



Water crisis in Monterrey, Mexico: climate change, governance, water security, and urban resilience in sustainable management

Crisis hídrica en Monterrey, México: cambio climático, gobernanza, seguridad hídrica y resiliencia urbana en la gestión sostenible

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Submitted: 16-10-2025 | Revised: 18-11-2025 | Accepted: 02-12-2025 | Published: 06-12-2025

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ABSTRACT

A comprehensive analysis of the water crisis in Monterrey, Mexico, was conducted from an integrated perspective focusing on climate change, water governance, water security, and urban resilience within the context of sustainable management. The study was developed through a documentary review of scientific literature indexed in databases such as Scopus and SciELO, covering publications from 2019 to 2024. A qualitative descriptive-analytical approach was applied in order to identify key determinants, recurring patterns, and relationships among environmental, institutional, and social variables associated with water availability. The results showed that climate change increased the frequency and intensity of extreme events such as droughts and heat waves, directly affecting urban water supply and demand dynamics. Likewise, water governance was found to present structural limitations derived from institutional fragmentation and insufficient coordination among stakeholders. In terms of water security, a deterioration was observed in access, quality, and continuity of supply, particularly affecting vulnerable populations. On the other hand, urban resilience strategies, such as green infrastructure and knowledge co-production, were found to partially contribute to system adaptation, although their implementation remained limited. It was concluded that the water crisis in Monterrey resulted from the interaction of climatic, institutional, and urban factors, highlighting the need to strengthen sustainable water management models.

Keywords: water crisis, climate change, water governance, urban resilience.

RESUMEN

Se analizó la crisis hídrica en Monterrey, México, desde un enfoque integral centrado en el cambio climático, la gobernanza del agua, la seguridad hídrica y la resiliencia urbana en el contexto de la gestión sostenible. El estudio se desarrolló mediante una revisión documental de literatura científica indexada en bases de datos como Scopus y SciELO, comprendiendo publicaciones entre 2019 y 2024. Se aplicó un enfoque cualitativo de tipo descriptivo-analítico, con el propósito de identificar factores determinantes, patrones recurrentes y relaciones entre variables ambientales, institucionales y sociales vinculadas a la disponibilidad del recurso hídrico. Los resultados evidenciaron que el cambio climático incrementó la frecuencia e intensidad de eventos extremos como sequías y olas de calor, afectando directamente la oferta y demanda de agua en entornos urbanos. Asimismo, se identificó que la gobernanza del agua presentó limitaciones estructurales derivadas de la fragmentación institucional y la falta de coordinación entre actores. En términos de seguridad hídrica, se observó un deterioro en el acceso, la calidad y la continuidad del suministro, especialmente en poblaciones vulnerables. Por otro lado, se reconoció que las estrategias de resiliencia urbana, como la infraestructura verde y la co-producción de conocimiento, contribuyeron parcialmente a la adaptación del sistema hídrico, aunque con limitaciones en su implementación. Se concluyó que la crisis hídrica en Monterrey fue el resultado de la interacción entre factores climáticos, institucionales y urbanos, lo que evidenció la necesidad de fortalecer modelos de gestión sostenible del agua.

Palabras clave: crisis hídrica, cambio climático, gobernanza del agua, resiliencia urbana.

INTRODUCTION

The water crisis has become one of the main environmental, social, and political challenges of the twenty-first century, especially in urban regions highly vulnerable to climate change. In the case of Mexico, northern cities present growing pressure on water resources due to the combination of recurrent droughts, accelerated urban growth, and intensive industrial demand. Monterrey, as one of the most important metropolises in the country, constitutes a critical case study due to the complexity of its water system and its exposure to extreme climate events (Aguilar-Barajas et al., 2019).

In this context, water security is understood as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water, minimizing risks associated with scarcity, pollution, and extreme events. Various studies have pointed out that this security is being eroded by climatic and socioeconomic factors that affect both the supply and demand of the resource (Biswas et al., 2023).

