Scalar mismatches in metropolitan water governance
A comparative study of São Paulo and Mexico City
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1. INTRODUCTION

1.1 INTRODUCTION

Large cities have heavy impacts on their rural hinterlands, while also depending on these and the natural resources they provide. In 2018, the city of Cape Town made international news headlines for months as it was battling a severe water shortage and heading closer to ‘Day Zero’, the day that municipal water supplies would be shut off (Alexander, 2019). The reallocation of water earmarked for agriculture to urban residents helped mitigate the looming disaster. In 2003, a dam that supplies water to Mexico City through an inter-basin water transfer flooded 300 ha of fields cultivated by the Mazahua indigenous community (Marcos and Fernández, 2016). The Federal government did not respond adequately to their claims, leading to peaceful but long and highly mediatized protests by Mazahua women for compensation and access to drinking water1. Such examples illustrate the rising tensions between cities and their river basins, leading to challenges in terms of water quantity, quality and climate change adaptation. These tensions are triggered by a combination of population growth, urbanization, economic growth, consumption patterns, anthropogenic climate change, land use and other driving forces at multiple levels (Vörösmarty et al., 2000; Elmqvist et al., 2013; Nobre and Marengo, 2016; UN-HABITAT, 2016). Water challenges are particularly severe in megacities of the Global South, marked by stark inequalities within the urban agglomeration and between the city and its rural hinterlands, and where the urbanization process is unfolding at an accelerated pace (Elmqvist et al., 2013; Azzam et al., 2014). Although the world’s 100 largest cities occupy less than 1% of the planet’s land area, the basins that provide their water resources cover more than 12% of it (ARUP, 2018). Estimates indicate that cities with populations larger than 750,000 people draw water from almost half of the global land surface and transport it over a cumulative distance of 27,000 km (McDonald et al., 2014).

This thesis examines the tensions between urbanization and river basins through interactions between metropolitan governance regimes with integrated basin management regimes. More specifically, it explores the role that institutions play in urban water challenges, how effective existing policy instruments are in addressing these challenges within metropolitan regions and how more sustainable and inclusive institutions could be designed for this purpose. It does so by focusing on the cases of São Paulo in Brazil and Mexico City, in Mexico (see 2.2.2 for details).

This chapter presents the growing worldwide tensions between water use at urban and river basin scales, their theoretical underpinnings, the gap in scholarly knowledge, and their policy implications (see 1.2). It then introduces the ensuing research questions that this thesis aims to answer, as well as its focus and limits (see 1.3), provides a background on the nature of water (see 1.4), discusses the position of the researcher (see 1.5) and, finally, the overall structure of the thesis (see 1.6).

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1 Despite living near the large dam, local Mazahua communities were not connected to the public water supply network.
1.2 WATER CHALLENGES AND METROPOLITAN REGIONS

1.2.1 RISING WATER CHALLENGES IN AN URBANIZING WORLD

Today, around 55.3% of the global population is urban (UN-DESA, 2018). As this number rises in the coming decades, the burden cities impose on their river basins is likely to intensify, even if in an uneven manner (see Map 1.1). The Global South will lead this urban growth. Asia and Africa will add 2.5 billion urban residents by 2050 (see Figure 1.1) (UN-DESA, 2018). Latin America, already one of the world’s most urbanized regions, should see urban populations increase from 81% in 2015 to 88% by 2050 (see Figure 1.2) (UN-DESA, 2018). By comparison, 82% of Northern America’s population lived in urban areas in 2018 (UN-DESA, 2018).

Map 1.1 Large cities and basins around the world in 2015

Source: Author

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2 Recent research suggests that urbanization levels are much higher, due to the fact that countries self-report their demographic statistics and use very different standards (Scruggs, 2018).
Figure 1.1 Global expansion of urban population, 1950-2050 (thousands)

![Graph showing global expansion of urban population from 1950 to 2050.](image)

Figure 1.2 Urban population per region (percentage)

![Bar chart showing urban population distribution by region.](image)

Table 1.1 Evolution of the number of urban settlements per population size

<table>
<thead>
<tr>
<th>Population size</th>
<th>Number of urban settlements</th>
<th>1950</th>
<th>2015</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 million or more</td>
<td></td>
<td>2</td>
<td>29</td>
<td>43</td>
</tr>
<tr>
<td>5 to 10 million</td>
<td></td>
<td>5</td>
<td>45</td>
<td>66</td>
</tr>
<tr>
<td>1 to 5 million</td>
<td></td>
<td>69</td>
<td>439</td>
<td>597</td>
</tr>
<tr>
<td>500 000 to 1 million</td>
<td></td>
<td>101</td>
<td>554</td>
<td>710</td>
</tr>
<tr>
<td>300 000 to 500 000</td>
<td></td>
<td>129</td>
<td>707</td>
<td>827</td>
</tr>
</tbody>
</table>

Source: Based on raw data from UN-DESA (2018)
As the global urban population rises, so does the number of cities of various sizes. More and more people are living in metropolitan regions, characterized by a contiguous urban area often governed by multiple political jurisdictions (see Box 1.1). In 1950, 177 cities had more than 500,000 inhabitants. This increased to 1,067 by 2015 and it is expected to further rise to 1,416 by 2030 (see Table 1.1) (UN-DESA, 2018). Megacities, the focus of this thesis, are defined as cities of 10 million inhabitants or more; they have increased from 2 in 1950 to 29 in 2015 and possibly 43 in 2030 (UN-DESA, 2018). Urban settlements with less than 300,000 inhabitants will remain the largest in number and in total population. Nevertheless, the population of larger cities is increasingly predominant both in relative and in absolute terms. In 1950, there were over 250 million inhabitants in cities larger than 500,000 inhabitants (less than 10% of the global population); by 2015 this population had increased to over 2 billion (more than 27%), and it is projected to reach almost 3 billion by 2030 (more than 33%) (see Figure 1.3) (UN-DESA, 2018). This recent, yet accelerated, worldwide transformation of the natural environment through urbanization is a characteristic of the ‘Anthropocene’.³

