Operational Plan for Evacuation and Settlement was completed in 2021 and can be updated anytime.

Plans for local preparations to ensure the operationalisation of the Istanbul evacuation plan are still underway. Meso-level district intervention plans are prepared using a top-down approach rather than a participatory and collaborative approach that does not subjectivise the variable local needs, existing capacities, and vulnerability levels of local units. While this non-participatory approach keeps local entities limited and secondary in the system (Genç, 2021, p.210), it also risks ignoring their existing institutional and managerial capacities during the preparedness process. Crisis preparedness with this approach does not allow local actors, who have roles and responsibilities in operations during and after disasters, to develop their ability to take authority on the ground (Yurtcanlı Duymaz & Kahveci, 2023, p.15). However, the operational success of emergency and response plans is only possible if each working group distributes authority and responsibility in a fair, open, and equitable manner in its vertical relationship (main support solution partners) (Genç, 2021, p.212; Budak, Kahveci, & Tiryaki, 2022, p. 193).

[1] See the Official Gazette dated 24.02.2022. https://www.resmigazete.gov.tr/eskiler/2022/02/20220224-31.pdf.
[2] See https://www.afad.gov.tr/kurumlar/afad.gov.tr/e_Kutuphane/Planlar/TAMP.pdf.

As far as the quarter-scale is concerned, micro-level preparations have started to be developed, especially after the earthquakes of February 2023. The lack of prioritisation of preparations at the local level indicates a lack of prioritisation in terms of the applicability of intervention plans. At this point, the planning process for managing the crisis phase should evolve into a participatory approach that supports the capacities of all local actors, especially local administrations, and civil society (Genç, 2023, 28).

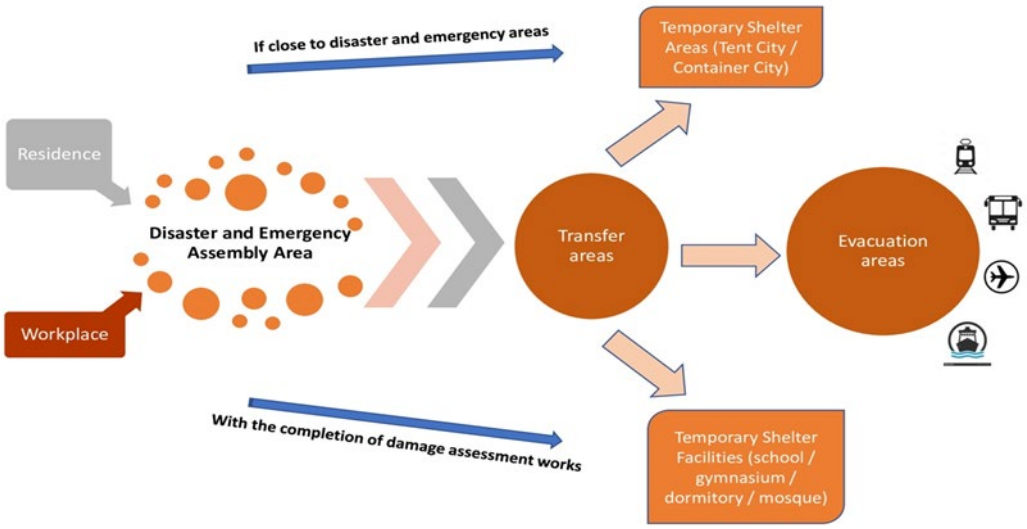

Figure 1 Istanbul Macro Level Evacuation Scheme - The Evacuation and Settlement Operational Provincial Plan 2021

Preparations for the mobility of the population after a disaster in Istanbul focus on evacuation and temporary shelter processes organised by public authorities. Regarding population mobility after a major earthquake, evacuation planning in Istanbul should include citizens who will be sent to other locations within the country and tourists who will be sent to their home countries. The basic limit for those who will act on their own is the rule of not moving for the first 72 hours. Support for these is limited to covering their travelling expenses.

In the Provincial Operational Plan for Evacuation and Settlement, evacuation is conceived as a process to be carried out with the consent of the disaster victims. As a rule, the principle of non-coercion about evacuation and the temporary shelter process after the disaster are included in the planning. However, it has also been noted that, depending on the destructive power of the expected earthquake, evacuation may become a mandatory practice, as it is a solution that supports and facilitates the "response" and "recovery" process.

In line with the principle of meeting basic needs without discrimination, the operational evacuation provincial plan identified persons with disabilities, children, the elderly, and women as priority groups for evacuation. However, the 'irregular foreign population', considered another vulnerable group, is yet to be included in Istanbul's disaster response and operational plans. Furthermore, there needs to be more planning for those needing to remain in Istanbul. The capacity study for assembly areas and temporary shelter needs was conducted based on citizenship criteria. The Sendai Framework for Action, on which the TAMP is based, emphasises risk assessment, especially for vulnerable groups at high risk of displacement. Given the number and density of undocumented people living in Istanbul, there is a severe data gap. This ignoring perspective exposes the risk of dealing with much larger crowds than anticipated in the disaster area during a crisis.

Therefore, social vulnerability analyses must be conducted (Flanagan et al., 2011; Kalaycıoğlu, 2021) while determining the risk status of cities in the face of earthquakes (Thiri, 2017, 213; İBB, 2018). Deprivation and poverty are common causes of social vulnerability that increase vulnerability to disasters (Wisner et al., 1994). To understand and manage the forced migration scenario of a possible major earthquake, a detailed presentation of the state of social vulnerability

in Istanbul is necessary; this is because Istanbul is a vulnerable megacity due to its cumulative subjective conditions such as cultural and historical richness, geopolitical location, dense and overpopulation, cosmopolitan social structure, irregular and rapid urbanisation practices, and its place in the national economy. To understand the risk, the vulnerability data must be accurate and up to date. However, it has been observed that there are deficiencies in the exchange of information between central and local administrations and even within the units themselves during the preparation and planning processes. At this stage, the Law 6698 on the Protection of Personal Data and political concerns were the main obstacles to information sharing. The need for an information network covering the micro level with the flow from the community - local administration - and governorate for possible mass population mobility after an earthquake should also be expressed. It was found that identifying and preparing for risk scenarios in Istanbul is based on estimation rather than data. The need for an information network covering the micro level with the flow from the community - local administration - and governorate for possible mass population mobility after an earthquake should also be expressed.

İSTAMP 2021 has established a set of fundamental principles based on human rights in all planning and response activities related to disasters and emergencies, as well as in the preparation of all relevant working groups. In this regard, the following are envisaged:

- The priority of all activities during and after disasters and emergencies is to save lives, protect human health, and ensure the safety of life;

- Interventions and pre-rehabilitation activities should not involve conduct that violates human rights and offends human dignity;

- The sensitivities of individuals and society will be respected during response and pre-response activities;

- All actors involved in the process are obliged to act by the principles of truthfulness, honesty, and impartiality;

- Individuals must not be discriminated against based on differences such as age, identity, gender, ethnic origin, religion, language, sect, disability status, sexual identity, political opinion, etc., and disaster victims must not be asked to disclose such information (except age and gender for health reasons, religion for burial, disability status for the organisation of special services);

- Priority will be given to vulnerable people (elderly, children, pregnant women, disabled people, etc.);

- Information communicated about the disaster and emergency should be clear, understandable, consistent, and based on concrete facts and data;

- Information should be provided with appropriate frequency, and the language used should consider the sensitivities of both the event and the community affected by it;

- All decisions taken about disasters and emergencies (before, during, and after) should be legal, ethical, impartial, and based on certain universally accepted principles and where appropriate, those making the decision should be accountable to those who will be affected by the decision; therefore, the prerequisite for accountability is transparency and adherence to the principles of the rule of law;

- Channels for individuals to obtain information should be kept open;

- Decisions should be supported as far as possible by documentation, and intervention methods that cannot be monitored and evaluated should not be used.

Although these principles express the possibility of dealing with the forced migration scenario and the management of the possible Istanbul earthquake with a human rights-based approach, it is believed that these principled assumptions will remain adequate and appropriate if they are not supported by a legal framework (Zartner Falstrom, 2002; Cournil, 2006, p.1047,1048; Delmas-

Marty, 2012, p.574; CADHOM, 2013; Prieur, 2014; Zetter & Morrissey, 2014, p.69; Sironi & Guadagno, 2018, p.309; Yurtcanlı Duymaz, 2021, p.313 et seq.). The Turkish Disaster Response Plan 2022, which came into effect on 15 September 2022 with a presidential decree and disaster laws and regulations, did not include these basic principles.

Within the framework of legal and administrative regulations, crisis management is shaped by the priority of the institutional organisation, as can be seen in planning practice. Regulations are either silent on judicial and administrative responsibilities (Genç, 2021, p.195 -215) or are constructed with language that gives practitioners broad discretion and an irresponsible understanding of imposing obligations (Yurtcanlı Duymaz & Duymaz, 2022, p. 44 etc.). This approach makes it impossible to monitor and control whether adequate protection is realised in practice 'fully' and 'without fail' (Kalin, 2005; IASC, 2018; May & Daly, 2018, p.28,29); this increases the risk of severe disruptions at all stages of support and assistance to those affected by disasters in general and those displaced by disasters in particular (Oliver-Smith, 2019).

Table 3 Comparison of all the provisions we have put forward in terms of national disaster legislation with international standards for the protection of people displaced by disasters.

International standards for building resilience to crises (Guiding Principles on Internal Displacement)	**National legislation for crisis resilience (Law No. 7269, Regulation on Disaster and Emergency Response Services, TAMP)**
Personalised, rights-based process management	State-oriented, institutional functioning, and organisationally-based crisis management
The displaced person in a disaster is an active actor in the process.	The victim of a disaster is in a passive position.
Diversity, equity, and inclusion in disaster relief	Potential for discrimination in disaster response due to - Uncertainty - Arbitrariness
Inclusive positive discrimination in favour of groups at a disadvantage	Positive discrimination in favour of vulnerable groups - limited and discretionary
Transparent, participatory process management that can be monitored and audited	Insecure, coercive, and arbitrary crisis management

The phenomenon of forced migration is a widespread and high-risk factor, and this risk corresponds to a closer and more destructive possibility for the province of Istanbul. However, İSTAMP and the related operational plans (at the macro level) are insufficient about the priority of "understanding the risk of earthquake-induced forced migration in Istanbul", and the relevant legislation is inadequate to provide an adequate protection mechanism for displaced persons. It was noted that the disaster legislation does not show a rights-based understanding and does not contain any significant regulation that provides national-level guarantees for the fundamental rights and freedoms of those who have to leave their homes due to disasters.

5. Conclusion

In terms of disaster and emergency preparedness in Istanbul, it is observed that there is a tendency to become more concrete and increasingly applicable in provincial planning. This dynamic planning approach and preparation process shows that the preparations against possible earthquake hazards are open to improvement to achieve more effective and efficient results (Genç, 2021, p.239 et seq.). However, a change of approach is essential for this improvement.

In this context, firstly, 'law' must be seen as one of the most fundamental tools for ensuring resilience in crisis. To this end, a legal framework supported by mechanisms to protect fundamental rights and freedoms is essential for those displaced by disasters. In order to answer the question of how these people can benefit from practical and adequate legal protection, it is essential to determine the protection status of those who have to leave their permanent place of residence due to disasters (Kalin, 2005; Biermann & Boas, 2008, 2010; Docherty & Gianni, 2009; Prieur, 2012; Sironi & Guadagno, 2018; Yurtcanlı Duymaz, 2021).

Second, it is necessary to interpret the concepts of disaster-related forced migration scenario and displacement risk broadly from a "community-based disaster management perspective" (Kadıoğlu, 2013). Understanding, planning, and managing the disaster-related forced migration scenario is not limited to managing acute and temporary mobilities during the crisis. On the other hand, prioritising life-saving acute evacuation practices instead of realistically understanding and trying to prevent the risk of disaster-related displacement points to a reality that increases the risks of permanent forced migration itself (Ginnetti, 2015).

In particular, the economic and social consequences of prolonged displacement have a significant impact on a country's ability to achieve its overall development goals (Oliver-Smith, 2019; Spitzer, et al. 2020). A destructive earthquake can change the economic, social, and demographic structure of the place where it occurs. It also has the potential to transform the demographic, social, economic, political, and urban fabric of a country due to the strategic location of the disaster area (Spitzer et al. 2020). This determination points to a significant risk, especially about the earthquake that awaits the megacity of Istanbul. Although the probability of a devastating earthquake is very high, a long-term migration strategy has yet to be defined for Istanbul at the national and local levels; this is a failure to fulfil the obligation to protect.

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Resume

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Crisis and resilience in psychology

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Abstract

Crises that occur after natural disasters are real and serious issues that can cause serious depression. A crisis is a situation in which a smooth process suddenly turns into a depression with negative, dangerous consequences. Since our country is in an earthquake-prone region and has experienced earthquakes with great losses, it has a very traumatic history. The concept of crisis, which spreads over a wide area, is a phenomenon that needs to be talked about by drawing boundaries. Natural disasters cause crises, and crises cause trauma. Resilience is the most effective way to deal with natural disasters and the traumas that follow. Resilience can be considered as the ability to adapt to the adverse conditions caused by external factors causing the crisis for disaster management. Psychological resilience is defined as the ability to cope with the negative consequences that may follow a natural disaster and adaptation to a negative situation. The phenomenon of resilience is important for both the individual and the society in societies where major natural disasters such as earthquakes are experienced. This definition of psychological resilience points to an approach that leaves the individual on his/her own in the face of disaster, crisis, and trauma by placing a great responsibility on the individual. However, individuals who have been exposed to natural disasters should not be left on their own and all opportunities should be mobilised to help them. Passive exposure to the wounds caused by natural disasters decays both the individual and the society. Instead, engaging in emotional, mental, social, and artistic investments and taking part in new and multiple fields will benefit the individual and the society in order to tackle the wounds.

