Water governance in Brazil

The need to share water in the anthropocene

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8.

8. CONCLUSION

8.1. Introduction

This chapter brings the different elements of the thesis together by recalling the 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? The research sought to answer the sub-research questions presented in section 1.3:

- Why is equitable water-sharing becoming increasingly important in the Anthropocene?

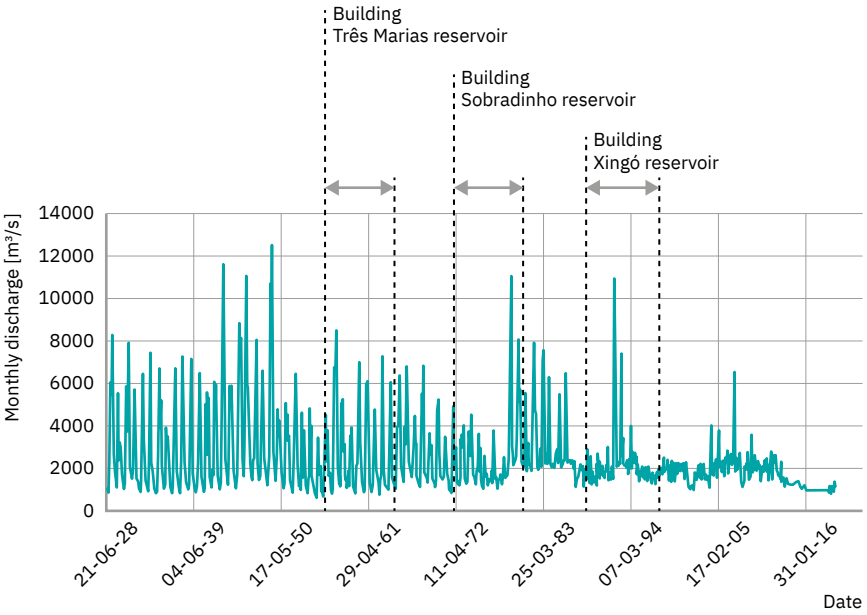
- How can water-sharing be addressed in general and in the specific context of federal countries?

- 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?

8.2. Progression of water governance

Increasing pressure on water resources and intensifying competition over access to water are altering the hydrology of many rivers worldwide. Among various ecological problems, basins are becoming highly polluted and many river basins are overexploited (Molle, Wester & Hirsch, 2009; Wester, 2009) (see Table 3.3). There are several examples of overexploited river basins, such as the Yellow River in China (Ren & Walker, 1998), the Colorado River in the United States (Kenney et al., 2021), the Indus in India & Pakistan (Khero, Khahro & Samejo, 2020), the Murray-Darling in Australia (Molle, 2021), and most rivers in the Middle East and Central Asia (Molle et al., 2007). In São Paulo city, Brazil, reservoirs decreased so significantly in 2015 that emergency water trucks were needed in some areas (Milano et al., 2018; van den Brandeler, 2020). Cape Town in South Africa, Jakarta in Indonesia, Bangalore in India, also experienced a severe water shortage recently (Welch, 2018; Muller, 2020; Oki & Quiocho, 2020). With so

Figure 8.1. Schematization of development of the SFRB considering river flows registered downstream of Sobradinho reservoir from 1928 to 2017 at Juazeiro station (code 48020000)



Source: Author's elaboration based on raw data from ANA (2020) and CPRM (2020)

many water systems reaching the closed phase, it is therefore urgent to discuss water redistribution.

As a consequence of both direct drivers (e.g., water demands for energy, commercial agriculture, industries and services, and households) and indirect (global) drivers (e.g., population and economic growth, technological innovation, rapid urbanization, and climate change) pressure on water resources and competition increase. For example, compared to 2010 records, the global use of energy is projected to increase by 20% by 2030 and 85% by 2050 (IEA, 2012; Boretti & Rosa, 2019); water demand for industries is projected to increase by 800% in Africa and 250% in Asia (Boretti & Rosa, 2019). Meanwhile, the world population is estimated to reach 8.5 billion by 2030 and 9.7 billion by 2050 (United Nations, 2019), increasing demand for drinking water and food production at all levels.

Brazil is no exception to the increasing demand and decreasing supply (see 5.2.3). In the SFRB, the dramatic reduction of the river flow over the years indicates the influence of the built reservoirs during the hydrological regime (see Figure 8.1). This synthesizes the general evolution of

the increasing demand and decreasing supply in the river, pointing out that, should the trend continue into the future, the system will collapse, because demand is far exceeding supply, especially if one reserves water for nature (Barros & Naves, 2022). This calls for a new sharing paradigm.

8.2.1. Progress in water governance in Brazil

Different water paradigms have dominated water governance over time (see Chapter 3). Some of these paradigms have highly influenced the water sector in Brazil (chapter 5). Figure 8.2 presents the progression of water governance in Brazil from 1950 to 2050, following three phases of water demand: meeting supply needs, increase in demand, and crisis (see 3.3.3). Each phase assesses how water-sharing has been incorporated into water governance.

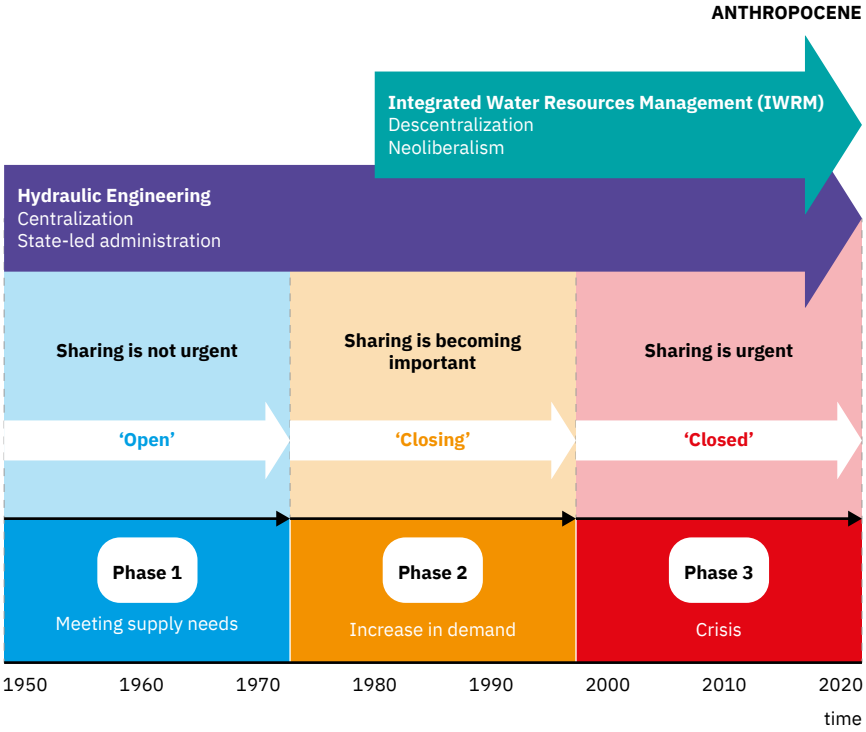
As Brazil is presented in the crisis phase, there is a clear indication of the urgent need to engage in adaptive water governance. More than that, if Brazil intends to have an equitable system, it must engage a new paradigm, prioritizing inclusive development and where sharing water becomes the norm.

In summary, in the first phase (Meeting supply needs), policies were aimed at meeting supply needs and Brazil's water supply was higher than demand. Brazilian water governance was highly influenced by oligarchs who held authority and political control (Abers and Keck, 2013). Water allocation was mainly focused on commercial agricultural users, and water-sharing was not really an issue (see 5.2.1). In the second phase (Increase in demand), demand increased. Under military dictatorship (1964-1985), water governance was centralized in the federal government and the electricity sector was responsible for water management (ANA, 2018). Decision-making processes were top-down, reinforcing national sovereignty and explicitly following the hydraulic engineering paradigm. Environmental issues were not fully recognized in public policy or political discourse and water allocation was highly focused on the single purpose of energy development (Barros, 2017).

Currently, Brazil is in the 'crisis phase', where water demand is higher than there is supply in some country areas such as São Paulo[50] and Rio

50 Water crisis in Sao Paulo in 2020 and 2021. *Source: https://www.cnnbrasil.com.br/business/crise-hidrica-em-sp-e-pior-do-que-a-de-2013-diz-professor*

Figure 8.2. Schematic representation of the phases of Brazilian water governance in terms of water demand from 1950 to 2020



Source: Author's elaboration

de Janeiro[51]. Water governance is decentralized, encouraging stakeholder participation, and the basin has been adopted as the main unit of water management since the 1990s (Libanio, 2014). This approach reflects the IWRM paradigm and has stimulated privatization and public-private partnerships based partly on the ideology of neoliberalism (Ioris, 2010). While the need for water-sharing between humans and nature is recognized on paper; in practice, hydroelectricity and commercial agriculture interests remain of higher priority. This contradiction presents an urgent need for the adoption of a new paradigm of water governance that is focused on prioritizing water and environmental justice matters through an inclusive adaptive approach.

