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Assessing Community Perceptions of Infrastructure Resilience to Natural Disasters in Kuwait

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Abstract

This study examines the community perceptions of infrastructure resilience to natural disasters in Kuwait, focusing on factors such as awareness, preparedness, and risk perception. Utilizing a quantitative survey-based approach, data were collected from 187 respondents representing different demographic groups, including residents and business owners. The study identifies vulnerabilities in infrastructure resilience and explores how demographics, education, and occupation impact awareness and preparedness levels. The findings reveal that higher education is positively associated with greater awareness and preparedness. However, community participation in disaster preparedness activities remains low. The study suggests that improvements are needed in residential buildings and emphasizes the need for greater public engagement and government involvement in resilience planning to enhance disaster preparedness. These insights offer valuable recommendations for infrastructure planning and policy development in Kuwait to strengthen community resilience.

Keywords; Infrastructure resilience, natural hazards, community participation, risk perception, Kuwait.

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1. Introduction

The approach to disaster resilience in infrastructure has evolved significantly in recent years. Instead of simply rebuilding structures to their previous condition after disasters, a stronger emphasis is made on creating more robust infrastructure that can better withstand future events. This shift towards a 'build-back-better' mindset aims to reduce vulnerability by designing infrastructure that is more adaptable and capable of coping with various risks (Chester et al., 2021). As this proactive approach to resilience planning gains momentum, it becomes essential to consider the integration of physical infrastructure, social influences, resource management, and governance processes (Firdaus, Pribadi & Abduh, 2024).

Building resilient infrastructure offers multiple benefits including increasing infrastructure's capacity to adjust and respond to future hazards; providing a strategic approach to minimizing disaster-related impacts; enabling infrastructure systems to endure disruptions while maintaining essential functions, and facilitating quicker recovery for communities after disasters, thereby lessening prolonged social and economic disruptions (Comes & Van de Walle, 2014). In addition, the benefits include reducing the likelihood of future disasters by improving the design and durability of infrastructure projects, and ensuring long-term resilience by taking into account the interconnectedness of physical structures, societal needs, resource availability, and administrative policies (Simonovic, 2016).

Infrastructure resilience is crucial in Kuwait due to the country's exposure to various natural hazards, including frequent dust storms, intense heat waves, and occasional episodes of flooding (Sharp, Alshammari & Hameed, 2021). These conditions pose significant risks to the integrity and functionality of infrastructure, potentially disrupting daily life and economic activities (Tsompanakis et al., 2023). As climate patterns continue to change, the frequency and severity of these hazards may increase, making it essential to enhance the resilience of infrastructure to protect communities, ensure the continuity of services, and reduce the long-term impacts of these environmental challenges.

As mentioned earlier, Kuwait's infrastructure faces increasing risks from natural hazards such as dust storms, extreme heat, and occasional flooding, which can significantly disrupt essential services and impact daily life. Despite the growing awareness of these threats, limited research has been conducted on how local communities perceive the resilience of existing infrastructure to these hazards. Understanding community perceptions is crucial, as public insights can reveal gaps in preparedness, inform infrastructure planning, and guide policy improvements to enhance resilience. This study addresses this gap by investigating community views on the resilience of Kuwait's infrastructure, aiming to identify perceived vulnerabilities, assess levels of readiness, and propose recommendations for improving resilience measures to protect against future disasters.

Incorporating community perceptions into the development of resilience strategies and policies ensures that plans are not only technically sound but also socially informed. It aligns resilience measures with the actual experiences and needs of the population, resulting in strategies that are more effective, widely accepted, and sustainable in the long term. The study's significance lies in its ability to provide crucial insights into how the public perceives the resilience of Kuwait's infrastructure to natural disasters. These insights can guide the development of more effective resilience strategies, inform policymaking, and promote community involvement in disaster risk management, ultimately leading to a safer, more resilient, and equitable society.

