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Articles

Towards a comprehensive water sustainability plan for the Metropolitan Valley of San Luis Potosí

Hacia un plan integral de sostenibilidad hídrica para el Valle Metropolitano de San Luis Potosí

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Abstract

This paper analyzes the water management process in the Metropolitan Valley of San Luis Potosí (VMSLP) in the face of a complex water resource scenario. Based on a multifactorial study of this problem, the objective of this section was to determine, analyze, and explain the valley's urban water system. This allowed for the identification, analysis, correlation, and understanding of various conflicts that constitute the region's water issues and are often unknown to a large part of the population and ignored by public authorities. Through an exhaustive review of scientific literature

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from different specialized fields on the subject, as well as the compilation of data from various sources and consultations with key stakeholders from all levels of government, academia, decentralized and civil organizations, communities, and affected population groups, a model of the urban water system was generated, and a detailed analysis was conducted. The results allowed for the identification and analysis of the main water conflicts at each stage of this system, including externalities, consequences, actors involved, and their roles, as well as the establishment of causal and aggravating relationships between them. Based on this diagnosis, guidelines were proposed for the development of a comprehensive and sustainable local water management plan, a multidisciplinary, participatory, and humanistic approach to address the root causes of the problem and offer long-term sustainable solutions. This resulted in the proposal for a new water system model.

Keywords: water resources management, water conflicts, sustainable development, urban areas, community participation, Mexico.

Resumen

En el presente trabajo se analiza el proceso del agua gestionada en el Valle Metropolitano de San Luis Potosí (VMSLP) frente a un complejo escenario en torno al recurso hídrico. Derivado de un estudio multifactorial sobre tal problema, el objetivo de este apartado fue determinar, analizar y explicar el sistema urbano del agua en el valle, el cual permitió la identificación, análisis, relación y comprensión de diversos conflictos que conforman la problemática del agua en la región, y que suelen ser desconocidos para gran parte de la población y omitidos por las administraciones. A través de una revisión exhaustiva de literatura

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científica de distintos campos especializados en el tema, así como de la recopilación de datos de diversas fuentes y la consulta de actores clave del sector gubernamental de todos los niveles, sector académico, organismos descentralizados y civiles, comunidades y grupos afectados de la población, se generó un modelo del sistema urbano del agua y se realizó un análisis detallado sobre este. Los resultados permitieron identificar y analizar los principales conflictos del agua en cada etapa del sistema, externalidades, consecuencias, actores involucrados, sus roles, y establecer las relaciones causales y agravantes entre ellos. Con base en este diagnóstico se propusieron pautas para el desarrollo de un plan de gestión integral y sostenible del agua local, humanista, multidisciplinario y participativo para abordar las causas profundas del problema y ofrecer soluciones sostenibles a largo plazo, lo cual resultó en la propuesta de un nuevo modelo de sistema hídrico.

Palabras clave: gestión de los recursos hídricos, conflicto relacionado con el agua, desarrollo sostenible, zona urbana, participación comunitaria, México.

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Introduction

Water studies have gained increasing importance in the current context, marked by climate change and the growing scarcity of this essential resource in various parts of the world. Despite the complexity of the hydrological situation, the most common solutions tend to be technocratic and one-dimensional, focusing primarily on the construction of infrastructure to increase water supply, without adequately considering the social, environmental, political, and cultural dimensions that form part of the problem.

This approach, limited to expanding resource availability, conceals a chronic process of constant extraction that is becoming increasingly unsustainable in the face of rapid population growth, uncontrolled urbanization, intensive industrialization, and the consumption and production patterns of the global hegemonic culture (Bauman, 2022; Bauman, 2007; Peña, 2013). This model, based on the notion of unlimited growth and the accumulation of capital in a few hands, intensifies the overexploitation of already scarce natural resources, generating numerous social and environmental externalities that directly affect communities, ecosystems, and biodiversity.

In this context, the present study focuses on analyzing the Water System of the Metropolitan Valley of San Luis Potosí (MVSLP). The developed model allowed the observation of how water behaves within the urban environment of the region, the management processes for its supply, the actors involved, and the conflicts that emerge. The combination of these conflicts constitutes what is commonly referred to as the "water crisis," whose deterioration in the MVSLP has become particularly evident in recent decades, within a global context of climate

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change and environmental degradation that exacerbates social and territorial inequalities (Quintero-García, 2025).

The increasing overexploitation of water in urban environments—driven more by consumerist lifestyles than by basic needs (Peña, 2013)—has heightened pressure on ecosystems and led to the depletion of both surface and groundwater sources, which are the main sources of supply for cities (Quintero-García, 2025). Given the insufficiency of these sources, water has been increasingly brought from distant locations, deepening the ecological footprint and associated environmental conflicts (López-Álvarez, 2021).

In this sense, it is crucial to understand the "life cycle" of water in cities: ¿Where does the water we consume come from? What processes make its daily availability possible? What social and environmental implications does this process entail? Following Leonard's (2010) critical perspective, which examines the production and consumption of goods in relation to their external effects, this study seeks to pose those same questions about water—a vital resource for life that, nonetheless, often remains invisible in terms of its trajectories and real costs.

To address these questions, the research employed an interdisciplinary approach that combined document review, fieldwork, and interviews with key actors. The study involved collaboration with representatives from various governmental institutions (Comisión Nacional de Agua, Conagua; Secretaría de Medio Ambiente y Recursos Naturales, Semarnat; Comisión Nacional de Áreas Naturales Protegidas, Conanp; la Comisión Estatal del Agua, CEA, de San Luis Potosí; y el Organismo Intermunicipal Metropolitano de Agua Potable, Alcantarillado, Saneamiento y Servicios Conexos de San Luis Potosí, Interapas); academy (El Colegio de San Luis, Universidad Autónoma de San Luis

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Potosí), as well as civil organizations and citizen groups such as the State Water Council, the Groundwater Technical Committee, Guardianes de la Sierra, and the Autonomous Water Oversight Committee of the State of San Luis Potosí.

The information gathered enabled the modeling of the urban water system of the MVSLP, providing an analytical and methodological framework that highlights the complexity of the water crisis in the region. Based on this diagnosis, an integrated plan with multifaceted strategies and actions was proposed, aimed at developing a sustainable, equitable, and regionally adapted water management model.

Materials and methods

This study, focused on the complex water-related issues in the MVSLP and on the detailed analysis of its Urban Water System (Quintero-García, 2025), was based on a rigorous methodology that combined the review of documentary sources with fieldwork (Figure 1).

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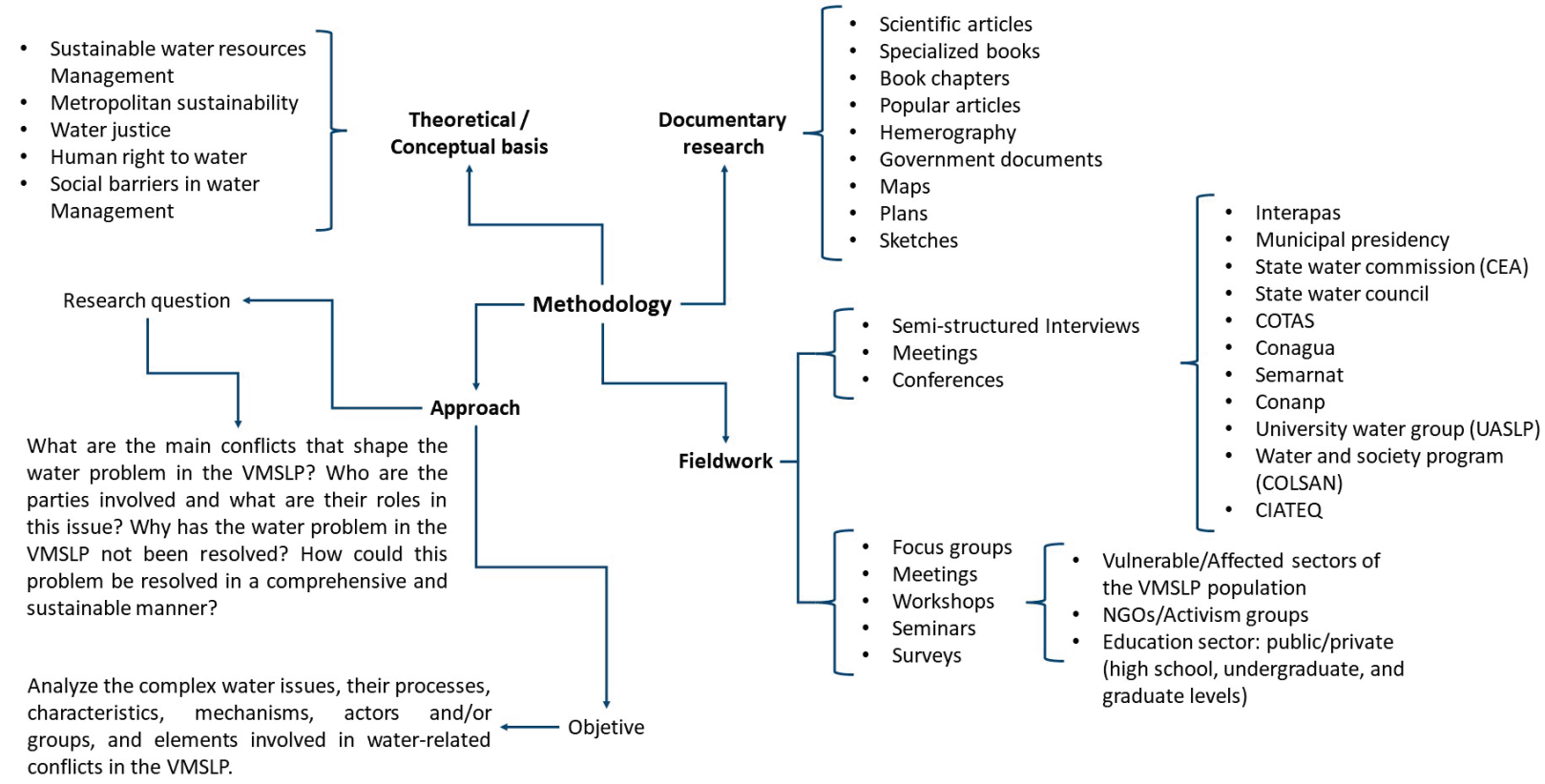