51 Water crisis in Rio de Janeiro in 2020 and 2021. *Sources:* https://diariodorio.com/rio-de-janeiro-ja-vive-crise-hidrica-e-situacao-pode-se-estender-e-ate-piorar-em-2022-e-2023/; https://www1.folha.uol.com.br/cotidiano/2020/02/entenda-a-crise-de-abastecimento-de-agua-no-rio-de-janeiro.shtml

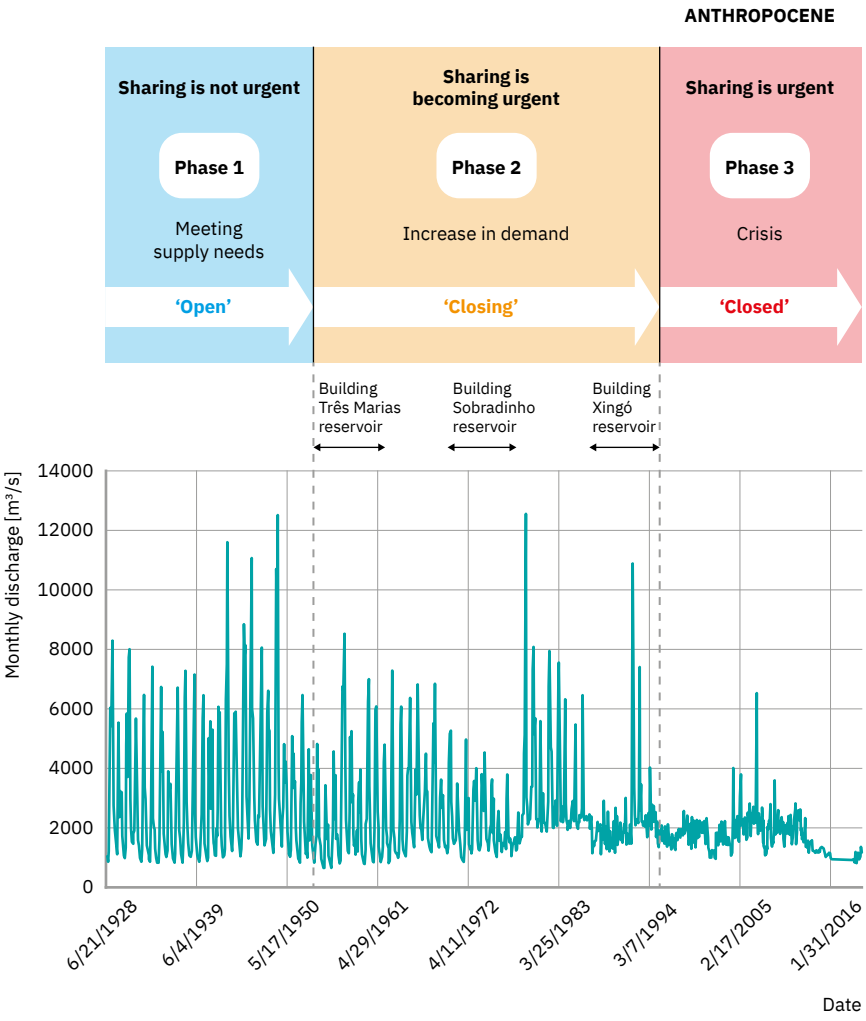
8.2.2. Progress in water governance in SFRB

At the basin level, river basin development can be understood as a manifestation of how societies have tried to control and use water over time. These factors are also very present at the state level (Chapter 7). Most of the population in the SFRB is concentrated upstream in the state of Minas Gerais, where water resources are used mainly for urban domestic needs, mining, and industrial wastewater disposal. In the drier middle (states of Bahia and Pernambuco) and lower (states of Sergipe and Alagoas) areas of the basin, the primary uses of water resources are irrigation and energy. Over time, water availability has decreased downstream and water allocation has become an issue in the last two decades. The state of Bahia has faced drastically deteriorating biodiversity and increasing desertification (Rios, Silva &Carvalho-Santos, 2020; da Silva et al., 2021). In Pernambuco, the biggest water-related problem has been an extensive decline in groundwater levels causing various negative impacts, including saltwater intrusion, water quality degradation, and potential subsidence risks (see Table 7.2) (Cary et al., 2015; Chakrabarti et al., 2017; Marques, Gunkel & Sobral, 2019). The state of Alagoas is marked by an asymmetrical relationship in water-sharing between upstream and downstream users in the SFRB. It has also been affected by increasing salinization and saltwater intrusion, indicating that the damming of the SFRB has reduced freshwater flows and increased saltwater levels in this state. This situation has caused many adverse effects on the estuary (see Figure 7.2).

Figure 8.3 provides a schematic representation of the development of the SFRB as a domestic transboundary river basin. It synthesizes the same three phases of meeting supply needs, increase in demand and crisis in showing how the river flow has been changing over time. The schematization demonstrates the general evolution of the SFRB towards becoming a closed basin, recognizing that a basin can be 'reopened'. It is important to note that the definition of the phases proposed at this level are not mutually exclusive and can overlap.

During the phase of meeting supply needs, the SFRB was 'open' and water governance discussions focused on strategies to cope with recurring drought episodes. Water-sharing occurred mainly among commercial agricultural users, who received proportionally more water than their counterparts in subsistence agriculture. Historically, until the 18th

Figure 8.3. Schematization of development of the SFRB considering river flows registered downstream of Sobradinho reservoir from 1928 to 2017 at Juazeiro station (code 48020000)



Source: Author's elaboration based on raw data from ANA (2020) and CPRM (2020)

century, water governance was highly influenced by the colonial system (Benjamín, Marques & Tinker, 2005). As the Portuguese administration was unable to control the sizeable Brazilian colony, it created an alliance with the country's oligarchs who held power, authority, and political control (Bursztyn, 1990).

In the 19th century, the great drought of 1877–1879 in the SFRB region led to a large influx of refugees from poor rural areas to regional urban centres, claiming the lives of hundreds of thousands of people from hunger and diseases (Ab'Sáber, 1999; Andrade, 2006; Rios, 2014). This put the region on the national political agenda (Livingstone & Assunção, 1989; Goodman, 1992; Lindoso et al., 2018). The federal government confined the refugees in temporary camps and implemented large hydraulic works as the main strategy to cope with the situation (Andrade, 2006). Many dams and reservoirs of medium size (açudes) were built to guarantee water security (Molle, 1991; Assunção & Livingstone, 1993). However, they were often built on private lands and did not guarantee adequate water-sharing (Buckley, 2010). The hydraulic solution was rather used as an instrument of domination, corruption, and control over people through infrastructure, becoming recognized as the "drought industry" (Lindoso et al., 2018).

The early 1950s brought along a significant shift. Water governance changed from a hydraulic focus to a 'developmentalism' focus, recognizing the socioeconomic causes of poverty, hunger, and refugee influxes (Campos, 2015:Lindoso et al. 2018). The federal government applied direct modernization measures in agriculture through systems of "credit, cooperatives, and rural extension linked to the green revolution technological" package (Bursztyn, 2008; Lindoso et al., 2018, p.3). This strategy led to an increase in agricultural production; yet, these actions were ill-adjusted to local culture and only a few areas (e.g., Juazeiro and Petrolina) experienced economic development and prosperity from high productivity systems and irrigation (Bursztyn, 2008; Lindoso et al., 2018; Rocha, 2008). Once more, prevailing interests in large hydraulic works favoured the oligarchs, contributing to further inequalities between the few oligarchs who had access to federal opportunities and the majority of Brazilians who were excluded from such access (Sampaio, 2002; Barros &Naves, 2022).

In the phase of increased demand (hydraulic mission), water demand was almost in line with or equal to the available water supply. This phase was strongly influenced by the hydraulic engineering paradigm. As a result of damming the SFRB, the river flow changed significantly and started to reach the "closed" stage. Water governance discussions were centred on sectoral issues such as managing hydroelectric energy and irrigation water. Water-sharing occurred mostly among uses and users. The energy sector was responsible for water management in the basin and the commercial

agricultural sector received proportionally more water than subsistence agriculture. Conflicts increased as a result of the unequal water-sharing relations among uses, users, and between humans and nature.

By the mid-1960s, the federal government strategically used water resources to promote development. The federal government controlled all decisions related to water use and management in a centralized and top-down approach (Empinotti et al., 2018). The Ministry of Mining and Energy was responsible for water management in the basin and its main strategic plan was to support hydroelectricity projects to promote industrialization. The Ministry created regional organizations such as the Company of Hydroelectricity of the São Francisco River and the Company of Development of the São Francisco Valley to explore the agricultural potential of the respective water bodies. The hydroelectricity projects were funded by the federal government and foreign capital and included active participation of state governments.

Three massive reservoirs were constructed with seasonal storage capacity: Três Marias, Sobradinho, and Luíz Gonzaga (Itaparica) (Chesf, 2016). These infrastructure developments intersected with increased implementation of irrigation systems along the rivers and an expansion of agricultural frontiers using capital-intensive agriculture and technological packages. Equity was not considered, and ecological concerns were neglected, causing further social and environmental conflicts throughout the region. Protests against large water projects along the São Francisco River increased and gained support from priests of the Catholic Church and civil society organizations.