As cities around the world grow, so does their demand for goods and services, including resources such as water, food and energy, which come largely from surrounding areas (Jenerette and Larsen, 2006). Besides population growth, the economic development that often follows urbanization further increases per capita water use in cities (McDonald et al., 2014). Urban water demand is expected to increase by 80% by 2050 while total available freshwater remains more or less constant (Flörke et al., 2018). This demand is unevenly distributed across the world’s river basins. Between 1.6 and 2.4 billion people live in river basins that experience water scarcity (Gosling and Arnell, 2016). In quantitative terms, ‘chronic water shortages’ take place when an area’s annual water supply drops below 1000m³ per person, and ‘absolute water scarcity’ takes place below 500m³ per person (FAO, 2012).⁴ Managing water resources across large cities and their river basins has led to increasing competition, tensions and conflicts (Varis et al., 2006; Tortajada, 2008). Despite the far-reaching impacts of these cities, and their potential to influence basin management, cities invest very little in their basins (ARUP, 2018).

³ The term ‘anthropocene’ is a geologic term for an epoch that starts when human activities began to have a significant global impact on the Earth’s ecosystem (Crutzen and Stoermer, 2000).

⁴ Population growth and climate variability and change may lead to as many as 3.1 billion people (37% of the global population) living in water scarce river basins by 2050 (Gosling and Arnell, 2016).
Box 1.1 Definitions of large cities

There are multiple terms to refer to cities, but no internationally-recognized definitions with standardized criteria for determining the boundaries of any given urban area (Slack, 2007; Knieling, 2014; United Nations, 2016b). ‘City proper’ is generally used to define a city according to an administrative boundary (United Nations, 2016b). Terms associated with large, multi-jurisdictional urban areas include metropolis, metropolitan area, metropolitan region, megacity, urban agglomeration, and more. Definitions generally refer to a large urban core with adjacent urban and rural areas that are socially and economically integrated with the core (Slack, 2007). The key terms are:

**Urban agglomeration**: This definition is based on physical characteristics as it considers the extent of the contiguous urban area, or built-up area, as the limits of the city’s boundaries (United Nations, 2016b).

**Functional urban areas**: Urban area defined by a method that relies on settlement patterns and commuting flows rather than administrative borders (OECD, 2012).

**Metropolitan regions**: The term ‘metropolitan region’ is used by international institutions (OECD, World Bank, etc.) and European authors (Herrschel and Newman, 2002; Salet et al., 2003; Sellers et al., 2013) to describe highly urbanized, city-regional areas characterized by high population densities and the concentration and interconnectedness of economic, political and cultural activities (Knieling, 2014; United Nations, 2016b). These cities are typically composed of multiple jurisdictions with independent political authorities. Minimum population thresholds for the city core are not necessarily very high (i.e. 50,000 or 100,000 in some cases), but adjacent areas of lower density are connected to the core and under its influence (United Nations, 2012; Knieling, 2014).

**Megacities**: The term ‘megacity’ has been defined by the United Nations as an urban agglomeration of at least 10 million inhabitants (United Nations, 2012).

**Metacities**: UN-Habitat introduced the term ‘metacity’ to describe “massive conurbations of more than 20 million people” (UN-Habitat (United Nations Human Settlements Programme), 2006).

**Megalopolis**: This term refers to a clustered network of cities. There is no consensus on population size, with definitions ranging between 10 million (Doxiadis, 1970) and 25 million (Gottmann and Harper, 1990).

The definition of a city’s boundaries has implications for population assessments (United Nations, 2016b). Although the two case studies in this study – São Paulo and Mexico City are ‘megacities’, this study favours the terms metropolitan region or area as these are the terms used by the relevant authorities of each jurisdiction.
Rapid urbanization and land use changes have also caused water quality deterioration through drastic interferences in ecosystems and the hydrological cycle (Azzam et al., 2014). Deteriorating water quality poses significant risks to human and environmental health (OECD, 2015b). Estimates indicate that around one third of all rivers in Latin America, Africa and Asia are affected by severe pathogen pollution\(^5\), although it is not clear how many people are at risk of coming into contact with polluted waters as current estimates only account for rural populations (UNEP, 2018). Water quality in urban rivers is often heavily impacted by point source pollution, such as untreated wastewater discharge, and this is worsened by high population density and the concentration of polluting activities (Vlachos and Braga, 2001; Elmqvist et al., 2013). Diffuse pollution from agriculture (e.g. fertilizers and pesticides) and urban sources (e.g. runoff from sealed surfaces and roads) also affects urban areas and is particularly challenging to regulate (Martinez-Santos et al., 2014). Water contamination by large and mega-cities aggravates issues such as regional water stress and unequal access to water resources (Varis et al., 2006). In addition, treating water to meet adequate drinking water standards can represent a considerable cost for some countries (OECD, 2015b). However, inaction is also costly, as contaminated water bodies can lead to outbreaks of waterborne diseases and negatively impact both urban residents and communities and the environment far downstream (Vlachos and Braga, 2001; OECD, 2015b).