Keywords: resilience, earthquake, psychology

1. Introduction

A crisis is a situation in which a smooth process suddenly turns into a depression with negative, dangerous consequences. Crises can occur in the economy, climate, politics, social processes and individual physical and mental health. The concept of crisis, which spreads over a wide area, is a phenomenon that needs to be talked about by drawing boundaries. For example, crises that occur after natural disasters are real and serious issues that can cause serious depression. Since our country is in an earthquake-prone region and has experienced earthquakes with great losses, it has a very traumatic history. Although earthquake experiences of Turkey are considered to be a thing of the past, they still carry unresolved burdens. The fact that earthquakes will not cease to occur makes it obligatory to make rapid and urgent plans and take precautions for the crises that will occur. Crises can occur in many different areas, or they can occur in a single area and affect all areas. The crisis caused by a natural disaster covers a wide range of phenomena from resilient buildings to resilient mentalities. The wide spread of resilience multiplies and diversifies the work to be done and the measures to be taken. Resilience can be considered as the ability to adapt to the adverse conditions caused by external factors causing the crisis for disaster management (Kundak, 2017). For psychology, disaster and post-disaster crises can be evaluated from different

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perspectives. In general, what is expected from psychology is the trauma and the resilience developed against trauma, even before the disaster occurs. However, as well as individual exposure to trauma and resilience, exposure to trauma and resilience on a social level should also be taken into consideration. Trauma and resilience are two opposing concepts that have no meaning without each other. Traumas are situations that disrupt the physical and psychological integrity and balance to which an individual or individuals are exposed. The exposed event inflicts wounds that are either easy or difficult to cope with. The healing of the wounds varies according to the resilience or recovery skills constituted by the individuals and the environment. In social psychology, resilience or recovery skill is defined as the ability of people to heal their wounds to rebuild the old structure after a traumatic event. In other areas of psychology, resilience is defined as an individual trait and is also seen as a developable trait. The scientific validity of this understanding is open to debate.

2. Resilience, Disasters and Psychology

In the field of psychology, resilience has been emphasised in studies on individuals and children at risk of developing psychopathology after the World War II. After the studies, there has been a tendency to consider resilience as an individual characteristic, a process or a result. Resilience has often been examined in cases where psychopathology is not observed or within the context of evaluating various personality traits (İkizer, Karancı, & Doğulu, 2016). Psychological resilience is defined as the ability to cope with psychological difficulties, to tolerate restrictions on life, not to lose the will to live in the face of negative life events such as trauma, death and loss, not to lose mental balance despite all negative conditions, and not to lose the ability to adapt regardless of the conditions (Karaırmak, 2007). Psychological resilience is a complex concept in which individuals are thought to effectively develop a positive adaptation process in the face of great challenges. According to this definition, resilience is the ability to maintain mental health or to remain healthy in the face of difficulties despite adverse conditions. Like character and personality, resilience is sometimes thought to be an innate character trait. It is also considered as a predisposition developed as a part of the process of specialisation in certain abilities through experiences in the context of environmental change as well as biological, psychological and social aspects of the individual experiences (Okuyama, Funakoshi, Tomita, Yamaguchi, & Matsuoka, 2018). It is also referred to as the ability to recover from trauma, deprivation, threat or stress (Atkinson, Martin, & Rankin, 2009). The evaluation of resilience due to disasters and the crisis and trauma during the post-disaster stage has attracted attention (Wang, Shi, Zhang, & Zhang, 2010). Disasters are a potential problem of international importance. Disasters interrupt the daily lives of individuals and societies. Psychological resilience is defined as the ability to cope with the negative consequences that may follow a natural disaster and adaptation to a negative situation. Resilience is the ability to successfully adapt to exposure to a significant threat, severe distress, and stressor. Other mediating factors include disaster readiness, indirect trauma, understanding issues such as compassion, fatigue, burnout, and having an idea of one's own responses to stressors (Trip, Kosta, Maskill, Richardson, Dolan, Josland, McKay, Richardson, Cowan, Hickmott, & Houston, 2018). The phenomenon of resilience is important for both the individual and the society in societies where major natural disasters such as earthquakes are experienced. This definition of psychological resilience points to an approach that leaves the individual on his/her own in the face of disaster, crisis, and trauma by placing a great responsibility on the individual. However, individuals who have been exposed to natural disasters should not be left on their own and all opportunities should be mobilised to help them. Passive exposure to the wounds caused by natural disasters decays both the individual and the society. Instead, engaging in emotional, mental, social, and artistic investments and taking part in new and multiple fields will benefit the individual and the society in order to tackle the wounds (Bilgin, 2016). Psychology is generally expected to heal these wounds with the magic wand that it is almost assumed to have. Science has not yet found such a way. It is appropriate to consider what psychology can do within its limits to make resilience viable, especially in the post-crisis phase.

It can be expected that the effects of disasters can be immediately understood and eliminated by psychology. In daily life, psychology is defined as a science that produces formulae that enable people to control their emotions. Psychologists are defined as people who know how to regulate people's emotional states and solve problems with endless goodwill and understanding. Of course, this definition between a mother and a nurse is not correct, but this is generally the expectation. The first feature that requires us to move away from this definition is to recognise that human beings are not only made up of emotions and that the science of psychology is not only responsible for the healing of emotions. Concepts such as deprivation, mourning or grief, which have important cultural equivalents, are concepts that need to be dealt with in all dimensions of psychology. Psychology consists of many dimensions including psychological, cognitive, developmental, and social aspects. The relationship that individuals establish with themselves and the world, the way they produce these relationships, what other people have created before them, and everything that creates the present time of human beings is the subject of psychology. The human spirituality is located in a different sphere from what is going on in the surroundings. The space of the individual's relationship with self is spirituality. Losses have a crucial impact on the human psyche because losses require rebuilding of the order. Scientific psychological studies conducted to date indicate that losses should be evaluated distinctively from other life factors, both cognitively and psychologically. Crisis leads to trauma; trauma leads to loss, anxiety, fear, and mourning processes. Anxiety and fear are commonly felt emotions that belong to human beings. Managing anxiety and fear are the cornerstones of the human psyche. Grief after loss is a process that needs to be addressed, analysed, and regulated. Loss and the grief after loss begin as a self-overcoming process which the individual must manage on his/her own. But it does not always end and cannot be dealt with.

In the aftermath of disasters, it may take a long time for the crisis to be resolved, the effects of the trauma to be reduced, the mental balance to be restored, the outside world to become in accordance with the rules, and the usual environment and social environment to become ordinary and legitimate. Undoubtedly, the cognitive structures and environmental conditions that support the formation of social behaviour are indispensable elements for spirituality. However, repairing the losses of individual spirituality may require more effort. In short, daily life practices can be continued. But when you lay your head on the pillow at night, your conversation with yourself is important for waking up in the morning. That is if you have a pillow to rest your head on (Narter, 2020). It takes time to be able to grieve after a loss, to know that it is necessary to grieve and to accept mourning as a normal process. Each loss will be a reminder of previous losses. Disaster losses cannot be limited to loss of life. The houses, the neighbourhood, the grocery stores, the markets, the playgrounds, the schools, the bagel seller who is greeted every day, or the whole city may have been lost. Depending on the maturity of the self and the ability to soothe oneself, the spirituality will regress to the reminiscence of the first loss. With each subsequent loss, we start again from the point of the first spiritual loss. This first experience provides guidance in dealing with losses. In this sense, the losses also come from the outside as the other. But it is faced in spirituality. Only the spiritual construction itself knows the bond it will establish with the other. The bond with loss is established through mourning.

Cultural structures are the most important supporter of the individual during the mourning process. Continuing to live together is essential in culture. Death is the irreversible end for every individual. The loss of each relative serves as both an end and a remembrance of one's own death. Every culturally developed and religiously enriched death ritual is of great importance. Although it is believed that funeral gatherings and ceremonies after the death and the fulfilment of religious rules are important and necessary for the deceased. In fact, they are equally important and necessary for the ones left behind. Firstly, the person experiencing the loss needs to pay their debt of loyalty to the deceased and fulfil their duty completely. Then they must fulfil what their culture and beliefs expect of them. Because they need to be a good person. The individual encounters death and remembers that death is the ultimate reality. Therefore, individuals need to bless life and must continue to carry on living with their losses where death has left off. But this is a very

difficult experience. Culture is an important source of guidance. Every culture offers its members a form of mourning. The fact that this can be realised under customary conditions is an important gain in the spirituality of the person who has suffered loss. Human life cannot be completed without experiencing any loss. Every loss makes us question the meaning of life once again. It interrupts hanging on to life, enjoying life, producing, and creating new things. If the mourning experienced after the loss does not consume the individual's self-power, the individual finds the power to breathe again. Another situation that should be pointed out here is that losses are not only the loss of loved ones or their representation. The fields of psychology and often psychiatry have structured their theories on this psychological dimension and have made important explanations. But the endeavour here is about curing patients and diagnosing, identifying, and treating mental disorders. And so it should be. Loss, grief or mourning do not always declare their independence through a mental disorder. For example, indefinite grief can last a lifetime. Uncertain loss is one of them. These concepts, to which psychology and psychiatry seek answers today, have been on the agenda since the moment humans meet death. When non-psychological dimensions of psychology are involved, the process of mourning can be explained in other ways.

In Türkiye, funeral rituals are highly valued and carefully elaborated. Respect for the deceased and their relatives is an important cultural value. The desire to preserve the lost and not to forget them is very deep. Death is a situation in which this culture actually prefers to bless life. Deaths are manageable as long as this cultural sensitivity is kept alive. In the absence of funeral ceremonies, prayer events and condolence visits, the process becomes more challenging. The mourning process is, of course, unique to the individual. But every individual expects the country in which he/she lives to help him/her to calmly recover from this disaster that has befallen him/her through no fault of his/her own. The emotion that arises at the end of this process is hope. Hope indicates and even convinces that there is a life worth living. Almost the entire surface area of our country consists of fault lines. However, no progress has been made on measures to deal with earthquakes and the damage they may cause. Therefore, it cannot be said that governments and the state promise their citizens a life worth living.

3. Norms and Information that Change with Disasters

Disasters also rewrite the norms of daily life. Changes in norms require people to rebuild their social behaviour. Social behaviour is based on living together with others, establishing pleasant relationships, mutually constructing life and developing appropriate behaviours. When social rules are internalised on a personal level, they become regulators and promoters of social behaviour. It starts with the acceptance of the individual by the group to which he/she belongs and extends to the divinised hero or leader to whom he/she applies for the solution of any problem he/she trusts in his/her mind (Narter, 2022). If the individuals lose this basis, they also lose the guidelines for social behaviour. Social behaviour, which is often guided by the social environment, is private, complex, delicate, and symbolic (Moscovici, 1988). Social environments are a structure in which rituals, symbols, institutions, norms, and values are differentiated and defined through the processes of production and consumption. This structure is not universal. It is peculiar to the societies in which it exists or emerges. The origin and functioning of the social environment are also shaped by the individual, society and the time period experienced by society. At the same time, each society has a shared history, norms, rules, laws, and dynamics. The unique characteristics of social environments will lead societies to react differently to events or situations that occur in a given period. Of course, social environments cannot be evaluated independently of space. Spaces are effective in the formation of identity, in making the place unique to the individual and the individual unique to the place, in creating social control, and in finding one's roots. Losses of space after disasters cause irreversible damage to the identity, to the unique relationship of the individual with the space and to the relationship with the place where the individual finds his/her roots. The unique values and belief systems of societies are formed through and together with spatial relations. Cultural characteristics such as traditions, customs, beliefs and folk tales are often synonymous with the names of places. These names are important elements in conveying real and

reliable information to individuals. In order to understand the traditions, customs, customs and habits of an individual, the question "Where are you from?" is asked to get to know the individual. This question, which is asked in order to get to know the individual in front of you, is actually about where the individual in question sees himself/herself from, where he/she feels he/she belongs and the information he/she wants to give to the other individual about himself/herself. In this way, we can learn the place where the individual belongs, where he/she has made himself/herself unique and where he/she has taken root. The name of the place carries information explaining the characteristics of the individual. Therefore, for both individuals themselves and others, spatial information transmitted through common sense knowledge is an important transmitter. Common sense knowledge can be defined as a form of knowledge that is presented to the individual in a dominant and taken-for-granted form in accordance with the way of life of the society from the past. (Moscovici, 1984, 2008). Common sense is the body of knowledge produced by members of the same social or cultural group in a unique form and logic. Opinions, ideas, and thoughts produced in a certain way are shared and disseminated among the members of that society (Narter, 2012). Almost all situations encountered in daily life originate from common sense and are recognized in the individual's mind with common sense values. In other words, the thing for which a solution is sought comes from common sense and is analysed in common sense (Moscovici, 2001).