Figure 1. Research Methodology. Source: Quintero-García (2025).

Documentary review

First, an exhaustive review of scientific, technical, and legal literature was conducted, including the Ley de Aguas Nacionales (National Water Law), the Reglamento de la Ley de Aguas Nacionales (Regulations of the National Water Law), Normas Oficiales Mexicanas (Official Mexican Standards), the Ley Federal de Equilibrio y Protección Ambiental (Federal Law on Environmental Balance and Protection), the Ley General de Bienes Nacionales (General Law of National Assets), the Ley de Aguas para el Estado de San Luis Potosí (Water Law for the State of San Luis Potosí), and the Ley Ambiental del Estado de San Luis Potosí (Environmental Law of the State of San Luis Potosí), among others related to water

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management in the case study. Specialized databases, government reports, academic publications, and scientific articles were also consulted, aiming to obtain a comprehensive overview of the water problem and identify the main influencing factors.

Fieldwork

To complement the information obtained through documentary review, several field activities were carried out, including:

- **Interviews with key stakeholders**: Representatives of major governmental actors involved in water management were interviewed. At the federal level, officials from Semarnat, Conagua, Conanp were consulted. At the state level, interviews were conducted with the head of the Comisión Estatal del Agua (CEA). At the local level, meetings were held with the municipal president and executives of the operating agency Interapas.
- **Academic and civil society consultations**: Experts from academic institutions such as the Universidad Autónoma de San Luis Potosí (through its University Water Group) and El Colegio de San Luis, A. C. (particularly from the Water and Society Program) were consulted, along with representatives from civil and advisory bodies such as the State Water Council, the Technical Committee on Groundwater of the San Luis Valley Aquifer, the Autonomous Water Oversight Committee of the State of San Luis Potosí, and Guardianes de la Sierra, among others.
- **Participation in meetings and workshops**: The research team participated in meetings and workshops organized by civil

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organizations, undergraduate and graduate students from public and private institutions, and citizen committees from affected sectors. This participation provided first-hand insights into their perspectives and strategies.

- **Collection of primary data**: Primary data were gathered through interviews, workshops, and meetings with different stakeholder groups.

Comparative analysis

The collected information, characteristics, involved actors, impacts, and consequences were analyzed and compared with other case studies: Mexico City (Pastrana-Miranda & González-Caamal, 2022), Monterrey (Ramírez-Pichardo, 2024), Tijuana (Miranda *et al*., 2023), Querétaro (Bajo Tierra Museo del Agua, 2023; Granados-Ramírez & Villaseñor-Franco, 2007), and Guanajuato (Rocha-Díaz *et al*., 2024), which exhibit similar characteristics, conditions, and water-related problems.

Based on the information gathered from the document review and fieldwork, a conceptual model of the Urban Water System in the MVSLP was constructed. This model systematically integrated the various elements of the water system—such as water sources, infrastructure, management processes, and stakeholders—and examined how they interact with one another.

To understand the complexity of water-related problems in the MVSLP, a systemic approach (Martínez-Austria & Vargas-Hidalgo, 2016) and a correlational approach (Menchaca-Dávila, 2020) were employed. This methodology facilitated the identification and analysis of multiple

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variables, factors, and substructures that together form the general structure of the problem (Quintero-García, 2025).

Drawing on studies and research from different fields, this model enabled the identification, categorization, and characterization of a wide range of latent and manifest water conflicts that are interconnected and co-evolve within a complex system. This was achieved through a detailed analysis of the causal relationships among the various elements of the system (Figure 2).

Figure 2 illustrates the complexity of the water problem in the MVSLP. It was developed based on the identification and connection of water-related conflicts, as well as the stakeholders and responsible actors involved, using information from various studies and interviews. The figure reveals a network of political, administrative, technical, social, environmental, and territorial conflicts, among others, which are exacerbated by the effects of climate change—such as rainfall uncertainty and the recurrence of extreme droughts.

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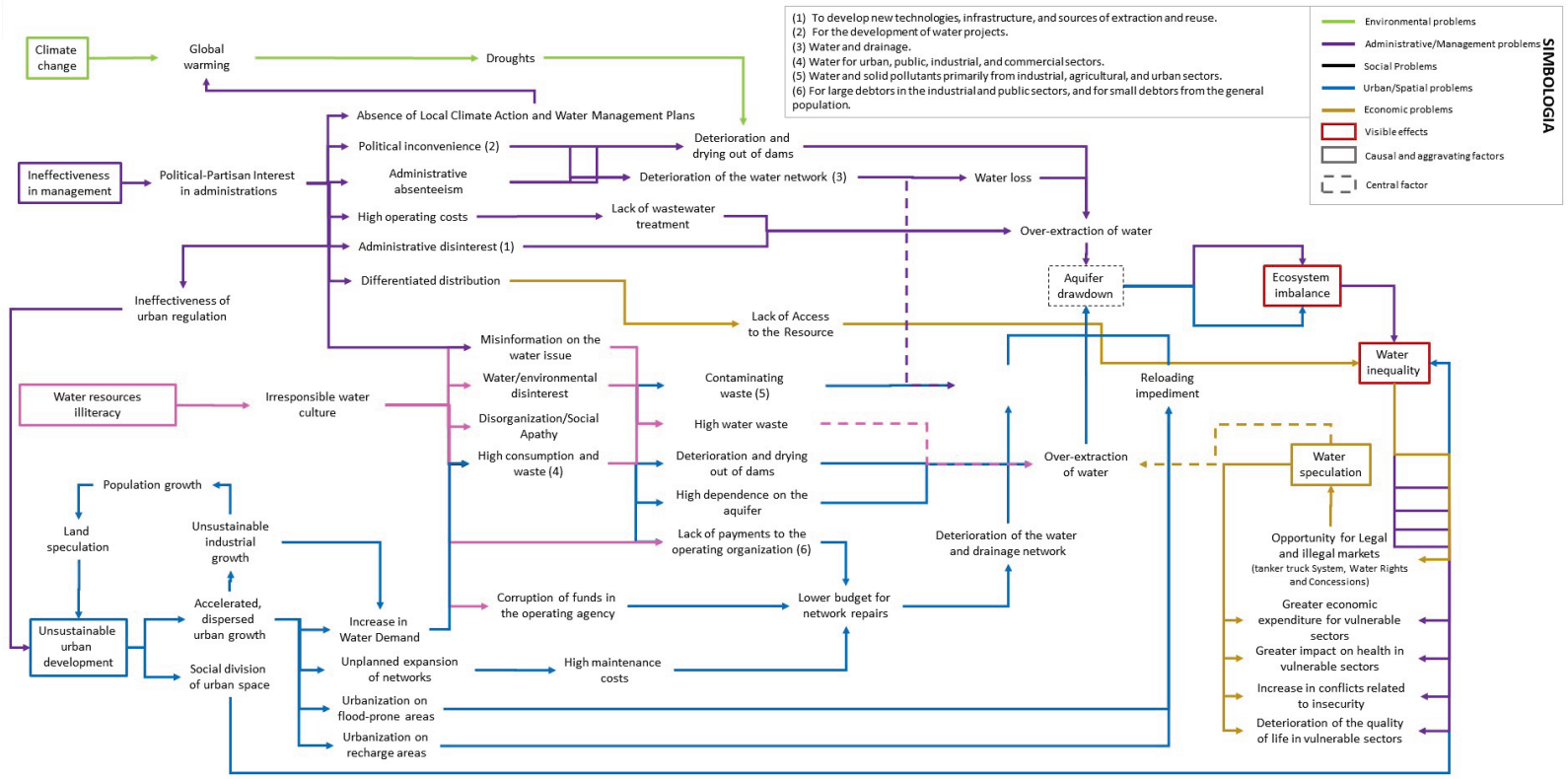

