Mexico City's Rainwater Harvesting Program (Cosecha de Lluvia)

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Keywords	Water scarcity, water insecurity, blue insfrastructure, Mexico City
City Population	9,209,944
City Area	1485 km^2
City GDP	176.6 billion USD
Climate Zone	Cwb (subtropical highland)
ARC3.3 Linkage	Nature-based Solutions Element

Introduction. Climate change has altered the temperature and precipitation patterns affecting Mexico City's aquifer recharge rate, as well as the Lerma and Cutzamala watersheds, the three main sources providing water for Mexico City. It is expected that long-term changes in temperature and precipitation will result in a significant decrease in freshwater availability. These shortages will affect water access for the most vulnerable people, who have already experienced water insecurity for decades due to inefficient water public services and inadequate infrastructure, as well as pre-existing social, economic and gender inequalities.

To address this problem, beyond implementing traditional infrastructure solutions, which are time and resource-intensive, Mexico City's government has implemented a program since 2019 aimed at increasing water access through rainwater harvesting at the household level. The Rainwater Harvesting (RWH) Program or Cosecha de Lluvia is oriented to benefit the most vulnerable population in the city in terms of both water scarcity and marginalization. From 2019 to 2021, more than 30 thousand systems have been installed benefiting more than 150 thousand people from the implementation of such "blue infrastructure" by increasing water access. The program is expected to benefit at least another 150 thousand people in the next three years, making it the largest rainwater harvesting program globally in an urban context.

Mexico City metropolitan area's general demographics. Mexico City's metropolitan area, integrated by 76 municipalities of Mexico City, the State of Mexico and Hidalgo, comprises one of the largest urban systems in the world, with an estimated population of 21.3 million inhabitants (9.2 million for just Mexico City) spread in 7,866 km^2. By the year 2030, it is estimated that the metropolitan area's population will grow to 30 million people posing an enormous challenge in access to resources, including water (PNUMA, 2021). Water demand is expected to grow in the city along with increased temperatures and changes in precipitation patterns due to climate change, all of which will affect water security.

Water sources for Mexico City. Mexico City's access to potable water relies on three main sources:

1. The aquifer of the Mexico City metropolitan area, which is the main water source, providing 72% of the water supply (Mazari-Hiriart et al., 2019).

2. The Lerma watershed in the neighboring State of Mexico, supplying water to the City through a system of pumps and pipelines (Tellman et al., 2018).

3. The Cutzamala system, a 127 km pipeline spanning an elevation difference of more than 1,200m built to import water collected in dams located in the Cutzamala River basin (Martinez et al., 2015). Built in the second half of the 20th century, the overall Cutzamala-Lerma system now supplies 28% of Mexico City's potable water (Torres-Bernardino, 2017). Hence, potable water sources have evolved from the main dependence on local sources (wells, springs, and rivers) in 1950, to a mixture of both local and external sources (Romero-Lankao, 2010).

This dependence on external water sources has made Mexico City particularly vulnerable to larger magnitudes in drought events in the Basin of Mexico. For instance, a drought in 2008 that affected the Cutzamala Basin led to water shortages in 11 boroughs of Mexico City (Martinez et al., 2015). Moreover, according to the National Commission on Water (CONAGUA) during April 2021, the main dams from the Cutzamala water system that supply Mexico City and the State of Mexico were at their lowest level in 25 years due to extreme droughts (Santos Téllez et al., 2021).

Vulnerable population. Despite enormous efforts to build and maintain public infrastructure to import water to the city, 32% of the resident population (i.e., around 2,800,000 inhabitants) do not have access to enough water to meet their basic needs, and 18% of the city's population is already experiencing water shortages (Martinez et al., 2015). These households bear higher costs for water access and are more vulnerable to water insecurity, partially induced by climate change. Additionally, the effects of water insecurity are unequally distributed among households and households' members. Of particular interest are the effects that water insecurity has on women and girls, since they are often responsible for providing water to their households due to traditional gender norms (Duflo, 2012). These households cope with unreliable and infrequent water deliveries through diverse strategies such as water rationing and private provision (most of the time of informal kind). However, climate hazards have the potential to exacerbate water stress, leading to even higher costs in terms of time, labor, health, and income for these households, likely resulting in greater poverty and reduced resilience (Devoto et al., 2012; Eakin et al., 2016).

Cosecha de lluvia. Since 2019, Mexico City's government has implemented he Rainwater Harvesting Program to install rainwater harvesting systems at the household level in the neighborhoods experiencing the most severe levels of water scarcity and socio-economic marginalization. To date, over 30,000 rainwater harvesting systems have been successfully installed in half of the municipalities of Mexico City (Iztapalapa, Tláhuac, Xochimilco, Tlalpan, Magdalena Contreras, Coyoacán, Azcapotzalco, and Gustavo A. Madero; see map on following page), with a goal to install at least 10,000 additional systems by the end of 2022. The program has directly benefited more than 150,000 inhabitants, with some of the main benefits being:

i) an average monthly harvest of 1,852 liters per household during the rainy season;

ii) a more gender-equal distribution of water procurement tasks within beneficiary households; and

iii) a generalized improvement in welfare for beneficiary households, product of an increase in available free time and a reduction in water-related expenses.