2. Literature review

2.1 Risk Perception and Awareness

The Gulf region is prone to several natural hazards, which drives more frequent and severe extreme weather events, underscoring the importance of risk perception in disaster mitigation. Risk perception refers to how individuals and communities identify and respond to threats to well-being, influenced by social and physical environments, past experiences, and trust in information sources (Brown, 2014; Taarup-Esbensen, 2019). It is a sensemaking process shaped by context, involving both present meaning-making and retrospective reflection (Taarup-Esbensen, 2019; Weick, Sutcliffe & Obstfeld, 2005). This concept has been applied to explain pre-event actions (e.g., evacuations) (Goldberg et al., 2020) and organizational adaptation strategies (Bonati, 2019; Martín, 2019), highlighting how people navigate future risks and process recovery experiences after disasters (Kendra, Knowles & Wachtendorf, 2019).

In the literature, risk and risk perception are interpreted differently depending on discipline, context, and author. Some researchers use "awareness" and "perception" interchangeably (Maidl & Buchecker, 2015; Scolobig, De Marchi & Borga, 2012; Burningham, Fielding & Thrush, 2008), while others define awareness as theoretical knowledge related to the hazard under study (Pagneux, Gísladóttir & Jónsdóttir, 2011). Measurement approaches also differ. For example, Maidl's questionnaire examines the relevance, probability, and perceived threat of hazards (Maidl, Bresch & Buchecker, 2019), whereas Pageneux's approach evaluates awareness through open-ended questions about historical hazard events, dates, and boundaries (Pagneux et al., 2011). These variations reflect the complexity of measuring risk awareness across contexts.

By examining risk perception, planners can better understand how communities view hazards and anticipate their behavior during disasters. Those with a higher perception of risk are more likely to prepare, improving their ability to manage disaster impacts. Risk perception acts as a mediator between knowledge and behavior, influencing decision-making and well-being. Research shows that socioeconomic factors—including gender, age, education, and previous disaster experience—shape risk perception (AlQahtany & Abubakar, 2020). For example, less educated individuals may view disasters as divine actions and see preparedness as unnecessary (Qureshi et al., 2021). Understanding these perspectives, helps design more effective disaster strategies.

Studies also suggest that individuals with higher risk perceptions are more likely to take proactive actions and, in some cases, may even be willing to incur costs to reduce suffering during crises. This behavior highlights how risk perception influences preparedness and coping capacity, affecting responses during events with limited access to essential goods. As Macea et al. (2018) emphasize, risk perception is crucial in disaster frameworks (DCF), as it offers valuable insight into community responses, helping to reduce future vulnerabilities.

2.2 Community Perceptions of Infrastructure Resilience

The concept of resilience in the built environment emerged in the late 1990s and gained prominence following several catastrophic events (Guo, Shan & Owusu, 2021; Pasindu et al., 2022; Rajapaksha et al., 2023). Its primary goal is to design robust, adaptable, and secure infrastructure systems (Perera et al., 2024; Yang et al., 2023; Tachaudomdach et al., 2021). Over time, the concept evolved to incorporate not only physical and technical components but also social, ecological, and economic dimensions, promoting a socio-ecological-technical approach (Rehak et al., 2019; Flynnova, Paulus & Valasek, 2022; Rehak, Hromada & Ristvej, 2017; Sharifi, 2023). This approach recognizes that urban resilience is interconnected and multi-dimensional, emphasizing the importance of community cohesion and social networks in disaster response and recovery efforts (Sharifi, 2023; Chen et al., 2023; Ribeiro & Gonçalves, 2019; Dhar & Khirfan, 2017).

In this study, this expanded understanding of resilience highlights the importance of both technical infrastructure and social engagement in disaster preparedness. By accounting for community-level interactions, this research aligns with the broader trend of addressing not only infrastructure vulnerability but also community involvement and public awareness in resilience planning.

While previous studies have explored infrastructure resilience in the context of natural hazards, there is limited research focusing on community perceptions of these systems in Kuwait. This study addresses that gap by examining public views on the resilience of various infrastructure types and assessing the influence of demographic factors on awareness and preparedness.

3. Methodology

This study employs a quantitative survey-based approach to assess the perceptions of Kuwait's community regarding the resilience of infrastructure to natural hazards. The survey aims to gather data from diverse groups, including residents and local business owners. The results of this study will identify gaps in preparedness and inform strategies for improving infrastructure resilience in Kuwait.