Figure 2. Water Problems in the Potosino Valley. Source: Quintero-García (2025).

This analysis identifies the root of the problem as the inefficient management of soil and water resources, historically influenced by business groups (Quintero-García, 2021; López-Valle, 2013). Several aggravating factors stem from this root: the lack of adequate infrastructure for water capture, distribution, use, and reuse; an urban model driven by speculation and environmental degradation, largely controlled by powerful real estate actors (Guerrero-Serrano, 2015; Ortiz-Brizuela, 2015); the adoption of an unsustainable economic model that favors high-extraction industries in a region with finite resources, propelled by political and private interests; the concentration of water

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rights among a few political and business elites (Conagua, 2025), leading to irregular or even illegal markets; and a water culture characterized by overconsumption and waste among certain population sectors.

Furthermore, externalities associated with these various factors were identified. Together, these conditions have generated multiple conflicts resulting in unequal access to quality water, public health issues, resource overexploitation, and increasing ecosystem degradation in the region.

Through this comprehensive analysis, the study identified the factors that trigger and exacerbate water conflicts, as well as their consequences across different temporal scales (Figure 3). It also laid the groundwork for a deeper understanding of the water problem in the Potosi Valley by connecting sectoral approaches that are usually fragmented. By making the interconnections among the different aspects of the system visible, it became possible to identify the roots of the conflicts and propose more integrated and sustainable solutions. Within this framework, a comparative analysis was conducted to contrast the collected information, characteristics, actors, impacts, consequences, proposals, and recommendations with other case studies—Mexico City (Pastrana-Miranda & González-Caamal, 2022); Monterrey (Ramírez-Pichardo, 2024); Tijuana (Miranda *et al*., 2023); Querétaro (Bajo Tierra Museo del Agua, 2023; Granados-Ramírez & Villaseñor-Franco, 2007), and Guanajuato (Rocha-Díaz *et al*., 2024)—which share similar conditions and water challenges.

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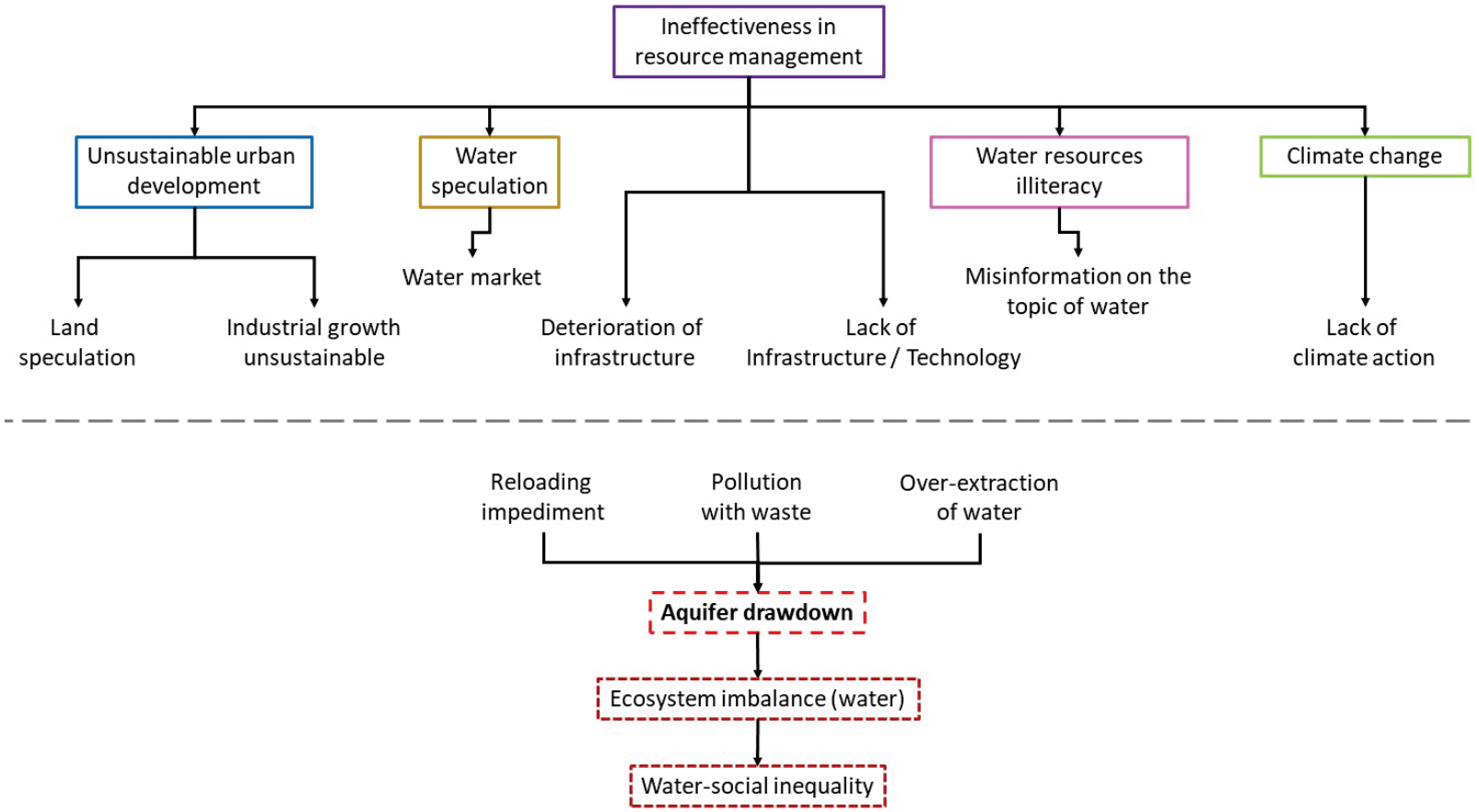

Figure 3. Causes, Aggravating factors, and consequences of the water problem in the MVSLP. Source: Quintero-García (2025).

Results

The linear water system in the MVSLP: Overexploitation, disposal, and waste

A method for problem analysis and identification

The results of this study enabled the modeling of the urban water system, which can be described as a linear process (Figure 4). This model

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illustrates how water flows from the moment it is captured until its final disposal, showing the various interactions with human activities at each stage.

Figure 4. Urban water system of the MVSLP.

Unlike circular systems—characterized by cyclical dynamics—linear systems exhibit a unidirectional flow. Although both can operate continuously, the linear system does not return to its starting point upon completing its cycle, as noted by Leonard (2010). This feature prevents the reuse of resources at the end of the process, thereby creating a constant need to extract new inputs and contributing to the progressive depletion of water in both natural and built ecosystems.

Applying this linear model to productive systems that pursue unlimited growth poses major challenges. Growing demand requires intensive use of finite natural resources (Peña, 2013), which in turn exerts unsustainable pressure on ecosystems and adversely affects biodiversity and human populations (CHE, 2024). This dynamic—typical of infinite-growth models—clashes with the finite nature of natural resources, heightening depletion risks and triggering a range of environmental impacts that are often underestimated in the name of economic growth. A clear example of this system is the human water-use cycle: for both domestic and industrial activities, water demand follows a linear pattern that requires continuous aquifer extraction and culminates in wastewater disposal that frequently fails to meet environmental quality standards.