Knowledge is an abstract but valid concept that fulfils, satisfies and sometimes disappoints the interests, needs and desires of people from the environment in which they co-exist and interact. Knowledge is a set of concepts that are usually linked to specific, precise designs and produced under special conditions. (Bauer & Gaskell, 1999). The reality of our everyday lives is constructed through our interactions. This reality is shaped around common principles that are established and agreed upon in social environments. Social realities have an important place in common sense (Duveen, 2001). Social realities, which are part of common sense and almost govern daily life, can be a hindrance as well as a comfort to individuals. Today, we encounter too much unprocessed information that threatens our social reality and the information that constitutes it. This persistent information outside our knowledge completely envelops us. Evaluating and making sense of this persistent information overwhelms our minds. What is happening in the world and in our social environment is autonomous on the one hand and challenging on the other. While preserving the autonomy of the individual's cognitive world, what is going on in the world and the social environment of the individual have challenging aspects. Individuals try to establish an abstract cognitive process and concept chain without ignoring what is happening in the world and the pressure of their social environment while maintaining the autonomy of their cognitive world (Moscovici, 2001). This structure allows the individual to live his/her life without being anxious. But individuals may not always be so lucky. Sometimes individually and sometimes socially, situations or events where uncertainty prevails may occur. Disasters are important examples of these situations. Disasters and their aftermath will present an uncertain and ambiguous environment. Crises and traumas are the environments where uncertainty and ambiguity are experienced the most. Uncertainty and an uncanny environment create confusion. Human beings have never been friends with uncertain and uncanny situations. Individuals usually try to neutralise the elements of confusion as quickly as possible. Human beings want to know what will occur and what kind of a future awaits them. But in order to achieve this cognitive balance, the basic needs of human beings must be met. These basic needs are water, food, and a safe and sheltered living space. It cannot be said that human beings, who are biological beings, can be cognitively, emotionally, spiritually, and behaviourally healthy if their needs to feel safe for survival are not met. Psychological resilience is not an innate ability or an ability that can be created by psychological treatment. In disasters, individuals are exposed to trauma starting with the individual trauma caused by witnessing the event and extending to the loss of family members, neighbours, house, neighbourhood, and city. The opportunities provided to survive after these losses directly affect the resilience level of the individual. burying more bodies than he/she can remember after the disaster for an individual who has never seen a deceased body in his/her lifetime, is an example

of one of the traumas that shatter the physical and mental integrity of the individual. The effects of this severe trauma can of course be overcome with the help of specialists. However, the measures to be taken in the acute period following the traumatic incident must be measures that guarantee survival and promise a secure future. Only in this way can they be expected to develop a balanced psyche and be able to plan their future.

Disasters are situations that interrupt reasoning and problem-solving capabilities. Disasters and subsequent crises are major tests for individuals, communities, local authorities, governments, states and countries in building resilience, developing knowledge about the domain in which the crisis occurs, and establishing problem-solving skills. Kruglanski and Ajzen (1983) claim that knowledge is structured according to the stages of expression and solution of problems. According to this theory, Everyday Epistemology, the knowledge that individuals acquire in their daily lives to fulfil their cognitive needs is governed by their prior beliefs about which knowledge and the way of acquiring knowledge will be useful (Kruglanski, 1990). These beliefs, which are previously acquired in the pursuit of knowledge and solving problems, and which enable finding the truth, are the mobilisers of the cognitive drive to knowledge. Satisfying this impulse is an important stage. From time to time, people may also tend to cease to receive new knowledge. They may stop their search for information, decision-making and finding solutions. He/she may prefer to finalise an issue, to fix the account related to that issue. This concept is called cognitive closure or need for closure (Webster & Kruglanski, 1997). Cognitive closure or the need for closure is the individual's attempt to simplify the information he/she has acquired about the problem he/she wants to solve in order to eliminate its complexity. Underlying this endeavour is the impulse to avoid uncertainty. The need for simplification to avoid uncertainty enables the individual to show two tendencies. The first one is to try to solve the problem by reaching a judgement quickly in order to provide closure or completion in haste. This is called seizing. The second is the tendency to maintain closure or completion or to ensure continuity by freezing. This freezing tendency continues to use old and acquired knowledge to eliminate new and contradictory information (Atak, 2016). Every uncertain, uncanny, confusing and confusing external incident will push individuals to search for solutions. Especially the losses experienced will further accelerate this situation. Losing a loved one, norms, order of life, freedoms and rights will drive individuals to search for a solution. Disasters challenge cognitive structures. Everything is turned upside down and the world is perceived as a different place than it used to be. The resulting difference will be tested by the adaptation skills of human beings. The social life changes completely after a disaster and such a change is a loss. This loss most probably accompanies the mourning process. Mourning is a compulsory process to maintain the balance of the psyche. Places, societies, countries, and states cannot mourn like individuals. The loss of the past initiates a sad process of change.

4. Conclusion

Change is always met with resistance. The crisis that develops during and after a disaster is a negative change process. Change and constancy are concepts that we experience while changing our habits, shaping our relationships, solving our problems, and questioning our choices in daily life, in other words, concepts that we understand through living experiences. We conceptualise change and constancy as the cornerstone of shared social knowledge while trying to survive and evaluate the events that occur before us (Markovà, 2003). Social knowledge can be defined as knowledge in communication and action. Knowledge that has not been shaped, found meaning, echoed, transformed and formed a common opinion among individuals, individuals and groups, subgroups and culture cannot be regarded as social knowledge. The concepts of change and constancy are asymmetrical. Within the context of social knowledge and social structures, change is perceived as dangerous until it turns into constancy. Everything that comes from the external world and proposes change causes the shaking of the constants that have been decided and fixed in the past. This will bring serious cognitive confusion for human beings. Until this uncertainty is absorbed and legitimised, or more precisely, until it is convinced that the enemy will no longer do any harm, society will cling tightly to the constants of the past. This restlessness and conflict will

continue to be experienced until change becomes a constant. Since we cannot talk about self-belonging to society, the mourning experienced in the spiritual sense will not offer a functional explanation here. Because the state of pain caused by the loss in the spiritual sense can only be experienced individually to avoid the loss of interest in the outside world. It is not possible for a society or a country to avoid all reminders of their loss. The reason for this is quite simple. When a person's heart stops beating, they die, but a society or a country does not even have a heart to die when it stops beating. The conditions are very different. It is often thought that change hides the new and perhaps the good, but this is often not the case. Change is challenging in every field. As in the dilemma of "should I remain a child or should I become an adult" that the individual experiences during adolescence. Or as in the questions of "Should I get lost in the destruction of the old or should I move forward in the energy of the new?". Of course, this dilemma of change does not last forever. When this process is completed, you will either become a mature adult or remain a child who looks like an adult. In other words, you either fade away from past losses or look forward and try to seize the opportunity to develop. This is not a situation that can be overcome by individual psychological resistance. Determining the direction and form of change is more related to the resilience of governments and states - in crises such as disasters - than to individuals. It is critically important which government will govern the society, the state and the country. The ability of the governments to manage the crises that may arise before, during and after a disaster is considered the ability to govern the country in many countries of the world. In the case of disasters, it is usually not clear by whom the crises will be solved. Therefore, as the area of crises expands, the traumatised area grows. In an earthquake country like Türkiye, securing life, property and future is among the most vital tasks. Securing life, property and future is necessary to increase the resilience of governments, states and countries against potential disasters. Security of life and property usually implies the security mechanisms that the state should provide for its citizens, such as the police and military forces. The security provided by the state is usually never questioned in the practice of daily life. It either exists or will establish control as soon as possible. However, when the enemy that threatens life safety is a disaster, it is not clear who will fight against it. Is it individuals, neighbours, volunteers, doctors, search and rescue teams, mine workers, members of parliament, celebrities, the rich of the country, scientists, economic power, or military prowess? None of them alone is sufficient for resilience against disasters. With a good organisation, all units must take part effectively. Otherwise, it is not possible to develop resilience against disasters. Crises and traumas caused by disasters will consume the members of the society, the community, the country and all its resources. Trauma renders its victims helpless with an overwhelming force; if this overwhelming force is caused by nature, it is a disaster, but if it is the product of a human being, it is an atrocity (Herman, 2016).

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Resume

Meltem Narter graduated from İstanbul University Faculty of Literature Department of Psychology in 1996. In 2002, she received the title of doctor with doctoral thesis on "Republican Identity of College Youth"; at Institute of Social Sciences of İstanbul University, Psychology Department. In 2002, she received the second prize in the research writing competition titled "Republic through the Eyes of Youth", organized by the Publications Department of the Ministry of Culture, with her research titled "Republican Identity Definitions of University Youth". She completed his work titled "Social Representations of Psychoanalysis in Turkey", supported by Istanbul University Scientific Research Projects Unit, in 2008, and his book of the same name, which she wrote based on this study and published in 2012, was deemed worthy of the 2012 Psychoanalysis Writings achievement award by the Istanbul Psychoanalysis Association. Narter is currently a faculty member of the Department of Psychology at the Faculty of Humanities and Social Sciences at Üsküdar University.

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Earthquakes, sustainable settlements and traditional construction techniques

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Abstract

Urbanization is increasing all around the world due to population growth and big cities receive a high volume of migrants due to economic and social reasons. However, rapid population growth should be prevented in big cities in order to provide comfortable living conditions to the population. When urban planning practices do not catch the speed of urbanization; the tendency towards vertical architecture increases, the amount of green space decreases and problems related to unplanned urbanization come to the fore. These important problems, which have considerably increased recently in Türkiye, may lead greater problems in many respects. The parallel and self-sufficient development of urban and rural areas, which is defined as urban sustainability, is considered as the best-case scenario in urban planning practices. This aim is adopted nowadays by most of the countries in the world as it prevents rapid population growth in cities and depopulation in rural areas. Decisions which are taken to ensure urban sustainability are important for all countries. However, these decisions become even more important in regions with disaster risk. As the majority of Türkiye's land area is under seismic risk, the problems which may arise due to rapid urbanization during an earthquake should be prevented. The damage and losses which could occur during an earthquake and the security, health, education problems which will arise after the earthquake can be solved by preventing dense housing and uncontrolled migration in urban areas. The connection between urban and rural areas should be strengthened. Besides, the social and economic sustainability of the rural area should be ensured. Settlements should be designed away from fault lines with a holistic approach as "*living spaces*" which consist components such as; transportation, infrastructure, green spaces and educational spaces. Additionally; the use of appropriate construction techniques and materials should be accepted as a priority. In this context, it can be mentioned that traditional building techniques, which have been developed over centuries and whose deficiencies have been improved during this period, should be preferred especially in rural areas. In this study, the criteria that gain importance in the construction of earthquake resistant and sustainable settlements are evaluated on Türkiye case. The precautions which should be taken to ensure rural sustainability and to prevent the depopulation of rural areas are emphasized. Within this scope, the importance of protecting the architectural texture and regenerating traditional building culture was discussed in constructing earthquake resistant settlements.

Keywords: conservation, rural region, seismic resilience, sustainability, traditional building systems

1. Introduction

The world has a population of more than 8 billion people and all countries have similar problems regarding urbanization. One of the most prominent among these problems is "employment" which supports the growing population financially. Leading industries and manufacturers that provide employment is usually concentrated in certain parts of the countries. Therefore, the population

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gets denser in some parts of the country and population growth increases especially in cities surrounding these regions. In urban planning practices, the location of important industries and direction of the development of cities is usually foreseen. However, in some cases, urban planning practices fall behind the practical development of cities, leading to “unplanned urbanization”.

According to TUIK data; there is a high unemployment rate in southeastern parts and its surroundings, while there is a low unemployment rate in the coastal and western regions of Türkiye. Accordingly, while unemployment is less in the western and coastal regions, it is more in the southeastern regions. As a result, there is a high migration rate to regions with high employment (TUİK, 2023.03.23).

In TUIK's Urban-Rural Population Statistics for 2022; it is stated that 67.9% of Türkiye’s population lives in dense cities, 14.8% in medium dense cities and 17.3% in rural areas. As a result of the increasing trend of migration to urban areas since the 1950s, cities develop rapidly and sometimes unpredictably. This result with a building stock shortage and create densely populated areas which lack green areas. Besides, unplanned urbanization patterns occur in the undeveloped parts of the city (TUİK, 2023.05.11).

The uncontrolled increase in population and construction in some parts of the city primarily causes problems in providing comfortable living conditions and security in those regions. However, these regions become the focus of much bigger problems in the case of any disaster.

Türkiye has another important problem which is also related to employment and urbanization. Türkiye is an earthquake prone country located in the Alpine-Himalayan orogenic belt. When the global seismic hazard map and the earthquake hazard map of Türkiye are examined together, it can be observed that approximately 95% of the surface area of Türkiye is under the risk of earthquakes (ThoughtCo, 2019).

In the "Building Regulation for Resilience" report which was published by the World Bank (TWB) in 2016; it was stated that the disasters that took place in the world in the last 20 years have affected 4.4 billion people, caused the loss of 1.3 million lives and an economic loss of 2 billion dollars. It was also added that 80% of the losses occur in low and middle-income countries and that legal regulations are not sufficient enough in reducing the risk in these countries (Moullier & Krimgold, 2016).

The most important reason that spreads the disaster risk was stated as rapid urbanization and illegal housing in settlements where legal regulations are not effective. In order to reduce the possible losses in the event of a disaster; building regulations should be established, safety should be increased in new buildings and practices which aim to reduce risk should be adopted in existing vulnerable buildings (Moullier & Krimgold, 2016).

In order to prevent disaster-related losses in Türkiye, where disaster risk is very high and urbanization is very rapid, it is crucial to protect the growth of urban population, to strengthen the existing structures, and to construct new structures in accordance with regulations.

In this study, protecting and encouraging the use of traditional building techniques in rural areas is discussed on the basis of the need to protect the rural population and to construct earthquake resistant settlements.

2. Earthquake Resilient Settlements

Many people prefer cities for living due to economic and social reasons. Accordingly, cities usually become the main portals of migration and get crowded. Rapid urbanization and illegal construction numbers increase when the high demand in the construction industry is not balanced with efficient urban planning strategies. As a result, the problems which arise in these environments affect many people.

Due to its geographical location, Türkiye is under the risk of different natural hazards such as; earthquakes, floods and landslides. The disasters that have occurred in Türkiye in the last 65 years were caused by; 55% earthquakes, 21% landslides, 8% floods, 7% rockfalls and 2% avalanches according to the "Disaster Resistant City Planning and Construction" report (İSMEP, 2014).

In the "Climate and Disaster Resilient Cities Project" it is mentioned that Turkey ranks 45th among 191 high-risk countries (TC Ministry of Environment, Urbanization and Climate Change, 2022).

Different researches state that approximately 95-96% of Türkiye's surface area and 98-99% of its population is under the risk of earthquakes (Akıncıtürk, 2003; Türkoğlu, 2001). When the global seismic hazard map (ThoughtCo, 2019) in Figure 1 and the Turkey Earthquake Hazard Map (AFAD, 2023) in Figure 2 are examined, it can be observed that a very large part of its surface area is at risk.

