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Evaluate and design public policies to address water supply and quality issues in the water crisis in Monterrey and its metropolitan areas

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Abstract: The present article focuses on the evaluation and design of public policies aimed at addressing the issues of water availability and quality in the water crisis affecting Monterrey and its metropolitan area. As water demand has increased due to population growth and urban development, a situation of water scarcity has emerged, posing a threat to water security and the well-being of the region. The implementation of effective public policies on water is crucial to confront this crisis. Through rigorous evaluation of water availability and quality, it becomes possible to identify problem areas and sources of contamination, enabling concrete measures to be taken for mitigation and control. Additionally, appropriate design of public policies promotes water conservation, encourages sustainable water management practices, and establishes governance mechanisms to ensure their implementation. The successful implementation of these public policies entails a range of benefits and utilities. Firstly, it ensures the provision of potable water to the population, meeting their basic needs and improving their quality of life. Moreover, it promotes the conservation of water resources, preventing their overexploitation and ensuring long-term availability. Furthermore, it prevents water pollution, preserving its quality and safeguarding the health of the inhabitants. Encouraging results have been observed as a result of the implementation of effective public policies. There has been a decrease in water scarcity and an improvement in the quality of water available for human consumption and industrial use. Additionally, citizen participation and community engagement in water management have been promoted, strengthening the region's resilience to future water challenges.

Key words: evaluation; design of public policies; water scarcity; water conservation; citizen participation; water resilience

1 Introduction

The water crisis in Monterrey and its metropolitan areas has been a challenge that has affected the region for decades. It is crucial to analyze the historical background that led to this water crisis in order to fully understand this issue and seek effective solutions. Exploring the historical factors that led to water scarcity and low water quality in the region, as well as the measures taken in the past can address this challenge. By understanding the historical trajectory of the water crisis, we can gain a more comprehensive understanding of the current situation and propose sustainable strategies to ensure future water supply.

1.1 Population growth and industrial development

In recent decades, the accelerated population growth and industrial development in Monterrey and its metropolitan areas have led to an increase in demand for water. With the increase of population and the expansion of economic activities, the pressure on water resources has greatly increased. This rapid urbanization and uncontrolled industrial development have led to low water efficiency, overexploitation of underground aquifers, which are key sources of water supply in the region [1].

Fig. 1. The city of Monterrey and its metropolitan areas are experiencing a drought that has never been seen in recent decades. The second largest city in Mexico, with over 5.3 million people living, has been experiencing drought since the beginning of 2022. This drought is now classified as "extreme" and reached its peak that year, with plans to occur again in 2023. (Image source. Website: Getty Images. BBC News World)

1.2 Infrastructure and water management

The lack of appropriate infrastructure for water collection, storage, and distribution is another factor contributing to the Monterrey water crisis. With the increasing demand for water, the water supply system has not expanded at the same speed, resulting in insufficient distribution and supply in certain areas of the region (including more than 47 out of 51 cities nationwide) [6]. Lack of effective water management and proper planning further worsened the situation. In a situation where this is not enough, the National Energy Control Center (CENACE) declared a state of emergency operation on Friday, June 23, in Monterrey, New Leon, due to a power outage of 40 megawatts in temperatures above 45 degrees Celsius [7].

The agency clearly stated that the emergency statement is due to a malfunction of the 73180 Villa technology line in San Diego, which prevents the transfer of this load to the National Transmission Network (RNT) or the General Distribution Network (RGD). The 40 megawatt urban and industrial loads at LDA (Ladrillera), ALN (Allende), and MTN (Montemorelos) substations have been affected. There are a total of 19 cities in the Monterrey freight zone, the vast majority of which are large industrial and business centers, such as Monterrey, Santa Catalina, Apodaca, San Pedro Garza Garcia, San Nicolas de Los Garza, Guadalupe, Cardreta, etc.

Fig. 2. "The Monterrey metropolitan area has declared a state of emergency", said the CANACE in a brief press release. A scenario of blackout protests in the midst of the heat wave suffered by the entire population.

1.3 Climate change and drought

Climate change played an important role in the Monterrey water crisis. Higher temperatures and changing precipitation patterns have led to more frequent and persistent droughts in the region. These extreme weather events have exacerbated water scarcity, making it more difficult for populations and industrial activities to access water.

