Leveraging Gamification to Strengthen Social Resilience and Climate Resilience

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Abstract. Climate change presents challenges to urban areas and vulnerable communities, making resilience strategies crucial. Climate resilience refers to a system's ability to withstand, adapt to, and recover from climate-related stresses while minimizing future vulnerabilities. Social resilience, which relies on strong networks, collective action, and knowledge-sharing, plays an important role in improving climate resilience. However, a theoretical gap exists in linking these concepts within climate change research. This study, through a systematic literature review, explores the relationship between social resilience and climate resilience in urban communities and examines how gamification can enhance resilience-building efforts. The findings present conceptual frameworks that show social resilience strengthens climate resilience by improving governance, fostering knowledge-sharing, and helping communities adapt to climate challenges. The research also highlights that gamification can drive behavior change, improve disaster preparedness, and increase policy engagement, all contributing to social and climate resilience. By integrating gamification into resilience strategies, communities can improve adaptation practices, strengthen social connections, and enhance collective responses to climate challenges.

Keywords: Gamification · Social resilience · Climate resilience · Game App · Gamified Place · Urban Gamification · Sustainable development

1 Introduction

Climate change strains urban environments and society [1] and causes severe impacts on vulnerable communities [2]. Therefore, climate resilience is vital for communities facing climate change crises [3, 4]. Climate resilience encompasses a range of strategies and practices aimed at mitigating the impacts of climate change across various sectors [5–7]. It refers to the capacity of a system to withstand external ecosystem stresses imposed by climate change, enabling it to organize, mobilize, and evolve toward a sustainable configuration that minimizes future climatic impacts and vulnerabilities [8–11]. Based on the concept of climate resilience, social resilience serves as a foundation for enhancing climate resilience, meaning that cities with stronger social networks perform better in responding to environmental crises.

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In simple terms, social resilience refers to the capacity of a community to cope with, adapt to, or transform in response to changes, shocks, or stressors [12]. Social resilience is crucial for climate resilience as it enhances community capacity to withstand and recover from climate-related shocks [13]. There remains a theoretical gap in linking the concepts of social, resilience, and climate within climate change research [14]. Since social resilience is influenced by social relations and network structures, institutions and power relations, and knowledge and discourses [15], an innovative tool which effects on these factors can be useful. Gamification has the potential to transform the way cities and communities manage disasters and risks by making resilience strategies more engaging and interactive [16]. Gamification, which originated in marketing, involves using game design elements in non-game contexts to engage and motivate people, with the goal of improving participation, encouraging behavior change, and enhancing learning [17]. By integrating gamification into resilience planning, communities can better prepare for climate-related challenges while promoting inclusive and participatory decision-making. This study explores its role in resilience-building efforts and examines its potential to bridge gaps between social and climate resilience. Based on this approach, it poses two research questions:

– What is the relationship between social resilience and climate resilience in urban communities?
– How can gamification be used to enhance social resilience and contribute to climate resilience?

This study reviews existing research to highlight the importance of social resilience in enhancing climate resilience. Based on these findings, the study emphasizes the need to incorporate gamification into urban planning and resilience strategies to create more sustainable and resilient cities.

2 Methodology

This study will adopt a qualitative research methodology, using a literature review to address the research questions. The approach will focus on secondary data and existing research to understand the relationship between social resilience and climate resilience, as well as the role of gamification in enhancing these resilience aspects.

– Literature Review

A systematic review of existing literature will serve as the primary method for addressing the first and second research questions. The review will focus on academic articles, books, and reports that explore:

The search for relevant articles was conducted in two phases. In the first phase, to address the first research question—examining the relationship between social resilience and climate resilience in urban communities—the search string included the following keywords: (social OR communit*) AND (resilience OR adaptation) AND (climate) AND (urban OR cities OR municipal). In the second phase, to explore the second research question—how gamification can theoretically enhance both social and climate resilience—the search was expanded by adding gamification-related terms to the previous string:

AND (gamification OR game* OR gamif*). To ensure the relevance of the selected studies, a two-step screening process was applied: first, by reviewing the abstracts and then by a full-text analysis.

– Synthesis and Analysis

After reviewing the literature and analyzing studies, the findings will be combined to give a clear understanding of how social resilience, climate resilience, and gamification are connected. This synthesis will help identify important patterns and insights. The goal is to provide practical recommendations for urban planners and decision-makers, helping them use gamification as a tool to improve resilience and create more sustainable cities (Fig. 1).

