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Modeling the Impact of Urban Climate on Urban Resilience in Sari: The Mediating Role of Social Participation and Institutional Trust

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ABSTRACT

Climate change has increasingly transformed urban resilience into a key strategy in urban planning. The present study aimed to model the impact of urban climate on urban resilience in Sari, with the mediating role of social participation and institutional trust. In terms of purpose, this study was applied, and in terms of nature, it employed a descriptive-correlational design. The study was conducted during the first half of 2026 among 410 citizens aged 20–65 years in Sari, selected through multistage cluster random sampling. Data were collected using a researcher-developed questionnaire, whose reliability was confirmed with a Cronbach's alpha coefficient of 0.71. The findings from stepwise regression analysis showed that the research model explained a total of 44% of the variance in urban resilience. Social participation ($\beta = 0.33$) and institutional trust ($\beta = 0.30$) were the strongest positive predictors of resilience, while among the urban climate components, only urban humidity and precipitation ($\beta = -0.21$) had a significant direct effect. Furthermore, the mediating roles of social participation and institutional trust were confirmed at the 95% confidence level. The results indicate that urban resilience in Sari, rather than being merely a function of physical infrastructure, is largely the outcome of social capacities and institutional effectiveness. Enhancing urban resilience therefore requires the institutionalization of strategic participation and the rebuilding of public trust.

Keywords: *urban resilience, urban climate, social participation, institutional trust, Sari City.*

1. Introduction

Accelerating climate change, rapid urbanization, intensification of environmental pressures, and growing complexity in the management of cities have transformed urban resilience from a primarily disaster-oriented concept into a multidimensional framework for urban governance and sustainable development. Contemporary cities operate as interconnected social, environmental, infrastructural, economic, and institutional systems in which disruption in one subsystem can rapidly influence the performance of others. Urban resilience therefore refers not merely to the ability of physical structures to withstand shocks, but also to the capacity of urban systems to anticipate disturbances, absorb their impacts, adapt to changing conditions, reorganize available resources, and recover while maintaining essential functions. Reviews of resilience theory emphasize that this concept has evolved from an engineering-oriented focus on returning to equilibrium toward an adaptive and transformative perspective in which learning, institutional capacity, social networks, governance quality, and long-term adjustment are central components of resilient urban development (Irani & Rahnamayiezekavat, 2021; Kong et al., 2022). Similarly, urban resilience has increasingly been understood as a management framework through which cities can integrate risk reduction, adaptive planning, institutional coordination, and social capacities into routine decision-making processes (Cao, 2023; Hossein Dousti et al., 2023).

The multidimensional character of urban resilience is particularly important because cities are simultaneously exposed to climatic hazards, infrastructure disruption, public-health emergencies, earthquakes, water insecurity, socioeconomic instability, and other interconnected risks. Research in Iran has therefore examined resilience from a wide variety of perspectives, including the physical resilience of urban spaces against earthquakes (Pasandideh Talemi et al., 2024), earthquake resilience in cities such as Islamabad-e Gharb (Haseli et al., 2024), seismic resilience in Tabriz (Mirzajani Naneh Karan, 2026), resilience of new urban settlements exposed to earthquake risk (Karimi Qotb & Zangiabadi, 2025), and the development of conceptual resilience models for earthquake-prone cities such as Bam (Farahani et al., 2024). Other studies have considered resilience in urban housing (Mousavi et al., 2023), neighborhood shelter planning from the perspective of passive defense (Kameli & Hosseini Amiri, 2026), and the resilience of urban infrastructure within smart-city frameworks (Ahmadi et al., 2025). Collectively, these studies demonstrate that the continuity of urban functions depends on far more than structural robustness; it also requires coordinated management, institutional preparedness, accessibility of services, adaptive decision-making, and the ability of citizens and organizations to act collectively under uncertain conditions.

Within this broader resilience agenda, climate change has become one of the most persistent and pervasive sources of urban risk. Unlike isolated hazards, climatic pressures can alter everyday environmental conditions while simultaneously intensifying acute events. Rising temperatures, urban heat islands, deteriorating air quality, changes in humidity and precipitation patterns, water stress, altered wind and ventilation conditions, and increased thermal discomfort can influence not only infrastructure and ecosystems but also human behavior, social interaction, public space use, mobility, and confidence in urban management. A meta-analysis of research on climate change and urban resilience in Iran has demonstrated the growing importance of integrating climatic variables into resilience assessments rather than treating climate-related risks as peripheral environmental issues (Davari Zarnaghi & Kalantari, 2024). The development of a multidimensional climate-adaptation resilience index for Tehran similarly illustrates the necessity of examining climatic adaptation through multiple social, spatial, institutional, and environmental dimensions (Jamali et al., 2023). Assessments of climatic resilience at the neighborhood level further demonstrate that urban areas within the same city may differ markedly in their capacity to withstand and adapt to climatic pressures, emphasizing the need for locally sensitive resilience planning (Pirasteh et al., 2026).

Urban climate constitutes a particularly significant component of this relationship because climatic conditions are experienced by citizens at the neighborhood and public-space levels. The urban heat island effect, for example, can alter thermal comfort, outdoor activity, population distribution, and the everyday usability of urban environments. Research conducted in Sari has already examined the impact of urban climatic changes, particularly heat islands, on the spatial distribution of the population, indicating that the relationship between climate and urban spatial organization is directly relevant to this city (Mesri Alamdari & Rasouli, 2021). At the broader methodological level, recent research has also sought to predict the Universal Thermal Climate Index in urban outdoor spaces through advanced deep-learning approaches, reflecting the increasing importance attached to accurate assessment of thermal conditions in urban planning (Norouzi & Mohammadi, 2025). Climate-sensitive urban design has accordingly become an important adaptation strategy; for example, studies of urban green infrastructure have emphasized its role in moderating climatic pressures and improving the environmental performance of neighborhoods (Teymi et al., 2025). Research on urban agriculture likewise suggests that urban ecological systems can contribute to resilience through functions such as carbon storage and sequestration while supporting densely populated urban areas (Veisi Nabi Kandi et al., 2024).

