Scalar mismatches in metropolitan water governance
A comparative study of São Paulo and Mexico City
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8. THE IMPLEMENTATION OF UWM IN MEXICO CITY

8.1 INTRODUCTION

This chapter examines how different drivers and institutions at multiple levels of the urban water governance regime shape water-related challenges in the Metropolitan Valley of Mexico City (MVMC). It uncovers the causal chains behind these water challenges and the effectiveness of existing policy instruments. It reviews the relevant historical and geographical context of Mexican urban water governance and its main drivers (see 8.2). It analyses the driving forces on the city from local to global level. Section 8.3 then explores which formal actors and institutions shape Urban Water Management (UWM) in the MVMC. Section 8.4 analyses the instruments of UWM according to their stated mandates, their effect on actors’ behaviour and their impacts on inclusive and sustainable water governance. Finally, the chapter summarizes the main empirical findings and considers how more appropriate instruments could be (re)designed for the Mexico City case study in relation to UWM (see 8.5).

8.2 CONTEXT AND DRIVERS OF MEXICO CITY’S URBAN WATER CHALLENGES

8.2.1 CONTEXT IN RELATION TO THE METROPOLITAN REGION

Mexico City was founded by the Spaniards in 1521 on top of the ruins of Tenochtitlán, which had approximately 70,000 inhabitants at the time of the Spanish conquest (Escamilla and Santos, 2012). As the capital expanded, it formed the Metropolitan Valley of Mexico City (MVMC), which includes Mexico City and 60 municipalities located primarily in Mexico State, but also in the states of Hidalgo and Tlaxcala (Spring, 2011). Mexico City itself is a federal entity, composed of 16 districts that are similar to municipalities.

8.2.2 MAIN DRIVERS OF MEXICO CITY’S URBAN WATER CHALLENGES

Urbanization

The MVMC grew rapidly during the 20th century, especially after 1950, through urban-rural migration. By 2010 it contained a fifth of Mexico’s population, with 20 million inhabitants (INEGI, 2014). While Mexico City’s growth rate has declined since 1990, it increased in the surrounding municipalities, intensifying pressure on water resources through increased water use (Spring, 2011; Escamilla and Santos, 2012). Moreover, the city could no longer absorb all the newcomers into the labour market, leading to high levels of unemployment and underemployment, and the spread of informal settlements in peri-urban localities (Romero Lankao, 2010; Spring, 2015). The speed of urbanization, the lack of planning and local

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76 Population estimates for Tenochtitlán vary from 50,000 to 175,000 and even 300,000 inhabitants (Evans, 2013; Matos Moctezuma, 1988; Hardoy, 1964; Vaillant, 1941). Recent estimates are more conservative.

77 The MVMC has one of the world’s largest informal settlements, Neza-Chalco-Itza, with around 4 million inhabitants.
governments’ weak financial and institutional capacities led to neighbourhoods constructed without basic infrastructure (World Bank, 2013).

Climate

The MVMC is likely to experience the greatest impacts of climate change in Mexico due to ecological degradation and population density (Sosa-Rodriguez, 2014). Temperatures have increased by almost 4°C due to the heat-island effect and climate variability and change (Sosa-Rodriguez, 2014). Current models predict an increase in the mean temperature by 2 to 4°C and a decrease in mean precipitation of up to 20% by 2080, which could further disrupt Mexico City’s aquifers (Sosa-Rodriguez, 2014). The metropolis is highly vulnerable to floods due to soil subsidence and its location within an endorheic basin (Spring, 2011)\(^78\).

Economic development

National economic policies since the 1980’s have transformed Mexico City into a hub of financial and service activities, stimulating, along with the increasing lack of economic prospects in rural areas, population flows to the capital (Romero Lankao, 2010). The Mexican capital has the largest concentration of wealth in Mexico, generating a third of the national GDP (Romero Lankao, 2010). Poverty and socio-economic inequalities across the country continues to foster migration to the MVMC.

Table 8.1 Multi-level drivers of water-related challenges on the city

<table>
<thead>
<tr>
<th>Direct</th>
<th>Indirect</th>
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</thead>
<tbody>
<tr>
<td>Local</td>
<td>Regional/global</td>
</tr>
<tr>
<td>Urbanization</td>
<td>Urban growth</td>
</tr>
<tr>
<td>Informal expansion at MVMC’s margins</td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td>Economic centre of the country</td>
</tr>
<tr>
<td>Climate</td>
<td>Heavy Summer rains</td>
</tr>
</tbody>
</table>

Source: Author

\(^78\) Soil subsidence has inverted the land slope, so expelling wastewater requires more engineering and energy and represents a greater flood risk (Martínez and Enciso, 2015).
8.3 THE INSTITUTIONAL FRAMEWORK FOR UWM IN MEXICO CITY

8.3.1 GLOBAL LEVEL

International institutions in the MVMC influence UWM by setting standards and providing financing. For instance, in 2010, the World Bank approved a USD 450 million loan to support the development of climate change adaptation policies for the Mexican water sector (Score, 2010). The IDB also provides funding to the water sector, for instance by supporting water operators (IDB website). However, as Mexico continues to develop, the role of development partners in financing the Mexican water sector is expected to diminish (OECD, 2013).

Furthermore, the Millennium Development Goals (MDGs) (UN, 2000) targets for Wat&San have influenced water policies in Mexico. By 2010, the supply of previously disinfected piped drinkable water in Mexico reached 90.9% of the population, slightly above the 2015 target of 89.2% set by the MDGs (UN, 2013). Access to sewerage reached 87.7% in 2010, above the 79.3% target defined for 2015. However, data about access to piped water also includes households that have a tap but do not receive water every day (Martínez and Enciso, 2015).