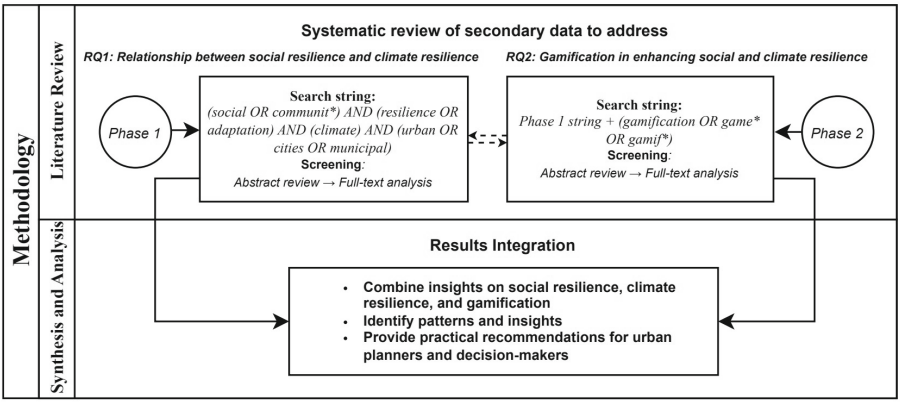

Fig. 1. Research Methodology

3 Understanding the Concepts

3.1 Climate Resilience in Urban Communities

Climate resilience is defined in various ways, reflecting its broad scope and importance in addressing climate-related challenges. It is the ability to anticipate, prepare for, and respond to hazardous climate events, trends, or disturbances [7]. It also refers to how systems, communities, and households absorb shocks, adapt to changes, and recover in ways that improve their conditions [13]. Furthermore, climate resilience involves maintaining critical functions such as food production and well-being while adapting to and transforming in response to climate change [4]. It encompasses the capacity of both human and natural systems to cope with climate-related disasters and extreme events [11]. According to UN Climate Change, climate resilience includes preventing, anticipating, absorbing, adapting, and transforming in response to climate extremes, ensuring sustainable and equitable development [18]. In urban settings, resilience is the ability of a city and its inhabitants to endure, recover, and adapt to environmental stresses

while maintaining continuity and progressing toward sustainability [6]. Overall, climate resilience is essential for enabling communities and systems to respond effectively and sustainably to climate challenges.

Climate resilience requires the capacity of interconnected social, economic, and ecological systems to cope with disturbances while maintaining their core functions. It involves adaptive capacity that is negotiated and built through inclusive engagement and consideration of diverse community needs [9]. Table 1 shows the main elements that help cities become more resilient to climate change. Green Infrastructure and Nature-Based Solutions include things like trees, green roofs, and natural spaces that reduce risks, manage water, and support biodiversity. Infrastructure Resilience and Resource Management focus on strong buildings, flood protection, clean energy, and emergency plans to handle climate impacts. Community Engagement and Social Support highlight the need to involve people in planning and building strong social networks for recovery. Climate Adaptation Knowledge and Sharing help communities understand climate risks and make better decisions. Collaborative Risk Assessment and Planning means working together—governments, businesses, and communities—to assess risks and improve climate resilience. These elements, supported by different studies, create a strong foundation for making cities more prepared for climate challenges.

Table 1. Key Elements Contributing to Climate Resilience in Urban Communities

Key Item Group	Description	References
Green Infrastructure and Nature-Based Solutions	Urban greening, green roofs, and nature-based solutions that reduce risks, improve water management, and enhance biodiversity in cities	[4, 18, 19, 20, 21, 22]
Infrastructure Resilience and Resource Management	Resilient infrastructure, including flood protection, renewable energy, and emergency planning, to withstand climate impacts	[4, 18, 21, 22]
Community Engagement and Social Support	Involving local communities in planning and fostering social networks to help recover from climate impacts	[11, 18, 23–26]
Climate Adaptation Knowledge and Sharing	Building community knowledge and awareness about climate risks and adaptation strategies for better decision-making	[1, 18, 21, 26]
Collaborative Risk Assessment and Planning	Collaborative efforts across governments, businesses, and civil society and continuous climate risk assessments	[8, 20, 21, 22, 25]

3.2 Social Resilience in the Context of Climate Change

Social resilience is a relatively new concept that has recently attracted researchers in the social sciences [27]. It has an interdisciplinary nature, which means that its definitions can draw from various fields, including sociology, economics, and environmental science [15]. By adapting Cutter's resilience framework, social resilience can be conceptualized both as a process of capacity building (e.g., disaster planning) and as a post-disaster outcome (e.g., population retention rates after an earthquake) or as a combination of both [28]. In the disaster management context, social resilience is about the ability of communities and social systems to withstand, adapt to, and recover from disasters, emphasizing the importance of social structures and mechanisms throughout the disaster cycle [29]. Almost all definitions relate to social resilience as the ability or capacity to withstand, recover, and maintain [27].