The effects of climate, however, extend beyond temperature alone. Variations in precipitation, humidity, water availability, air quality, and ventilation can produce distinct forms of urban vulnerability. Water insecurity has emerged as an important resilience challenge in cities such as Mashhad, illustrating the dependence of urban stability on reliable water resources and effective urban management (Mansouri Etminan et al., 2025). The development of hybrid resilience models for urban water-supply networks, including work conducted in Babol, further demonstrates that resilience requires both infrastructural reliability and adaptive management of essential urban services (Mohammadpour et al., 2025). Drought and climate-change crises have also been associated with changes in environmental behavior and sustainable urban development, highlighting the relationship between environmental stress and citizen responses (Bagheri et al., 2025). Similarly, investigations of tourism climate under climate-change scenarios indicate that climatic shifts can alter the suitability and functioning of urban and regional environments for human activities (Ahmadzadeh et al., 2025). International experience with urban adaptation, including analyses of Japanese urban communities, additionally confirms that successful climate adaptation depends on institutional planning, anticipatory governance, and the capacity to translate environmental knowledge into practical urban responses (Kiasat & Ilanlou, 2024).

These observations suggest that climate-resilient urban management cannot be reduced to technological or physical interventions. Although infrastructure, smart technologies, green systems, and spatial planning are essential, the resilience of a city also depends heavily on the behavior and relationships of its residents and institutions. Research on smart-city components has emphasized the potential of intelligent urban systems to support resilience (Farajpour et al., 2025), while futures-oriented work on agile cities has highlighted adaptability, flexibility, and dynamism as central features of resilient metropolitan development (Ahangari, 2025). Integrated approaches linking sustainable development and urban resilience similarly demonstrate that physical development should be coordinated with environmental, managerial, and social objectives rather than pursued as an isolated planning process (Khoshtarsah Langeroudi et al., 2025). Consequently, resilient urban governance requires an understanding of how environmental pressures interact with social capacities and institutional performance.

Among these capacities, social participation occupies a central position. Participation enables residents to share information, identify local problems, mobilize resources, cooperate during emergencies, contribute to neighborhood improvement, and engage with formal urban institutions. It can therefore function as both a preventive and adaptive mechanism within resilience systems. Empirical research in Iranian cities has shown that citizen participation can contribute to higher levels of urban resilience by strengthening collective action and local problem-solving capacities (Majnuni Toutakhaneh et al., 2023). Research in Sari is particularly relevant in this regard. A sociological study of deteriorated urban fabrics in District 4 of Sari Municipality has demonstrated the importance of social capital and citizen participation in urban rehabilitation, suggesting that community networks and participation constitute significant resources for the management of urban change (Aghaei Azad et al., 2025). International studies similarly emphasize the influence of social capital on urban and rural communities and its importance for collective capacity and sustainable development (Prastyo et al., 2024). In peri-urban agricultural communities, social capital and innovation adoption have also been identified as mechanisms through which communities can strengthen resilience in the face of urban expansion and associated pressures (Azzahra et al., 2026).

Nevertheless, social participation is not automatically equivalent to resilience. The effectiveness of participation depends on its continuity, organization, inclusiveness, access to reliable information, and relationship with formal governance structures. Reactive participation that emerges only in response to crises may mobilize citizens temporarily but may not generate lasting adaptive capacity unless it becomes embedded within institutional processes. This distinction is particularly important from a management perspective because urban authorities must move beyond treating residents as passive beneficiaries of municipal services and instead incorporate them as stakeholders in risk identification, planning, implementation, and evaluation. Research on urban social resilience reinforces the idea that resilience is produced through networks, interactions, and adaptive social relations rather than through physical characteristics alone (Akbari et al., 2024). Studies of resilience drivers in border communities have similarly demonstrated that urban resilience is influenced by interconnected social, managerial, economic, and institutional determinants (Saeidi, 2024). Even in the context of epidemic diseases, the urban resilience literature emphasizes the importance of coordinated societal and institutional responses, illustrating the wider applicability of social capacities across different forms of urban disruption (Rafiei et al., 2024).

A second critical social-management factor is institutional trust. Urban resilience depends partly on whether citizens believe that municipal organizations, emergency agencies, public authorities, and other institutions are competent, fair, transparent, and capable of responding effectively to risks. During environmental stress or crisis, residents frequently depend on official information, public warnings, municipal services, infrastructure agencies, and emergency institutions. Where institutional trust is strong, citizens may be more willing to follow official guidance, cooperate with authorities, participate in collective actions, report problems, and accept adaptive policies. Conversely, weak institutional trust can reduce cooperation and undermine the implementation of even technically sound resilience strategies. Literature on urban climate resilience capacity building has therefore highlighted institutional and governance capacities alongside technical knowledge and physical interventions, particularly in cities facing substantial environmental and developmental pressures (Wieszczeczynska et al., 2024). The growing emphasis on smart and adaptive urban governance also indicates that resilience is partly a question of institutional quality, coordination, learning, and the credibility of decision-making structures rather than simply the availability of infrastructure.

The relationship between participation and institutional trust is especially important because these variables can reinforce or constrain each other. Citizens who trust urban institutions may be more willing to participate, while meaningful opportunities for participation can, in turn, increase perceptions of institutional responsiveness and legitimacy. From a resilience-management perspective, these processes suggest that the social consequences of climatic conditions may be transmitted through citizens' evaluations of institutions and their willingness to engage in collective urban action. This possibility provides a more comprehensive interpretation of the climate–resilience relationship than models focusing exclusively on direct environmental impacts. Climate-related discomfort, recurrent urban service disruption, waterlogging, pollution, excessive heat, or inadequate ventilation may alter evaluations of urban management and influence participation patterns. Thus, urban climate may affect resilience both directly and indirectly through the social and institutional mechanisms that determine whether communities can coordinate and adapt.