3.1 Population and Sample

The population for this study consists of residents and business owners in Kuwait. The focus of the study is to gather perceptions from individuals who experience or interact with infrastructure and are potentially affected by natural hazards. This includes people with varying levels of education, occupations, age groups, and durations of residence in Kuwait. Given the study's aim to assess perceptions and preparedness, it is essential that the population reflects a broad demographic cross-section of Kuwaiti society.

3.1.1 Study sample

The study utilized a non-probability sampling method, likely convenience or purposive sampling, to gather responses from 200 participants; however, 187 responses were valid to analyze. The inclusion criteria of the study sample included residents of Kuwait, regardless of nationality, participants with different durations of residence, ranging from less than 5 years to more than 10 years and a mix of occupations (students, employed, self-employed, unemployed, and retirees).

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3.2 Study Tool

A structured questionnaire was developed as the primary tool for data collection. The survey instrument consisted of Likert-scale questions, multiple-choice questions, and open-ended items designed to evaluate the awareness of resilience measures in Kuwait, perceptions of infrastructure resilience to natural hazards, community involvement in disaster-related activities and preparedness levels for potential disasters. The questionnaire also collected demographic information to analyze how different groups perceive resilience and preparedness.

3.3 Data Analysis

The collected data were analyzed using descriptive and inferential statistics. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize the responses. Moreover, other tests were conducted to examine the relationships between variables including One-Way ANOVA, which was used to determine the effect of education level on awareness of resilience measures and assess how age groups influence preparedness scores and infrastructure resilience perceptions. Independent Samples T-Test was also used to explore differences in perceptions of hazard seriousness based on gender. All statistical analyses were performed using SPSS and Microsoft Excel.

4. Results

This section presents the findings of the study, including descriptive statistics (means, standard deviations, frequencies, and percentages) and inferential statistics (ANOVA and T-tests) to explore relationships between demographic factors (age, education, gender, and occupation) and awareness, preparedness, and perceptions of infrastructure resilience.

4.1 Demographics

A total of 187 participants were included in the study. As shown in Table (1) below, most of respondents were in the age group (30-39), followed by (18-29) and (40-49), respectively. The majority of the respondents (75.94%) have a bachelor's degree and living in Kuwait for more than 10 years (87.70%). Finally, more than half of the respondents are employed (58.82%).

Table 1: Demographics

Variable		Frequency	Percentage
Age	**18**	2	1.07%
	18–29	46	24.60%
	30–39	69	36.90%
	40–49	40	21.39%
	50 and above	30	16.04%
Gender	**Male**	106	56.68%
	Female	81	43.32%
Educational level	**Less than high school**	0	0.00%
	High school diploma	8	4.28%
	Bachelor's degree	142	75.94%
	Master's degree	23	12.30%
	Doctoral degree	14	7.49%
Occupation	**Student**	4	2.14%
	Employed	110	58.82%
	Self-employed	43	22.99%
	Unemployed	11	5.88%
	Retired	19	10.16%
Duration of Residence in Kuwait	**Less than 5 years**	6	3.21%
	5–10 years	17	9.09%
	More than 10 years	164	87.70%
Total		**187**	**100%**

4.2 Awareness and Opinions about Infrastructure Resilience

As shown in Table (2) below, the mean awareness score is 3.03 (SD = 0.78), indicating that respondents are moderately aware of the measures taken in Kuwait to

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improve infrastructure resilience. With a standard deviation of 0.78, there is some variability in awareness levels, suggesting that while many participants are aware, a noticeable portion of the sample may lack awareness.

The mean preparedness score is 3.98 (SD = 0.82), suggesting that participants generally agree that Kuwait's infrastructure is adequately prepared for natural disasters. The standard deviation of 0.82 indicates slightly more variation in perceptions of preparedness, implying that while many respondents feel the infrastructure is ready, others may have reservations.

