Scalar mismatches in metropolitan water governance
A comparative study of São Paulo and Mexico City
van den Brandeler, F.A.

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7. THE IMPLEMENTATION OF IWRM/IRBM IN MEXICO CITY

7.1 INTRODUCTION

This chapter examines how drivers and institutions at multiple levels of the river basin 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 river basin governance and its main drivers, analyses the driving forces on the river basin from local to global level (see 7.2), explores how Integrated Water Resources Management (IWRM) actors and institutions at multiple levels address water challenges at the basin scale (see 7.3), analyses the instruments of IWRM/IRBM according to their stated mandates, their effect on actors’ behaviour given the drivers and their impacts on inclusive and sustainable water governance (see 7.4). 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 IWRM/IRBM (see 7.5).

7.2 CONTEXT AND DRIVERS OF MEXICO CITY’S RIVER BASIN CHALLENGES

7.2.1 CONTEXT IN RELATION TO THE RIVER BASIN

Mexico is a water-stressed country with uneven water distribution. Average annual precipitation ranges from below 500mm in the North, to more than 2,000mm in the Southeast, and around 650mm in the central region where Mexico City is located (CONAGUA, 2015). When population distribution is considered, these contrasts become even starker. More than three-quarters of the population live in regions with little water (OECD, 2013). In addition, rainfall is unequally distributed throughout the year: 67% of rainfall occurs between June and September and droughts are frequent (OECD, 2013).

Most of the MVMC lies within the lower part of the Valley of Mexico Basin (VMB), around 2,200 metres above sea level (masl). This is an endorheic basin, enclosed by mountains and volcanoes reaching 5500 masl (Martínez and Enciso, 2015). Surface and groundwater resources originate from the springs in these mountains. 65.5% of the VMB’s surface area is urban, while 34.5% is rural, with agricultural, livestock, forest and conservation uses (World Bank, 2013). Urban growth has reduced water availability in the VMB to around 144m³/inhabitant/year⁶⁹.

⁶⁹ A region faces absolute water scarcity if renewable water resources are below 500m³/inhab./year (FAO, 2012).
7.2.2 **MAIN DRIVERS OF MEXICO CITY’S RIVER BASIN CHALLENGES**

**Climate**

Recent research on climate change forecasts increases between 1.5 and 5°C from 2050 to 2100 for Mexico (Guido Aldana, 2017). Precipitation is likely to be concentrated in fewer but more intense rainfalls, and to decrease on average by 5.8% in the 2020s, and by 10.4% in the 2070s (Sosa-Rodriguez, 2014; Guido Aldana, 2017). This may contribute to an intensification of mid-Summer droughts and impact water demand and alter water quality in surface water bodies (IMTA, 2007). However, vulnerability to climate change varies significantly per region. Areas in the dry North, the Centre-West, and the VMB are considered highly vulnerable (Guido Aldana, 2017).

Average annual precipitation varies between 1,200mm in the South of the VMB and 600mm in the North, and is mostly concentrated between May and September (Romero Lankao, 2010). Heavy summer rains increase flood risks. The basin tends to alternate between wet years and drought episodes, some of which last longer than ten years (Romero Lankao, 2010).

Glaciers and eternal snows in the surrounding mountains, crucial for groundwater recharge, may disappear before 2025 (Burns, 2009). With the depletion of local aquifers, longer and more intense droughts risk increasing the basin’s dependency on external water sources (Sosa-Rodriguez, 2014). Overall, Mexico City is likely to experience more intense droughts and heat waves, aggravating water shortages, and more frequent floods and increased risks from waterborne diseases (Sosa-Rodriguez, 2014).

**Demographics**

Mexico’s population grew from 35 million inhabitants in 1960 to approximately 120 million in 2015 (INEGI, 2015).

The VMB’s temperate climate and fertile soil attracted settlements long before the Spaniards arrived (Escamilla and Santos, 2012). Around the Aztec city of Tenochtitlán, which would become Mexico City, peri-urban and rural communities developed highly productive floating farms (Escamilla and Santos, 2012). These supplied urban areas and allowed for Tenochtitlán’s growth. By the 17th century, the Spaniards first population census registered a total of 144,760 inhabitants (Escamilla and Santos, 2012). In 2010, the basin had 20.6 million inhabitants across 85 municipalities, though mostly concentrated within the MVMC (Rodríguez Tapia and Morales Novelo, 2013).

**Economic development**

The 1910 revolution centralized power and led to large-scale economic development projects (Aguilar et al., 2010). In addition, technological innovations brought dams, canals, inter-basin transfers, and the electric pump (Aguilar et al., 2010). As a result, the ability to abstract and
transport water resources over large distances increased significantly, and water consumption rose sharply after 1950. By the late 1980’s, water infrastructure was decaying and the government, struggling to handle a severe economic crisis, was unable to address the sector’s extensive needs (Wilder, 2010).

The GDP of the VMB is 23.8% of the national GDP. Besides hosting the financial capital of the country, the basin has important agricultural and industrial sectors.

Land use changes

The natural hydrology of the VMB has been radically altered since the Spanish conquest of the Aztec empire, when lakes still covered large parts of the basin (see Map 7.1). The Aztecs developed a sophisticated system of terraces, reservoirs, canals, irrigation ditches, dikes and aqueducts to both use the hydrological conditions to their advantage and cope with its risks. From the 16th century onwards, the lake-bed was progressively drained by the Spaniards (Wilder, 2010; Mazari-Hiriart et al., 2014). As urbanization accelerated, the remaining water bodies were polluted by open sewage canals, spreading waterborne diseases and increasing reliance on groundwater (Romero Lankao, 2010). Today, only one river system, the Magdalena-Eslava, still provides surface water to the city, albeit heavily contaminated and with a diminishing flow, while other rivers have been piped to avoid flooding and unsanitary conditions (Mazari-Hiriart et al., 2014).

Map 7.1 Lakes in the Valley of Mexico around 1519

The lakes have been reduced to two small water bodies and a few canals – a fraction of their original size. The rest of the lake waters were drained and today the MVMC expands across the vast expanse of the dried lakebed.

Source: Madman2001 / CC BY-SA 3.0

The surface area of the VMB’s urban sprawl increased over 5 times between 1950 and 2000, and its population multiplied by 5.65 times between 1950 and 2005 (World Bank, 2013). As urbanization spread to the mountainous areas of the basin, the capacity of these areas to infiltrate water and recharge aquifers was drastically diminished, reducing water availability and increasing flood risks through soil-sealing (Romero Lankao, 2010; World Bank, 2013). The growth of informal settlements without access to basic infrastructure and services in the green belt also degraded the quality of local springs and aquifers.
Moreover, primary activities, such as logging and agriculture, have led to environmental degradation and land surface erosion, accelerating the desiccation of lagoons and siltation of drainage systems (Romero Lankao, 2010; Pina, 2011). Land use changes in neighbouring basins also affect the MVMC as these areas supply water through inter-basin transfers (see 7.4.1). Between 1980 and 2011, the population in the sub-basins of the Cutzamala System, the main inter-basin transfer, increased by almost 150%, occupying mainly informal settlements deprived of sewage collection and treatment (World Bank, 2015). Moreover, agricultural activities and deforestation also increased around these reservoirs (Martínez, 2018).

The direct and indirect drivers of water-related challenges at multiple levels are summarized in Table 7.1 below.