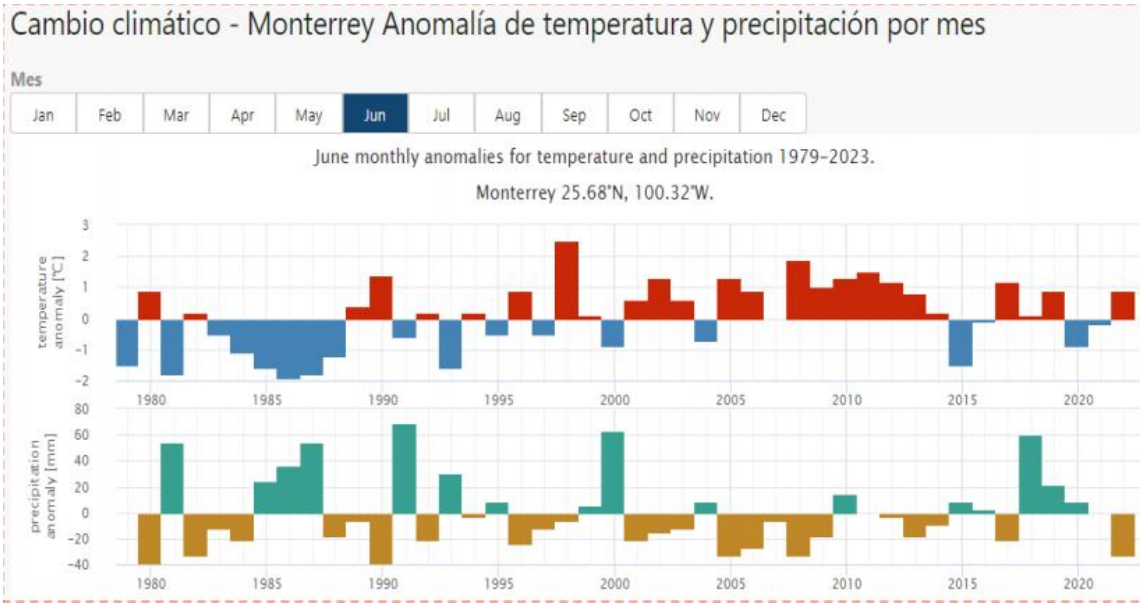

Fig. 3. The focus of this chart is on the specified month, displaying temperature and precipitation anomalies for all months of the year since 1979. Through this method, it can be seen in which years or months they have had the greatest impact, so each month can be displayed whether it is hotter or colder than normal (drier or wetter). Image source. Website: Monterrey Climate Change Meteoblue

1.4 Measures taken in the past

Over the years, various measures have been taken to address the water crisis in Monterrey. Infrastructure projects have been carried out to improve water storage and distribution capabilities, as well as water protection and reuse plans. This may include the construction of new ongoing dams, such as the Libertad Dam, dams, pipeline systems, and more efficient distribution networks. However, due to the complexity and scale of the problem, the effectiveness of these measures was limited. The need for integrated water management, including conservation, efficient use and protection of water sources, has been recognized.

From a historical perspective, the water crisis in Monterrey and its metropolitan areas revealed a series of events that led to the current situation. In recent decades, the Monterrey region and its metropolitan areas have experienced significant population growth and urban development. The increase in population and urbanization has led to an increase in demand for water, which has put considerable pressure on the existing water resources in the region. During the early years of industrial development in Monterrey, economic activities and population growth were not accompanied by adequate water management policies. This led to inefficient use and overexploitation of subway aquifers, which were an important source of water supply in the region [5]. If we take a chronology of the water crisis in Monterrey and its metropolitan area, we start through the years from 1960 to the present.

In 1960 to 1980, during this period, Monterrey and its metropolitan areas experienced rapid population growth and industrial development without adequate water supply planning. Lack of effective policies and regulations led to inefficient

water use and overexploitation of subway aquifers.

In 1990, the Rio Bravo Basin Organization was established to manage and regulate water use in the northern region of Mexico, including Monterrey. Measures began to be implemented to control groundwater extraction and regulate its use. In 1996, the construction began on the Cerro Prieto System, an important infrastructure for Monterrey's water supply. This system includes the Cerro Prieto dam, the Monterrey VI aqueduct (unbuilt and discarded) and the Monterrey Water and Drainage water treatment plant.

In 2004, the National Water Commission (CONAGUA) issued a drought declaration in the state of New Leon, where Monterrey and some metropolitan areas are located. This statement emphasizes the seriousness of water scarcity in the region and the necessity of taking appropriate management measures.

In 2010, *The Monterey Metropolitan Water Plan* was developed with the aim of developing strategies to ensure long-term water supply in the metropolitan area. This plan includes measures to save water, reduce allocation losses, and promote the reuse of treated wastewater.

In 2014, to address the water shortage problem in Monterrey and its metropolitan areas, water supply restrictions have been imposed, including distributing water at certain times and days of the week, as well as campaigns to raise awareness of responsible resource use.