Extreme weather events can cause floods, landslides and droughts with devastating effects on urban and rural settlements. Many large urban agglomerations are located in the Global South and have limited coping capacities (Kraas et al., 2014). As cities grow, they tend to expand into risk-prone areas as available land becomes scarcer and more expensive (UCLG, 2016). In 2000, about 30\% of global urban land was in high-frequency flood zones. By 2030, this will rise to 40 per cent (Güneralp et al., 2015). These hazards can be part of seasonal variations (e.g. monsoons) and climate variability, but climate change is expected to aggravate their frequency and intensity by causing changes in hydrological patterns, with more evaporation and melting through warming, and more frequent and intensive extreme weather events (Engel et al., 2011). Large cities are particularly vulnerable to climate change, as they are often located in coastal areas, flood-prone areas or areas suffering from water scarcity and droughts (Biswas, 2004; Varis et al., 2006; Hansjürgens and Heinrichs, 2014). In addition, water-related risks are compounded by human factors such as population density, socio-economic inequality, poor urban planning and the environmental impact of land use changes (e.g. erosion from deforestation, rapid urbanization) (Rietveld et al., 2016).

1.2.2 The Policy Challenge: Implementing IWRM is Key to Advancing

There have been many discussions within global policy circles on water-related challenges since the UN Conference on the Human Environment in 1997, including special attention paid to Agenda 21 adopted in 1992 (see Conti, 2017; Obani, 2018 for details). The most recent global discussions on water-related goals took place in 2015 within the context of Agenda 2030, where the UN General Assembly adopted water-related goals within its Sustainable

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5 Severe pathogen pollution occurs where monthly in-stream concentrations of faecal coliform bacteria are >1000 cfu/100ml.
Development Goals (UNGA, 2015). These Goals highlight areas of priority for the global community to work on. Goals 6 (Ensure availability and sustainable management of water and sanitation for all), 11 (Make cities and human settlements inclusive, safe, resilient and sustainable) and 13 (Take urgent action to combat climate change and its impacts) and their associated targets and indicators are relevant for this research. These goals are linked to water quantity, water quality and climate change adaptation in multiple ways (see Table 1.2).

SDG target 6.5 promotes the implementation of IWRM (Integrated Water Resources Management) at all levels, implicitly recognizing it as the most appropriate management approach to the world’s diverse water-related challenges and necessary to attain all other SDG 6 targets (UNEP, 2018). The suggestion that this implementation should take place “at all levels” highlights the multi-scalar nature of these challenges. IWRM is deemed critical for the 2030 SDG agenda as a way of allocating water resources efficiently, equitably and sustainably and coordinating sustainable development in the global context of increasing water scarcity and pollution. Progress on SDG 6.5 is measured by two indicators: a score of 0 to 100 on the degree of IWRM implementation and the proportion of transboundary basins with cooperation agreements. Nonetheless a 2018 self-assessment survey answered by 172 countries as part of a UN Progress Report on SDG 6, indicates that around 60% are unlikely to implement IWRM by 2030 (UNEP, 2018). Survey results further revealed that sub-national and lower levels lag even further behind and emphasized the need for coordination across levels to ensure the flow of resources to where they are most needed and effective.

The survey results mention links with SDG 11 on ‘Sustainable Cities and Communities’ and SDG 13 on ‘Climate Action’, but they do not provide clarifications on how to develop synergies between them. There seem to be clear interlinkages between the goals: SDG target 6.5 (Implement IWRM) relates to SDG 11.5 (Reduce effects of water-related disasters) and to SDG 13.1 (Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters). In fact, the first indicators for the SDGs 11.5 and 13.1 are identical: “Number of deaths, missing persons and persons affected by disaster per 100,000 people”. In addition, targets 6.1 and 6.2 (access to drinking water and sanitation) are closely intertwined with target 11.1 (ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums). Target 6.3 (reduce pollution, including from untreated wastewater) could be linked to target 11.6 (reduce the adverse per capita environmental impact of cities), but the latter is only focused on pollution from solid waste and air pollution. Moreover, IWRM planning has potential synergies with SDG 11.B and SDG 13.1, which both promote the adoption of local and national disaster risk reduction strategies.

This brief review demonstrates that there are clear interlinkages between these three Goals. Nonetheless, the abovementioned report does not clarify how countries can explore these links, allowing for coordinated responses and promoting win-win strategies. This research aims to help fill this gap, contributing to the SDGs by focusing on how these inter-linkages positively and negatively impact urban water challenges and how these synergies can be harnessed.