### Table 7.1 Multi-level drivers of water-related challenges on the river basin

<table>
<thead>
<tr>
<th></th>
<th>Direct</th>
<th>Indirect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Local</td>
<td>Regional/global</td>
</tr>
<tr>
<td><strong>Land use</strong></td>
<td>Urbanization, expansion into</td>
<td>Logging and deforestation</td>
</tr>
<tr>
<td></td>
<td>green belt</td>
<td>for agriculture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agricultural</td>
</tr>
<tr>
<td></td>
<td></td>
<td>intensification</td>
</tr>
<tr>
<td><strong>Demography</strong></td>
<td>Rapid population growth in</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the basin</td>
<td></td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td>Heavy summer rains, frequent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>dry spells</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Author*

### 7.3 THE INSTITUTIONAL SET UP FOR IWRM/IRBM IN MEXICO CITY

#### 7.3.1 Global level

The World Bank and IDB have provided loans to Mexican authorities for climate change adaptation, and more specifically for drought forecasting, for the protection of water reserves and for supporting the development of IWRM in the VMB (CONAGUA, 2012b). The federal government and users finance the bulk of the Mexican water sector, and international actors represent only a minuscule fraction of total investments in water resources management (OECD, 2013). The presence of international cooperation is stronger within UWM (see 8.3.1).

#### 7.3.2 Transboundary level

The MVMC is contained within one river basin, the VMB, although water shortages lead it to depend on several other basins for water supply. The VMB spreads across the entire federal entity of Mexico City, and parts of the states of Mexico, Hidalgo and Tlaxcala (CONAGUA,
This has important implications for WRM as the governments of these four federal entities must negotiate and agree on decisions related to the river basin.

### 7.3.3 National Level

The Federal Constitution defines all waters within Mexican territory as national property to be administered and managed by the federal government (Mexican Constitution, 1917, Art. 27). Until the 1980’s, water policy remained highly centralized within a limited authoritarian political system ruled by a powerful presidency and top-down regulation (Wilder, 2010). It was conducted in a top-down fashion without social participation.

The emergence of political pluralism in the late 1980s, including democratic power sharing between different political parties and levels of government, led to the reform of Mexico’s water management institutions (Hearne, 2004). The federal government introduced decentralized water management policies and adopted three WRM goals: (1) develop large infrastructure projects with combined public and private funds, (2) increase water use efficiency, and (3) control water pollution (Hearne, 2004). In 1989, the National Water Commission (CONAGUA) was established to develop a new water policy to carry out these goals (Hearne, 2004). This led to the 1992 National Water Law (NWL), which defines the principles and mechanisms for managing water resources, including the use of national waters, their distribution and control, as well as the preservation of their quantity and quality for ‘integrated sustainable development’ (NWL, 2004; OECD, 2013). Its set of reforms are centred around decentralization and marketization, and the river basin or aquifer as the unit of water management (Wilder, 2010). River basin councils were created in 1996, with the aim of promoting citizen participation and coordinating water management across three levels of government within watershed boundaries (Hearne, 2004). The NWL thus indicated the possibility of a new state-citizen relationship but also increased private sector involvement in water supply and sanitation services.

In 2004, after heated discussion among intellectuals and water sector professionals, the NWL was significantly rewritten, with greater emphasis on decentralization and sustainability (Wilder, 2010). It led to the creation of thirteen regional Basin Agencies that operate as CONAGUA’s implementing agencies (Hearne, 2004; OECD, 2013). These agencies are based on hydrological boundaries, often grouping together multiple river basins.

CONAGUA is an autonomous agency of the SEMARNAT (Ministry for the Environment and Natural Resources). The SEMARNAT, together with CONAGUA, and state and municipal authorities, establishes official norms in relation to water management and supervises their enforcement (OECD, 2013). CONAGUA receives 70% of its budget from the SEMARNAT, though it maintains significant autonomy, and is responsible for water policy, water planning, financing and strategy-setting (Spring, 2011; OECD, 2013). It grants water use permits, maintains the national water user registry (REPDA), constructs and operates federal water infrastructure and provides bulk water to Wat&San utilities, large industries, and irrigation districts. In addition, CONAGUA contributes to developing and managing irrigation and flood control systems (Hearne, 2004).
Other federal-level actors include the National Commission for Protected Areas (CONANP) and the National Forestry Commission (CONAFOR) through their efforts to preserve ecosystems (for a detailed overview see Annex F - Main actors in Mexico City’s metropolitan governance). In addition, the Federal Attorney's Office for Environmental Protection (PROFEPA), a deconcentrated branch of the SEMARNAT, is responsible for supervising the compliance with environmental regulations.

The Ministry of Agriculture is responsible for addressing agricultural pollution (i.e. regulation of the use of fertilizers), whereas CONAGUA oversees water quality norms and standards issued by the Health Ministry. CONAGUA is thus limited to localized discharges from industries and water utilities (Spring, 2014). Overall, national legislation on water quality was considered weak due to institutional fragmentation, a lack of enforcement and political will, and the PROFEPA’s ineffectiveness (Interviews-M40/M42/M58).

7.3.4 State level

At state level, the main institutions are the State Water Commissions. These autonomous entities, usually under the authority of the State Ministry of Public Works, foster coordination between the federal government and municipalities (OECD, 2013). Their attributions vary per states and can include WRM, irrigation, technical assistance to municipalities and the provision of Wat&San services (when municipalities choose to delegate these) (OECD, 2013). States also have environmental departments that are responsible for carrying out the state environmental policy, but their capacity varies significantly. For Mexico City, this is the SEDEMA (Environmental Secretariat of Mexico City) and its branch the CORENA (Mexico City’s Commission for Natural Resources).

7.3.5 River basin level

The 2004 revision of the NWL introduced IRBM into Mexican water policy and key water management functions were transferred to the river basin. The MVMC is located within the hydrological-administrative region managed by the Basin Agency ‘Waters of the Valley of Mexico – Region XIII’, which is responsible for formulating regional water policy, planning and maintaining water use registries (see Map 7.2). Region XIII has two river basins: The Basin of the Valley of Mexico and the Basin of the Tula River, each with its own basin council (CONAGUA, 2012a). The borders of the basins do not overlap perfectly with those of Region XIII as the former are based on hydrological boundaries and the latter uses municipal borders as delimitations of its territory. Basin councils are multi-stakeholder platforms established as consultative bodies that bring together government representatives, civil society representatives and users. Other water management entities include the basin commissions, the basin committees and the groundwater technical committees (see Table 7.2). These are voluntary and meant to provide support to the Basin Councils (Interview-M55).

While the creation of these multi-stakeholder entities was an important step towards implementing IWRM/IRBM, they were seen as ineffective, leading many participants to retreat
from the process (Interviews-M5/M17/M38). The VMB’s size and complexity, and the numerous interests and actors involved, made negotiations virtually impossible (Interviews-M17/M55). In addition, as ‘consultative entities’, basin councils lacked the necessary planning, regulatory, financing and enforcement power to implement decisions (OECD, 2013) (Interviews-M17/M31/M33/M38/M54).

Map 7.2 Map of Region XIII and the metropolitan region of the Valley of Mexico

Moreover, basin commission plans were not considered by basin councils, resulting in incoherencies between sub-basin and basin management (Interview-M40). The groundwater committees lacked information and decision-making power, and they depended on funds from CONAGUA, which restricted their autonomy (Interview-M40). The basin agency had decision-making power and funds, and ultimately implemented CONAGUA’s agenda at regional level. Other spaces seemed to serve to give legitimacy to decisions already taken by CONAGUA (Interviews-M15/M40/M58).