In 2018, a *Comprehensive Water Supply Plan* for the Monterrey metropolitan areas has been proposed, aimed at ensuring long-term water supply. The plan proposes the construction of new infrastructure such as dams and treatment plants by 2022, and the implementation of sustainable water management measures (proposed Monterey VI Aqueduct). The water crisis remains a major challenge for Monterrey and its metropolitan areas, requiring continued measures to address shortages and ensure access to water for the people. Water management is an ongoing process that requires collaboration among various actors and the implementation of public policies and measures that adapt to changing circumstances.

In addition, the lack of appropriate infrastructure to collect, store, and distribute water during rainfall and hurricanes has also contributed to the water crisis. The expansion rate of the water supply system is different from the growth rate of cities, leading to insufficient water supply and distribution problems in certain areas of the region [2]. Another factor affecting the water crisis is climate change mentioned earlier. As temperatures rise and precipitation patterns become more unpredictable, water supply is affected. More frequent and persistent droughts have further exacerbated the water shortage in the region.

2 Methodology

The stages of this methodological research study are based on six proposals of sustainable urban strategic design for the metropolitan areas of Monterrey, with the main goal of avoiding water crises through effective territorial planning, responsible use of resources, sustainable water management, and citizen engagement. These six strategies must be adapted to the specific characteristics and needs of the region, while taking into account the integration of all aspects to achieve fair and sustainable water management in society, economy, and environment [3].

2.1 Land use planning

▪ Promote urban density in developed areas to avoid uncontrolled urban expansion and reduce water demand

▪ Encourage mixed use (residential, commercial, industrial) to minimize travel and improve water efficiency.

2.2 Efficient water use

▪ Develop strict regulations and rules to promote the installation of efficient water use technologies and equipment, such as natural and intelligent irrigation systems, as well as low-energy sanitation equipment.

▪ Implement awareness and education programs to promote responsible water use practices in households, shops, and industry.

▪ Promote the reuse of grey water and rainwater for non-potable purposes such as garden irrigation (SUDS) and public space cleaning.

2.3 Sustainable water management

▪ Implement rainwater collection and treatment systems at the urban level to supplement aquifers and reduce surface runoff.

▪ Develop green infrastructure, such as parks and nature reserves, to promote water infiltration and protect aquatic ecosystems.

▪ Establish surface and groundwater quality monitoring and control plans to ensure their preservation and protection.

2.4 Water infrastructure planning

▪ Design an efficient water supply and distribution system to minimize leakage losses and ensure fair distribution of resources.

▪ Building more modern and efficient wastewater treatment plants (strategically located in the Monterrey metropolitan areas) to ensure safe reuse of industrial and agricultural water.

▪ Establish a water storage infrastructure system, such as wetlands, dams, and reservoirs, to manage shortages appropriately and ensure supply during peak demand periods.

2.5 Public spaces and green spaces

▪ Design and maintain public spaces with sufficient vegetation to reduce water demand (dry gardening) and facilitate rainwater infiltration.

▪ Encourage the establishment of green spaces in cities, such as parks, boulevards, pocket parks, and gardens, to help regulate the climate, improve air quality, and conserve water.

▪ Implement sustainable urban design technologies, such as permeable pavements in public and private parking areas, to allow water infiltration and reduce runoff on urban streets and avenues.

2.6 Citizen participation and governance

▪ Promote community participation in decision-making related to water management through public consultation and dialogue spaces.

▪ Establish a participatory governance mechanism to promote cooperation between the government, civil society, private sector, foundations, trade unions, and academic institutions.

▪ Develop training and civic empowerment programs on issues related to water management and urban sustainability through radio and television media, as well as in courses, diplomas, symposiums, seminars, and workshops.

On this basis, general guidelines are provided for the formulation and implementation of public policies to address the water crisis in Monterrey and its metropolitan areas. Citizen participation and knowledge about municipal and state actors are important.

2.7 Diagnosis and assessment of water conditions

▪ Conduct a comprehensive study on the availability and water quality of the region.

▪ Assess current and projected water demand considering population growth, urban development, and economic activities.

▪ Identify areas of water scarcity and pollution issues.

2.8 Participation of relevant actors

▪ Engage key actors such as government authorities, civil society organizations, academic institutions, and citizens in the design and implementation process of public policies.

▪ Promote citizen participation through public consultation, dialogue tables, and forums.

2.9 Define clear goals and indicators

▪ Set specific and measurable goals to improve water supply and quality in the region.

▪ Determine short-term, medium-term, and long-term goals to gradually address the water crisis.

2.10 Development of strategies and actions

▪ Develop a comprehensive strategy to address water supply and demand.

▪ Implementing water resource conservation actions, such as resource efficiency programs and promoting sustainable technologies

▪ Develop appropriate water infrastructure, such as treatment plants, rainwater collection systems, and efficient distribution networks

▪ Develop education and awareness programs for responsible water use.