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6 Indicator 6.5.2 on transboundary agreements concerns basins and aquifers shared by at least two countries.
<table>
<thead>
<tr>
<th>Water quantity</th>
<th>Water quality</th>
<th>Climate change adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6.1</strong> Access to drinking water</td>
<td><strong>11.5</strong> Reduce effects of water-related disasters</td>
<td></td>
</tr>
<tr>
<td><strong>6.2</strong> Access to sanitation</td>
<td><strong>11.1</strong> Access to housing, basic services &amp; slum upgrading</td>
<td></td>
</tr>
<tr>
<td><strong>6.3</strong> Reduce water contamination</td>
<td><strong>11.B</strong> Increase the number of cities with integrated policies &amp; plans for inclusion, resource efficiency, climate change adaptation &amp; disaster resilience. Develop holistic multilevel disaster risk management</td>
<td></td>
</tr>
<tr>
<td><strong>11.6</strong> Reduce cities’ environmental impact, including through waste management</td>
<td><strong>11.2</strong> Integrate climate change measures into national policies, strategies and planning</td>
<td></td>
</tr>
<tr>
<td><strong>13.1</strong> Strengthen resilience &amp; adaptive capacity to climate-related hazards &amp; natural disasters</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>13.2</strong> Integrate climate change measures into national policies, strategies and planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>13.3</strong> Improve education, awareness-raising &amp; human/ institutional capacity on climate change adaptation, impact reduction and early warning</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6.4</strong> Increase water use efficiency</td>
<td><strong>11.3</strong> Enhance inclusive &amp; sustainable urbanization &amp; participatory planning</td>
<td></td>
</tr>
<tr>
<td><strong>11.B</strong> Increase the number of cities with integrated policies &amp; plans for inclusion, resource efficiency, climate change adaptation &amp; disaster resilience. Develop holistic disaster risk management at all levels</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6.5</strong> Implement IWRM at all levels</td>
<td><strong>6.A</strong> Expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes</td>
<td></td>
</tr>
<tr>
<td><strong>6.6</strong> Protect and restore water-related ecosystems</td>
<td><strong>11.C</strong> Support least developed countries, including through financial &amp; technical assistance, in building sustainable &amp; resilient buildings using local materials</td>
<td></td>
</tr>
<tr>
<td><strong>11.4</strong> Protect the world’s natural heritage</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6.B</strong> Support &amp; strengthen local communities’ participation in improving water &amp; sanitation management</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>11.5</strong> Reduce effects of water-related disasters</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: Compiled from https://sustainabledevelopment.un.org/?menu=1300*
Figure 1.4 Links between SDGs 6, 11 and 13
The above-mentioned social and policy challenge has led to a growing literature on River Basin Management (see Chapter 3) and Urban Water Management (see Chapter 4). While extensive, I see three main gaps on how the existing literature addresses water-related challenges in large metropolitan regions.

First, the dominant scholarly bodies of literature that analyse water management in river basins are the Integrated Water Resources Management (IWRM) and Integrated River Basin Management (IRBM) literatures (see Chapters 2 and 3). IWRM and IRBM adopt the river basin as the ideal unit for water management, although IWRM also has a national spatial focus (Watson, 2004; Jones et al., 2006; Bahri, 2012). They address water quantity concerns such as managing water resources for multiple users and avoiding conflicts, water supply through large-scale infrastructure, and the need for more water demand-focused measures and soft approaches (Abdullah and Christensen, 2004; Watson, 2004; Barrios et al., 2009). Concerns about water quality centre on contamination risks within the river basin and the adoption of ecosystem-oriented approaches (Renner et al., 2017). Adaptation to climate change risks is not a focus of the literature, being only laterally addressed through specific topics such as droughts (Hurlbert, 2016) and irrigation practices, minimum environmental flows, water allocation, and others (Barrios et al., 2009; Brandeler et al., 2019). Both IWRM and IRBM take a holistic approach to water management, emphasizing the need to integrate upstream and downstream issues, surface and groundwater, land and water systems, humans and ecosystems, multiple sectors, and viewpoints (Jønch-Clausen and Fugl, 2001; Watson, 2004; Grigg, 2008; Medema et al., 2008; Savenije and Van der Zaag, 2008; Barrios et al., 2009; Molle, 2009a; Agyenim, 2011; Closas et al., 2012; Foster and Ait-Kadi, 2012; Anokye, 2013). However, it is not clear how water services and planning at local levels should be addressed. Although IWRM/IRBM aim to integrate urban water concerns, including water services, this is challenging in practice, as natural hydrological borders rarely coincide with political-administrative borders (Bahri, 2012; OECD, 2016). A review of the literature on IWRM/IRBM in titles, abstracts and keywords in ScienceDirect indicated that, despite an exponential increase in the number of publications in the last 15 years, few contained terms referring to the urban scale (urban, city/ies, megacity/ies and metropolitan) (see Figure 1.5).

Second, the (social sciences) literature on urban water has largely focused on the provision of water services and infrastructure, as well as issues of risk and adaptation (Engel et al., 2011; GTT, 2014). However, adaptation and ‘resilience thinking’ are often limited to the field of disaster management (Baud and Hordijk, 2009). It has evolved from a technocratic and sectoral approach with a focus on public health and risk control, towards including considerations for sustainability, integration and participatory decision-making (Brown and Farrelly, 2009; Rauch and Morgenroth, 2013). This has led to new paradigms, such as Sustainable Urban Water Management (SUWM) and Integrated Urban Water Management (IUWM). Yet, the literature often leaves out the broader context of the river basin, and the relationship between the city and its rural hinterlands, including that of their respective water systems (Pearson et al., 2010; Brandeler et al., 2019). Only a fraction of the literature reviewed with ‘SUWM’ or ‘IUWM’ in titles, abstracts and keywords included terms related to the river basin scale (see Figure 1.5).
The pressure on local officials to provide certain services within their jurisdiction and the relatively short time span and scope of their mandates mean that they often lack strong incentives to consider the long-term impacts on the wider basin. The SUWM literature emphasizes local level, infrastructure-oriented initiatives (Marlow et al., 2013; Rietveld et al., 2016). However, as the river basin is typically considered as the ideal unit for water resources analysis and management, addressing water problems at the local level could lead to issues of administrative/institutional mismatch between the basin and city scales, with various social, environmental, economic and relational implications.