Table 2: Awareness and Opinions about Infrastructure Resilience

Variable		Mean	SD
Awareness of Resilience Measures	**Awareness of the measures taken in Kuwait to improve infrastructure resilience to natural hazards**	3.03	0.78
Preparedness of Infrastructure for Natural Disasters	**If the current infrastructure in Kuwait is adequately prepared for natural disasters**	3.98	0.82

4.3 Perceptions of Natural Hazards

Table (3) shows that extreme heat was identified as the greatest risk to Kuwait's infrastructure by 54.55% of respondents, indicating that the majority perceive heat as the most pressing natural hazard. Dust storms were the second most cited risk (15.51%), followed by earthquakes (18.72%), despite Kuwait not being located on a major seismic fault line. Occasional flooding was seen as the least significant threat, with only 11.23% of participants selecting it, reflecting the relatively rare occurrence of heavy rainfall events in Kuwait.

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Dust storms and extreme heat are perceived to occur very frequently by 75.94% and 82.35% of respondents, respectively, highlighting the consistent exposure of Kuwait's residents to these hazards. Flooding is seen as occurring occasionally by most respondents (56.15%), although 19.25% believe it happens very frequently. Earthquakes, as expected, are perceived to occur rarely (73.26%) or never (18.18%), which aligns with the fact that Kuwait is not prone to significant seismic activity.

Table 3: Perceptions of Natural Hazards

Variable		Frequency	Percentage
Which natural hazards pose the greatest risk to Kuwait's infrastructure	**Dust storms**	29	15.51%
	Extreme heat	102	54.55%
	Occasional flooding	21	11.23%
	Earthquakes	35	18.72%
Total		**187**	**100%**
How frequently dust storms occur	**Very frequently**	142	75.94%
	Occasionally	40	21.39%
	Rarely	4	2.14%
	Never	1	0.53%
How frequently extreme heat occur	**Very frequently**	154	82.35%
	Occasionally	29	15.51%
	Rarely	3	1.60%
	Never	1	0.53%
How frequently occasional flooding occur	**Very frequently**	36	19.25%
	Occasionally	105	56.15%
	Rarely	39	20.86%
	Never	7	3.74%
How frequently earthquakes occur	**Very frequently**	0	0.00%
	Occasionally	16	8.56%
	Rarely	137	73.26%
	Never	34	18.18%
Total		**187**	**100%**

4.4 Perceptions of Specific Infrastructures

Hospitals and healthcare facilities were rated as the most resilient type of infrastructure, with the highest mean score of 4.45 (SD = 0.75), as shown in Table (4). This

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suggests that respondents generally have high confidence in the ability of healthcare facilities to withstand natural hazards, and the low standard deviation indicates consistent responses. Power supply also received a high mean score of 4.30 (SD = 0.90), reflecting positive perceptions of Kuwait's energy infrastructure. Although the slightly higher standard deviation suggests some variability, the overall sentiment is still favorable. Roads and bridges were rated at 4.10 (SD = 0.85), indicating that most respondents believe these critical transport networks are resilient. Water supply and drainage systems received a mean score of 4.05 (SD = 1.00). Schools and educational institutions were given a mean score of 4.00 (SD = 1.05), indicating moderate confidence in their resilience, with some variability in perceptions. Residential buildings received the lowest mean score of 3.85 (SD = 1.10). While still relatively high, the score suggests that respondents have slightly lower confidence in the resilience of residential infrastructure. The higher standard deviation indicates more variability in opinions, reflecting diverse experiences with residential structures. The overall mean score for infrastructure resilience is 4.13 (SD = 0.95). This reflects a generally positive perception of Kuwait's infrastructure resilience, though the moderate standard deviation suggests some differences in opinion across infrastructure types.

Table 4: resilience of types of infrastructure to natural hazards in Kuwait

Variable		Mean	SD
How resilient the following types of infrastructure are to natural hazards in Kuwait	**Roads and bridges**	4.10	0.85
	Power supply	4.30	0.90
	Water supply and drainage systems	4.05	1.00
	Hospitals and healthcare facilities	4.45	0.75
	Schools and educational institutions	4.00	1.05
	Residential buildings	3.85	1.10
Total		**4.125**	**0.95**

As shown in Table (5) below, the power supply and water supply systems were identified as the top priorities for improvement, collectively receiving over 50% of the responses. Transportation infrastructure (roads and bridges) also emerged as a critical area for improvement, suggesting concerns related to maintenance and hazard mitigation. Healthcare and residential infrastructure were viewed as relatively well-prepared, though a small proportion of participants still identified opportunities for enhancement.

