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Investigating urban resilience in case of climate change: A case study of region 12 of Tehran

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Abstract

Given the critical importance of urban resilience in the face of climate change, this paper aims to assess the urban resilience of District 12 in Tehran. District 12 was chosen for its high pollution levels, and the research methodology employed is analytical-descriptive. Data collection relies on library sources and documents, and for analysis, descriptive-inferential statistics including one-sample T-Test and Likert scale are utilized. The statistical population comprises urban planning and meteorological experts. To gauge resilience levels, five variables were identified, each encompassing six components tailored to the region's conditions. The primary objective is to pinpoint components exhibiting poor resilience in response to climate change. Findings indicate a stronger economic dimension of resilience contrasted with a weaker physical dimension, thus suggesting that Region 12 lacks resilience to climate change. The paper offers a comprehensive overview of disasters and provides recommendations for enhancing urban resilience. Studies on climate resilience can prove valuable for urban planners in revising and updating existing plans in the future.

Keywords: Urban resilience; Climate change; Climate resiliency; Region 12 of Tehran

1. Introduction

More than half of the global population currently resides in urban areas, and this trend of urbanization is projected to persist throughout the 21st century (Cohen, 2006; Montgomery, 2008). The population growth has led to heightened energy consumption across various sectors such as commercial, industrial, residential, and transportation, consequently resulting in greenhouse gas (GHG) emissions. Urban centers encounter substantial energy demands for activities like heating, cooling, and transportation, all of which contribute to GHG emissions (Chapman, 2007; Karl & Trenberth, 2003). Recognizing the challenge of climate change, cities have been collaborating to exchange knowledge and promote climate leadership. One notable example is the C40, a network comprising 40 megacities and 19 affiliate cities, which focuses on reducing GHG emissions through the adoption of energy-efficient practices and clean-energy initiatives (Rosenzweig et al., 2012). Smart cities have emerged as a response to climate change challenges, leveraging the integration of information concerning population and resources within the city. To harness this information effectively, a smart city must employ data-driven decision-making to establish goals and make informed choices (Batty et al., 2012).

Various studies indicate that climate change is underway, and by 2030, over 100 million people are projected to fall into poverty due to its effects, particularly in South Asia and sub-Saharan Africa (Stephane et al., 2017). Climate change results from a gradual rise in Earth's temperature, known as global warming, due to the accumulation of greenhouse gases, primarily carbon dioxide, in the atmosphere (Romero-Lankao et al., 2012; Cowan et al., 2004). This includes alterations in average climatic conditions, occurrences of heat-waves, droughts, floods, storms, and other severe weather events. Climate change can occur naturally or as a consequence of human activities (Masih, 2010; Elahi Gol et al., 2006). Globally, climate change has led to the melting of polar ice caps and rising ocean levels, with human activities

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being the primary driver, causing an increase in atmospheric gases (Ramazanzadeh & Jumehpour, 2016). Presently, we are witnessing migrations and fatalities among humans and animals due to climate change in various regions worldwide, with many cities not been prepared for the sudden or gradual onset of these climate shifts (Pearson, 2003; World Bank, 2010). The adverse effects of this phenomenon could intensify in the future due to societies' rapid industrial development and inadequate attention to environmental concerns, leading to heightened climatic phenomena such as floods and droughts across different regions (Carmin et al., 2012).

As urbanization advances, the impacts of climate change become increasingly pronounced. Climate-resilient development can empower countries to diversify and reduce reliance on sectors more vulnerable to climate change effects, thereby enhancing people's ability to withstand shocks. This approach also allocates more resources to countries, communities, and individuals to minimize risks (Smith, 2011; World Bank, 2010). Identifying individual, social, economic, physical, environmental, and managerial characteristics is crucial for effectively restoring balance against natural hazards (Martin et al., 2017). This ability to restore equilibrium is resilience (C.S. Holling, 1973), which signifies continuity in relation to a system and measures the system's capacity to withstand change while maintaining stability. Initially, resilience assessment focused on natural hazards, emphasizing communities' ability to recover using their resources (Béné et al., 2012; Amaratunga et al., 2011; Mileti, 1999).Climate resilience represents the ability and capacity of a city to respond to the challenges of severe weather events and the risks of climate change (UN-DESA, 2017) Climate resilience is a unique opportunity to reduce inequalities and the challenges of natural hazards (Godschalk, 2003) and make individuals enable to adopt strategies to increase the resilience of existing systems and to recover from disturbances such as fire, flood, storm, etc. (Vasseur, 2015)