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The case of the MVSLP reveals an urban water system structured in six stages, ranging from the extraction of surface and groundwater to its final disposal (Quintero-García, 2025). This analytical model helps identify and characterize conflicts at each phase of the cycle, indicating causes, effects, aggravating factors, and actors involved (directly responsible, co-responsible, and affected). The interconnection among these phases shapes a complex web of problems that deepens the region's water crisis, as shown in Figure 2.

Stage 1. Water resource extraction

The first phase involves water withdrawal from two main sources: (a) the El Realito, San José, El Peaje, and El Potosino dams, which contribute between 8 and 25 % (López-Álvarez, 2021; Interapas, 2023) of supply; and (b) the groundwater system—particularly the deep aquifer—which provides between 75 and 92 % (Interapas, 2023; López-Álvarez, 2021) of urban consumption. These proportions vary according to the availability of surface water bodies, which depends on both climatic variability and urban consumption patterns. Summer intensifies water demand—even as it coincides with an uncertain rainy season—thereby reducing the recharge capacity of natural and artificial reservoirs.

This stage is marked by intensive groundwater extraction, a situation compounded by low storage levels in dams due to operational issues, lack of maintenance, and scarce rainfall (Conagua, 2024a). As a result, the 2411 aquifer has been under an extraction ban (*veda*) since the 1960s due to overexploitation (López-Álvarez, 2021; IPICYT, 2018; Cotas & Conagua, 2005).

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The MVSLP's strong dependence on this source is intensified by excessive consumption in the urban, industrial, and commercial sectors Aguirre *et al*., 2023; López-Álvarez, 2021; Peña, 2013), which has led to a progressive decline in the water table. This trend is exacerbated by insufficient investment in infrastructure and in technologies for capture, treatment, potabilization, and reuse, as well as by obsolete distribution networks (Quintero-García, 2025). According to Félix-Díaz (2024) and Díaz-Barriga (Corpus, 2024), it is estimated that more than 50 % of water is lost through leaks into the subsoil, while sewer networks also exhibit wastewater leaks that contaminate the aquifer, accelerate its deterioration, and create significant public-health risks. These deficiencies largely stem from a long-standing governmental neglect of network maintenance and renewal at the local and state levels (CHE, 2024).

As presented by the State Water Council (CHE, 2024), institutional inefficiency is explained by electoral-political criteria: governments often postpone water-infrastructure projects—considered to yield low political returns—in favor of highly visible, image-boosting works such as street lighting, paving, or monumental projects, reducing water actions to distributing household saving devices or cisterns for temporary storage. This short-term approach has a twofold consequence: on the one hand, the water problem is deferred and worsens as it is passed from one administration to the next; on the other, public resources are channeled to politicized works that do not truly benefit the population and sometimes even produce adverse effects (CHE, 2024), as in the emblematic case of the "El Realito" dam, discussed further in Stage 2.

The repercussions of this dynamic are multiple, including: a) hydrological imbalance and disruption of the natural water cycle in ecosystems, as explained by López-Álvarez (2021); b) unequal access to

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the resource among social strata due to differentiated allocation, as noted by Peña (2013) and Guevara-Gasca (2008); c) progressive aquifer depletion driven by overexploitation, contamination, and inhibited recharge, evidenced by Quintero-García (2025), CHE (2024), and COTAS (Cotas & Conagua, 2005), and d) growing vulnerability to droughts and extreme climatic events (Moreno-Mata *et al*., 2016). Added to this is a rising water demand propelled by an accelerated, fragmented, and speculative urban-development model (Guerrero-Serrano, 2015; Ortiz-Brizuela, 2015), as well as by water-intensive industrial activity incompatible with the region's semi-arid conditions (Zurita *et al*., 2015; López-Álvarez, 2021).

In this regard, the prevailing development model—marked by short-termism and disregard for environmental and social externalities—constitutes a structural factor in the water crisis. Public administrations, urban developers, and business-industrial groups emerge as key and responsible actors (Quintero-García, 2025; Guerrero-Serrano, 2015; Ortiz-Brizuela, 2015; López-Valle, 2013), privileging short-term economic interests over long-term socio-environmental sustainability and water security, in line with reports by the Contraloría Autónoma del Agua del Estado de San Luis Potosí (2024) and the State Water Council (CHE, 2024).

One example is the modification of urban-development laws and the creation of the 2019 territorial and urban development plan under market-oriented logics benefiting private interests. This enabled the hoarding of large land tracts and land-use changes in the Sierra de San Miguelito, along with urbanization over strategic recharge areas by these groups—aggravating the inhibition of natural aquifer recharge and

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increasing flood risks in the metropolitan area (CHE, 2024; Quintero-García, 2021).

Stage 2. Water storage

Once water is obtained from dams or the aquifer via wells, it must be stored in supply facilities through pumping, mainly in engineered structures such as dams or storage tanks for subsequent treatment, potabilization, and/or distribution. However, according to the then head of Conagua in the state, existing hydraulic infrastructures are in a deteriorated condition and are inefficiently managed, exacerbating the water crisis (Félix-Díaz, 2024).

The "El Realito" dam—initially conceived to reduce dependence on the aquifer (López-Álvarez, 2021)—has suffered multiple structural and operational failures that have prevented it from supplying the projected volume and continuity (GUA, 2025). According to CHE (2024) and Félix-Díaz (2024), its construction was marred by acts of corruption that continue to burden the public purse, further undermining water conditions for residents. This has prompted public statements from academia urging the authorities to assign responsibility and resolve the issue—e.g., from the Water and Society Program at El Colegio de San Luis and the University Water Group at the state university.

Its planning did not reflect the population's real needs but rather real estate and industrial interests, which began marketing land for housing and industry by promoting secure supply from this source even before construction (Quintero-García, 2025). This influenced accelerated, expansive, and unplanned urban growth, primarily over recharge zones. Harmful social processes also ensued—land dispossession, real-estate

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harassment of communal landholders, forced displacements, and fraudulent or advantageous acquisitions by powerful groups—conditions that enabled urban production under a capital-accumulation model supported by successive local and state administrations (Quintero-García, 2021).

The project was built to supply the MVSLP through a system comprising a dam, a water-treatment plant, and an aqueduct of approximately 132 km. It was designed to deliver 1 000 l/s (Aqualia, 2025; Salvador *et al*., 2018; Peña, 2013), but in practice its operation has been intermittent and below projected volumes. Conagua has acknowledged that, even when operating, it typically conveys only 450–500 l/s, and the dam wall has shown leaks estimated at 500 l/s, prompting repair works (Conagua, 2024b). In 2024, there were 76 service interruptions, and by August 11, 2025, an additional 11 failures had been recorded; altogether, the metropolitan area has experienced roughly 300 days without service due to system interruptions over the last two years (Contreras, 2025; Torres, 2025; Robledo, 2025), confirming the lack of continuity due to failures in both the dam wall and the aqueduct.

Beyond supply impacts, the project is entangled in a legal-contractual framework: conveyance and potabilization are concessioned to Aquos (Aqualia) under a service-provision contract managed via a trust, with per-m³ payments and penalties. Even so, the state authority has stated that canceling the contract would be "unaffordable," while disputes persist over sanctions and rehabilitation obligations (Landeros, 2025; SLP; El Express SLP, 2024). Taken together, this financing scheme has entailed significant public outlays ("millions in payments") despite poor service continuity, shifting costs to the treasury and sustaining dependence on a system that has not met performance expectations

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(Segura, 2025).

The "San José" dam faces severe water-quality issues due to fecal coliform contamination and water hyacinth proliferation (GUA, 2025; Corpus, 2024). Moreover, insufficient desilting maintenance has significantly reduced its storage capacity.
As for the "El Peaje" dam, a recent project raised the crest level to increase storage capacity. However, although it currently exceeds 85 % capacity, Conagua itself is unaware of how that water is being managed due to opacity on the part of state authorities.

Meanwhile, the "El Potosino" dam has limited storage capacity and supplies only a minimal share of the population.

Management of stored water in these dams is characterized by arbitrariness, opacity, and inequity (CHE, 2024). Reports by the Contraloría Autónoma del Agua del Estado de San Luis Potosí (2024), together with the CHE diagnosis (CHE, 2024) and studies such as López-Valle (2013) and Guevara-Gasca (2008), indicate that water is preferentially allocated to private interests to the detriment of public needs, thereby generating marked inequality in access and deepening the water crisis.

Stage 3. Water conveyance

In the third stage, water is transported from the storage site—by gravity, pumping, and/or re-pumping—to a regulation tank, a water-treatment plant, or a predetermined network junction.