This integrated perspective is particularly relevant to Sari. As an important urban center in northern Iran, Sari contains diverse residential, commercial, recreational, historical, and peri-urban environments in which environmental quality, public-space use, social interaction, and municipal management intersect. Existing studies in the city have examined several dimensions relevant to sustainable urban governance. Research on the role of handicrafts in sustainable tourism development in Sari's traditional market environments illustrates the significance of local economic and cultural capacities in urban sustainability (Melania Jaloudar, 2025). Studies of rural markets in Sari's peri-urban areas have similarly highlighted entrepreneurship and employment creation, indicating the importance of local economic networks and peri-urban relationships within the wider urban system (Shamsoddini et al., 2026). Together with evidence concerning heat islands and population distribution in Sari (Mesri Alamdari & Rasouli, 2021) and citizen participation in the rehabilitation of deteriorated urban fabrics (Aghaei Azad et al., 2025), this body of research indicates that Sari provides a valuable context for studying how environmental conditions interact with social and managerial capacities.

Despite the increasing volume of resilience research, several gaps remain. A substantial proportion of existing Iranian studies has focused on earthquake resilience, physical vulnerability, infrastructure, housing, or spatial preparedness, while fewer studies have simultaneously modeled climatic conditions, citizen participation, institutional trust, and urban resilience. Even studies that recognize the multidimensional nature of resilience often assess environmental, social, and institutional indicators as parallel dimensions rather than testing the mechanisms through which one domain influences another. This limits the ability of urban managers to determine whether improvements in resilience should primarily target climatic adaptation, public participation, institutional performance, or interactions among these areas. In addition, the literature increasingly recognizes that the same environmental pressure can produce different outcomes depending on the social and institutional capacities of the affected community. Consequently, identifying mediating mechanisms is essential for moving from descriptive resilience assessment toward explanatory models that can support evidence-based urban management.

The need for such integrative modeling is strengthened by the fact that resilience is context-dependent. The characteristics that increase resilience in one city may not produce identical effects elsewhere because climatic conditions, infrastructure systems, socioeconomic structures, institutional arrangements, and citizen–government relationships vary geographically. Studies across Iranian cities have documented this diversity, from smart-city and infrastructure resilience in Ahvaz (Ahmadi et al., 2025) and water-related resilience in Mashhad (Mansouri Etminan et al., 2025) to earthquake resilience in Isfahan-region settlements (Karimi Qotb & Zangiabadi, 2025), climatic resilience in Tehran neighborhoods (Pirasteh et al., 2026), and integrated resilience planning in Rudsar (Khoshtarsah Langeroudi et al., 2025). Such variation reinforces the importance of city-specific empirical evidence. For Sari, a model that simultaneously considers urban heat and thermal conditions, air quality and pollution, urban humidity and precipitation, and wind and ventilation can capture climatic experiences that are directly relevant to everyday urban life while also assessing whether social participation and institutional trust explain how these conditions translate into resilience outcomes.

Accordingly, the present study aimed to model the impact of urban climate on urban resilience in Sari, with social participation and institutional trust examined as mediating variables.

2. Methods and Materials

The present study was applied in terms of purpose and descriptive-correlational and survey-based in terms of nature, employing a quantitative approach. It was designed on the basis of structural equation modeling to simultaneously examine the direct and indirect relationships among the variables. The statistical population consisted of all citizens aged 20–65 years residing in Sari or visiting the city's public, recreational, commercial, and historical spaces during the first half of 2026, from whom a sample of 410 participants was estimated. Sampling was conducted using a multistage cluster random sampling method. Accordingly, Sari was divided into eight main clusters, including Melal Park, Zare Forest Park, Qaem Park, Qaren Pedestrian Street, the pedestrian area surrounding Imam Hossein Square, Clock Square, modern commercial complexes, the traditional Rajaei Bazaar, and Sari Daily Market. Within each cluster, participants were then randomly selected from among citizens available at those locations. The data collection instrument was a researcher-developed questionnaire comprising four sections: demographic characteristics; the independent variable of urban climate, consisting of four components and 16 items; the mediating variables of social participation and institutional trust, consisting of eight items; and the dependent variable of urban resilience, consisting of seven items. Responses were measured using a five-point Likert scale. Table 2 presents the indicators of all research variables in detail. The face and content validity of the questionnaire were confirmed based on the opinions of ten experts and specialists and through calculation of the Content Validity Ratio (CVR) and Content Validity Index (CVI). Its reliability was also assessed using Cronbach's alpha in a pilot study involving 30 participants, with coefficients exceeding 0.70 for all components, indicating satisfactory instrument reliability. Data analysis was performed at two levels: descriptive analysis based on respondents' age groups and educational attainment, and inferential analysis using structural equation modeling to test causal relationships and assess the fit of the conceptual model.

Table 1

Reliability of the Research Instrument

Cronbach's Alpha	KMO and Bartlett's Indices	Number of Items	Scale	Construct
0.72	0.73 for the four components of the independent variable	4	Urban heat island and thermal conditions (increased neighborhood temperature, heat storage in surfaces, lack of cooling green spaces, and reduced presence in outdoor spaces)	Independent variable: Urban climate (overall α = 0.71)
0.70	—	4	Air quality and pollution (vehicle emissions, respiratory discomfort, dust deposition, and reduced air clarity)	Independent variable: Urban climate
0.71	—	4	Urban humidity and precipitation (humid weather, street flooding, disruption of sewage systems and drainage channels, and difficulty commuting during rainfall)	Independent variable: Urban climate
0.74	—	4	Urban wind and ventilation (fresh airflow, obstruction of wind by apartment buildings, persistence of stagnant air, and locally disturbing winds)	Independent variable: Urban climate
0.71	0.70	4	Social participation (neighborhood cooperation, participation in local activities, reporting urban problems, and voluntary cooperation during crises)	Mediating variable: Social participation
0.85	0.80	4	Institutional trust (trust in the municipality, trust in emergency-response institutions, trust in official information, and trust in institutional fairness)	Mediating variable: Institutional trust
0.79	0.86	7	Preparedness for crises, rapid return to normal conditions, effective crisis management, access to essential services, institutional coordination, support for citizens, and a sense of security and confidence	Dependent variable: Urban resilience

3. Findings and Results

In this section, background variables, including the respondents' age groups and educational attainment, are described.