Various researches have been done in order to discuss resilience, including the internal example:

Farzaneh Sasanpour and Navid Ahangari demonstrated the resilience of Tehran's social, ecological, and institutional (organizational) dimensions by examining various components. The results revealed that this area is not resilient and stable in the face of natural hazards. (Farzaneh Sasanpour, Navid Ahangari, 2018) Sanaz Manafluyan employed a descriptive-analytical method, based on documentary studies, to identify and address the problem. The TOPSIS method was also utilized to analyze the factors. The findings indicated that the most crucial factors for climate resilience in the city of Tabriz include the utilization of specialized and skilled manpower in disaster management, protection of water infrastructure, promotion of public transportation, and ensuring food security. Hence, these factors, possessing both adaptive and mitigating characteristics, should be leveraged to enhance Tabriz's resilience to natural hazards induced by climate change. (Manafluyan, 2020)

The World Organization for Human Settlements serves as a guide for urban planners. According to this organization, effective planning equates to smart climate planning. The planning methodology comprises nine-stage models and illustrates, through diagrams, the increase in temperature across all continents from 1910 to 2010. It highlights Iran's vulnerability to drought among middle-income countries and the widespread impact on most Asian countries. The book introduces planning initiatives in community soil water management, among other areas, and identifies key issues (UN-Habitat, 2014).Furthermore, while most studies have focused on adaptation to climate change, resilience to climate change has received less attention. In Tehran, climatic data indicates a rise in the average annual temperature over the past thirty years, coupled with a decrease in average rainfall (Azaranfar et al., 2006). Additionally, due to air pollution, particularly prevalent in winter, climate change is unlikely to abate in the future (Weichselgartner et al., 2014). Factors such as intensified industrial activities, population growth, urban sprawl, etc., have contributed to climate change and global warming (Asakereh et al., 2018; Ashofteh, 2008). Conversely, climate change manifests in rising temperatures and diminishing rainfall. Presently, Tehran experiences drier conditions compared to the past, signaling significant climate changes and underscoring the necessity for research on strategies to mitigate or adapt to these changes effectively.

Moreover, the downward trend in average rainfall and escalating temperatures in Tehran have led to consequential alterations in water resources, agricultural production surrounding the city, intensified urban heat islands, increased pollution levels, destructive floods, ecological impacts (affecting various plant and animal species), and heightened energy consumption for cooling purposes. As the capital and most populous city in the country, Tehran is among the most polluted cities and is highly susceptible to climate change (Bavand Consulting, 2007). Furthermore, due to its proximity to the city center, region 12 was chosen as a focal point due to its compromised infrastructure, making it a prime area for studying resilience against climate change. Thus, the objective of this study is to address the query: 1) Is District 12 of Tehran resilient in the face of climate change?

