Water governance in Brazil

The need to share water in the anthropocene

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1.

1. INTRODUCTION

1.1. Introduction

This thesis aims to contribute to the debate on water governance in advancing inclusive development (ID; see 1.5). It focuses on the challenges facing federal states and uses Brazil as a case study (see 1.4). It addresses the role and influence of three evolving paradigms (hydraulic engineering, integrated water resource management (IWRM), and adaptive water governance) in the phases of water governance and proposes that as water demand exceeds water supply, water-sharing principles and instruments will become increasingly important (see Chapter 3).

This proposal is based on the idea that in the context of the Anthropocene (see Box 1.1), we are on the verge of overusing and over polluting water resources. This results from human demand exceeding the water supplies from nature, from human demand influencing different dimensions of the water cycle and from the impacts of climate change (IPCC, 2022). But beyond that, this thesis will argue that inequality has shaped human impact on the water regimes, that the most vulnerable are affected by the growing competition over scarce water resources – even though they have had a limited impact on the degradation of the water system inequality, and that there is an urgent need for a new paradigm – the paradigm of water-sharing. This paradigm can be implemented by the interpretation and implementation of an existing menu of water-sharing instruments. This paradigm is rooted in the inclusive development perspective used in this thesis but is also justified by the empirical evidence generated in the case study chapters.

Focusing on how water-sharing has been organized within the water sector, this introductory chapter explains the current and future practical challenges to water allocation and the theoretical gaps in scientific knowledge pertaining to water governance (see 1.2). It presents the research questions and the focus and limits of this thesis (see 1.3). It justifies the focus on federal states in general, and Brazil in particular (see 1.4). It then explains why this thesis takes an inclusive development perspective (see 1.5) and demonstrates the policy relevance of this thesis (see 1.6). The chapter concludes with an explanation of the structure of the thesis (see 1.7).

Box 1.1 The Anthropocene

The Anthropocene refers to a geological epoch that starts when human activities began to have a significant global impact on the Earth's ecosystem (Crutzen, 2002; Steffen, Crutzen & McNeill, 2007; Clémençon, 2012). The main characteristics of the Anthropocene are: (i) accelerated climate changes associated with high levels of greenhouse gases; (ii) transformation of the biogeochemical and hydrological cycles; and (iii) extensive loss of habitat and biodiversity (Barnosky et al., 2011; Steffen et al., 2011). While the term 'Anthropocene' has been adopted by the global change research community, it has not been formally accepted as a geological term in Earth's history (Steffen et al., 2011). Around the 1950s the debates seeing to be converging as the start of the Anthropocene. Therefore, it is also fundamental that other scholars, such as social scientists take ownership of Anthropocene concept to help to re-define it (Gupta, Hordijk & Vegelin, 2019).

1.2. Problem definition: Intensive Water Use and Water Allocation

1.2.1. Societal relevance

Most countries worldwide have increased the exploitation of surface and groundwater to promote economic growth (UN Water & UNESCO, 2022). These countries create conditions for economic development by investing in river water harnessing projects, such as hydropower infrastructures and irrigation systems (Pearce, 2018). For many developing countries and emerging economies with limited water resources, traditional development requires large-scale water use. Meanwhile, there is need for adopting global water governance policies to deal with the impacts of climate variability and change (IPCC, 2021) and promote sustainable and inclusive development consistent with the 2030 Agenda and the Sustainable Development Goals (SDGs) (UNGA, 2015; Gupta, Pouw & Ros-Tonen, 2017). This requires states to reconsider their understandings of development or run the risk of exacerbating the global water crisis. Moreover, it requires them to share water resources.

Freshwater is societally relevant being vital for the well-being of people, ecosystems, and society in various ways. It enables the provision of ecosystem services – supporting (e.g. transporting water, water storage, erosion control), regulating (e.g. climate regulation, hydrological regulation, disease regulation, flood management, water treatment, and waste management), provisioning (e.g. including food, freshwater, fibres, genetic materials, and ornamental materials) and cultural (e.g. material and non-material benefits to communities through a variety of spiritual and religious services) services (MEA, 2005), for the global world population and supports approximately 126,000 species (Chapagain & Orr, 2008; Hayat & Gupta, 2016). People benefit from various ecosystem services that directly contribute to human well-being (MEA, 2005), nowadays referred to as Nature's Contributions to People (Díaz et al., 2018).

Almost all freshwater is derived from atmospheric precipitation in the form of snow, rain, hail and mist or precipitation, and only 0.4% of water is directly available as surface water in rivers, lakes, and wetlands (UNEP GEO, 2019). The availability of freshwater, including groundwater, has been decreasing in recent years (Rodell et al., 2018). With climate change, the number of floods and droughts has increased (Huntington, 2006; Arnell et al., 2019), and there is also a great loss of glaciers (Rodell et al., 2018; UNEP GEO, 2019).

One way to understand how response strategies should be developed includes the DPSIR (drivers, pressures, state, impact, response) approach used by the United Nations Environment Programme and the European Environment Agency (Stanners et al., 2007; Gupta et al., 2020). Drivers refer to the underlying causes of a problem, pressures are the direct causes of a problem, state refers to how the environment has been affected, impacts refers to the impact of the problem on humans and responses refers to how policies can be crafted to address the problem. Table 1.1 denotes how the direct and indirect drivers of the increasing demand and supply lead to effects (coined the 'State'), in this case including decreased resource pools or intensified droughts, which subsequently yield 'Impacts' in the form of e.g. increased competition for water resources or adverse impacts on humans from droughting.

Global **drivers** of the increasing demand and supply include population growth, economic growth, technological innovation, rapid urbanization, and climate change (UNEP GEO, 2019).

The demand for agriculture, industries, energy and households is embedded in the pursuit of economic growth to meet the needs of growing populations. There is a strong correlation between water demand

Table 1.1. The drivers, effects and impacts on freshwater and people (impact)

Indirect drivers	Direct drivers	Effects	Impact
Population growth Economic growth Technological innovation Rapid urbanization Climate change	Agriculture Industry and service Energy Households	Decreasing seasonal availability and overall resource pool; also affected by poor quality Increasing floods and droughts	Increasing competition among and within categories of water uses (e.g. agriculture, industry), users and nature Human impact of shortages, drought and floods

Source: Based on UNEP GEO (2019)

and economic growth, as is currently happening in China, for example (Wang and Wang, 2020). While economic growth is expected to drive water use, this varies significantly, particularly across developing countries (Amarasinghe & Smakhtin, 2014). The main expected consequences are increasing water pollution and shortage (Boretti &Rosa, 2019).

Technology innovation is a notable driver of freshwater. As technology provides solutions for the water sector, it also creates unplanned negative consequences, particularly the ability to extract large quantities of water and pollution (Muyibi, Ambali & Eissa, 2008; Sultana, 2013). Because groundwater cannot be accessed without technology, the availability or lack of technology thus affects the use and quality of groundwater (Cosgrove & Cosgrove, 2012; Gupta, Pahl-Wostl & Zondervan, 2013).

As a society develops, rapid urbanization also tends to increase. "By 2050 the population of the world is projected to be 68 per cent urban, with urban dwellers numbering 6.7 billion"(United Nations, 2018, p. 10). This has several direct effects on water, e.g. an increasing demand to safe drinking water and sanitation facilities (Levy et al., 2014) as well as rising demand for other goods and services, all of which require water (UN Environment, 2019).