Table 2

Univariate Distribution of Frequency and Percentage for Respondents' Age Groups and Educational Attainment

Variables	20–30 Years	31–41 Years	42–65 Years	Below High School Diploma	High School Diploma	Associate Degree	Bachelor's Degree or Higher
Frequency	62	181	167	66	180	22	142
Percentage	15%	44%	41%	16%	44%	5%	35%

Table 2 describes the respondents' age groups and educational attainment. The results of the present study showed that, among the total 410 respondents, 62 individuals (15%) were aged 20–30 years, 181 individuals (44%) were aged 31–41 years, and 167 individuals (41%) were aged 42–65 years. In terms of educational attainment, 66 respondents (16%) had less than a high school diploma, 180 (44%) held a high school diploma, 22 (5%) held an associate degree, and 142 (35%) held a bachelor's degree or higher. Thus, the largest proportions of the study respondents belonged to the 31–41-year age group and the high school diploma educational category. These findings indicate the predominance of middle-aged individuals and respondents with secondary-level education in the study sample.

The proposed hypotheses were examined using Pearson's correlation test and multiple regression analysis, and the following results were obtained. Table 3 presents the relationship between each independent variable and the dependent variable. Given that the dependent variable (urban resilience), the independent variable (urban climate), and the two mediating variables (social participation and institutional trust) were measured at the interval level, the parametric Pearson correlation test was employed. Subsequently, multiple regression and path analysis were conducted to examine the five research hypotheses. To determine the significance of the indirect effects, the Sobel test was conducted for the main research hypothesis as well as Hypotheses 6 and 7.

Table 3

Results of Pearson's Correlation Test Between the Independent Variable and the Mediating Variables, and Between the Mediating Variables and the Dependent Variable

Independent Variable	Dependent Variable	Correlation Coefficient	Significance
Urban climate	Social participation	-0.34**	0.001
Urban climate	Institutional trust	-0.32**	0.001
Social participation	Urban resilience	0.58**	0.001
Institutional trust	Urban resilience	0.56**	0.001
Urban climate	Urban resilience	-0.37**	0.001

According to the results presented in Table 3, given that the significance level of the test error at the 99% confidence level was below 0.01, Hypotheses 1, 2, 3, 4, and 5 were confirmed. There was a significant inverse and moderate relationship between urban climate and both social participation and institutional trust, while urban climate also had a moderate negative relationship with urban resilience. Moreover, the two mediating variables, namely social participation and institutional trust, had strong positive relationships with the dependent variable of the study (Table 3).

To test the main research hypothesis regarding the mediating roles of social participation and institutional trust in the relationship between urban climate and urban resilience, the Sobel test was employed. The results of the mediation tests, particularly the Sobel analysis, indicate that urban climate significantly affects urban resilience through the two psychological-cognitive mechanisms of "social participation" and "institutional trust." In other words, the effect of urban climate on urban resilience is not merely a simple and direct relationship; rather, this effect is transmitted through the formation of positive perceptions of institutional trust and increased social participation.

The very large and significant Z coefficients for both mediation pathways (social participation: $Z = -7.24$; institutional trust: $Z = -6.72$; $p < 0.001$) indicate that urban climate plays a fundamental role in activating these mechanisms.

To examine Hypothesis 6 of the study concerning the mediating role of social participation in the relationship between urban climate and urban resilience, the Sobel test was employed. The results of the path analysis and Sobel test demonstrated that social participation plays a significant mediating role in the relationship between urban climate and urban resilience. The Sobel test yielded a Z value of -7.24, which was significant at $p < 0.001$; therefore, the research hypothesis was supported. Urban climate significantly increases social participation; however, this participation, which under conditions of climatic stress is reactive and episodic in nature, ultimately contributes to a reduction in resilience (indirect effect = -2.717). In other words, a quantitative increase in participation without linkage to institutional trust and sustainable mechanisms of urban governance cannot contribute to enhanced resilience. This finding emphasizes the need to institutionalize social participation and improve its quality in urban policymaking in Sari.

$$Z = (a \times b) / \mathrm{sqrt}(b^2 \times SE\_a^2 + a^2 \times SE\_b^2)$$

$$Z = [21.737 \times (-0.125)] / \mathrm{sqrt}[(0.125)^2 \times (0.538)^2 + (21.737)^2 \times (0.017)^2]$$

$$Z = -2.717125 / 0.37537147 = -7.24$$

$$|Z| = 7.24 > 1.96$$

Therefore, Hypothesis 6 was fully and strongly supported, and the findings indicate that social participation is one of the most important mechanisms through which the effects of urban climate are transmitted to urban resilience outcomes. This finding is consistent with the theoretical frameworks of social capital and adaptive capacity, because it emphasizes that social participation contributes to urban resilience only when it is sustainable, institutionalized, and grounded in citizens' trust in planning authorities. In the absence of such conditions, reactive and episodic participation becomes a channel through which the adverse effects of urban climate are transmitted rather than a mechanism that strengthens adaptive capacity. Therefore, merely increasing the quantity of participation without linking it to institutional trust and sustainable governance mechanisms cannot play a constructive role in enhancing urban resilience.

To examine Hypothesis 7 concerning the mediating role of institutional trust in the relationship between urban climate and urban resilience, the Sobel test was used. The results of the Sobel test for the institutional trust mediation pathway likewise showed that this pathway significantly mediates the relationship between urban climate and urban resilience. The Sobel Z value was reported as 10.95 and was significant at $p < 0.001$. This large value indicates that the indirect effect of urban climate on urban resilience through increased institutional trust is strong and stable.

$$Z = (a \times b) / \mathrm{sqrt}(b^2 \times SE\_a^2 + a^2 \times SE\_b^2)$$

$$Z = [21.785 \times (-0.137)] / \mathrm{sqrt}[(0.137)^2 \times (0.630)^2 + (21.758)^2 \times (0.020)^2]$$

$$Z = -2.984545 / 0.444167 = -6.72$$

$$|Z| = 7.24 > 1.96$$

Because path coefficient a is positive and path coefficient b is negative, the indirect effect of urban climate on urban resilience through the mediating variable was found to be negative. In other words, through increasing the mediating variable, urban climate exerts a reducing effect on urban resilience.