Currently, the SFRB is in the crisis phase. Water demand is higher than the supply of the resource. Over the years, the river flow has been decreasing due to overexploitation of surface and ground water and extreme weather events (e.g., droughts)(Lucas et al., 2020). The basin has reached the “closed” phase, where new demands cannot be accommodated unless existing demands are reduced to enable an increase in the water supply (Keller et al., 1998, p.146). Water governance is decentralized and engages stakeholder participation (Braga & Lotufo, 2008; Kleemans, 2010). Water-sharing is dealt with in terms of managing energy, irrigation, and drinking water.

By the 2000s, water governance in Brazil had shifted from singular to an integrated focus. Inspired by the IWRM paradigm, the National Water Law of 1997 influenced the creation of the São Francisco River Basin

Committee (CBHSF) in 2001. The SFRB was adopted as the main unit of planning; stakeholder participation was high; and several mechanisms, such as the basin plan, the basin agency, and water charges, were implemented in the last decade.

Nevertheless, the SFRB continued to suffer prolonged droughts. The most recent drought began in 2012 and lasted until 2017 (de Jong et al., 2018). In the short term, this caused salinization of soil and coastal aquifers, arsenic pollution of deep groundwater, depletion of wild fish stocks, and reduced flow of water and sediments downstream of the river (delta), impacting the quantity and quality of water and food available. In the long term, the delta itself may entirely disappear due to unsustainable growth. Increased demand for energy, food, and water for the growing population and economy has also increased disputes between powerful economic users across the different sectors.

In conclusion, the proposed model can be useful to help understand dynamics in basins to assess the need for sharing. Generally speaking, first supply increases higher than demand, then vice versa.

8.3. Sharing of Responsibility, Rights, and Risks: addressing drivers and water-sharing instruments

8.3.1. Addressing drivers and problems

The empirical chapters showed increasing influence of neoliberalism at all three levels (nation basin, states). Neoliberalism is considered the driver of water use and it has not been addressed by the current water-sharing instruments implemented in Brazil. The neo-liberal capitalist trend has been converting nature into commodities and selling these. This trend tends to externalize the impacts on nature and the environment. It also means that the neoliberal market contributes to growing inequality. The growing environmental degradation and inequality contribute more to climate change via pollution. Therefore, all political levels need to reassess the prioritization of the economy over the environment and the resulting loss of ecosystem services.

Indirectly, the commercial agriculture and rapid urbanization driver could potentially be addressed if a combination of water-sharing instruments would be implemented. If well managed, the combination of the water budget, the river basin plan, water use permits for allocating

water to large users, and the bulk water charge instruments can prevent further ecological degradation while ensuring more sustainable access to water resources in the long term. For instance, in Brazil in 1960, water consumption for irrigation represented 33.2% of the withdrawal. In 2020, consumption had risen to 50.1%, doubling over 60 years (Pasqualetto et al., 2019, p. 53). This shows how important it is that Brazil develops water governance instruments that do effectively address the driver of commercial agriculture. The water permit instrument could have this potential if well implemented. if well implemented.

The climate change driver is also indirectly addressed by the protected area instrument. If well managed, protected areas can increase carbon sequestration, provide resilience to catastrophic events and ensure connections across landscapes that allow plants and animals to move (4.6.2.2). However, Brazil still has limited resources to manage this instrument at all levels, as deforestation and deterioration inside these areas are increasing (Paiva et al., 2020).

Other drivers not addressed by instruments at any level include population growth, technological innovation, rural-urban migration and growing inequality. Effective instruments addressing these drivers in the Brazilian context were not identified in my research. More research is required about these unaddressed drivers and their relationship to water-sharing instruments.

8.3.2. Water-sharing instruments

In Brazil, several instruments are being used to address water-sharing at different levels. Table 8.1 summarises the previously discussed instruments in Chapters 5, 6, and 7. It shows how they can be organized within the six categories of sharing: (1) sharing of responsibility between levels; (2) water-sharing between states; (3) water-sharing between uses; (4) water-sharing between users; (5) sharing between humans and nature; and (6) sharing of water-related risks. Overall, my research found that, the instruments used at the national and basin levels performed better than those used at the state level in terms of design, effects on water-sharing, and impacts on inclusive development. These instruments are used in a broad sense to cover all concepts that may have an impact on water-sharing. There is, of course, still room for improvement in all the levels towards inclusiveness that were identified through the interviews and literature review.

Table 8.1. The categorization of water-sharing instruments in the Brazilian multilevel case study

Water-sharing categories	Instruments	BR	SFRB	BA	PE	AL
Sharing of responsibility between levels	Federal system	✓				
Sharing of water between states	'Water Pact'	✓	✓	✓	✓	✓
Sharing of water between uses	Priority of Use	✓	✓	✓	✓	✓
	Human Right to Water and sanitation	✓				
Sharing of water between users	Water use permit for allocating water to large users	✓	✓	✓	✓	✓
	Bulk water charge	✓	✓			
	Irrigation systems	✓	✓	✓	✓	✓
Sharing of water between humans and nature	Minimum flow	✓	✓	✓	✓	✓
	Protected areas	✓		✓	✓	✓
Sharing of water-related risks	Climate proofing	✓			✓	
	Disaster risk reduction	✓				
	Drought management			✓		

Source: Based on Chapters 5, 6 and 7

8.3.2.1. Sharing of responsibility between levels

Federal system

The evaluation of Brazilian federalism indicates that the 1988 Constitution has often been praised as transformative because of its egalitarian aspirations. For instance, the 1988 Constitution had four aims: To (i) build a free, fair society characterised by solidarity; (ii) guarantee national devel-

opment; (iii) eradicate poverty and marginalization and reduce social and regional inequalities; and (iv) promote the good of all, without prejudice to origin, race, sex, colour, age and any other forms of discrimination (Art. 3, Constitution 1988). It also entrusted considerable power to sub-national governments, establishing a joint federal water governance system. The decentralized system gave more autonomy to the states over groundwater and facilitated the implementation of the Crisis Chamber instrument (see 6.4.5). This new perspective brought on a high degree of legitimacy to the government by enabling the participation of stakeholders in the decision-making processes of water allocation and re-allocation during severe droughts in the SFRB region. Without the joint government, this implementation may not have been feasible for the central government alone as it required the active participation of stakeholders at different levels.

However, compared to Canada's federal system, for instance, the lack of a dominant role at the central government level in Brazil has resulted in a slow, but nonetheless democratic, implementation of instruments such as the 'Water Pact' agreement (see 6.4.1).

The joint government can draw inspiration from Articles 5 and 6 of the UN Convention on Watercourses to favour more equitable sharing of water resources between upper riparian states and provinces and those with less access to water downstream. The equitable and reasonable utilization principle of the Convention offers significant insight into the relevant factors that can be considered in discussions and decision-making processes of water allocation. In addition, many countries may wish to prevent the crisis phase and jump to the Inclusive Adaptive Water Governance phase (3.3.4) and adopt a 'leapfrog' strategy to stay ahead of a crisis. However, given the strong anthropogenic influences on water resources, for example, this can also entail implementing approaches that consider equal water-sharing between humans and nature (e.g., environmental impact assessment, monitoring, pollution prevention, protection and preservation of ecosystems, and protection of water recharge and discharge zones).

8.3.2.2. Water-sharing between states

Water Pact

Evaluation of the Water Pact in the SFRB, a domestic federal river basin, indicates that the instrument has a great potential to realize adequate

water allocation. The Water Pact has been proposed as an agreement between the states part of the river basin to re-determine water allocation rules and procedures. This agreement is important because it became essential to manage competition between the upstream and downstream states. However, it has not been politically accepted because upstream states such as Minas Gerais and Bahia do not want to share with downstream states (e.g., Alagoas and Sergipe). However, if political conditions change and states become willing to consider the sharing alternative, finalization and implementation of the Water Pact would be my first suggestion to realize water-sharing between states.

It is crucial that allocation agreements begin to explicitly reserve water for the environment. If the government is serious about ensuring equitable water uses for humans, conservation of ecosystems and allowing for efficient use of water resources, then this agreement would require taking into account the needs of nature. Articles 5 and 6 of the UN Convention on Watercourses can be used as the fundamental references to establish more equitable sharing of water resources between upper riparian states and provinces. Furthermore, the ANA and CBHSF should invest in and promote win-win collaboration with all states (e.g., mutual protection of water quality).

8.3.2.3. Water-sharing between uses

Priority of use

Evaluation of priority of use is the same at all levels. Progress has been made with the priority of use principle being coordinated between water availability, water resources plans, and water permits instruments. In the SFRB, for instance, the São Francisco River Basin Plan and the water permit instrument were designed taking into account the priority of use as a principle.

However, the instrument has not been operationalized in terms of how much water should be reserved for humans and which animals get priority.Therefore, this principle needs improvement because if not designed adequately, operationalized or implemented, it cannot work well. If the government is serious about this, this principle would require strategic guidance on how water can be allocated between different geographic or administrative regions. The design of this instrument

can be further improved if: it can set clear criteria for implementation (e.g., a specific amount of water directed to each water use such as water supply, irrigation); and it can introduce specific actions for the protection of marginalized groups (e.g., people living in the slums area); and it can set accountability mechanisms that work in practice during the crisis periods.

The priority of use instruments has been not properly implemented at any level. To enable proper use, it should set well-defined roles for authorities such as ANA, states agencies and river basin committees (e.g., CBHSF), and accountability mechanisms that work in practice during the crisis periods (e.g., water budgets).