8.3.2 NATIONAL LEVEL

During the 20th century, Wat&San functions were gradually transferred to states and municipalities. However, Wat&San has no overarching legal framework at national level, which has hindered efforts to expand these services (OECD, 2013). This vacuum was brought to light in 2012, when Wat&San services were recognized as a human right within the Constitution (OECD, 2013)79. This Constitutional reform required the publication of a new NWL that guaranteed this right across the three levels of government. However, as of May 2019 no new bill had been approved. In March 2014, CONAGUA sent a bill to Congress but the text was met with strong rebuttal and was removed from the parliamentary agenda by March 2015 (Godoy, 2015)80.

Despite the transfer of UWM responsibilities to lower levels, CONAGUA intervenes within the MVMC through its management of deep drainage infrastructure and the canal that discharges wastewater to the Tula Basin (Spring, 2011) (see 8.4.3). The SEMARNAT, CONAGUA, the Ministry of Health and the Ministry of Economy have issued standards relevant to UWM, such as permissible limits of pollutants in wastewater discharges, guidance on how to evaluate tariffs for water services and quality standards for drinking water (CONAGUA, 2018).

79 Article 4 states that: “Every person has the right to water access, disposal and sanitation for personal and domestic consumption in a sufficient, clean, acceptable and affordable manner”.

80 A coalition of CSOs and academics argued that the bill commodified water resources, banned water quality research and favoured the diversion of river flows and dam construction (Godoy, 2015). Members of the ruling coalition retorted that public investment was insufficient to respond to water demand and only the private sector could fill this gap (Adler, 2015).
The General Law for Climate Change was adopted in 2012 and led to the creation of the National System for Climate Change (Mexico (Cámara de Diputados), 2012). CONAGUA states that water-related climate change adaptation and prevention measures that diminish the vulnerability of the population are a priority (CONAGUA 2016a). This is exemplified by the inclusion of these concerns and measures in various federal programmes, including the Special Programme for Climate Change (2014-2018). These programmes focus on mitigation, and adaptation-related measures at national level are mostly limited to monitoring and forecasting of extreme weather events (Interviews-M6/M7/M12). In addition, although a number of laws have been established, implementation in practice has been slower, especially at lower levels of government, in part due to a lack of stable funding sources (Interviews-M6/M7/M15/M46).

8.3.3 **STATE LEVEL**

The lack of an overarching framework for Wat&San services means that the role of state governments varies significantly. State governments are responsible for planning, regulating and developing infrastructure for water resources. State congresses approve tariffs and are involved in approving state water plans and allocating financial resources for water infrastructure (OECD, 2013). Municipalities can choose to delegate Wat&San services to the State Water Commissions. Besides sometimes acting as Wat&San operators, the latter may be responsible for standard setting, monitoring service provision, improving efficiency and promoting public participation, but they often lack capacity to adequate regulate Wat&San services (OECD, 2013). Within the MVMC, the state water commissions also coordinate with the basin agency and the civil defence and firefighters in case of flood risks (Interview-M19). However, information sharing between these commissions, basin institutions and academics could be improved through the integration of water information systems (OECD, 2013). Overall, state governments have few mandates in relation to water, creating a gap between the federal government and the almost 2500 municipalities (Interviews-M4/M15).

Mexico City’s water commission is the SACMEX (Water System of Mexico City) and operates as a water utility. It also operates several large wells within the city and the Lerma System (see 7.4.1). It is a deconcentrated entity of the SEDEMA and has limited technical, budgetary and decision-making autonomy (Interview-M20). Mexico State’s Water Commission (CAEM) manages large volumes of water (e.g. water abstraction from the Lerma-Cutzamala systems)\(^81\), treats wastewater and provides Wat&San services in some municipalities. The limited mandates of states and state water commissions in UWM leads to fragmentation in the MVMC as the metropolis spreads over several states.

8.3.4 **METROPOLITAN LEVEL**

The Federal Constitution states that municipalities within a metropolitan area must coordinate their actions (Mexican Constitution, 1917, sec. Art. 122). It establishes a normative framework that enables the creation of metropolitan committees with representatives from municipalities,

\(^81\) It provides bulk water to 16 municipalities of the MVMC.
the Mexico City and Mexico State governments, and sectoral entities. Several committees have been created in the MVMC, such as the Metropolitan Committee for Water and Drainage (CADAM) (1994), Metropolitan Committee for Human Settlements (1995) and Metropolitan Committee for Civil Defence (2000). The Environmental Commission of the Megalopolis, created in 2013 to replace the Metropolitan Environmental Committee (1996), focuses on air pollution in the MVMC (Interviews-M14/M15/M16/M17/M48/M57). There is no policy for conservation at metropolitan or regional scale.

Nevertheless, most metropolitan commissions did not coordinate in terms of shared planning and decision-making (Interviews-M9/M14/M46). Metropolitan-level coordination was mainly limited to day-to-day technical operation of large-scale infrastructure, as the hydraulic systems were completely interconnected (Interview-M14). This type of coordination was more effective when governments at multiple levels are from the same political party (Interview-M6/M7). The financing of metropolitan-scale infrastructure is carried out through the Metropolitan Fund, formed from federal funds to finance not only hydraulic infrastructure but also roads and transportation in Mexico’s metropolitan regions (SAF, 2019) (Interview-M15). Municipalities are not directly involved, and there is no long-term, strategic regional vision for water supply management (Interview-M14).

Metropolitan coordination was a divisive topic, with respondents defending decentralization to local levels, while others argued that metropolitan management was necessary to address shared water-related challenges (Interviews-M9/M17/M19/M40/M52). Coordination is also particularly challenging in the MVMC, as it involves three different federal entities (Mexico City, Mexico State and Hidalgo State). Party politics reinforced the fragmentation as they created tensions between levels of government and between state, municipalities and districts across the MVMC (Interviews-M5/M9/M14/M15/M17/M33/M47/M49/M54). Metropolitan entities did not coordinate with basin entities (Interview-M48).