The Sobel test results indicated that the indirect effect of urban climate on urban resilience through the mediating variable was significant. The indirect effect was -2.98, with a standard error of 0.444. Furthermore, the Sobel statistic was -6.72, whose absolute value exceeded the critical value of 1.96 at the 0.05 significance level. Therefore, the mediation hypothesis was supported. The negative indirect effect indicates that, under the existing conditions, the mediation pathway is associated with a reduction in urban resilience rather than its enhancement. Accordingly, Hypothesis 7 was also strongly and significantly supported, indicating that institutional trust is one of the key channels through which urban climate can influence urban resilience.

Before conducting multiple regression analysis for the four components of the independent variable and the two mediating variables, the relevant assumptions were examined as follows:

a) Independence of random errors: This assumption concerns the independence of the observed error terms. A Durbin–Watson statistic ranging from 1.5 to 2.5 indicates that the assumption of independence of errors is satisfied, whereas values below 1 or above 3 may constitute a serious threat to regression analysis. Because the obtained Durbin–Watson statistic was 1.808, the assumption of independence of random errors was satisfied.

b) Assessment of the absence of multicollinearity: As one of the assumptions of regression analysis, predictor variables should be sufficiently independent of one another; in other words, an independent variable should not be excessively influenced by another independent variable. For this purpose, the present study employed the Tolerance index and the Variance Inflation Factor (VIF). Theoretically, a Tolerance value below 0.10 and a VIF value greater than 10 indicate a potential multicollinearity problem in regression analysis.

Table 4

Independence of Random Errors and Assessment of Multicollinearity

Predictor of Urban Resilience	Tolerance	VIF (Variance Inflation Factor)	Durbin–Watson
1. Social participation	0.616	1.625	1.808
2. Institutional trust	0.639	1.564	—
3. Urban humidity and precipitation component	0.861	1.161	—

As shown in Table 4, the Tolerance values for the variables were greater than 0.10, and the VIF values were substantially below 10. Therefore, the assumption of absence of multicollinearity among the variables was satisfied, and regression analysis could be performed. Multiple regression analysis was employed to determine the multiple correlation among the variables. Accordingly, the four components of urban climate as predictor variables and the two mediating variables were entered into the regression equation simultaneously using the stepwise method.

Table 5

Multiple Regression Coefficients for the Variables Entered into the Regression Model

No.	Variables	Unstandardized b	Std. Error	Beta	t	Significance
—	Constant	18.413	1.216	—	15.147	0.001
1	Social participation	0.460	0.066	0.33	6.950	0.001
2	Institutional trust	0.359	0.056	0.30	6.437	0.001
3	Urban humidity and precipitation component	-0.261	0.050	-0.21	-5.276	0.001

Table 5 presents the results of the stepwise multiple regression analysis for the dependent variable of "urban resilience." The components of the independent variable that had significant relationships with the dependent variable were entered into the equation. Of the four components of the independent variable and the two mediating variables examined in the study, one component of the independent variable and both mediating variables met the criteria for entry into the regression equation. These three variables explained 44% of the variance in the dependent variable.

Table 6

Statistics for the Multiple Regression Analyses Used to Prepare and Design Model

Dependent Variable	Independent Components/Predictors	R	R^2	SEE	Adjusted R^2	F (p-value)
Urban resilience	1. Social participation; 2. Institutional trust; 3. Urban humidity and precipitation component	0.67	0.44	2.394	0.43	107.819 (0.001)
Social participation	1. Institutional trust; 2. Urban humidity and precipitation component; 3. Urban wind and ventilation component; 4. Urban heat island and thermal conditions component; 5. Air quality and pollution component	0.64	0.41	1.759	0.40	56.971 (0.001)
Institutional trust	1. Social participation; 2. Air quality and pollution component; 3. Urban humidity and precipitation component	0.61	0.37	2.112	0.36	79.986 (0.001)
Urban humidity and precipitation component	1. Social participation; 2. Urban heat island and thermal conditions component; 3. Institutional trust	0.40	0.16	2.371	0.15	25.843 (0.001)

The multiple correlation coefficient (R) between the two mediating variables and one component of the independent variable—1. social participation, 2. institutional trust, and 3. the urban humidity and precipitation component—was 0.67. Squaring this coefficient yields $R^2 = 0.44$. Thus, 44% of the variation in the dependent variable can be explained by these three variables. In other words, 56% (1 - 0.44 = 0.56) of the variation in urban resilience is determined by other factors that require further investigation. Given that this domain of urban behavioral analysis is highly dependent on both macro- and micro-level structures, explaining 44% of the variance through these two mediating variables and one component of the independent variable appears reasonable and satisfactory.