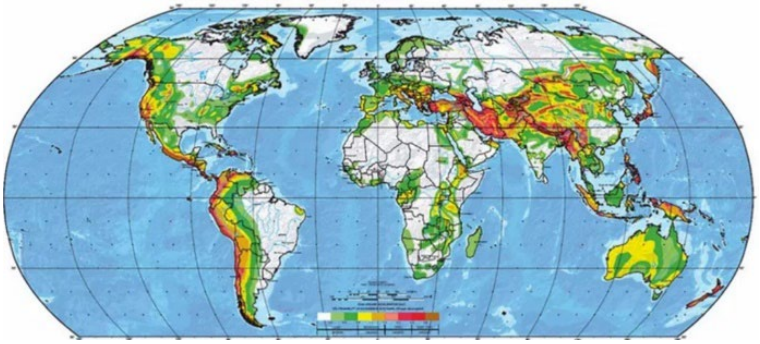

Figure 1 Seismic hazard map of the World (ThoughtCo, 2019)

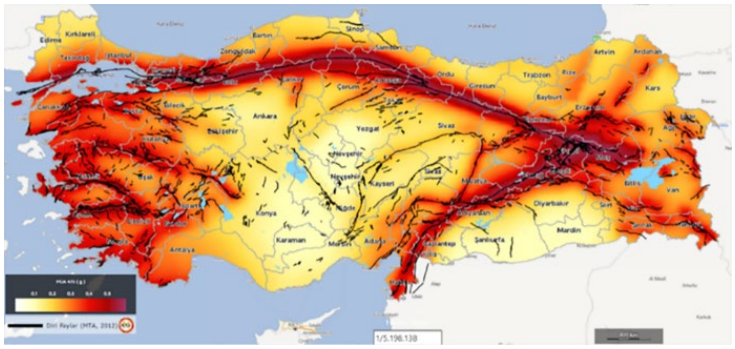

Figure 2 Seismic hazard map of Türkiye (AFAD, 2023)

Nevertheless, the regions which have high earthquake risk also have high employment potential, therefore high immigration and urbanization possibility. The regions with the highest unemployment and the highest employment rates (TUİK, 2023.03.23) can be seen in Figure 3 and Figure 4.

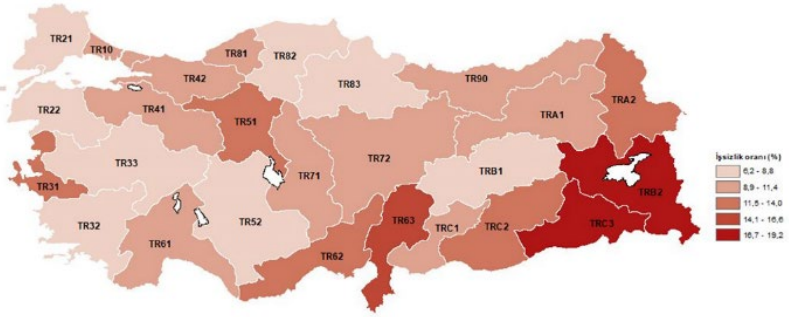

Figure 3 Unemployment rate map according to 2022 TUIK Labor Force Statistics report (TUİK, 2023.03.23)

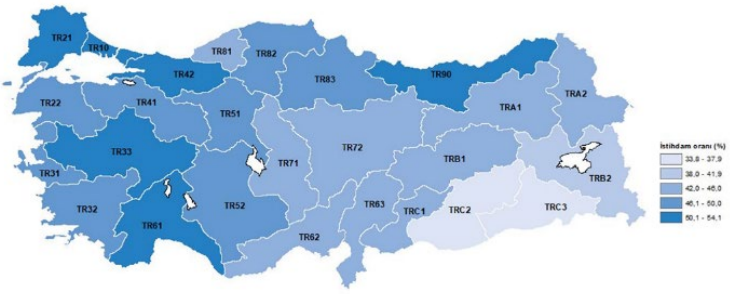

Figure 4 Employment rate map according to 2022 TUIK Labor Force Statistics report (TUİK, 2023.03.23)

Unplanned urbanization and dense housing problems mainly occur at the coastal and western regions of Türkiye as a result of employment related migration. Fatal problems will arise in these regions in the case of an earthquake, in regions where the constructions are built with low-quality materials and poor workmanship.

All practices, which aim to prevent the risks related to earthquakes and rapid urbanization, should be effectively included to urban planning strategies in order to build disaster-resilient settlements. Besides, practices which protect the urban population and prevent the depopulation of rural areas should be adopted.

2.1. Population Growth, Settlement Planning and Sustainability

Urbanization, which accelerated after the Industrial Revolution, started a rapid change in the lives of communities and caused an intense social mobility. The people of the agricultural societies began to migrate to the cities. Accordingly, the residential areas started to be constructed densely in relatively narrow regions (Çetin, 2012).

Policies which do not consider urbanization as a part of development result with; low life quality, poor development, social unsustainability, rapid and unplanned urbanization, illegal construction and vulnerable building blocks (Çetin, 2012).

Ensuring a controlled population growth in cities, integrating urban – rural settlements and providing urban planning that appropriately respond to the needs of population are the most important components of the *"sustainable city approach"*, which is the common goal of cities nowadays.

2.1.1. Population Growth

Today 55% of the world's population lives in cities and it is estimated that this rate will increase to 68% in 2050. According to the European Union statistics of 2021; 38.9% of the population lives in cities, 35.9% in medium-density cities and 25.2% in rural areas in European Union countries (Eurostat Statistics Explained, 2022).

The TUIK report which was published in 2022 (Figure 5) mentions that; 67.9% of Türkiye's population lives in dense cities, 14.8% in medium dense cities and 17.3% in rural areas. (TUİK, 2023.05.11).

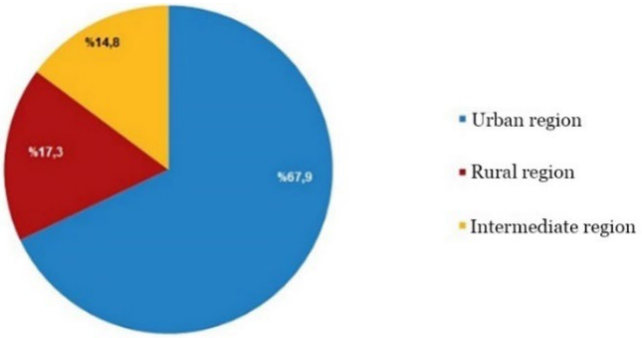

Figure 5 2022 TUİK Urban-Rural Population Statistics (TUİK, 2023.05.11)

2.1.2. Settlement Planning & Rural and Urban Sustainability

The rapid urbanization trend is trying to be reduced with sustainability approach. The Brundtland Commission Report, released in 1987, stated that poverty, rapid population growth, excessive consumption of resources and uncontrolled growth of cities are the most important problems of the world. A great amount of environmental degradation occurs during this process (Figure 6) and these problems can be solved by adopting sustainability approach.

Figure 6 Effect of rapid urbanization on the environment, India (Wired,2016)

"The CIB Agenda 21", published in 1999, examines the sustainability approach through the relationship between built environment and construction industry and evaluates it through;

- Sustainable building practices of different regions
- Problems of these regions
- Effects of construction industry on the economy, environment and society
- Boundaries and potential problems of sustainable building production
- Strengths and opportunities of traditional building techniques of different cultures
- Proposed steps regarding the society, government and construction sector (Du Plessis, 2002).

Additionally, Agenda 21 mentions that; each country has different conditions regarding the scale, priorities, local capacity, capabilities and problems. Therefore, each country should prepare a unique sustainable development plan that considers its priority during the planning process (Du Plessis, 2002).

The basic principles proposed by Agenda 21 for the construction of sustainable cities are;

- *Urbanization and development of rural areas*: The link between urban development and investment strategies and the impact of these on rural areas are not well studied. Usually, the development in rural areas remains limited as the governments only aim the development of cities. Therefore, there is a significant boundary between rural and urban areas (Figure 7). In order to prevent this difference and ensure a sustainable development model in cities, urban plans should be reviewed. Rural areas should be defined as the most important part of this model during this process.

Figure 7 Contrast between rural and urban areas, Ehningen, Germany (Kemper, 2020)

- *Sustainable housing production*: Housing production is an essential part of the urban fabric. When the sustainability of formal and informal housing constructions in cities are evaluated, it can be mentioned that, although they have many deficiencies, informal housing constructions are more sustainable than formal housing production methods. Therefore, informal housing production methods needs to be examined, improved and implemented in urban policies (Du Plessis, 2002).
- *Innovations in building materials*: Construction industry is one of the leading industries that contribute the most to carbon emissions. Therefore, sustainable improvements in this industry will have noticeable environmental outcomes. Instead of using modern building materials which are produced by using non-renewable resources and by consuming great amount of energy, environmentally compatible materials should be produced by using alternative materials. New materials and techniques should be affordable for local people with limited financial possibilities (Du Plessis, 2002).

The most important subject which needs to be mentioned in this context is the use of traditional materials which can be obtained easily and which have low environmental impact. The integration of traditional and modern construction techniques is also important. (Du Plessis, 2002).

- *Modernization of traditional construction techniques*: Traditional construction techniques are being used and improved by the local people for centuries. As these techniques are developed by using locally available materials and as these buildings are constructed without competing with the nature, they integrate with the nature even when they are abandoned. Although traditional construction systems cannot be easily integrated with the modern construction industry, efforts to modernize the traditional systems (Figure 8) can encourage more sustainable construction techniques and help to develop better urban area examples (Du Plessis, 2002).

Figure 8 A modern vernacular structure (Re-Thinking the Future, n.d.)

- *Increasing the effectiveness of administrative staff*: Changing the behavior of local authorities and improving their environmental approach is important in extending sustainable policies. Training the management staff, finding resource to develop sustainable buildings and making regulations that encourage sustainable construction techniques are important necessities (Du Plessis, 2002).
- *Creating a new model for development:* All developed and developing countries achieve economic growth through a high production-consumption model. However, the social and environmental implications of this model are enormous. This approach, which leads to a rapid environmental deterioration, also destroys the social structure and deepens the gap between rich and poor. The communities which adopt this approach and focus only on economic growth distance from spiritual values, cultural heritage and all traditional practices. Nowadays, new approaches, which offers to share the Earth's resources fairly and suggest a more reasonable consumption, gain strength (Du Plessis, 2002).

In light of this information; it can be mentioned that the earthquake risk, which is one of the most important problems of Türkiye, should be determined as the most important priority in urban planning. It is also an important necessity to take measures to protect the population in rural areas in order to prevent the population growth of cities and to ensure social and economic sustainability.

When the common features of sustainable settlement practices are evaluated, they can be briefly summarized as; they preserve traditional values, improve rural-urban linkage, draw attention to the environmental and sustainable importance of traditional building methods and aim to improve the environmental approach of administrative staff.

Türkiye's first Urbanization Council which was held to implement the main topics mentioned in Agenda 21 agreed on similar goals regarding "Sustainable Urban Development" approach;

- Improving the disaster resilience of settlements,
- Protecting natural and cultural assets,
- Preventing illegal housing,
- Providing local development (Kocaoğlu & Sert, 2018).

These goals can be achieved by determining appropriate urban and rural policies and by managing the population growth in urban areas.

3. Ensuring Rural Sustainability to Construct Earthquake-Resilient Settlements

"Rural sustainability" is defined as the social and ecological conditions required to provide the needs of local community, to strengthen urban-rural linkages and to support regional economies. Rural sustainability policies have been built in a social and political framework for many years and have been carried out with an approach mostly focused on agriculture. However, there are other features which are thought to be effective on rural sustainability. These features can be defined as follows;

3.1. Agriculture

The agriculture-focused approach emerged in opposition to two different perspectives. The first, "agro-industrial" approach, aims to provide sufficient food for expanding urban areas. This industry uses the soil, plants and animal products as resource and uses these resources in the manufacture of food and clothing. The "post-productivism" approach, on the other hand, evaluates agricultural land use with a productive, ecological, social and aesthetic perspective which contributes to the farm's income (Sonnino et.al., 2014).

These approaches, which consider the rural area as the source of agricultural production, has evolved markedly over the last few decades. The new approach which is defined as the "sustainable rural development approach", aims to combine agriculture with different practices that have the potential to improve both the relationship between farms and people, and the linkage between rural and urban areas. It focuses on improving the economic conditions of the community to

maintain social sustainability, aims to create new areas for the production, distribution, processing and consumption network of agricultural products and cares about the support of community (Sonnino et.al., 2014).

3.2. Tourism

Development of tourism industry is another approach adopted to ensure the social sustainability of rural areas. Tourism activities help to prevent migration by ensuring the development of local community and support the economy. Different tourism activities can be carried out by highlighting the strong characteristics of the region.

Although mass tourism is important in terms of the economic development of countries, it causes permanent damage to the environment (Figure 9). As the buildings are designed to accommodate a great number of people, they usually cannot harmonize with the natural environment. Besides, as they are usually designed self-enclosed, they cannot blend with the cultural characteristics of the local community and can damage the social structure of the surrounding.

Figure 9 Buildings of mass tourism and the natural environment, Bodrum, Muğla (Independent Türkçe, 2019)

3.3. Entrepreneurship

The existence of local entrepreneurs who can contribute to the development of the region is also an important requirement. Local entrepreneurs who have contacts in urban area can be effective in strengthening the links between the urban and rural areas. As local entrepreneurs are equipped in terms of qualifications such as marketing and knowledge, they can bridge the urban and rural areas (Mayer et.al, 2016).

3.4. Mobility

Another important feature that ensures the social integration of the rural community and supports the economic and demographic features of rural area is mobility. Increasing the strength of mobility and accessibility to urban areas is a crucial necessity in supporting the demographic and economic structure (Camarero et.al., 2016).

Rural life is generally considered suitable for elderly people. Making rural life suitable for young individuals as well can be achieved by increasing employment in the rural area and by ensuring accessibility to the urban area.

3.5. Urban texture and cultural heritage

Preserving the originality of the rural area and protecting the urban texture are other important features which may have effect in managing the urban growth and preserving sustainability (Tutal, Topçu, 2018).