2. Material and methods

2.1. Case study

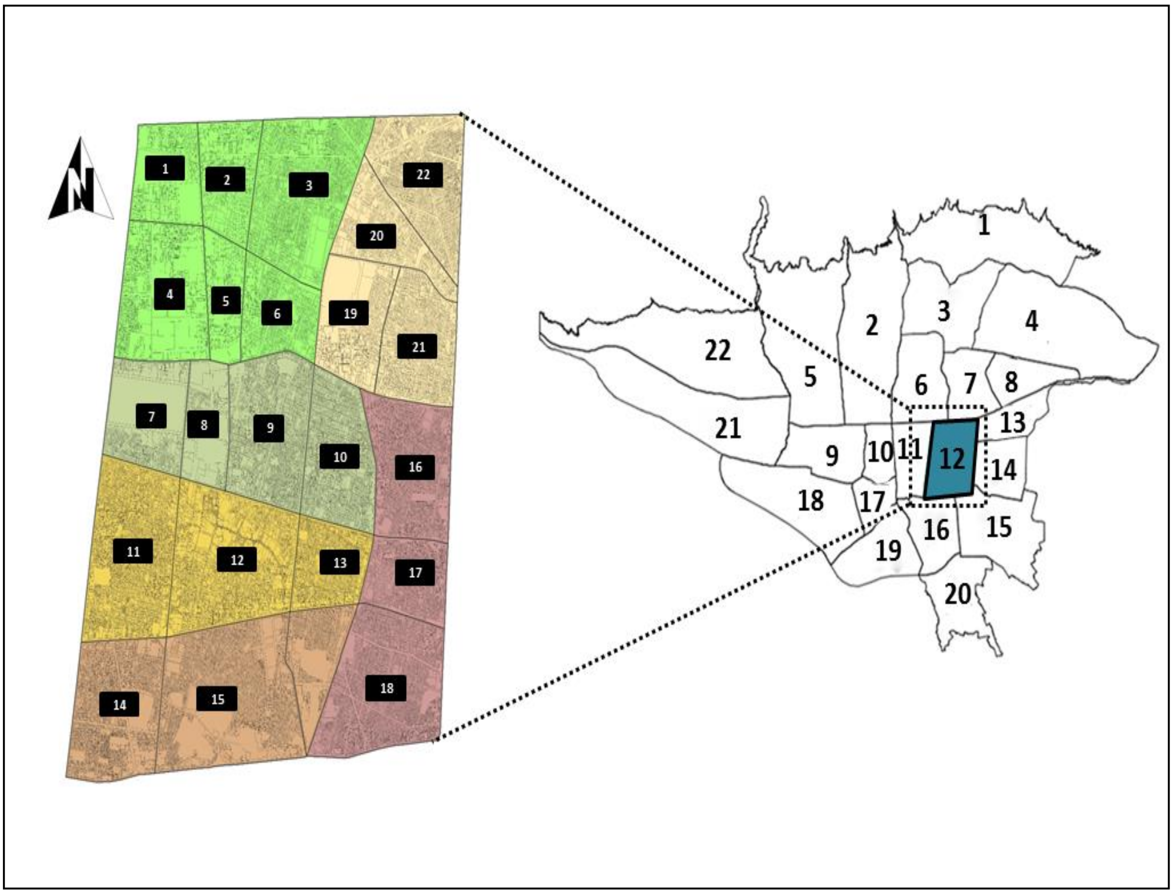

Figure 1 Location map of area12 in Tehran City

District 12 of Tehran serves as the historical core of Tehran, encompassing an area of 1600 hectares (2.3% of Tehran's total area). Over recent decades, the physical, spatial, and functional structure of District 12 has undergone chaotic and uncoordinated changes, resulting in a gradual reduction in its spatial, functional, and environmental qualities due to neglect in guiding and controlling its development (Bavand Consulting, 2007).

Tehran is experiencing a general trend towards hotter and drier climatic conditions, except for the slightly humid and temperate northern mountainous areas. Positioned on the border between contrasting humid climates in the north and arid deserts in the south, Tehran province is in a sensitive and fragile climatic position. The province's southern desert border region is witnessing a developing trend of uncontrolled land use, disregarding its capabilities and climatic limitations. Moreover, the concentration of urban and industrial activities in the central areas of the province poses a significant threat in terms of environmental pollution and adverse effects on the region's climate. The recorded maximum temperature in Tehran is 39.4 degrees Celsius, with a minimum of -7.4 degrees Celsius, and an average monthly maximum of 29 degrees Celsius and a minimum of 0.1 degrees Celsius (Mohammadi, 2010).

The findings of a 45-year study on Tehran's temperature patterns indicate a warming trend over this period. Tehran's nights have also experienced warmer temperatures, with winter temperatures rising more significantly than summer temperatures. Analysis of rainfall patterns during the mentioned 45-year period suggests that Tehran's rainfall has not undergone significant changes. However, according to the drought equation, which considers both rainfall and air temperature, Tehran's climate has become drier (Alijani, et al., 2017).