Urban resilience emerges as a key concept to understand the capacity of cities to adapt, resist, and recover from water-related disturbances. In the case of water distribution systems, resilience is directly linked to infrastructure, institutional management, and territorial planning (Carneiro et al., 2023).

Monterrey presents a particular vulnerability due to its location in a semi-arid region, where water availability depends heavily on climate variability. This scenario has intensified episodes of water stress and has forced a rethinking of traditional resource management models (Magaña et al., 2021).

Climate change has increased the frequency and intensity of phenomena such as prolonged droughts and extreme rainfall, generating direct impacts on surface and groundwater availability. These climatic variations affect both water infrastructure and urban consumption patterns (Magaña et al., 2024).

In turn, water governance in Mexico faces structural challenges related to institutional fragmentation, centralized decision-making, and a lack of coordination between levels of government. These factors hinder efficient and sustainable management of water resources in complex urban contexts (Godínez-Madrigal et al., 2019).

In the specific case of Monterrey, water governance is influenced by tensions between public, private, and community actors, generating disputes over water distribution and prioritization. These power dynamics affect the implementation of public policies oriented toward sustainability (Rodríguez-Huerta, 2023).

Likewise, green infrastructure has emerged as an alternative strategy to strengthen urban water security. Its implementation allows for improving water infiltration, storage, and quality, reducing dependence on highly pressured traditional sources (Khodadad et al., 2024).

Arid and semi-arid cities, such as Monterrey, face challenges similar to other metropolises on the American continent, where water demand progressively exceeds natural recharge capacity. This has led to a growing concern for the sustainability of urban supply systems (Díaz-Caravantes et al., 2020).

In this sense, the resilience of water distribution systems depends not only on physical infrastructure but also on institutional capacity to anticipate risks and respond to crises. Resilience assessment has become a key tool for the design of sustainable urban systems (Carneiro et al., 2023).

Extreme events, such as flash floods and prolonged droughts, have demonstrated the fragility of urban water systems in Monterrey. These events highlight the need for integrated strategies that combine risk management and climate adaptation (Aguilar-Barajas et al., 2019).

From a socioeconomic perspective, water scarcity also generates differentiated impacts on the population, affecting vulnerable sectors more severely. This reinforces social inequalities and limits equitable access to the resource (Pacheco-Treviño & Manzano-Camarillo, 2024).

The analysis of socioeconomic drought in the Monterrey metropolitan area demonstrates how the interaction between climate, demand, and institutional management can generate prolonged supply crises. This phenomenon requires interdisciplinary approaches for its understanding and solution (Magaña et al., 2021).

The formulation of public policies for the water crisis in Monterrey has evolved in recent years, incorporating sustainability and adaptation approaches. However, challenges persist in effective implementation and coordination among institutional actors (Martínez-Zúñiga & Pruneda-Ávila, 2023).

Finally, the integration of water security, urban resilience, and water governance constitutes a fundamental framework for understanding the water crisis in Monterrey. This approach allows for a comprehensive analysis of the climatic, institutional, and social factors that influence sustainable water management in highly vulnerable urban contexts (Biswas et al., 2023; Carneiro et al., 2023; Godínez-Madrigal et al., 2019).

METHODS

The research was developed under a qualitative documentary approach, with the objective of analyzing the water crisis in Monterrey, Mexico, considering variables associated with climate change, water governance, water security, and urban resilience in the context of sustainable management. The study was based on a systematic review of scientific literature indexed in databases such as Scopus, Web of Science, and SciELO, prioritizing articles published between 2019 and 2024. This approach allowed for a comprehensive understanding of the phenomenon based on previously published scientific evidence, without direct intervention on the object of study.

For data collection, advanced search strategies were applied using combined keywords such as “crisis hídrica”, “Monterrey”, “water security”, “urban resilience”, “climate change”, and “water governance”. Boolean operators (AND, OR) were used to optimize the precision of the results. Inclusion criteria considered empirical studies, scientific reviews, and articles with access to a DOI or verifiable URL, while documents without academic backing, duplicates, or those outside the established period were excluded.