Modern construction techniques became widespread in rural areas with the acceleration of urbanization and spread of modern construction techniques. The main reason of the burst of

modern construction techniques is that traditional construction techniques are not flexible in terms of installation of mechanical, electrical and plumbing systems. As everyone wants to easily access to technology and draws away from everything that does not support technological developments the traditional construction techniques were abandoned in time.

However, while low-rise adobe or half-timbered traditional structures have a low collapse and loss possibility during an earthquake, a multi-storey reinforced concrete structure is more likely to collapse and cause losses as the construction and workmanship quality of modern buildings constructed in rural areas is usually low.

Besides, modern buildings in rural areas usually lead the loss of authenticity and urban texture in terms of cultural heritage. The traditional buildings which remain idle after abandonment (Figure 10) also lead to the loss of cultural identity and arise security concerns in rural areas. When this common trend and their results are evaluated; loose of attraction, declining in employment, increase in migration and accordingly failure in social sustainability can be observed in these regions.

Figure 10 Abandoned traditional house, Birgi, İzmir (Küçük Oteller, 2018)

The traditional building techniques evolved throughout the centuries. These buildings are designed in harmony with the climatic and topographic characteristics of the region, are built by using local materials and their disaster resilience was increased within this period by using trial and error method (Özdemir, Topçu, 2022). Therefore, traditional construction techniques are considered as an important component in building earthquake resilient settlements. Researches in this field reveal that traditional structures should be modernized and their extended use should be encouraged.

Anatolia has a rich culture in terms of traditional construction techniques. A large number of building typologies have been developed as a result of the abundance of material diversity and the presence of different cultures in the region. The most important of these building types was the traditional Ottoman House. This house typology emerged in the 13th-14th centuries, widely used until the 17th century and gradually abandoned after the Industrial Revolution.

The features of Ottoman House were improved against disasters, especially against earthquakes in time and this building type provided a significant contribution to the architectural texture and cultural richness of Anatolia. It may still provide contribution to the architectural texture and cultural richness of Türkiye today.

4. Importance of Traditional Building Techniques in Creating Earthquake Resilient Settlements

Rural sustainability is an important goal in preventing the rapid increase of urban growth, solving the problems which arise due to population increase and building earthquake-resilient settlements. The use of traditional construction systems is important in ensuring rural sustainability all over the world.

Many European countries, especially Italy and United Kingdom, make great efforts for different reasons to preserve traditional construction techniques and the buildings constructed with these techniques. The main reason for the conservation efforts is that the weaknesses of these techniques against disasters were eliminated during their evolution. The most important disaster risk in Anatolia is the earthquake risk.

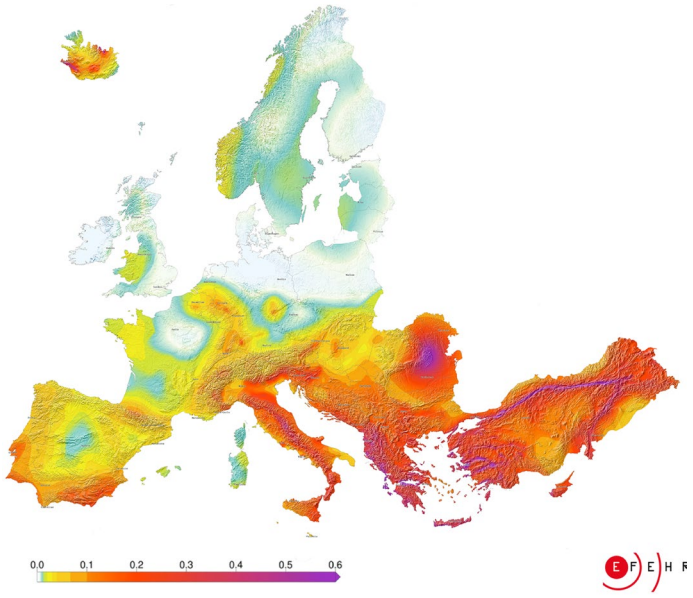

Figure 11 European seismic hazard map (EFEHR, n.d.)

Although Europe's earthquake risk is less than Türkiye, as can be seen in Figure 11, Greece, Italy and Portugal are European countries which have higher earthquake risk. Therefore, there are traditional building typologies developed and used in these countries which have high earthquake resistance.

Previous earthquakes and researches reveal that properly located and detailed traditional buildings have high earthquake resistance. They absorb seismic energy in sufficient amounts and reduce damage by providing structural integrity. Accordingly, it is an important necessity to understand the strengths and weaknesses of traditional building systems, integrate them with modern construction systems and encourage their use with the help of carefully designed master plans.

4.1. Earthquake resistant systems

Communities that experience frequent and severe earthquakes develop building techniques in order to prevent earthquake-related hazards. The pragmatic and theoretical knowledge gained over time by the communities that experience earthquake-related problems is defined as "seismic culture" (Correira et.al, 2014).

Seismic culture practices which were developed, sustained and transferred by local communities is mostly unwritten. It consists rules to be followed for land selection and settlement location. This information can be observed from the general appearance of the settlement. Traditional buildings which evolved within seismic culture are particularly designed to ensure earthquake resistance. They were built by using the most advanced techniques and equipment of the period they belong and they were perfected over time (Correira et.al, 2014).

Site selection is the most important issue in developing an earthquake resilient settlement. The destructive properties of the earthquake are related to the soil type, distance to epicenter, depth and duration of the earthquake. Active or potentially active faults around the settlement is important. Buildings should be constructed within a reasonable distance on both sides of the fault, which is defined as a buffer zone (Figure 12), to prevent construction in high-risked areas. Besides,

the construction site should not be a landfill or an agricultural land in order to prevent hazards in case of an earthquake (Akıncıtürk, 2003).

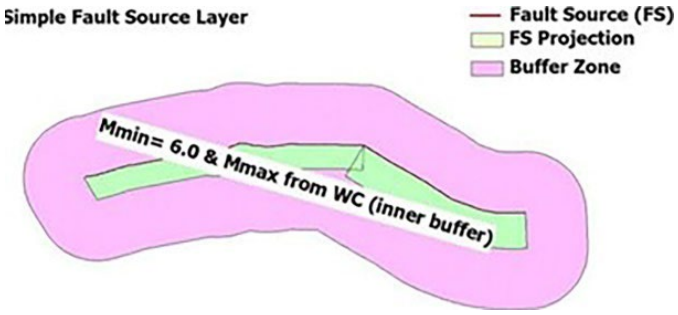

Figure 12 Fault source and buffer zone (Demircioğlu et.al., 2018)

However, the structural features of the buildings, construction and workmanship quality are also important in increasing the earthquake resistance of a building. All types of structural system can be earthquake proof with the appropriate design of these features.

4.1.1. Response of buildings to earthquakes

Earthquakes affect structures with horizontally transmitted seismic forces which moves from the ground level to upwards. This force starts a rotation out of lane and the structural elements with a heterogeneous structure try to overturn with this effect.

"Overturning" is the first type of damage that affects structures and can lead to partial or general collapse of the structure. If the connection between the walls is strong, the building presents a significant ductility during the earthquake which is defined as “box-behavior”. Buildings which have box-behavior do not overturn and the horizontal forces generated during the earthquake are transferred to the walls in the direction of the earthquake. During the earthquake, the shear forces create cracks at the mortar joints, as seen in Figure 13, and this is the second type of damage (Correira et.al, 2014).

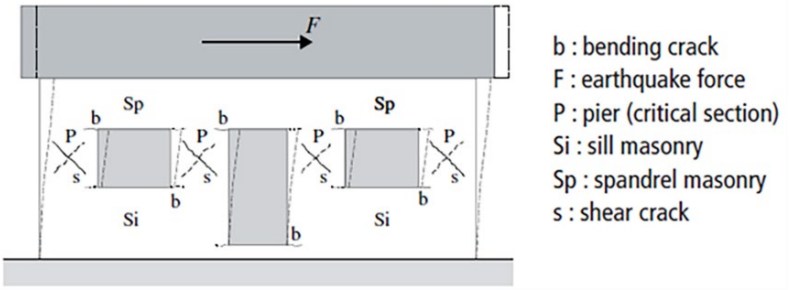

Figure 13 Deflection and cracks due to earthquake (Arya et.al., 2014)

4.1.2. Techniques to increase strength of traditional buildings against earthquakes

Box behavior must be ensured to avoid overturning and this can be achieved by producing effective joints and using horizontal connections. Walls are the fundamental elements of masonry buildings and must behave as a whole under seismic forces (Correira et.al, 2014).

As openings create discontinuities on wall surfaces and reduce the resistance of the wall, the distribution and dimension of wall openings needs to be carefully designed. Wall surface should have good workmanship with less openings in order to increase the strength of the wall and help the building to survive during the earthquake (Correira et.al, 2014).

The buildings in rural areas are not strong enough as they are usually constructed without the intervention of a qualified professional. In order to increase the earthquake resistance and absorb the seismic forces in such buildings, the flexibility of them should be increased. Instead of strong

masonry walls which show less flexibility, walls including wooden ring beams which have strong floor-wall connections are more suitable (Langenbach, 2015).

When the earthquake resistant building techniques of different cultures are evaluated, some common features can be observed. These features can be briefly summarized as follows;

- Masonry walls supported by buttresses
- Form dense rectangular mesh networks in order to increase resistance
- Wooden ring beams placed within the masonry walls (Figure 14)

Figure 14 Timber ring beams in a masonry wall, Cumalıkızık, Bursa

- Using flexible binding materials such as clay or lime mortars
- Constructing strong connections between the elements to provide “box behavior”
- Rows of brick added horizontally within the masonry walls
- Lowering the center of gravity by using half-timbered systems

The use of heavy masonry walls, especially on the ground floors, and buttresses constructed to support the walls are common traditional devices used for increasing the earthquake resistance of buildings. The dense rectangular plan scheme produced with walls placed perpendicular to each other aims to provide high strength against strong dynamic loads (Correira et.al, 2014).

The most common technique which is used to lower the center of gravity is preferring heavier building materials in the ground floor and lighter materials in the upper floors. Heavy stone masonry walls are usually preferred in the ground floor to increase the earthquake resistance of the building and also in order to protect the building against the effects of water and humidity. On the other hand, thinner stone walls or light wooden-framed walls were used in the upper floors. Buttresses, staircases (Figure 15) and vaulted spaces are the other common features used for lowering the center of gravity (Correira et.al, 2014).

Figure 15 Outside staircase, *(profferlo),* Italy (Minor Sights, 2015)

One of the most common devices which is used to decrease the weight of the building is the use of wood. Wood is preferred due to its high flexibility, high deformation capacity and its high ability in the dissipation of seismic energy. Nevertheless, wooden ring beams prevent the progression of cracks by separating the wall into horizontal sections in masonry walls. Horizontal and vertical connections made with wooden materials increase the shear, bending and torsional resistance of structures. (Correira et.al, 2014).

These methods have been used for centuries. The most ancient examples of these methods which is visible in some archaeological sites show holes in stones drilled to place wooden elements in order to increase the flexibility of the walls.

4.2. Timber frames as an earthquake resistant system

Wood is used in two different ways in increasing the earthquake resistance of the buildings. The first is the use of wood as a "*ring beam*" and the second is its use as a *"wooden frame"*. It is believed that the use of ring beams dates back to 9000 years ago in Anatolia. Ring beam is known as *"hatıl"* in Anatolia and it spread to many parts of the world due to migrations and cultural influence over centuries. Ring beams are placed horizontally on masonry walls to transmit and distribute the load evenly to the ground. Two lines of wooden beams are placed to the inner and outer sides of the masonry wall and then connected to each other with wooden pieces added in the other direction (Hughes, 2000).

"Wooden frames" have been used for centuries to increase the earthquake resistance of the building. They are constructed by producing a frame with circular or rectangular wooden elements and then by filling the empty spaces defined by the frame with local abundant materials. "Frame", "masonry panels" and "masonry structure", which are the components of wooden frame systems, are not independent and they are structurally integral with each other during an earthquake. The panel size is important in the determination of the earthquake resistance of the system. There is evidence that small panels have higher earthquake resistance. Another important detail which increases the earthquake resistance of this system is the diagonal braces added to the corners of the frames to increase the lateral resistance of the building. Diagonal braces (Figure 16) are common features of Ottoman Houses (Langenbach, 2015; Correira et.al, 2014).

Figure 16 Diagonal bracings of an Ottoman House, Safranbolu, Karabük (BBC Travel, 2023)

These systems have been produced and used in earthquake prone regions of the world for centuries. Previous earthquakes reveal that, appropriately constructed and detailed structures which have evolved in this way show high earthquake resistance. Anatolia and its surroundings, especially Europe, Middle East and Asia, also produced earthquake-resistant traditional building typologies.

Masonry buildings has been built together with wood in Greece since the Minoan civilization. The system was initially built by using wood horizontally to bond and strengthen the masonry walls. Then the system evolved into a frame built both in horizontal and vertical directions to prevent the

progression of cracks which occur due to the transfer of loads (Poletti et.al., 2015; Ortega et.al, 2017).

A building system called *"La Casa Baraccata"* (Figure 17) became widespread in Southern Italy after a series of devastating earthquakes occurred in Calabria in 1783. La Casa Baraccata, which was first constructed in the 14th century, was built with a wooden internal frame embedded into the rubble construction (Tobriner, 1983; Correia et.al., 2014; Poletti et.al., 2015; Scibilia, 2017).