Third, neither the RBM nor the UWM literature clarifies how their principles apply to the context of large metropolitan regions, despite the multiplication of the world’s large urban agglomerations (Brandeler et al., 2019). A review of publications with the term ‘metropolitan water management’ revealed only 113 results between 1970 and 2015, compared with 314 for SUWM and 349 for IUWM (see 2.3). They made virtually no mention of the river basin. Megacities sometimes expand across large parts of river basins and even beyond their boundaries and impacts are felt even further. They are often composed of a multitude of local governments with autonomous decision-making powers, and the coordinated management of urban water and water resources is particularly challenging in these contexts. A relevant question is thus whether institutions dealing with the metropolitanization of cities should be coordinated with those for water management (Roche et al., 2001). Despite their unique characteristics and challenges, the existing scholarship fails to address whether metropolises should receive special consideration in urban water or river basin management, or whether they require a completely different approach.

**Figure 1.5** The occurrence of terms linked to the urban and river basin within the main concepts

![Graph showing the occurrence of terms](image-url)
1.3 Research Questions, Approach and Limits

1.3.1 Research Questions

Hence, this thesis investigates river basin and urban water governance in relation to metropolitan water challenges through the following overarching question: How do interactions between drivers and institutions at different spatial and institutional scale levels shape metropolitan water challenges, and how can policy instruments from river basin and urban water governance frameworks be (re)designed to foster more sustainable and inclusive metropolitan water governance?

This thesis is grounded within the water governance literature. More specifically, in the absence of a theory of metropolitan water governance, it explores what the literature on river basin governance and on urban water governance can tell us about how to understand and address metropolitan water challenges. The ensuing theoretical chapters combine a more normative perspective to evaluate how the literature frames urban and river basin governance in relation to inclusive and sustainable development and are critical to examine the spatial scalar dimensions of water governance. Chapters 3 and 4 engage with the literature on IWRM and IRBM and UWM respectively. River basin governance and urban water governance are focused on different spatial scales and have a different scope, which determines the actors that are involved and the institutional arrangements that shape water-related decision-making and policy. This thesis adopts and integrates elements of IWRM/IRBM and UWM to analyse the relevant institutions, instruments, actors and drivers that shape water-related challenges in metropolitan areas. Based on this theoretical framework, the empirical analysis follows three steps, inspired by the three research foci of causality, performance and design of the Science Plan of the International Human Dimensions Programme’s Institutional Dimensions of Global Environmental Change (IHDP/IDGEC, 2005).

As a first step, this study examines causality, which means understanding the role that institutions in general, and more specifically river basin and urban water governance regimes, play in causing and confronting metropolitan water challenges. Institutions are often treated as intervening variables that affect the impact of underlying forces (or drivers) but are not such forces themselves (Young et al., 2008: 9). However, institutions can affect the behaviour of a variety of individual actors, something critical in shaping outcomes of human/environmental relations (IHDP/IDGEC, 2005). In addition, institutions at multiple levels interact with other forces, such as biophysical and cultural systems. Studying institutions thus requires understanding ‘joint effects’, as institutional mechanisms interact with other mechanisms to coproduce outcomes (Underdal, 2008: 66). Within environmental and resource regimes there are so many underlying factors (biophysical and socioeconomic forces) that contribute to collective outcomes that it is almost impossible to separate the causal linkages from different elements and evaluate the salience of each for explaining collective outcomes (Young et al., 2008). This thesis then relies on a case study method and comparative analyses as a methodology that enables the assessment of the profound complexities of the interactions between human and biophysical systems, although it has limitations in terms of providing generalizations (see 2.2).
The second step is to evaluate the performance of existing institutions on actors’ behaviour towards urban water challenges, given the drivers and contextual factors that affect their behaviour. According to the environmental governance literature, specific regimes are established to address well-defined problems, and performance analysis is used to evaluate how successfully it solves, or at least alleviates, these problems (Young, 2003a: 100; Mitchell, 2008). As a more normative lens for looking at institutions, performance analysis can be used to evaluate various dimensions (or criteria), such as sustainability or equity (Young et al., 2008: 21). It corresponds to an ‘actual-versus-aspiration’ comparison that establishes how much an institution has contributed to a specified goal (Mitchell, 2008: 79). This thus requires using a performance scale or measurement system for each dimension being evaluated, as well as a reference point to which outcomes can be compared, leading to a numeric or non-numeric performance score (Mitchell, 2008: 80). Thus, this research selected and evaluated instruments of each governance regime in relation to four dimensions of inclusiveness and sustainability, defined below (see 1.5.1).

The final step considers how to improve institutional design so as to better address urban water challenges in metropolitan regions. It consists in the (re)design of policy instruments for both Mexico City and São Paulo in order to enhance the sustainability and inclusiveness of policy responses to metropolitan water challenges. This is built on the greater understanding of the interactions between the urban water and river basin governance regimes and the effectiveness of existing policy instruments. The specific format and purpose of these instruments therefore depends on the findings of the first two steps (causality and performance).

Consequently, to answer the main research question, this study explores the following sub-questions:

1) What does the literature on urban water governance and on river basin governance tell us about how to understand and address metropolitan water challenges?

2) How do multiple drivers as well as river basin and urban water governance institutions shape current metropolitan water challenges? [causality]
   a. What are the current drivers of urban water challenges in the metropolitan regions of São Paulo and Mexico City and in their respective river basins?
   b. What IWRM/IRBM actors and institutions exist at multiple levels to address urban water challenges in São Paulo and Mexico City?
   c. What UWM actors and institutions exist at multiple levels to address urban water challenges in São Paulo and Mexico City?