The Basin Agency implements the ‘Regional Water Programme 2030’, which promotes integrated and sustainable basin and aquifer management (CONAGUA, 2012a). This includes strategies focused on increasing supply and reducing demand, improving water quality, attaining universal coverage of water services and reducing risks from weather events. Climate change does not have a strong presence within the programme, and the NWL (Art. 13) only

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70 Basin council meetings are also infrequent: during six months of fieldwork, the only meeting that I could hear of took place in Cancún during a parallel event. Civil society was mainly represented by (large) users, whereas representatives from CSOs and basin commissions were not given a voice or informed on how to participate (Interviews-M28/M38/M40/M48/M54/M55).
mentions that basin agencies should “evaluate the effects of climate change on the hydrological cycle”.

### Table 7.2 IWRM/IRBM entities

<table>
<thead>
<tr>
<th>IWRM/IRBM entities</th>
<th>Description</th>
<th>Mandates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin agencies</td>
<td>13 deconcentrated agencies of CONAGUA, based on hydrographic boundaries. The MVMC is in Basin Agency Region XIII</td>
<td>Formulate and implement regional policy; recommend rates for water user fees and collect them; program, build, operate and maintain federal water works</td>
</tr>
<tr>
<td>Basin councils</td>
<td>2 basin councils in Region XIII</td>
<td>Guide the work of the Basin Agencies through coordination, concertation, support, consultation and advice</td>
</tr>
<tr>
<td></td>
<td>Composed of government representatives, civil society representatives and users</td>
<td></td>
</tr>
<tr>
<td>Basin commissions</td>
<td>4 in the VMB</td>
<td>Provide support to basin council at sub-basin level or on a specific issue</td>
</tr>
<tr>
<td></td>
<td>Same composition as basin councils. Independent from CONAGUA</td>
<td></td>
</tr>
<tr>
<td>Basin committees</td>
<td>2 in the VMB</td>
<td>Address issues relevant to a specific area by bringing together residents and stakeholders</td>
</tr>
<tr>
<td></td>
<td>Micro-basin level</td>
<td></td>
</tr>
<tr>
<td>Groundwater technical committees</td>
<td>1 in the VMB Multi-stakeholder platform at aquifer level, independent from CONAGUA</td>
<td>Technical work and discussions relating to groundwater management</td>
</tr>
</tbody>
</table>

*Source: Mexico, 2004; CONAGUA, 2018*

### 7.4 Instrument Analysis

#### 7.4.1 Inter-basin Transfers

**Design**

The MVMC has long relied on its aquifers to respond to rising water demand. As these became increasingly over-exploited, the region developed a complex system of large engineering works spanning multiple federal entities and basins to provide bulk water services to the VMB, mainly for public/urban use. These aimed to reduce the pressure on local aquifers while sustaining the MVMC’s growing population and economic development. Table 7.3 shows the multiple water supply sources to this basin.

The first of these inter-basin water transfers was the Lerma System, inaugurated in 1951 and managed by the SACMEX, Mexico City’s water utility (see 8.3.3) (CONAGUA, 2018). It extracts and transfers groundwater from the Lerma River aquifer to Mexico City and parts of Mexico State. It measures 60 km in length, provides 5% of the VMB’s water supply and has a capacity of 14 m³/s, although actual supply is around 5 m³/s due to the over-exploitation of the Lerma aquifers (CONAGUA, 2018).
The Cutzamala System supplies water to 11 districts of Mexico City and 11 municipalities of Mexico State (CONAGUA, 2018). It corresponds to 17% of the volume of water used within the VMB annually (~15 m³/s of 88 m³/s) (CONAGUA, 2018). Besides supplying water from 160 km away (one of the largest water supply systems in the world), it also pumps water up 1100 m, making it energy-intensive and expensive, representing around 0.6% of Mexico’s total electrical energy demand (Tortajada, 2008; Engel et al., 2011). The Cutzamala System alone costs around USD 240 million a year (World Bank, 2015). 48% of this cost is financed by water use fees, and the rest is paid with federal government resources (World Bank, 2015).

Table 7.3 Overview of water supply in the Valley of Mexico Basin (VMB)

<table>
<thead>
<tr>
<th>Source</th>
<th>Volume (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>73</td>
</tr>
<tr>
<td>Local aquifers</td>
<td>68</td>
</tr>
<tr>
<td>Lerma System (inter-basin transfer)</td>
<td>5</td>
</tr>
<tr>
<td>Surface water</td>
<td>20</td>
</tr>
<tr>
<td>Local rivers and springs</td>
<td>3</td>
</tr>
<tr>
<td>Cutzamala System (inter-basin transfer)</td>
<td>17</td>
</tr>
<tr>
<td>Water reuse</td>
<td>7</td>
</tr>
</tbody>
</table>

*Source: Adapted from Aneas (2015)*

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

The MVMC’s aquifers and nearby aquifers in Mexico State continue to be over-exploited and this has worsened in the last decades. Nevertheless, as external sources contribute roughly 22% to the VMB’s water use, the pressure on the MVMC’s aquifers would be much more drastic and water shortages more severe without centralized control of water resources (Interview-M32). The MVMC’s aquifers may run dry by 2060, so relying on external sources seems unavoidable (EFE, 2019). CONAGUA announced that the Cutzamala System’s water supply capacity would increase by two additional cubic metres per second in 2020 through investments in water treatment efficiency (López, 2019).

However, a first issue regarding inter-basin transfers concerns allocation rules, which are still largely based on a federal decree of 1972 (DOF, 1972). Mexico City was granted around five times more water than Mexico State, under the unstated rationale that it had a much larger population. Since then, the MVMC expanded largely into Mexico State. Although the volumes apportioned to both entities increased over time, the decree was never adjusted and Mexico City continues to be entitled to a much larger volume of water (Mendoza, 2016). This may have contributed to the sharp rise in groundwater extraction in metropolitan municipalities of Mexico State since at least the 1990’s (Neri-Ramírez et al., 2013).

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71 The energy use of the Cutzamala System corresponds to Puebla’s, a Mexican city of 8.3 million inhabitants (Escolero et al., 2016).
Moreover, the decree does not specify where imported water comes from, nor the capacity of the Cutzamala System (Mendoza, 2016). This opened the door to the possibility of constant expansion of water transfers and encouraged CONAGUA and other actors to expand water imports rather than reduce water use (Spring, 2015).

Furthermore, the Federal government partially subsidizes the inter-basin transfers, so users are not sufficiently incentivized to increase their water use efficiency, leading to high levels of physical and commercial water losses (i.e. leaks and theft), and excessive water consumption. Moreover, the water fees for private uses (i.e. uses other than public supply) and basin transfer fees paid to the Basin Agency are collected by the Federal Treasury, while bulk water supply fees (from water utilities) go to the Fideicomiso 1928 budget (a regional trust fund for water infrastructure). The latter is mostly spent on drainage and sanitation works in the VMB (World Bank, 2015). These fees therefore do not return to the donor basins to be reinvested in preserving regional ecosystems, managing urban and rural development or treating wastewater.