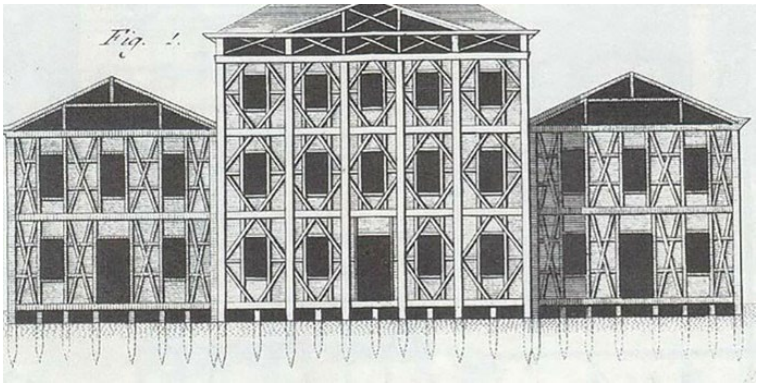

Figure 17 Typical elevation of Casa Baraccata (Niglio & Valencia-Mina, 2013)

After the Lisbon earthquake destroyed the Lisbon Downtown in 1755, a new building system called *"Pombalino"* was proposed for the reconstruction of the city. The proposed building system was a part of the urban plan which was the first known study that fully documented the effects of an earthquake and provided recommendations for urban planning (Poletti et.al., 2015).

Pombalino was designed to increase the earthquake resistance and fire safety of the building. An affordable and faster construction period was aimed by the standardization of the construction system components. The wooden frame forms a "X" with horizontal and vertical elements as in Figure 18, and the panels defined by the frame are then filled with different materials (Gülkan & Langenbach, 2004; Ferah 2009; Poletti et.al., 2015).

Figure 18 *Pombalino* wall system (ConservationTech, n.d.)

The *importance* of *Pombalino* is that this system was designed and proposed for the reconstruction of the downtown of a multi-storey city center after a devastating earthquake (Figure 19). After the 1909 Benavente (40 km north of Lisbon) earthquake which was also felt in Lisbon, very slight damages were determined in Pombalino buildings. Although the earthquake resistance of the buildings could not be fully observed at that level of damage in that period, recent experiments show that the wooden frame has high resistance to numerous shaking tests and absorbs seismic energy without losing its structural integrity (Cardoso et.al., 2003, Gülkan & Langenbach, 2004).

Figure 19 *Pombalino* buildings of Baixa Region, Lisbon, Portugal (Documentary Tube, 2022)

Traditional wooden framed buildings of India and Pakistan showed high resistance and did not collapse during the 2015 Gorkha earthquake, which took 80.000 lives and left 3 million people homeless. However, masonry and reinforced concrete structures were greatly destroyed in the same earthquake (Langenbach, 2015).

A similar condition can be mentioned about Haiti, which is also an earthquake prone country and has experienced a very strong earthquake recently. In the 2010 earthquake, which had a magnitude of 7 and took at least 200.000 people's lives, the traditional buildings maintained their structural integrity and experienced less damage. Nevertheless, most of the reinforced concrete structures in the city center collapsed. In the same year, approximately 500 people lost their lives in the Chile earthquake, which had a magnitude of 8.8. Although the Chile earthquake was larger, it was less destructive than the Haiti earthquake due to Chile's earthquake resistant urban planning strategies and construction techniques (Langenbach, 2010).

In the light of this information, it can be mentioned that, although most of the earthquake resilient traditional building techniques have been abandoned in time, these techniques perform well during the earthquakes as their weaknesses were improved during their evolution process.

As the construction process of modern buildings cannot be easily controlled in rural areas and accordingly the construction quality is often low, it is necessary to prevent the abandonment of traditional techniques in rural areas. This requirement is important not only in terms of earthquake resistance, but also in ensuring the sustainability of rural settlements.

4.3. Traditional Ottoman House as an earthquake resistant and sustainable system

The Ottoman Empire, which ruled between the 14th and early 20th century, produced many significant works that contributed to the architectural history for more than 600 years. The Ottoman residential architecture emerged from general tendencies of the nomadic communities which moved into Anatolia in the 11th century. Accordingly, the houses showed similarities with a traditional nomadic tent for a long period of time. Ottoman houses were built single-storied and consisted one or two rooms in the beginning. They evolved into traditional Ottoman House with the addition of wooden-framed upper floors in the 17th century (Tanyeli, 1996; Topçu, 2019, Güçhan, 2007). The Ottoman House were built with different plan types as can be seen in Figure 20.

Figure 20 Different plan types of traditional Ottoman House

This system, which is built with wooden-framed upper floors on a masonry ground floor, is defined as *hımış*. The empty spaces between the frame are filled with local abundant materials such as stone, adobe, brick or lath and plaster. Lath and plaster *hımış* buildings are also quite common as they don't increase the weight of the structure and considered safer in earthquake prone regions. Figure 21 shows an example of a *hımış* building built with brick infilled wooden-frame (Güçhan, 2007; Koca, 2018).

Figure 21 *Hımış* house, Cumalıkızık, Bursa

As they are mostly built without the interference of any professional *hımış* buildings are defined as "non-engineered buildings".

4.3.1. Evaluation of traditional Ottoman House according to earthquake resistance

Non-engineered buildings are constructed by using empirical knowledge in solving the specific problems of the region in which they are located. However, buildings may confront serious problems in cases where these references are not fully or inadequately implemented. Therefore, it is a necessity to introduce and implement a set of rules in order to increase the earthquake resistance of these structures, as they are built without the support and control of professionals. *"Guidelines for Earthquake Resistant Non-Engineered Construction"* describes measures and practices to increase the earthquake resistance of non-engineered buildings (Arya et.al., 2014).

Earthquake is a natural phenomenon and the major result of an earthquake which cause damage is "ground shaking". Buildings may take hazard or collapse due to earthquake induced acceleration, velocity or displacement during an earthquake (Arya et.al., 2014).

Buildings give an unseen respond to the seismic force and this resistance is defined as "inertia force". Inertia force is directly proportional to the weight of the building (Figure 22). Therefore, the weight of the building material is important in seismic design. The lighter the material, the smaller will be the seismic force (Arya et.al., 2014).

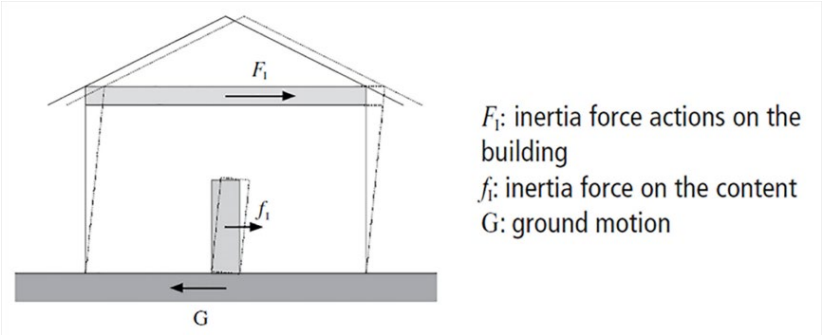

Figure 22 Inertia forces caused by the earthquake ground motion (Arya et.al, 2014)

Building elements normally only bear to vertical loads. However, horizontal bending and shearing effects on the building also increase during an earthquake due to the increase in bending tension stress. Accordingly, the tensile strength of the materials should be high to increase the

earthquake resistance of the building. As the tensile strength of brick and stone is relatively low, significant cracks occur in masonry walls and this reduces the resistance to bending load (Arya et.al., 2014).

There are different factors that affect the building during an earthquake. The intensity of the earthquake, ground acceleration, duration of the shaking, distance to the center of the earthquake, etc. are factors that cannot be controlled. However, the seismic characteristics of the building site, soil type and the structural properties of the building can be controlled (Arya et.al., 2014).

The following features a can be listed as in Table 1 in the design of earthquake resistant buildings;

Table 1 Important features of earthquake resistant design in relation to soil and building properties

1	**Soil type**	Settlements placed on bedrock and hard soil is safer
		Settlements placed on soft soil is riskier
		Flat topographies are less likely to be hazardous
		Cliffs, narrow valleys and steep topographies are more likely to suffer damage
		Precautions should be taken for ground water
2	**Plan type**	Regular and symmetrical plan schemes are safer
		The seismic response of single-storey buildings with a rectangular plan is better
		Torsional effects can be observed in L or U plan schemes, these plan schemes should be separated
		Dimensions of enclosed areas should be small, interconnected walls should be added in order to build a rigid box
3	**Wall openings**	Size and number of wall openings affect the seismic resistance Larger and numerous wall openings lead to vulnerability
4	**Distribution of structural elements**	Load-bearing walls should not be interrupted.
		"Aspect ratio" of a load-bearing wall is important Walls with large aspect ratio may slide Diagonal cracks occur on walls with moderate aspect ratio Diagonal and horizontal cracks occur on walls with small aspect ratio.
		A complete wall enclosure with a roof will provide box behavior
5	**Strength properties of the building**	All structural elements should be connected to each other in order to lead the building act as a single unit during the earthquake
6	**Foundations**	Mixed foundations (different foundation types used together) have a very high risk
		The depth of foundation is important, shallow foundations have high risk as they are more affected by climatic conditions (freezing in cold regions)
		In areas with high earthquake risk, isolating the structure from the earthquake effect is a suitable solution to prevent friction between the structure and the foundation A flexible connection must be created between the structure and the foundation to ensure insulation A well-known method which is used for this purpose is to place the structure on a solid ground and support it with short poles
7	**Material selection**	Materials with high tensile, compressive and shear strength are safer
		Unit weights of the materials should not be high
		The deformation ability and bending strength of the material should be high
		Mortar should be flexible enough to allow elastic behavior
		Brittle materials such as; adobe, brick and concrete are risky as they can cause sudden collapse under high rates of loading Strengthening brittle materials with steel increases ductility
		Using ductile materials such as; steel and wood are useful
8	**Features about fire**	Fire is one of the most common problems after an earthquake and therefore, fire-resistant and non-flammable materials should be preferred to prevent fire
		Materials which prevent fire progression should be selected
9	**Workmanship**	Providing proper construction details and a careful construction process is crucial in improving the earthquake resistance of the building

Traditional timber-framed *(hımış)* buildings are considered one of the most important building types of the Ottoman Period. Hımış system emerged after a long trial and error process and the construction techniques improved during this process in order to increase the earthquake resistance. The techniques estimated to be used for this purpose can be listed as follows;

- Adding wooden ring beams at certain intervals to prevent masonry walls from collapse due to earthquake load
- Using lightweight materials, such as wood, at the upper floors in order to lower the center of gravity
- Supporting the corner studs and the studs on the bay window edges with secondary wooden elements and diagonals to increase the lateral strength of the wooden frame
- Connecting wooden elements with nails to allow small movements, instead of using wooden joints that reduce flexibility
- Building lath and plaster upper floors to lighten the wooden panels of the system (Figure 23)

Figure 23 Lath and plaster *(bağdadi)* wall

When the traditional Ottoman House is evaluated according to the earthquake resistance improvement methods which are put forward by UNESCO (Table 2);

Table 2 Evaluation of Traditional Ottoman House in relation to soil and building properties

No	Feature	Evaluation
1	**Soil type**	When the settlement pattern of the Ottoman Empire is evaluated, it can be observed that the settlements were built on bedrocks and hard soiled lands. The settlements were usually located on slightly sloping lands to benefit from heat and light.
2	**Plan type**	The traditional Ottoman House was usually rectangle or square planned. The depth of oriel windows was designed proportional with the street width and supported with angle braces and diagonals added to strengthen the masonry walls
3	**Wall opening**	As ground floor walls are more important in increasing the earthquake resistance of building, they are often built of masonry and with less openings. Wooden ring beams were placed along the masonry walls in order to transfer and evenly distribute the loads and also to prevent overturning of masonry walls during an earthquake
4	**Distribution of structural elements**	The masonry walls of the ground floor were usually built with no openings or few openings. Wooden ring beams were placed along the wall to increase the earthquake resistance. Wooden framed upper floors were connected to the masonry walls with horizontal wooden elements which surround the inner and outer surface of the masonry wall, and then the frame is completed with regularly placed wooden studs.

		Secondary wooden elements and diagonals are placed at corners, near the openings and oriel windows to increase the lateral resistance of the wooden frame. The panels were then filled with local abundant materials. The "panels" and the "wooden frame" structurally integrate with each other during an earthquake. The wooden frame absorbs the seismic energy and maintains the structural integrity of the building. The collapse of panels usually does not lead to the complete collapse of the structure. Lighter and more earthquake resistant systems can be obtained instead of using heavy infill materials such as; brick, adobe or stone. Lath and plaster technique is a light, elastic and earthquake resistant alternative rather than these infill materials. The roof is built with a wooden frame and connected to the system with nails. Wooden elements are fixed with nails, in order to increase the flexibility of the structure under seismic loads.
5	**Strength properties of the building**	In order to ensure the structural integrity of traditional Ottoman House; • wooden ring beams are added inside masonry walls, • wooden wall plates are laid on top of the masonry wall to increase the resistance of masonry walls • corner posts and studs are added to tie the upper and lower floor plates diagonals and secondary wooden elements are added to the corners to absorb lateral loads.
6	**Foundations**	Different types of foundations such as individual footings or continuous foundations were used in the construction of traditional Ottoman House. At the beginning of its evolution process usually shallow foundations were observed (Cerasi, 1998). However, the depth of the foundations increased and the building-soil integration became stronger in later periods as the builders excavate until they find a hard ground (Azezli, 2009).
7	**Material selection**	As wood is a ductile material which has the ability to undergo significant plastic deformation under stress, wooden ring beams make an important contribution in absorbing seismic energy. They are added along the masonry walls in order to reduce the risk of cracking, overturning and collapse of the wall as stone is a brittle material. Lowering the center of gravity and decreasing the weight of the building is important in increasing the earthquake resistance. Therefore, traditional wooden framed constructions such as *hımış* is very efficient in ensuring the earthquake resistance of the building. It lowers the center of gravity by using stone in the ground floor and using wooden frame in the upper floors and decreases the inertia force by keeping the weight of the building low. Clay-based and lime-based mortars are frequently preferred as binding materials, both in masonry walls and wooden panels. They are advantageous because of their high flexibility and deformation ability.
8	**Features about fire**	Since the upper floors are mainly built with wood, the fire resistance of the building is low. Wood can catch and spread fire easily. In some cases, it can cause a whole neighborhood to burn down with the help of the wind. The construction of Traditional Ottoman House was prohibited several times during the Ottoman Era to prevent this problem. However, this prohibition was not implemented due to many advantageous features of this building type. Building a masonry wall outside the wooden frame could be preferred just like the Pombalino style buildings, to avoid this problem. However, this practice both increases the weight and the inertia force of the structures. In order to increase the fire resistance of the Traditional Ottoman House, precautions such as fire retardants can be more efficient.
9	**Workmanship**	Proper construction details are one of the most basic parameters in increasing the earthquake resistance of the buildings. Therefore, trainings should be given to the builders and local authorities to increase the awareness and to control the buildings during the construction process.