3) Which policy instruments are effective, and which are not, in dealing with these water challenges and their drivers? [performance]
   a. In relation to water sharing (Quantity)
   b. In relation to water preservation (Quality)
   c. In relation to unpredictable and extreme water-related weather events (Climate Change)

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7 “Effective” here should be understood to mean: Enhance sustainability and inclusiveness.
d. How are the policy instruments at the urban scale linked to those at the river basin scale, and are these coherent within the metropolitan region and across multiple levels of governance?

4) Based on this analysis, how can more appropriate instruments be designed to address metropolitan water challenges, with the aim to guide metropolitan regions towards inclusive and sustainable development? [(re)design]

1.3.2 FOCUS OF THE RESEARCH

This research focuses on large cities and their unique characteristics and water-related challenges, within Latin America. The urban population produces about 80% of global wealth, counts for over half of the global population, accounts for three quarters of global demand for natural resources, produces 50% of its waste (IRP, 2018). Latin America is the most urbanized region of the Global South and is still urbanizing. As most of the world’s future urbanization will happen in the Global South, the experiences of Latin America’s cities may provide lessons or insights that are more relatable for other growing cities than the experiences of cities in the Global North, which underwent very different development paths.

1.3.3 LIMITS OF THE RESEARCH

A first limitation of this research is in terms of the spatial scope, as it focuses on large metropolitan areas. Smaller cities and rural areas far from large cities also face important water-related challenges. However, the thesis argues that the size and complexity of large cities, and political and economic factors, lead to challenges of a different nature.

For both case studies, historical developments of the past centuries shaped their water-related problems and their water governance regimes. However, the thesis mainly focused on developments dating back to the early 1990’s, when IWRM received international recognition and began to be implemented in Brazil and Mexico. Moreover, the research limits its forward outlook to 2030, as this is the timeframe for attaining the Sustainable Development Goals. This corresponds to 15 years from the start of the research, which is enough to estimate medium-term challenges and implement significant reforms. The timeframe of 2050 is occasionally considered for longer-term dynamics, such as climate change effects. This study favours scope over depth by considering a wide range of water-related challenges and responses to these within the metropolitan regions of Mexico City and São Paulo. Analysing these challenges and the effectiveness of existing responses to attain sustainable and inclusive metropolitan water governance regimes requires considering the metropolitan water cycle as a whole, including both the ecosystem functions it depends on and land use considerations, and the efforts of actors across different sectors and within governments at multiple levels. This limits a deeper understanding of large metropolitan regions’ specific water-related challenges, in order to shed light on the complexity, transdisciplinarity and multi-dimensionality of metropolitan water governance. Moreover, the research mostly addresses the governance of ‘blue water’ (water resources in surface and groundwater bodies), as well as ‘grey’ and ‘black’ waters
(wastewater), as current water governance regimes and policies are mainly limited to these types of water. Further research is first needed on ‘green water’ (soil moisture) and ‘rainbow water’ (atmospheric moisture), before policies can be designed to better manage these within and around large cities.

1.4 THE NATURE OF WATER

Before delving deeper, it is important to briefly overview the elementary features of water. Water has one simple chemical formula composed of two hydrogen atoms and one oxygen atom, but there are multiple types or ‘colours’ of water, notably: rainbow water, green water, blue water, grey water, black water (see Table 1.3) (Hayat and Gupta, 2016). Most freshwater is not (easily) accessible as it is stored in saltwater in oceans and seas or locked away in the polar caps.

**Table 1.3** Colours of water and their characteristics

<table>
<thead>
<tr>
<th>Colours of water</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue water</td>
<td>Accessible clean freshwater resources (surface and groundwater). Blue water availability is the volume of water that can be consumed without causing adverse ecological impacts</td>
</tr>
<tr>
<td>Rainbow water</td>
<td>Waters in their vaporized stage (atmospheric moisture). It can travel long distances as clouds, is depleted by precipitation and replenished through evaporation</td>
</tr>
<tr>
<td>Grey water</td>
<td>Volume of water required to dilute pollutants so that water quality remains above agreed water quality standards. This includes water polluted by pesticides from agriculture and household wastewater (excluding inputs from toilets)</td>
</tr>
<tr>
<td>Black water</td>
<td>Water polluted with human faeces (sewage). Ecological buildings nowadays separate blackwater and greywater</td>
</tr>
<tr>
<td>Green water</td>
<td>Rainwater that is stored in the soil, absorbed by plant roots and evaporates through plant transpiration. It corresponds to 60% of freshwater flow</td>
</tr>
</tbody>
</table>

*Source: Hayat and Gupta (2016: 1233-1237)*

Blue water can be captured for human uses and is discharged as grey or black water. Besides taking different forms, water also flows through the hydrological cycle, and does not follow socially constructed boundaries such as national or sub-national borders. Managing these flows is necessary to sustain and protect human settlements, in particular in large cities. The delimitation of river basins and aquifers as governance scales developed as societies were particularly concerned with blue water and led to the emergence of IWRM/IRBM as dominant paradigms for water resources management. Given that water flows can be transformed

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8 The circulation of water and other material inflows and outflows in and out of cities is sometimes referred to as “urban metabolism” (Heynen *et al.*, 2005; Carlo Delgado-Ramos, 2015).
through engineering for the benefit of certain groups (Swyngedouw, 2009), choosing the river basin as a management unit is also a political process as it transforms these spaces into territories of governance and raises questions about who will take decisions and how (Warner et al., 2008). Consequently, the flow of water can then be understood as a hybridization of physical and social processes.