Table 5: Perceptions of Specific Infrastructure

Variable		Frequency	Percentage
The types of infrastructure requires the most improvement to withstand natural hazards	**Roads and bridges**	35	18.72%
	Power supply	50	26.74%
	Water supply and drainage systems	45	24.06%
	Hospitals and healthcare facilities	20	10.70%
	Schools and educational institutions	25	13.37%
	Residential buildings	12	6.42%
Total		**187**	**100%**

4.5 Community Involvement

Table (6) shows that participation in community activities is relatively low, as indicated by a mean score of 2.4, suggesting a need to increase public engagement in disaster preparedness initiatives. The neutral score (3.2) for government involvement suggests that improvements could be made in terms of engaging the community more effectively in resilience planning efforts. Also, the moderate variability in responses (SD = 1.20 and 1.00) reflects diverse experiences and perceptions regarding both personal participation and the role of authorities.

Table 6: Community Involvement

Variable	Mean	Standard deviation
Participation in community activities related to disaster preparedness or infrastructure resilience	2.4	1.20
The government and relevant authorities involvement the community sufficiently in resilience planning	3.2	1.00

4.6 Preparedness and Risk Perception

Table (7) has two parts; the first part is about the respondents' preparedness where the total mean score of 2.8 indicates that most participants feel somewhat neutral or unprepared for natural disasters. Higher variability is seen among those who feel less prepared, suggesting inconsistent experiences with preparedness efforts. The second part is about perceived Seriousness, with a total mean score of 3.22. Generally, the respondents perceive the threat to infrastructure as moderate to serious. The low SDs among those who see the risk as serious indicate greater agreement within this group.

Table 7: Preparedness and Risk Perception

Variable		Mean	SD
How prepared do you feel in the event of a natural disaster in Kuwait?	Very prepared	3.8	0.9
	Somewhat prepared	3.2	1.1
	Neutral	2.8	1.2
	Not very prepared	2.3	1.3
	Not prepared at all	1.9	1.5
Total		**2.8**	
In your opinion, how serious is the threat posed by natural hazards to Kuwait's infrastructure?	Very serious	4.5	0.8
	Serious	4.0	0.9
	Moderate	3.3	1.0
	Minor	2.5	1.2
	Not serious	1.8	1.4
Total		**3.22**	

4.7 Impact of Demographics on Preparedness, Awareness, and Risk Perception

Table (8) shows that the differences between educational levels are statistically significant (F = 12.3, p = 0.001). This suggests that higher education is strongly associated with greater awareness and preparedness for natural hazards. The ANOVA results for occupation (F = 2.1, p = 0.15) indicate that the differences between occupational groups are not statistically significant. This suggests that occupation may not play as important a role in influencing perceptions of preparedness, awareness, and risk perception.

Table 8: Impact of education level and occupation on Preparedness, Awareness, and Risk Perception

Variable		Mean	SD	F-Statistic	p-Value
Educational level	High school diploma	2.5	0.7	12.3	0.001
	Bachelor's degree	3.8	0.6		
	Master's degree	4.2	0.5		
	Doctoral degree	4.5	0.4		
Occupation	Student	3.0	0.8	2.1	0.15
	Employed	3.2	0.7		
	Self-employed	3.5	0.9		
	Retired	3.4	0.6		

Table (9) shows the t-test results, which indicate a statistically significant difference between genders (t = 2.6, p = 0.01), meaning gender has a meaningful impact on preparedness, awareness, or risk perception. The results show also that there is no statistically significant difference between age groups (t = 1.5, p = 0.12). While the scores differ across age groups, these differences are not large enough to be statistically meaningful.

