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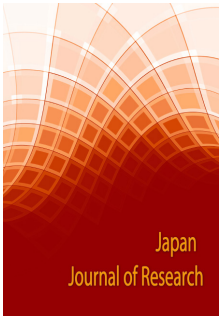

Water Crisis in the Megalopolis of the Center of Mexico. Indigenous and Gender-based Management

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Abstract

This article analyzes misguided hydraulic policies and proposes sustainable human and environmental management by Indigenous people and woman. Since 1950, engineers have pumped water from neighboring states up to 1,100 m into the Megalopolis of Central Mexico (MCM), drilling through mountains and discharging rain and toxic wastewater from an endorheic basin into a nearby arid state. High energy costs, air pollution, sewage flooding in marginal neighborhoods, depletion of rivers, destruction of storage in adjacent states, and overexploitation of aquifers have resulted in increasing water shortages for 32 million inhabitants, poor drinking water quality, and an annual subsidence of 40 cm, affecting infrastructure, buildings, and the metro. These destructive processes began with the Spanish conquest, when they drained lakes in an endorheic basin to gain land for real estates. Today, climate uncertainty, prolonged droughts, higher temperatures, erratic rainfall, flash floods, and flooding in the densely populated MCM basin require alternative water policies. There is hope for sustainable water policies in the hands of newly elected female authorities, involving citizens, Indigenous people, business people and peasants in this semiarid region. Furthermore, climate change obliges the society and the government to promote environmental security with resilience, including territorial planning, the protection of mountain forests surrounding the MCM, local sanitation of wastewater to recharge the groundwater table, and rainwater infiltration to recover overexploited aquifers. The conclusions mention the Indigenous peoples who cared for the forest for thousands of years, until chaotic urbanization and economic interests destroyed nature and created man-made shortages of water. Women are central to water-saving techniques, harvesting rainfall, roofing gardens, and using gray water to irrigate gardens and parks. Within their homes and in public, they have promoted a care economy with a sustainable water culture and ecosystem recovery that allows them to collectively ensure safe water for a growing population over the long term.

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Keywords

Megalopolis of Central Mexico (MCM); water scarcity; hydrological mismanagement; Indigenous protected forest; gendered care economy; climate change resilience.

Introduction, objectives, hypothesis and organization of the research

The aim of this article is to analyze the misguided hydraulic policies in the Megalopolis of Central Mexico (MCM) and to propose alternative hydric management with agreements among the three levels of government, Indigenous people, women's groups, peasants, citizens, and entrepreneurs with sustainable management of the environment that provides safe drinking water to 32 million inhabitants. A destructive process began after the Spanish conquest, when they drained lakes in an endorheic basin to gain land for real estates. From 1950 on, massive migration from the countryside to the city in search of better jobs and public services, as well as water shortages, led the municipal authorities and entrepreneurs to develop a complex hydraulic system. Starting in the 1950s, the Lerma-Cutzamala (L-C) system pumped water from neighboring states up to 1,100 m, drilled through the mountains [1], and expelled rain, domestic, and toxic industrial wastewater from an endorheic basin into a nearby arid region, the Mezquital Valley, in the state of Hidalgo [2].

The hypothesis postulates that with the involvement of Indigenous people, women's groups, female authorities, organized society, and conscientious entrepreneurs, alternatives exist to purify the waters inside of the endorheic basin, recharge the aquifers with water from the high altitude forest surrounding the MCM, capture rainfall, reuse the purified water in gardens or parks, and mitigate the effects of climate change with increasing drought and higher temperatures [3]. Newly elected female authorities are looking for these alternative water supplies and a cheaper and sustainable system. Overexploited aquifers must be recharged. Local sewage systems should treat separately industrial and domestic wastewater through eco-techniques and recharge the phreatic table. Wastewater treatments in situ avoid soil pollution in the Mezquital, evade the toxic sewage floods in marginal colonies and recharge aquifers. Crucial is the infiltration of

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rainfall into the subsoil from the surrounding forests and natural protected areas. The participation of multiple citizen groups in the MCM, led by woman´s organizations and schools, develops water-saving techniques and reuse of clean wastewater.