**8.3.5 LOCAL LEVEL**

Democratization reforms allocated numerous UWM responsibilities to local governments. The Constitution gives municipalities the mandate to provide water services (Mexican Constitution, 1917, sec. 115). This includes drinking water supply, drainage, sewage collection, treatment and disposal. Drainage, stormwater and solid waste management are also municipal responsibilities (SEMARNAT, 2003). State laws specify the form in which these services will be provided. Municipalities are responsible for developing a municipal water policy.

Across Mexico, the provision of these services is highly heterogeneous due to the lack of an overarching regulatory framework and the lack of financial and human capacity in most municipalities, which depend on federal and state funds (OECD, 2013) (Interviews-M4/M6/M7/M15/M17/M33). Municipalities can delegate Wat&San services to the state or a private company. Within the MVMC, Mexico City has one public water utility, the SACMEX, for its sixteen districts (although it outsources many activities to third parties), some municipalities of Mexico and Hidalgo States delegate this service to their respective state water commissions and others have their own utility, causing a coordination challenge at regional
level (Interviews-M2/M6/M7/M28). Some regions created inter-municipal Wat&San utilities\textsuperscript{82}.

Water utilities cannot provide regular services in informal settlements, as their legal status prohibits the installation of basic infrastructure. Consequently, these areas are supplied through water trucks or alternative systems (e.g. rainwater harvesting) (Interviews-M24/M26/M49). NGOs and companies fill this gap by developing rainwater harvesting and wastewater recycling initiatives and selling water filtering or water saving equipment. However, despite the deficit in Wat&San services across the metropolis, these organizations claimed to receive little support from local or higher-level authorities (Interviews-M41/M42/M49).

The municipal civil defence addresses water-related risks through monitoring, implementing security measures and elaborating civil defence programmes (SEGOB, 2014). The Municipal Civil Protection Programme outlines goals, strategies and actions, and the necessary resources to implement this, and is based on a risk diagnosis (SEGOB, 2014). It requires municipalities to develop a Risk Atlas that identifies the type and severity of local risks (SEGOB, 2014). Municipalities are also expected to develop, implement and evaluate a municipal climate change policy framework and instruments in accordance with the national and state climate change frameworks (Mexico, 2012).

Municipalities are also responsible for land use management and zoning, and can create ecological reserves within their territory (Mexico, 2009). However, due to its special status as the nation’s capital, Mexico City’s central government is responsible for the planning of the whole territory, delegating certain implementation tasks to its districts (Connolly and Wigle, 2017). Mexico City’s districts coordinate certain actions (e.g. on environmentally protected areas, through the SEDEMA), but coordination is absent between districts and the surrounding municipalities (Interview-M26). Water and other urban policies also lack continuity as municipal and district administrations change every three years (Interviews-M14/M17/M21/M55). Moreover, officials are often political appointees rather than professionals, as there is no professionalization of the careers within these departments (Interviews-M17/M55/M57).

\textsuperscript{82} One challenge for this form of water provision is that, when municipalities have wells, they often consider themselves owners of the water resources and are reluctant to share these (Interview-M4).
8.4 INSTRUMENT ANALYSIS

8.4.1 WATER TARIFFS

Design

With no overarching legal or policy framework for Wat&San, utilities largely defined their own objectives. However, the Constitution defined Wat&San as a human right, implying that all utilities should universalize these services within their jurisdiction. Broadly, utilities in the MVMC, such as SACMEX, CAEM and municipal utilities, established goals such as the provision of clean and accessible drinking water, including to marginalized communities that comply with land tenure laws, and tariff systems that allow for autonomy and financial self-
sufficiency, and that incentivize rational water use (CAEM, no date; SEDEMA, 2012; ODAPAS, 2016). Residents in informal settlements are therefore excluded from such services.

Multiple factors fostered wide inter-municipal disparities in Wat&San tariffs: The absence of a national framework, highly unequal distribution of water resources across Mexico, different levels of costs, and differences in cost-recovery efforts (OECD, 2013; CONAGUA, 2018). However, even within regions there were stark disparities. In Region XIII, water tariffs, set by different utilities, range from USD 0.95/m³ (in Pachuca de Soto, Hidalgo State) to USD 0.28/m³ in several municipalities of Mexico State (Hernández, 2014). A price variability analysis revealed that municipalities with similar water availability sometimes had significant disparities in tariffs (Hernández, 2014). While the State Congress generally approved tariffs, this was sometimes done by the board of directors of municipal operators, and municipal councils have the option to grant subsidies, surcharges or cancel fines (OECD, 2013).

Tariffs were typically composed of a fixed charge, a volumetric charge (sometimes divided in increasing blocks) and a surcharge for wastewater treatment (OECD, 2013). The latter was not applied by all utilities. For instance, the SACMEX charged a water tariff with a fixed rate up to 15m³ with increasing block rates above this volume, but no separate sewage tariff (Mexico City Government, 2018). Tariffs depended on the quantity of water consumed, with rates increasing steeply for higher consumption (Interview-M9). The SACMEX applied a development index to subsidized rates based on socio-territorial characteristics, including social marginalisation, property values and income, allowing for cross-subsidies between consumers paying the full rate and those receiving subsidies. Each street block had a specific tariff based on these characteristics (Mexico City Government, 2018) (Interview-M24). As a result, tariff rates varied across the city (Interview-M2). Comparing water tariffs across the MVMC is difficult due to differences such as the inclusion of fixed rates or sewage fees, but overall Mexico City proper’s tariffs were much lower than other metropolitan municipalities (OECD, 2015a).