Despite the dependence on external basins, the Region XIII agency does not interact with the basin agencies where the Lerma and Cutzamala systems have their production areas, and there is no policy at that larger scale (Interviews-M28/M33). These water transfers are coordinated in a top-down manner by the central CONAGUA office (Interview-M33):

“These agencies do not meet, do not dialogue. There is no policy at that scale. [...] The federal government should guide coordination processes, create spaces for debate and joint decision-making, not tell them what to do. [...] These administrative borders are a straitjacket as our new socio-hydrological realities no longer fit these moulds. We need to create a new entity; rethinking the scale we need to use as the policy of inter-basin transfers is unlikely to change in the short and even medium term”.

The relevant basin councils, state and municipal governments, and other regional entities (e.g. metropolitan commissions (see 8.3.4)) also do not coordinate regarding water transfers despite the many inter-connections between them (OECD, 2013) (Interviews-M17/M28/M48). Overall, the inter-basin transfers are not part of a sustainable and integrated basin management vision (Interviews-M13/M28).

**Impacts on inclusiveness and sustainability**

Large infrastructure works mitigate water shortages for the MVMC in the short-term and reduce pressure on the MVMC’s aquifers but in the longer-term they are inadequate in themselves to address water scarcity in the VMB, as demand will continue to rise and water would need to be imported from constantly further at increasing costs (e.g. infrastructure, energy, environmental degradation, on displaced local communities) (M6/M7/M9/M28/M40/M48/M49/M50). Moreover, climate change forecasts project an overall decrease in precipitation, which will put additional stress on the region’s water systems, and this is not considered in current water supply planning (Interview-M55). The emphasis on importing water comes at the expense of efforts such as conservation in areas crucial for aquifer recharge, reusing water or reducing leaks, which are part of an integrated and long-term vision of the basin (M9/M15/M40/M44).
Large engineering works have altered the original hydrological balance of the basin of the VMB and surrounding regions by artificially unifying not only the urban areas but also the regions beyond the city (Interview-M32). Consequently, the water system has been configured into a sort of mega-basin (Perló and González, 2005; Romero Lankao, 2010). Around the dams, forest cover has decreased, while unsustainable farming practices and human settlements with inadequate sanitation have increased (World Bank, 2015) (Interview-M51). Erosion has caused severe siltation; algae blooms have resulted from the disposal of organic matter and agrochemicals (Martínez, 2018) (Interview-M48). Toxicity levels in the dams have reached such high levels in 2014 that the CONAGUA considered suspending water imports. This was ultimately avoided by adding an additional treatment step (Martínez, 2018). The degradation of the dams’ water quality thus contributes to higher water treatment costs. In addition, uncertainty remains around the effects of climate change on surface water systems, and basin transfers rely on diesel pumps and hence emit greenhouse gas emissions (Interviews-M14/M40).

The power structures in place favour the city, where water is heavily subsidized by the central government, at the expense of water producing areas, where locals often lack access to basic water services while their water is piped and exported (Interviews-M12/M28/M32/M33/M51). However, urban dwellers do not benefit equally from this system. Poorer, peri-urban areas in the East of Mexico City and the MVMC do not receive these waters (Interviews-M28/M32/M48/M50/M52). Top-down management of basin transfers has contributed to rising political opposition and socioenvironmental conflicts with communities in the donor basin (Tortajada, 2008; Engel *et al.*, 2011; Pina, 2011; Spring, 2015). For instance, in 2004, indigenous women from the Mazahua group shut down the megacity’s water supply by peacefully occupying a water treatment plant in Mexico State, after CONAGUA flooded their fields (Spring, 2011). Tensions date back to the 1970’s, when federal authorities started to exploit the communities’ water resources without consultation or compensation. Plans for additional inter-basin transfers have stalled in part because of opposition by local communities, but tensions could escalate if a drought arises (Interview-M12).

Finally, the cost of inter-basin transfers is high, and it is not only borne by users but also by the general population, due to large subsidies. As the systems expand and new sources further away are connected, the costs will increase (Interviews-M15/M48). Cost-benefit analyses are not transparent, and it is not clear whether investments in alternative solutions (i.e. reducing leaks, water reuse) have been adequately considered (Interviews-M40/M48).

### 7.4.2 WATER USE PERMITS

#### Design

Water use permits aim to control water use and provide users with rights and obligations (NWL, 2004, sec. Art. 20). Due to (relative) water scarcity, the water allocation regime is crucial to control water use, as it establishes water abstraction restrictions in certain zones through water use permits and fees (see 7.4.3). CONAGUA grants water use permits through its basin agencies or directly when appropriate (NWL, 2004, sec. Art. 20). Permits specify the
maximum amount of water a user can abstract, the use’s purpose (e.g. domestic, industrial, agricultural), the abstraction’s location and the duration of the right (OECD, 2013). They must be registered in the Public Registry of Water Rights (REPDA), which was created in 2004 to regulate water use and provide information on water uses and legal security to users (Art. 9, NWL). The CONAGUA also grants water discharge permits (see ANNEX G – ADDITIONAL INSTRUMENTS).

Permits are the NWL’s main instrument to achieve hydrological balance, and the CONAGUA is responsible for verifying water availability in the relevant watersheds and aquifers to cover all registered water use permits (CONAGUA, 2015). Mexico is divided in several water availability zones that determine the volume of water that users can request to be granted via a permit. There is no official limit to the total amount of water a user can be granted. However, new concessions cannot be emitted in restriction zones, such as most of Region XIII, which aims to create a ceiling for the level of abstraction within the region (OECD, 2013). In addition, an environmental and economic impact assessment must be presented when requesting a water use permit (CONAGUA, 2018). Water use can be temporarily restricted when it affects the minimum environmental flow and during droughts, and the NWL guarantees priority for public supply in times of scarcity. CONAGUA has the power to sanction those who violate their water extraction agreements, as well as users who grossly abuse or misuse urban water resources (Acevedo et al., 2013).

Domestic and public-urban uses represent about 75% of the total volume of water granted in concessions in the VMB, 18% is allocated to agricultural use and around 5% to industrial use (World Bank, 2013).

Permits are somewhat flexible. SACMEX can relocate its extractions points to new areas within the same aquifer and dig new, sometimes deeper, wells if it does not extract more water (and receives CONAGUA’s authorization). Moreover, water users can transfer their permits to other users within a same basin or aquifer (Federal Constitution, Art. 27). CONAGUA can approve, reject or apply conditions to such transfer request, depending on whether the hydrological or environmental conditions of the concerned basins or aquifers are altered in the process (Art. 34, NWL). CONAGUA charges a small administrative fee for reviewing and authorizing the transfer and registering changes in the REPDA.

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72 Surface water use permits are required if abstraction significantly alters water quality or flow (NWL 2004, Art. 17). Groundwater can be abstracted without a permit, except when the Federal Executive establishes regulatory means to limit extraction and use (NWL 2004, Art. 18). The following zoning restrictions apply: 1) In ‘regulated zones’ aquifers have sufficient mean annual water availability, and addition volumes can be allocated without jeopardizing the aquifer balance; 2) In ‘prohibition zones’ more water is leaving the aquifer (e.g. extractions, natural discharge) than entering it. No new water use permits can be issued. This concerns a large part of Region XIII; 3) ‘Reserve zones’ limit water use for conservation or specific uses.