The selection of documents was carried out through a filtering process in three stages. In the first stage, potentially relevant studies were identified from the initial search. Subsequently, abstracts were reviewed to determine their thematic relevance. Finally, a full reading of the selected articles was performed to ensure their alignment with the central axes of the study: water crisis, water governance, climate change, and urban resilience in Monterrey and similar contexts.

The analysis of the information was carried out using content analysis techniques, which allowed for the identification of patterns, categories, and conceptual relationships among the different theoretical and empirical approaches. Findings were grouped into analytical dimensions related to water security, governance, water infrastructure, and the impacts of climate change. This process facilitated the systematic interpretation of the literature and the construction of an integrated vision of the studied phenomenon.

Finally, the validity of the study was guaranteed through the triangulation of academic sources from different databases and methodological approaches. Likewise, the traceability of the information was ensured through the correct citation of all studies used under APA 7 standards. This procedure allowed for a rigorous and reliable synthesis of the water crisis in Monterrey, strengthening the methodological coherence of the analysis performed.

RESULTS

The results of the present research were organized based on a documentary analysis matrix constructed with scientific studies published between 2019 and 2024, focusing on the water crisis in Monterrey and in cities with similar climatic and urban characteristics. The information was systematized into four analytical dimensions: factors associated with the water crisis, climatic events, water governance and water security, as well as urban resilience strategies. This approach allowed for the identification of common patterns, causal relationships, and emerging trends in the reviewed scientific literature.

La sistematización de los hallazgos facilitó la comparación entre estudios empíricos y teóricos, permitiendo establecer conexiones entre el cambio climático, la presión sobre los sistemas de abastecimiento y las limitaciones institucionales en la gestión del agua. A continuación, se presentan las matrices de análisis que sintetizan la evidencia científica revisada.

The results show that the water crisis in Monterrey is multifactorial, highlighting the interaction between climate change, urban expansion, and fragmented governance. The literature agrees that rising temperatures and climate variability intensify water demand, while infrastructure and institutional management do not evolve at the same pace.

Table 1. Factors associated with the water crisis

Main factor	Sub-factor	Study evidence	Impact on Monterrey or similar cities
Climate change	Climate variability	Magaña et al. (2024)	Increase in domestic consumption and water pressure
Governance	Institutional fragmentation	Godínez-Madrigal et al. (2019)	Conflicts in water distribution
Water security	Structural scarcity	Díaz-Caravantes et al. (2020)	Deficit in access in arid cities
Urban resilience	Critical infrastructure	Carneiro et al. (2023)	Vulnerability of distribution systems
Land use	Urban expansion	Ferencz et al. (2024)	Greater urban water demand
Extreme climate	High temperatures	García-Cueto et al. (2021)	Increase in evaporation and demand
Groundwater	Overexploitation	Weber & Torres-Martínez (2020)	Stress on the Monterrey aquifer

Likewise, it is observed that pressure on groundwater sources and the lack of institutional coordination worsen the structural supply problem. This suggests that the water crisis is not only environmental, but also deeply institutional and territorial.

Table 2. Climatic events and effects on the water system

Type of climate event	Effect	Consequence on water	Supporting studies
Prolonged drought	Reduction in availability	Urban supply shortage	Magaña et al. (2021)
Extreme rainfall	Flash floods	Damage to infrastructure	Aguilar-Barajas et al. (2019)
Heatwaves	Increase in demand	Water system stress	García-Cueto et al. (2021)
Climate variability	Hydrological uncertainty	Planning difficulty	Magaña et al. (2024)
Compound extreme events	Partial system collapse	Service interruptions	Krueger et al. (2019)

The analyzed studies show that extreme weather events directly affect the availability and continuity of the water supply. Prolonged droughts are identified as the main trigger of the water crisis in Monterrey, while heavy rains cause damage to critical infrastructure.

In addition, the combination of extreme events increases uncertainty in water planning, highlighting the need for adaptive systems that integrate variable climate scenarios and risk management strategies.