When the methods which are recommended by UNESCO to increase earthquake resistance of non-engineered traditional buildings and the production methods of traditional Ottoman House are compared, it can be observed that it was designed in accordance with most of these methods.

Wood's sensitivity to various organisms and its low fire resistance are the shortcomings of the Ottoman House that need to be solved among the mentioned topics. Nowadays, wood's fire resistance and biological durability is increased by preserving wood with different chemicals.

Beside many positive features in terms of earthquake resistance, traditional Ottoman House also has the potential to support the sustainability of rural settlements by strengthening the connection between the users and their local knowledge and cultural heritage. For this reason, wooden-framed buildings have significant advantages in terms of sustainability.

4.3.2. Evaluation of traditional Ottoman House according to sustainability goals

The buildings are expected to be compatible with the natural environment, contribute to sociocultural sustainability and support the economic development of the region in building sustainable settlements.

In the European Union Project titled "*Versus, Heritage for Tomorrow: Vernacular Knowledge for Sustainable Architecture*" the characteristics of traditional buildings built in different parts of the world were evaluated in terms of sustainability.

Environmental, sociocultural and socioeconomic characteristics of the buildings were examined in this project (Figure 24).

Figure 24 Environmental, socio-cultural and socio-economical sustainable principles (Correia et.al., 2014)

Criteria related to *"environmental sustainability"* focus on minimizing human being's intervention in the environment, taking measures to reduce the negative effects of built environment and finding solutions to remove the deteriorations that have already occurred because of the built environment. In this context, some subtitles have been determined regarding environmental sustainability as;

- To respect nature
- To be appropriately situated
- To reduce pollution and waste materials
- To contribute to health quality
- To reduce natural hazards (Correia et.al., 2014).

Constructing the building in harmony with the topography, making minimal intervention in the natural environment, orienting the building in the proper direction to benefit from the environmental factors, using local materials, combining technical and empirical methods are some strategies being discussed in the context of environmental sustainability (Correia et.al., 2014).

Criteria regarding *"sociocultural sustainability"* examines the effects of built environment on social relations such as, sense of belonging, identity, personal and social development. The sub-

criteria which are discussed within this framework aims to support all positive social and cultural developments in society. Accordingly, these are;

- To protect cultural landscape
- To transfer construction cultures
- To enhance creativity
- To recognize intangible values
- To encourage social cohesion (Correia et.al., 2014).

Social sustainability subtitles emphasize subjects such as; understanding the value and dynamics of the settlement area, protecting biological diversity in the region, valuing collective memory, providing the support of local community and ensuring the transfer of cultural and historical values (Correia et.al., 2014).

Finally, *"socioeconomic sustainability"* criteria deal with the environmental characteristics of the construction process of traditional buildings. Here "cost" is related with "labor" as traditional building construction is not a capital-intensive industry. The subtitles related to this criterion are;

- To save resources
- To extend the building's lifetime
- To optimize construction efforts
- To promote local activities
- To support autonomy (Correia et.al., 2014).

Fair sharing of resources, encouraging shared use of spaces, constructing appropriate scaled buildings, eliminating transportation problems, constructing resistant and durable structures, preferring recycled materials and supporting passive systems are discussed under this title (Correia et.al., 2014).

"Traditional *Ottoman* House" was also evaluated within the scope of the study which examines the relationship between sustainability and architecture. According to the evaluation of these fifteen subtitles defined under three main titles; it can be mentioned that the Ottoman House meets the sustainability criteria above average (Correia et.al., 2014).

5. Conclusion

Most of the common features of earthquake-resistant buildings are found in the traditional Ottoman House. However, when the current situation of rural settlements is evaluated, it is observed that traditional Ottoman Houses are often abandoned or neglected. Due to the lack of a broad conservation and restoration culture, traditional buildings are damaged or destroyed during earthquakes. Positive results could be achieved if the construction, use and maintenance terms of traditional buildings are encouraged by governments, inspected by local authorities and maintained by the owner.

Another important requirement is to understand traditional skills and knowledge, improve this knowledge by combining it with modern materials and techniques and to make innovations.

As well as traditional knowledge and authenticity of traditional building techniques are important in improving modern construction techniques and-abilities, it is also beneficial in reducing the long-term vulnerability of local communities in terms of earthquake.

In conclusion, taking advantage of traditional building techniques, particularly traditional Ottoman House in Türkiye, to build sustainable and earthquake-resistant settlements will help to;

- Control the population growth in urban areas by preventing migration from rural areas
- Reduce financial and emotional losses related to earthquakes
- Protect the natural environment and biodiversity
- Protect historical and cultural heritage

- Ensure agricultural development
- Develop alternative tourism types by highlighting the values specific to the region in the long term.

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Resume

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Resilience of hospital in disaster

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Abstract

Disasters and crisis situations are unforeseen events. When a disaster occurs, the most critical step after the intervention at the scene is the health and treatment services provided in hospitals. Since it is of vital importance that hospitals, where health services are provided, are accessible and operational when faced with natural and man-made disasters such as earthquakes, fires, epidemics, CBRN events, wars, and crises such as cyber-attacks, economic problems, hospitals must protect themselves against a disaster hazard and plan what to do during and after the disaster. This review was written to emphasize the importance of hospitals and their resilience in times of crisis and disaster.Hospitals can enhance their resilience by strengthening both their physical and social aspects. It is essential to create resistance in hospitals not against specific dangers such as fire and earthquake, but against all crises that may occur in the system. A hospital must first identify its structural and non-structural risks to enhance its physical resilience. To enhance social resilience, a hospital should plan its organisations and human resources, establish accurate information communication, and engage in logistics and financial planning. It is crucial to guarantee uninterrupted patient care and all supportive services. Measures should be taken for decontamination and evacuation of patients when necessary while also ensuring the overall security of the hospital. As a result, hospital resilience plays a critical role in maintaining healthcare services, effectively managing emergencies, and generally protecting public health. Further studies are needed to strengthen this resistance.

Keywords: resilience, crisis, disaster, hospital

1. Introduction

Resilience can be interpreted with different essential components in different disciplines. However, it can be defined in common in all sectors as the ability of a system to adapt, change, recover and reorganise to a more desirable state after a disruptive event, a stressful event or a shock (Walker, 2020; Wulff, Donato, & Lurie, 2015). It is vital to build resilience not only against specific threats but also against crises of all kinds in all parts of the system (Walker, 2020).

Resilience holds critical importance in healthcare services. The healthcare system is required to deliver high-quality and safe patient care consistently. Simultaneously, it is expected to adapt during crisis situations, maintaining its functions and emerging from crises through self-improvement (Wiig et al., 2020). Although fundamentally similar, healthcare settings (nursing homes, home care services, hospitals, pre-hospital care) vary, so resilience should be increased by making different preparations for each environment in crisis situations.

The Regulation on the Functioning of Inpatient Treatment Institutions by the Ministry of Health defines hospitals as places where the observation, examination, diagnosis, treatment, and rehabilitation of patients, the injured, those suspecting illness, and those wishing to have their health conditions checked are conducted either on an outpatient or inpatient basis and where births are also performed (Sağlık Bakanlığı, 1983).

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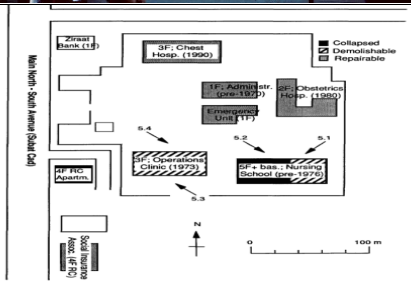
Hospitals are complex organisations where health services, hotel management, support services, and administrative services are provided. These institutions utilise many technological devices and hazardous substances, consist of diverse human communities, and operate 24/7 to provide health services. The processes in these organisations are dynamic, not static (Khalil et al., 2022).

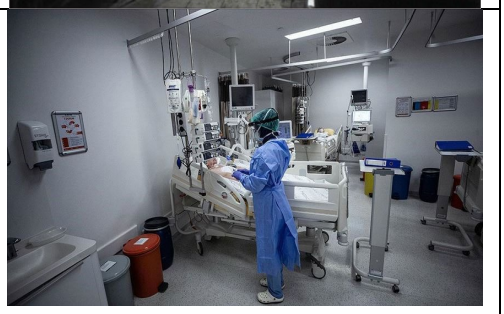
Disasters and crises are unexpected situations. Hospitals must be equipped to be ready and resilient to various disaster and crisis scenarios. The most crucial aspect of hospital resilience is ensuring the quality and continuity of patient care during all kinds of disasters and crises, along with the uninterrupted continuation of education and research activities (Khalil et al., 2022).

Disasters and crisis situations that affect hospitals can include natural and man-made events such as earthquakes, fires, floods, epidemics, terrorist attacks, CBRN events, technological problems, cyberattacks, financial problems, interruptions or deficiencies in the supply chain, infrastructure damages, human resources problems, etc.

Numerous scientific studies and media reports present the effects of disasters and crisis situations on hospitals (Table 1).

Table 1 Effect of Disasters and Crisis situations on hospitals

Date	Place	Impact	
1971	San Fernando California Earthquake (World.Bank, 2010)	San Fernando Veterans Hospital completely collapsed, 50 people receiving treatment at the hospital died	
1972	Managua-Nicaragua Earthquake (World.Health.Organization, 1973)	Most hospitals were destroyed, and 1250 patient beds were damaged.	
1985	Mexico City Earthquake (Villazon-Sahagun, 1986)	5090 patient beds were damaged. Due to the collapse of 2 hospitals, approximately 1000 people, including medical school students, patients and healthcare workers, died.	
1992	Erzincan Earthquake (Birand & Ergünay; Williams, Pomonis, Booth, Vaciago, & Ring, 1992)	Most of the hospitals in the center were severely damaged, the nursing school was completely destroyed and the victims were sent to hospitals in neighboring provinces.	 Layout of buildings at the Erzincan state hospital

1999	Marmara Earthquake,	One of the 10 public hospitals in Izmit was destroyed and four were partially damaged.	
2003	Iran Bam Earthquake (Eshghi & Naserasadi, 2005)	Due to structural, non-structural and mechanical damages in the buildings, all hospitals stopped working and the injured were transferred.	
2004	Indonesia tsunami (Morrow & Llewellyn, 2006; Redwood-Campbell & Riddez, 2006)	80% of the hospitals in the region were destroyed and the rest became unusable. Ship hospitals were used.	
2011	Van Earthquake	A hospital became unusable. Health services in Erciş were provided through field hospitals.	
2013	Philippines Super Typhoon Haiyan (Barmania, 2014)	Health system health information management system collapsed	
2019	Whole world Covid-19 (Anadolu.ajansı, 2023a; Blumenthal, Fowler, Abrams, & Collins, 2020; Iyengar, Mabrouk, Jain, Venkatesan, & Vaishya, 2020)	Telemedicine applications have been developed in hospitals around the world where the healthcare system has been affected, routine patient care has been restricted and medical equipment and consumables have been in short supply.	
2021	All over the world Cyber Attacks (Kolouch, Zahradnický, & Kučínský, 2021)	Following cyber-attacks on hospitals all over the world, disruptions have occurred in the services of many hospitals.	

2023	Kahramanmaraş Earthquake	Kahramanmaraş destroyed and damaged hospitals in 11 provinces. Field hospitals were established in these provinces.	
2023	Gaza War Genocide (Anadolu.Ajansı, 2023b; Cumhurbaşkanlığı, 2023)	471 people died as a result of the bombing of the hospital.	

The initial effects of the event that caused the crisis can be overcome in a certain period for society and many institutions. However, especially in disaster situations, hospitals are among the institutions that have to sustain crisis management for a long time.

When disasters and crises occur, endangering the continuity of medical services and the hospital itself, the hospital must first secure basic emergency coverage and, secondly, recover from the crisis situations(Bai, 2023).

Upon examining the literature, it is evident that information on the general characteristics of resilient hospitals is limited. There are difficulties in defining the elements or dimensions of resilient hospitals, and inconsistencies exist in language and terminology.

However, in general, the literature on hospital resilience is discussed within the framework of physical and social resilience (Ali et al., 2021; Khalil et al., 2022).