2.2. Climate change in region 12

District 12 of Tehran is located in the center of Tehran, so that due to its location and also due to the prevailing wind current in the west and the establishment of an important part of the province's industries in the west of Tehran, most pollutants from industries located in the west of Tehran are driven to the city center. Mountains located in the north and northeast of Tehran prevent pollution from escaping by the wind. As a result, the air in the central areas of the city due to the accumulation of pollution from cars, chimneys and other sources become more polluted with transmissible pollution from the suburbs and its pollution increases more than before. On the other hand, high air temperature in the city center creates heat waves which cause the transfer of pollution in the suburbs to the city center by local winds, the pollution situation in the city center increases dangerously. So that in winter the greenhouse phenomenon in this area occurs (Mohammadi, 2010)Also, this area has less urban green space to reduce pollution due to the construction process, in general, these factors can Indicates vulnerability to climate change (Bavand Consulting, 2007). Therefore, according to various studies, in general if climate change occurs, it can have the following consequences. Possibility of occurrence of these consequences in district 12 of Tehran is not impossible due to the mentioned conditions. Therefore, according to various studies, climate change in general, can have the following consequences.

Table 1 Consequences of climate change (Khoshmanesh et al., 2015)

Consequences of climate change				
Impact on the spread of poverty	Regional threat to human health and the spread of infectious diseases	Impact on internal and external migration	Threat of water and food resources	War and conflict

2.3. Discussion of Procedure (Research method):

The time frame of this research is 2020 and the spatial range of district12 of Tehran. This research is a kind of cognitive research that is done in a descriptive-analytical way. In order to explain the questions, the descriptive research method has been used with the aim of objectively and systematically describing the characteristics, then the exploratory method has been used to answer the questions.

2.4. Components and variables of research:

In this research, first the variables and components of resilience to climate change have been extracted and then adapted to the conditions of region 12 by first using previous studies in this field relevant indicators were extracted. More precisely, the components in this study were selected based on studies conducted inside and outside Iran, and due to the importance of each to the study area, were reviewed and approved by several urban planning management experts. Finally, five variables, each of which consisted of six components, were extracted. The survey included completing a questionnaire to identify the most important components and variables and analyze the status of each of them in terms of resilience to climate change. (Table 2)

Table 1 the most important components and variables in region 12

Components of resilience to climate change				
Institutional	Physical	environmental	social	Economical
Coordination and relations between organizations	The degree of resistance and environmentally friendly materials	Risk planning	social Identity	Employment and income status
Ability to adapt the system	Consistency of land use pattern with transportation development	Environmental diversity	Social Security	Economic dynamics
International cooperation	Soil permeability	Environmental sustainability	Social order in the city	Access to services
System reversibility	How to place buildings and alleys according to the direction of the wind	Natural energy	People's migration	Business Continuity
System support	Height limit	Collect surface water	Social Welfare	Economic stability

Urban management costs	Slope of streets to drain water	Planning to prevent pollution	Public participation	Ability to compensate

2.5. Data collection method

The methodology employed in this study encompassed documentary research and library resources, including articles, dissertations, books, scientific journals, and specialized documents such as statistics from the Statistical Center of Iran and the Meteorological Organization. The study's statistical population comprised experts in urban planning and meteorological planning, as well as university scholars. A total of 20 participants were selected using the snowball sampling method until theoretical saturation was reached. The questionnaire, distributed based on the Likert scale, assigned scores ranging from 1 (unimportant) to 5 (extremely important) based on the importance of factors in Region 12.

Quantitative data analysis utilized descriptive statistics, involving the preparation of charts and tables using Excel and SPSS software. SPSS was employed for data entry and analysis using various statistical methods. The reliability of resilience dimensions was assessed using Cronbach's alpha coefficient, yielding a value of approximately 0.8 for all questions, indicating high internal consistency. Cronbach, L.J. (1951)

Subsequently, data analysis was conducted using the one-sample T-Test method, which compares means to determine significant differences. This statistical approach facilitated the examination of resilience dimensions and their significance in the context of Region 12.

3. Results and discussion

3.1. Investigating research variables

Descriptive statistics of resilience dimensions for each variable and its corresponding component are given. The average of each item is given based on the five-level Likert scale. The purpose of the table is to show the most important components in district12 of Tehran, to identify the most important components of the physical variable according to its average and pay more attention to the weaker component for future plans and presentation strategies.