2.11 Monitoring and evaluation

▪ Establish a system for continuous monitoring of water supply and quality, as well as the impact of implemented policies

▪ Regularly evaluate progress and achievements, identify areas for improvement, and adjust strategies as needed.

2.12 Inter institutional coordination and cooperation

▪ Promote cooperation between different government entities, academic institutions, civil society organizations, and businesses to manage water in an integrated manner.

▪ Establish effective coordination and communication mechanisms to ensure consistent implementation of public policies.

2.13 Regular evaluation and updates

▪ Regularly evaluate the policies implemented to assess their effectiveness and make necessary adjustments.

▪ Continuously updating technological advancements in water management to incorporate new solutions and methods.

3 Discussion

It is evident that due to population growth and urban development, the demand for water is increasing and has exceeded the supply capacity of the region. In addition, this crisis highlights the interrelationship between the availability and quality of water resources. Pollution from surface and underground sources is a direct consequence of industrial, agricultural, and household activities, which has a negative impact on the drinkability of water and poses a threat to public health. In terms of consequences, the water crisis in Monterrey has had significant impacts in multiple aspects. Firstly, the supply of drinking water is restricted, which affects the satisfaction of people's basic needs and damages their quality of life.

In addition, the lack of clean and safe water increases the risk of water related diseases. Another important consequence is the impact on aquatic ecosystems and biodiversity. Overexploitation of water resources and pollution cause irreversible damage to ecosystems, thereby affecting the provision of environmental services and long-term sustainability.

There is a need to adopt measures and public policies that promote sustainability and efficient water governance. It is essential to establish comprehensive and participatory management to make informed decisions and develop collective solutions that effectively address the crisis. Finally, the water crisis in Monterrey is a complex and multifaceted situation

that requires a comprehensive approach to address both the availability and quality of the resource. It is necessary to implement policies based on the principles of efficiency, sustainability, and citizen participation, and recognize the rules and consequences related to this crisis. Only through responsible and cooperative management can we ensure safe water supply for present and future generations.

4 Conclusion

The crisis in Monterrey and its metropolitan areas stems from a drought that has lasted for more than eight years, increasingly high temperatures (45° C), poor planning by the authorities and excessive use of water by the population, according to experts and officials. The situation forced the state government to declare a state of emergency in the month of February, 2022 and implement harsh measures such as reducing the water supply to only seven hours a day, from 4:00 to 11:00 a.m. and in other regions up to months without this supply. Some governments of metropolitan municipalities have installed large-capacity water tanks in public squares to provide water on a limited basis. Juan Ignacio Barragan, director of Agua y Drenaje de Monterrey - the agency in charge of supplying water for urban consumption in the city - said that the increasingly high temperatures in the region and the scarcity of rainfall have deepened the crisis even today [4].

El Cuchillo, Cerro Prieto and La Boca dams recorded historically low storage with 45%, 2% and 8%, respectively, according to official figures. Barragan said at a conference on June 15, 2022 that the water stored in Cerro Prieto and La Boca was only enough for a few more days of supply. Balagan said that the government is currently working to raise people's awareness and reduce their use of water because consumers have always abused resources. He said that users in Monterrey and metropolitan areas use an average of 160 to 170 liters per person per day, far higher than the World Health Organization's (WHO) recommendation of 100 liters.

In this crisis, state and federal authorities have implemented a program to build dozens of shallow and deep wells to increase water supply sources. In addition, they have announced new infrastructure such as an aqueduct that will increase water supply capacity to supply water to the city from the El Cuchillo dam, the largest in the state. A fourth dam in the municipality of Linares is currently under construction.

Faced with the measures taken by state and federal authorities in response to the Monterrey water crisis, they are a positive step towards alleviating water scarcity in the region and ensuring adequate water supply. The construction of shallow and deep wells will provide additional sources of supply, while announcing new infrastructure such as the El Cuerro dam's aqueduct and the construction of a fourth dam in Linares, demonstrating a commitment to increasing water storage and distribution capacity. These actions are crucial for addressing the current and future challenges related to water supply in Monterrey and its metropolitan areas. By increasing supply sources and improving water infrastructure, the aim is to ensure more reliable supply for the population as well as the industrial and agricultural sectors.

However, it is important to remember that long-term solutions are not limited to infrastructure construction. It is also necessary to address water resource protection issues and promote effective utilization and enhancement of community environmental awareness practices. The comprehensive management of water must include both quantity and quality aspects to ensure adequate supply, ensuring water quality for human consumption, and protecting aquatic ecosystems.

In this regard, a comprehensive and coordinated approach is needed to involve all relevant actors, including civil society, in decision-making and implementing effective public policies. Only comprehensive management based on sustainability and citizen participation can overcome the water crisis in Monterrey and ensure a more prosperous and sustainable future for the region.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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