Table 7

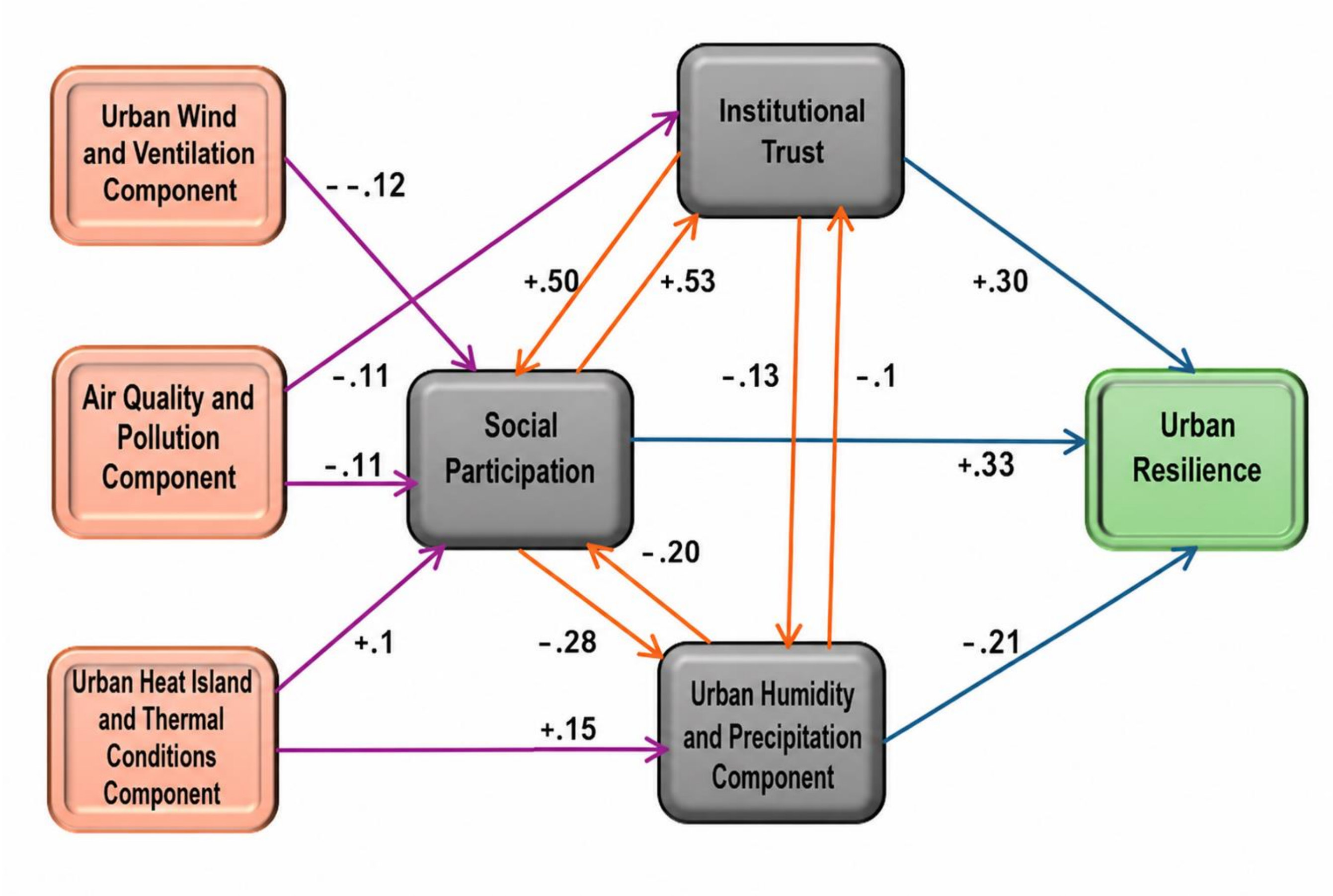
Total Effects (Direct and Indirect) of the Two Mediating Variables and Four Urban Climate Components on the Dependent Variable

Components	Direct Effect (Without Mediation)	Indirect Effect (With Mediation)	Total Effect
Social participation	0.33	0.06 = -0.21 × -0.28 0.24; 0.16 = 0.30 × 0.53 0.01 = 0.30 × -0.10 × -0.28 0.01 = -0.21 × -0.13 × 0.53	0.57
Institutional trust	0.30	0.03 = -0.21 × -0.13 0.24; 0.17 = 0.33 × 0.50 0.01 = 0.33 × -0.20 × -0.13 0.03 = -0.21 × -0.28 × 0.50	0.54
Urban humidity and precipitation component	-0.21	-0.03 = 0.30 × -0.10 -0.15; -0.07 = 0.33 × -0.20 -0.02 = 0.33 × 0.50 × -0.10 -0.03 = 0.30 × 0.53 × -0.20	-0.36
Air quality and pollution component	—	-0.07 = 0.54 × -0.11 -0.12; -0.06 = 0.57 × -0.10	-0.12
Urban wind and ventilation component	—	-0.07 = 0.57 × -0.12	-0.07
Urban heat island and thermal conditions component	—	0.06 = 0.57 × 0.10 0.01; -0.05 = -0.36 × 0.15	0.01

Table 7 presents the direct and indirect effects, as well as the total effects, of the independent variables of the study. The total effect was calculated as follows: the direct effect corresponds to the standardized Beta coefficient representing the effect of the independent variable on the dependent variable. The indirect effect was obtained by multiplying the coefficients along the path vectors extending from the independent variable to the dependent variable. The effect of the air quality and pollution component was obtained by multiplying its direct effect by the sum of the total coefficients for social participation and the sum of the total coefficients for institutional trust. Finally, the total effects of the two mediating variables and the four components were calculated by summing their direct and indirect effects.

Figure 1

Factors Affecting Urban Resilience Along With Their Path Coefficients



4. Discussion and Conclusion

The present study investigated the effect of urban climate on urban resilience in Sari and examined the mediating roles of social participation and institutional trust. The findings showed that urban climate was significantly and negatively associated with urban resilience (r = -0.37), social participation (r = -0.34), and institutional trust (r = -0.32). In contrast, social participation (r = 0.58) and institutional trust (r = 0.56) had relatively strong positive relationships with urban resilience. The stepwise multiple regression model further indicated that social participation (β = 0.33), institutional trust (β = 0.30), and the urban humidity and precipitation component (β = -0.21) were significant predictors of urban resilience and collectively explained 44% of its variance. Thus, the findings support a multidimensional conception of urban resilience in which climatic exposure, collective social capacity, and institutional functioning operate simultaneously rather than independently. This interpretation is consistent with resilience literature emphasizing that resilient cities depend on the interaction of environmental, infrastructural, managerial, and social capacities (Cao, 2023; Irani & Rahnamayiezekavat, 2021; Kong et al., 2022). Iranian research has likewise increasingly approached resilience as an integrated urban-management issue rather than a purely physical response to hazards (Davari Zarnaghi & Kalantari, 2024; Hossein Dousti et al., 2023).