This stage is primarily affected by the deterioration of distribution networks. According to Conagua, CEA, and Interapas, more than 50 % of

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potable and sewer water is lost through pipeline leaks, generating a dual problem (GUA, 2025): reduced supply and aquifer contamination—issues previously noted. Peña (2013) adds that limited financial resources and pressure to serve growing areas have sidelined rehabilitation of existing networks, directly affecting the quality and quantity of water delivered to the population (CHE, 2024). Illegal water extraction through clandestine wells and unauthorized connections further aggravates the problem, causing financial losses for utilities and contaminating aquifers (Félix-Díaz, 2024).

Moreover, the insufficiency of potable-water treatment plants limits the capacity to ensure high-quality supply for the entire population. High operating and maintenance costs, the lack of diversified infrastructures for treatment and reuse—such as nature-based solutions—and the short-term vision of authorities have hindered development (CHE, 2024).

Stage 4. Water distribution

In the fourth stage, water is supplied to the population through the network (Interapas, 2023), revealing marked inequality in access within the MVSLP (Guevara-Gasca, 2008). Historically, the most vulnerable sectors have faced scarcity and restrictions, while higher-income residential areas enjoy more continuous and higher-quality supply—even where such areas contain high water-consumption amenities (golf courses, swimming pools, and extensive green areas with exotic vegetation—primarily turfgrass and palms) and often maintain sizable arrears.

Quintero-García (2021) and Peña (2013) document how water management has favored private interests, such as the concession

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granted to Aguas del Poniente Potosino S.A. de C.V., which commercialized water in the city's highest-income sectors while accumulating a 14-year historical debt to the utility.

Another related case is the hoarding of 91 % of regional wells by private actors through acquisition or transfer of water rights—often registered irregularly as agricultural use (Conagua, 2025), which by law pays no extraction fees—even when these wells are located within the urban area and their actual use is industrial. The remaining 9 % of wells supply over 85 % of the MVSLP population (Félix-Díaz, 2024).

Through this mechanism, a private and irregular water market has operated to serve large shopping centers, industries, and vulnerable sectors facing curtailed public-network supply by authorities. This has created significant access gaps and financial shortfalls for the utility, with negative consequences for public health, quality of life among the most disadvantaged, and the city as a whole. It has also fostered public distrust and discontent toward water-management authorities (Contraloría Autónoma del Agua del Estado de San Luis Potosí, 2024).

Poor water quality—particularly in areas supplied by the aquifer and the El Realito and San José dams—is another recurrent problem. The presence of contaminants such as fecal coliforms, fluoride, and others (Corpus, 2024; López-Álvarez, 2021; Peña, 2013) poses serious health risks.

Stage 5. Water use

In this stage, water is used across sectors (domestic, urban, industrial, commercial, agricultural, among others) and is characterized by excessive consumption and inefficient management (Aguirre *et al*., 2023). Domestic

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wastage, poor maintenance of facilities, and the absence of a conservation culture contribute to high per-capita consumption.

Inequity in distribution is evident: while some high-income residential sectors enjoy continuous supply, socioeconomically disadvantaged sectors experience scarcity and restrictions. Non-payment by large consumers—such as public agencies and industries—further strains utility finances and limits infrastructure investment (GUA, 2025).

Although industry accounts for a smaller share of total recorded consumption, its actual usage is uncertain because it is often supplied by unmonitored wells, private water rights, or registrations as agricultural use that differ from industrial use. Consequently, the percentage reported by Conagua is imprecise (Contraloría Autónoma del Agua del Estado de San Luis Potosí, 2024). Even so, the sector exerts significant pressure on the aquifer by demanding large volumes of high-quality water through indiscriminate extraction for industrial purposes (Aguirre *et al*., 2023). During periods of extreme drought, this contrasts with the restrictions imposed on domestic consumption by authorities.

The lack of information on industrial water use hampers accurate assessment of its real impact on the system (Félix-Díaz, 2024). Nevertheless, studies by the State Water Council (CHE, 2024), Aguirre *et al*. (2023), Zurita *et al*. (2023), and Peña (2013) suggest that the industrial sector—like the domestic sector—contributes to aquifer overexploitation and water-quality degradation in a context of profound inequality.

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Stage 6. Water disposal

This final stage of the water system reveals inadequate management of wastewater. The misguided conception of wastewater as refuse—rather than as a potentially reusable resource—has led to practices such as direct discharge of untreated effluents into water bodies and soils, causing severe contamination and socio-environmental degradation (Quintero-García, 2025; López-Álvarez, 2021; Peña, 2013).

The insufficiency of wastewater-treatment plants and the high operation and maintenance costs of existing facilities (GUA, 2025), along with the lack of political will to implement long-term, low-cost alternative infrastructures and technologies—such as nature-based solutions—limit the MVSLP's capacity to treat and reuse water. Combined with the absence of a reuse culture, this perpetuates a cycle of contamination, inequality, and scarcity of water resources.

Discussion

The Water Crisis of the Potosino Valley in relation to other urban contexts in Mexico

Comparative analysis

The discussion confirms that the mixed methodology—documentary review, interviews with key stakeholders, and systemic analysis—provides a robust foundation for problematizing the water crisis in the MVSLP. The evidence gathered aligns with experiences in other Mexican cities such as the Valley of Mexico City (Pastrana-Miranda & González-Caamal, 2022),

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the Monterrey Metropolitan Area (Ramírez-Pichardo, 2024), Tijuana (Miranda *et al*., 2023), Querétaro (Bajo Tierra Museo del Agua, 2023; Granados-Ramírez & Villaseñor-Franco, 2007), and the State of Guanajuato (Rocha et al., 2024), where aquifer overexploitation, real-estate speculation, resource hoarding, and governmental permissiveness–inefficiency–complicity generate and deepen inequality in access to water, as shown in Table 1.

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Table 1. Comparative Table of Case Studies on the Water Crisis in Mexico.

City/region	Main problems	Actors involved	Structural causes	Proposals/ recommendations
Metropolitan Zone of Mexico Valley	• Overexploitation of aquifers; • Scarcity and unequal distribution • Subsidence • Pollution • Irregular settlements • Socio-environmental conflicts	Federal Government, Mexico City, State of Mexico, peripheral municipalities, Conagua, peripheral communities.	○ Centralization of resources toward the capital ○ Territorial marginalization ○ Expansive urban-industrial model ○ Lack of participatory governance	• Update concessions • Decentralize management • Strengthen municipal autonomy • Invest in infrastructure and training • Transition from clientelist governance to governance with social participation.
Metropolitan Area of Monterrey	• Overexploitation and aquifer deficit • Pollution • Uncontrolled urban growth • Water crisis • Lack of monitoring • Illegal wells	Conagua, Monterrey Water and Drainage Services (SADM), Río Bravo Basin Council, industry, irrigation districts, civil society (FAMM, NGOs).	○ Sectorized and utilitarian management ○ Over-concessioning ○ Weak institutional oversight ○ Industrial expansion (nearshoring) ○ Accelerated urbanization ○ Climate change.	• Creation of COTAS (Regulatory Watersheds) • Transparency in concessions; greater monitoring and control • Use of wastewater in industry/agriculture • Investment in watershed conservation • Environmental education programs

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City/region	Main problems	Actors involved	Structural causes	Proposals/ recommendations
Tijuana	• Lack of institutional capacity • Discontinuity in water projects • Bureaucratization • Lack of long-term planning • Politicization of the resource	SEPROA, State Water Commission, municipal agencies, local governments, citizens.	○ Six-year changes and turnover of officials ○ Political interests in the public agenda ○ Lack of institutional autonomy.	• Promote an autonomous structure with a long-term vision • Strengthen municipal-state coordination • Avoid clientelist use of water • Consolidate stable water governance.
Querétaro	• "Man-made" shortages • Overexploitation of aquifers • Dependence on water transfers (Aqueduct II) • Real estate speculation • Inequality in access • Pollution	State and municipal government, real estate and industrial sector, local communities, social organizations.	○ Water management model dependent on water transfers ○ Fragmented and exclusionary urbanization ○ Water hoarding by elites ○ Lack of comprehensive assessments.	• Repair leaks and improve wastewater treatment • Regulate land use • Citizen information platforms • Industrial monitoring • Urban water sovereignty • Halt mega-transfer projects.