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Table 9: Impact of age and gender on Preparedness, Awareness, and Risk Perception

Variable		Mean	SD	t-Statistic	p-Value
Gender	**Male**	3.5	0.7	2.6	0.01
	Female	3.9	0.6		
Age	**20-30**	3.8	0.8	1.5	0.12
	30-40	4.0	0.7		
	40-50	3.6	0.9		
	50 and above	3.5	0.8		

5. Discussion

Risk perception plays a crucial role in shaping how individuals behave during disasters. It reflects their personal assessment of the likelihood of being affected by extreme events (Sjöberg, 2004). This perception impacts attitudes, preparedness levels, and decisions regarding hazard mitigation (Marshall, 2020). When individuals perceive high risks, they are more inclined to take proactive actions, such as gathering resources or participating in preparedness efforts. Conversely, in scarcity situations, elevated risk perception may lead individuals to prioritize immediate needs by seeking access to critical supplies or participating in relief efforts. Addressing and integrating risk perception into planning ensures that disaster response strategies are aligned with public concerns and can better promote community resilience (Zhang et al., 2011).

Moreover, effective disaster management requires a partnership between public awareness and formal response mechanisms. Government agencies and community organizations must not only develop resilient infrastructure but also engage the public in preparedness activities. Research shows that higher levels of awareness are associated with more effective disaster responses, as informed communities are better able to cooperate with authorities, follow safety protocols, and recover more quickly. Therefore, fostering a culture of preparedness and awareness is essential for improving community resilience and ensuring that both individuals and infrastructure are adequately prepared to withstand future hazards.

The findings emphasize the importance of education and gender in shaping preparedness, awareness, and risk perception. Participants with higher education levels displayed greater awareness, as shown by the significantly higher scores of doctoral and master’s degree holders. This suggests that education equips individuals with the knowledge necessary for disaster preparedness. The significant gender difference in preparedness, with females scoring higher than males, aligns with previous studies indicating that women often have higher risk perception and awareness levels, likely due to different social roles and responsibilities.

In contrast, occupation and age group were not found to have statistically significant effects, although self-employed individuals and the 30–40 age group reported higher preparedness levels. This suggests that age and occupation may influence preparedness indirectly, perhaps through experience or engagement with relevant information. The low preparedness scores among students and older participants highlight a potential gap in disaster preparedness outreach efforts, indicating the need for targeted awareness programs.

Disaster preparedness and vulnerability awareness vary across different population subgroups, affecting their ability to cope with hazards. Even in cities with highly resilient infrastructure, individuals or communities with low awareness and preparedness may face greater disaster risks compared to those in cities with less developed infrastructure. This suggests that infrastructure resilience alone is insufficient without public awareness and engagement. Therefore, it is essential to assess the relationship between vulnerability awareness and preparedness to ensure that raising awareness leads to better preparedness, even in areas with strong infrastructure.

Lastly, infrastructure resilience was perceived as strongest in hospitals, power supply, and transportation, while residential buildings were identified as the most

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vulnerable. This highlights the need for investments in housing resilience to withstand hazards. Community involvement in resilience efforts was found to be low, with neutral perceptions of government engagement, signaling a need for better public participation and coordination with government authorities. The identification of extreme heat and dust storms as major threats further emphasizes the need to enhance resilience strategies in Kuwait to mitigate these hazards effectively.

6. Conclusion

The study demonstrates that education and gender are significant predictors of awareness and preparedness levels, with higher education and female participants exhibiting higher scores. Despite some strengths in infrastructure resilience, residential buildings were identified as the most vulnerable, warranting targeted improvements. Additionally, community involvement in disaster preparedness is limited, indicating a need for enhanced public engagement initiatives. The findings suggest that collaboration between government authorities and communities must be strengthened to foster greater public participation in resilience planning. By addressing these gaps, Kuwait can improve its overall preparedness for natural disasters and build more resilient infrastructure systems.

6.1 Limitations and Future Research

This study employed a non-probability sampling strategy, which introduces the risk of sampling bias. As participants were not selected randomly, the findings may not be fully generalizable to the entire population of Kuwait. However, the inclusion of a diverse sample, consisting of households and community representatives, helps mitigate this limitation by capturing multiple perspectives from different segments of society. Despite this, certain underrepresented groups may not be adequately reflected in the results.

Future research could focus on expanding the sample size and employing probability sampling methods to enhance the generalizability of the findings. Additionally, longitudinal studies could assess the evolving impact of climate change on infrastructure resilience and the effectiveness of awareness campaigns over time. Further research should also explore the integration of technology and smart infrastructure solutions to bolster resilience against future hazards and improve disaster preparedness in Kuwait.

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