*Effectiveness on actors in terms of mandated goals*

SACMEX’s tariff structure aimed for equity, by charging increasing block rates and lower tariffs for low-income households, and other utilities in the MVMC applied similar policies. In fact, water tariffs were heavily subsidized in many municipalities, including in Mexico City (Interviews-M6/M19/M28/M38/M42/M46/M50/M56). Subsidized tariffs were often a tool used by local politicians in their campaigns (Interviews-M4/M19/M38). Mexico City residents without subsidies paid a flat rate of approximately USD 13 per month for water consumption up to 15m³ (see ANNEX H – WATER TARIFFS). However, it was estimated that at least 75% of consumers in Mexico City received subsidies of up to 91% (Roa, 2018). There are four categories of subsidies for domestic consumers: Popular, Low, Middle and High. Their respective water tariffs for consumption up to 15m³ were USD 1.14, 1.29, 4.27 and 5.12 per month. Therefore, large parts of the population with the financial means to pay higher tariffs are charged subsidized water tariffs. In addition, many residents paid fixed tariffs, regardless of their consumption, because they lacked water metres (World Bank, 2013; Mexico City Government, 2018) (Interviews-M6/M7/M15). However, residents purchasing water from
water trucks spent around 14 times more than residents with access to the piped network, for water of much lower quality (Mendoza, 2016). Subsidized tariffs therefore do not reach the most marginalized citizens. Only 43% of CAEM’s consumers, in Mexico State, had water metres and the rest paid fixed rates, which also varied according to subsidies (Hidalgo, 2018). Although Mexico City has the same tariffs across its 16 districts, tariff rates in the rest of the MVMC vary per municipality, including those serviced by the CAEM.

Wastewater treatment services were increasingly included into tariffs (OECD, 2013). More households had water metres (OECD, 2013) (Interview-M50). However, most utilities still struggled with cost-recovery. Tariffs collected within the MVMC barely covered 51% of the costs of service provision (World Bank, 2013). In Mexico City proper, the annual revenue collected from water tariffs is USD 116 million, whereas service provision costs reach USD 405 million (Ciencias, 2018). SACMEX was therefore in complete deficit and is subsidized by the federal and Mexico City governments (OECD, 2015a) (Interviews-M7/M9/M46/M51/M56). Mexican water utilities were almost always in financial deficit, not only due to subsidized tariffs, but also because many consumers did not pay their water bills (Interviews-M5/M50/M56). In 2018, it was estimated that 45% of SACMEX’s consumers did not pay their water bills regularly (Navarro and Gómez, 2018). SACMEX can cut off the water to households that recurrently do not pay as a last resort, but usually attempts to seek agreements with consumers and it sometimes reduces the water pressure in the network as a deterrent (Interview-M19).

Tariffs are largely determined by congressmen, who are reluctant to increase rates due to the political cost (IMCO, 2014; Flores et al., 2016) (Interviews-M4/M6/M15/M32/M46)83. Water tariffs increased above inflation rates in many cities, but remained far from allowing for cost-recovery (OECD, 2013) (Interview-M6). For many municipal utilities in the MVMC, their small scale was an obstacle for cost-recovery (IMCO, 2014).

**Impacts on sustainability and inclusiveness**

Approximately 97% of the MVMC’s population had access to piped water infrastructure (Romero Lankao, 2010). However, access – in both quantitative and qualitative terms – was not equally distributed across the city (Romero Lankao, 2010; Hackett and Eakins, 2015; Spring, 2015). Drinking water services were irregular and unreliable in certain areas, particularly for peri-urban residents (Romero Lankao, 2010; Acevedo et al., 2013). While Mexico City’s districts received on average 300 l/per person/per day, the Eastern districts of Tláhuac, Xochimilco and Iztapalapa received 177 l, 214 l and 238 l respectively (Rodea, 2016). Even these numbers hide the heterogeneity of water supply distribution, as wealthy neighbourhoods of Mexico City consume up to 800 l/per person/per day, while certain marginalized areas receive only 14 l/per person/per day (Spring, 2015; Rodea, 2016). Some marginalized areas are not connected to the public supply network, leading to precarious access to drinking water. Survey evidence across the MVMC indicates that drinking water access is

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83 CONAGUA had recently started to help municipalities set tariffs through more technical approaches based on cost-recovery (Interview-M4).
even more precarious outside Mexico City (OECD, 2015a). In many parts of the MVMC, residents had water a few hours a day every other day, or less frequently, but at a higher cost as water was frequently brought by trucks (Burns, 2009) (Interviews-M14/M24;M46). Water delivered by trucks was generally free in regularized neighbourhoods, but in informal settlements residents organized this delivery and paid for it themselves. Subsidized water tariffs therefore did not benefit those who most needed these.

Residents sometimes resorted to clandestine connections, which caused water losses as well as health risks from contamination. In one informal settlement visited in July 2016 in the Xochimilco District, in the South of Mexico City, flimsy drinking water hoses criss-crossed the polluted canals that were the vestiges of the ancient lake city (see Figure 8.2). Data on contaminants is not provided, and although data on water quality in the Cutzamala is available, there is no information on water quality after water enters local delivery networks (OECD, 2015a). The South and Southeast of Mexico City were among the most affected by poor drinking water quality (Sosa-Rodriguez, 2010). Although the CONAGUA stated that 88% of water in the MVMC was chlorinated, independent studies showed that only 60% of tap water was suitable for human consumption (Spring, 2011). Sources of contamination included deteriorated pipes, insufficient treatment processes and high levels of dissolved minerals in groundwater (Spring, 2011). Although the SACMEX frequently states that the piped water meets official quality standards, there is no transparency around this data (Durán and Gómez, 2018).

Unequal access to water services reflects and reinforces broader patterns of inequality and power imbalances between residents across the MVMC (Interviews-M47/M50), with impoverished communities in the East suffering much more than rich inhabitants in the West (Interviews-M14). Women carry the burden of ensuring that their families have water and they are vulnerable to harassment by water truck deliveries (Interviews-M27/M59/M60).

Furthermore, the lack of effective communication to the population about drinking water reliability has resulted in a general distrust of tap water (Interviews-M47/M50). In combination with inconstant supply, this has led Mexicans to become the world’s largest consumers of bottled water per capita, at 234 l/person/year in 2015 (Martínez and Enciso, 2015).