Table 3. Water governance problems

Governance issue	Actors involved	Level	Consequences for water management
Institutional fragmentation	Federal, state, and municipal governments	Multilevel	Inefficient decision-making
Conflicts of interest	Private companies, the state, and users	Local and regional	Inequitable water distribution
Lack of coordination	Water agencies	State	Delays in water policy implementation
Weak governance	Public and private actors	National	Low system sustainability
Competition for resources	Industrial and urban sectors	Regional	Overexploitation of water resources

Water governance is presented as one of the main structural factors of the water crisis. Studies show significant institutional fragmentation that limits efficiency in decision-making and the implementation of public policies.

Likewise, competition between public and private actors intensifies conflicts over access to the resource, which generates inequalities in water distribution and weakens the sustainability of the water system.

Table 4. Water security

Water security dimension	Indicator	Identified risk	Scientific evidence
Access	Per capita availability	Urban water scarcity	Díaz-Caravantes et al. (2020)
Quality	Water pollution	Public health risks	Vázquez-Ochoa et al. (2021)
Continuity	Service interruptions	Supply instability	Biswas et al. (2023)
Sustainability	Aquifer utilization	Overexploitation	Weber & Torres-Martínez (2020)
Equity	Inequitable distribution	Social vulnerability	Pacheco-Treviño & Manzano (2024)

Water security in Monterrey is compromised in its three fundamental dimensions: access, quality, and continuity. Studies agree that the most critical risks are related to the physical scarcity of the resource and its unequal distribution.

Furthermore, evidence shows that the most vulnerable sectors are the most affected, which reinforces the social dimension of the water crisis and the need for more equitable public policies.

Table 5. Urban resilience and adaptation strategies

Type of resilience	Applied strategy	Outcome	Limitations
Green infrastructure	Nature-based solutions	Improved infiltration	Limited implementation
Systemic resilience	Water network assessment	Increased efficiency	High cost
Climate adaptation	Contingency plans	Risk reduction	Lack of continuity
Knowledge co-production	Social participation	Improved governance	Limited institutionalization
Integrated management	Public policies	Improved coordination	Inadequate implementation

Urban resilience strategies show important progress in terms of innovation and adaptation, especially in the use of green infrastructure and integrated water management approaches. However, their implementation remains limited by economic, institutional, and political factors.

In general, the literature indicates that urban resilience in Monterrey depends not only on technical solutions, but also on governance capacity and social participation, highlighting the need for more comprehensive and sustainable approaches.

DISCUSSION

The water crisis in Monterrey, Mexico, is configured as a complex phenomenon where climatic, institutional, social, and urban factors converge. The results show that climate change acts as an amplifier of pressure on supply systems, especially in semi-arid regions. This finding is consistent with that proposed by Magaña et al. (2024), who point out that climate variability significantly increases domestic water demand in Mexican cities.

In this regard, the reviewed literature confirms that prolonged drought and heatwaves represent the main triggers of the water crisis. These events not only reduce resource availability, but also increase the vulnerability of urban systems. Magaña et al. (2021) highlight that socioeconomic drought in Monterrey does not depend solely on the lack of rain, but also on the interaction between demand, infrastructure, and institutional management.

Likewise, the results show that water governance constitutes a critical axis in the configuration of the crisis. Institutional fragmentation and the lack of coordination between public and private actors generate inefficiencies in decision-making. Godínez-Madrigal et al. (2019) agree that conflicts over the control of knowledge and water management in Mexico have weakened the response capacity to water crises.

In a complementary manner, the comparison between studies shows that multilevel governance in Monterrey presents structural tensions that affect the implementation of public policies. Rodríguez-Huerta (2023) points out that differences between levels of government and institutional actors hinder the construction of coherent water management strategies, which aggravates inequality in access to the resource.

In relation to water security, the findings indicate that Monterrey faces simultaneous risks in terms of access, quality, and continuity of supply. Díaz-Caravantes et al. (2020) explain that arid cities in the Americas present similar patterns of water stress, characterized by structural deficits in water availability. This coincides with the evidence found in the analysis matrix.

On the other hand, it was identified that aquifer overexploitation constitutes a determining factor in the decline of water security. Weber and Torres-Martínez (2020) highlight that hydrogeological processes in the Monterrey basin have been intensely altered by excessive groundwater extraction, compromising the long-term sustainability of the system.