Climate variability and change generates uncertainties about future water availability (OECD, 2015a, p. 19). With rising temperatures, there is more evaporation, which increases the risk of droughts and floods in many regions (Bates et al., 2008). Droughts and floods affected more than 3.4 billion people between 1995 and 2015 and cost approximately USD 596 billion in reparations between 2000 and 2017 (He et al., 2020). Developing countries are predicted to be disproportionately affected by climate variation than industrialized countries as they are more economically dependent on climate-sensitive sectors, such as agriculture and fishery, and lack the institutional and financial capacity to anticipate and respond to the effects thereof (Thomalla et al., 2006; Aryal et al., 2020). Meanwhile, industrialized countries like the United Kingdom and the Netherlands have already been investing in projects such as Living Rivers (Karr & Chu, 2000) and Room for the River (Rijke et al., 2012) respectively to cope with climate variation.

Direct drivers include demands for food, industry and service, energy, and households.

The most important use of fresh water is for the agricultural system. Global food demand is rising (FAO, 2017; Bahar et al., 2020) while it remains unclear how increased demand for agricultural products will be addressed (Bahar et al., 2020). Currently, global agricultural water use is estimated at around 70% of total available fresh water (Grasby, 2004; Boretti & Rosa, 2019). It is estimated that the world population will reach 8.5 billion by 2030 and 9.7 billion by 2050 (United Nations, 2009), thus increasing demand for drinking water and food production at all levels, although this increase is marginal compared to the current overuse of food resources by the privileged (D'Odorico et al., 2019). Hence, increasing agriculture to meet global needs will require more water, unless the agricultural system is redesigned.

Industries[2] use 20% of available water (Boretti & Rosa, 2019), with the highest increases in demand expected in North America (e.g., the USA) and Western Europe (e.g., Germany) (Wada et al., 2016). By 2050, water demand for industries is projected to increase by 800% in Africa and 250% in Asia (Boretti & Rosa, 2019), subsequently affecting water quality with increased pollution.

The production of energy, such as electricity and biomass, directly rely on water. Between 2010 and 2035, the global use of energy is projected to increase by 20%, and 85% by 2050 (IEA, 2012; Boretti &Rosa, 2019).

The global demand for household water accounts for 10% of total available water, with significant increase projected between 2010 and 2050 (Boretti & Rosa, 2019). In Central and South America, the demand

2 Primary energy extraction, electricity production and manufacturing.

is expected to increase by 200% in 2050 as a direct result of the increase in water supply services to urban settlements (Wada et al., 2016).

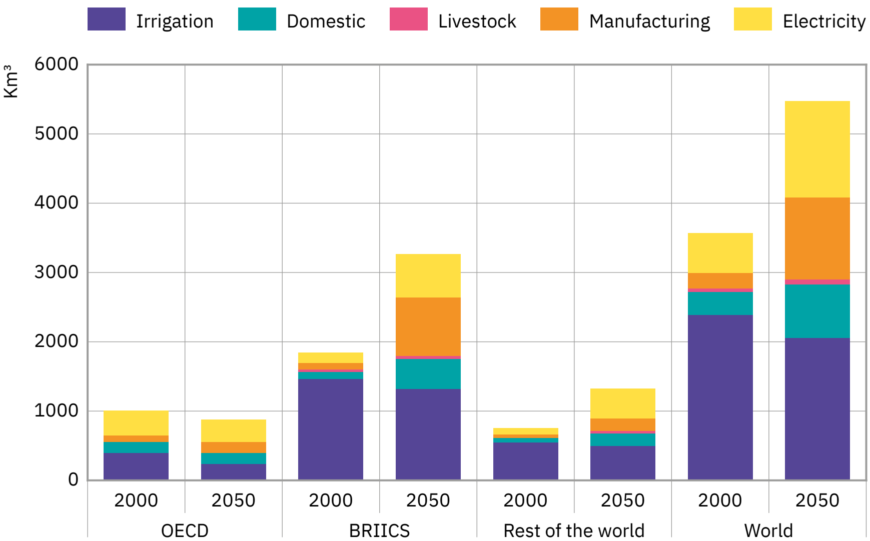
These changes have direct and indirect impacts on human and ecosystem health (Wang, Wang, & Tong, 2016; Liu et al., 2018; UNEP GEO, 2019). Increasing pressures on water resources and intensifying competition for access and use are extensively documented (see e.g. OECD, 2015a; UN Environment, 2019; UNEP GEO, 2019). Responses can be directed at the direct and indirect drivers drivers, effects and impact.

According to the UN World Water Development Report, global water demand is estimated to be around 4,600 km^3 per year and expected to rise by 20% - 30% to between 5,500 and 6,000 km^3 per year by 2050 (Burek et al., 2016; WWAP, 2018). Even though the prediction at the global scale are complex (WWAP, 2018). They are particularly restricted due the limited data available and data considering environmental, social, economic, and political aspects, such as: global climate change, population growth, land use change, globalization and economic development, technological innovations, political stability, and the state of international cooperation (Mancosu et al., 2015; Distefano & Kelly, 2017; WWAP, 2018). Because of these dynamics, local water management has global impacts and vice versa (Wada et al., 2016, p. 216).

In 2012, the Organization for Economic Co-operation and Development (OECD) projected global water demand in terms of freshwater withdrawal. The projection, illustrated in Figure 1.1, used a baseline scenario, assuming a linear growth rate in water demand trends and the absence of new policies that could better address the drivers. Global water demand for freshwater withdrawal was projected to increase by some 55% as a result of the growing demands in manufacturing (400%), thermal electricity generation (140%), and domestic use (130%) (OECD, 2012). What stands out in the illustration is the demand for electricity generation, which was projected to grow by more than one third between 2000 and 2035.

In a world where many countries have little internal renewable freshwater resources, demand already outweighs supply and leads to 'basins closing' and 'day zero' in cities (see 3.3.2 and Table 3.3), and still global water demand is expected to grow significantly. This will exacerbate conflicts between uses and users (see Chapters 2-4) and raises the question of how and through which instruments to share water resources (see Chapter 4 and 8.3.2).

Figure 1.1. Growing water demand versus limited supply of water worldwide



Source: OECD (2012) p. 22

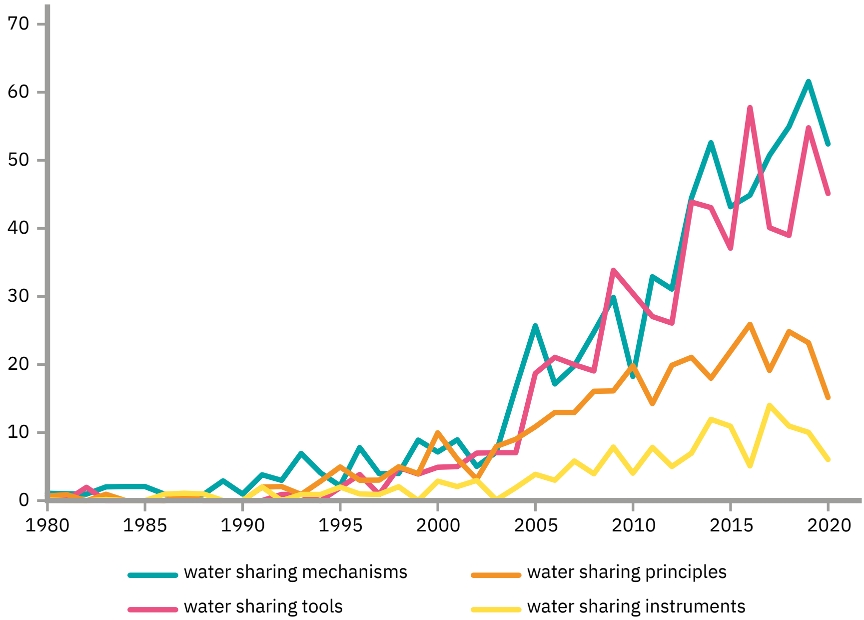
N.B. Withdrawal is the total amount of water taken from a lake, river, or aquifer for any purpose; BRIICS[3] = Brazil, Russian Federation, India, Indonesia, China, and South Africa; The figure measures the "blue water" demand only and does not consider rain-fed agriculture.