73 The term ‘environmental use’ or ‘ecological conservation use’ is used to refer to the minimum flow or volume of water needed in receiving bodies or the minimum natural discharge flow of an aquifer, which must be preserved to maintain environmental conditions and the system’s ecological balance (Art. 3, LIV, NWL)
Effectiveness on actors in terms of mandated goals

Water use permits are designed to meet sustainability and inclusion criteria (i.e. preserving minimum environmental flow, guaranteeing priority for human consumption, charging fees to encourage rational use), but they are not adequately enforced. CONAGUA lacks the capacity to continuously monitor all users and rarely sanctions misuse (Acevedo et al., 2013; OECD, 2013) (Interviews-M5/M6/M9/M32/M50). Moreover, bulk water use metres are often absent. As a result, clandestine extractions (without water permits) have persisted despite restrictions in place since the 1950’s (prohibition zones) (Interviews-M6/M7/M9/M32). Inspections are often conducted following ‘citizen complaints’ that inform about irregular activities.

During the last few decades, users have had several opportunities to regularize irregular wells (Interviews-M9/M32). The legalization of irregular uses after the 1992 reforms led to a significant reduction in irregular wells, although not a reduction in extractions, as irregular wells became legal wells (Interview-M32). This sudden legalization meant that the groundwater allocated was greater than the rate of aquifer recharge (Interviews-M32/M48/M52). Worse, actual extraction rates were often much higher still – problems that persist due to strong resistance by permit holders to decrease consumption (see Table 7.4). 864 hm$^3$ are over-extracted each year from the VMB’s aquifers, as shown by calculations based on government data. This corresponds to 27.3$m^3$/s – slightly higher than the volume imported from the Cutzamala System.

Permit transfers are in theory efficient; they allow for new uses without increasing extraction. However, the difficulty of obtaining a permit and the lack of monitoring have encouraged irregular water uses. In addition, permit transfers have spurred a black market where sellers and buyers agree on a (sometimes exorbitant) price (Interviews-M9/M31). Through this black market, permits are often bought for a different purpose than the one they serve on paper: Many wells in the MVMC’s periphery were used for industrial or public-urban purposes but were registered for agricultural use (Interview-M9). As the city grew, and the demand for both water and land increased, real estate companies and industries bought lands from farmers in the periphery to build housing developments, and they also often bought the farmers’ water permits without CONAGUA’s approval and only legalized this permit transfer afterwards (Interviews-M6/M7/M9/M32). Permit transfers are not supposed to involve a financial transaction between users – just an administrative fee to CONAGUA – and require CONAGUA’s approval before the transfer is carried out, yet developers suffered no consequences (Interview-M9/M51/M58). Developers also often infringed rules and regulations regarding land acquisition and building norms, and the local governments either turned a blind eye or eventually legalized the land (Interviews-M22/M23/M50/M51). Permit-holders who no longer need to extract water, should cancel their permit, but this has rarely happened (Interviews-M6/M7). Groundwater permit-holders often consider themselves ‘owners’ of this water and feel entitled to sell it as their property (Interview-M31). In addition, building regulations (i.e. number of floors, percentage of surface area free from construction) are often violated, with no serious consequences (Interview-M51).
Table 7.4 Water availability in the Valley of Mexico Basin's aquifers (in hm$^3$ per year)

<table>
<thead>
<tr>
<th>Aquifers</th>
<th>Aquifer recharge</th>
<th>Natural discharge</th>
<th>Groundwater volume allocated</th>
<th>Groundwater volume extracted</th>
<th>Over-allocation*</th>
<th>Over-extraction**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuautitlán-Pachuca</td>
<td>357</td>
<td>0</td>
<td>415</td>
<td>751</td>
<td>-58</td>
<td>-394</td>
</tr>
<tr>
<td>Metropolitan Zone of Mexico City</td>
<td>513</td>
<td>0</td>
<td>1104</td>
<td>624</td>
<td>-591</td>
<td>-111</td>
</tr>
<tr>
<td>Tecocomulco</td>
<td>28</td>
<td>1</td>
<td>1</td>
<td>13</td>
<td>26</td>
<td>15</td>
</tr>
<tr>
<td>Apan</td>
<td>30</td>
<td>0</td>
<td>19</td>
<td>15</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Chalco-Amecameca</td>
<td>80</td>
<td>0</td>
<td>90</td>
<td>128</td>
<td>-10</td>
<td>-48</td>
</tr>
<tr>
<td>Texcoco</td>
<td>49</td>
<td>0</td>
<td>93</td>
<td>465</td>
<td>-44</td>
<td>-416</td>
</tr>
<tr>
<td>Soltepec</td>
<td>93</td>
<td>42</td>
<td>16</td>
<td>18</td>
<td>77</td>
<td>75</td>
</tr>
</tbody>
</table>

* = Aquifer recharge - Natural discharge - Volume allocated to users
** = Aquifer recharge - Natural discharge - Volume extracted

Source: Adapted from SEGOB (2016a, 2016b, 2016c, 2016d, 2016e, 2016f)

Furthermore, the ability of water utilities to open new, deeper wells if old ones run dry, does not incentivize water use efficiency or efforts to reduce water demand (Interviews-M6/M7/M9/M19/M52). Moreover, permits are issued for a certain amount of time and their renewal should involve an evaluation, which rarely happens due to a lack of capacity and will on behalf of CONAGUA (Interview-M31). Many users even had permits that had long expired without suffering any consequences, although in 2014-2016 CONAGUA carried out a nationwide process to renew such permits without sanctions for a period of three years, after which they would need to apply for a regular renewal (De Regil, 2014; Valadez, 2016).

The basin councils are considered ineffective to address problems related to water use and permits. In part, this is due to inadequate knowledge-sharing mechanisms (Interviews-M31). The COTAS within the VMB do not interact with the basin councils and other entities, impeding integration between surface water and groundwater management (Interview-M32). In fact, significant uncertainty remains regarding surface and groundwater interactions, and about aquifers themselves, due to limited available data on the location of aquifers’ recharge and discharge areas, their depth, flows and more (Interviews-M31/M32). Aquifer and (sub)basin boundaries also do not (necessarily) coincide, but this is often ignored as basin boundaries are taken as management units (Interview-M32). This means that quantitative or qualitative alterations of aquifers may affect a neighbouring basin more than the one directly above it. Moreover, water allocation is mainly calculated on the basis of the average annual availability and the preservation of the minimum environmental flow (or minimum natural discharge in aquifers), but it does not consider the impacts of climate change (OECD, 2013).
Impacts on sustainability and inclusiveness

Aquifers, the main source of water, are recharged through summer rains and natural springs in the surrounding mountains, but extraction rates exceed recharge rates—estimates point out that 45% of water supplied to the MVMC comes from over-exploited aquifers (Tortajada, 2008; Pina, 2011; Martinez and Enciso, 2015) (Interviews-M6/M7/M9). This has led the groundwater table to fall by about one metre per year which, in turn, causes soil subsidence (5-40 cm per year) (Tortajada, 2008; Engel et al., 2011; Pina, 2011). Over-extracting groundwater can lead to the disappearance of ecosystems, wetlands and lakes, and reduced river flow, and the link is not always identified due to delayed effects (groundwater flows are slow) appearing far from their cause (Interviews-M32). Experts warn that Mexico City will run out of water within the next decades if it does not urgently develop sustainable water management (Spring, 2015) (Interview-M9). A business-as-usual scenario for 2030 estimates that renewable water sources will only cover 53.8% of demand, with 21.1 m³/s supplied through over-exploiting current sources and a remaining deficit of 25.1 m³/s (World Bank, 2013). Over-exploiting aquifers will contribute 23% (if they are not pumped dry first)\textsuperscript{74}, while for the remaining 27% new sources are yet to be determined (World Bank, 2013).