After this short Introduction, the article starts with a description of the interdisciplinary methodology and the participative research methods. A virtual platform, developed in collaboration with academics, Indigenous communities, peasants, and citizens assesses the natural potential of the infiltration sites and the existing biodiversity of the MCM region. A participatory research method with organized Indigenous people, women's groups, and peasants develops an in-depth understanding of the socioenvironmental complexity of the differences in the region of the MCM. At the same time, these activities support Indigenous forest custodians in the face of threats from organized crime for logging. The cooperation and permanent interactions open opportunities for a sustainable management of their natural resources, and open new opportunities for quality of life to these marginalized people, who care about the water supply for the MCM. Collaboration between scientists and concerned citizens in a Citizen Water Monitoring Committee improves also governmental transparency. It provides authorities with multidisciplinary expertise to deal with complex realities and supports them in creating sustainable alternatives. The third part describes the hydrological destruction of the water supply in the neighboring states, the overexploitation of aquifers, and the sewage devastation in the Mezquital Valley in the state of Hidalgo and the flooding during the monsoon with toxic wastewater of marginal colonies in the MCM. This past destructive hydraulic system of water supply and the irresponsible discharge of mixed industrial water with domestic sewage and rainfall, often flooding marginal neighborhoods with toxic sewage and causing serious health consequences requires a new hidric policy. As Mexico is severely affected by the impacts of climate change given its location in the tropics [4] and between two warming oceans that are causing stronger hurricanes and longer droughts, water scarcity is increasing. Alternatives are discussed for a long-term sustainable water supply and affordable clean sanitation, as well as the preservation of the water forest that surrounds the megacity, which is crucial for atmospheric humidity and torrential rainfall protection. In the conclusion, clean water and safe wastewater are crucial for human and environmental health. Indigenous and woman´s care economy with environmental protection are crucial for the future of nature, humanity, and livelihood in a growing megacity in the Global South [5].

Methodology and Methods

This article is based on documentary data from local, national and international sources on climate change, water scarcity, pollution, overexploitation of aquifers [6] and alternative forestry management. The RIOCCADAPT report [4], a collective work of 120 researchers from Ibero-America, collectively guided by a scientific committee of five members, analyzed risks and adaptation in Latin America, Spain and Portugal. The report shows that Mexico is the most affected country in this region, due to its geology, its location between two warming oceans, the high socio-environmental vulnerability of its population, and chaotic urbanization processes with a high number of marginalized people without formal work conditions and a large number of impoverished Indigenous people.

Approaching the complexity of social and environmental factors in Mexico, including governance, public violence, climate factors [3], investments and urbanization, requires an integration of multiple factors in a transdisciplinary manner [7]. Vulnerability and risks have increased due to different public policies and private investments in the past 7 decades, especially the deforestation of the water forest surrounding the MCM [8], have avoided the application of existing environmental laws [9]. Global conceptual frameworks, such as the Assessment Reports of the IPCC [3], are based on a broad consensus accepted by all member states of the UNFCCC [10]. However, the research of women and Indigenous communities from the Global South [11] is still highly under-represented, especially in the water sector of the Global South [12].

Therefore, the present methodology provides an interdisciplinary approach where a devastating hydrological system with polluting wastewater is first assessed with documentary and historical reviews. Methods include literature review, stakeholder engagement through field research, in-depth interviews, analysis of social interactions, and several complementing diagnosis of existing socio-environmental conditions. Later, imagery studies with satellite starts to understand the potential of the remaining water forest in the mountains surrounding the MCM and the existing biodiversity of this region. Participatory research supported by the Anahuac Biosphere Foundation (FUNBA: Fundación Biósfera del Anahuac, A.C.) has resulted in a petition to the three state authorities signed by 1,183 Indigenous Peoples and peasants from 191 communities belonging to the water forest, asking for the protection of their valuable natural resources and their life threatened by criminal groups. They are actively participating in the development of an Internet platform with researchers from GEO and universities, which will allow them to know and manage better their natural resources and to explore potential commercial uses, early forest fire detection, pest or fungi identification, and illegal logging by organized crime.