1.2.2. Academic relevance of focusing on water-sharing

There is a large body of literature on water governance which covers different paradigms of water governance, principles of water governance, hegemonic approaches in water governance and the different kinds of instruments (see Chapters 2-4). Most of the literature focuses on efficiency (e.g. Graymore & Wallis, 2010), integration (see 3.2.3), effectiveness of water use (e.g. Young, 2010; Sønderlund et al., 2016), the water, food, energy nexus (e.g. Benson, Gain & Rouillard, 2015; Rasul & Sharma, 2016), and show how water resources have been used for diverse purposes across different economies and natural ecosystems over time (e.g. GWP-TAC, 2000; Shah et al., 2004; Hoff, 2011; Albrecht, Crootof & Scott, 2018).

3 BRIICS "is a group of six large emerging market economies that have grown rapidly in the past three decades on the backdrop of increased global financial integration" (*Rai and Garg, 2021, p. 1*).

Figure 1.2. Number of papers covering water-sharing



Source: Prepared using data from Scopus (Scopus www.scopus.com, September 15, 2020)

While the issue of water-sharing was scarcely discussed in the last century except in relation to legal scholarship on transboundary river basins (Edum, 2021), we note that since the 2000s, there is a growing interest in scholarship on water-sharing, especially also on the mechanisms for water-sharing. Figure 1.2 presents the papers covering water-sharing mechanisms, tools, principles, and instruments. Between 1940 and 2020, there was increasing academic research that explicitly addressed water-sharing mechanisms (715 references), water-sharing tools (612 references), water-sharing principles (369 references), and water-sharing instruments (142 references). My search criteria were based on the explicit use of these terms (e.g., water AND sharing AND tools) in the title, abstract and keywords (see the search terms used in Annex A). These papers were analyzed and assessed to contribute to the development of the theoretical approach of the case study (see Chapter 5, 6 and 7). These papers reveal (a) a growing academic interest in water-sharing instruments and/or questioning the inequalities in existing water instruments; and (b) a growing policy need for further developing such instruments.

Based on a reading of the literature, this thesis identifies three key gaps in knowledge. First, although there is growing literature on water sharing, the Anthropocene (see Box 1.1), planetary boundaries (Rockström et al., 2009; Steffen et al., 2015) and tipping points (Lenton, 2011; Botero et al., 2015); on how water supplies are increasingly inadequate for agriculture, industry, drinking water, and nature (WWAP, 2018; UNEP GEO 2019); on how water problems affect income, jobs and health (WHO/UNICEF, 2019); and on whether water disputes can lead to conflicts around the world (Bradbury & Smith, 2020); there is inadequate exploration of why sharing water is becoming an important and unavoidable necessity in water governance in the Anthropocene and what this means for water governance.

Second, although there are individual papers covering specific water sharing instruments (e.g., water permits, water pricing, prior appropriation, and infrastructure, see Chapter 4), or the equity and justice aspects of other instruments (Roa-García, 2014; Boelens et al., 2016), the existing literature scarcely focuses on a comprehensive discussion of instruments dealing with water-sharing. For example, globally, there is a recognition of the human right to water and sanitation (see 4.4.2.2), but 2 billion people still do not have access to safe managed drinking water services and 3.6 billion people lack access to managed and safe sanitation services (WHO/UNICEF, 2021); possibly because of the way in which water is being priced, making these services unaffordable for the poor (Weststrate et al., 2019; World Health Organization, 2021). Globally, there is recognition of the need to maintain freshwater ecosystems and natural river flows (Swainson, de Loë & Kreutzwiser, 2011), but in practice, water-sharing, particularly between nature and humans, remains insufficiently considered in development and planning of water management. There is thus a need to understand how water-sharing instruments can be identified, clustered and analysed and how other existing instruments are affecting equity. I also note that there is inadequate scholarship on the specific challenges that federal states face in water sharing. This is explored further in Section 1.4.

Third, there is considerable scholarship on the different paradigmatic approaches in water governance – e.g. there is a huge literature on integrated water resources management. There is also a growing literature on how water governance passes through a number of different phases (see

Chapter 3). This thesis builds on this literature to address the relationship between three evolving paradigms (e.g., the hydraulic paradigm, integrated water resource management, see 3.2) and the way in which water governance transitions from one phase to another (e.g., from when supply exceeds demand and when demand exceeds supply, see 3.3). However, are current descriptions of the phase that we would like to achieve adequate? This is inadequately explored in the literature and hence this thesis explores a possible next phase in water governance.

1.3. Research questions and focus and limits

Hence, this study aims to answer the following overarching research question: What is the role of water sharing in the Anthropocene and what does this imply for the design of policy instruments and the phases of water governance, with special reference to Brazil?

This question has the following sub-questions:

- Why is equitable water-sharing becoming increasingly important in the Anthropocene?
- How can water-sharing be addressed in general and in the specific context of federal countries?
- What lessons can be learnt from previous water governance paradigms and studies on the phases of water governance to develop a more comprehensive paradigm which prioritizes appropriate water-sharing instruments that better promote inclusive development?

These questions are addressed through a multi-layered case study carried out in Brazil, the results of which are then discussed in relation to other countries and contexts. This study aims to address Chapter specific research questions as illustrated in Table 1.2. Chapter 2 addresses the methods and theoretical approaches.

Focus and limits

This research focuses substantively on blue water (surface and groundwater). In particular, it focuses on transboundary surface water resourc-

Table 1.2. Research questions

No.	Questions per chapter	Chapter
1	How have water paradigms unfolded over time and how have they addressed issues of water-sharing?	Chapter 3 (Theory)
2	What does the existing literature tell us about instruments that deal with water-sharing, and what are their advantages and disadvantages?	Chapter 4 (Literature review)
3	What are current drivers of water challenges in Brazil and which policy instruments address these challenges and what are the implications for water sharing?	Chapter 5 (Case study)
4	What are current drivers of water challenges in the São Francisco River Basin, which policy instruments address those challenges and what are the implications for water sharing?	Chapter 6 (Case study)
5	What are current drivers of water challenges in the states of Bahia, Pernambuco, and Alagoas, respectively, which policy instruments address these challenges and what are the implications for water sharing?	Chapter 7 (Case studies)
6	Why is equitable water-sharing becoming increasingly important in the Anthropocene? How can water-sharing be addressed in the context of federal states? What lessons can be learned from previous water governance paradigms to develop more appropriate water-sharing instruments that promote better inclusive development?	Chapter 8 (Conclusion)

es, and indirectly on groundwater as there is little substantive data available in the case study area. The study looks indirectly at green water (rainwater that is stored in the soil and in plants) when discussing the instrument of protected areas. Besides, this research looks at how different drivers have contributed to water challenges, looking more at quantity than quality concerns. The main reason for this is because the thesis mainly focuses on water sharing, but also because many developing countries do not have substantial data on water quality.