Furthermore, water contributes in multiple ways, directly or indirectly, to humans and human well-being (Hayat and Gupta, 2016). Green water, largely ignored by research and policy until recently, is the largest freshwater water resource, the basis of rain-fed agriculture and all life on land and performs crucial functions by sustaining water-dependent ecosystems such as forests and wetlands and their biodiversity (Ringersma et al., 2003). These ecosystems are essential for sustaining blue water as they often hold the springs of rivers and streams. Therefore, the degradation of ecosystems in the urban/rural interface impacts sustainable water resources management and water supply for urban users (Avissar and Werth, 2005). The disruption of water-related ecosystem services/nature’s contributions within the hydrological cycle leads to challenges in terms of water quantity and water quality, and risks related to climate change.

1.5 Positionality

This study aims for a multi-disciplinary approach to examine the social, economic, environmental and relational impacts of metropolitan water governance regimes. It is multidisciplinary in that it builds on existing knowledge in the natural and social sciences disciplines, including diverse and alternative knowledge claims, and comparisons between two different case studies, with the aim to frame questions in a broad manner (IDGEC 2005). This is done by combining a sustainable and inclusive development approach and a political science and geography perspective.

1.5.1 Sustainable and inclusive development perspective

This research combines both a sustainable development and inclusive development perspective. The former is well-established and was institutionalized within the Sustainable Development Goals. It is typically defined by the balance of three pillars: Economic, social and ecological. The latter is a pull away from the neoliberal bias towards economic growth, through its focus on marginalized people, environmental sustainability and empowerment (Gupta, Pouw, et al., 2015). The SDG framework does not mention ‘inclusive development’ but includes the term ‘inclusive’ 41 times (Gupta and Vegelin, 2016). Combining both perspectives allows for integrating social, ecological, economic and relational dimensions (see Figure 1.6). This thesis will consider these four dimensions to analyse the impact of policy instruments on the multiple water challenges experienced by large cities and their river basins and in the process clearly focuses on the more marginalized people in society.
Figure 1.6 Dimensions of inclusive and sustainable development

These four dimensions have the following characteristics:

- Social inclusiveness implies accounting for the multiple dimensions of poverty and striving for the social inclusion of specific individuals and groups. It reduces their exposure to various risks and enhances their well-being by investing in human capital and increasing opportunities for participation, meeting basic needs, reducing inequality and promoting equal rights (Gupta and Vegelin, 2016; Pouw and Gupta, 2017).

- Ecological inclusiveness requires recognizing that the growing demand for limited natural resources due to population growth and economic development may lead to ‘ecospace’ grabbing (i.e. large-scale transfer of these resources from local communities to governments, corporation and the private sector) (Gupta, Pouw, et al., 2015; Gupta and Vegelin, 2016). It aims for local to global sharing of water resources, protecting equitable access to and ownership of resources and preserving ecosystems and their biodiversity (Gupta, Pouw, et al., 2015; Gupta and Vegelin, 2016). People’s well-being, particularly the poorest, is closely related to investments in preserving ecosystem services (Chopra et al., 2005; Gupta, Pouw, et al., 2015).

- The economic pillar is understood here as cities’ ability to manage their resources and develop (Gupta, Pouw, et al., 2015). Water is crucial for economic activities that sustain lives and livelihoods within and outside urban areas. Large cities are embedded in local to global political economic structures (Hordijk et al., 2015), but are also important economic actors that can spearhead changes in economic development models and push for economic efficiency (e.g. rational water use, cost-efficient technology and infrastructure) to ensure the viability of various policy instruments. The focus of the economic pillar has often been on profit-maximization, reproducing inequalities and allowing for environmental degradation to persist through neo-liberal thinking and market-driven approaches (Pahl-Wostl, 2018). This thesis aims to rectify this imbalance and considers that sustainable and inclusive economic development should occur within planetary boundaries and without limiting the potential economic development of future generations.

- Relational inclusiveness recognizes the role of politics and local and global drivers of inequality in shaping poverty and ecological degradation (Gupta, Pouw, et al., 2015; Gupta and Vegelin, 2016). These relations operate at multiple levels, and addressing...
these requires dealing with all actors (Gupta and Vegelin, 2016). This requires addressing inequality and aims for the redistribution of power and resources, and ensuring that the most vulnerable and marginalized populations have access to affordable water services and receive protection from water-related risk (Swyngedouw, 2009; Pouw and Gupta, 2017).

This framework is used to examine the impact of institutional responses to water-related challenges. Institutions and instruments can empower social actors to respond to water quantity, water quality and risks related to climate change through planned or creative measures that stimulate certain types of behaviour and discouraging others (Gupta et al., 2010; Majoor and Schwartz, 2015). Their effectiveness determines whether cities and their river basins can develop sustainably and inclusively. This thesis focuses on institutions and instruments derived from IWRM/IRBM and UWM, as these were identified as the dominant paradigms. IWRM and IRBM emphasise the sustainable management of all water and related ecosystems (linking to SDGs 6.4, 6.5 and 6.6), with an emphasis on decentralized and participatory decision-making (SDG 6.B) (Watson, 2004; Medema et al., 2008; Molle, 2009a; Huitema and Meijerink, 2014). UWM addresses the provision of water and sanitation services (SDGs 6.1 and 6.2), including the treatment of wastewater and its recycling (SDG 6.3), as well as mitigation and adaptation to risks from extreme weather events (SDGs 13.1, 13.2 and 13.3) and control of waterborne diseases (SDGs 6.1 and 6.2) (Barraquè, 2011; Engel et al., 2011; GTT, 2014). The linkages between the three SDGs are useful to consider the policy implications of metropolitan water governance.