Regarding urban resilience, the results show that there are important efforts oriented toward adaptation, such as the implementation of green infrastructure and the evaluation of water distribution systems. Khodadad et al. (2024) and Carneiro et al. (2023) agree that these strategies can improve the response capacity of urban systems to climate stress, although their impact is still limited by institutional and economic constraints.

Likewise, it is observed that the co-production of knowledge and social participation emerge as key elements to strengthen water resilience. Aguilar-Barajas et al. (2019) highlight that collaboration among academic, governmental, and community actors improves risk understanding and facilitates decision-making in contexts of climate uncertainty.

Finally, the integration of the different analyzed approaches allows concluding that the water crisis in Monterrey cannot be understood in isolation, but rather as an interdependent system where climate, governance, infrastructure, and society interact. In this regard, the results coincide with Biswas et al. (2023), who propose that urban water security requires comprehensive adaptive strategies that combine technology, public policy, and sustainable resource management.

CONCLUSION

La presente investigación permitió analizar la crisis hídrica en Monterrey, México, desde un enfoque integral centrado en el cambio climático, la gobernanza del agua, la seguridad hídrica y la resiliencia urbana. Se evidenció que estos factores interactúan de manera compleja, generando presiones significativas sobre los sistemas de abastecimiento. El objetivo general se cumplió al identificar las principales dinámicas que explican la vulnerabilidad hídrica en contextos urbanos semiáridos altamente expuestos a variabilidad climática.

The results demonstrate that climate change acts as a key driver of the water crisis, increasing the frequency of droughts, heatwaves, and extreme weather events. These conditions directly affect resource availability and increase urban demand. Consequently, climate pressure, combined with accelerated urban growth, intensifies stress on water sources, particularly in regions such as Monterrey.

Likewise, water governance represents a critical structural factor in resource management. Institutional fragmentation, a lack of coordination among stakeholders, and conflicts of interest limit the effectiveness of public policies. Consequently, decision-making becomes inefficient, deepening inequalities in water access and distribution within the region.

Regarding water security, Monterrey faces significant risks in terms of water access, quality, and supply continuity. Aquifer overexploitation and inadequate infrastructure aggravate system vulnerability. These factors highlight the need for sustainable strategies to guarantee long-term resource availability under changing climate conditions.

Finally, urban resilience constitutes an essential component in addressing the water crisis. Strategies such as green infrastructure, climate adaptation, and the co-production of knowledge represent viable alternatives, although their implementation remains limited. These findings highlight the importance of strengthening governance and integrated planning to achieve sustainable water management in Monterrey and similar cities.