In terms of the spatial scale of this research, it looks at the global literature, but the field work is focused on the multi-level aspects in Brazil examining the national (Brazil), basin (São Francisco River Basin), and sub-national (Bahia, Pernambuco, and Alagoas) levels and links back to the global level (see also 1.4.2).

In terms of the temporal scale, this study looks at the historical context of water-related problems, in order to be able to assess the issue of water sharing. Hence, it covers the period 1950 to 2020. The research targets government institutions at the national, basin and sub-national levels, nongovernmental organizations (NGOs), and research institutions.

In terms of academic approach, **this research does not examine the politics of the design of water-sharing instruments through political sociology or ecology approaches; instead it takes a critical instrumentalist approach to assess these instruments from a functionalist and inclusive development perspective**. In the attempt to systematically evaluate the instruments I also encountered certain limitations. There is very little monitoring of the effectiveness of the instruments by the government; scholarship on these instruments is patchy, and interviewees often had a perspective, but could not always supported their views with data. Thus, the evaluation in this thesis must be seen as a first attempt at making sense of the existing instruments to share water within Brazilian policy.

1.4. Focus on federal states in general and Brazil in particular

1.4.1. Why federal states need to be studied

As argued above (see 1.2), much of the water governance literature focuses on water governance in unitary states; some focus on individual federal states (see 4.2.1.2). Federal systems have been systematically influencing water management in various geographical, political and economic contexts (Garrick et al., 2013, p. 2). Table 1.3 presents the types of water-sharing challenges experienced by the world's 25 federations. In some cases, federal governments have dominant control over the federation's water resources, as in Canada (Cohen et al., 2006), Iraq (Abd-El-Mooty et al., 2016), Mexico (van den Brandeler, 2020) and Nigeria (King & Spangler, 2017), among others. In other cases, the federal government and state governments jointly control water resources, as in Austria (Collins et al., 2016), Belgium (Warner, 2016), and Brazil (Braga et al., 2009). As such, often state laws for water management apply in tandem with constitutional laws in cases in which both federal and state governments jointly manage these resources. Moreover, column #4 in Table 1.3 denotes examples of critical basins that are under federal or state control, which have often prompted sharing disputes at the intra-national level. For instance, the Mackenzie River Basin in Canada has yielded sharing problems between Canadian states (Morris & de Loë, 2016), while in the São Francisco River in Brazil, disputes have originated between users of the basin and its surrounding nature ecosystems (Roman, 2017).

Apart from the differing nature of the water sharing challenges in federal states, I argue below that there are four reasons for focusing on federal states:

(a) They have a different allocation of power as compared to unitary systems and the dominant literature tends to ignore the difference between federal and unitary governments; Within unitary states, water governance is often centralized, in federal states, water governance can be concentrated in the hands of the central state or it can be delegated to the provinces within the country (see 4.2).

(b) They are generally very large countries with vast differences in culture and context across the country (except Kitts and Nevis) and one cannot easily scale up governance systems that apply to small unitary systems to large countries;

(c) They often include complex structures involving multiple levels of governance (Schlager et al., 2011; Garrick et al., 2013); and

(d) Their intra-national water sharing options could benefit from learning from equitable water-sharing mechanisms at international level (Garrick, Anderson & Webster, 2014).

Since this thesis focuses on federal states and in particular on Brazil, Box 1.2 and Map 1.1 shows water availability by country within unitary and federal systems for the year 2014. Map 1.1 displays the renewable internal freshwater resources per capita (in m^3) on a global level; as shown, Brazil has some of the highest freshwater resources per capita (over $20m^3$), along with Canada, Russia, Australia, and few others in South America, establishing Brazil as a major global player in terms of water resource availability. Map 1.1 also shows that the bulk of all European nations manage low ($3\text{-}5m^3$) to very low (1-2 m^3) freshwater resources, while several African counterparts manage even lower (less than 1 m^3) reserves per capita. Accordingly, lessons learned from Brazil's freshwater management may bear major implications for global freshwater management.

Table 1.3. Federal states and their treatment of water sharing problems[a,b]

Federal states	Role of central government*	Defining roles	State law
Argentina	Joint	Constitution, Law, Ad hoc	Yes
Australia	Joint	Law, Ad hoc	Yes
Austria	Joint	Law, Ad hoc	Yes
Belgium	Joint	Constitution, Law	Yes
Brazil	Joint	Constitution, Law	Yes
Bosnia and Herzegovina	Joint	Law, Ad hoc	Yes
Canada	Dominant	Constitution, Law	Yes
Comoros	Dominant	Law	No
Emirates	Dominant	Law	No
Ethiopia	Dominant	Ad hoc	No
Germany	Joint	Law	
Kitts and Nevis	Dominant	Ad hoc	No
India	Joint	Constitution, Law, Ad hoc	Yes
Iraq	Dominant	Constitution, Ad hoc	
Malaysia	Dominant	Law, Ad hoc	
Mexico	Dominant	Constitution, Law, Ad hoc	
Nepal	Dominant	Constitution	No
Nigeria	Dominant	Law, Ad hoc	
Russia	Dominant	Law, Ad hoc	No
Switzerland	Joint	Law	Yes
South of Sudan	Dominant	Law, Ad hoc	No
Pakistan	Joint	Constitution, Law, Ad hoc	Yes
United States	Joint	Constitution, Law	Yes
Venezuela	Dominant	Law	No

Source: See Annex C

a. Joint refers to deciding about water sharing problems by federal or provincial/state while dominant refers to decision being centralized at the federal level;

b. complementary table in Annex C.

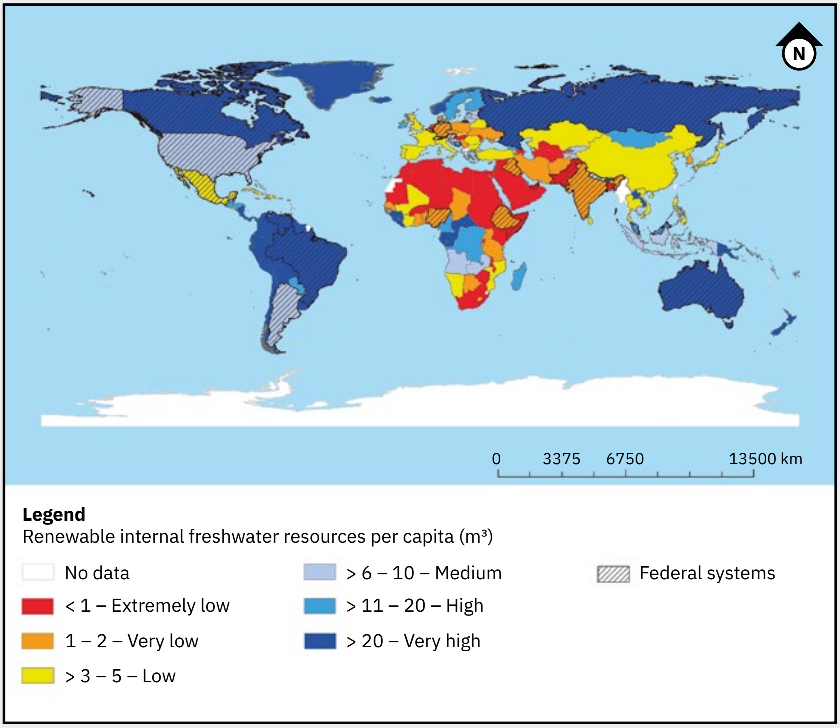
c. Snow and glaciers are expected to decline in the future due to a warming climate (based on the 307 catchments in Switzerland in the five main geographical regions: Jura, Plateau, Pre-Alps, Alps, and Southern Alps)