1.5.2 Multi-level governance through a political science and geography perspective

This thesis also adopts elements from geography and political science disciplines to analyse actors and institutions, and their interactions, within and across spatial scales. Metropolitan water challenges are shaped by biophysical and social factors at multiple levels. While environmental impacts, such as water scarcity, are often experienced locally, the complex web of factors behind them cannot realistically be addressed by local governments alone. When externalities appear in different jurisdictions than those that caused them, this requires multilevel responses (Hooghe and Marks, 2003; Newig and Fritsch, 2009; Termeer et al., 2010). Yet, many analyses of urban sustainability have divorced the local from other governance levels (Marvin and Guy, 1997). A multilevel governance perspective allows for examining how local problems are constructed and contested at different scales of governance and through multiple political spaces (Hooghe and Marks, 2003; Bulkeley and Betsill, 2005). This is also the case for addressing water-related challenges in metropolitan regions, which are nested within social, economic and political contexts at local, national and global levels.

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I interpret the concept of ‘governance’ as a process, and more specifically as “the shaping and sustaining of the arrangements of authority and power within which actors make decisions and frame policies that are binding on individual and collective actors within different territorial bounds” (Hanf and Jansen, 1998, p. 3). I take this perspective to examine (urban water and river basin) management approaches and their associated policy instruments.
Multilevel governance is broadly understood as the participation in decision-making processes of governmental actors and non-state actors at different administrative levels and across administrative jurisdictions (Pierre and Peters, 2000; Hooghe and Marks, 2003; Bache and Flinders, 2005; Papadopoulos, 2007; Kluvánková-Oravská et al., 2009; Newig and Fritsch, 2009). This involves vertical interactions across administrative levels and horizontal interactions between agencies at central level, and different actors at sub-national level (Peters and Pierre, 2004; OECD, 2011, 2015b). These interactions may involve continuous negotiation among nested governments at multiple territorial levels (Pierre and Peters, 2000; Hooghe and Marks, 2003). Multilevel governance can also be an alternative to hierarchical government, with more complex and contextually defined relationships. In fact, the concept of multilevel governance emerged in order to make sense of the “unravelling of central state control” and the diffusion of authority more generally (Hooghe and Marks, 2003). Nevertheless, the traditional state-centric and constitutional perspective has not lost relevance (Peters and Pierre, 2004: 75). Rather, the “shift” towards multilevel governance” is occurring in an incremental manner, where relations between institutions at different government levels are “fluid, negotiated and contextually defined”.

In addition, multilevel governance allows for a more flexible approach to issues of spatial fit between natural and institutional (governance) scales, thereby striving for better institutional performance in terms of sustainability (Young, 2003b; Newig and Fritsch, 2009). For instance, the provision of public services and policy responses can be designed at the most appropriate scale in each context (Pahl-Wostl, 2015). This flexibility is necessary in order to face rapid and unpredictable environmental changes and to foster sustainable development (Bavinck and Gupta 2014: 78). However, designing institutions to fit natural scales should not be considered a panacea. Such institutions are more likely to face coordination challenges with other actors, particularly in terms of financing due to the difficulty of sustaining joint funding schemes (Ingram, 2008; Newig and Fritsch, 2009). It requires collaboration between actors who may otherwise compete for political and financial support. Political leaders whose constituencies have little relationship to the territory defined by river basin institutions also tend to feel estranged from the latter. Indeed, they are not directly held accountable to the population within the institutionalized river basin territory (Ingram, 2008).

Furthermore, dynamics at multiple levels not only shape metropolitan water challenges, and the institutions that address these, but also the power of actors at different levels. This research recognizes the fundamentally political nature of these regimes in both shaping and responding to water-related challenges and the responses to these, from the dominant discourses to the chosen policy instruments. However, it is beyond the scope of this study to formulate recommendations that require important shifts in the political, economic, social and cultural fabric of the two case studies and of other large metropolitan regions. The objectives of this study are limited to (re)designing policy instruments that can lead to changes within existing metropolitan water governance regimes. Nevertheless, such changes can have broader repercussions when there is sufficient political will and public support.
1.6 STRUCTURE OF THESIS

Following this introductory chapter, Chapter 2 grounds the research methodology and methods. The theoretical framework unpacks the literature on RBM and UWM from a multilevel governance perspective in Chapters 3 and 4 respectively. The four following chapters discuss the findings from the empirical research on the two case studies. Chapters 5 and 7 analyse the driving forces causing metropolitan water challenges and the institutions and instruments of IWRM/IRBM in place to address them in São Paulo and Mexico City respectively. In Chapters 6 and 8 a similar analysis focuses on UWM. Chapter 9 draws comparisons between the two cases, with a particular focus on the interactions between IWRM/IRBM and UWM, and reflects on the scalar mismatches that arise in each case’s metropolitan water governance regime. It answers the research questions in relation to São Paulo and Mexico City, discusses the policy implications and proposes a redesign of their policy instruments. Finally, Chapter 10 concludes this thesis by answering the research questions in relation to the literature review, reflecting on the implications for international development studies and providing recommendations, not least in the context of the Sustainable Development Goals.