Although residents are wary about drinking water from public supply, highly subsidized tariffs encourage high water consumption for other purposes – e.g. washing, cleaning, filling swimming pools (Interviews-M6/M15/M46). This is compounded by the many households without metres or with fixed tariffs (Interviews-M9/M15/M19/M56). Consumers with access to the (subsidized) piped network have few incentives to switch to alternative systems, such as rainwater harvesting or water reuse (Interviews-M32/M46/M49). In addition, up to 40% of water was lost in leakages due to decaying infrastructure and soil subsidence (Martínez et al., 2015; Ciencias, 2018) (Interview-M46). Besides contributing to water shortages, leaks lead to revenue losses and reduced investment capacity (Interview-M51). Under current conditions,
the deficit between demand and supply may reach between 25 and 46 m$^3$/s by 2030 (World Bank, 2013).

**Figure 8.2** Improvised water supply in Amalacachico, Mexico City

![Improvised water supply in Amalacachico, Mexico City](Image)

Source: Author

Furthermore, as utilities are unable to recover costs, they depend significantly on federal state and municipal funds (IMCO 2014). As a result, taxpayers across Mexico subsidized utilities by paying an annual economic cost of around USD 1.5 billion, or almost a triple of the amount paid in tariffs (World Bank, 2013). With access to external funds, cheap bulk water and relatively little revenue from tariffs, utilities lack incentives to improve services (Interviews-M19/M32).

### 8.4.2 Metropolitan Drainage System

**Design**

Managing drainage and stormwater is challenging in the MVMC due to its location within a closed basin and much of the soil’s impermeability. While the region has always been flood-prone, soil subsidence has aggravated this risk as parts of the city have sunk by more than 12m. The macro-drainage system aims to mitigate flood risks by rapidly removing excess water from the basin and depositing it in the Tula basin. Four artificial exits (canals and large tunnels) interconnected within the metropolis have been built over the years to discharge stormwater,
with the first inaugurated in 1789 and the last in 1975 (SACMEX, 2013). CONAGUA began construction of an additional mega-tunnel that can evacuate up to 150 m$^3$/s from the basin in 2008 (CONAGUA, 2012a). It had not started operations as of August 2019.

CONAGUA, Mexico City and Mexico State jointly manage this infrastructure through the CADAM and shared operation protocols (e.g. infrastructure maintenance, warning systems, emergency strategies. The Fideicomiso 1928 funds the approximately USD 160 million per year in costs (Burns, 2009) (Interviews-M15/M19). The Valley of Mexico Metropolitan Fund also finances drainage infrastructure in the MVMC. However, the latter has been used mainly for transportation and urbanism investments, and just USD 1.3 million were spent between 2014 and 2017 on stormwater management. It is managed by the governments of Mexico City, Mexico State and Hidalgo State, to reduce vulnerability to extreme weather events through studies, plans, evaluations, projects and hydraulic infrastructure (DOF, 2011). The 2019 budget was around USD 170 million.

**Effectiveness on actors in terms of mandated goals**

There is a recognition that managing stormwater and floods requires a metropolitan approach between the federal government, states and sectoral entities, as the metropolitan drainage infrastructure is entirely interconnected (Interviews-M14/M19). This coordination is relatively efficient in daily operations to control large infrastructure works, with the three governments in constant communication (Interviews-M7/M14/M19).

While respondents recognize the impressive engineering feats of managing stormwater and drainage systems in a highly challenging location, many also criticized the lack of an integrated, strategic, long-term vision of water management and metropolitan planning (Interviews-M9/M14/M15/M46). SACMEX was “in the day-to-day, in constant battle”, focusing exclusively on flushing water out of the city with pumps and pipes (Interview-M14). The CADAM, which should plan stormwater management at metropolitan scale, only addressed hydraulic infrastructure (SACMEX 2013) (Interview-M46).

Furthermore, the metropolitan scale was not always considered ideal to address drainage and stormwater challenges. Municipalities were responsible for drainage networks within their borders, but these were often clogged from inadequate solid waste management, which aggravated flooding (SACMEX 2013) (Interviews-M5/M19). There are arguments for focusing efforts at local or sub-basin levels rather than exporting these problems. This would still require metropolitan coordination, but to a lesser degree. Supporters of such an approach argue for capturing surface runoff, treating it, reusing it when possible and returning it to the sub-basin or aquifer, thereby reducing dependence on external sources and limiting negative externalities (Interviews-M40/M52).

**Impacts on sustainability and inclusiveness**

Rapidly expelling water from the city has prevented catastrophic floods in recent decades. However, as stormwater mixes with sewage and diffused pollution, it also allows for ignoring
worsening water contamination in the metropolis and exporting this problem to the neighbouring basin (Interview-M52). While many industries moved out of the MVMC, domestic wastewater is still mostly discharged untreated (Interview-M40). These waters are then reused for irrigation in the Tula basin, contaminating surface and groundwater (Interview-M58).

In addition, this infrastructure presents risks for human settlements within the MVMC during heavy storms (Hackett and Eakins, 2015). When infrastructure fails, surrounding settlements are flooded with contaminated waters, and these risks increase with soil subsidence (Interviews-M50/M57). This often affects informal settlements in the East of the MVMC, disadvantaged by their peripheral location and historical power relations (Interviews-M27/M57). Clientelism is widespread in such areas, as residents and politicians trade votes for promises of better water services and land tenure (Interviews-M17/M20/M26/M46).

Moreover, soil subsidence inverts the slope of canals that discharged water out of the basin. Consequently, diesel pumps force these waters out, which contributes to significant costs and emissions (Interview-M40). Siltation in the drainage infrastructure adds additional risks and costs. Meanwhile, due to their limited financial resources, many municipalities in Mexico struggle to do their share of the drainage responsibilities (Interviews-M6/M15).