The human right to water and sanitation

The human right to water and sanitation has been adopted as a principle in Brazil, but it has not been adequately implemented at all levels. This principle can potentially impact a broad range of people, including vulnerable groups (e.g., women, children, poor, marginalized) (Gupta & Lebel, 2010; Obani & Gupta, 2014; Hurlbert, 2020); ensure that individuals or groups are given legal mechanisms to improve their conditions (e.g., marginalized groups are guaranteed rights that can be enforced) (Obani, 2018); and ensure access to clean water, which has the potential to significantly reduce the burden of disease (e.g., water-borne diseases including cholera, hepatitis A, typhoid, and arsenic poisoning).

However, Brazil has been systematically violating this right. For instance, more than 34 million Brazilians lack access to drinking water and another 100 million to sanitation services (IDS, 2018b) (Interviewees N-2) (see 5.4.3). In practice, Brazil does not guarantee people immediate access to water. Therefore, more effective actions to support the human right to water and sanitation principle are needed.

If the government is serious about the universalization of drinking water and sanitation, then the Human right to water and sanitation principle would require: clear information regarding sewage collection and treatment per municipality as approximately 55% of municipalities do not have this information (IDS, 2018b); design of sanitation plans for all municipalities as only 30% of the municipalities have it (IDS, 2018b); and implementation of a budget to operationalize the universalization of drinking water and sanitation (IDS, 2018a).

8.3.2.4. Water-sharing between users

Water use permits for allocating water to large users

Water permits are a fundamental regulatory instrument to allocate water through administrative processes. Water use permits for allocating water to large users have nuances in the implementation at different levels. The national and basin levels performed better than those used at the state level in terms of implementation.

Even though the advantages of the water permit system are direct impact, clarity, and applicability to a broad group of actors, the combination with other instruments can improve its effectiveness. This is the case in a combination of the water permit system, river basin plans, and water information management systems instruments. The degree of effectiveness resulting from combining multiple instruments however also depends on other aspects like their operationalization.

A disadvantage of combining multiple instruments is that it requires adequate information about water availability, quantity and quality (i.e., considerable knowledge and expertise) and the ability to make an appropriate water budget. This is a challenge especially for many developing countries that lack adequate information on how much water is available for human uses and where water governance systems tend not to allocate water to the environment. Another challenge is that such permits and contracts may allocate water ownership de facto for a long period of time and thus limit the flexibility of the state in terms of redistribution(Bosch & Gupta, 2021).

There is, of course, still room for improvement in all the levels towards inclusiveness that were identified through the interviews and literature review. First, water use permits for allocating water to large users lack enforcement and inspection (sections 5.4.4 and 7.4.2). Strengthening "inspection and control mechanisms, and sanctions and penalties in case of non-enforcement and compliance" is urgently needed at all levels (OECD, 2018,p. 32) (Interview N- 14 /N- 19/N-23). Second, at state level, it is fundamental to have updated state registries of water abstractions and discharges. Third, there is a need for developing technical capacities to carry out regular ex-post evaluations to monitor the effectiveness of abstraction and pollution charges. For instance, although Bahia designed the State Environmental and Water Resources Information System (SEIA)

in 2011 aiming to minimize the risks of water damage and support the water permit system, the SEIA remains inoperative due to a lack of budget, low number of technicians, and unmotivated political will.

Bulk water charges

The bulk water charges instrument is well implemented especially for large users (e.g., industries, agriculture, and sanitation companies) in the SFRB, yet not at the state level. This is because the water permit systems offers adequate information to implement the bulk water charges instrument. In the SFRB, the instrument has allowed for sharing of financial benefits with everyone. Charges for financing specific purposes (e.g., Integrated Preventive Inspections, hydro-environmental projects and designing the Municipal Sanitation Plans in the municipalities part of the SFRB (Interview B-7/B-8) are indicated in the SFRB Water Resources Plan. Since 2010, the Water National Agency (ANA) collects the charges which are fully transferred to the Basin Agency (Peixe Vivo), encouraging participatory, decentralized, and integrated action (CBHSF, 2016, p.124).

The implementation of the bulk water charges also reveals how the instrument has been influencing behaviours of actors (e.g., irrigators). Since the updated values of water resources in 2018, irrigators have been more interested to participate in the basin committee (CBHSF) and have been discussing the water permits with ANA (see 5.4.4). As the water price was low, the irrigators requested permits with higher volumes than they needed in order to reserve water for expanding their productions (ANA, 2019b). The current standard makes this behaviour difficult as it requires irrigators to inform ANA of their actual water usage and requires ANA to extensively review water permits (ANA, 2019b). Therefore, this new actors' behaviour helps ANA to know the exact amount of water use and improve the water-sharing discussion.

The bulk water charges instrument still needs improvement like improving the inspection and control (Assirati, Chaves & de Tomi, 2021); promote and carry out regular monitoring and evaluation of the adequacy, implementation, and results of water charges to assess to what extent they fulfil the intended outcomes and adapt where necessary (OECD,2018;Assirati, Chaves & de Tomi, 2021); and it can ensure transparency on how revenues from water charges are used (e.g., demonstrate

that revenues are being spent in an accountable way, effectively, equitably, and efficiently for the benefit of the river basin).

Irrigation systems

The implementation of the irrigation systems has had different nuances in the SFRB, as noticed in Figure 6.1 which presents the total irrigated areas in Alagoas, Bahia, and Pernambuco states between 1960 to 2015. Even though, this infrastructure instrument of water-sharing has a direct performance such as producing food, and benefiting a lot of users, it is also true that the irrigation system is contributing to increase inequality, fast degradation of the soil, deforestation and decreasing biodiversity.

In the SFRB, the implementation of the irrigation systems and the programmes and policies proposed were ill-adjusted to local dynamics (Bursztyn, 2008; Lindoso et al., 2018) and increased inequalities between the few who had access to federal opportunities and the majority who were excluded (Sampaio, 2002). This happened because: the agricultural modernization process did not contribute to local knowledge of the design of the irrigation systems nor accounted for the lost areas of traditional subsistence farming (Lindoso et al., 2018); the irrigation development policies did not enable small farmers to access water for food production and, in most cases, required them to have a basic managerial, technological, and financial capacity that they did not have (Bursztyn, 2008; Arrobas & Enei, 2009; Lindoso et al., 2018). The economic boom of development and prosperity still occurred in the Northeast regions, leading to cities like Juazeiro and Petrolina becoming irrigation polygons with high productivity systems (Rocha, 2008)(see 6.4.3), but mainly to the profit of the elites.

The irrigation systems still needs improvement in several aspects. It is fundamental to have a combination between the water basin plans, the permit instrument and irrigation system components, to avoid overexploitation of the resources. Second, it needs “strong inspection and control mechanisms, as well as sanctions and penalties in case of non-enforcement and compliance” (OECD, 2018,p. 32). Third, environmental monitoring of groundwater, surface water, and soil is needed (Cooperman, McLarty & Seim, 2021). Fourth, there is need to consolidate and establish a water fee system within the irrigation schemes as a contribution to consumption reduction (Interview B-7). Fifth, inte-

grated nutrient management practices need to be adopted, with an emphasis on the importance of systematic soil analysis and the nutrient demand of each crop as well as on crop rotation techniques and principles of fertilization practices to reduce pollution (Jat et al., 2015; Siegmund-Schultze 2017)). Finally, incentivize dry agroecosystems using a combination of farming practices (including soil management), animal husbandry, and agroforestry (Petersen & Silveira, 2017).

8.3.2.5. Sharing between humans and nature

Protected Areas

Protected areas have nuances in the implementation at different levels. At the national level they performed better than at the state level. Even though protected areas provide direct allocation of water to ecosystems, preserve biological diversity, maintain native habitats, (Hermoso et al., 2016; Jones, McGinlay &Dimitrakopoulos, 2017), protected areas are costly and few resources are currently allocated to their management of all levels (da Silva, da Anunciação &de Araújo, 2020).

If the government is serious about water-sharing between humans and nature, it is recommended that more financial resources are invested in management, monitoring, and enforcement of protected areas at all levels; and creation of protected areas located in the Cerrado and Caatinga biomes which are extremely vulnerable (see Box 5.4) (Interview B-2)(Siqueira Filho, 2012).

Minimum flow

Evaluation of minimum flow indicates that the instrument is more developed in terms of implementation at basin level when compared with the state level. Yet, even though progress has been made, the value of the minimum flow mistakenly is named as ecological flow by Brazilian policies and laws (da Silva, Pereira & de Oliveira Vieira, 2020, p. 19). This is a conceptual error, because “in establishing this percentage of flow that must remain in the watercourses in the most critical periods does not take into account the actual needs of the river ecosystem in terms of flows and, therefore, shouldn’t be called ecological flow” (da Silva, Pereira & de Oliveira Vieira, 2020, p. 19). In practice it is possible to notice that

water-sharing between humans and nature has not been enough for nature (Barros &Naves, 2022). For instance, in the SFRB, the water released from dams indicates that there is not sufficient water supporting aquatic species (de Souza Castro et al., 2015; Medeiros et al. 2013; Knoppers et al., 2005), nor for recharge of the aquifers (see chapter 7).