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City/region	Main problems	Actors involved	Structural causes	Proposals/ recommendations
Estado De Guanajuato	• High water stress in 86 % of municipalities • Agricultural overuse • Low irrigation efficiency • Climate vulnerability	Municipalities, farmers, state government, Conagua.	○ High agricultural demand ○ Low water efficiency ○ Low rainfall ○ Dependence on overexploited aquifers.	• Irrigation technology (95 % drip) • Reduction in agricultural consumption • Differentiated management plans by municipality • Long-term mitigation.
MVSLP	• Structural water crisis • Overexploitation of the aquifer • Urbanization in recharge zones • Pollution • Inequality in access • Water rationing and pipelines • Water speculation • Socio-environmental conflicts	State and municipal government, Conagua, CEA, Interapas, industry, real estate, civil society, communities, academia.	○ Centralized and clientelist management ○ Speculative urban-industrial model ○ Commodification of water ○ Fragmented governance ○ Deficient infrastructure	• Comprehensive multidisciplinary and participatory plan • Water justice • Depoliticized and sustainable actions • Halting urbanization in the Sierra de San Miguelito • Inter-institutional collaboration • Strengthening citizen participation.

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The comparative analysis among the six case studies allows for the identification of both local particularities and common patterns that traverse different regions of the country in relation to water management. The results show that, despite geographical, historical, and institutional differences, water problems in Mexico share structural roots that explain the persistence of the crisis and the challenges of moving toward sustainable and equitable management.

In all the cases studied, aquifer overexploitation emerges as a common denominator. The Valley of Mexico (Pastrana-Miranda & González-Caamal, 2022), the Monterrey Metropolitan Area (Ramírez-Pichardo, 2024), Querétaro, Guanajuato (Rocha-Díaz *et al*., 2024), and San Luis Potosí (Quintero-García, 2025) exhibit recharge deficits in comparison to extraction rates, while in Tijuana (Miranda *et al*., 2023), although institutional capacity is emphasized, pressure also exists on the available sources. This overexploitation is directly linked to an expansive urban–industrial model that prioritizes demographic concentration, the installation of high water–demand industries, and real-estate speculation in environmentally vulnerable territories.

Likewise, all six cases reveal deficient water governance, characterized by centralized decision-making, institutional fragmentation, political clientelism, and a lack of continuity in public policy. In Tijuana (Miranda *et al*., 2023), politicization of the resource and six-year administrative cycles prevent long-term planning; in Monterrey (Ramírez-Pichardo, 2024) and San Luis Potosí (Quintero-García, 2025), institutions operate under pressure from private actors; in Querétaro (Bajo Tierra Museo del Agua, 2023; Granados-Ramírez & Villaseñor-Franco, 2007) and the Valley of Mexico (Pastrana-Miranda & González-Caamal, 2022),

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management has historically been subordinated to the needs of central metropolitan areas to the detriment of peripheral and local communities.

The comparison also shows that inequality in access to water is a constant. In the Valley of Mexico (Pastrana-Miranda & González-Caamal, 2022), peripheral zones lack basic services while their aquifers sustain the capital; in Monterrey (Ramírez-Pichardo, 2024), per capita consumption varies drastically between low-income municipalities and elite residential areas; in San Luis Potosí, the population endures water rationing and delivery by tankers, while industrial and high-income residential sectors enjoy continuous supply; in Querétaro (Bajo Tierra Museo del Agua, 2023; Granados-Ramírez & Villaseñor-Franco, 2007), water speculation benefits business groups while rural communities bear the externalities of water transfers. These inequalities manifest not only in the quantity and quality of water available, but also in health risks, forced displacements, and climatic vulnerability.

Across the six cases, three structural factors underpin the water crisis in Mexico:

- **Accelerated and uncontrolled urbanization**: Urban growth in the Valley of Mexico, Monterrey, Querétaro, and San Luis Potosí has sealed recharge zones and driven speculative land expansion, increasing water demand.
- **Intensive industrialization**: In Monterrey and San Luis Potosí, the establishment of industrial parks and high-consumption industries has deepened overexploitation; in Guanajuato, intensive agriculture adds another pole of water pressure.
- **Water commodification**: The resource is treated as a commodity and object of speculation—whether through the Querétaro water

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transfers, the private water market in San Luis Potosí, or administrative arrangements benefiting industry in Monterrey.

Despite the critical diagnoses, the six studies converge on the need to transform water management toward more sustainable, participatory, and inclusive models. Several relevant experiences and recommendations emerge:

- **Decentralization with local autonomy** (Valley of Mexico, Tijuana), aimed at overcoming political centralization and strengthening municipal capacities.
- **Citizen participation and multilevel governance** (Monterrey, San Luis Potosí), through watershed councils, groundwater committees (COTAS), or social-monitoring platforms that include communities, academia, and civil society.
- **Technification and water-use efficiency in agriculture** (Guanajuato), as a mitigation measure against water stress, even if with medium-term effects.
- **Urban water sovereignty** (Querétaro), to reduce dependence on transfers and megaprojects that exacerbate inequalities.
- **Comprehensive and long-term planning** (San Luis Potosí), capable of integrating multidisciplinary approaches, water justice, and ecosystem-based management.

The comparison of these cases reveals that Mexico's water problems are neither isolated nor circumstantial phenomena, but local expressions of a national model of unsustainable water management. This model—based on intensive extraction, urban–industrial expansion, and institutional capture by private and political interests—reproduces conditions of inequality and vulnerability.

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Nevertheless, emerging alternatives—though fragmented—point toward a transformative horizon: strengthening democratic water governance, integrating socio-environmental perspectives into territorial planning, and recognizing water as a common good and a human right. These elements constitute a starting point for rethinking water management in Mexico and advancing toward scenarios of sustainability and socio-environmental justice.

The circular water system for the Metropolitan Valley of San Luis Potosí: Optimization, reuse, and utilization

A comprehensive proposal for water sustainability in the Potosino Valley

In GUA (2025), Quintero (2025), Corpus (2024), López-Álvarez (2021), and Peña (2013), it is explained that the water crisis faced by the MVSLP results from a complex interaction of historical factors associated with the development of the urban settlement. Among the main causes are the depletion of the aquifer due to overexploitation and contamination, the obstruction of recharge caused by the impermeabilization of infiltration zones through urban encroachment, a deficient and obsolete distribution network, the increase in highly extractive industrial activity, and an irregular or illegal market that encourages speculation over water.

Altogether, these factors—combined with inadequate water-resource management—have considerably reduced the availability of water for the population and created a significant hydro-ecological imbalance in the region. Likewise, poor water quality, both surface and groundwater, has limited its use for human consumption and productive

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activities.

In this context, the water crisis in the MVSLP emerges as a multifactorial and multisectoral problem that demands the implementation of comprehensive solutions in the short, medium, and long term. For this reason, it is essential to adopt urgent measures that improve water-resource management, prioritizing preventive and corrective approaches over the usual palliative measures. This shift requires a profound transformation of prevailing paradigms in water policy and of the current management model toward one based on sustainability, social participation, environmental protection, equity in water access, and the separation of private accumulation interests from the management of natural, communal, and universal resources.

Analyzing the issue from the multiple conflicts surrounding water and from diverse perspectives provides a broader and more objective understanding of the hydrological panorama in the MVSLP. This, in turn, facilitates the generation of more accurate and effective responses to the multiple challenges posed by the water crisis.

Based on the analysis of the various conflicts that constitute the complex water problem in the MVSLP (Quintero-García, 2025), specific strategies and actions were designed for each of them, organized into six interrelated and complementary categories, as shown in Table 2.

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Table 2. Comprehensive strategies and actions for sustainable water-resource management in the MVSLP.