The importance of social resilience lies in its ability to empower communities to respond to crises effectively, adapt to changing circumstances, and transform their social structures for better future preparedness [30]. Accordingly, social resilience is dynamically strengthened over time as people gain new knowledge and skills from past disaster relief activities, enriching the social knowledge system and passing it on to future generations [31]. Building urban social resilience is essential as it reduces patterns of inequality and improves the well-being of the population, which contributes to the community's ability to cope with various stresses and shocks [32].

In the context of climate change, social resilience includes important factors that help communities deal with and recover from challenges. These factors are Social Capital, Networks, and Cohesion, which bring people together through trust, shared values, and cooperation. Knowledge, Adaptability, and Support improve resilience by using local knowledge, technology, and social support to help people cope and find new solutions. Governance, Decision-Making, and Preparedness ensure communities are ready for climate impacts through planning and making decisions together. Economic Resources and Infrastructure help reduce risks by providing financial support and improving resources like insurance. Finally, Inclusive, Cultural, and Psychological Resilience supports vulnerable groups and strengthens psychological well-being by encouraging inclusive planning and respecting cultural values. Table 2 shows these key elements that help build social resilience against climate change.

3.3 Gamification for Social and Climate Resilience

Gamification aims to create engaging experiences that can lead to cognitive and behavioral changes [44]. It involves transforming monotonous tasks, which usually require collaboration and engagement, into more interactive and motivating experiences [45]. In this study, we focus on two aspects of gamification—game apps and gamified places (urban gamification)—in the context of serious games.

Serious games are designed with specific educational, informational, or training objectives, integrating learning directly into the gameplay [46, 47]. Serious games provide immersive experiences that promote active participation, problem-solving, and critical thinking [48]. Unlike serious games, gamification does not necessarily involve a complete game but rather uses game-like elements to achieve specific objectives [49].

Table 2. Key Elements Contributing to Social Resilience in the Face of Climate Change

Key Item Group	Description	References
Social Capital, Networks, and Collective Action	Encompasses trust, social connections, interpersonal relationships, community cohesion, shared values, reciprocity, volunteerism, and interdependence to foster collective action and mutual aid	[2, 11, 27, 33–39]
Knowledge, Technology, and Adaptability	Includes local knowledge, technology development, knowledge co-production, adaptability, social support, family/community backing, and psychological factors to enhance coping and innovation	[11, 23, 27, 33, 37, 40]
Governance, Decision-Making, and Preparedness	Combines participatory decision-making, effective governance, risk-informed strategies, disaster preparedness, proactive adaptation, and climate impact assessments to align responses with community needs	[13, 37, 39–42]
Economic Resources and Infrastructure	Covers resource acquisition, economic diversification, cash transfers, weather-index insurance, sustainable practices, and infrastructure improvement to reduce vulnerability and support resilience	[13, 33, 34, 40, 41]
Inclusive, Cultural, and Psychological Resilience	Integrates tailored approaches for vulnerable groups, addressing disparities, inclusive planning, cultural adherence, psychological resilience, and positive deviance for equitable and meaningful adaptation	[2, 11, 23, 37, 43]

Gamification refers to the application of game design elements in non-game contexts to achieve different aims, like encouraging participation and involvement [17].

Game apps are primarily for entertainment and do not typically provide the educational framework that serious games offer [50], But they can be designed by utilizing gamification for specific aims, such as facilitating community engagement, increasing

knowledge, and enhancing decision-making [44, 46]. On the other hand, Urban gamification applies game elements to urban environments to engage citizens in civic activities and enhance public understanding of urban issues [51].

In summary, while gamification and serious games both aim to enhance learning and engagement, they differ in their approach and application. Gamification uses game elements in non-game contexts, whereas serious games are complete games with educational purposes. Urban gamification extends these concepts to civic engagement, while game apps primarily focus on entertainment. The aim of this research, which seeks to use gamification in two types—game Apps and urban gamification—as an innovative tool for enhancing social resilience, falls within the realm of serious games.