Although the system was meant to foster a regional approach, in practice the governors and finance departments of each federal entity determine the destination of the funds, and these often end up in projects of local and personal interest, rather than projects of metropolitan scale (Interviews-M15/M17/M33/M57). Negotiations and agreements on metropolitan-scale measures between governments at state and federal level are even more complicated when they were from different political parties (Interview-M7). While the CADAM supposedly manages this coordination, it is not transparent and does not involve other regional entities (e.g. basin councils, other metropolitan commissions) or public participation (Interviews-M15/M17/M28/M46/M48/M52).

8.4.3 Metropolitan wastewater infrastructure

Design

In 2017, only 10% of wastewater in Mexico City proper was treated, despite dozens of treatment plants spread across the MVMC (Ambiental, 2017). To address the lack of sewage treatment in the MVMC, the Atotonilco wastewater treatment plant was inaugurated in 2017 at the junction of the enormous drainage infrastructure and the Tula River (Ambiental, 2017). This strategic location allowed for easily capturing wastewater from the metropolitan drainage system. This treatment plant was part of CONAGUA’s planning for the VMB and received funding from the Fideicomiso 1928 (SACMEX, 2013). The plant aims to discharge treated waters into the Tula basin’s irrigation canals. Its treatment capacity of 35 m³/s make it the largest in Latin America and the treated discharge can more safely be reused by farmers to irrigate 80,000ha than the previously untreated flows (SACMEX, 2013; Tamargo, 2016; Ambiental, 2017). The biogas produced in the process is used for energy, covering approximately 60% of the plant’s energy requirements.
**Effectiveness on actors in terms of mandated goals**

Most treatment plants in the MVMC are significantly underused or even abandoned, mostly because they reached the end of their lifecycle or funds for their rehabilitation were never invested. The effluents from these plants are partially reused in the irrigation districts in the South of Mexico City, and therefore the plants do not operate during the rainy season (Ambiental, 2017).

The Atotonilco plant has significantly increased the volume of wastewater that is treated before being discharged *in natura*. Respondents claimed that building large sewage treatment plants is more attractive to local politicians than rehabilitating existing ones, as they often bring in substantial federal funds (Interviews-M4/M15/M40/ M42). Federal funds do not cover operational costs and time will tell if this plant can meet its high expectations.

Furthermore, critics argue that this mega-plant reproduces the linear approach of taking, using and expelling water. It reduces the viability of decreasing the dependence on water imports, as the huge investments made have to be recovered, which requires large volumes of sewage and stormwater to leave the VMB. These critics argue that sewage treatment capacity should have been distributed across the VMB to allow for wastewater recycling and reuse and groundwater infiltration (Enciso, 2018) (Interviews-M9/M32M40/M52). Recycled wastewater is mainly used to irrigate parks and fill the Xochimilco canals, although it could be used more extensively (e.g. in industrial processes, to infiltrate into aquifers or for toilet flushing) (Interview-M40). A demand for treated wastewater must be created for wastewater reuse initiatives and policies to be successful (Interviews-M27/M44). However, the authorities seem hesitant to support such initiatives (Interviews-M6/M40/M44).

Moreover, despite the Atotonilco plant’s direct effect on basin management, decision-making on sanitation is not discussed within nor between basin councils, nor between basin councils and state and municipal governments, and the metropolitan commissions (Interviews-M17/M28/M48).

**Impacts on sustainability and inclusiveness**

In 2017, Mexico City treated only around 3 m³/s, or 15% of total wastewater, significantly below the national average of 57.7% for municipal wastewater and 38.3% for industrial and other wastewater (CONAGUA, 2018). It is not yet clear how much the Atotonilco plant has increased sewage treatment rates in Mexico City and the VMB, but this increase will likely be significant, with positive effects on the Tula basin’s water quality, including its groundwater. This is crucial, as earlier studies revealed that irrigated lands in the Tula Basin received 44,000 tons of nitrogen and 17,000 tonnes of phosphorus yearly, causing severe risks of waterborne diseases and contaminated crops (Burns, 2009)\(^8\).

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\(^8\) Children in the parts of the Tula Basin exposed to contaminated irrigation waters were 16 times more likely to suffer from gastrointestinal diseases than those in areas where clean water was used (Peña *et al.*, 2013).
Building the Atotonilco plant was expensive, at approximately USD 630 million, several times the initially projected amount (Acciona Agua, 2018). Maintaining operations is estimated to cost around USD 5.5 million per month (Interview-M9). These numbers do not include the additional costs of building sewage pipes within the city and pumping this sewage out. The construction of the plant is also clouded by corruption allegations (Interview-M9).

Finally, many farmers in the Tula basin are unhappy, as untreated sewage was better for their crops’ productivity (González, 2018). In addition, residents living near the treatment plant complained about a rise in skin diseases (González, 2018).

8.4.4 THE CONSERVATION LAND

Design

Within Mexico City proper, an area known as the ‘Conservation Land’ occupies 59% of the surface area of the city, spread across nine southern districts (Escamilla and Santos, 2012). The Conservation Land holds high ecological value and its preservation is considered crucial for the city’s sustainable development (SEDEMA, 2013). This area was defined in 1976 through a Federal District law, modified in 1982, which classified the territory in either urban or conservation land (Federal District Legislative Assembly, 1982). This special zoning category established strict restrictions through a zero-growth land use policy (Aguilar and Santos, 2011). Its preservation requires collaboration between sectoral entities and districts and a common land use management vision. This is implemented through conservation measures, such as monitoring activities, forest fire prevention, land use planning and PROFACE (see 7.4.4). Across the MVMC, Environmentally Protected Areas have also been established at smaller scales – including within the Conservation Land – and are created by the state or federal government (SEDEMA, 2016). These areas have particular value in terms of biological diversity and have individual plans and strategies.

Around half of the Conservation Land is covered in forests, a third by agricultural lands, 12% by grasslands and 11% by urban uses (Escamilla and Santos, 2012). About 30% of the Conservation Land is within environmentally protected areas, which have their own advisory councils (SEDEMA, 2013). The Conservation Land hosts over 1,800 flora and fauna species and provides important ecosystem services for the MVMC, including climate regulation, water provision\(^86\), soil and water retention and contamination reduction (Escamilla and Santos, 2012; SEDEMA, 2013). The Conservation Land is part of a larger green belt that surrounds the MVMC and extends across state borders.