Examples of basins	Water-sharing problems in these basins	Reference
Trahunco Basin	Between users	(Moreyra & Wegerich, 2006; Moreyra & Warner, 2007)
Murray-Darling Basin	Between humans and nature	(Leblanc et al., 2012)
Danube Basin	Between uses and users concerning water-related risks	(Collins et al., 2016)
River Meuse	Between uses (water quality) - international river	(Warner, 2016)
São Francisco River	Between humans and nature and users	Chapter 6
Sava River Basin	Between uses (lack of drinking water)	(Vukmir, Lj & Cero, 2009)
Mackenzie River Basin	Between states	(Cohen et al., 2006)
None	Between uses (lack of drinking water)	(Beauchamp, 2017)
Groundwater	Between uses (lack of drinking water)	(Shahin & Salem, 2015)
Nile River Basin	Between other countries part of the same river basin	(BBC, 2018)
Elbe River Basin	Between uses (water quality)	(Förstner et al., 2016)
Wingfield Basin	Between uses (water quality)	(Brewster & Mwansa, 2001; World News, 2017)
Cauvery River	Between states	(Sharma, Hipel & Schweizer, 2020)
Shatt al-Arab River	Between uses (water quality)	(Zolnikov, 2013; Issa et al., 2014; Abd El Mooty, Kansoh & Abdulhadi, 2016)
Klang river basin	Between uses (water quality)	(Afroz et al., 2014)
Valley of Mexico basin	Between uses and humans and nature	(Castro, 2005; van den Brandeler, 2020)
Pandai river	Between other countries part of the same river basin	(Condon & Lang, 2009; Siddiqui, 2017)
Lake Chad Basin	Between users	(King & Spangler, 2017)
West of Russia	Between regions	(OOSKAnews, 2018)
Snow and glaciers[c]	Between uses	(Brunner et al., 2019)
Nile Basin	Between other countries part of the same river basin	(Salman, 2011; Baratta et al., 2021)
Kabul River Basin	Between states/countries	(Sayama et al., 2012; Hayat, 2020)
Colorado River Basin -	Between uses	(Craig, Feng & Gilbertz, 2019; Mueller ¨& Gasteyer, 2021)
Tuy river basin	Between uses	(Buxton, 2016)

Box 1.2. Water availability by country with unitary or federal systems of governance

Quantities of available water throughout the world vary by region (see Map 1.1). Federal states have differing availabilities of water on a per capita basis although this does not say anything about the need of nature for water.

Map 1.1. Water availability by country with unitary or federal systems of governance in 2014



Source: Author's elaboration based on raw data from AQUASTAT (2020) and World Bank (2020)

Hence, this thesis explores some of the issues around the division of responsibility within unitary versus federal states (see 4.2.1), and then examines these issues in greater depth in the case study on Brazil. This brings me to my reasons for selecting Brazil as a case study.

1.4.2. Criteria for selecting Brazil as a case study

I selected Brazil for a multi-level case study for five reasons. First, Brazil is the fifth-largest country in the world at 8.5 million square kilometres (following Russia, Canada, China and the United States), and has the fifth largest population of 201 million inhabitants (following China, India, the United States and Indonesia). The population of Brazil represents half of the population of South America (World Bank, 2022)[4]. Second, although Brazil has one of the largest quantities of renewable water resources (see Map 1.1), this water is inequitably distributed both geographically and demographically, therefore increasing challenges to water governance (Shiklomanov, 2000; Gleick, 2012). Moreover, Brazil is a very unequitable society and the need for water sharing and what this implies to an unequitable society is important to assess (Assouad, Chancel & Morgan, 2018; Ferreira, Firpo & Messina, 2022).

Third, Brazil is classified as a developing country and often grouped among emerging economies (BRIICS: Brazil, Russian Federation, India, Indonesia, China, and South Africa) (Lund-Thomsen & Wad, 2014). Emerging economies, that follow the development paths of the industrialized countries, rapidly increase the demand for water and prioritize cost-recovery with consequent challenges for sharing water (see 2.5). Lessons from Brazil may be useful and extrapolated for other emerging economies.

Fourth, Brazil is a federal state. Looking at the multi-level Brazilian federal system allows for the unpacking of water governance processes and enables focus on the country's transboundary river basin within different states. Lessons from Brazil may be useful for other large federal states (i.e., Russia, Canada, the United States, Australia, India, and Argentina).

Finally, as a Brazilian, I am familiar with the language, context, and challenges – and this will allow for a more authentic assessment of the challenges faced there.

Within Brazil, I selected the São Francisco River Basin (SFRB) out of 12 transboundary river basins (see Map 1.2) because:

- It has continuous water quantity problems (e.g., droughts); and it is extremely susceptible to the impacts of climate change as almost half of its territory is located in the driest region of Brazil;

4 https://data.worldbank.org/indicator/SP.POP.TOTL?locations=ZJ

- It faces challenges with developing coherent water governance as the river crosses more than five states; and

- The basin serves one of the most populated semi-arid areas in the world with more than one million people (Rufino & Silva, 2017; Alves et al., 2020).

The SFRB flows through the Brazilian federal district and five states (Minas Gerais, Bahia, Pernambuco, Alagoas and Sergipe). There is also a megaproject going on to transfer freshwater from the São Francisco River to four federal units (Ceará, Paraíba, Pernambuco, and the Rio Grande do Norte). Within the SFRB, I selected the states of Bahia, Pernambuco and Alagoas in order to:

- Explore water-sharing challenges, as well as asymmetrical interdependencies and upstream-downstream dynamics between the jurisdictions. The three states are physically linked by the same hydrological system; and

- Assess commonalities and differences as they are also part of the same historical conjuncture as they share intervention programmes, policies, laws and culture.

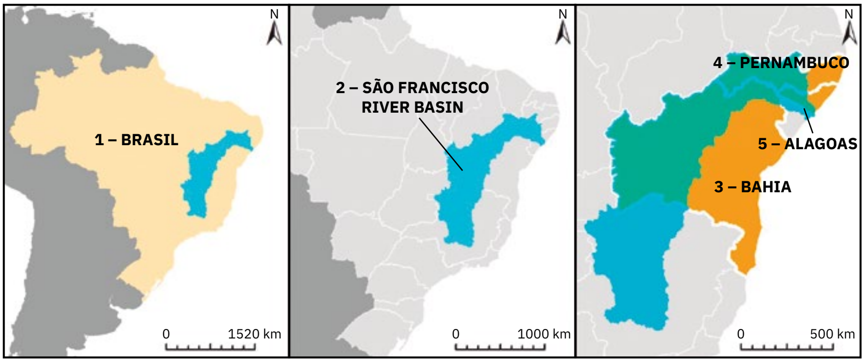
Bahia state is located in the high-medium part of the SFRB and is the largest water consumer in the basin. Pernambuco state is highly dependent on the intermittent tributaries of the SFRB and has implemented a risk management plan. Alagoas state is located downstream of the SFRB and has been suffering environmental harms, particularly saltwater intrusion into drinking water supplies due to upstream development (see 7.2.2.3).