Gamification has been successfully applied to enhance social resilience through various mechanisms such as Community Engagement and Participation [17, 44, 52], Education and Awareness [17, 38, 53], and Behavioral Change [52, 54]. Gamification also plays a crucial role in enhancing climate resilience by Promoting Climate Action [52, 54], Supporting Policy and Planning [53, 55], and Enhancing Disaster Preparedness [56]. By incorporating urban gamification (gamified places), key outcomes such as building a sense of ownership, influencing public behavior, and fostering community engagement can be achieved. Similarly, through game apps, intrinsic motivation and scalability can enhance engagement and awareness [17]. In the context of social resilience and climate resilience, especially within specific locations, creating a sense of community and ensuring scalability for use in different places are crucial for sustaining long-term involvement and collective action.

4 Addressing the Research Questions

After reviewing the scholarly literature related to the concepts of our study, we now turn to answering the research questions based on the insights gained in the previous section.

4.1 Relationship Between Social Resilience and Climate Resilience

The relationship between social and climate resilience in urban communities is multifaceted. The connection between social resilience and climate resilience in urban communities is complex. It involves understanding how social systems adapt to and recover from climate challenges. These two types of resilience are closely linked, as both depend on shared resources, governance, and the ability to adjust to change. Social resilience is a community's ability to cope with and adapt to external shocks, like climate change, by using social networks and support systems. Climate resilience, on the other hand, focuses on how urban areas manage and recover from environmental impacts. By fostering social networks, collective action, knowledge-sharing, and psychological well-being, social resilience enhances climate resilience, enabling communities to better prepare for, respond to, and recover from climate disruptions.

The diagram in Fig. 2 visually represents the interplay between social resilience and climate resilience in urban settings. On the right side, social resilience in the face of climate change is highlighted with a purple circle, showing its key elements: Social

Capital, Networks, and Collective Action; Knowledge, Technology, and Adaptability; Governance, Decision-Making, and Preparedness; Economic Resources and Infrastructure; and Inclusive, Cultural, and Psychological Resilience. These components are interconnected, as each influences and reinforces the others.

On the left side, climate resilience in urban communities is displayed with a blue circle, including elements such as Green Infrastructure and Nature-Based Solutions; Infrastructure Resilience and Resource Management; Community Engagement and Social Support; Climate Adaptation Knowledge and Sharing; and Collaborative Risk Assessment and Planning. Like social resilience, these components are also interlinked, collectively strengthening a city's ability to cope with climate-related challenges.

Each element has direct and indirect connections to elements in the other category. For example, Economic Resources and Infrastructure (social resilience) directly support Infrastructure Resilience and Resource Management (climate resilience), while Collaborative Risk Assessment and Planning (climate resilience) reinforces Governance, Decision-Making, and Preparedness (social resilience). Indirectly, improvements in Green Infrastructure and Nature-Based Solutions can enhance psychological resilience, fostering community well-being.

Overall, social resilience and climate resilience affect each other, so improving one also strengthens the other. For example, Collaborative Risk Assessment and Planning depends on strong social networks because communities with high social capital are more likely to work together in decision-making and crisis response. Likewise, Knowledge-Sharing and Technological Adaptability help climate resilience by making sure urban communities have access to the latest climate adaptation strategies. In addition, Community Engagement and Social Support build trust and cooperation, which are important for carrying out sustainability projects and managing resources during crises.

Understanding these relationships enables decision-makers to implement holistic strategies that enhance both social and climate resilience simultaneously, making urban communities more adaptive and sustainable.

4.2 Gamification to Enhance Social and Climate Resilience

The second research question aims to answer how gamification, as an innovative tool, can contribute to enhancing social and climate resilience. This question encompasses the first research question, as shown in Fig. 3, where elements of climate resilience are represented in blue, social resilience in purple, and their connection is indicated by the gray line. These elements are exactly the same as in Fig. 2. In the center of Fig. 3, we have the element of gamification in dark green, with the impact of each element on social and climate resilience shown by the same color. There is a direct connection represented by solid lines and indirect contributions indicated by dotted lines.