Table 2 Descriptive statistics of variables

Descriptive Statistics	**N**	**Mean**	**Std. deviation**	**Min**	**Max**
Economical					
Employment status and income	24	3.0526	1.17727	1.00	5.00
The degree of economic dynamism	24	2.4211	0.96124	1.00	4.00
The level of access to services	24	2.0000	0.88192	1.00	4.00
The degree of economic stability	24	2.1579	0.95819	1.00	4.00
Ability to compensate	24	2.1579	0.89834	1.00	4.00
Planning for business continuity	24	1.9474	0.77986	1.00	3.00
Social					
The extent of social identity	24	1.6842	0.58239	1.00	3.00
The level of social security	24	1.6316	0.68399	1.00	3.00
Creating social order in the city	24	1.8421	0.76472	1.00	3.00
Social Welfare	24	1.9474	1.02598	1.00	4.00
Increase public participation	24	2.1579	0.89834	1.00	4.00
The rate of migration of people	24	3.7895	1.13426	1.00	5.00
environmental					

Planning to reduce hazards and pollution	24	3.8947	0.87526	2.00	5.00
The extent of environmental diversity	24	2.0000	0.88192	1.00	4.00
The degree of environmental sustainability	24	2.0526	0.70504	1.00	3.00
Natural energy	24	1.1579	0.37463	1.00	2.00
Ability to collect surface water	24	1.6842	0.58239	1.00	3.00
Long-term planning to prevent contamination	24	1.2105	0.41885	1.00	2.00
Physical					
The degree of resistance and environmentally friendly materials	24	1.5789	0.69248	1.00	3.00
Consistency of land use pattern with transportation development	24	1.6316	0.68399	1.00	3.00
Soil permeability	24	1.6842	0.67104	1.00	3.00
How to place buildings and alleys according to the direction of the wind	24	1.6842	0.67104	1.00	3.00
The amount of height restriction	24	1.8421	0.76472	1.00	3.00
The Suitable slope of streets	24	1.5789	0.69248	1.00	3.00
Institutional					
The degree of coordination and relationships between organizations	24	1.7368	0.73349	1.00	3.00
The degree of ability to adapt the system	24	1.5789	0.69248	1.00	3.00
The extent of international cooperation	24	1.7368	0.73349	1.00	3.00
System reversibility rate	24	1.7368	0.65338	1.00	3.00
System support rate	24	1.6842	0.67104	1.00	3.00
Reduce urban management costs	24	3.6842	1.05686	2.00	5.00

3.1.1. Study of the economic variable of region 12

Among the economic dimensions, most of the variables are at the level between (2) and (3). Among these, the component of income and employment status is 3.05 at the level of quite important and planning for continuity business with a score of 1.94 is the least important component just under somewhat important level.

3.1.2. Investigating the social variable of region 12

Among the social dimensions, most of the variables are at the level between (1) and (2). However, the amount of immigration of people in the area with an average score of 3.78 is the most important component, but it is at the quite important level. And the levels of social identity and social security have the lowest values and are less important.

3.1.3. Study of the environmental variable in region 12

Among the environmental dimensions, the variable of planning to reduce pollution and hazards with a score of 3.8 is in the quite important level and has the highest importance, and the use of natural energy with a score of 1.15 is at the lowest and is at the unimportant level.

3.1.4. Investigation of the physical variable of region 12

Among the physical dimensions, below all variables are located at the level between (1) and (2). The highest importance component in the region is the height limit with a score of 1.82 although it is under a somewhat important level, and the lowest components are environmentally friendly materials and street slope to drain in the area.

3.1.5. Investigating the institutional variable of region 12

Among the institutional dimensions, all components are at unimportant level, except for the reduction of urban management costs with a score of 3.68, which is the most important however it is at quite important level.

The number of hazards and pollution with an average rank of 3.89 is the most important and natural energy with an average of 1.15 is the least important. Also, planning to reduce pollution and environmental pollution with a mean of 3.8 and high migration with the mean of 3.7 and urban management costs with a mean of 3.6 are the most important issues regarding climate change and natural energy, with an average of 1.1, it has the lowest importance.

3.1.6. Assessing the resilience of Region 12 based on the main components

The average of the main components of the urban resilience variable in the table (4) against climate change based on the five-point Likert scale indicates that the average economic variable is 2.3 and its level is somewhat important. The mean of the social variable with a level of 1.85 is at the unimportant and just under somewhat important level, the mean of the environment variable is 1.86 with a level as same as social variable and urban resilience against climate change with a mean of 1.99. Finally the level of the institutional (organizational) variable is somewhat important with a mean of 2.08.