1.5. An Inclusive Development Perspective

1.5.1. Water and development

My focus on water sharing implies a specific theoretical perspective, which I further explain in this section. I will first argue that water is closely linked to development, why I have selected an inclusive development perspec-

Map 1.2 Location of the multi-level case study



Source: Author's elaboration

tive (see 1.5.2), how I operationalize this perspective (see 1.5.3), and why this perspective implies a different approach to development (see 1.5.4).

Water is closely linked to development as societies need water to develop and prosper. The early civilizations, for instance, mainly developed in regions where rainfall and runoff were not a problem, and irrigation canals allowed farmers to grow crops in drier seasons (Gleick, 2000). From the world history of water it is possible to discover how the practices have changed in different directions at different times considering also the transcultural transmissions. People settled along river banks and water bodies because they saw water as a necessary resource for survival and agriculture (Hassan, 2010).

In the nineteenth century, water uses and consumption of water resources expanded. Population growth demanded the expansion of irrigated areas; the development of hydroelectricity and industrialization led to the additional need to use water (Gleick, 2000; Rasul et al., 2021). The development of technology and infrastructure including dams enhance water extraction and use (Smith, 1995; McCartney, 2009; Ahlers, 2020). As almost every activity (e.g. agriculture, industry, energy, transport service provision, recreation) requires water, water is essential for increasing the GDP of countries; and the lack of water can hamper the increase of GDP (Klingensmith 2007; Ahlers et al. 2014). The projections of the increased demand for water accompany projections of the growing demands of a growing populations (see Figure 1.1).

1.5.2. Introduction: why an inclusive development perspective?

There are many different development paradigms – sustainable development, inclusive growth, green economy, inclusive development and many others including buen vivir (van Norren, 2017). I explain below why I choose inclusive development in relation to the other perspectives.

Sustainable development, the most popular term used in the international context today, is defined by the balance between economic, social, and ecological concerns (Murphy, 2012), and between present and future generations. Historically, the concept became important since its use in the 1987 report from the UN World Commission on Environment and Development (WCED), and it was defined as "development that aims to meet the needs of present generations without compromising on the ability of future generations to meet their own needs" (WCED, 1987, p. 43). In that period the concept became politically popular (Paul, 2008), "through rising public concern in the developed countries over the new and alarming phenomenon of global environmental change, and in some ways, it replaced fears of nuclear war that had prevailed in the early 1980's" (Vogler, 2014, p. 435). However, when there are trade-offs to be made between social, ecological and economic issues, economic aspects are prioritized over and above social and ecological ones (see 1.2).

Environmentally concerned scholars and policymakers have instead focused on the green economy concept which was defined as one that results in improved "well-being and social equity, while significantly reducing environmental risks and ecological scarcities"(UNEP, 2011, p. 2). The green economy concept became popular in response to the financial crisis that started in 2008 as scholars and others hoped that economic recovery should integrate environmental issues (Bina & La Camera 2011); and because there was a realization that the environment needs protection in order to enable growth to happen (Georgeson, Maslin & Poessinouw, 2017). The green economy concept and framework has been influencing discourses and policy worldwide in industrialized countries such as the UK and France, in emerging economies like China (Bailey & Caprotti, 2014), and in several countries in Africa (e.g., Rwanda, Morocco, Ethiopia, Senegal, and South Africa) (Georgeson, Maslin & Poessinouw, 2017). However, the green economy does not always address social issues and is an umbrella concept that lacks operationalization, in other words, the "green economy covers a lot of diverse concepts and its links with sustainability are not always clear" (Borel-Saladin & Turok, 2013; Loiseau et al., 2016, p. 361).

Many scholars and countries prefer the term inclusive growth which is defined as "a new approach to economic growth that aims to improve living standards and share the benefits of increased prosperity more evenly across social groups" (OECD, 2014, p. 8). This concept is directly connected with the pro-poor growth concept, and some definitions are interchangeable (Ranieri and Almeida Ramos, 2013). Multilateral, international and regional governmental organizations, donors, and NGOs such as the World Bank, Asian Development Bank, the African Development Bank, the Organisation for Economic Cooperation and Development, and the United Nations Development Programme have promoted the inclusive growth concept (AfDB & UNDP, 2013; OECD, 2014; Ngepah, 2017). However, one of the main problems of inclusive growth is that it inadequately addresses environmental issues and inequality is often aggravated (Gupta & Vegelin, 2016).

The exclusiveness of much of the development discourses gave rise to the concept of inclusive development. Inclusive Development (ID) is defined as "development that includes marginalized people, sectors, and countries in social, political and economic processes for increased human well-being, social and environmental sustainability, and empowerment" (Gupta, Pouw & Ros-Tonen, 2015). Inclusive development implies "focusing on social wellbeing and protecting the ecosystem services of nature through redefining political priorities, especially in the context of the Anthropocene" (Pouw & Gupta, 2017, p. 104). The concept of inclusive development challenges the neoliberal capitalist preoccupation with maximizing economic growth, the focus on cost-recovery and that the poor must support themselves and find ways to generate income (Gupta, Pouw& Ros-Tonen, 2015). It builds on ideas of redistributive instruments that address the structural drivers of marginalization at all levels of governance (Obani & Gupta, 2016). Within the principles of inclusive development is the claim that unregulated economic growth may lead to social exclusion and increased economic and ecological inequality (Rammelt &Gupta, 2021). The recognition that GDP does not adequately incorporate the environment has been made very clear in Lord Dasgupta's new and influential report (2021) and that it is compatible with exclusion is evident since, for instance, in 2019, the world's 2,153 billionaires held more wealth than the poorest 4.6 billion people (60% of the planet's population) (Oxfam, 2020).

Hence, this thesis adopts an inclusive development approach that combines global insights with local contextualization. I choose inclusive development over sustainable development because the latter tends to prioritize economic concerns over and above social and ecological ones. I choose inclusive development over inclusive growth because inclusive growth externalizes the environment (UNEP, 2020; Rammelt & Gupta, 2021). Third, I choose inclusive development over the green economy, because the green economy narrative is most focused on the optimization of economic growth and less promoting socio-ecological inclusion (Rammelt &Gupta, 2021, p. 144). Inclusive development allows for adopting concepts like buen vivir and is consistent with recent amendments to the constitutions of countries like Ecuador (Radcliffe, 2012) and Bolivia (Lalander, 2014).

1.5.3. The evolution of inclusive development

The roots of inclusive approaches to development arose during the decolonization process following World War II. The development concept was first articulated in the post-War and decolonization context of the mid-1940s and 1950s. Development was equated to increasing Gross Domestic Product (GDP) (Gupta & van der Grijp, 2010). In the 1960's, along with the recognition of especially political human rights came the state-centric and economic-focused international system. This period is marked by an increased focus on GDP, the notion of economies of scale, infrastructure development, and investments in large-scale industry (Gupta & van der Grijp, 2010). However, by the 1970s, the GDP-oriented development strategy was perceived as problematic from an environmental perspective in the Limits to Growth Report (Meadows, Randers & Meadows, 2013).