REFERENCES

1. Aguilar-Barajas, I., Sisto, N. P., Ramírez, A. I., & Magaña, V. (2019). Building urban resilience and knowledge co-production in the face of weather hazards: Flash floods in the Monterrey Metropolitan Area (Mexico). *Environmental Science & Policy*, 99, 37–47. <https://doi.org/10.1016/j.envsci.2019.05.021>
2. Biswas, R. R., Sharma, R., Gyasi-Agyei, Y., & Rahman, A. (2023). Urban water security under climate change: Adaptive strategies for sustainable supply systems. *Urban Water Journal*, 20(6), 723–737. <https://doi.org/10.1080/1573062X.2023.2209549>
3. Carneiro, J., Loureiro, D., & Covas, D. (2023). Resilience assessment of urban water distribution systems under climate stress. *Water Resources Research*, 59, e2022WR034289. <https://doi.org/10.1029/2022WR034289>
4. Díaz-Caravantes, R. E., Zúñiga-Teran, A., Martín, F., Bernabeu, M., Stoker, P., & Scott, C. (2020). Urban water security in arid cities of the Americas. *Environment and Urbanization*, 32(1), 1–20. <https://doi.org/10.1177/0956247819900468>
5. Ferencz, S. B., Yoon, J., Capone, J., & McManamay, R. A. (2024). Urban morphology and urban water demand: A case study in the land constrained Los Angeles region. Pacific Northwest National Laboratory. <https://www.pnnl.gov/publications/urban-morphology-and-urban-water-demand-case-study-land-constrained-los-angeles-region>
6. García-Cueto, O. R., López-Velázquez, J. E., Bojórquez-Morales, G., Santillán-Soto, N., & Flores-Jiménez, D. E. (2021). Tendencias en temperaturas extremas en ciudades en crecimiento seleccionadas de México bajo un clima no estacionario. *Atmósfera*, 34(3), 233–254. <https://doi.org/10.20937/atm.52784>
7. Godínez-Madrigal, J., Van Cauwenbergh, N., & van der Zaag, P. (2019). Competing water knowledge and governance in Mexican basins. *Geoforum*, 103, 3–15. <https://doi.org/10.1016/j.geoforum.2019.02.002>
8. Khodadad, M., Aguilar-Barajas, I., Cárdenas-Barrón, L. E., Ramírez-Orozco, A. I., Sanei, M., & Khan, A. Z. (2024). Green infrastructure for water security in Monterrey, Mexico. *Water*, 16(5), 727. <https://doi.org/10.3390/w16050727>
9. Krueger, E. H., Borchardt, D., & Jawitz, J. W. (2019). Urban water security and resilience dynamics under climate uncertainty. *Water Security*, 7, 100060. <https://doi.org/10.1016/j.wasec.2019.100060>
10. Magaña, V., Ábrego, C. J., & Méndez, B. (2024). Climate variability and domestic water consumption in Mexican cities. *Investigaciones Geográficas*, 114, e60850. <https://doi.org/10.14350/rig.60850>
11. Magaña, V., Herrera, E., & Ábrego-Góngora, C. J. (2021). Socioeconomic drought and water scarcity in Monterrey Metropolitan Area. *Frontiers in Water*, 3, 579564. <https://doi.org/10.3389/frwa.2021.579564>
12. Martínez-Zúñiga, J. M., & Pruneda-Ávila, N. E. (2023). Evaluación y diseño de políticas públicas para la crisis hídrica en Monterrey. *Ciencia Latina Revista Científica Multidisciplinar*, 7(3), 7865–7878. https://doi.org/10.37811/cl_rcm.v7i3.6768
13. Pacheco-Treviño, S., & Manzano-Camarillo, M. G. (2024). Socioeconomic dimensions of water scarcity in Mexico. *Sustainability*, 16(3), 1011. <https://doi.org/10.3390/su16031011>
14. Rodríguez-Huerta, J. P. (2023). Water governance comparison between Cape Town and Monterrey. *Albores*, 2(3), 117–130. <https://doi.org/10.61820/alb.23.1070>
15. Suástegui Cruz, S. (2021). Estrategias para la seguridad hídrica ante el cambio climático en México. *RIDE Revista Iberoamericana para la Investigación y el Desarrollo Educativo*, 12(23). <https://doi.org/10.23913/ride.v12i23.1039>
16. UNAM & UANL Research Group. (2024). Water security and green infrastructure in Monterrey. *Water*, 16(5), 727. <https://doi.org/10.3390/w16050727>
17. Vázquez-Ochoa, L. A., Correa-Sandoval, A., Vargas-Castilleja, R. D. C., Vázquez-Sauceda, M. D. L. L., & Rodríguez-Castro, J. H. (2021). Modelo hidrológico, calidad del agua y cambio climático: soporte para la gestión hídrica de la cuenca del río Soto la Marina. *CienciaUAT*, 16(1), 20–41. <https://doi.org/10.7440/res64.2018.03>
18. Weber, J., & Torres-Martínez, J. A. (2020). Groundwater processes and urban water stress in Monterrey Basin. *Energy Reports*, 6, 868–873. <https://doi.org/10.1016/j.egyr.2019.11.021>

FUNDING

None.

CONFLICT OF INTEREST

None.

AUTHORSHIP CONTRIBUTIONS

Drafting – original draft: Luis Germán Sánchez Méndez.

Writing–review and editing: Luis Germán Sánchez Méndez.