If the government is serious about water-sharing between humans and nature, then there is an urgent need for studies on river flows to support ecosystem services (Interview B-7); and re-design this instrument, taking into account the water needs of nature.

The re-design of the minimum flow instrument taking into account the needs of nature is recommended because water permits are granted considering the amount of water that can be diverted from the water body, taking into account the percentage of the minimum flow required. Hence, minimum flow can be seen as ecological flow (see 4.6.2.1). This is because ecological flows take into account the percentage of flows that must remain in the watercourses even in the most critical periods to attend the needs of the river ecosystem. However, the ecological flow is costly in the short-term, requires considerable knowledge and expertise (i.e., needs to consider the magnitude, frequency, duration, seasonality, and periodicity of the natural flow) (Richter et al., 2012), and socially acceptable limits for river development (Dickens et al., 2019). It can be combined with the water permit system for greater effectiveness.

The ecological flow instrument can secure enough water for the environment to ensure the health of ecosystems. The disadvantage of not securing enough water for the environment means significant costs. If the water level falls too much, saltwater can destroy agricultural land and deny drinking water. Not respecting the ecological flow can thus have costly negative effects in the long term.

8.3.2.6. Sharing of water-related risks

Climate proofing

Only national level and among the states under study Pernambuco explicitly adopt, the climate-proofing instrument as a policy. In Bahia and Alagoas, the climate-proofing policy has not yet been adopted. The advantages of adopting climate-proofing are direct impacts (less loss of lives and material damage) and relates social and socio-economic ben-

efits. Climate-proofing avoids damage repair costs and postpones drastic actions (Kabat et al., 2005). The Netherlands, for instance, has been climate-proofing by implementing protective dikes and surge barriers (Kabat et al., 2005). In terms of disadvantages, climate-proofing is expensive to build and maintain (Renaud et al., 2013) and requires specialized knowledge and expertise on climate change and trust in, and legitimacy, of precautionary policies (Vogel & Henstra, 2015). This is also evident in the Netherlands considering the country's high dependence on specialized knowledge and expertise on climate change to deal with higher risks of river and water drainage flooding due to intense precipitation (Edelenbos et al., 2017).

Both Bahia and Alagoas could use the design of climate-proofing instruments in Pernambuco as an inspiration and learn from its experience. One of the elements that they should take into consideration is participation. In the case of Pernambuco, the state agency (APAC) has been promoting participation through daily information in the news and social media (Interview PE- 3/4/5). Therefore, APAC has been seen by society as a positive and trustful connection, people can easily access the information, thereby reducing asymmetry in knowledge.

Disaster risk reduction

Brazil has been making slow progress around the disaster risk management instrument at national, state and local levels. The commitment and investment from the national government to strengthen local capacities to implement disaster risk management and local risk assessments is not satisfactory (see 5.4.7).This is because the federal government is responsible for providing emergency funds to the municipalities to manage the effects thereof, and the money allocation is not a straightforward process. Therefore, there is a significant bargaining process to access the emergency funds involving the municipality in need, the state and federal governments

But if Brazil wants to improve this instrument, several recommendations can be considered such as: commitment and investment from the national government to strengthen local capacities to develop local risk assessments, regular monitoring, implementation of flood warning networks based on long term scenarios.

Drought management

Brazil has been making progress around Drought Management at basin level, however, this is not implemented at other levels. In the SFRB several proactive actions have been implemented (e.g., the Crisis Chamber) while at national level the responses have been most of the time reactive. At state level this instrument is absent.

The advantages of adopting the drought management instrument include direct impacts such as guaranteeing food security and accessible food prices (Carrão, Naumann &Barbosa, 2016), while the disadvantages are that it is costly, it requires extensive climatic data records and accuracy of measurements of precipitation data and is often difficult to implement (De Stefano et al., 2015).

If Brazil wants to have a more inclusive response, it is recommended that Brazil should prioritize proactive responses, that are continually updated. Then, it is fundamental to increase the investments in proactive mechanisms such as building resilience at the farm level and include planning, monitoring, and implementation of planned measures to avoid the most severe impacts of droughts (Rossi & Cancelliere, 2016), recognizing that drought planning is permanent and therefore actions must be continuous (FAO, 2019).

8.3.3. Combining the instruments for optimal effect

A strategic combination of various policy instruments should successfully address inclusiveness. Of course, the degree of effectiveness resulting from combining multiple instruments may also depend on other aspects like the operationalization of those instruments. In the context of Brazil, policy and instrument mixes are one way to combine the strengths and weaknesses of different instruments to ensure a desired outcome. Table 8.3 assesses these instruments taking into account inclusiveness and considering social, ecological, and relational components.

First, a well-developed priority of use instrument can determine which uses get priority. This requires knowledge of a water budget and how much water needs to be reserved for nature. Such a reserve can be promoted through a combination of protected areas (e.g., national parks) and ecological flow instruments which should take into consideration the magnitude, frequency, duration, seasonality, and periodicity of the

Table 8.2. Water-sharing instrument, strengths, weakness and recommendation

Instrument (assessment)	Strengths	
Federalism (works well)	Power diffusion easier to accommodate political, cultural, and related differences that are locally specific	
'Water Pact' (not implemented)	Provides an objective agreement for allocating water resources	
Priority of use	Provides an objective foundation for allocating a limited resource; can prioritize water allocation to vital human needs and reserve water for nature; direct impact and benefit for a greater number of people and animals, depending on whether they are prioritized	
(remains poorly implemented at all levels)	Recognizes rights to potable water and improved sanitation resources (direct impact); applicable to a broad group of actors	
Human Rights to Water and Sanitation (not properly implemented at all levels)	Direct impact, is clear and can be made applicable to a broad group of actors	
Water use permits for allocating water to large users (works well at the national and basin levels; not properly implemented at the state level)	Steer actors' behaviour through market signals; resources acquired can be used to finance specific purposes	

	Surface	Weakness
	Problems with coordination between federal, state, and local governments. Many jurisdictions are leading to fragmented responsibilities between actors at multiple levels of government	• Entail implementing approaches that consider equitable water-sharing between humans and nature (e.g., ecological flow)
	Not signed by states. Requires considerable commitment and willingness to share among all the participants	• ANA and CBHSF can invest and promote win-win collaboration with all states to sign the 'Water Pact'; • Equitable and reasonable utilization principle of the Convention can offer significant insight into the relevant factors to be considered in the decision-making processes of water allocation • Take into account the needs of nature
	Requires setting the priorities and allocate quantitative divisions (including water allocation to vital human demands and nature)	• Set explicit administrative procedures for faster implementation of priority of use (e.g., a specific amount of water directed to each water use such as water supply, irrigation) • Introduce specific actions to the protection of marginalized groups (e.g., people living in the slums area) • Set well-defined roles to authorities and accountability mechanisms that work in practice during the crisis periods
	The rights are not self-enforcing and require considerable administration and investments to ensure implementation	• Promote instruments to address affordability and other equity issues (e.g., cross-subsiding)
	Does not allocate water to the environment in all levels; BA/PE/AL: Lack of enforcement and inspection Requires considerable knowledge of water budget and expertise	• Allocate water to the environment (e.g., adoption of the ecological flow instrument) • Strengthen inspection and control mechanisms, as well as sanctions and penalties in case of non-enforcement and compliance • Update states' registries of water abstractions and discharges to charge • Develop technical capacities to carry out regular ex-post evaluations to monitor the effectiveness of abstraction and pollution charges
	Lack of inspection and control; difficult to design and enforce a water pricing system; rich water users do not conserve water	• Promote and carry out regular monitoring and evaluation of the adequacy, implementation, and results of water charges to assess to what extent they fulfil the intended outcomes and adapt where necessary • Ensure transparency on how revenues from water charges are used and demonstrate that revenues are being spent in an accountable way, effectively, equitably, and efficiently for the benefit of the river basin

Table 8.2. Water-sharing instrument, strengths, weakness and recommendation

Instrument (assessment)	Strengths	
Bulk water charge (works well at basin level)	Relatively direct impact in their performance by making supplies available	
Irrigation systems (work well at the basin level but not as an instrument for equitable water- sharing)	Allocates water to ecosystems; focuses on maintaining native and intact habitats (direct impact)	
Protected areas (designed well at all levels)	Direct impact	
Climate proofing (not properly designed at national and Pernambuco state; lacking in Bahia and Pernambuco)	Direct impact; in the case of using early warning systems such as flood warnings can be time-saving	
Disaster Risk Reduction (not properly implemented at all levels)	Direct impact as it can lead to a proactive response to guarantee food security and accessible food prices; costs of action are (usually) lower than the costs of inaction	

Drought management (not properly implemented at all levels)