3.2. Analysis of the desirability of urban resilience components:

The above tables show the T-Test for five indicators. The T-Test is used to show the desirability of the resilience dimensions and to compare the mean of each variable with the T-value to determine the resilience of region 12**.**

Table 3 T-Test dimensions of resilience

One-Sample Statistics				
Variables	N	mean	Std. Deviation	Std. Error Mean
Environmental	20	1.8660	0.39389	0.08808
Economical	20	2.3018	0.32330	0.07229
social	20	1.8590	0.31840	007120
Physical	20	1.7953	0.24749	0.05534
Institutional	20	2.0865	0.36174	0.08089

Table 4 T-Test dimensions of resilience

Variables	**Test Value**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**95% Confidence Interval of the Difference**	
						Lower	Upper
Environmental	1.9	-0.386	19	0.704	-0.03400	-0.2183	0.1503
Economical	2.3	0.025	19	0.980	0.00183	-0.1495	0.1531
Social	1.9	-0.576	19	0.571	-0.04100	-0.1900	0.1080
Physical	1.79	0.096	19	0.924	0.00533	-0.1105	0.1212
Institutional	2.08	0.080	19	0.937	0.00650	-0.1628	0.1758
Resilience	1.99	0.224	19	0.825	0.00833	-0.0695	-0.0863

As can be seen from the tables, according to this test, the value of the economic dimension with the largest mea is 2.3, and the value of t for this dimension is 0.025, which indicates the weakness of the economic dimension.

For the environmental dimension, the variable exhibits a weak position, as indicated by the significant difference between its value and the mean. Similarly, the social dimension, with a mean of 1.85 and a T-value of -0.8, signifies the poor status of social variables in this region. The physical dimension, with a mean of 1.79 and a T-value of 0.9, underscores the weakness of this dimension, with its instability being the lowest average observed. Conversely, the institutional variable, akin to the economic variable, presents a higher mean of 2.08 and a T-value of 0.8, indicating a relatively stronger position.

In summary, the resilience dimension, with a mean of 1.99 and a T-coefficient of 0.224, suggests a general weakness in climatic resilience. Moreover, the significance value (Sig. 2-tailed) for resilience is 0.825, further indicating the general weakness of the climate resilience dimension, with a very weak level. Since the significance value is not smaller than 0.01 or 0.05, we can conclude that the mean of the resilience variables in Tehran is not higher than the final mean of resilience, and all variables have the same mean grade point. Ultimately, Region 12 demonstrates a lack of resilience to climate change. With a 95% probability, it can be stated that Region 12 is not resilient to climate change.

4. Conclusion

Climate change poses a significant challenge to the modern world, characterized by its unpredictability. However, approaches such as urban resilience offer a means to mitigate its effects. Through the analysis of resilience dimensions and component determination, it has been revealed that all variables and components lack resilience, indicating that District 12 of Tehran is not resistant to climate change, as illustrated in Tables 4 and 5. These findings align with previous research presented in this study. Among the identified components, factors such as employment, economic dynamism, and access to services are particularly noteworthy. Based on the quantitative and qualitative measures outlined in the study area, it is evident that building a resilient society is imperative to mitigate the consequences of climate change. Informing the populace can serve as a viable approach in this regard. Presently, increased attention must be directed towards resilience. Embracing a preventive approach and prioritizing risk assessment are crucial steps forward. Engaging people in governance and planning processes is pivotal, as it fosters collective action and ownership. Given that climate change is a global phenomenon, fostering a nuanced understanding of climate change and urban resilience within society is paramount. Rather than merely replicating foreign examples, it is essential to tailor solutions to the unique components and conditions of each city and region, drawing from local experiences. Enhancing the quality and quantity of these components can significantly bolster a city's resilience against climate change. Strengthening the role of managers and government emerges as a key strategy to bolster the resilience of Region 12. A robust governmental presence is indispensable for implementing effective solutions. Additionally, promoting the use of public transportation can mitigate traffic congestion and air pollution, considering that a significant portion of cars operate with single-passenger occupancy. Furthermore, prioritizing green spaces and environmental protection initiatives is vital. Developing comprehensive plans and robust forecasting systems that offer timely information can significantly enhance preparedness for any climate change-related events, thereby reducing both human and financial risks.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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