Some of the aquifers with higher levels of extractions than registered use, such as Cuautitlán-Pachuca and Texcoco, export water to Mexico City (Escolero et al., 2016). The groundwater table of the Cuautitlán-Pachuca aquifer, just north of Mexico City, was reported to decline by two metres per year (Ramírez, 2015; Escolero et al., 2016) (see Table 7.4). The inauguration of a soda drink plant that would extract large volumes of water annually—despite the aquifer’s classification as a ‘prohibition zone’ and the low priority of this use—caused conflicts between civil society, CONAGUA and the soda drink company in 2017, as experts warned this threatened public water supply (Olvera, 2017). Illegal abstractions are also estimated to be among the highest nationwide (Galindo, E. et al., 2011; Ramírez, 2015). The pressure on aquifers surrounding Mexico City highlights that this is a metropolitan problem requiring a regional solution with coordination between actors from the jurisdictions involved. Considering that the Cuautitlán-Pachuca and Texcoco aquifers are home to large, low-income peri-urban populations, questions of unequal access and power relations arise: Of every 100 residents of the VMB, only 6 do not suffer from water scarcity (Burns, 2009). Of these 6, two residents consume on average 567 l a day, and four 399 l. As many as 77% of residents consume less than 150 l a day, but often for a higher cost as water is frequently transported through trucks (Burns, 2009).

The maps in Figure 7.1 build on Table 7.4 and highlight the water availability based on calculations derived from CONAGUA’s data on water allocation (official calculation to determine water availability) and water extraction\textsuperscript{75}. The MVMC spreads mainly across the Mexico City aquifer in its South and the Cuautitlán-Pachuca aquifer in its North. Comparing the two maps reveals that CONAGUA’s current water availability calculations may be

\textsuperscript{74} The current knowledge on the exact volume and flows of groundwater in the MVMC are still limited, making it difficult to develop accurate forecasts (Interview-M32).

\textsuperscript{75} CONAGUA calculation of water availability = Aquifer recharge – natural discharge – water allocated. Alternative calculation of water availability = Aquifer recharge – natural discharge – water extracted
misleading, as water extractions can be significantly below or above the volumes allocated to users within an area. In fact, tensions between Mexico City and Mexico State (where the Cuautitlán-Pachuca aquifer, in dark orange on the right-hand map, is located) are rising. This indicates that while Mexico City’s aquifer may be more over-exploited, surrounding aquifers are rapidly depleting.

**Figure 7.1** Water balance per aquifer based on allocated water (left) and extracted water (right)

![Water balance per aquifer](image)

Source: Author

Water allocation remains a top-down process. The lack of data transparency creates confusion about real water abstraction and the areas that require greater support in addressing unsustainable water use practices. Ineffectiveness and corruption favour wealthy users willing and able to pay high prices for water permits, as CONAGUA lacks capacity to pursue irregular permit holders. In addition, this black market for permits is most likely facilitated by insiders. One groundwater expert claimed that CONAGUA employees attempted to sabotage the COTAS as monitoring and accountability-holding activities threatened entrenched (and corrupt) interests (Interview-M32). In April 2019, a fire broke out in a CONAGUA building over the weekend, and amidst rumours of an upcoming audit, within an area that held important documentation relating to water use permits (Martínez, 2019).

7.4.3 **WATER USE FEES**

*Design*

CONAGUA employs a ‘user-pays’ principle, meaning users must pay a fee for the abstraction and use of water resources (NWL, 2004). These bulk water fees aim to incentivize water utilities to invest in reducing per capita consumption, while representing the main mechanism for water users’ contribution to financing WRM (OECD, 2013). They were introduced in Mexico in 1982 and their rates vary according to the type of use (e.g. industry, urban,
hydropower, aquaculture and recreation) and geographical location. Water use for agriculture, for domestic use related to agricultural activities and for rural settlements of less than 2500 inhabitants are exempt from paying water use fees (DOF, 1981). Mexico’s basins and aquifers are classified in one of four different ‘availability zones’ that reflect water scarcity, and typically the cost of the cubic metre is higher in low availability zones (CONAGUA, 2018). The bulk water rate is determined by an algorithm published in the Federal Law of Rights (DOF, 1981) and adjusted annually by CONAGUA (CONAGUA, 2018).

The Federal Treasury, collects fees from users other than water utilities and from inter-basin transfers through the Basin Agency (World Bank, 2015). These fees fund the bulk of CONAGUA’s budget and programmes such as the federal payment for ecosystem services programme (PSAH) (see 7.4.4) (World Bank, 2013). Since 2004, water utilities pay bulk water fees to the regional Fideicomiso 1928 trust fund, which invests in large-scale drainage and sanitation works in the VMB (World Bank, 2015). The governments of Mexico State and Mexico City are the fund’s settlors and CONAGUA acts as president and technical coordinator (World Bank, 2015). The SACMEX also includes this trust fund as part of its financing plan (OECD, 2013).

Users also pay a fee for wastewater discharge, based on the ‘polluter-pays’ principle (NWL, 2004). These fees are set at Federal level. However, this fee is only charged if the discharge does not meet minimum quality standards (Interviews-M5/M6/M7). The fee aims to cover investments in wastewater treatment (DOF, 1981).

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

The delimitation of availability zones and the identification of the VMB as a water scarce region means that water use fees should ideally reflect the gap between water availability and water demand (Interview-M32). Indeed, as water availability decreased in the VMB, bulk water use fees charged increased significantly (World Bank, 2013), even if they remain generally low and were restricted mostly to industrial uses (Interviews-M5/M32). Agricultural users were exempted if they remained within their licensed quotas and the rate for water use exceeding their licensed quota was only between 0.7% and 8% of the general rate (depending on the availability zone) (OECD, 2013) (Interviews-M32/M50).

Most fees collected reflect users’ self-reported volume of water use. Users have some incentives to regularize their water usage and pay some fees. In particular, energy costs for pumping groundwater are subsidized but to apply for these subsidies, users must show their water use permit. Audits of industries also often start with a request to see water use permits and bills from water use fees (Interview-M32). Nonetheless, Basin Agencies cannot afford to inspect most users, so these self-reported values were rarely verified (Interview-M58). The lack of macro-metering also encourages under-reporting (Interview-M19). Lack of monitoring, enforcement and exemptions also impacts wastewater discharge fees (Interview-M40). The total value of the collected water use fees (for public supply and other uses) in Mexico has increased slightly between 2008 and 2017, reaching just over USD 860 million in 2017, and Region XIII contributes over a third of this amount (CONAGUA, 2018). In 2017, the value of
the wastewater discharge fees collected in Mexico was only USD 80 million. In 2009, the collected wastewater discharge fees represented 0.4% of the amount needed per year for 2011-2015 to clean water bodies according to CONAGUA (CONAGUA, 2012a). The fees go to the Federal Treasury and are reinvested in Federal level programmes, which are unlikely to be related to preventing contamination (Interview-M58). As a result, all users lacked incentives to reduce water use, invest in water saving technologies or prevent water contamination (Interviews-M5/M9).