	Surface	Weakness
	Lack of inspection and control; Relatively inflexible requires considerable underlying knowledge and expertise, costly; can have significant social and environmental costs; hydropower has a high risk due to climate change and low water availability	• Strengthen inspection and control of water permits and irrigation system components, as well as sanctions and penalties in case of non-enforcement and compliance • Environmental monitoring of groundwater, surface water, and soil • Adoption of integrated nutrient management practices, with an emphasis on the importance of systematic soil analysis and the nutrient demand of each crop as well as on crop rotation techniques and principles of fertilization practices • Consolidate and establish a water fee system within the irrigation schemes as a contribution consumption reduction • Incentivize dry agroecosystems using a combination of farming practices (including soil management), animal husbandry, and agroforestry
	Lack of enforcement and inspection; costly; requires considerable knowledge and expertise, and PA implementation can have negative social impacts	• Increase financial resources available for management, monitoring, and enforcement of protected areas • Strengthen inspection and control mechanisms (sanctions and penalties) • Create protected areas focusing on Cerrado and Caatinga biomes
	Costly; requires specialized knowledge and expertise on climate change, trust, and legitimacy of policies	• The national government needs to invest in designing the climate-proofing instrument
	Requires considerable commitment and investment from governments to strengthen local capacities and local mechanisms; requires sufficient levels of implementation for each monitored DRM activity	• The national government needs to invest in designing local mechanisms (e.g., risk assessments, risk information, regular monitoring, implementation of flood warning networks based on long term scenarios)
	Requires a long climatic data record and accuracy of measurements of the precipitation data	• Increase investments in proactive mechanisms such as building resilience at the farm level • Adopt drought-resilient crops

natural flow. Thus, it recognizes ecosystems as legitimate water 'users', which makes steps towards an ecologically inclusive water management scheme. After deducting the water needed by nature, the priority of use instrument may not need to reserve water for nature. But if such water has not already been reserved for nature, then priority of use may need to account for nature. The priority of use instrument may also be linked to priorities for providing permits to users for different uses. Therefore, it embodies socially inclusive elements as it can increase the probability that the urban and rural poor people have access to drinking water. In summary: the priority of use instrument potentially can be a very strong instrument to ensure sharing of water in times of crisis.

Second, the climate change instruments can be used to create a situation which allows for suspension of some water permits during extreme droughts and floods without compensation.

Third, some instruments can be combined for greater effectiveness of the water permit system, such as river basin plans and water information management systems. If one knows how much water is available for human use, then one can design a permit system that stays within that limit.

Fourth, the Crisis Chamber combined with water information management systems provides a political platform for broader stakeholder participation and negotiations, which is critical from a relational inclusiveness perspective. Besides, this combination incorporates process-based learning in complex adaptive systems and enables decision-making despite uncertainties (Pahl-Wostl et al., 2007), as presented in section 6.4.5.

8.3.4. Adopting appropriate missing instruments

Combining between instruments that are already in place (see 8.3.3), and some missing instruments such as: water pricing of goods and services incorporating the water footprint; water-saving irrigation technologies; water budgets and ecological flow is critical. These four independent instruments are closely connected, and they can reinforce each other.

First, water-saving irrigation technologies can be adopted by commercial farmers because it improves the efficiency of water use (Kumar, 2016; Chen *et al.*, 2020), for instance, reducing water use while maintaining the same production (e.g., drip irrigation)(Çetin & Akalp, 2019). The

disadvantages are that these technologies are costly and require high financial investment to implement (Neissi, Albaji & Nasab, 2020). One possible solution is to offer a discount as proposed by a new study regarding the bulk water charge (CHSF/Direct Observation, 2016).

Second, water budgets estimate the availability and sustainability of a water supply, focusing on regional or basin-scale, and provide the water budget of the surface water. Some of the Brazilian river basins already have a water budget incorporated in their river plan such as the SFRB (see 6.4.4). However, as Brazil is a big country is fundamental to estimate the water budget per region. The disadvantages of adopting this instrument is that it requires a reliable data record and accuracy of measurements of the precipitation data (Guo, Liang & Leung, 2004; Pan *et al.*, 2012). Thus, it can be costly and difficult in some regions.

Third, a more drastic step would be to incorporate the costs of the water footprint in goods and services. This will motivate producers to use more water-efficient production technologies. This is however much more difficult to implement. It requires accurate measurements, reliability of data records and an accepted translation of the costs incurred in the prices of goods and services. This is difficult and costly to develop. Moreover, because it increases the costs of goods and services, products and services might become unaffordable for the poor.

Fourth, the ecological flow can secure sufficient water for the environment to ensure the health of the ecosystems (see 4.6.2.1). The disadvantage is not securing sufficient water for the environment means significant costs. In particular, if the water level falls too much, saltwater can destroy agricultural land and unviable drinking water.

8.4. Research questions

This thesis aimed to contribute to the discourse on water governance in advancing inclusive development (ID). The thesis addressed the relationship between three evolving paradigms (hydraulic engineering, integrated water resource management (IWRM), and adaptive water governance) and presented an overview of water policy instruments dealing with water-sharing. Using inclusive development as the guiding norm was useful for analysing the menu of water- sharing instruments in terms of social, ecological and relational dimensions.

Table 8.3. Inclusiveness and water-sharing instruments in Brazil

Instruments	Social	
Federal system	[+] Intends to eradicate poverty and reduce social and regional inequalities	
'Water Pact'		
Priority of use	[+] Increase the probability that the urban and rural poor people have access to drinking water	
Human Right to Water and sanitation	[+] Access to water recognized as a human right	
Water use permit for allocating water to large users	[+] Beneficial uses of water such as small farmers or household	
Bulk water charge		
Irrigation systems	[+] Aims at addressing social challenges with respect to water [+] Increases standards of living through infrastructural works (e.g.; irrigation systems)	
Minimum flow	[+] Aims at addressing social challenges with respect to water	
Protected areas	[+] Minimizes the risk of water damage to humans	
Climate proofing	[+] Minimizes the risk of water damage to humans	
Disaster Risk Reduction	[+] Minimizes the risk of water damage to humans	
Crisis Chamber - Drought management	[+] Reduces the risk of more water damage (e.g., River day, adaptation of the river's flow)	

Source: Author's elaboration

N.B.: [+] = positive effects in terms of inclusiveness; [-] = negative effects in terms of inclusiveness

	Ecological	Relational
		[+] Promotes participatory approaches
	[+] Recognizes ecosystems as legitimate 'users' of water [-] Does not consider the sustainable use of the water resource (e.g., ecological flow)	
	[+] Considers water availability (based on water resources plans and water permits)	[-] Equity in the process is not ensured through the involvement of stakeholders in the definition of "exceptional circumstances" and the sequence of priority uses
	[+] Considers water availability (based on water resources plans) [-] Does not consider the sustainable use of the water resource (e.g., ecological flow)	
	[+] Finances programme and interventions proposed by the water resources plans	
	[-] Dominance of human activities over natural processes overlooking many negative ecological issues	[+] Creates new relations in terms of those who own and control the distribution of water and related benefits; it can be potentially positive if well designed, implemented and rooted in the inclusive development perspective [-] narrow stakeholder involvement creating issues of integrating information sources, legitimacy, and justice
	[-] Does not consider the sustainable use of the water resource (e.g., ecological flow)	
	[+] Recognizes ecosystems as legitimate 'users' of water [+] Recognizes of the high value of the ecosystem services and the necessity of recharge areas for groundwater	[+] Considers the marginalized groups living in nature such as indigenous people
	[+] Recognition of the high value of the ecosystem services (e.g., the preservation, conservation and recovery of environmental resources)	
		[+] Provides a political platform for broad stakeholder participation, negotiation, and promotion of shared values [+] Reduces asymmetry information among the participants and supports more homogenous conditions of knowledge to be shared by the stakeholders [+] Incorporates process-based learning in complex adaptive systems and enables decision-making despite uncertainties

8.4.1. Why is equitable water-sharing becoming increasingly important in the Anthropocence and what does this imply for theory development?

Why is equitable water-sharing becoming increasingly important in the Anthropocene? In addressing this first research question, the thesis looked at the characteristics of the Anthropocene including climate change, changes to the biogeochemical and hydrological cycles; and extensive loss of habitat and biodiversity (Barnosky *et al.*, 2011; Steffen *et al.*, 2011). But social scientists argue that the Anthropocene is also characterized by inequality (Rammelt et al. in review); and is framed in averages which hide the distributional aspects and the underlying inequalities (Gupta, Hordijk & Vegelin, 2019).

I argue that water-sharing is becoming important in the Anthropocene because:

(a) The Anthropocene scholarship on planetary boundaries shows the clear limits to the amount of resources we can use at global through to local level. At global level, the water boundary is set at an annual maximum of 4,000 km³ consumptive blue water use (Wang-Erlandsson et al., 2022); Brazil is considered to have abundant is blue and green water resources, although the availability of water is highly heterogeneous in the different states (Flach et al., 2016, 2020). Many surface water bodies have become closed meaning there is no additional water for use from these basins (see Table 3.3). In fact growing scholarship shows that we may have to reverse the trend of extracting water from groundwater without replenishing it adequately (UN Water & UNESCO, 2022) and that we may have to leave much more water in the water bodies for nature than previously was seen as necessary, if we want to ensure that nature can continue to support life on Earth.

(b) If there are clear limits, this means that only the 'usable' water is available for use between different uses. If the boundaries reserve water for nature, then we only need to think about how the usable water can be divided or shared between the other actors and levels. This is not an abstract exercise, it is a reality facing many water scarce regions worldwide. They do not just have to reallocate water because of the inequitable water distribution today, they have to drastically

reduce their use of total water which will cause even greater stress unless they have a clear vision on how to deal with water.