The negative association between urban climate conditions and urban resilience indicates that unfavorable climatic experiences can reduce the perceived capacity of the urban system to withstand disturbance, maintain essential functions, and recover effectively. Climatic stress in urban environments can affect mobility, use of public spaces, access to services, infrastructure performance, environmental comfort, and citizens' assessment of the manageability of their city. This result is consistent with research showing that climate change constitutes an increasingly important source of pressure on urban resilience and requires adaptation measures extending beyond conventional disaster-response systems (Jamali et al., 2023; Pirasteh et al., 2026). The finding also corresponds with the broader Iranian literature demonstrating that urban climatic hazards and environmental crises can affect sustainable development and adaptive behavior (Bagheri et al., 2025). At the local level, previous research in Sari has identified relationships between urban climatic change, particularly heat-island conditions, and the spatial distribution of the population, demonstrating that climate-related pressures are already relevant to urban functioning in the study area (Mesri Alamdari & Rasouli, 2021). Therefore, the observed negative climate–resilience relationship can be understood as an indication that recurrent climatic discomfort and environmental disruption may gradually weaken the adaptive functioning of the city.

Among the four climatic dimensions considered, urban humidity and precipitation was the only component that retained a significant direct effect on urban resilience in the final regression model (β = -0.21). This finding is particularly meaningful in a city such as Sari, where climatic conditions can involve considerable humidity and precipitation and where rainfall-related waterlogging, disruption of drainage systems, difficulties in mobility, and service interruptions may directly shape citizens' everyday evaluations of urban preparedness. The result indicates that climatic variables may differ in the immediacy with which they affect perceived urban resilience. While heat, air quality, and wind conditions may influence resilience through indirect pathways or in interaction with other urban characteristics, precipitation and humidity can generate visible and immediate disruptions to streets, drainage, transportation, and access to services. Studies addressing urban water insecurity and water-system resilience have similarly shown that water-related risks represent a major component of contemporary urban resilience (Mansouri Etminan et al., 2025; Mohammadpour et al., 2025). Research on climate-sensitive urban design also suggests that green infrastructure and environmentally responsive planning can moderate climate-related pressures and improve urban adaptive capacity (Teymi et al., 2025). Accordingly, the significant effect of humidity and precipitation emphasizes the importance of integrating climatic conditions with infrastructure and service-management strategies.

The absence of significant direct effects for the other climatic components in the final regression equation should not be interpreted as evidence that thermal conditions, air pollution, or urban ventilation are unimportant. Rather, their effects may operate through social, institutional, behavioral, or spatial mechanisms and may overlap statistically with the stronger predictors included in the model. Thermal comfort, for example, influences the usability of outdoor spaces, pedestrian activity, and citizens' willingness to remain in public environments. Recent efforts to predict the Universal Thermal Climate Index in urban outdoor spaces highlight the importance of thermal exposure for urban planning and environmental management (Norouzi & Mohammadi, 2025). Air quality and ventilation similarly influence perceptions of environmental quality and the livability of neighborhoods. Research on climate-sensitive design, urban green infrastructure, and urban agriculture further demonstrates that environmental interventions can contribute to adaptive urban capacity through interconnected ecological and social functions (Teymi et al., 2025; Veisi Nabi Kandi et al., 2024). Therefore, climatic components that did not enter the final regression model may remain relevant as distal or indirect determinants of resilience.

One of the strongest findings of the study was the positive contribution of social participation to urban resilience. Social participation was the strongest predictor in the final regression model (β = 0.33) and was positively correlated with resilience (r = 0.58). This finding supports the view that citizens are not merely recipients of urban resilience policies but constitute active resources within the resilience system. Neighborhood cooperation, participation in local activities, reporting urban problems, and voluntary action during crises can increase collective awareness, accelerate local responses, strengthen communication networks, and improve the distribution of information and resources. This finding is consistent with research in Bonab showing the role of citizen participation in strengthening urban resilience (Majnuni Toutakhaneh et al., 2023). More importantly, research conducted in Sari has demonstrated a meaningful relationship between social capital and citizen participation in the rehabilitation of deteriorated urban fabrics, indicating that local social networks can support urban improvement and collective problem solving (Aghaei Azad et al., 2025). International evidence also emphasizes the contribution of social capital to the functioning and sustainability of both urban and rural communities (Prastyo et al., 2024).

The importance of participation can also be explained through the concept of adaptive capacity. Communities with stronger networks and higher levels of participation have greater capacity to identify risks, exchange knowledge, mobilize resources, and coordinate behavior when environmental disruptions occur. Social participation therefore creates a form of distributed resilience that complements formal governmental capacity. Recent research on peri-urban communities has similarly indicated that social capital and innovation adoption can strengthen community resilience under conditions of rapid urban change (Azzahra et al., 2026). Meta-synthetic work on urban social resilience also portrays social relationships, networks, collective capacity, and social organization as central elements of resilient urban systems (Akbari et al., 2024). The present finding therefore suggests that strengthening participation in Sari could improve resilience not only by increasing the number of citizens involved in urban affairs but also by enabling communities to function as active components of risk management and adaptation.

Institutional trust was another major positive predictor of urban resilience ($\beta = 0.30$) and showed a strong positive bivariate relationship with resilience ($r = 0.56$). This result indicates that citizens' confidence in the municipality, emergency institutions, official information, and institutional fairness represents an important component of perceived urban capacity. Urban resilience involves situations in which residents must rely on official organizations for warnings, infrastructure management, emergency services, coordination, and recovery. When citizens perceive these institutions as credible and competent, they are more likely to accept official information, cooperate with policies, engage in collective initiatives, and consider the urban management system capable of responding to crises. This interpretation is compatible with research emphasizing governance, institutional learning, coordination, and capacity building as fundamental components of urban climate resilience (Wieszczeczynska et al., 2024). The growing literature on smart and agile cities likewise stresses that resilience depends on responsive and adaptable governance structures rather than merely technological capacity (Ahangari, 2025; Farajpour et al., 2025).