**Impacts on sustainability and inclusiveness**

The limited effectiveness of bulk water use and wastewater discharge fees aggravates that of water use and wastewater discharge permits, reinforcing the same impacts (see Impacts – Section 7.4.2). Nevertheless, the fees paid by water utilities in the VMB are partly reinvested in water supply and sanitation infrastructure through the Fideicomiso 1928 trust fund (see 7.4.1), which has supported the cash-strapped utilities (OECD, 2013) (Interview-M19). However, a large volume of water used by utilities in the MVMC comes from other basins, but their fees benefit infrastructure within the VMB. This does not compensate donor basins for infrastructure maintenance or ecosystem preservation. Fees from other users are absorbed at national level and do not benefit the MVMC or its donor basins.

### 7.4.4 PAYMENT FOR ECOSYSTEM SERVICES (PES)

**Design**

Several water-related PES programmes have been implemented in Mexico. At federal level, the CONAFOR (National Forestry Commission) manages the Payments for Hydrological Ecosystem Services Programme (PSAH) – the main PES programme focused on hydrological services. It was implemented in 2003 to protect and restore ecosystems, and preserve their services through direct economic compensation to the providers of environmental services (OECD, 2013; Perevochtchikova and Torruco Colorado, 2014). It is one of the world’s largest PES programmes focused specifically on watershed services and was mainly funded by revenues from bulk water use fees, ensuring it stable, long-term funding (OECD, 2013). Landowners were eligible for different payment levels depending on the type of ecosystem in combination with their score on a deforestation risk index, and payments were issued yearly after verification of the forest cover (through satellite image analysis or ground visits) (OECD, 2013). Areas that lost forest cover were removed from the programme and payments were reduced proportionally (OECD, 2013).

In Mexico City, the CORENA (Natural Resources Commission of Mexico City) manages the PROFACE (Support Funds for the Conservation and Restauration of Ecosystems Program) programme, which covers 13,000 hectares. It financially compensates landowners or designated groups for conservation efforts in important sites, including through fire prevention, productive reconversion, the preservation of agroforestry systems and silvopastoral systems. Brigades are trained for each participating area for environmental monitoring, including
through GIS (Interview-M30). These payments are generally focused within the Conservation Land (see 8.4.4). Mexico State also has a PES programme, similar to the PSAH, financed by a percentage of the Wat&San tariff.

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

Results appear to be mixed. To be effective, PES programmes must compensate for the opportunity cost of preserving rather than developing land. This opportunity cost varies greatly across the country, being higher close to Mexico City and lower in isolated, distant areas (Interview-M48). The financial compensation of the PSAH is much lower than the opportunity cost of refraining from exploiting or selling the land, as payments only average USD 15-20 per hectare per year (Interviews-M2/M9/M26/M48/M50/M54). Landowners often worry about informal occupations of their land and illegal loggers and choose to develop or sell their land (Interview-M10/M26/M48). As a result, CONAFOR encourages alternative activities compatible with environmental protection, such as honey and essential oils production, or ecotourism (Interview-M10). Those involved with the programme compared the payments to seed money supporting local projects in their initial stages (Interview-M55).

There have been virtually no studies on the impact of PROFACE, although respondents familiar with the programme claimed it had modest yet positive results, despite a low budget (Interviews-M15/M17/M29/M37). Supporters argue that it is more permissive but also more pragmatic than the PSAH. To expand, the SEDEMA would need to be convinced that the programme was effective, but without evaluations this was difficult (Interview-M30). The PES programme in Mexico State ensures a stable, reliable inflow of funds, although these remain low due to subsidized tariffs and consumers who did not pay their water bills (Interview-M15). Nevertheless, this financial stability gave recipients security.

Despite the existence of multiple PES programmes, there were no coordination mechanisms between these or with similar policy instruments. In addition, PES programmes focused on water were not always designed based on basin or aquifer boundaries, which hindered the ability to measure changes in ecosystem services (Interview-M55).

**Impacts on sustainability and inclusiveness**

PES programmes have potential to preserve areas important for springs and aquifer recharge. This is crucial for the MVMC to continue using groundwater in the coming decades. However, near large urban centres the opportunity cost of protecting land rather than selling it to real estate developers or others is too high for many landowners (Interview-M46/M48). Recent studies show that areas of Mexico City included in the PSAH programme sometimes had higher deforestation indices than other areas (Saavedra Diaz et al., 2017). As those areas were under pressure from real estate and agricultural interests, it was difficult to evaluate whether deforestation would have been worse without the programme. Although there has been no formal assessment of the PROFACE programme, respondents claim that biodiversity and reforestation increased in the areas involved in recent years (Interview-M30).
However, critics argue that PES programmes put an arbitrary value on water resources and reinforce their commodification (Interview-M58). It is also politically difficult to charge fees or taxes in one jurisdiction, in order to reinvest these funds elsewhere for results that would only be apparent in the medium to long term (Interview-M28). This would likely be the case with a PES programme for the Cutzamala System financed by the MVMC. However, supplying water is increasingly expensive (e.g. groundwater pumped from deeper depths and inter-basin transfers from more distant regions), and these costs will rise much more sharply if no urgent measures are implemented to preserve ESSs.

7.5 INSTRUMENT ASSESSMENT AND REDESIGN

The instruments employed in the MVMC’s river basin governance were sometimes promising on paper, but generally failed to effectively change actors’ behaviour and foster more sustainable and inclusive water governance. The linear approach still dominated key institutions and policy frameworks. Water resources from multiple states were transported into the MVMC and out (as wastewater) through a complex infrastructural network of inter-basin transfers, deep drainage tunnels and canals. This artificially connects four basins and multiple jurisdictions, leading some to use terms such as ‘City-basin’ (Peña-Ramirez, 2012) or the ‘Hydropolitan Region’ (Perló and González, 2005). This multi-basin structure has lowered incentives for rational water use, reducing contamination and preserving vital ecosystems (see Table 7.5).
Table 7.5 Assessment of IWRM/IRBM policy instruments in the MVMC

<table>
<thead>
<tr>
<th>Instrument design</th>
<th>Effects on actors</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-basin transfers</td>
<td>[0/+] Ability to respond to rising water demand (for now), though water supply is unequal across the MVMC; Subsidies reduce incentives to decrease water use and losses</td>
<td>Env: [--] Reduced pressure on aquifers, but externalities are transferred to donor basins; Soc: [--] Peri-urban and rural dwellers receive less water; Econ: [--] Subsidies hide real costs; Rel: [--] Conflicts with donor basin. Decisions are centralized and lack transparency</td>
</tr>
<tr>
<td>Water use permits</td>
<td>[0] Necessary to respond to growing demand and reduce pressure on aquifers; Subsidies reduce incentives to decrease water use and losses</td>
<td>Env: [--] Groundwater table has fallen, and local sources may dry up in next decades; Soc: [--] Peri-urban poor lack adequate access to drinking water; Econ: [--] Industrial and real estate actors obtain permits, but they are hardly enforced, leading to (unsustainable) economic and urban growth; Rel: [--] Industrial users receive permits despite scarcity. Lack of transparency</td>
</tr>
<tr>
<td>Water use &amp; wastewater discharge fees</td>
<td>[0] Rates vary per use and area; Reinvested in drainage and sanitation works in the VMB or go to Federal Treasury or prohibition zone and other strict regulations exist, but lack of metres, cost of monitoring and impunity hindered enforcement. Low fees and energy subsidies promote high use. Only part of the fees was reinvested regionally</td>
<td>Env: [--] Same as water use and wastewater discharge permits; Soc: [--] Same as water use and wastewater discharge permits; Econ: [--] Fees were not all reinvested locally or even in water management; Rel: [--] Donor basins are not compensated for their ESSs</td>
</tr>
<tr>
<td>Payments for Ecosystem Services programmes</td>
<td>[0] Does not always compensate for opportunity cost, but demand grew, and funds are insufficient. Stable funds are important</td>
<td>Env: [--] Deforestation and degradation continue on urban fringe. Difficult to link programmes to local impact; Soc: [0] Restricting urbanization does not address the affordable housing deficit; Econ: [+] Programmes are costly, but degradation is much more so in long-term; Rel: [+] Alternative for landowners. Recognition of the value of ESSs</td>
</tr>
</tbody>
</table>

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

Based on the evaluation of the above instruments, the following redesign options look promising.