The framework in Fig. 3 illustrates how gamification can create direct and indirect connections between different resilience factors, ultimately leading to more adaptive and sustainable communities. Gamification helps build both social and climate resilience by encouraging people to change their behavior, engage with their community, and support better policies. In Fig. 3, gamification is at the center, showing how it affects education, community participation, and policy planning. These elements play a big role in disaster preparedness, governance, and social networks, all of which help communities become

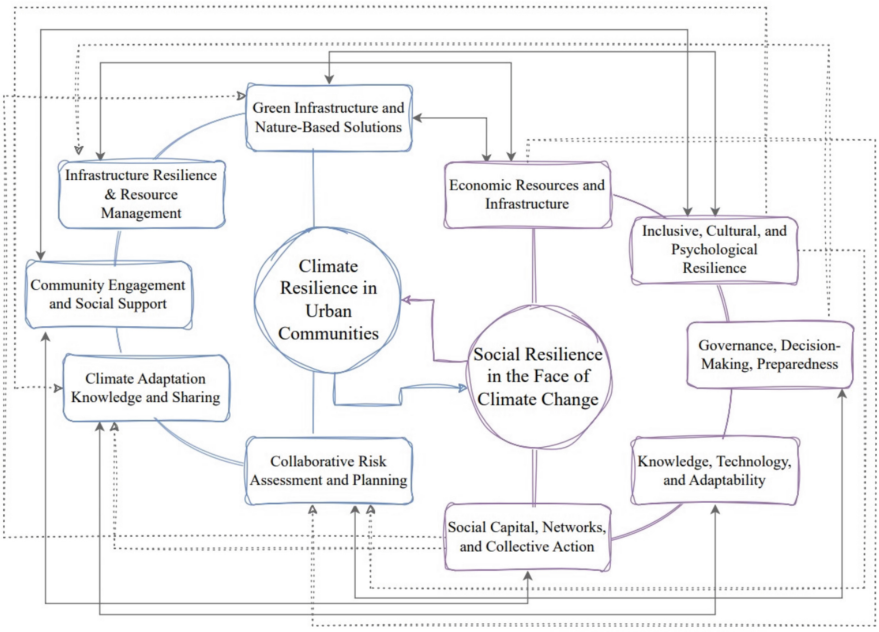

Fig. 2. Interconnections Between Social Resilience and Climate Resilience

stronger. The diagram also shows how infrastructure and resource management improve when people are involved and aware.

One of the main benefits of gamification is that it motivates people to change their behavior in a positive way. By using challenges, rewards, and leaderboards, it encourages actions like preparing for disasters, adopting eco-friendly habits, and working together on climate solutions. These small actions can lead to big improvements in how communities adapt to climate change. Also, gamification makes learning about climate adaptation and disaster response easier and more fun, which helps more people understand these important topics.

Gamification also brings people together and strengthens communities. Games and interactive activities help build trust and cooperation, making people more likely to support each other in tough situations. This idea is represented in Fig. 3 through social capital and networks, which connect directly to governance and preparedness. When communities are more connected and engaged, they can respond faster and more effectively during disasters.

Another important way gamification helps is by supporting policy and planning. It can be used to train people for emergencies, test different solutions, and involve the public in decision-making. For example, serious games and simulations help governments and organizations plan for disasters and develop better infrastructure. These activities support climate adaptation and risk assessment, as shown in the diagram.

Gamified platforms or game apps can simulate disaster scenarios, enabling participants to practice response strategies in a safe, controlled environment. These experiences

help people understand the importance of planning, coordination, and swift action during climate-related crises, thus improving the overall resilience of urban communities to extreme weather events or natural disasters. Specifically, Urban gamification can foster a sense of ownership and collective action. By turning urban spaces into gamified zones, people can engage with climate adaptation projects and contribute to solutions like improving green infrastructure or managing water resources. This sense of ownership encourages sustained community involvement and collective decision-making, which are key factors in building both social and climate resilience.

Both game apps and urban gamification in real of gamification are powerful ways to connect social and climate resilience by encouraging action, educating people, strengthening communities, and improving policies. By leveraging gamification strategies, stakeholders can effectively address climate challenges while promoting inclusive, participatory, and resilient societies.

Ultimately, gamification serves as a powerful tool to bridge social and climate resilience by fostering participation, education, and collective action. When incorporated into urban planning and resilience strategies, gamification can make climate adaptation efforts more accessible, engaging, and effective.