(c) If available water is treated as a common good, it risks a tragedy of the commons (Hardin, 1968) where everyone maximises their use of the resource at the cost of their resource. Hardin went on to argue that as there was not enough for everyone, it was important to enclose the resource, and not share it with the others in his paper on life boat ethics (Hardin, 1968). He recommended, in addition to strong population policies, reducing aid, stopping migration and not accepting migrants (Gupta, 2019). However, I disagree with lifeboat ethics. I think resource scarcity does not mean that a minority should monopolise the resource. Instead, I think resource scarcity implies that we have to revisit allocation mechanisms and learn to share.

(d) Hence, if available water is limited, the literature tells us there are four possible governance responses (Gupta, 2016): (a) a neoliberal capitalist response which prices the resource and allows markets to distribute; in this model as the price of the scarce commodity goes up, mostly only rich people can access the resource; (b) a hegemonic response where states securitize water and do not wish to share the resource with others; in this response states are unwilling to collaborate with each other; (c) a polycentric response where multiple actors govern water simultaneously; this reflects in many ways how water is governed today but does not ensure that we all live within contextual water budgets; and (d) a sustainable development approach such as the 2030 Agenda which makes the effort to identify principles and standards for water-sharing. Like some others, I believe we need some common principles and instruments of water-sharing and within a regulatory framework that promotes universal access to resources, reduces harm to others, and ensures equitable allocation of water. This thesis has attempted to present the key instruments that are critical for water-sharing between states, administrative levels, uses, users, and nature and argues that we should analyse exactly how these share the scarce water resource if we are to meet the goal of not leaving anyone behind. This may be difficult to achieve politically as many see water as key to maximizing profit and increasing GDP if it is used for its most economically productive use.

Such division or sharing takes place through the use of a wide variety of instruments. Understanding the impact of these instruments on actors is critical – If these instruments exclude the poor by design or implementation this violates human rights and can enhance the potential of conflict and crises (Adams, Stoler & Adams, 2020)[52]. Hence, it is critical that instruments collectively ensure some degree of justice.

This has led me to call for a theoretical and empirical focus on instruments that have a serious impact on justice. From a theoretical perspective, I argue that neither the hydraulic, nor the IWRM, nor the adaptive governance paradigm have prioritized sharing, although they have taken some aspects of sharing into account. I argue that in the Anthropocene, when we have to (a) reduce our water use; and (b) correct for existing inequities, we need an inclusive adaptive paradigm that prioritizes sharing. Adaptiveness encourages rethinking key assumptions and coordinating water resources systems on account of the complexity and uncertainty associated with climate variability and change in the Anthropocene (Koontz et al., 2015). Adaptiveness also means recognizing the interdependencies and feedback loops between systems and across scales (Pahl-Wostl et al., 2007). Although Adaptive Water Governance also looks at fairness, it is just one component and often gets ignored in the pressure to prioritize economic returns from water. Therefore, it is fundamental to add the inclusiveness element which calls for social, ecological and relational inclusiveness and focuses on sharing scarce resources (Gupta, Pouw & Ros-Tonen, 2015).

I argue that such sharing is in line with human rights approaches, with the principle of equitable and optimal utilization of water in the Watercourses Convention of 1997, and with the 2030 Agenda (see 1.6). It requires institutional learning that market based approaches may not address the water needs of half the world's population that lives below $5.50 per day and can possibly preempt water conflicts. Without prioritizing fairness, I am afraid water inequity will grow and water use, and pollution will increase as it is not possible to completely exclude the poor from using and polluting water. Therefore, equitable water-sharing is becoming increasingly important in the Anthropocene because it is the only way to address water-sharing challenges between levels, states, uses, users, humans and nature, and water-related risks.

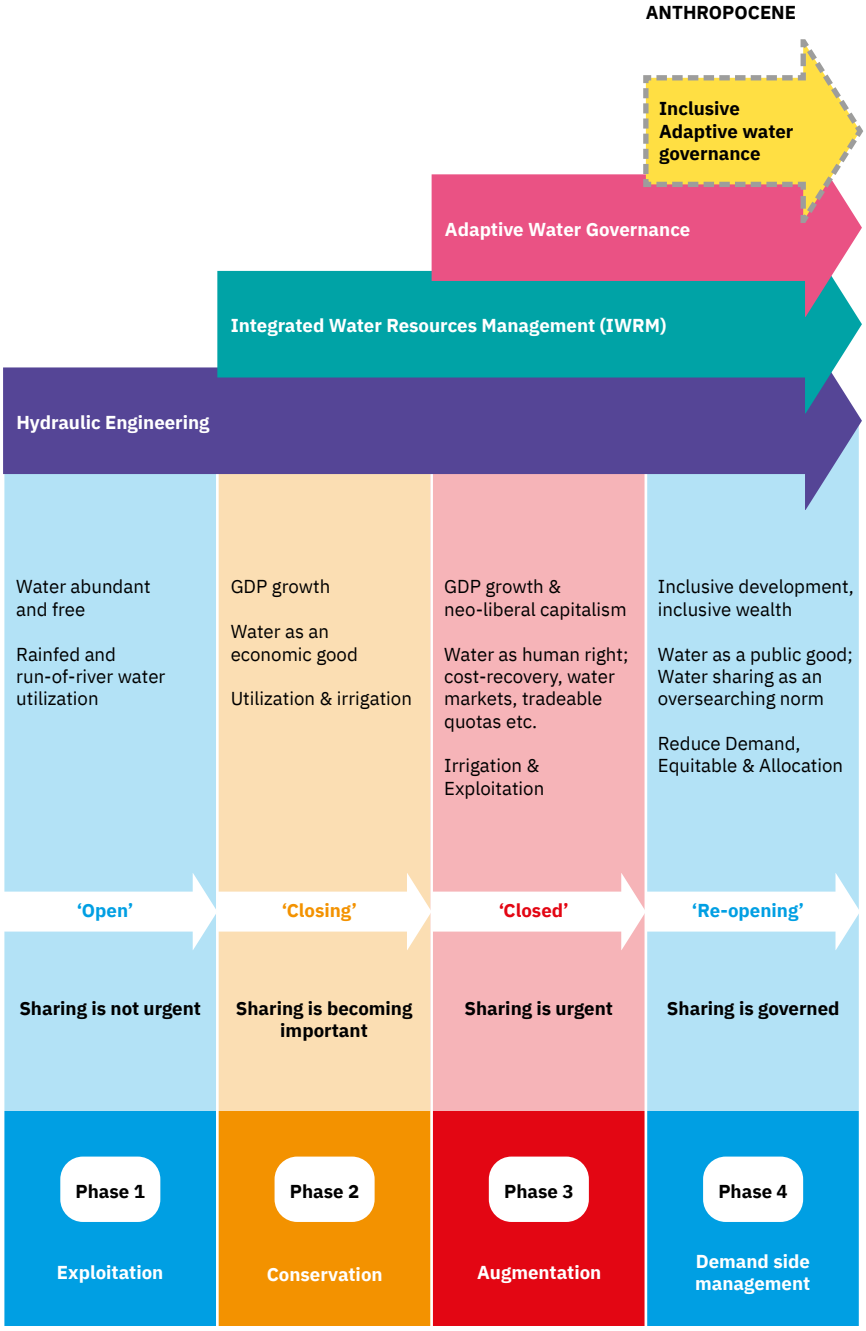
52 They present the relationship between water insecurity and urban poverty through human biological pathways (e.g., gastrointestinal diseases, mosquito-borne diseases, injuries, and mental illness).

Reflecting on the empirical chapters, this thesis offers a historical perspective on water governance in Brazil as means to understanding today's water-sharing policy instruments in relation to inclusive development. It is possible to notice some elements of an inclusive and adaptive water governance phase emerging in the SFRB (e.g., the creation of the São Francisco River Basin Committee and Crisis Chamber). Unfortunately, it is not strong enough to counter the dominating neoliberal mindset that has reinforced high water demands in the energy and commercial agriculture sectors. In order for the SFRB to reach the "reopened" phase, water governance must prioritize inclusive, and adaptive development actions. Priority actions include a) use of the Crisis Chamber, a management water policy instrument implemented and coordinated by ANA, b) explicit reservation of water for the environment; and c) shared decision-making processes (e.g. the São Francisco River Basin Committee) to facilitate participation, negotiation, and transparency. These actions of decentralization will need to be improved and implemented if the water problems of Brazil are to be addressed (Pahl-Wostl et al., 2013). This thesis also clearly showed the need to improve the information and knowledge base. When developed from an inclusive adaptive approach the accessibility and sharing of information is important. Knowledge co-creation can increase its legitimacy among different actors. Process based learning is key in dealing with uncertainty. Redundancy may need to be prioritized over efficiency.

Reflecting on the theory, this research develops a theoretical framework by constructing a model of inclusive adaptive water governance based on how water paradigms have unfolded over time and addressed issues regarding water-sharing. This focuses on equitable water-sharing and how it is becoming increasingly needed in the Anthropocene. It is important to highlight that governments begin to explicitly reserve water for the environment. Currently, ecosystem services and water-sharing between nature and humans are insufficiently considered during development and planning processes of water management in most countries. Therefore, this is the case of Brazil which has not been reserving enough water to maintain freshwater ecosystems (Barros & Naves, 2022).