The three recently elected authorities of the MCM: Mexico City, the State of Morelos, and the urbanized part of the state of Mexico, including the industrial region of Toluca, received the signature of these Indigenous communities and, together with the rest of civil society, committed to protect the water forest through participatory water management in their states [13]. In addition, the Citizen Water Monitoring Committee of Morelos, Mexico City, and the State of Mexico, together with academic advisors [14], presented to the national authorities in Conagua an interdisciplinary diagnosis of the conditions of water scarcity [1], over-exploitation of aquifers [6], subsidence, collapse of drinking water and drainage pipes, illegal water pumping, and pollution in the MCM [2], including the Mezquital Valley in the State of Hidalgo [15]. Together with other citizen initiatives and some entrepreneurs, these committed communities have explored the restoration of ecosystems and the alternatives of cheap local sewage technologies, gray water reuse, rainwater harvesting, green roofs, and other eco-techniques [16], where women and Indigenous people are crucial participants in these processes.

Results: Hydraulic mismanagement, ecosystem destruction, overexploitation of natural resources, and alternatives

Climate change-related risks have increased in megacities throughout the Global South, where clean water supplies are a major problem, exacerbating inequalities in poor neighborhoods where the intra-family division of patriarchal domestic work has affected women more severely [17]. Water scarcity demonstrates

the impact of the Patriacene [18] on a specific territory [19] by analyzing the case of the Megalopolis of Central Mexico, which includes 16 municipalities of Mexico City, 56 local municipalities of the states of Mexico, some municipalities in the states of Hidalgo, Morelos, part of Tlaxcala, Puebla and Querétaro. It is a densely populated area of 7,180 km^2, of which 2,884 km^2 are urbanized and another 4,296 km2 are covered by forests [1], national protected areas and cultivated lands (Figure 1).

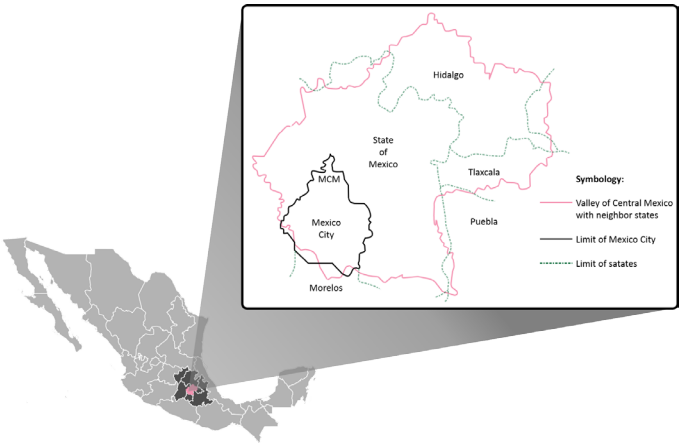

Figure 1. *Megalopolis of Center Mexico (drafted by the author with population updated to 2024)*

The MCM has grown since 1950 with rural-urban migration due to better opportunities for employment and services. In the last 20 years, the growth rate has been 79%, and estimates for the 2020 census a population of 29 million [20] and in 2024 32 million inhabitants. This region is the result of recent volcanic eruptions and has a good permeability of precipitation to the subsoil. One hundred years ago, this region was largely covered by high altitude forests, mainly pine-oak, and the water table was at ground level. These ecosystems, now damaged by illegal logging in the hands of organized crime and chaotic urbanization, surround the MCM with high biodiversity [8]. They have traditionally supplied water to the inhabitants and to Nature, thanks to numerous lakes, ponds and wetlands fed by rivers and streams masterfully managed by the Indigenous authorities of Tenochtitlán before the Spanish arrival [21].