The simultaneous significance of social participation and institutional trust is especially important from an urban-management perspective. Participation without institutional responsiveness may become temporary, fragmented, or reactive, while formal institutions without citizen trust may encounter difficulties in mobilizing public cooperation. These two variables may therefore represent mutually reinforcing dimensions of resilience. Research on resilience drivers in urban communities similarly suggests that urban resilience arises from combinations of social, institutional, managerial, and physical factors rather than isolated determinants (Saeidi, 2024). Integrated approaches to sustainable urban development likewise emphasize coordination between physical planning, governance, and social capacities (Khoshtarsah Langeroudi et al., 2025). The findings of the present study consequently suggest that institutional effectiveness and community engagement should not be designed as separate policy domains. Instead, citizen participation may become more effective when supported by trustworthy institutions, while institutional legitimacy can potentially be strengthened through meaningful and transparent public participation.

The mediation analyses further supported this interpretation. The Sobel test indicated that social participation significantly mediated the relationship between urban climate and urban resilience ($Z = -7.24$, $p < 0.001$), while institutional trust also constituted a significant mediating pathway ($Z = -6.72$, $p < 0.001$). The negative indirect effects indicate that adverse urban climatic conditions can be associated with lower resilience through their relationships with these social and institutional capacities. In substantive terms, climatic pressures do not affect resilience only by damaging physical environments; they may also influence how citizens interact with one another and how they evaluate the institutions responsible for urban management. Recurrent problems such as flooding, thermal discomfort, pollution, or insufficient environmental management may influence citizens' willingness to participate and their confidence in institutional competence. When participation and trust are weakened, a city may lose two important resources needed for collective adaptation. This mechanism is compatible with climate-resilience frameworks that emphasize capacity building and the integration of social and institutional dimensions into adaptation strategies (Pirasteh et al., 2026; Wieszczeczynska et al., 2024).

The mediation results also help explain why resilience should not be understood exclusively in terms of infrastructure. Although physical preparedness remains important, the effectiveness of infrastructure ultimately depends on management, coordination, public cooperation, and institutional capacity. Studies examining resilience against earthquakes and other hazards have consistently shown the importance of physical preparedness and spatial characteristics (Haseli et al., 2024; Mirzajani Naneh Karan, 2026; Pasandideh Talemi et al., 2024), while research on infrastructure and smart-city resilience highlights the contribution of technological and managerial systems (Ahmadi et al., 2025). The current findings extend this perspective by demonstrating that social participation and institutional trust explain substantial variation in resilience even when climatic variables are considered. Thus, physical investment without parallel investment in social and institutional capacities may produce an incomplete resilience strategy.

The overall explanatory power of the final model also deserves attention. Social participation, institutional trust, and urban humidity and precipitation collectively explained 44% of the variance in urban resilience. In research on complex urban systems, this represents a substantial proportion because resilience is shaped by many interconnected variables, including infrastructure quality, socioeconomic status, spatial inequality, environmental conditions, governance arrangements, access to services, risk perception, and previous experience with disruption. The remaining 56% of unexplained variance therefore does not weaken the model; rather, it reflects the multidimensionality of urban resilience described in previous theoretical and empirical research (Cao, 2023; Irani & Rahnamayiezekavat, 2021; Kong et al., 2022). The finding also supports the argument that urban resilience should be investigated through integrated models that combine environmental exposure with social and institutional capacities rather than relying on a single category of indicators.

Taken together, the findings show that resilience in Sari is produced through an interaction between climatic conditions and the capacity of the urban social and institutional system to respond to them. Urban humidity and precipitation exerted a direct adverse effect, whereas social participation and institutional trust emerged as the strongest positive predictors of resilience and as significant mediating mechanisms in the urban climate–resilience relationship. These findings extend previous research on climatic resilience, community participation, social capital, and adaptive governance by demonstrating how these dimensions can operate within a single explanatory model. They also reinforce the broader transition in resilience scholarship from hazard resistance toward adaptive urban governance in which resilient cities are understood as systems capable of learning, coordinating, mobilizing citizens, and maintaining institutional legitimacy under changing environmental conditions.

The present study has several limitations that should be considered when interpreting its findings. First, its cross-sectional and correlational design does not permit definitive causal conclusions regarding the relationships among urban climate, social participation, institutional trust, and urban resilience. Second, the variables were assessed using a researcher-developed self-report questionnaire; therefore, responses may have been influenced by individual perceptions, social desirability, recent climatic experiences, or respondents' subjective evaluations of urban institutions. Third, participants were recruited from selected public, recreational, commercial, and historical locations in Sari, which may limit the representation of residents who use such spaces less frequently. Moreover, resilience is a complex phenomenon that can also be influenced by socioeconomic conditions, neighborhood characteristics, infrastructure quality, risk experience, governance performance, and access to services, which were not comprehensively incorporated into the present model.

Future studies should employ longitudinal designs to determine how climatic conditions, institutional trust, participation, and urban resilience change over time and to provide stronger evidence regarding the direction of the observed relationships. Researchers could also combine subjective questionnaire data with objective climatic and spatial indicators, including temperature, humidity, rainfall intensity, air-pollution measurements, green-space availability, drainage capacity, and geographic information system data. Comparative studies across neighborhoods with different socioeconomic and environmental characteristics, as well as comparisons between Sari and other cities with different climatic conditions, could clarify the generalizability of the present model. Future models could additionally examine variables such as social capital, risk perception, place attachment, institutional transparency, digital participation, environmental awareness, socioeconomic vulnerability, infrastructure quality, and previous disaster experience as mediators or moderators.

Urban managers in Sari should approach climate resilience as an integrated governance objective rather than as a solely infrastructural or environmental issue. Priority should be given to improving drainage and stormwater management, reducing recurrent rainfall-related disruption, strengthening climate-sensitive public-space design, and ensuring continuity of essential urban services during unfavorable weather conditions. At the same time, municipalities and other responsible organizations should establish permanent and transparent mechanisms for citizen participation in neighborhood planning, environmental monitoring, risk reporting, and crisis preparedness instead of relying on temporary participation during emergencies. Institutional trust should be strengthened through timely and accurate public communication, transparency in decision-making, visible responsiveness to reported problems, equitable delivery of municipal services, and coordination among municipal and emergency institutions. Integrating these measures could transform citizen participation and institutional trust into durable components of Sari's adaptive capacity and thereby enhance long-term urban resilience.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

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