Effectiveness on actors in terms of mandated goals

This instrument recognizes the high value of the territory’s ecosystem services. However, as the only undeveloped land, this region is under heavy pressure from continued urban growth. The district governments are largely responsible for enforcing zoning regulations, but often

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\(^86\) 57% of the water consumed by the city came from aquifers recharged in this area.
lack capacity and political will (Connolly and Wigle, 2017) (Interview-M17). Residents pressure local politicians to legalize informal settlements, further contributing to corruption and clientelism (Interviews-M17/M26). For instance, district authorities changed zoning regulations without informing the Mexico City government (Interviews-M6/M7). This prevented the development of alternative solutions that addressed the affordable housing gap while preserving the Conservation Land, such as housing programmes with higher densities and better access to basic infrastructure and services in less ecologically valuable areas and meant that official land use maps are often inaccurate (Escamilla and Santos, 2012).

Disjointed environmental and urban policies within Mexico City lead to incoherent planning, as sectoral departments for conservation, housing and agriculture have conflicting interests (Interview-M15). This ultimately hinders the city’s ability to contain urban sprawl in the Conservation Land. Moreover, there is also no regional or metropolitan land use planning, and basin entities and metropolitan commissions are not involved, even though the green belt extends beyond Mexico City and the VMB (Interviews-M9/M17). This coordination is the role of the Environmental Commission of the Megalopolis. Additionally, 70% of the Conservation Land is communally held by traditional agrarian communities. Any intervention in these areas involves negotiations with (all) the landowners (Interview-M48).

**Impacts on sustainability and inclusiveness**

Despite land use restrictions and multiple conservation measures, informal settlements have expanded, causing environmental degradation with severe impacts for the city, including in terms of aquifer recharge (Escamilla and Santos, 2012) (Interviews-M15/M46). Informal urbanization of 2700 hectares in the Conservation Land may have prevented the infiltration of around seven billion litres of water per year (Macdonald, 2016). The current trend indicates that the Conservation Land would continue to urbanize significantly in the next years, and forest cover could entirely disappear by 2030, further jeopardizing the city’s groundwater resources (Hernández, 2016) (Interview-M29).

Moreover, weak land use regulation and monitoring have facilitated the expansion of illegal logging and intensive agriculture that causes groundwater contamination from pesticide use (Interview-M48/M50). In some cases, conflicts erupt between communities in the Conservation Land and local authorities (Interview-M33). Although multiple sectors at Mexico City and district levels are involved, non-governmental voices are not included in planning.

8.5 **INSTRUMENT ASSESSMENT AND REDESIGN**

UWM in the MVMC was disconnected from environmental management and the real cost of water services (see Table 8.2). Although the basin agency, Mexico City and Mexico State closely coordinated mega-infrastructure that expelled stormwater and wastewater from the basin, they maintained a mainly technical, top-down and linear approach (Interviews-M6/M7/M19/M40).
<table>
<thead>
<tr>
<th>Instrument design</th>
<th>Effects on actors</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water tariffs</td>
<td>[0] No overarching framework leads to large disparities. Many utilities use subsidies for low-income residents.</td>
<td>[0] Tariff design promoted equity and inclusion of low-income residents through block rates and subsidies. Lack of metres and cost-recovery reduced investments. Informal settlements were excluded.</td>
</tr>
<tr>
<td>Metropolitan drainage system</td>
<td>[-] Coordination between state governments for infrastructure funding and operation</td>
<td>[-] Metropolitan management is necessary as infrastructure is interlinked. Coordination does not involve regional planning. Disconnect with local level hindered overall efforts.</td>
</tr>
<tr>
<td>Metropolitan sewage infrastructure</td>
<td>[0] Mega-sewage plant built downstream of MVMC, centrally managed. Treated water can be reused for irrigation.</td>
<td>[0] Sewage treatment increased with new mega-plant, but its location prevented reuse of treated wastewater within the basin.</td>
</tr>
<tr>
<td>Conservation Land and Cross-sectoral planning</td>
<td>[+60% of Mexico City under special zoning and land use restrictions. Cross-sectoral planning. Does not extend beyond Mexico City proper.</td>
<td>[0] Weak enforcement of regulations due to lack of capacity and political will. Fragmented policies further weaken efforts.</td>
</tr>
</tbody>
</table>

Relative assessment scores: ++ Very positive; + Positive; 0 Neutral; - Negative; -- Very negative (See 2.4)
Redesign

**Water tariffs**: Subsidies for low-income households are crucial to ensure affordability, as the population has large disparities in their capacity to pay. However, such subsidies do not benefit the most marginalized residents of the MVMC, as utilities are not allowed to provide services in informal settlements. Special programmes to provide drinking water, and when possible sanitation, have been successful in expanding access to established informal settlements in the MRSP, through cooperation between utilities and local governments, and could be considered for the MVMC. Besides benefits to residents, this can reduce commercial water losses (i.e. clandestine connections). Furthermore, as subsidies were extended to around 75% of the population of Mexico City proper, a review of subsidies’ qualifying criteria is necessary, as many households may have the capacity to pay. This process requires the creation of an independent regulatory agency to set criteria and approve tariff rates, transferring this mandate from the State Congress. The design of an overarching national policy framework for Wat&San could establish minimum standards and general goals.

In addition, the tariff system should reflect the social, economic, relational and environmental impacts of importing water from other basins and over-exploiting aquifers (see 7.5). Criteria for designing tariffs are based on local socio-economic characteristics to ensure affordability (in formal settlements) but do not consider water availability within the basin and the effect of tariffs on water demand. A more independent process of setting tariffs could ensure rates that would improve cost-recovery for utilities and reduce excessive consumption. This could incentivize repairs of leaks and the installation of water metres where there are none and water saving equipment. The reduction or elimination of subsidies for households with the capacity to pay could lead to internal investments by the utility. A portion of the added revenue could also fund PES programmes or conservation measures in donor basins, as is done in Mexico State.