After the conquest, the hydric story of the MCM's destruction began when Tenochtitlán had 1,100 km^2 of lakes and no natural outlets. The Spanish's poor water management caused frequent flooding, waterborne disease, and limited urban expansion [21]. Flooding and a growing population forced first colonial and then Mexican authorities to remove rain and sewage from the endorheic basin. In 1781, the Spaniards built the Nochistongo pit on the lake of Texcoco, drained several lakes, and distributed the land for real estate. As the population increased, so did the demand for water, and hydraulic engineers first extracted water from the neighboring agricultural areas of the Lerma, in the state of Mexico, with multiple water conflicts and protests in the state of Mexico [22].

Confronted with greater demand and opposition, since the 1950s, a complex engineering system was built in three phases. It includes 72.5 km of canals, 44 km of tunnels and six siphons to the Colorines dam. It was called Lerma-Cutzamala, providing 19 m^3/s to Mexico City and the capital Toluca of the state of Mexico. This expensive and environmental destructive public work, damaged ecosystems in the states of Michoacán and Mexico [19], polluted the air by pumping water from wells, and substantial costs [23]. The system was planned for water supply for a century, but from 2023 the stream was reduced by 1 m3/s, despite the drilling of deeper wells in the Lerma Valley and 976 deep wells in Mexico City. The drought in 2024 obliged to reduce further the supply and inhabitants in marginal colonies were without water during weeks [24]. The MCM continues to discharge industrial and domestic sewage combined with rainwater out of the endorheic valley. In the east the dirty water was sent through a 62 km-long open-air canal of 7 m of diameter that dumps the stinking water into the Salado River [2], which joins the Tula River (Figure 2). Heavy rains, lack of maintenance, subsidence, and earthquakes have caused the canal to collapse, and the MCM's popular colonies have frequently been flooded with toxic wastewater, causing serious illnesses among the population. This violent and destructive engineering vision was complemented by the Western and Central Emitters, where tunnels contained the bad smells for Mexico City. This mixed sewage is treated in the largest wastewater treatment

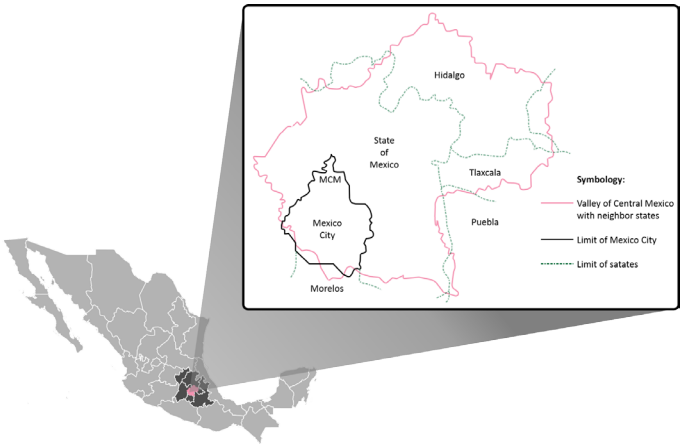

Figure 2. *Drainage system in the MCM (2: 28; adapted by the author and with permission for publication).*

plant in Latin America in the state of Hidalgo, depriving the MCM and its aquifers from potential clean recharge.

This discharge of 32 to 45 m^3/s of hazardous wastewater from an endorheic basin and a subsoil previously covered by lakes has caused an annual subsidence of 10 to 40 cm, which has damaged urban infrastructure (subway, drains, drinking water pipes, drainage, avenues, streets, airport, etc.) and housing. Climate change was and additional factor of water scarcity, when 76% of the country suffered from an exceptional drought [24] related to a severe El Niño Year, affecting also the center of Mexico. After four months of high temperatures and lack of rainfall, the authorities had to ration the water supply. The reduction of the water led to multiple conflicts, and gender violence was unleashed when the distributors of free water pipes delivered the liquid only in exchange for sexual services to women desperate for water.