Tag	Problem identified	Strategy (to change)	Specific actions (how to do it)
Political-administrative (poor management)			
PA-01	Lack of a Sustainable, Comprehensive and Participatory Water Management Plan (state and local)	Formulate and institutionalize a Local Sustainable Water Management Plan (PGSAL) with a focus on watersheds, human rights, and water justice	Develop the Local Sustainable Water Management Plan (PGSAL) with pillars (human right to water, water justice, environmental protection), participatory governance, 5-10-20 year goals, indicators, and biannual review
PA-02	Centralist and extractivist model that ignores climate, water pressure and social conflict	Transition to a sustainable, comprehensive, and equitable model articulated with urban-territorial and environmental plans	Mandatory staff training; portfolio of nature-based and circular economy projects; alignment of laws/plans; water-social cost-benefit assessment
PA-03	Unidisciplinary/technocratic actions that omit socio-environmental contexts	Multidisciplinarity and citizen participation in water decisions	Permanent roundtables with social sectors, academia, and organizations; public opinions; social oversight of projects, policies, and budgets
PA-04	Short-term responses (e.g., new wells in closed areas)	Medium and long-term planning with climate risk management	Phased programs and standards (5–15 years); biannual evaluation and continuous improvement; drought/extreme rainfall plans
PA-05	Without local climate action or circular water models	Local water climate policy with mitigation and adaptation	Local public lands; reforestation/restoration plans; urban sprawl control; water sector GHG reduction targets
PA-06	Hermeticism and low citizen/academic participation	Transparency, participation and social oversight	Citizen water assemblies and committees with voice and vote; autonomous comptroller's offices; public audits of utility agencies

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Tag	Problem identified	Strategy (to change)	Specific actions (how to do it)
PA-07	Tax management/unilateral and low impact	Co-creation of solutions with affected communities	Joint government-citizen committees; binding agreements; public monitoring of commitments
PA-08	Low commitment to technologies for collection, distribution and reuse	Open innovation aimed at mass reuse	Calls for research, technological development, or innovation, and pilot projects; scaling up nature-based and rainwater-based solutions
PA-09	Lack of sectorization and monitoring in extraction/use/disposal	Comprehensive sectorization of drinking water and drainage	Design measurement and control zones (DMAs); telemetry; discharge regulation by sector
PA-10	Lack of interest in rescuing surface water bodies	Water body rescue and management program	Restore, conserve, and protect rivers, runoff, and lagoons; ecosystem uses and the water landscape
PA-11	Insufficient maintenance of dams and networks	Asset management and planned investments	Dam dredging and safety plan; gradual replacement of pipelines coordinated with sectorization (see PA-09)
PA-12	Deficit of treatment/purification plants	Diversify and modernize treatment and purification infrastructure	New wastewater treatment plants (WWTPs) and water treatment plants; reuse schemes; nature-based solutions; sustainable OPEX (biogas, etc.)
PA-13	Indiscriminate opening of wells and high-extraction industry	Gradual closure and control with productive transition	Scheduled well closures; strict enforcement of bans; limits on new intensive industries; tripartite monitoring; extraction/reuse regulations
PA-14	Permissiveness for developments in recharge, floodplains and primary ecosystems	Effective planning and sanctioning	Citizen committees with voting rights; financial/criminal sanctions; and immediate reparation for damages

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Tag	Problem identified	Strategy (to change)	Specific actions (how to do it)
PA-15	Ineffective land use regulation	Water territorial planning with social control	Planning instruments with a right to the city approach; inventory and monitoring of uses with GIS and participation
PA-17	Lack of network planning, maintenance and monitoring	Integrate sectorization + predictive maintenance	See PA-09, PA-11 and TIC-03/04 for coordinated execution
PA-18	Absence of permanent social/educational programs on water	Mandatory and continuing water education	Curricular programs by level; teacher training; local materials; and ongoing campaigns
PA-19	Uneven water distribution.	Priority to basic domestic use and territorial equity	Public monitoring; rationing rules in crises; guarantees of the human right to water
PA-20	Partisanization of water actions	Institutional protection against electoral cycles	Prohibit proselytizing; transparent methodologies and criteria; technical and public justification
PA-21	Biased campaigns that blame only the population	Evidence-based communication and co-responsibility	Ongoing campaigns targeting all sectors, focusing on large debtors/extractors
PA-22	Private/elite conflicts of interest in decisions	Integrity and influence control	Authentic, nonpartisan committees; public approval of projects/budgets; integrity rules
PA-23	Low socio-environmental sensitivity in administrations	Continuous professionalization	Mandatory programs in sustainable management, participation, and the Human Right to Water for all staff
Urban-spatial-territorial (urban unsustainability)			
UE-01	Inefficient planning allows for urbanization of recharge/floodplains; changes in land use favor real estate	Democratize and oversee planning; public ethics	Sanctions for public officials; codes of ethics; voting citizen committees; control of changes in use

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Tag	Problem identified	Strategy (to change)	Specific actions (how to do it)
UE-02	Urbanizations in the Sierra de San Miguelito reduce recharge and worsen shortages/subsidence	Do not build in recharge and areas of environmental value	Regulate and prohibit recharge expansion; remediation/regeneration programs
UE-03	More frequent/costly floods subsidize developments in sensitive areas	Polluter pays / value capture	Environmental taxes and capital gains capture to finance mitigation; risk criteria in licenses
UE-04	Urban sprawl raises service costs and fragments socio-spatial aspects	Cooperative and non-prescriptive metropolitan planning	Interinstitutional/intermunicipal frameworks; integrating operating agencies from the outset; social participation
UE-05	Landscaping with unsuitable species and high-water consumption	Native xeriscaping	Public guides to native vegetation; green space conversion; list of unsuitable/invasive species
UE-06	Non-sustainable facilities (e.g., golf, swimming pools)	Water usage rules by type of equipment	On-site WWTP; prohibit irrigation with first use/potable water; monitoring and sanctions
UE-07	Accelerated changes in land use with high water impact	Land use planning and real-time monitoring	Stricter regulations; GIS/satellite for alerts; inspections and sanctions; reporting channels; densification/rehabilitation; training
Environmental (water and ecosystem imbalance)			
A-01	Over-extraction and aquifer imbalance	Concessionary adjustment to actual availability	Concession audits; reductions and conversion of uses; watershed balance targets
A-02	High dependence on the deep aquifer	Mass reuse and stream separation	Agricultural technology; separation of black/gray/rainwater; compliance with NOM regulations in industry and housing
A-03	Drainage leaks contaminate shallow aquifer	Renew and monitor drainage	Prioritized replacement; sensors/remote inspection; expedited repair
A-04	Irrigation with sewage	Transition to treated water with support	Program with farmers, technical assistance and financing; effluent quality control

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Tag	Problem identified	Strategy (to change)	Specific actions (how to do it)
A-05	Untreated urban/industrial discharges	Recover WWTP and discharge control	Reactivate/convert WWTP (biogas/energy); before/after monitoring; financial autonomy.
A-06-A-09	Urbanization in recharge and cycle intervention; management without a watershed approach	Recharge protection and basin approach	Implement UE-02/07 and PA-14/15 management plans with infiltration and lamination targets
A-10	Heavy metals in drinking water by deep extraction	Preventive water health	Access to certified reverse osmosis water; health surveillance; risk campaigns
Sociocultural (urban inequality)			
SC-01	Inequality in access (high-income/productive vs popular sectors)	Guarantee the Human Right to Water and territorial equity	PGSAL with a multifactorial approach; domestic prioritization; public distribution monitoring
SC-02	Without a responsible water culture in key sectors	Environmental education with a local focus	Partnerships with federal and/or state Ministries of Education (SE) and higher education institutions (HEIs)—universities, technical schools, teacher training colleges, public and private—to co-design, implement, and evaluate water plan actions; content by level; materials; and community workshops
SC-03	Lack of training for decision-makers	Mandatory continuing education	Programs with an academy; periodic certifications
SC-04	Opacity and low accountability in Operating Organizations	Open governance	Open data portals; quarterly reports; social auditing
SC-05	High water consumption landscaping ("green desert")	Cultural change towards the native-xerophilous	Native species guides; green space conversion; list of non-recommended species
SC-06	Urban/industrial models foreign to the territory	Participatory and prospective planning	10–20-year vision; carrying capacity assessment; water compatibility guidelines

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Tag	Problem identified	Strategy (to change)	Specific actions (how to do it)
Construction infrastructure technology (delay and linearity)			
TIC-01	Underutilization of nature-based solutions (NBS)	Evaluate and scale locally appropriate NBS	Guides, manuals, and catalogs; technical assistance and demonstration pilots
TIC-02	Little cooperation with expert academy	Science-policy collaboration network	State consortium (government-HEI-schools); exchange of best practices (e.g., CICY-Mérida)
TIC-03	Aging/collapsed network with leaks	Renew with asset management	Prioritized replacement; durable materials; multi-year financing
TIC-04	Lack of sectorization and monitoring	DMAs + telemetry as standard	Mandatory in new subdivisions; metropolitan expansion; integration with PA-09/11
TIC-05	Abandoned water infrastructure	State maintenance program	Inventory, criticality, and annual plan; modernization of dams, aqueducts, and wastewater treatment plants
TIC-06	Investments imposed without technical-social consensus	Democratic investment management	Rules for consultation and evidence; public project dashboards; social control of expenditure
TIC-07	Linear and extractive approach (dependence on transfers)	Water balance and circular economy	Multi-criteria assessments; targets for reducing extraction and increasing reuse/infiltration
Economic (water speculation and finance)			
E-01	Inefficient and partisan public spending	Autonomy and budget protection	Operating agencies with operational independence; transparency, oversight, and open accounts
E-02	Indirect subsidies to privileged/polluting sectors	Evidence-based regulation of land and construction	Urban equity policies; incentives/disincentives; correction of market distortions
E-03	Lack of transparency in collecting payments from large consumers	Zero exceptions and full transparency	Elimination of discretion; open audits and reports