**Macro-drainage**: It is necessary to shift from linear to more circular stormwater management, while remaining realistic about the basin’s propensity to flood. Efforts could be made to retain surface runoff within the Conservation Land through preservation, and in the rest of the MVMC through green areas and a combination of decentralized grey and green infrastructure (e.g. bioswales, green roofs) adapted to the local context (i.e. available space, permeability of soil, uphill/downhill). Small-scale initiatives to capture, filter and inject surface runoff into the ground have increased in recent years to simultaneously address groundwater over-exploitation, soil subsidence and recurrent floods. Retaining water within the basin could also reduce the costs of pumping stormwater and wastewater out of the basin. These could be scaled up within a regulatory framework with strict norms for the infiltrated water quality. This decentralized infrastructure could be managed locally or at sub-basin level to adjust to local needs and to be treated and reused or returned to streams or aquifers rather than to be funnelled downstream. Decentralized stormwater management should be part of a regional plan that considers basin and aquifer dynamics, with coordination between the MVMC’s municipalities and state governments and shared financing. Nevertheless, centrally managed artificial drainage exits will continue to play an important role because of infrastructure lock-in. In
addition, the concentration of rainfall in a short timeframe makes it more difficult to store water (Interview-M28).

**Mega-sewage:** Sewage and stormwater are currently combined and expelled together, and as with stormwater, efforts are needed to retain, treat and reuse wastewater within the MVMC. Separate sewer and stormwater systems could be installed in new developments or when replacing old pipes, but the total replacement of combined systems is prohibitively costly and unrealistic in the short-term. Initiatives for decentralized stormwater and wastewater treatment, recycling and reuse already exist, and have great potential for non-drinking uses such as school toilets and industrial processes (CCRAC 2011) (Interviews-M4/M52). Similarly, such measures require a clear normative framework. Users, such as industries, were often reluctant to shift to water reuse because this meant giving up their water extraction permits and thereby the security of stable access to water. Introducing flexibility within water use permits could facilitate transitions to water reuse while maintaining a water allocation guarantee, thereby enhancing environmental sustainability and avoiding the alienation of large users.

A mega-sewage plant was recently built downstream of the MVMC, although most sewage treatment plants within the metropolis operated significantly under capacity or were abandoned. Investing in these plants rather than the mega-plant would have reduced the need for transporting sewage across the entire MVMC. The mega-plant disincentivizes measures to retain and treat stormwater and wastewater within the basin. Nevertheless, smaller plants within the basin could still play a role as not all wastewater is currently collected and treated. Expanding the network has to do with the financial capacity of utilities, but also issues of land tenure, as many unconnected households are in informal settlements. This justifies a greater involvement of local governments within regional wastewater planning.

**Conservation Land:** Efforts are fragmented as the Conservation Land is limited to Mexico City, and there was no regional approach for preserving the MVMC’s green belt. However, coordinated actions between Mexico City and surrounding states are crucial for preserving ecosystem services. More effective coordination could be achieved by harmonizing the states’ land use management plans and conservation policies. Funding for a regional approach could be linked with PES programmes or compensation mechanisms. Such an idea has emerged from civil society actors, through the Water Forest Conservation Strategy, which promotes a regional approach to conservation and sustainable land use management. Part of this strategy is to raise awareness about the interdependencies between the ecosystems surrounding the megacity and the water used by the latter. Whether through local or regional efforts, conservation of the MVMC’s ecosystems would require engaging local rural dwellers, including indigenous communities, whose livelihoods are threatened by urban encroachment. As land is largely privately owned, expropriating and compensating landowners may be necessary in areas identified as significant in terms of ecosystem services and at risk of development (Interview-M9/M15). In most cases, cooperation with landowners to ensure sustainable land use practices is the more pragmatic approach.

Ultimately, political leadership and political will are necessary. In 2018, the newly elected governor of Mexico City committed to a fivefold increase in the Conservation Land’s budget and to double resources for PES and compensation programmes. This presents a window of
opportunity for Mexico City’s leaders to engage surrounding regions for regional conservation efforts.

**Missing instruments**

UWM is currently excluded from urban policy and planning. If the aim is to achieve greater social inclusion, assessments could be conducted to identify informal settlements that can be legalized based on criteria such as the age of the settlement, viability of installing basic infrastructure and environmental impacts. Residents in areas considered at risk or highly valuable in terms of ecological functions should be relocated as part of a regional housing strategy. Slum upgrading programmes coordinated between the water utility, relevant sectoral departments and local authorities could lead to joint efforts to expand sewage collection.

In addition, in upgraded and newly built neighbourhoods, sewage and drainage systems could be separated. As climate change will bring more intense precipitation, this can mitigate floods of contaminated waters. Funds could partially come from construction companies.

Moreover, rainwater harvesting initiatives have multiplied and were used to complement water supply for non-drinking uses or for aquifer recharge. It was increasingly common in marginalized peri-urban areas without piped water but with space for rainwater tanks and filtering systems. This could significantly reduce dependence on water trucks, at least during the rainy season, and lower household expenses. While there were legitimate concerns about water quality, rainwater could be used for less noble uses such as toilets and watering gardens. The popularity and success of such initiatives indicated they had potential to be scaled up. Although it is estimated that the volume of rainwater that enters the MVMC’s drainage systems is greater than the volume of water imported from the Cutzamala System, only a fraction of rainwater could realistically be captured by rainwater harvesting systems (Sosa-Rodriguez, 2010) (Interview-M40). This is due to the surface area needed to capture rain and the irregularity of rainfall. While rainwater harvesting systems may make only a dent in reducing groundwater over-exploitation and water imports, it could be significant for households and users with precarious access to water, in particular those currently depending on water trucks.