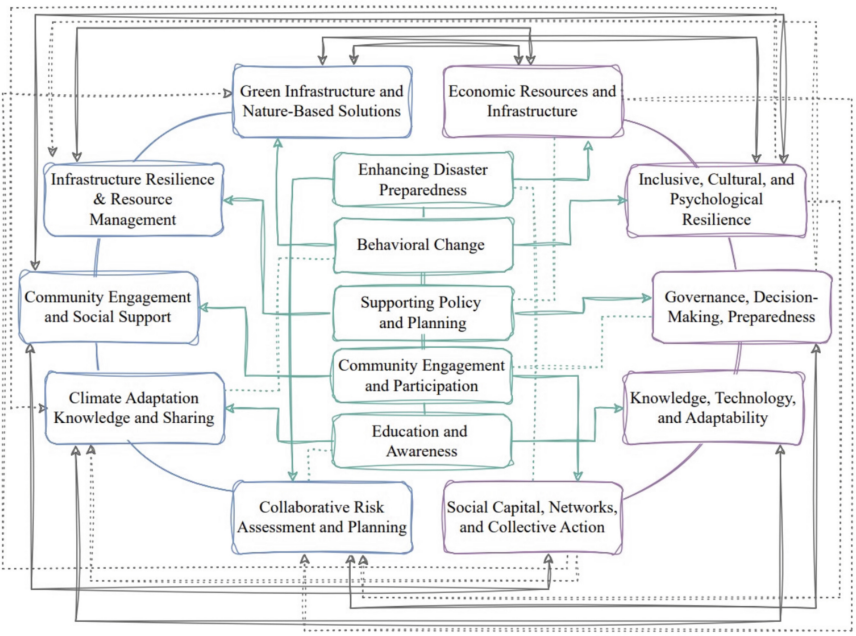

Fig. 3. Gamification for Social and Climate Resilience

5 Conclusion

Climate change puts significant pressure on urban environments and society, often causing severe impacts on vulnerable communities. As cities face increasing climate challenges, climate resilience becomes vital in ensuring they can manage and adapt to the consequences of climate change. It involves strategies and practices that help mitigate these impacts and enable systems to withstand stresses caused by climate change. Social resilience, which refers to a community's ability to cope with and adapt to shocks, plays an essential role in strengthening climate resilience. The more robust the social networks within a community, the better the response to environmental crises. Therefore, improving both social and climate resilience is crucial for sustainable urban development.

This study has shown the strong connection between social resilience and climate resilience in urban communities. Social resilience, which focuses on social networks, collective action, and sharing knowledge, helps improve climate resilience. At the same time, climate resilience, which includes infrastructure, resource management, and climate adaptation, also strengthens social resilience. These two types of resilience are closely linked, meaning that improving one can also help improve the other. Understanding this relationship is important for urban planners and decision-makers to create strategies that support both social and climate resilience, making cities more adaptable and sustainable.

Additionally, the research highlights how gamification can be a valuable tool to strengthen both social and climate resilience. Gamification, through games, challenges, and rewards, encourages people to change their behavior, get involved in their communities, and support better policies. It can motivate people to prepare for disasters, adopt eco-friendly habits, and engage in climate adaptation projects. Gamification also builds trust and cooperation within communities, which is essential in times of crisis. Furthermore, it supports decision-making and planning by allowing people to test solutions and take part in important discussions.

Building on the findings from this study, several areas for future research can further explore the relationship between social resilience, climate resilience, and the role of gamification in enhancing both. While this study offers a conceptual framework for understanding the relationship between social and climate resilience, future research could involve empirical studies to test these connections in real-world urban settings. Research could focus on specific communities that have implemented integrated resilience-building strategies and assess how improvements in one area (e.g., social resilience) lead to measurable benefits in the other (e.g., climate resilience). Longitudinal studies would help understand the dynamic and evolving nature of these interrelationships over time. Additionally, the incorporation of advanced technologies like augmented reality (AR) and virtual reality (VR) could enhance the immersive experience of gamification. Future studies could explore the use of these technologies to simulate climate-related disasters or test different urban resilience strategies in a controlled, virtual environment. This approach could offer communities and urban planners the opportunity to practice crisis management and explore solutions for real-world challenges in a risk-free setting.

In conclusion, gamification offers a powerful way to connect social and climate resilience. By making climate adaptation efforts more engaging and accessible, gamification helps people learn, participate, and take action. When used in urban planning and resilience strategies, gamification can play a key role in building more resilient, sustainable cities.

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