Most scholars discussing water governance paradigms focus on their structures and purposes, not explicitly presenting a plan for how we should redistribute or share water resources. Hydro-solidarity scholars propose the solidarity-based balancing of human livelihood interests

Figure 8.4. Schematization representation of water paradigms



Source: Author's elaboration

and achieving them against unavoidable environmental consequences (Falkenmark & Folke, 2002). This proposal is extremely vague and does not present requirements to promote water redistribution. Water justice scholars often discuss the challenges faced by the poorest, they do not present clear mechanisms or instruments to achieve redistribution (Zwarteveen & Boelens, 2014).

When thinking about the types of water-sharing instruments adopted by different countries over the years, we must reflect on morality and limits, considering that types of water-sharing instruments adopted determine who can access water resources, how, when, and where they can do so. Hence, water-sharing instruments incorporated by states reveal the states' values. Looking at the privatization of the drinking water sector, accessibility of water services for low-income consumers has clearly not been a priority in this regard. Despite strong support for privatization because it increases the efficiency of water services, the private sector tends to prioritize service delivery to areas with the highest profits (Swyngedouw, 2009), thereby prioritizing efficiency over equity (Jaglin, 2002; Roa-García, 2014; McDonald, 2016; Marson & Savin, 2015).

I do not focus on international sharing but on instruments relevant for the domestic level:

- **Sharing of responsibility between centre and states:** There are federal states (e.g. Canada, the United States, Australia, India), mostly large, that are all debating on whether water should be governed at federal, state or concurrent level. The advantages at central level is that national water issues can be addressed, but this may ignore contextual issues. The advantages at state level is that solutions may be better crafted, but may externalize issues outside the jurisdiction. My Brazil case studies show the need for multi-level governance.

- **Water-sharing between federal units (provinces/states):** Federal systems of transboundary river basins are facing water-sharing disputes such as within provinces in Pakistan on the Kabul river (Hayat, 2020), within Indian provinces on the Cauvery river (Wolf et al., 2005; Sharma, Hipel & Schweizer, 2020); and within Brazil on the Prata basin (Caminati, 2013). (see Table 1.3). The asymmetrical water-sharing relationship between upstream and downstream users can cause conflicts (De Stefano et al., 2017; Bernauer & Böhmelt, 2020); in Brazil, the

water-sharing in the SFRB is becoming urgent because there are (a) unequal distributions between people; (b) increasing water withdrawals for irrigation purposes (almost 78% of the total water withdrawn); and (c) increasing water pollution and shortage (chapter 6).

- **Water-sharing between uses:** Worldwide agriculture and water for animal husbandry is the major consumer of water (e.g. OECD, 2015a). Much of this water is used for goods exported elsewhere. It reduces water for drinking water and sanitation; however, where cities are powerful they use the water at the cost of small farmers. Van den Brandeler (2020) draws attention to two contemporary cases involving water-sharing between uses. São Paulo and Mexico City have been facing a conflict between the river basin and the metropolitan cities (ANA, 2018; van den Brandeler, 2020). This thesis has shown that demand is greater than supply in the SFRB (see Table 6.5 and Figure 7.2). This implies that activity has to reduce water consumption drastically (such as agriculture and animal husbandry) and other uses (e.g. industry, households) will have to enhance their efficiency of use. The Brazil case study shows Brazil as one of the major agricultural producers and net exporters of agricultural commodities (i.e., Brazil exports around 54.8 billion m^3 of virtual water per year)(Da Silva et al., 2016). In Brazil, there is an urgent need to guarantee an adequate amount of water for different kinds of human uses to reduce the conflicts in social-spatial exclusion processes.

- **Water-sharing between users:** Beyond the discussion of competition between uses, there is conflict between different users – local to global – which may impact on water-sharing. Global land and water grabbing and disputes have recently increased (Zoomers, Gekker and Schäfer, 2016; Borras et al., 2019). In Brazil, such experiences have forced many families to relocate to the favelas in urban areas (Borras et al., 2019), land and water grabbing disputes also increased recently leading to violent disputes between commercial farmers and small farmers (Dourado, 2015; Canuto, Luz & Andrade, 2016).

- **Water-sharing between humans and nature:** There are two ways of thinking about sharing water with nature. First, reserving a minimum amount for nature to ensure that it can continue to provide nature's

contributions to people and then dividing the rest between humans, or taking an integrated approach and adopt the ecological flow, for example. This choice is critical to make upfront to ensure that water-sharing is achieved for the benefit of all. However, the scholarship shows that neglecting environmental protection and focusing on economic interests has been the main approach of the countries dealing with water-sharing between humans and nature (Wallace, Acreman & Sullivan, 2003). In Brazil, deforestation is increasing in the last years (Escobar, 2020; Silva Junior et al., 2021). For instance, in the Cerrado biome, an area of 7,300 km² was deforested. Deforestation was greater in the states of Maranhão, Tocantins and Bahia[53].

- **Sharing of water-related risks (drought, flood, and other extreme weather events):** Climate variation and change have been affecting the frequency, intensity and duration of extreme water-related weather events, such as excessive precipitation, floods and droughts (IPCC, 2021). This has been becoming more evident during recent droughts in the Northeast of Brazil and São Paulo city (Rockmann, 2020; van den Brandeler, 2020).

Finally, reflecting on my theoretical and methodological choices, my decision to use an inclusive development framework led me to focus on how regulatory instruments of governance actually share water between different actors. Using inclusive development as the guiding norm for my analysis was important for analyzing water-sharing instruments in terms of social, environmental, and relational dimensions. This allowed for a more comprehensive critique of adaptive water governance. One of the most common criticisms of the inclusive development concept is its lack of parsimony. However, in my research, I found the scope of this concept to be advantageous in enhancing my understanding of water quantity problems considering the three aforementioned dimensions. My results show that the concept is relevant even considering normative issues that require to be understood beyond their legal-technical aspects. This gave me a relatively unique perspective on water governance; however, researching this was not easy as relevant data is not often collected or monitored by other actors. I hope that future researchers will be able to further this approach.

53 https://www.wwf.org.br/?77608/cerrado-prodes-desmatamento-aumenta-123-perde-73-mil-km2

Table 8.4. SDG 6 and potential new indicators for water-sharing instruments

Targets	Indicators	
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	
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	
	6.3.2 Proportion of bodies of water with good ambient water quality	
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	
	6.4.2 Level of water stress: Freshwater withdrawal as a proportion of available freshwater resources	
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)	
	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	

Source: Author's elaboration and the targets based on UN 2015[54]

54 UN. Transforming Our World: The 2030 Agenda for Sustainable Development: Resolution adopted by the General Assembly on 21 October 2015, A/RES/70/1 (UN, 2015).

	Category of sharing	**Include an indicator on**	**Contribution**
	The sharing of water between uses	Priority of use	• Access for people in informal settlements • Proportion of people in informal settlements using safely managed drinking water services
	Sharing of water between uses	Human Right to Sanitation	• Proportion of people in informal areas without proper sanitation facilities
	Sharing of risks	Water discharge permit	• Proportion of people in informal areas exposed to wastewater
	Sharing of water between humans and nature	Protected area	• Identify protected areas which are hotspots for ecosystems and vulnerable communities
		Ecological flow/Reserve for nature	• Is sufficient water reserved for nature (yes/no)
	Sharing of water between users and humans and nature		
	Sharing of water between humans and nature		
	Sharing of water between administrative levels and provinces/states	Article 5 & 6 of the UNWC on equitable and reasonable water use is specifically relevant for water cooperation	
	Sharing of water between humans and nature		

8.4.2. How can we draw lessons for the SDGs?

Agenda 2030 can play an important role in shaping future water governance regimes. Specifically, Goal 6 on water and sanitation can serve as an effective basis for aiming towards sustainability and inclusivity. Targets 6.1 and 6.2 explicitly address equitable access to drinking water and sanitation. However, they do not mention the mechanisms to achieve the goal. This is where policy instruments addressing distribution, redistribution, and water-sharing, such as those presented through my research findings, can contribute.

Table 8.4 presents SDG 6 having the six targets, indicators and the potentially new indicators for water-sharing instruments. This table presents some improvements towards a more sustainable and inclusive society. For instance, in indicator 6.1.1 would be beneficial to add an indicator on priority of use contributing with sharing of water between uses. In specific, it would be beneficial because the contribution could improve the access for people in informal settlements and proportion of people in informal settlements using safely managed drinking water services. In indicator 6.2.1 it may be productive to add the Human Right and Sanitation principle as it could increase the proportion of people in informal areas having access a proper sanitation facility. Regarding water quality, indicator 6.3.1, it would be beneficial to include an indicator related to identifying protected areas which are hotspots for ecosystems and vulnerable communities.

8.5. Epilogue

This thesis has argued for a shift away from the current market based neo liberal capitalist paradigm to a new water governance paradigm which takes the question ‘how do we share’ as the point of departure. This is based on recognizing the human rights of all people and the 2030 Agenda. In many ways there is nothing new about this paradigm. Through history people have been creating mechanisms to share water across different cultures. However, the need to share was marginalized by the need to increase power, profits and GDP growth which is possible through concentrating ownership and control of this resource. This thesis argues in favour of once more prioritizing sharing water in the inclusive and adaptive governance phase of water, as a way of reopening closed water.