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Tag	Problem identified	Strategy (to change)	Specific actions (how to do it)
E-04	Debtor portfolio with no effective collection	Progressive rates and collection management	Block-based tariff structure; payment agreements and penalties; effective metering
E-05	Financial secrecy at Interapas/CEA	Open financial data in real time	Public revenue/expenditure platform; open Application Programming Interface (API); periodic public hearings.
E-06	Underinvestment in maintenance and new infrastructure	Phased investment plan (short-medium-long term)	Prioritization via PGSAL; multi-year portfolio with mixed sources; performance monitoring
E-07	Unclear cost criteria; resource speculation	Transparent cost methodology	Comprehensive costing (production, distribution, treatment); annual publication and review
E-08	Parallel/black markets for water	Effective regulation and sanctions	Withdrawal of concessions for unauthorized uses; surveillance; harmonization with the new General Water Law
E-09	Over-concessioning and monopolization through the transfer of rights	Accumulation limits and periodic audits	Audits and public registries; user caps; reversal of undue accumulations

Taken together, these proposals aim to establish the foundation for an integrated and sustainable water-resource management plan for the MVSLP, adopting humanistic, multidisciplinary, and holistic approaches that enable the incorporation and linkage of various specialized disciplines in the field of water studies. In doing so, they also generate a water-management proposal that evolves from a linear system toward a circular one (Figure 5). This transition is grounded in the principles of the circular economy and draws inspiration from the models proposed by Delgado *et al*. (2021) and Leonard (2010) to ensure sustainable water management in the MVSLP.

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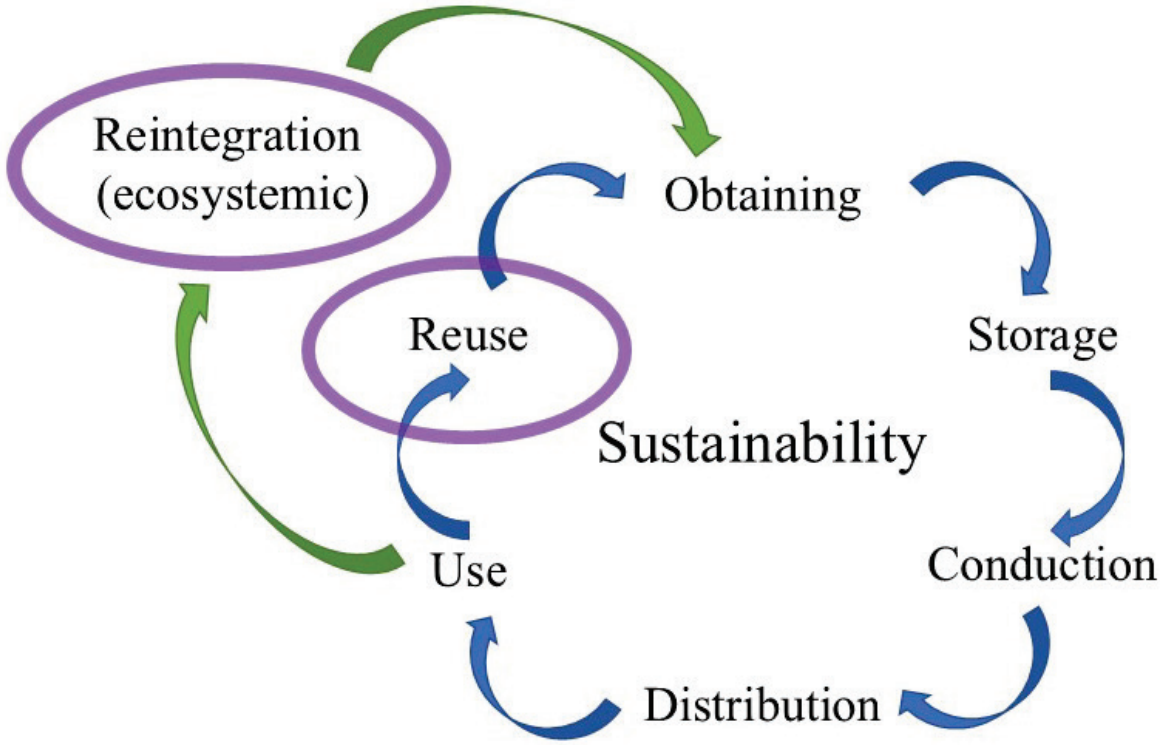

Figure 5. Circular urban water system. Source: Quintero-García (2025).

In this regard, the circular water system formulated for the MVSLP prioritizes the restoration and protection of the region's natural hydrological cycle, including the reduction of aquifer extraction, the remediation of surface and groundwater bodies, and the comprehensive territorial planning of the metropolitan area. These actions, implemented through multifactorial and participatory measures at each stage of the system, constitute an integrated and sustainable proposal for water management.

Unlike the linear system, in which water is excessively wasted and discarded in its final phase—forcing constant, repeated, and permanent

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extraction from supply sources, thereby compromising ecosystem balance and generating the series of conflicts previously identified and discussed—the circular system, formulated through a set of strategies, actions, programs, and projects, focuses on water treatment and reuse. This approach reduces the volume extracted from natural sources, providing time and opportunity for ecosystems to stabilize naturally.

Additionally, in special cases—such as during periods of extreme and prolonged drought—treated water, through specific procedures, can be temporarily reintegrated into ecosystems as a palliative and stabilizing measure against local and regional anthropogenic impacts. In this way, by gradually reducing water extraction, the circular system promotes ecosystem recovery, while correcting and redefining the sociocultural, productive, and management practices related to water and land resources in the region.

Conclusions

The MVSLP faces a structural water crisis of multifactorial and multisectoral nature, whose severity is being intensified by increasingly frequent and extreme drought scenarios resulting from climate change. This crisis manifests in three central dimensions: environmental degradation associated with aquifer depletion and the disruption of the hydrological cycle; inequality in access to the resource, with the greatest impact on vulnerable social sectors; and poor water quality supplied to the population.

The evidence analyzed reveals that state and local governments, rather than promoting sustainable management and addressing the structural causes of the complex water problem in response to socio-

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environmental demands and academic and civic proposals, have instead deepened the crisis through the continuity of a centralized, opaque, unilateral, and permissive model. Among the most critical factors are uncontrolled urbanization, real-estate speculation, the proliferation of irregular water markets, the hoarding of private concessions, the expansion of water-intensive industries in an ecologically fragile territory, and the implementation of inefficient water policies. This framework has led to overexploitation, unequal distribution, environmental deterioration, and high economic costs, consolidating a linear and unsustainable system based on continuous extraction and the underutilization of wastewater.

In this context, it is imperative to transition toward an integrated, sustainable, and equitable management model, grounded in the separation of political and private interests from the management of water and land resources. Such a transition requires recognizing the human right to water, ensuring water justice, and promoting an open governance framework that incorporates citizens—particularly vulnerable sectors—and academia into decision-making through mechanisms of transparency, effective participation, and accountability.

The challenge lies in constructing a Comprehensive and Sustainable Local Water Management Plan with a watershed-based vision, short, medium, and long-term goals, verifiable indicators, and periodic review mechanisms, shielded from electoral cycles. This plan should regulate urban growth according to hydrological criteria; prioritize operational efficiency through sectorization and loss control; modernize treatment and reuse infrastructure; and consolidate a circular water economy to reduce pressure on the aquifer. Furthermore, it must integrate ecological restoration actions, protection of recharge zones, and preparedness for droughts and floods, reinforced through partnerships with educational and

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scientific institutions.

In summary, the hydric future of the MVSLP will depend on the ability of water-management institutions, the private sector, and society as a whole to overcome the inertia of an extractive, market-oriented, and reactive model, and to promote a transition toward a resilient, equitable, and environmentally responsible system. Only through such a transformation will it be possible to ensure the sustainability of the resource, the well-being of the population, and the long-term preservation of ecosystems.

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