**Inter-basin transfers:** As aquifers are increasingly over-exploited, it is unrealistic to support the dismantling of inter-basin transfers in the short or medium-term, despite the many negative externalities they cause. In the longer-term, a combination of measures could alleviate the need for external resources, but in the meantime decision-making on water imports could be more transparent and inclusive of marginalized interests, as current decisions regarding the expansion of inter-basin transfers are centralized and made behind closed doors. Involving basin councils in discussions would allow for different interests to be voiced and greater social inclusion. While they may not have mandates to influence infrastructure decisions, members should at least have access to financial information to ensure accountability. Investing more resources in land use management and environmental conservation in the donor basins, as well as basic infrastructure for communities living near water supply dams, would reduce water losses, increase the productivity of water systems and include currently marginalized groups. This could be through federal funds, PES programmes or revenues from bulk water fees. This will sustain supply dams by ensuring that springs continue to replenish them, reducing the need for searching for new sources further away at increasing costs. Indeed, the strategy of supplying the MVMC with inter-basin transfers is reaching the limits of economic viability. Investments in donor basins could also come from the water use fees for uses other than public supply and from basin transfer fees. These fees are now collected by the Federal Treasury but at least part of them (e.g. those coming from basin transfers) could be reinvested in donor basins. Changes to water tariffs for domestic consumption (see 8.4.1) could also increase water conservation within the MVMC and reduce the need for water imports.

**Water use permits:** To increase their effectiveness, water use permits do not need to be redesigned but to be better enforced. Addressing irregular water use requires monitoring, which is costly as much of it involves groundwater extraction, which is less visible. However, monitoring teams do not need to inspect all users constantly. The current impunity for violations must be addressed by applying adequate fines that reflect the severity of the transgression (Interview-M9). This will make non-compliance more costly, reduce irregularities and reduce water use, while fines would help fund monitoring costs. These efforts can be focused on large water users, such as big industries, as their use significantly impacts other (potential) users and their development and investments plans are generally less affected by the payment of water use fees. Smaller users require technical assistance through CONAGUA, as the process of obtaining a permit can be burdensome and expensive (Sanz, 2015).

A significant challenge relates to permit transfers, as these are not adequately regulated. Combined with a lack of land use and building regulations and environmental regulations, users such as real estate developers and industries can obtain water use permits, thereby allowing for unsustainable urban expansion and economic activities. This could be prevented by requiring environmental impact assessments that address consequences on over-exploited aquifers and access to water for nearby residents and how these would be compensated. Strengthening the
basin councils and the COTAS could also better include diverse, local interests into decision on water allocation.

Moreover, more transparency is needed regarding data collection and calculations of water availability and extractions. CONAGUA calculates water availability based on how much water is already allocated rather than how much is extracted, seemingly assuming these values are the same. If the system to calculate water availability is not adjusted, at least relational inclusiveness can be enhanced by making its methods more transparent.

In addition, if CONAGUA aims for environmental sustainability and social and relational inclusiveness then the enforcement of priority uses is crucial. Water-intensive industries could undergo environmental impact assessments with a significant emphasis on their potential impacts on water availability for other users. If it is determined that these industries would jeopardize surrounding communities’ drinking water access and the sustainability of the aquifer, licensors could withhold approvals, in particular when these communities oppose the presence of such industries.

**Water use fees:** Expanding mandatory and tamper free metering and water use fees could promote more rational water use (Interviews-M13/M15/M46). This requires transgressions to be subjected to sanctions. While it may be difficult to implement water use fees for agricultural users, incentives can be put in place for farmers to transition to less wasteful irrigation techniques. This could involve a combination of subsidies for irrigation technologies and the strengthening of irrigation districts to seek collaborative solutions to growing water scarcity.

Another issue is that water use fees are not necessarily returned to the basin where they were charged, as is the case in the MRSP. This creates a disconnect between water users and the areas that produce water resources. By applying a system similar to that of the MRSP, the willingness to pay of users may increase and it could strengthen participatory basin management by creating a source of revenue for basin councils.

**Payment for Ecosystem Services:** As most land in Mexico is privately owned, implementing strict land use restrictions with no compensation would amount to expropriation and lead to time-consuming and costly litigation and uncertainty. Considering this context, PES programmes have potential in areas under pressure from urban and agricultural expansion. However, funding sources for PES programmes remain scarce. Integrating a small fee within water and sewage tariffs for such programmes, as is the case of Mexico State, is viable as Wat&San tariffs are currently very low (see 8.4.1). Low-income households could be exempted from paying this additional fee. The fee could increase proportionally with consumption. This would not only ensure stable funding and incentivize rational water use, but it could also raise awareness among consumers by emphasizing the link between water sources outside the city and their taps.

Furthermore, returning the collected fees proportionally to the areas where water came from can enhance sustainability and inclusiveness. More environmentally sustainable management of the river basins that drain into the Cutzamala system could reduce water imports. However, while there is some recognition (with still limited action) of the ecosystem services provided by areas within the metropolitan area, there is virtually none for the
ecosystem services provided in these other basins. This requires integrating PES programmes with basin and aquifer management and could strengthen the link between IWRM/IRBM and urban water services. It could also capacitate basin councils and increase their weight in negotiations (Interviews-M40/M55). PES programmes would then account for interconnections and spillovers across different basins. Ultimately, a mix of regulatory and economic instruments are necessary to preserve environmentally significant areas and landowners require greater support to contribute to these measures.

Coordinating PES programmes and environmental agencies with authorities responsible for urban planning and land use could also help address the challenge of environmental preservation at its root, by finding solutions for affordable housing in other areas or by promoting densification rather than sprawl.

**Missing instruments**

Water use should be compatible with the needs of current and future consumers but also with those of the basin(s) from which water is supplied. Reinvesting bulk water use fees and water tariffs in programmes to preserve ecosystem services are potential mechanisms for this purpose. For reinvestments of water tariffs, this requires Wat&San planning that looks beyond the boundaries of the utility’s jurisdiction, at a larger regional, scale.

Some alternative approaches have been gaining support, including facilitating groundwater recharge in the city through green infrastructure and artificial aquifer injections (where rainwater or treated wastewater is injected into the ground), or environmental protection in areas of aquifer recharge (particularly in the mountains surrounding the basin). These both mitigate excess surface water runoff and replenish water supply sources. The effectiveness of these measures is difficult to determine due to the many unknowns surrounding groundwater flows (e.g. velocity, impact on water quality from contaminants). Understanding groundwater flow dynamics is important for prioritizing preservation efforts and for installing water injection technology in optimal locations (Interview-M32). More groundwater studies are needed to evaluate the potential impacts and costs of such measures, and thereby the extent to which it could reduce the dependence on external water resources.