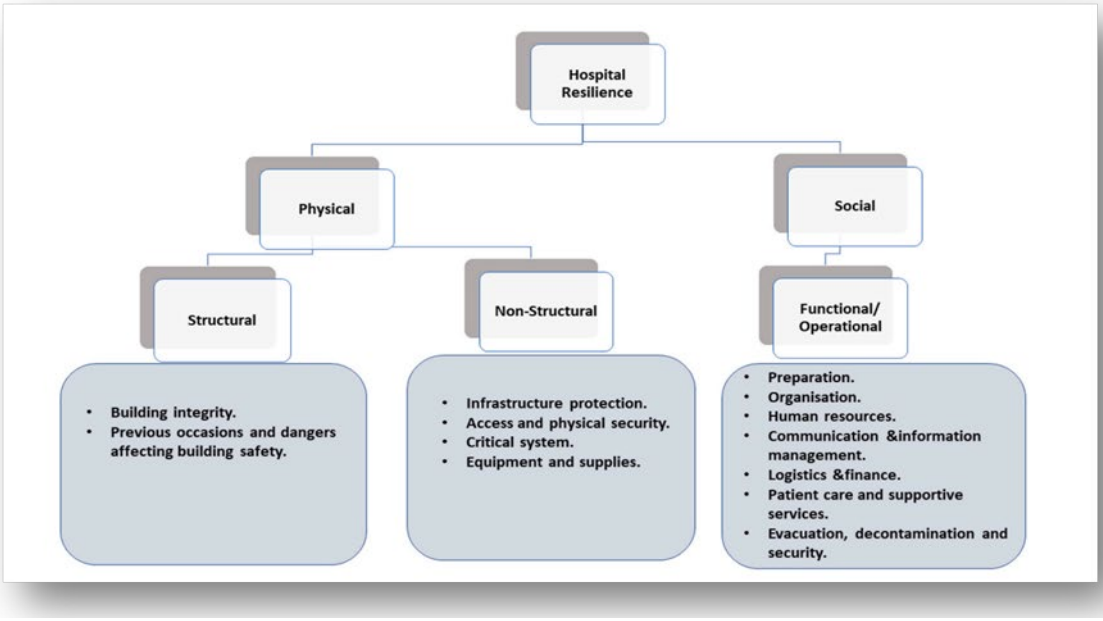


Figure 1 Factors contributing to hospital resilience (Ali et al., 2021)

"In this article, the resilience of hospitals in disaster situations will be assessed through the lenses of physical and social resilience. Additionally, the discussion will be framed within the context of prevention/risk assessment, mitigation, preparedness, response, and recovery phases in the disaster management cycle."

2. Prevention/Risk Assessment, Mitigation

All activities within healthcare institutions involve risks. Reducing risks in disaster and crisis situations is a vital responsibility for hospital management to mitigate risks and damages, a thorough risk analysis must be conducted. Since the most immediate and primary outcome of resilient hospitals is to maintain their functions, and ensure the continuity of high-quality basic and critical services to vulnerable groups, three main security objectives should be taken as basis; protection of life, protection of investment and uninterrupted continuity of activities (Khalil et al., 2022; Sağlık.Bakanlığı, 2021).

Headings taken into consideration during the hazard and risk analysis of hospitals include:

1. Determining the hazards that may be affected by the location of the hospital,
2. Safety of structural elements,
3. Safety of non-structural elements,
4. Ensuring its capacity and business continuity.(Sağlık.Bakanlığı, 2021)

Hospital projects are crucial in potential emergency situations. Hospital structures are designed within the framework of relevant regulations and quality standards, and they are supervised during construction. The vulnerability levels of healthcare institutions to disasters impact the trust and preferences of the community. Additionally, hospital resilience minimizes the impact on the community by absorbing the shock of disasters or emergencies (Khalil et al., 2022) The resilience of healthcare institutions ensures the safety of patients, healthcare professionals, and every individual who may be affected by the situation in the region. It guarantees the uninterrupted provision of health services during emergency and disaster situations

Mitigation of Structural Risks - Structural Resilience

When it comes to mitigating structural risks, it is crucial that hospitals are designed in compliance with the necessary legislation, inspected during the construction phase, and used in accordance with the project.

In this context, the Istanbul Project Coordination Unit (IPCU) of the Governorship of Istanbul has earthquake-proofed the buildings of hospitals, out-patient clinics, and health centers, particularly for earthquakes and various disasters and crises that may occur concurrently with earthquakes. Notably, important hospitals in Istanbul have been demolished and reconstructed using the seismic isolator system. This project is considered an exemplary case of good practice within the realm of hospital risk reduction(World.Bank, 2010).

Figure 2 Göztepe Training and Research Hospital Construction Seismic Isolator Usage (İPKB, 2023)

Mitigation of Non-Structural Risks - Non-Structural Resilience

All building elements other than the structural system can be categorized as non-structural risks. Mitigating non-structural risks is a crucial step in minimizing vulnerability during disasters and emergencies. Reducing non-structural risks in critical facilities like hospitals, which are exposed to multiple hazards, ensures the continuity of business operations in unusual situations, protects life and health, and prevents property loss.

Actions to be taken against non-structural risks in hospitals:

- ✓ Securing all medical devices to prevent displacement or damage.
- ✓ Securing cabinets, lighting fixtures, decorative objects, and other items prone to falling or shaking.
- ✓ Proper placement of oxygen tanks, stretchers, and other equipment to ensure open escape routes.
- ✓ Locking drawers and cabinets, using devices to prevent contents from spilling, especially during events like earthquakes.
- ✓ Implementing emergency lighting and signage for critical areas.
- ✓ Regular maintenance of firefighting equipment and conducting evacuation drills periodically.
- ✓ Adopting suitable storage methods for construction materials, especially for sensitive equipment and medications, to prevent falling or damage.
- ✓ Regular inspection of electrical installations and implementation of safety measures.
- ✓ Providing regular training to staff on disaster and emergency procedures to enhance awareness and preparedness.
- ✓ Reviewing and updating emergency plans on a regular basis.

Figure 3 Precautions taken against non-structural risks in hospitals(parkzon, 2023)

The occurrence of fatalities in the intensive care unit of Hatay Training and Research Hospital during the Kahramanmaraş earthquake on February 6, 2023, due to the failure to activate the generator following a power outage serves as a stark illustration, underscoring the importance of resilience in the face of disasters (Artıgerçek, 2023).

3. Preparedness

The preparation phase is when plans are formulated based on potential scenarios identified after conducting risk analyses and mitigation studies. In this phase, response plans for disaster and emergency scenarios, logistics plans for crisis moments, and evacuation plans are developed. At this stage, the standard operating procedures and workflow instructions must detail how each task will be executed (Sağlık.Bakanlığı, 2021). These guidelines serve as a reference for employees to carry out their duties in a sequential and accurate manner during times of crisis.

As a result of disasters and emergencies, mandatory or precautionary evacuations may be carried out. In cases requiring evacuation within the hospital, evacuation triage is required. Evacuation triage patients are grouped according to whether they can be evacuated on their own or with assistance. (T0,T1,T2,T3)(Sağlık.Bakanlığı, 2021)

Emergency Response Teams are established as part of health institutions' Hospital Emergency Preparedness (HAP). These teams, composed of trained employees, undergo both desk and field drills to strengthen their skills. Regular training sessions contribute to the resilience of health institutions against disasters. All employees are mandated to receive training in search and rescue, evacuation, firefighting, and first aid in alignment with emergency plans. Managers bear the responsibility of planning and conducting these training sessions and drills.

The unfortunate fire incident at Badim Hospital in Rio de Janeiro, Brazil in 2019 serves as an example of the consequences of inadequate training and improper practices. The fire, originating from the hospital's generator, resulted in challenges evacuating patients due to security deficiencies in the hospital infrastructure, inadequacy of disaster management plans, and a lack of sufficiently trained personnel. Despite the efforts of hospital staff to transfer patients in intensive care units to other health facilities, some patients and personnel were affected by the fire and lost their lives (Plotkowski, 2020).

4. Response

Plans developed during the preparation and mitigation phases outline the actions hospital staff should take based on the type and severity of crises and disasters. Patient safety is a priority. Comprehensive emergency evacuation plans are devised to evacuate both inpatients and outpatients, ensuring their safety and providing necessary treatment if the hospital capacity is exceeded in disaster and crisis situations.

To accommodate surge capacity, hospital corridors are converted into cafeterias and conference rooms into patient care areas. Underground parking lots in hospitals are designed to serve as underground hospitals, while parks and reserve areas in cities are earmarked for the establishment of field hospitals. (Bıçakçı & Ulutaş, 2019; Bulakh & Merylova, 2020; Karakoç & Erdoğan, 2020) Furthermore, in cases where hospitals cannot be utilized due to the nature of the disaster, existing hospital ships are employed as alternative healthcare centers to augment capacity for triage and emergency rescue care.(Çatak, 2021).

(a) (b) (c)

Figure 4 Alternative healthcare areas when the hospital building is not in use, ship hospitals(a,b) and field hospitals(c)(NTV, 2023)

Maintaining effective communication is crucial both within and outside the hospital. Regular reporting of patients and medical resources used to relevant units is vital. Additionally, incoming injured patients should undergo primary, secondary, and tertiary triage procedures, prioritizing them based on their urgent medical attention needs.

Since the morgue capacities of hospitals are arranged according to the population and the region they are located in, they will be insufficient in the event of a possible disaster. Morgue areas that

can be activated in extraordinary situations, accelerating burial procedures and pre-burial identification should be carried out as quickly as possible, following a certain procedure. Patient records and identity information of patients referred to different hospitals, provinces or institutions must be up-to-date and accessible. Stocks of medical equipment and supplies should be reviewed regularly and supply chain management should be constantly updated. Depending on the disaster or crisis situation, the models developed can be used in all response applications (Ali et al., 2021).

Personnel management in human resources is another important issue during the intervention phase. Especially the personnel in critical areas should be checked, and in case the relevant personnel cannot be reached, substitute assignments should be completed as included in the previously prepared disaster plan. It is essential to both fulfill the task assigned to the personnel and ensure the safety of the personnel. Cooperation while providing coordination and management by creating emergency response teams within the hospital; It should be done actively with local fire departments, police and other emergency response teams.

5. Recovery

After disasters, the rehabilitation and recovery process starts in hospitals. This is an important stage to meet the medical and psychosocial needs of the patients affected by the disaster. This process includes maintaining post-disaster health services, providing physical rehabilitation, offering psychosocial support and emotional recovery of patients and their families. Physical rehabilitation, physical therapy and supervision by specialised physicians are especially important for injured or disabled patients Additionally, it is important that the process of coping with the stress and post-traumatic difficulties caused by disasters is supported by psychologists, psychiatrists and social workers. Providing counseling services to patients and families provides better understanding and support of the post-disaster process. In this context, hospital employees should not be neglected.

The healing process of patients and the restructuring process of society, together with public resources, play an important role in recovery. These processes should be coordinated by hospital managements, healthcare professionals and the public. Hospital resilience should be determined dynamically within the disaster management cycle with an approach that covers all hazards and should include all components. Guidelines and conceptual frameworks for increasing resilience should be determined.(Khalil et al., 2022)

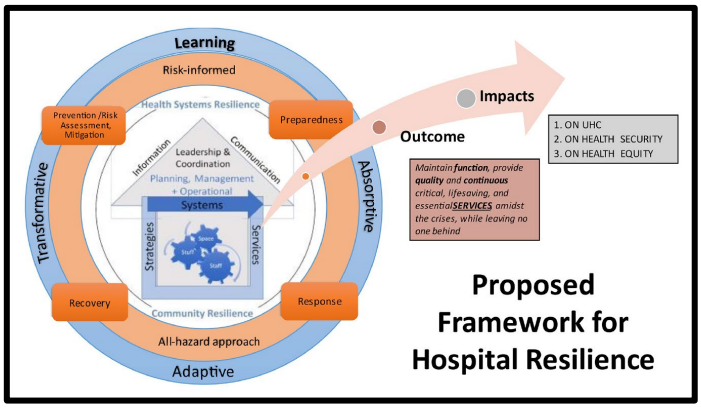


Figure 5 Proposed conceptual framework for hospital resilience.(Khalil et al., 2022)

The resilience of hospitals is critical in maintaining healthcare services, effectively managing emergencies and protecting public health. This resilience is of great importance not only for health systems but also for the overall health of the community. Therefore, it is important for hospitals to have plans ready in advance for crisis situations, communicate effectively in disaster situations, to consolidate infrastructure, to plan logistics, to train staff and to carry out drills in order to increase our capacity to deal with health risks globally.

Future studies aimed at enhancing hospitals' resilience to disasters and ensuring the sustainability of healthcare services should encompass several crucial areas. Firstly, there should be a focus on further research and development to strengthen the infrastructural resilience of hospitals. This is critically important for increasing the resistance of buildings to disasters such as earthquakes, floods, and fires, ensuring the continuity of hospital functions.

Moreover, efforts should be directed toward making emergency preparedness plans more effective and comprehensive. These plans should include aspects such as training emergency response teams, communication strategies, and the management of medical material stocks. Additionally, research focusing on the integration of new technologies, such as telemedicine, to manage healthcare services remotely and effectively is essential.

Studies in the areas of personnel training and psychosocial support can increase the resilience and effectiveness of healthcare personnel during disaster situations, contributing to the rapid recovery of affected communities. Lastly, efforts to enhance collaboration and coordination among stakeholders in the healthcare sector are crucial for providing a more effective response during disaster situations.

Advanced studies in these areas can contribute to increasing hospitals' resilience to disasters, thereby supporting endeavors to preserve and improve public health in the aftermath of such events.

6. Conclusion

In conclusion, the lack of resilience in hospitals to disasters can lead to a range of adverse effects. Disruptions in health services, challenges in emergency interventions, difficulties in patient care, and communication issues are among the factors that can prevent hospitals from providing effective services during disaster situations. Additionally, problems such as shortages of medical supplies and medications, staff shortages, and personnel fatigue can negatively impact hospitals. Therefore, it is crucial to enhance the resilience of hospitals to disasters through effective emergency preparedness plans, robust infrastructure, staff training, and efficient communication strategies. These measures contribute to hospitals responding more effectively and swiftly during disaster situations, ultimately serving the goal of preserving and improving public health.

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Resume

Professor Dr. Rümeyza Kazancıoğlu completed her medical education at Istanbul University Faculty of Medicine between 1985 and 1991. She completed her Internal Medicine residency in 1997 and her Nephrology fellowship in 2001 at the same Faculty of Medicine. She received a fellowship from the International Society of Nephrology (ISN) and worked at the Vanderbilt University Medical Center Transplantation Center, Nashville, TN, USA, from 2000 to 2001. She was an Assos. Professor of Nephrology between 2003-2010 at Istanbul Haseki Training and Research Hospital where she founded a Nephrology Clinic and served as its president. During his leadership, hemodialysis and peritoneal dialysis units and a nephrology fellowship program were launched. She become a full Professor at Bezmialem Vakif University Faculty of Medicine in 2010 and has been serving

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