In the 1990s, a shift occurred in the global community's approach towards human development and poverty reduction. There was a focus on capability and freedom (Sen, 2014) and on multi-dimensional poverty as emphasized among others by UNDP (1994). This shift overlapped with increasing attention to environmental concerns and the sustainable development agenda (Redclift, 2005; Adams, 2019). The concept of inclusive development emerged then as a way of focusing on marginalized communities and the poorest of the poor (Sachs, 2004). This concept has subsequently been expanded to include ecological and relational inclusiveness (Gupta et al., 2015).

1.5.4. Defining and operationalizing an inclusive development perspective

The three main components of inclusive development (social, ecological, and relational inclusiveness) are outlined below:

- *Social inclusiveness* means improving the wellbeing of people, communities, and states (Gough & McGregor, 2007). This considers human wellbeing according to people's own priorities, empowering them with a rights-based approach to ensuring their inclusion (Gupta, Pouw & Ros-Tonen, 2017). The purpose of social inclusion is to guarantee basic rights, such as access to water, food, health services, housing, and justice (Gupta, Pouw & Ros-Tonen, 2017). Social inclusion is operationalized in terms of principles and policy instruments of priority of use, equitable and reasonable use, and intergenerational equity (Conti, 2017).

- *Ecological inclusiveness* means recognizing that natural resources are finite and there is need for the conservation of biodiversity by decreasing resource extraction and pollution in the Anthropocene (see Box 1.1) (Gupta, Pouw & Ros-Tonen, 2017). This dimension is operationalized through instruments such as environmental impact assessment, monitoring, pollution prevention, protection and preservation of ecosystems, and protection of water recharge and discharge zones (Conti, 2017).

- *Relational inclusiveness* refers to the need to address the structural relational aspects underlying inequality (Rammelt &Gupta, 2021). Democracy, distribution of resources and participation are viewed as essential in preventing marginalization and poverty (Sachs, 2004; Mosse, 2010; Oxfam, 2014; Gupta, Pouw &Ros-Tonen, 2015). The relational component is linked to structural power politics that impact problem-solving through governance instruments. This dimension builds on ideas of redistributive instruments and the need to address the structural drivers of marginalization at all levels of governance (Obani &Gupta, 2016). Essentially, it focuses less on growth and more on shared wellbeing (Gupta, Pouw & Ros-Tonen, 2015; Bos & Gupta, 2016). The dimension is operationalized through principles and policy instruments of participatory approaches towards the protection of marginalized populations. While I examine how sharing instruments can theoretically change relational politics, this thesis does not focus on the politics taking a critical instrumentalist perspective.

I adopt these three components of ID in my analytical framework to test the performance of water-sharing instruments at different levels of governance (see 2.5). I also use this lens to examine the economic aspects of water.

1.5.5. How does inclusiveness redefine development

A recent study uses Toulmin's argumentative model to show that even though the 2030 Agenda (UNGA, 2015) has included the economic growth and Inclusive Development (ID) concepts, these are incompatible (Rammelt & Gupta, 2021). The main reason is that "since growth is entangled with socio-ecological exploitation and appropriation, it conflicts with ID where 'inclusive' encompasses social, ecological and relational dimensions, and fundamentally redefines 'development'" (Rammelt & Gupta, 2021, p. 144).

In essence, the study presents three main claims to support their argument. First, "growth cannot be effectively optimized towards social and ecological inclusion" (Rammelt &Gupta, 2021, p. 145). Second, "given a limited environmental utilization space (or 'ecospace'), ID implies transcending a focus on minimum access towards reallocating resources, responsibilities and risks" (Rammelt &Gupta, 2021, p. 145). Third, "such redistribution requires a post-growth development agenda, which calls for relational inclusion and a systemic transformation of the global economy" (Rammelt & Gupta, 2021, p. 145). Thus, they reiterate the need for a new paradigm in which distribution takes place taking into account social, ecological and relational inclusion. I return to the issue of what sharing implies for the implications for development in the last chapter of this thesis.

1.6. Policy Relevance

1.6.1. Evolution of water policy

This thesis focuses on water sharing and is thus policy relevant. Water has been governed from local through to global levels in water customs, policies and laws. This section briefly introduces the evolution of water law and the most relevant policies since the 1970s (see Table 1.3) before focusing on the 2030 Agenda (UNGA 2015)(see 1.6.2).

Attention to global water policy can be traced back to 1971 when the Ramsar Convention on Wetlands of International Importance Especially as Waterflow Habitat was adopted (Ramsar Convention, 1971). The Convention aimed to protect highly sensitive and globally important wetland ecosystems and prioritize water-sharing with nature. In 1972, the Stockholm Conference on the Human Environment (Stockholm Declaration 1972) discussed various aspects of environmental protection including the protection of water. In 1977, the Mar Del Plata Conference was the first global conference on water and discussed various issues including the need to meet basic needs of humans (Mar del Plata Action Plan 1977). In follow-up to the Mar del Plata Action Plan, the 1980s was denoted as the International Drinking Water Supply and Sanitation Decade (IDWSSD); however, progress to achieve these goals remained limited (Sadoff, Borgomeo &Uhlenbrook, 2020).

Later, at the 1992 International Conference on Water and the Environment (ICWE) in Dublin, 100 countries and eighty international, intergovernmental, and non-governmental organizations discussed water-related issues in the context of sustainable development (Conti, 2016). The non-binding Dublin Statement (1992) adopted four principles: (1) water is a finite resource, (2) water policy development should consider a participatory approach, (3) women have a central role in water provision and management, and (4) water has an intrinsic value and is an economic good. These principles have often been considered the foundation of the IWRM paradigm (see 3.2.3) and indirectly contributed to the commodification and pricing of water.

Also in 1992, the UN Conference on Environment and Development produced four key documents that have notably contributed to the water-sharing narrative: (1) the Rio Declaration on Environment and Development (1992), which included 27 principles for governing the environment and social issues; (2) Agenda 21 which included a chapter on freshwater (Agenda 21, 1992); (3) the United Nations Framework Convention on Climate Change (UNFCCC, 1992), which addressed the impact of climate change on water, and (4) The Convention on Biological Diversity (CBD, 1992) which emphasized the importance of protecting nature.

In 1997, the UN General Assembly (UNGA) adopted the UN Watercourses Convention (UNWC, 1997). This was a product of a 30-year process led by the UN's International Law Commission (ILC). The Convention, which was inspired by and built upon the International Law Association's Helsinki Rules (ILA, 1966), presented three important principles relevant to water-sharing: (1) equitable and reasonable utilization in water-sharing between countries; (2) priority of use for human consumption; and (3) the no harm principle. It also recommended the need to set up river basin organizations to help manage water issues. Another global water agreement, the UNECE Water Convention of 1992 does discuss equity issues, but does not elaborate it quite as much as the Watercourses Convention (Tanzi, 2020).