The hydric imbalance between the supply of 24% from the Lerma-Cutzamala system (approximately 15 m^3/s depending on the dry season and monsoon) and 76% extracted from the aquifer through 976 deep wells in Mexico City, has overexploited the

aquifers and destroyed ecosystems and dams in neighboring states [25]. The discharge of wastewater and precipitation varies between 32 and 50 m^3/s depending on the monsoon, creating a severe imbalance in water availability for a growing population in the MCM [1]. Severe climate impacts, high energy costs [23], air pollution from pumping, sewer flooding in marginal neighborhoods, depletion of rivers, destruction of reservoirs in surrounding states, ecosystem deterioration, and over-exploitation of aquifers have led to increased water scarcity, poor potable water quality, and severe land subsidence, where micro-earthquakes have frightened residents in the fragile subsoil of former lakes.

The hypothesis postulates that the present water supply system and displacement in the MCM are not sustainable. The newly elected female president is a scientist trained in climate change, and the three women elected in Mexico City, the states of Morelos and Mexico are aware that the surrounding water forest produces an evaporation of 166 m^3/s during the monsoon and a permanent supply of clean water [8]. However, organized crime is cutting down this forest and promoting real estates in this key infiltration regions. Further, the majority of this forest is managed by Indigenous people who live in precarious socio-economic conditions and whose rights are often violated, while communal (traditional indigenous rights) or ejidal rights (land given to peasants after the Revolution of 1910) are not legally enforced by the government and are often used by criminal actors to dispossess them of their land. Therefore, a platform with legal knowledge can help to protect collective land rights.

Jaramillo [8], based on updated statistics by satellite images, found that five rivers and 23 river sub-basins depend on the water forest, of which the Moctezuma River gets 42.88%, the Amacuzac 34.25% and Lerma-Toluca 22.44% of its water from the water forest. Very significant is the Ajusco-Chichinautzin Natural Protected Area producing 99.72% of the water for Mexico City and Morelos. The Nevado of Toluca provides 13.96% for the industries and the City of Toluca, while the volcanoes of the Sierra Nevada 9.79% to the east of Mexico City. Zhen et al. [26] calculated from a 25-year observation that forests provide eight times more water than all the rivers on Earth. Therefore, it is essential to protect the remaining 807,000 hectares of water forest, where 58% are natural protected reserves and 19 are biological and hydrological areas. In the medium term, scientists and communities propose a common biosphere among the three entities, managed by one authority, where environmental managed units, called UMAs, could improve livelihood for Indigenous people and farmers through a sustainable commercialization of wild flora and fauna, while protecting the water forest [27].

A second crucial point is the separation of industrial wastewater, domestic sewage and rainwater. Industries should clean up their toxic waste, while domestic sewage can be managed with bio-digesters or other cheap treatment plants. This treated water should be returned to the soil, similar to rain and forest water, to replenish the overexploited aquifers, limit land subsidence, and the destruction of urban infrastructure. Any kind of clean water should be preserved within the endorheic basin. Women's groups, community organizations, and conscientious entrepreneurs can support the collection of rainwater, create green roofs, and reuse clean water in gardens or parks. Increased humidity and green spaces in the MCM mitigate the effects of rising temperatures and increasing drought. The newly elected female authorities are seeking sustainable hydric alternatives to supply water, recovering over-exploited aquifers, enhancing local sewage systems, and increasing rainwater infiltration into the ground through eco-techniques and citizen participation in the MCM.

Conclusions

CXPA is a rare disease posing challenges to diagnose clinically and pathologically. T stage, lymph node involvement and extent of invasion are important prognostic features. Surgery is the prime modality of treatment for CXPA and radiotherapy can be used in patients with advanced disease or in patients with factors determining poor prognosis.

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