Beyond being successful from a technological standpoint, this solution has proved that there are alternatives to centralized infrastructure solutions for bringing sustainable water-access to vulnerable people in urban settings while contributing to reduce GHG emissions related to energy use in the current centralized system (a reduction estimated in the range of 0.55 – 0.64 kg of CO_2e daily or a total of 2,475 – 2,880 tons of CO_2e for all 30,000 systems [assuming a harvesting potential of 150 days per year]).

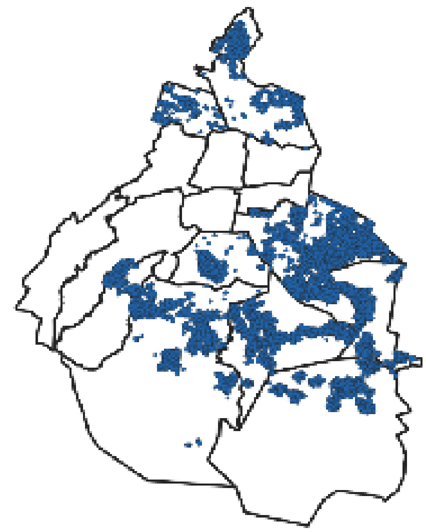

Figure 1. *Rainwater harvesting systems successfully installed in Mexico City municipalities*

Some of the key lessons learned from the implementation of this program during the last years were that it is needed: a) to strengthen the beneficiaries' capacities to maintain the rainwater harvesting systems to ensure their efficiency and the quality of the water captured; b) to continue enhancing the gender perspective of the program given that current efforts have shown the potential to reduce the gender gap in water security; and, in order to scale this solution beyond the program's reach, c) designing and implementing novel financial mechanisms that allow the acquisition of these systems to a wider population.

Innovation and challenges. To build a more accurate diagnosis, one of the main challenges the program has faced has been the limited data regarding water scarcity at the local level. Therefore, a comprehensive survey collection strategy was implemented to have data on the conditions of prospective beneficiary households and to better understand how water scarcity affects them economically and socially. In parallel to this, the program has continuously utilized data from other local institutions, allowing for more accurate indicators of water needs. Using data from the Water Network System (SACMEX; www.sacmex.cdmx.gob.mx) and the Unified Citizen Service System (SUAC; adip.cdmx.gob.mx), a water scarcity index was developed that allows the program to target those suburbs which are most in need of assistance, through an account of the water levels supplied through the water network, the demand for private provision of water, and by considering their belonging to the City's water rationing program. Additionally, throughout 2021, a set of water meters was installed in geographically distributed households to more accurately measure the levels of water harvested with installed systems. Through these efforts, the program has successfully upgraded the available information needed to improve its implementation and has allowed it to produce better internal evaluations of results, which are publicly available and contribute to the general knowledge of ecotechnologies use and effects (Ministry of the Environment, 2019; Ministry of the Environment, 2020).

This is a key aspect for ecotechnologies at the household level to succeed as an adaptation solution (Hanna et al., 2016). To address this challenge, every year the program has trained beneficiary households in the correct use and maintenance to ensure water quality, emphasizing chlorination. Furthermore, additional instruments were introduced when interacting with households to improve the involvement of all members of the household, irrespective of their gender, in the use and maintenance of the systems. For example, an emphasis on task distribution was implemented in household training sessions. Additionally, households were provided with a table to write down the task allocation among home members. These initiatives are part of the program's gender mainstreaming aimed at achieving equitable distribution of responsibilities in the maintenance of the systems. Through the implementation of key findings in behavioral science, these efforts have resulted in ever-increasing levels of system adoption every year. Additionally, these efforts have particularly benefited women since, as mentioned above, they are usually the ones responsible for water provision. By distributing maintenance and providing more accessible water access, the program has observed an increase in available time for other activities for all members of the household, especially for women, with an average weekly reduction from 4.6 hours to 3.8 hours spent on water-procurement activities.

Lastly, in terms of scaling up, in 2020, the program started exploring the possibility of expanding to less marginalized neighborhoods through a partial subsidy scheme - 50% subsidy in the neighborhoods with lower levels of marginalization. In 2022, the program will start implementing the same level of 50% subsidy in target neighborhoods with the added accessibility of allowing the payments to be made in three installments. This added ease in the number of payments is expected to increase demand for the systems for target households that experience water scarcity and are not part of the program's target population at a 100% subsidy due to lower levels of marginalization. In addition, one limitation Mexico City faces is the design of water access policies that can reach populations currently inhabiting informally occupied lands. Due to responsibilities to provide services to these vulnerable populations, on the one hand, while simultaneously having to protect conservation areas, on the other, this is a challenge and potential reach that Mexico City's government faces for the coming years.

Mexico City's Rainwater Harvesting Program has been one of the first in the world to successfully implement such a solution for water access in an urban setting on such a large scale, particularly in the context of the ever-increasing challenges that the climate crisis poses. The program has the potential to continue to scale and be replicated in other cities worldwide.

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Additional Data

- **Population Density:** 6,201 people/km^2
- **Gross National Income (GNI):** 11,980 USD (Higher-Middle Income)
- **Gini Coefficient:** 43.5
- **Human Development Index (HDI):** 0.781 (High)
- **Type of Climate Intervention:** Adaptation