More recently, progress has been made regarding the human right to water and sanitation. In 2010, the UN Human Rights Commission and UNGA adopted two separate resolutions (UNGA, 2010; UNHRC, 2010), both recognizing and prioritizing the human right to water and sanitation. In 2015, the UNGA adopted the Sustainable Development Goals (SDGs), which consists of 17 interdependent goals for social, economic, and environmental issues (UNGA, 2015). The SDGs were derived from a non-binding process involving 193 member states and civil society organizations. The purpose of the Goals is to achieve global sustainability across social, economic, and environmental issues by 2030 (UNGA, 2015). They provide an interesting and coherent way of thinking about complex global issues (Nilsson, Griggs & Visbeck, 2016) and intend to balance these often competing issues by linking the environment with socio-economic values (Harmancioglu, 2017). The SDGs build directly upon the structure of the 8 Millennium Development Goals (MDGs 2000), and many of its Goals and targets relate to water (UNGA 2015). Although there is considerable critique of the SDG agenda (Swain, 2018), I focus below on whether this agenda can contribute to the understanding of water sharing.

1.6.2. The 2030 Agenda and the Sustainable Development Goals

Although many of the SDGs are synergetic, there are still competing interests between some (Le Blanc, 2015). Competing use of natural resources is one of the main challenges nowadays (UN Environment, 2019). For instance, achieving the goal on food and agriculture (SDG 2) may stand in the way of achieving the goals on water (SDG 6) and energy (SDG 7). As the SDGs are not legally binding, prioritization of the goals varies from country to country and can be highly influenced by national

Table 1.4. Key international treaties that deal with water-sharing issues

International treaties and policies	Year	Water-sharing issues and how it is addressed	Inclusiveness
UNESCO Ramsar Convention	1971	Protects highly sensitive and significant wetland ecosystems: sharing with nature	Ecological inclusiveness
ICWE Dublin Statement (ICWE)	1992	Need to protect freshwater as a finite and vulnerable resource, (essential to sustain life, development, and the environment); Recognition of economic pricing of water resources	Social and ecological inclusiveness
UN Framework Convention on Climate Change (UNFCCC)	1992	Disaster risk reduction: sharing risks	Social and ecological inclusiveness
UN Convention on Watercourses (UN CTWC)	1997	Equitable and reasonable utilization (Art. 5); Relevant factors to equitable and reasonable utilization (Art. 6): sharing between users;	More social than ecological inclusiveness
		Priority of use: sharing between uses	Social inclusiveness
		No harm: sharing between users and nature	Social and ecological inclusiveness
UN Human Right to Water and Sanitation (UNGA)	2010	Human Rights to Water & Sanitation: sharing between users	Social inclusiveness
Agenda 2030	2015	Equitable access to safe and affordable drinking water for all; improve water quality: sharing between uses	Social and ecological inclusiveness

Source: Author's elaboration

NB. All the above documents have some sort of relational inclusiveness.

circumstances and politics (Le Blanc, 2015). However, Agenda 2030 requires that countries refrain from making trade-offs between the goals but whether this will happen in practice remains to be seen.

Agenda 2030 directly and indirectly addresses water resources through underlying principles, 17 goals, 169 targets, and 232 indicators (UNGA, 2015). The principles of Agenda 2030 that are relevant for water sharing include inclusiveness, universality, leaving no one behind, multi-stakeholder partnerships, interconnectedness, and indivisibility (Dahiya & Okitasari, 2018; Braeye et al., 2020). The emphasis on the indivisibility of goals implicitly prioritises equity issues.

SDG 6, which is the most relevant in this research, acknowledges the importance of an enabling environment to ensure safe drinking water and sanitation for all and sustainable management of water resources, wastewater, and ecosystems. Other relevant goals are those pertaining to poverty (SDG 1), hunger (SDG 2), inequalities (SDG 10), and climate action (SDG 13).

SDG 6 (see Table 1.4) and its 6 targets and 9 indicators address different aspects of social, ecological and relational inclusiveness. For example, social inclusiveness is in indicator 6.1.1; 6.2.1; ecological inclusiveness in 6.3.1, 6.3.2, 6.4.2 and 6.6.1; and relational inclusiveness is in 6.5.1 and 6.5.2. The question is whether these targets and indicators adequately capture elements of inclusive development. I return to this topic in the last chapter.

Agenda 2030 calls for "sustainable, inclusive and sustained economic growth, shared prosperity, and decent work for all" (UNGA, 2015, p. 6). Agenda 2030 implicitly recognizes that shared prosperity is not possible without shared resources, an issue which is central to this thesis, but Agenda 2030 is not explicit about this. Table 1.4 links the Targets and Indicators of SDG 6 to different categories of sharing mentioned in this thesis. This shows that the targets and indicators implicitly address the sharing issue. Table 1.4 also reconceptualises the key SDG targets and indicators from an inclusive development perspective (see rightmost column). For instance, target 6.1 ('achieve universal and equitable access to safe and affordable drinking water') can be understood as granting the world's most under-resourced and under-privileged access to basic needs and provisions (i.e., water), a central pillar of the social inclusiveness dimension. Similarly, target 6.3 ('improving water quality be reducing pollution, eliminating dumping…') speaks to the ecological inclusiveness dimension, which ensures that policies and water management do not themselves hamper access to ecosystem services for the world's most under-resourced and under-privileged.

1.7. Structure of the Thesis

This thesis is organized in 8 chapters. This chapter has presented an overview of current and future challenges facing water allocation. Chapter 2 explains the research methodology and elaborates on the methods chosen to operationalize the theoretical approach to this case study.

Table 1.5. SDG 6 indicators and main water-sharing issues

Targets	Indicators	Main water-sharing issues
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	6.1.1 Proportion of population using safely managed drinking water services	Implicitly contributes to social inclusiveness by prioritizing water access for drinking water and sanitation or sharing between users
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 Proportion of population using safely managed sanitation services, including a handwashing facility with soap and water	
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping, and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1 Proportion of wastewater safely treated	Implicitly contributes to social and ecological inclusiveness or sharing with humans and nature
	6.3.2 Proportion of bodies of water with good ambient water quality	Implicitly contributes to ecological inclusiveness, sharing with nature
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time	Implicitly reduces water demand and thus contributes to social and ecological inclusiveness, sharing between uses and nature
	6.4.2 Level of water stress: Freshwater withdrawal as a proportion of available freshwater resources	Implicitly contributes to ecological inclusiveness, sharing with nature
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1 Degree of integrated water resources management implementation (0–100)	Implicitly contributes to relational inclusiveness and sharing of responsibility
	6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation	
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes	6.6.1 Change in the extent of water-related ecosystems over time	Implicitly contributes to Ecological inclusiveness, sharing with nature

Source: Agenda 2030

Chapter 3 presents the literature review on water governance paradigms, focusing on the relationship between evolving water paradigms and water-sharing. Chapter 4 presents the literature review on the instruments that explicitly deal with water-sharing. Chapter 5 covers the historic development, current situations and anticipated future challenges of water governance approaches and looks at the institutional framework of water governance at the national level in Brazil. Chapter 6 discusses the evolution, current situation and expected changes in the transboundary São Francisco River Basin (SFRB). Chapters 7 discusses the current state and future challenges of water governance at the state level of three states that are part of the SFRB (Alagoas, Bahia, and Pernambuco). Chapter 8 presents the empirical analysis and conclusion of the research and provides recommendations for how water governance can be adapted to anticipate future challenges and further support equitable water-sharing and sustainable and inclusive development.